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#16

NEVADA TEST SITE

ANNUAL SITE ENVIRONMENTAL REPORT - 1993

VOLUME I

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U.S. DEPARTMENT OF ENERGY NEVADA OPERATIONS OFFICE ANNUAL SITE ENVIRONMENTAL REPORT - 1993

VOLUME I

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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 (EPA), Environmental Monitoring Systems Laboratory, 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 fifth 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.

ACKNOWLEDGEMENTS

The skill, dedication, and perseverance of Angela L. McCurdy in word processing and desktop publishing support were crucial to the production of this report. The review and advice offered by the Environmental Protection Division, Nevada Operations Office and the EPA Environmental Monitoring Systems Laboratory, Las Vegas (EMSL-LV) reviewers were valuable. Compilation and verification of onsite data were provided by Frank R. Grossman. The cooperative support of Anita A. Mullen of the EMSL-LV in production of this combined onsite and offsite environmental report was appreciated.

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MEASUREMENT UNITS AND NOMENCLATURE

Radioactivity data in this report are expressed in curies, microcuries (one millionth of a curie), and picocuries (one millionth of a millionth). The curie (Ci) is the customary unit used to express the rate of atomic nuclei transformations that occur each second. A curie is 37 billion (37×10^9) nuclear transformations per second. The unit of becquerel is also used. A becquerel (Bq) is equal to one disintegration per second; therefore, it takes 3.7×10^{10} becquerels to equal one curie.

The roentgen (R) is the customary unit used to describe the intensity of gamma radiation at a given measurement point (in air). The radiation exposure rate to external sources of penetrating radioactivity is expressed in milliroentgens per hour (mR/h), or one-thousandth of a roentgen per hour. Radiation exposure rates in the U.S. from natural radioactivity of cosmic and terrestrial origin varies between 0.005 and 0.025 mR/h.

The rem (for roentgen equivalent man) is a unit describing dose equivalent, or the energy imparted to human tissue when exposed to radiation. Dose is expressed in rem, millirem (mrem), or microrem (μrem). A typical annual dose rate from natural radioactivity (excluding exposure to radon) is 100 to 130 mrem per year. The unit of sievert (Sv) is also used. One sievert is equivalent to 100 rem.

The elements and corresponding symbols used in this report are:

Element	Symbol	Element	Symbol
Actinium	Ac	Lead	Pb
Americium	Am	Polonium	Po
Argon	Ar	Plutonium	Pu
Boron	B	Protactinium	Pa
Beryllium	Be	Radium	Ra
Bismuth	Bi	Rhodium	Rh
Cadmium	Cd	Radon	Rn
Carbon	C	Ruthenium	Ru
Calcium	Ca	Sulfur	S
Cerium	Ce	Antimony	Sb
Cobalt	Co	Strontium	Sr
Cesium	Cs	Technetium	Tc
Hydrogen	H	Thallium	Tl
Iodine	I	Thorium	Th
Potassium	K	Thulium	Tm
Krypton	Kr	Tritium	^3H
Lithium	Li	Uranium	U
Lutetium	Lu	Xenon	Xe
Nitrogen	N	Zinc	Zn
Oxygen	O		

LIST OF ACRONYMS AND EXPRESSIONS

AAR	AIHA Asbestos Analysts Registry
AEC	U.S. Atomic Energy Commission
AIRFA	American Indian Religious Freedom Act
AIHA	American Industrial Hygiene Association
ALARA	as low as reasonably achievable
ALI	Annual Limit of Intake
AMEM	Assistant Manager for Environmental Restoration and Waste Management
ANSI	American National Standard Institute
ASD	REECo Analytical Services Department
ASER	Annual Site Environmental Report
ASME	American Society of Mechanical Engineers
ASN	Air Surveillance Network (EMSL-LV)
AVO	Amador Valley Operations, EG&G/EM
BECAMP	Basic Environmental Compliance and Monitoring Program
BNA	base/neutral/acid
BOD	biochemical oxygen demand
CAA	Clean Air Act
CAP	College of American Pathologists
CAP88-PC	EPA software program for estimating doses
CCHD	Clark County Health Department
CCS	Calibration check standard
CCSD	Clark County Sanitation District
CEDE	Committed effective dose equivalent
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program (EPA)
COD	chemical oxygen demand
CP	Control Point
CRMP	Community Radiation Monitoring Program
CX	Categorical Exclusion
DAC	Derived Air Concentration
DAF	Device Assembly Facility
DCG	Derived Concentration Guide
D&D	Decontamination and Decommissioning
DDR	Data Discrepancy Report
DF	diesel fuel
DNA	Defense Nuclear Agency
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOE/HQ	DOE Headquarters
DOELAP	DOE Laboratory Accreditation Program
DOE/NV	DOE Nevada Operations Office
DOI	U.S. Department of Interior
DOT	U.S. Department of Transportation
DQO	Data Quality Objectives
DRI	Desert Research Institute
EA	Environmental Assessment
ECD	REECo Environmental Compliance Department
EDE	Effective dose equivalent
EG&G	EG&G, Inc.

List of Acronyms and Expressions, cont.

EG&G/EM	EG&G/Energy Measurements, Inc.
EHS	Extremely Hazardous Substances
Eh	Oxidation potential
EIS	Environmental Impact Statement
EMAD	Engine Maintenance, Assembly and Disassembly
EML	Environmental Measurements Laboratory DOE/NY
EMSL-LV	EPA Environmental Monitoring Systems Laboratory, Las Vegas
EOD	Explosive Ordnance Disposal
EPA	U.S. Environmental Protection Agency
EPD	DOE Environmental Protection Division
EPTox	extraction procedure toxicity
ERP	Environmental Restoration Project
ERWM	Environmental Restoration & Waste Management
ESA	Endangered Species Act
FFA	Federal Facilities Agreement
FFCA	Federal Facilities Compliance Act
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FOAV	Finding of Alleged Violation
GCD	Greater Confinement Disposal
GCP	Groundwater Characterization Project
GIS	geographical information system
GMX	Gadgets, Mechanics and Explosives
GOES	geostationary operational environmental satellite
GSD	Goleta Sanitation District
GZ	ground zero
HEPA	high-efficiency particulate aerosol
HF	hydrofluoric acid
HPD	REECo Health Protection Department
HRMP	Hydrologic Resources Management Program (DRI)
HSWA	Hazardous and Solid Waste Amendments
HTO	tritiated water
HWAS	Hazardous Waste Accumulation Storage
ICP	inductively coupled plasma
ICRP	International Commission on Radiological Protection
ID	identification
IH	REECo Industrial Hygiene
IRCR	International Reference Center for Radioactivity
JIT	Just-in-Time
KAFB	Kirtland Air Force Base
KO	Kirtland Operations, EG&G/EM
LANL	Los Alamos National Laboratory
LAO	Los Alamos Operations, EG&G/EM
LCS	laboratory control standard
LDAS	REECo Laboratory Data Analysis System
LDR	Land Disposal Regulations
LGFSTF	Liquified Gaseous Fuels Spill Test Facility
LINAC	linear accelerator
LLD	lower limit of detection
LLNL	Lawrence Livermore National Laboratory
LLW	low-level (radioactive) waste
LTHMP	Long-Term Hydrological Monitoring Program (EMSL-LV)

List of Acronyms and Expressions, cont.

LVAO	Las Vegas Area Operations, EG&G/EM
MAPEP	Mixed Analyte Performance Evaluation Program
MCL	Maximum Contaminant Levels
MDA	minimum detectable activity
MDC	minimum detectable concentration
MEI	maximally exposed individual
MGD	million gallons per day
MBAS	methylene blue active substances
MSL	mean sea level
MSM	Mounds Strategic Material
MSN	Milk Surveillance Network (EMSL-LV)
MSR	Management Systems Review
MWMF	Mixed Waste Management Facility
MWMU	Mixed Waste Management Unit
NAC	Nevada Administrative Code
NAEG	Nevada Applied Ecology Group
NAFB	Nellis Air Force Base
NAFR	Nellis Air Force Range
NCR	nonconformance report
NCRP	National Council on Radiation Protection and Measurement
NDEP	Nevada Division of Environmental Protection
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NEST	Nuclear Emergency Search Team
NGTSN	Noble Gas and Tritium Surveillance Network (EMSL-LV)
NIOSH	National Institute of Occupational Safety and Health
NIST	National Institute of Standards and Technology
NLV	North Las Vegas, Nevada
NLVF	North Las Vegas Facility
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollution Discharge Elimination System
NPL	National Priority List
NPS	National Park Service
NRACC	Nuclear Radiation Assessment Cross Check Program (EMSL-LV)
NRC	National Response Center
NRD	EMSL-LV Nuclear Radiation Assessment Division
NRDS	Nuclear Rocket Development Station
NRS	Nevada Revised Statutes
NTS	Nevada Test Site
NTSO	DOE Nevada Test Site Operations Office
NV-ERP	Nevada Environmental Restoration Project
NVLAP	National Voluntary Laboratory Accreditation Program
offsite	in the immediate area off the NTS
onsite	on the NTS
O&M	Operations and Maintenance
OP	Operating Permit
OR	Occurrence Report
ORNL	Oak Ridge National Laboratory
ORSP	Offsite Radiological Safety Program
OSHA	Occupational Safety and Health Administration
PAT	NIOSH Proficiency Analytical Testing Program

PCB	polychorinated biphenyl
pH	Hydrogen ion concentration
PHS	U.S. Public Health Service
PIC	pressurized ion chamber
POTW	Publicly Owned Treatment Works
PPA	Pollution Prevention Act
ppb	parts per billion
ppm	parts per million
QA	quality assurance
QAP	Quality Assessment Program
QC	quality control
QSG	Quality Support Group
RAM	remote area monitor
RC	residual chlorine
RCRA	Resource Conservation and Recovery Act
R&D	Research and Development
REECo	Reynolds Electrical & Engineering Company, Inc.
RESL	Radiological and Environmental Sciences Laboratory
RIDP	Radionuclide Inventory and Distribution Program
RI/FS	remedial investigation and feasibility study
RNMS	Radionuclide Migration Study
RPD	relative percent difference
RSD	relative standard deviation
RSL	Remote Sensing Laboratory
RSN	Raytheon Services Nevada
RSTN	Remote Seismic Test Network
RWMS	Radioactive Waste Management Site
s	sample standard deviation
SAM	Sample and Analysis Management System
SARA	Superfund Amendments and Reauthorization Act
SASN	Standby Air Surveillance Network (EMSL-LV)
SBO	Santa Barbara Operations, EG&G/EM
SCARS	System Control and Receiving Station
SDWA	Safe Drinking Water Act
SEE	specific effective energy
sem	standard error of the mean
SGZ	surface ground zero
SLB	shallow land burial
SLD	shallow land disposal
SMSA	Strategic Materials Storage Area
SMSN	Standby Milk Surveillance Network (EMSL-LV)
SNL	Sandia National Laboratories
SNTP	Space Nuclear Thermal Propulsion
SOP	Standard Operating Procedure
STL	Special Technologies Laboratory, EG&G/EM
TCLP	toxicity characteristic leaching procedure
TDS	total dissolved solids
TLD	thermoluminescent dosimeter
TP	TRU Pad
TRU	transuranic
TSCA	Toxic Substances Control Act

List of Acronyms and Expressions, cont.

TSI	Thermal System Insulation
TSS	total suspended solids
TTR	Tonopah Test Range
UCB	University Callifornia, Berkeley
UCLA	University of California, Los Angeles
UGTA	Underground Testing Areas
UNLV	University of Nevada, Las Vegas
URTD	upper respiratory tract disease
USDI	United States Department of Interior
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UST	underground storage tank
UTM	Universal Transverse Mercator
VOC	volatile organic compound
WAMD	Washington Aerial Measurements Department, EG&G/EM
WCO	Woburn Cathode Ray Tube Operations, EG&G/EM
WEB	Waste Examination Building
WHO	World Health Organization
WOD	REECo Waste Operations Department
WIPP	Waste Isolation Pilot Plant
WM&PPAP	Waste Minimization & Pollution Prevention Awareness Plan
WS	Water Supply

1.0 SUMMARY

Stuart C. Black and Wayne M. Glines

Monitoring and surveillance on and around the Nevada Test Site (NTS) by DOE contractors and NTS user organizations during 1993 indicated that operations on the NTS were conducted in compliance with applicable federal and DOE guidelines, i.e., the dose the maximally exposed offsite individual could have received was less than 0.04 percent of the 10 mrem per year guide for air exposure. No nuclear tests were conducted due to the moratorium. 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 effluents, or resuspension was not detectable offsite, and no measurable net exposure to members of the offsite population was detected through the offsite dosimetry program. Using the CAP88-PC model and NTS radionuclide emissions data, the calculated effective dose equivalent to the maximally exposed individual offsite would have been 0.004 mrem. Any person receiving this dose would also have received 97 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 is being achieved and, where mandated, permits for air and water discharges and waste management have been obtained from the appropriate agencies.

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

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 Environmental Protection Division and a Health Protection Division within the Office of Environment, Safety, Security and Health and upgrading the Environmental Restoration and Waste Management Division to the Assistant Manager level to address those environmental issues that arise in the course of performing the primary mission of the DOE/NV, underground testing of nuclear explosive devices. An environmental survey in 1987 and a Tiger Team assessment in 1989 identified numerous issues that must be resolved before DOE/NV can be considered to be in full compliance with environmental laws and regulations. At the end of 1993, 4 of the 149 Tiger Team findings remained open. These remaining items are long-term projects requiring additional time and funding before they can be completed. Progress on corrective actions to bring operations into compliance is reported to DOE Headquarters Environment, Safety and Health in a Quarterly Compliance Action Report.

Operational releases of radioactivity are reported soon after their occurrence to the Idaho National Engineering Laboratory through Environmental Impact Statement/Onsite Discharge

Information System (EIS/ODIS) reports. In compliance with the National Emission Standards for Hazardous Air Pollutants (NESHAP), the accumulated annual data from these reports are used each year as input to the Environmental Protection Agency's (EPA) CAP88-PC software program to calculate potential effective dose equivalents 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 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 a quantitative and qualitative 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 1993 consisted primarily of small amounts of tritium and radioactive noble gases and iodine released to the atmosphere that were attributed to:

- Diffusion of HTO in atmospheric moisture measured by an isokinetic sampler in the P Tunnel ventline.
- Continuing seepage of radioactive noble gases from higher yield (>20 kt) tests previously conducted on Pahute Mesa.
- Diffuse emissions calculated from the results of environmental surveillance activities.

Diffuse emissions included HTO, only slightly above detection limits, from the Radioactive Waste Management Site in Area 5 (RWMS-5), resuspended $^{239+240}$Pu from Areas 3 and 9, and ^{85}Kr from Pahute Mesa. Table 1.1 shows the quantities of radionuclides released from all sources, including postulated loss of laboratory standards. None of the radioactive materials listed in this table was detected above ambient levels in the offsite area.

Onsite liquid discharges to containment ponds included approximately 710 Ci (26 TBq) of tritium. This was about one-third of last year's tritium radioactivity because of efforts taken to seal the tunnels. Evaporation of this material could have contributed tritiated water vapor to the atmosphere, but the amounts were too small to be detected by the tritium monitors offsite. No liquid effluents were discharged to offsite areas.

1.2.1 ONSITE ENVIRONMENTAL SURVEILLANCE

Environmental surveillance on the 3500 km^2 (1350 mi^2) NTS is designed to cover the entire area with some emphasis on areas of past nuclear testing and present operational activities. There are 52 samplers for air particulates and reactive gases; 17 samplers collecting HTO in atmospheric moisture; 10 samplers collecting air for analysis of noble gas content; grab samples collected frequently from water supply wells, springs, open reservoirs, containment ponds and sewage lagoons; and thermoluminescent dosimeters (TLDs) placed at 193 locations on the NTS.

Data from these networks are summarized as annual averages for each monitored location. Those locations with concentrations above the NTS average are assumed to reflect onsite emissions. These emissions arise from diffuse (areal) sources and from particular operational activities (e.g., radioactivity buried in the Low-Level Waste [LLW] site). The calculated or estimated releases for 1993 are listed in Table 1.1.

Table 1.1 Radionuclide Emissions on the NTS - 1993[a]

Radionuclide	Half-life (years)	Quantity Released (Ci) [b]
Airborne Releases:		
^{3}H	12.35	[c]3.7
^{85}Kr	10.72	160.
^{131}I	0.022	[c]2.0×10^{-6}
^{133}Xe	0.0144	0.04
$^{239+240}Pu$	24065.	[c]1.8×10^{-3}
Tunnel Ponds:		
^{3}H	12.35	[d]710 .
^{238}Pu	87.743	1.8×10^{-5}
$^{239+240}Pu$	24065.	1.7×10^{-4}
^{90}Sr	29.	2.0×10^{-4}
^{137}Cs	30.17	7.8×10^{-4}
Gross Beta	---	6.9×10^{-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 and/or postulated loss of laboratory standards
(d) This amount is assumed to evaporate to become an airborne release

Approximately 2700 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). Plutonium analyses of monthly composited air filters indicated an annual arithmetic average below 10^{-16} μCi/mL (4×10^{-6} Bq/m^3) of $^{239+240}Pu$ and 10^{-17} μCi/mL (4×10^{-7} Bq/m^3) of ^{238}Pu for all locations during 1993, with the majority of results for both isotopes being on the order of 10^{-18} μCi/mL (4×10^{-8} Bq/m^3). A slightly higher average was found in samples from the air samplers in Areas 3 and 9, but that level was calculated to be only 0.01 percent of the Derived Air Concentration. Higher than background levels of plutonium are to be expected in some air samples because atmospheric testing in the 1950s and nuclear safety tests (where chemical explosives were used to blow apart nuclear devices) deposited plutonium on a small portion of the surface of the NTS.

The annual average concentration of ^{85}Kr from the ten noble gas monitoring stations was 27×10^{-12} μCi/mL (1 Bq/m^3), which is equivalent to the average reported by EPA's EMSL-LV (Environmental Monitoring Systems Laboratory, Las Vegas) for the offsite noble gas sampling network. This concentration is similar to that reported in previous years and is attributed to worldwide distribution of ^{85}Kr from the use of nuclear technology. As has been the case in the past, the ^{133}Xe results were below the detection limit.

Throughout the year atmospheric moisture was collected for two-week periods at 17 locations on the NTS and analyzed for tritiated water content (HTO). The annual arithmetic average of $(5 \pm 8) \times 10^{-6}$ pCi/mL (0.2 ± 0.3 Bq/m^3) was similar to last year's average. The locations on the border of the RWMS-5 and at the Area 15 EPA Farm had the highest concentrations.

The primary radioactive liquid discharge to the onsite environment in 1993 was seepage from the test tunnels in Rainier Mesa (Area 12) contributing 71 million liters of water containing approximately 710 Ci (26 TBq) of tritium to containment ponds near the tunnels. For dose calculations, all of this tritiated water was assumed to have evaporated.

Surface water sampling was conducted monthly at 15 open reservoirs, 7 springs, 9 containment ponds, and quarterly at 3 sewage lagoons. A grab sample was taken from each of these surface water sites for analysis of gross beta, tritium, and gamma-emitter concentrations. Each quarter a sample was taken for plutonium analysis, and ^{90}Sr was analyzed once per year for each location. Water samples from the springs, reservoirs, and lagoons contained background levels of gross beta, tritium, plutonium, and strontium. Samples collected from the tunnel containment ponds contained detectable levels of radioactivity as would be expected.

Onsite water derived from onsite supply wells and distribution systems was sampled and analyzed monthly for radionuclides. The supply well average gross beta activity of 7.1 x 10^{-9} µCi/mL (0.26 Bq/L) was 3 percent of the Derived Concentration Guide (DCG) for ^{40}K (used for comparison purposes); gross alpha was 6.1 x 10^{-9} µCi/mL (0.23 Bq/L), which was 41 percent of the drinking water standard; ^{90}Sr was 0.52 x 10^{-10} µCi/mL (1.9 Bq/L), about one percent of the DCG; ^{3}H concentrations averaged 5.0 x 10^{-9} µCi/mL (0.19 Bq/L), less than 0.006 percent of the DCG; $^{239+240}$Pu was -7.2 x 10^{-12} µCi/mL (-2.7 x 10^{-4} Bq/L), and ^{238}Pu was -6.6 x 10^{-12} µCi/mL (-2.4 x 10^{-4} Bq/L), both below detectable levels.

External gamma radiation exposure data from the onsite TLD network indicated the gamma exposure rates recorded during 1993 were statistically higher than the data collected in 1992. Recorded exposure rates on the NTS ranged from 90 mR/yr in Mercury to 1288 mR/year in a contaminated area in Area 4. The site-wide average for boundary and control stations of 144 mR/yr was about 14 percent higher than last year. This increase is suspected to be caused by analytical bias since the increase was consistent throughout the network.

1.2.2 OFFSITE ENVIRONMENTAL SURVEILLANCE

The offsite radiological monitoring program is conducted around the NTS by the EPA's EMSL-LV, under an Interagency Agreement with DOE. This program consists of several extensive environmental sampling, radiation detection, and dosimetry networks.

In 1993 the Air Surveillance Network (ASN) was made up of 30 continuously operating sampling locations surrounding the NTS and 77 standby stations (operated one week each quarter) in all states west of the Mississippi River. The 30 ASN stations included 18 located at Community Radiation Monitoring Program (CRMP) stations, described below. During 1993 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 possibly detected by this network was ^{238}Pu or $^{239+240}$Pu on a few air filter samples.

The Noble Gas and Tritium Surveillance Network (NGTSN) consisted of 21 offsite noble gas samplers (8 on standby) and 21 tritium-in-air samplers (seven on standby) located outside the NTS and exclusion areas in the states of Nevada, California, and Utah. During 1993 no radioactivity that could be related to NTS activities was detected at any NGTSN sampling station.

As in previous years, results for ^{133}Xe and HTO were typically below the minimum detectable concentration (MDC). The annual average results for krypton, 28 x 10^{-12} μCi/mL, although above the MDC, were within the range of worldwide values expected from sampling background levels and the range was similar to last year's.

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 Colorado, Mississippi, New Mexico, Alaska, and Nevada where underground tests were conducted. The results obtained from analysis of samples collected at those locations were consistent with previous data except for a sample from a deep well at Project GASBUGGY where the tritium concentration appears to be increasing and ^{137}Cs has been detected. No concentrations of radioactivity detected in water, milk, vegetation, soil, fish, or animal samples posed any significant health risk.

The Milk Surveillance Network (MSN) consisted of 24 sampling locations within 300 km (186 mi) of the NTS and 115 Standby Milk Surveillance Network (SMSN) locations throughout the major milk sheds west of the Mississippi River. Tritium and ^{90}Sr are rarely detected in milk samples at present and ^{89}Sr is practically never detected. The levels in both milk networks have decreased over time since reaching a maximum in 1964. The results from these networks are consistent with previous data and indicate little or no change.

Other foods were analyzed regularly, most of which were meat from domestic or game animals collected on and around the NTS. The ^{90}Sr levels in samples of animal bone remained very low, as did $^{239+240}$Pu in both bone and liver samples. Carrots, kohlrabi, broccoli, summer squash, turnips, pears, potatoes, green onions, and apples from several offsite locations contained normal ^{40}K activity. Small amounts of $^{239+240}$Pu and ^{90}Sr found on a few samples were attributed to incomplete washing of soil from the samples.

In 1993, external exposure was monitored by a network of 127 TLDs and 27 pressurized ion chambers (PICs). The PIC network in the communities surrounding the NTS indicated background exposures, ranging from 66 to 166 mR/yr, that were consistent with previous data and well within the range of background data in other areas of the U.S.

Internal exposure was assessed by whole-body counting through use of a single germanium detector, lung counting with six semi-planar detectors, and bioassay through radiochemical procedures. In 1993 counts were made on 144 individuals, of whom 56 were participants in the Offsite Internal Dosimetry Program. In general, the spectra obtained were representative of natural background with only normal ^{40}K being detected. No transuranics were detected in any lung counting data. Physical examination of offsite residents revealed only a normal, healthy population consistent with the age and sex distribution of that population.

No radioactivity attributable to current NTS operations was detected by any of the monitoring networks. However, based on the NTS releases reported in Table 1.1, atmospheric dispersion model calculations (CAP88-PC) indicated that the maximum potential effective dose equivalent to any offsite individual would have been 4 x 10^{-3} mrem (4 x 10^{-5} mSv), and the dose to the population within 80 kilometers of the emission sites would have been 1.2 x 10^{-2} person-rem (1.2 x 10^{-4} person-Sv). The hypothetical person receiving this dose was also exposed to 97 mrem from natural background radiation. A summary of the potential effective dose equivalents due to operations at the NTS is presented in Table 1.2.

Table 1.2 Summary of Effective Dose Equivalents from NTS Operations during 1993

	Maximum EDE at NTS Boundary[a]	Maximum EDE to an Individual[b]	Collective EDE to Population within 80 km of the NTS Sources
Dose	4.8×10^{-3} mrem (4.8×10^{-5} mSv)	$3.8 \pm 0.57 \times 10^{-3}$ mrem (3.8×10^{-5} mSv)	1.2×10^{-2} person-rem (1.2×10^{-4} person-Sv)
Location	Site boundary 58 km SSE of NTS Area 12	Indian Springs, 80 km SSE of NTS Area 12	21,750 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	0.05	0.04	-----
Background	97 mrem (0.97 mSv)	97 mrem (0.97 mSv)	1747 person-rem (17.5 person Sv)
Percentage of Background	5.0×10^{-3}	4.0×10^{-3}	6.9×10^{-4}

(a) The maximum boundary dose is to a hypothetical individual who remains in the open continuously during the year at the NTS boundary located 58 km SSE from the Area 12 tunnel ponds.

(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 1.0) using NTS effluents listed in Table 5.1, assuming all tritiated water input to containment ponds was evaporated, and summing the contributions from each NTS source.

A network of 18 CRMP stations is operated by local residents. Each station is an integral part of the ASN, NGTSN, and TLD networks. In addition, they are equipped with a PIC connected to a gamma-rate recorder. Each station also has satellite telemetry transmitting equipment so that gamma exposure measurements acquired by the PICs are transmitted via the Geostationary Operational Environmental Satellite (GOES) to the NTS and from there to the EMSL-LV by dedicated telephone line. Another nine PICs with the same capabilities are distributed in other locations around the NTS. Samples and data from these CRMP stations are analyzed and reported by EMSL-LV and interpreted and reported by the Desert Research Institute, University of Nevada System. All measurements for 1993 were within the normal background range for the U.S.

1.2.3 ECOLOGICAL STUDIES

Studies conducted under DOE/NV-sponsored programs included monitoring the flora and fauna on the NTS to assess changes over time in ecological conditions and to provide information needed to document NTS compliance with environmental laws, regulations, and orders. The monitoring effort has been arranged into three interrelated phases of work: (1) a series of five non-disturbed study plots in test-impacted ecosystems that are monitored at one to five-year intervals to establish natural baseline conditions; (2) a series of study plots in representative disturbed areas that are monitored at three- to five-year intervals to determine impacts of disturbance, document site recovery, and investigate natural recovery processes; and (3) observations of birds and large mammals throughout the NTS.

In 1993, the sixth full year of flora and fauna monitoring surveys were conducted at 17 sites. Ephemeral plants were monitored at 14 locations, some with multiple plots. Perennial plants were measured at 10 sites, mammals at 10 sites, and reptiles at 8 sites. Many of these sites included paired disturbed/undisturbed plots. Three baseline sites were monitored and perennials and ephemerals were measured at all of them. Sites in disturbed areas are monitored on a three year cycle. In 1993 three burned areas and two roadside study sites were sampled. In addition, baseline measurements were made near the Device Assembly Facility under construction in Frenchman Flat.

Monitoring of feral horses continued for the fourth consecutive year. All horses, including foals, were individually identified. In addition, field observations were made of raptors, mule deer, and raven in appropriate habitats throughout the NTS. Desert tortoises in the Rock Valley study enclosures were monitored in spring and fall, and free roaming tortoises were marked and measured when encountered by chance.

1.2.4 LOW-LEVEL WASTE DISPOSAL

Environmental monitoring at and around RWMS-5 indicated that radioactivity was just detectable at, but not beyond, the waste site boundaries. This monitoring included air sampling, water sampling, tritium migration studies, and external gamma exposure measurement. Vadose zone monitoring for hazardous constituents has been installed in mixed waste disposal pit (Pit 3) in RWMS-5 as a method of detecting any downward migration of mixed waste.

Elevated levels of plutonium were detected in several areas on the NTS, particularly in Areas 3 and 9 where operational activities and vehicular traffic resuspend plutonium for detection by air sampling. The presence of plutonium on the NTS is primarily due to atmospheric and safety tests in the 1950s and 1960s. These tests spread plutonium in the eastern and northeastern areas of the NTS (see Chapter 2, Figure 2.3 for these locations).

1.2.5 RADIOLOGICAL MONITORING AT OFFSITE SUPPORT FACILITIES

Fence line monitoring, using Panasonic UD-814 TLDs, was conducted at EG&G/EM's facilities in North Las Vegas, at Nellis Air Force Base, and in Santa Barbara, California. The 1993 results indicated that only background radiation was detected at the fence line.

1.3 NONRADIOLOGICAL MONITORING

Nonradiological environmental monitoring of NTS operations involved only onsite monitoring because there were no nonradiological hazardous material discharges offsite. The primary environmental permit areas for the NTS were monitored to verify compliance with ambient air quality and the Resource Conservation and Recovery Act (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. These emissions were covered by a series of 26 air quality permits and 17 permits to construct, issued by the state of Nevada. The only nonradiological air emission of regulatory concern under the Clean Air Act was due to asbestos removal during building renovation projects and from insulated piping at various locations onsite. There were seven notifications to the state and one to the EPA Region 9 Office under NESHAP requirements in 1993.

RCRA-required monitoring included waste management and environmental compliance activities that necessitated the analysis of soil, water, sediment and oil samples. Low levels of targeted chemicals were found in several samples.

As there are no liquid discharges to navigable waters, offsite surface water drainage systems, or publicly owned treatment works, no Clean Water Act National Pollution Discharge Elimination System permits were required for NTS operations. Under the conditions of state of Nevada operating permits, liquid discharges to 13 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 compliance with the Safe Drinking Water Act and five state of Nevada drinking water supply system permits for onsite distribution systems supplied by onsite wells, drinking water systems are sampled monthly for residual chlorine, pH, bacteria, and, less frequently, for other water quality parameters. Federal and state standards for fluorides and pH were slightly exceeded in the water system. In the case of fluorides, the state granted a variance to exceed Secondary fluoride standards as long as Primary standards were met. For the other exceedance, the state has been contacted to assist in developing a mitigation plan.

Monitoring for polychlorinated biphenols as required by the Toxic Substances Control Act involved analysis of 204 various samples. Only 16 samples contained detectable levels.

At the Liquified Gaseous Fuels Spill Test Facility, 4 planned spill tests using carbon dioxide were conducted during 1993. None of the tests generated enough airborne contaminants to be detected at the NTS boundary during or after the tests. Boundary monitoring was performed by EMSL-LV personnel.

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 Clean Air Act, Clean Water Act, Safe Drinking Water Act, Toxic Substances Control Act, and RCRA are summarized above. Also, National Environmental Policy Act activities included action on two Environmental Impact Statements (EIS), 17 Environmental Assessments (EA) and 100

Categorical Exclusions. Of these, seven Environmental Assessments and 89 Categorical Exclusions were initiated in 1993.

Wastewater discharges at the NTS are not regulated under National Pollutant Discharge Elimination System 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 of EG&G Energy Measurements, Inc. (EG&G/EM) were predominantly within the regulated levels established by city or county publicly owned treatment works. One notice of violation was issued to EG&G/EM, the Amador Valley Operation, from the Bay Area Air Quality Control District for exceeding the permitted 10 gallon annual use rate of solvent by 7.5 gallons.

During 1993 five underground storage tanks were removed and one was upgraded in accordance with state and federal regulations (see Appendix H, Table H.4). The two boiler house tanks in Areas 12 and 27 had reportable hydrocarbon releases and will require remedial action.

In 1993, 42 cultural resource surveys were conducted for historical and archaeological sites on the NTS, and reports on the findings were prepared. These surveys identified 23 sites containing previously unknown archaeological information. One data-recovery project was undertaken in 1993 and Native American monitors were present during the fieldwork.

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 1993, the draft technical report on this AIRFA Program was prepared and reviewed by all tribes and appropriate government agencies. This report includes the Native Americans' recommendations regarding the effects of DOE/NV's activities. The report will be finalized in 1994.

1.5 GROUNDWATER PROTECTION

DOE/NV instituted a Long-Term Hydrological Monitoring Program (LTHMP) in 1972 to be operated by the EPA under an Interagency Agreement. Groundwater was monitored on and around the NTS, at eight sites in other states, and at two off-NTS locations in Nevada in 1993 to detect the presence of any radioactivity 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 although none exceeded 0.2 percent of the National Primary Drinking Water Regulation level.

HTO was detected in samples from wells at formerly utilized sites, such as DRIBBLE (MS), GNOME (NM), and GASBUGGY (NM) at levels consistent with previous experience. The tritium concentration in Well EPNG 10-36 at GASBUGGGY began increasing about 1984, and ^{137}Cs was detected for the second year in a row.

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, an extensive program of well drilling for groundwater characterization has been started. The design of the program is for installation of approximately 100 wells at strategic locations on and near the NTS. Five of these wells have been completed, six existing wells recompleted and water quality parameters are being collected for future use in the characterization project.

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

1.6 RADIOACTIVE AND MIXED WASTE STORAGE AND DISPOSAL

Two radioactive waste disposal facilities are operated on the NTS; the RWMS-5 and the Area 3 Radioactive Waste Management Site (RWMS-3). During 1993 the RWMS's received low-level waste generated at the NTS and other DOE facilities. Waste is disposed of in shallow pits, trenches, and selected craters. Transuranic (TRU) and TRU mixed wastes are stored on a curbed asphalt pad on pallets in overpacked 55 gallon drums and assorted steel boxes pending shipment to the Waste Isolation Pilot Plant (WIPP) in New Mexico. The RWMS-3 is used for disposal of bulk low-level waste and LLW that is contained in packages that are larger than the specified standard size used at the RWMS-5.

Environmental monitoring at both sites included air sampling for radioactive particulates and reactive gases and external exposure measurements using TLDs. Sampling for HTO in air, water sampling, tritium migration studies, and vadose zone monitoring for moisture and hazardous constituents are conducted at the RWMS-5. Environmental monitoring results for 1993 indicated that measurable radioactivity from waste disposal operations was detectable only in the immediate vicinity of the facilities.

Because the NTS is not a RCRA permitted disposal facility, RCRA regulations require the shipment of nonradioactive hazardous materials to licensed disposal facilities offsite. No disposal of hazardous materials was performed at the NTS in 1993.

A Mixed Waste Management Unit (MWMU) is planned to be located immediately north of the existing pits within RWMS-5 and will be part of routine disposal operations. This area, designed to have a process capacity of 12.0 hectare-meters (97.6 acre-feet), will contain 10 landfill cells to be used for mixed waste disposal. Construction of the MWMU will commence upon completion of necessary National Environmental Policy Act (NEPA) documentation and issuance of a state of Nevada Part B Permit.

Mixed waste and low-level waste will only be accepted for disposal from generators (onsite and offsite) that have submitted a waste application as required by NVO-325, Nevada Test Site Defense Waste Acceptance Criteria, Certification, and Transfer Requirements; that have verified compliance to NVO-325; and that have received DOE/NV approval of the waste stream(s) for disposal at NTS.

1.7 QUALITY ASSURANCE

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

1.7.1 ONSITE NONRADIOLOGICAL QUALITY ASSURANCE

The onsite nonradiological QA program included sample acceptance and control criteria, quality control (QC) procedures, and use of EPA approved methods. External QA includes interlaboratory comparisons through participation in the National Institute of Occupational

Safety and Health (NIOSH) Proficiency Analytical Testing (PAT) Program, the American Industrial Hygiene Association (AIHA) Asbestos Analysts Registry (AAR) Program, the AIHA Bulk Asbestos Analysis Program, National Voluntary Laboratory Accreditation Program (NVLAP) Bulk Asbestos Fiber Analysis Program, and the College of American Pathologists (CAP) Analysis of Lead in Blood Program. Proficiency testing through participation in the EPA Contract Laboratory Program (CLP) was continued.

1.7.2 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. The external QA intercomparison program for radiological data quality assurance consists of participation in the DOE Quality Assessment Program (QAP) administered by the DOE Environmental Measurements Laboratory (EML); the Nuclear Radiation Assessment and Cross Check Program (NRACC) conducted by the EPA's EMSL-LV; and the quality assessment program sponsored by the International Reference Center for Radioactivity (IRCR) of the World Health Organization (WHO).

1.7.3 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 Nuclear Radiation Assessment Division (NRD) of the EMSL-LV for the Offsite Radiological Safety Program (ORSP) meets all requirements of EPA policy, and also includes applicable elements of the Department of Energy QA requirements and regulations. The ORSP QA program defines data quality objectives (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 1993

- In July 1993, DOE/NV, Reynolds Electrical & Engineering Company, Inc. (REECo), and the state of Nevada Division of Environmental Protection (NDEP) signed a settlement agreement resulting from a Finding of Alleged Violation (FOAV) and Order issued in December 1992. This FOAV and Order were based on violations of RCRA regulations identified during an inspection by EPA region 9 in July, 1992. The settlement included a penalty of $21,000.

- In mid 1990 the state of Nevada requested assistance from REECo to cleanup abandoned waste in Pahrump, Nevada. The site consisted of 780 containers of various sizes stored on wooden pallets. REECo or Defense Logistics Agency stamps were found on six containers, but no discernable labels to indicate ownership were found on the others. Cleanup activities began in September 1990 and were completed by year's end. A final report from REECo was submitted to DOE/NV in June 1991 for transmittal to the state. In December 1992, REECo was notified by Region 9, EPA of its potential liability for $48,608.63 in government incurred costs for stabilization and assessment actions at the Pahrump Drum Removal Site. DOE/NV Office of Chief Counsel advised REECo in January 1993 that DOE/HQ was not approving the payment, subject to further review.

REECo was instructed to obtain further information and data supporting a possible offer/payment based on volumetric calculations.

- The NDEP issued a FOAV for the suspected discharge of RCRA wastes to a mixed waste leachfield after the date land disposal was to cease. After investigation, this was amended to discharge of waste with pH less than 2 and a fine of $20,000 was levied.

- An FOAV was issued by the NDEP on May 24, 1993, related to drums of hazardous waste found at the Area 23 Motor Pool. It alleged failure to characterize and to meet storage and management requirements. Corrective actions were taken and a penalty of $20,400 was paid by REECo.

- Material known as Cotter Concentrate, once controlled by DOE/HQ, was released to DOE/NV control. Characterization of this material is required and will begin after NDEP approval of the "Sampling and Analysis Plan", and receipt of funding from DOE/HQ.

- An EPA inspection of EG&G/EM's North Las Vegas anodizing operation alleged a failure to comply with federal pretreatment standards for chromium in wastewater and violating the prohibition of using dilution as a pretreatment method.

- In 1993 the state of Nevada indicated a desire to begin negotiating a two-party Federal Facilities Agreement (FFA). DOE/NV and the state began negotiations for this agreement, a draft of which was sent to DOE Headquarters for review in November 1993.

ACCOMPLISHMENTS FOR 1993

- DOE/NV negotiated a Consent Agreement with the state to provide for storage of Land Disposal Restricted low-level mixed waste generated at the NTS.

- The Project Chariot sites in Alaska were remediated: soil, surface water, sediment, air, and biota samples were taken for analysis; the soil mound was removed; and other soil containing low levels of ^{137}Cs was transported to the NTS. Operations were completed in August 1993.

- DOE/NV developed and presented a NEPA Training Course covering Council of Environmental Quality regulations, the NV NEPA process, and DOE NEPA regulations and procedures. A complementary course on EAs and EISs was also developed. These are used for training DOE/NV and contractor employees.

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

- Of the 149 Tiger Team findings from their 1989 assessment, 15 were closed in 1993 so only 4 remain to be resolved. These involve Environmental Impact Statements, standardization of training and management of electrical service.

- Progress continued on the NTS groundwater characterization program. Five special wells have been completed and several existing wells have been recompleted to meet program requirements.

- In 1993, efforts associated with the NTS American Indian Religious Freedom Act Compliance Program include conducting an ethnobotanical study on the NTS with Native Americans that involved participation by 17 tribes. The ethnographers spent 18 days at the NTS taking different groups of Native Americans to eight locations in Areas 12, 19, and 20.

- At the state's request, the Waste Management Program installed three pilot wells at RWMS-5. Underground conditions were carefully monitored, and the data have been used for site characterization. The uppermost groundwater table was found at approximately 244 m (800 ft). Only naturally occurring radioactivity was detected in the groundwater.

The environmental monitoring results presented in this report document that operational activities on the NTS in 1993 were conducted so that no radiological exposure occurred to the offsite public. 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 outside all year) equated to 0.004 mrem to a person living in Indian Springs, Nevada. This may be compared to that individual's exposure to 97 mrem from natural background radiation measured by the PIC at Indian Springs.

There were no major incidents of nonradiological contaminant releases to the environment, and intensive efforts to characterize and protect the NTS environment, implemented in 1990, were continued in 1993.

2.0 INTRODUCTION

Stuart C. Black, H. Bruce Gillen, and Wayne M. Glines

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 until the present moratorium began. Historical 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, and (4) open-air nuclear reactor and engine testing. No nuclear tests were conducted in 1993. Limited non-nuclear testing has included controlled spills of hazardous material at the Liquified Gaseous Fuels Spill Test Facility. Low-level radioactive and mixed waste disposal and 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 U.S. Air Force lands. Also characteristic of this area are the great depths to slow-moving groundwaters and little or no surface water. These features afford protection to the inhabitants of the surrounding area from potential radiation exposures as a result of releases of radioactivity or other contaminants from operations on the NTS. Population density within 150 km of the NTS is only 0.5 persons per square kilometer versus approximately 29 persons per square kilometer in the 48 contiguous states. The predominant land use surrounding the NTS is open range used for livestock grazing with scattered mining and recreational areas.

In addition to the NTS operations, DOE/NV is accountable for eight non-NTS EG&G Energy Measurements, Inc. (EG&G/EM) facilities in eight different cities. These operations support the DOE/NV programs with activities ranging from aerial measurements and aircraft maintenance to electronics and heavy industrial fabrication. All of these operations are located in metropolitan areas.

The EPA's Environmental Monitoring Systems Laboratory in Las Vegas, Nevada (EMSL-LV), conducts hydrological studies at eight formerly used U.S. nuclear testing locations off the NTS. The last test conducted at any of these sites was in 1973 (Project RIO BLANCO in Colorado).

2.1 NTS OPERATIONS

2.1.1 NTS DESCRIPTION

The NTS has been operated by the DOE as the on-continent test site for nuclear weapons testing. It is located in Nye County, Nevada, with the southeast corner lying about 105 km (65 mi) northwest of the city of Las Vegas, Nevada, as shown in Figure 2.1. The NTS encompasses about 3500 km^2 (1350 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 access exclusion areas, previously designated the Nellis Air Force Base (NAFB) Bombing and Gunnery Range and the Tonopah Test Range (Figure 2.1). These two areas comprise the Nellis Base Range, which provides a buffer zone varying from 24 to 104 km (15 to 65 mi) between the NTS and public lands. The combination of the Nellis Base Range and the NTS is one of the larger unpopulated land areas in the U.S., comprising some 14,200 km^2 (5470 mi^2). Figure 2.2 shows the general layout of the NTS, including the location of major facilities and area numbers referred to in this report. The areas outlined in red in Figure 2.2 indicate the principal geographical areas used for underground nuclear testing over the history of NTS operations. Mercury, Nevada, at the southern end of the NTS, is the main base camp for worker housing and administrative operations for the Site. Area 12 Base Camp, at the northern end of the NTS, is the other major worker housing and operations support facility.

2.1.2 MISSION AND NATURE OF OPERATIONS

The NTS has been the primary location for testing the nation's nuclear explosive devices since January 1951. 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 of the tests were non-nuclear, i.e., "safety" tests, involving destruction of a nuclear device with non-nuclear explosives. Safety tests resulted in dispersion of plutonium in the test vicinity. One of these test areas lies just north of the NTS boundary on the Nellis Base Range (see Figure 2.3). All announced tests have been listed in DOE/NV Report NVO-209 (DOE 1992).

Underground nuclear tests were first conducted in 1957. Testing was discontinued during a moratorium from November 1958 through September 1961. Four small atmospheric (surface) tests were conducted in 1961 and 1962 following the resumption of underground and atmospheric testing. Two additional safety test series were conducted in the mid-1960s, one on the previously designated NAFB Bombing and Gunnery Range and one on the Tonopah Test Range. Since late 1962 nearly all tests have been conducted in sealed vertical shafts drilled into the valley floor of Yucca Flat and the top of Pahute Mesa or in horizontal tunnels mined into the face of Rainier Mesa. Five earth-cratering (shallow-burial) tests were conducted over the period of 1962 through 1968 as part of the Plowshare Program, which explored peaceful uses of nuclear explosives. Four of these were in the northwestern quadrant of the NTS. The first and largest (SEDAN) was detonated at the northern end of Yucca Flat.

Other nuclear testing over the history of the NTS has included the Bare Reactor Experiment - Nevada series of experiments in the 1960s. These tests were performed with a 14-MeV neutron generator mounted on a 465 m (1530 ft) steel tower used to conduct neutron and gamma-ray interaction studies on shielding materials, electronic components, live organisms, and tissue-equivalent simulations for biomedical and environmental research. From 1959 through 1973 a series of open-air nuclear reactor, nuclear engine, and nuclear furnace tests were conducted in Area 25 at the Nuclear Rocket Development Station (now the Nevada

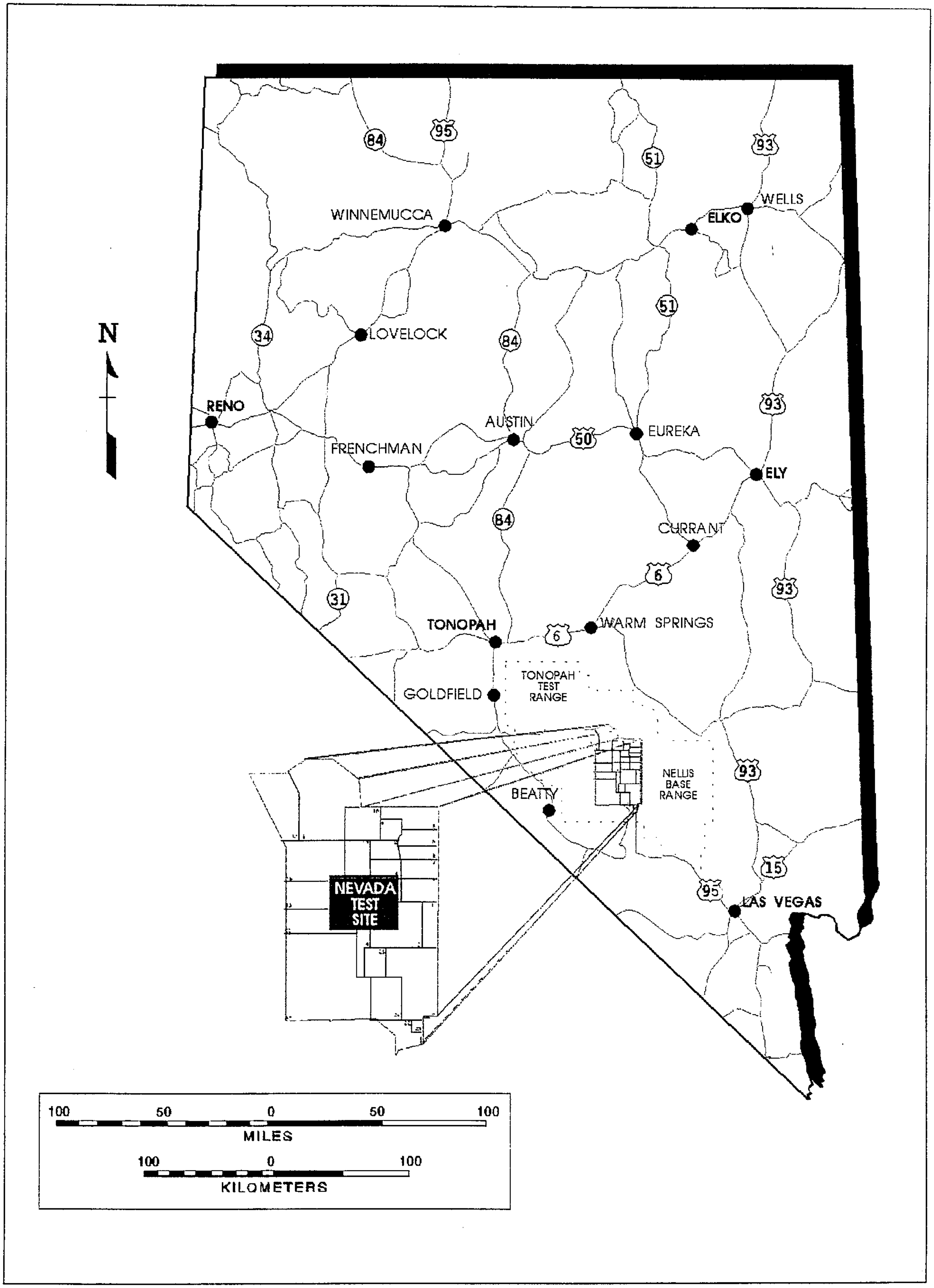


Figure 2.1 NTS Location

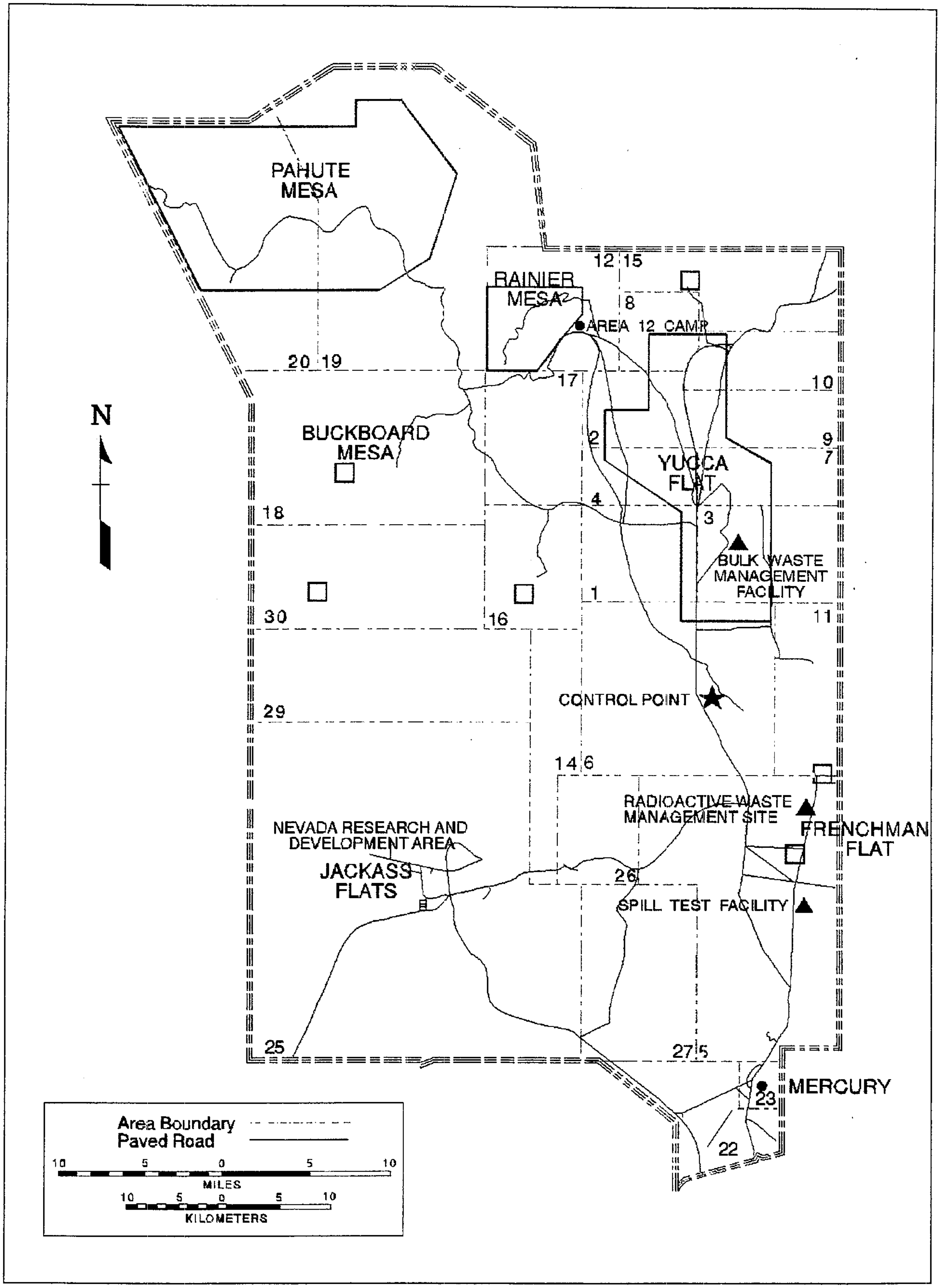


Figure 2.2 NTS Area Designations, Principal Facilities, and Testing Areas

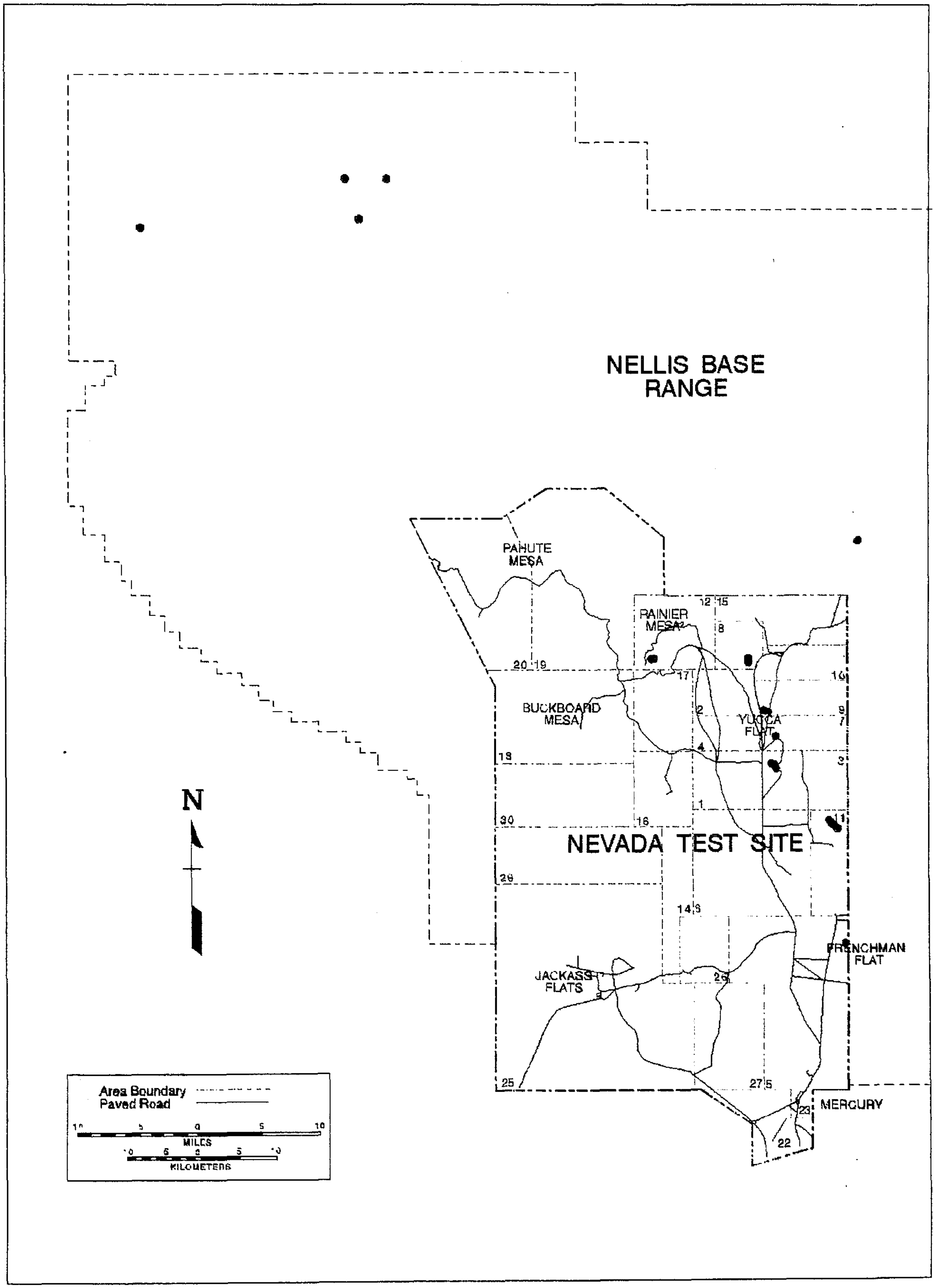


Figure 2.3 Location of Safety Shots in the Nellis Base Range

Research and Development Area). Another series of tests with a nuclear ramjet engine was conducted in Area 26 by the Lawrence Livermore National Laboratory, Livermore, California (LLNL).

Limited non-nuclear testing has also occurred at the NTS, including spills of hazardous materials at the LGFSTF in Area 5. These tests, conducted from the latter half of the 1980s to date, involved controlled spilling of liquid materials to study both spill control and mitigation measures and dispersion and transport of airborne clouds resulting from these spills. These tests are cooperative studies involving private industry, the U.S. Department of Transportation (DOT), and the DOE.

Waste disposal facilities for radioactive and mixed waste are also available at the NTS for defense waste disposal. Disposal sites are located in Areas 3 and 5. At the Area 5 Radioactive Waste Management Site (RWMS-5), low-level radioactive waste (LLW) from DOE-affiliated onsite and offsite generators are disposed of using standard shallow land disposal techniques. Mixed waste from one offsite generator (Rocky Flats) was disposed of at RWMS-5 until this activity was curtailed in 1990. The Greater Confinement Disposal technique, consisting of 3 m (10 ft) diameter shafts 37.5 m (120 ft) deep, are located at the RWMS-5. This technique was used for disposal of wastes not suited for shallow land burial because of high specific activity, high mobility, or not acceptable at WIPP.

Transuranic wastes are retrievably stored in surface containers at the RWMS-5 pending shipment to the Waste Isolation Pilot Plant facility in New Mexico. Nonradioactive hazardous wastes are accumulated at a special accumulation site before shipment to a licensed offsite disposal facility. At the RWMS-3 bulk LLW (such as debris from atmospheric nuclear test locations) and LLW in large non-standard packages, is emplaced and buried in selected surface subsidence craters (formed as a result of prior underground nuclear tests).

2.1.3 1993 ACTIVITIES

2.1.3.1 NUCLEAR TESTS

No nuclear explosives tests were conducted during 1993 due to the moratorium announced in late 1992. One exercise that was conducted was a drillback into the cavity formed by a nuclear test that was conducted in 1986. Also, 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. The surveillance program and results are described in Chapters 4 and 5.

2.1.3.2 LIQUIFIED GASEOUS FUELS SPILL TEST FACILITY (LGFSTF)

The LGFSTF is maintained by EG&G/EM, and is the basic research tool for studying the dynamics of accidental releases of various hazardous materials. Discharges from the LGFSTF occur at a controlled rate and consist of a measured volume of hazardous test fluid released on a surface especially prepared to meet the test requirements. LGFSTF personnel monitor and record operating data, close-in and downwind meteorological data, and downwind gaseous concentration levels. Calculation of the potential path of the test effluent is used to help control the test and monitor the data, which is done from a remote location. A total of four spill tests involving carbon dioxide were conducted in 1993 and the results monitored.

An array of diagnostic sensors may be placed up to 16 km downwind of the spill point to obtain cloud-dispersion data. Deployment of the array is test dependent and is not used for all experiments. The array can consist of up to 20 meteorological stations to gather wind speed and wind direction data and up to 41 sensor stations to gather data from a variety of sensors at various levels above ground. The array and associated data-acquisition system are linked to the LGFSTF control point by means of telemetry. The operation and performance of the LGFSTF are controlled and monitored from the Command Control and Data Acquisition System building located one mile from the test fluid spill area.

2.1.4 TOPOGRAPHY AND TERRAIN

The topography of the NTS is typical of much 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 (3000 ft) above mean sea level (MSL) in the south and east, rising to 2230 m (7300 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 created when the overburden above a nuclear cavity collapsed and formed a rubble "chimney" to the surface (Figure 2.5). A few craters have been formed as a result of tests conducted on or near the surface during atmospheric testing, by shallow depth-of-burial cratering experiments, or following tunnel events.

There are no continuously flowing streams on the NTS. Surface drainages for the Yucca Flat and Frenchman Flat are in closed-basin systems, which drain onto the dry lake beds (playas) in each valley. The remaining area of the NTS drains 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 or seeps into permeable sands and gravels. During extreme conditions, flash floods may occur. The surface drainage channel pattern for the NTS and its immediate vicinity is displayed in Figure 2.6. The northwest portion (Pahute Mesa) of the NTS has integrated channel systems which carry runoff beyond NTS boundaries into the closed basins and playas in Kawich Valley and Gold Flat on the NAFB Range Complex. The western half and southernmost part of the NTS have channel systems which carry runoff from intense storms towards the southern boundary of the NTS and offsite towards the Amargosa Desert.

2.1.5 GEOLOGY

The basic lithologic structure of the NTS is depicted in Figure 2.7. 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 and other organizations since 1951. As a result the NTS is probably one of the better characterized large areas, geologically, within the U.S. This is due to the large number of holes drilled onsite as shown in Figure 2.8.

In general the geology consists of three major rock units. These are (1) complexly folded and faulted sedimentary rocks of Paleozoic age overlain at many places by (2) volcanic tuffs and

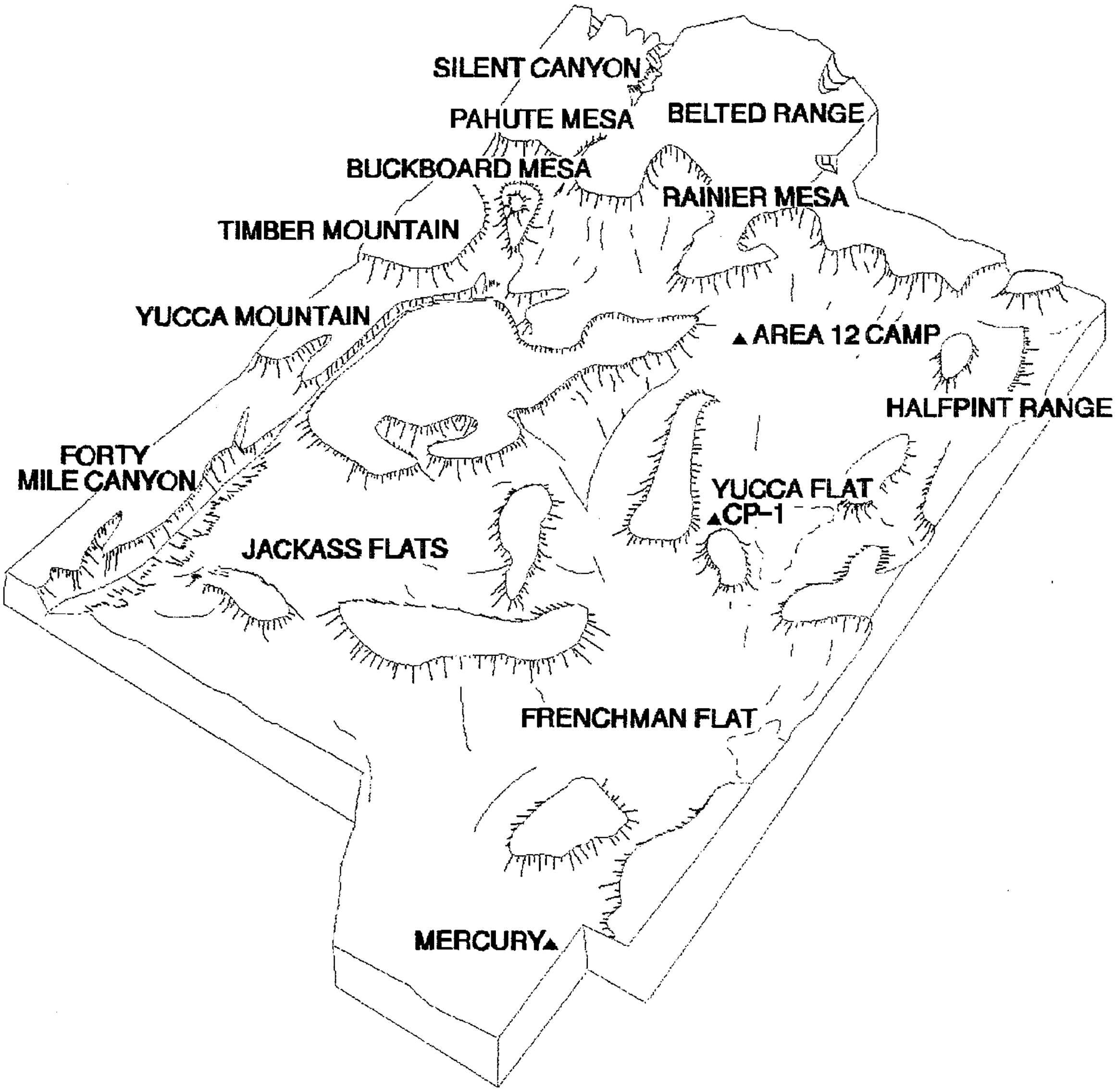


Figure 2.4 Topography of the NTS

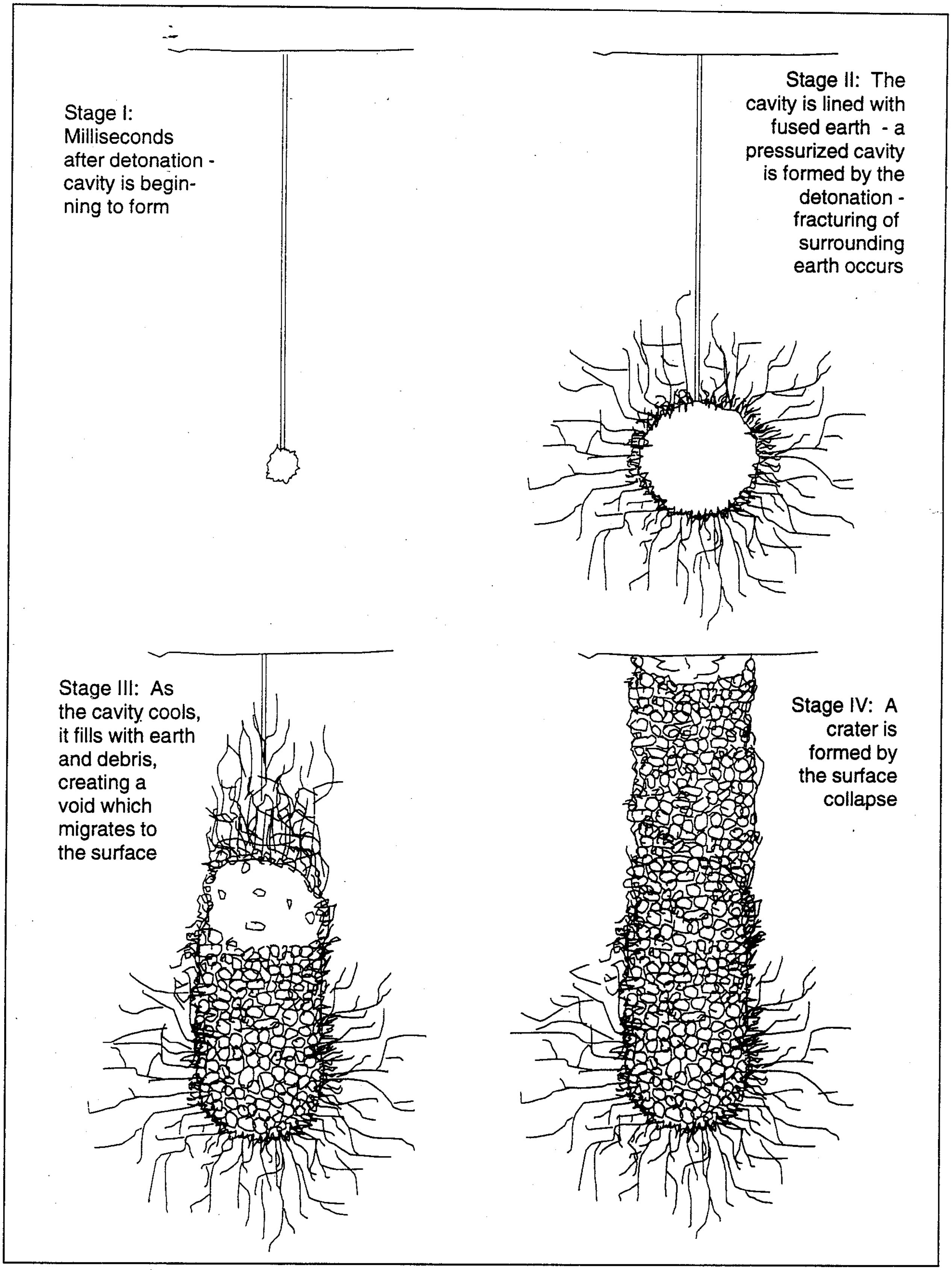


Figure 2.5 Formation of an Underground Nuclear Explosive Test Cavity, Rubble Chimney, and Surface Subsidence Crater

Figure 2.6 Surface Drainage Channel Pattern for the NTS

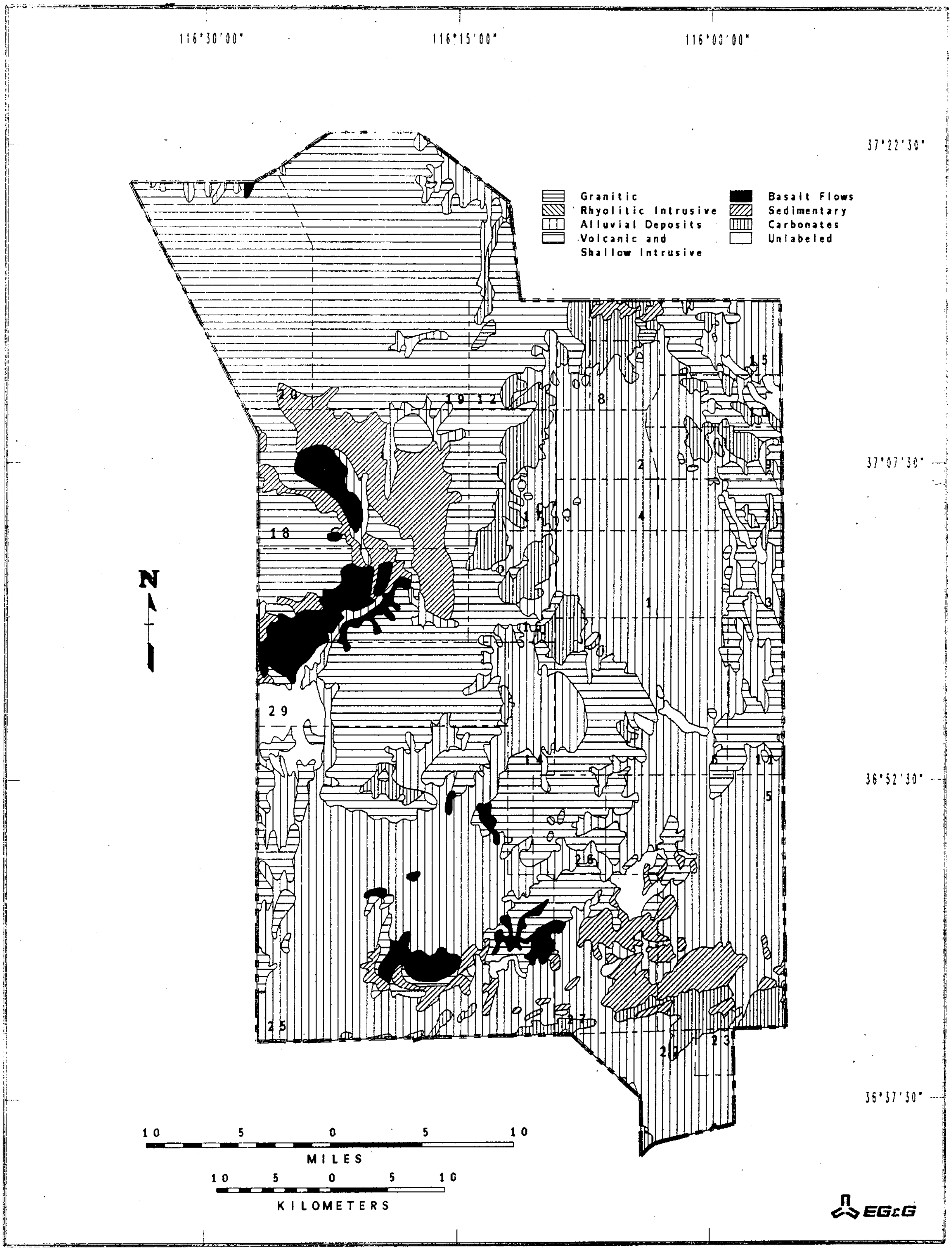


Figure 2.7 Basic Lithologic Structure of the NTS

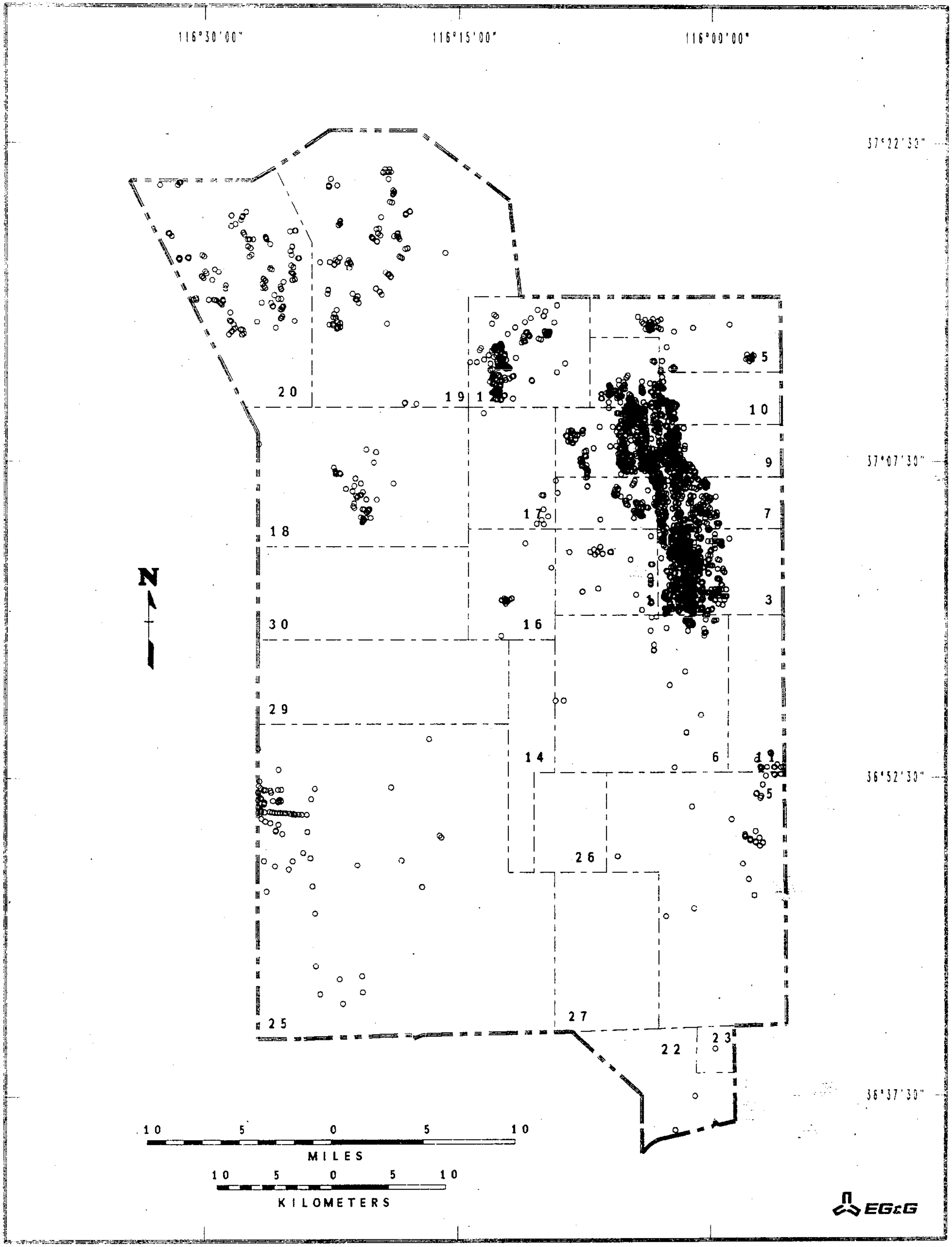


Figure 2.8 Drill Hole Locations on the NTS

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) in the upper and lower parts, separated by a middle section of clastic rocks (shale and quartzite). 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. Compared to the Paleozoic rocks, the Tertiary rocks are relatively undeformed, and dips are generally gentle. The alluvium is derived from erosion of Tertiary and Paleozoic rocks.

The volcanic rocks of Tertiary age are predominantly tuffs, which erupted from various volcanic centers, and lavas, mostly of rhyolitic composition. The aggregate thickness of the volcanic rocks is many thousands of feet, but in most places the total 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 (2000 to 3000 ft) in the central portions of the valleys. The alluvium in Yucca Flat is vertically offset along the prominent north-south-trending Yucca fault.

2.1.6 HYDROGEOLOGY

Some nuclear tests were conducted below the groundwater table, others were at varying depths above the groundwater table. The deep aquifers, slow groundwater movement, and exceedingly slow downward movement of water in the overlying 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. Nuclear tests below the water table have a greater potential for offsite migration. However, the great distance to offsite water supply wells or springs makes it unlikely for contaminants to be transported in significant quantities.

Depths to groundwater beneath NTS vary from about 157 m (515 ft) beneath the Frenchman Flat playa (Winograd and Thordarson 1975) in the southern part of the NTS to more than 700 m (2300 ft) beneath part of Pahute Mesa. In the eastern portions of the NTS, 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 body is generally toward the major valleys (Yucca and Frenchman) where it is believed to 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 2.9) has been summarized by the Desert Research Institute, University of Nevada System, in its report on the groundwater monitoring program for the NTS (Russell 1990). 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 160 m (525 ft) to about 580 m (1900 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 welded tuff and bedded tuff aquifers are saturated beneath the central and northern parts of the valley and occur under both confined and unconfined conditions. 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 travels to springs in Death Valley. Recharge for all of the subbasins most likely occurs by precipitation at higher elevations and infiltration along stream courses and in playas. Regional groundwater flow is

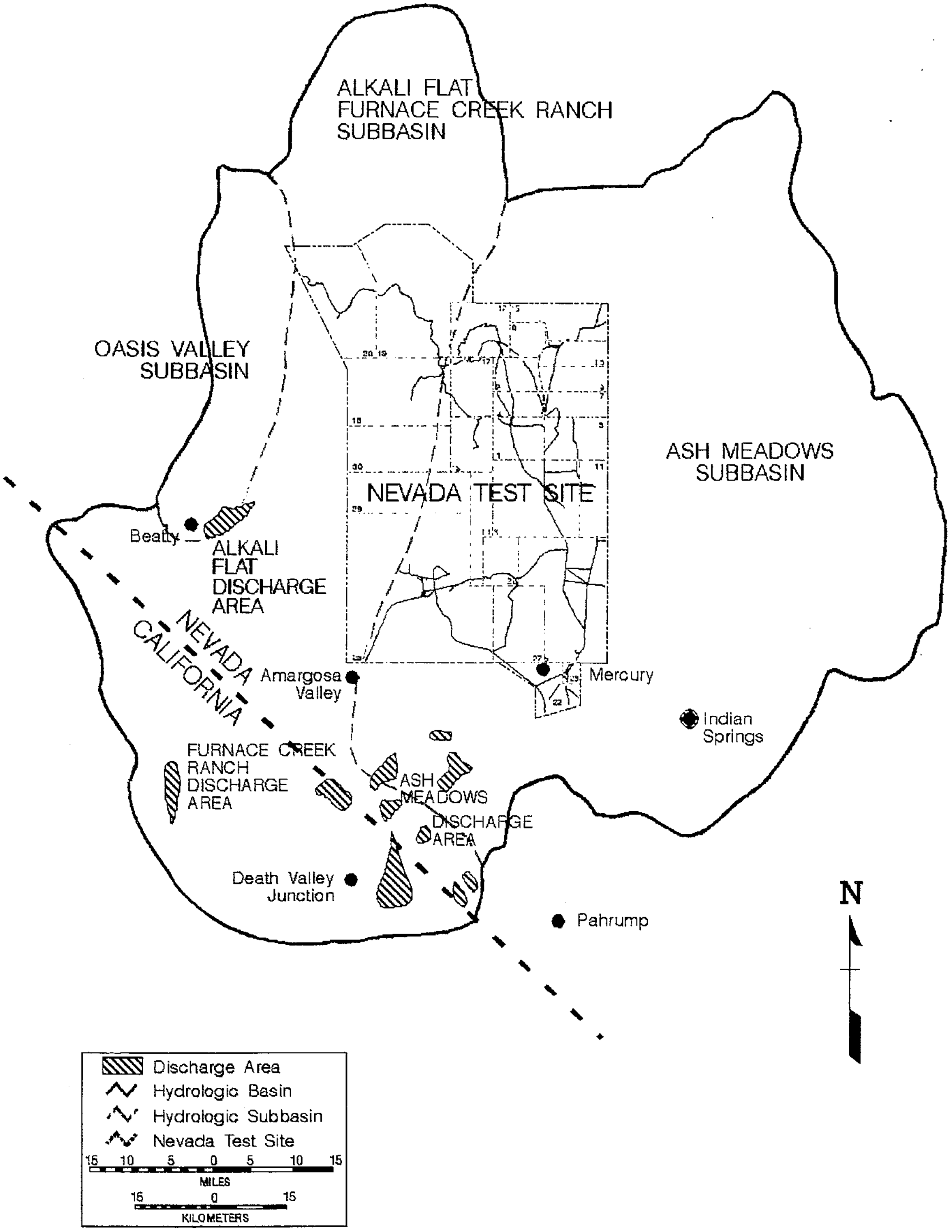


Figure 2.9 Groundwater Hydrologic Units of the NTS and Vicinity

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, 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. Wildlife use the springs for drinking water. 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 157 to 360 m (515 to 1180 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 southwestern part of the valley. In general, the depth to water is least beneath Frenchman playa (157 m [515 ft]) and depths increase to nearly 360 m (1180 ft) near the margins of the valley (Winograd and Thordarson 1975). The water table beneath Frenchman Flat is considerably shallower (and stratigraphically higher) than beneath Yucca Flat. Consequently, the areal 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 lower carbonate aquifer. In addition, 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. 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 (Blankennagel and Weir 1973). 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, zeolitized tuff aquitard, the lower carbonate aquifer, and the tuffaceous and lower clastic aquitards. 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 has not been defined and requires further investigation.

2.1.7 CLIMATE AND METEOROLOGY

Precipitation levels on the NTS are low, runoff is intermittent, and the majority of the active testing areas on the NTS drain into closed basins on the NTS. Annual precipitation in southern Nevada is very light and depends largely upon elevation. A characteristic of desert climates is the temporal and spatial variability of precipitation. Topography contributes to this variability. For example, on the NTS the mesas receive an average annual precipitation of 23 cm (9 in), which includes wintertime snow accumulations. The lower elevations receive approximately 15 cm (6 in) of precipitation annually, with occasional snow accumulations lasting only a matter of days (Quiring 1968).

Elevation also influences temperatures on the NTS. At an elevation of 2000 m (6560 ft) above MSL in Area 20 on Pahute Mesa, the average daily maximum temperatures range from 40 to 80° F, minimums from 21 to 57° F (4 to 27° C and -6 to 14° C, respectively). In Area 6 [Yucca Flat, 1200 m (3940 ft MSL)], the average daily maximums range from 51 to 96° F and the minimums from 28 to 62° F (11 to 36° C and -2 to 17° C, respectively).

Wind direction and speed are important aspects of the environment at the NTS. These are major factors in planning and conducting nuclear tests, where atmospheric transport is the primary potential route of contamination transport to onsite workers and offsite populations.

The movements of large-scale pressure systems control the seasonal changes in the wind direction frequencies. Predominating winds are southerly 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 and, on occasion, becomes intense enough to override the wind regime associated with large-scale pressure systems. This scenario is very sensitive to the orientation of the mountain slopes and valleys.

At higher elevations in Area 20, the average annual wind speed is 17 km/h (10 mi/h). The prevailing wind direction during winter months is from north-northeast, and, during summer months, winds prevail from the south. In Yucca Flat the average annual wind speed is 11 km/h (7 mi/h). The prevailing wind direction during winter months is north-northwest and during summer months is south-southwest. At Mercury the average annual wind speed is 13 km/h (8 mi/h), with a prevailing wind direction of northwest during the winter months and southwest during the summer months. The 1992 ten-meter wind roses for the NTS are shown in Figure 2.10.

2.1.8 FLORA AND FAUNA

The greater part of the NTS is vegetated by various associations of desert shrubs typical of the Mojave or Great Basin Deserts or the zone of transition desert between these two. There are areas of desert woodland (piñon, juniper) at higher elevations. Even there, typical Great Basin shrubs, principally sagebrushes, are a conspicuous component of the vegetation. Although shrubs (or shrubs and small trees) are the dominant forms, herbaceous plants are well represented in the flora and play an important role in supporting animal life.

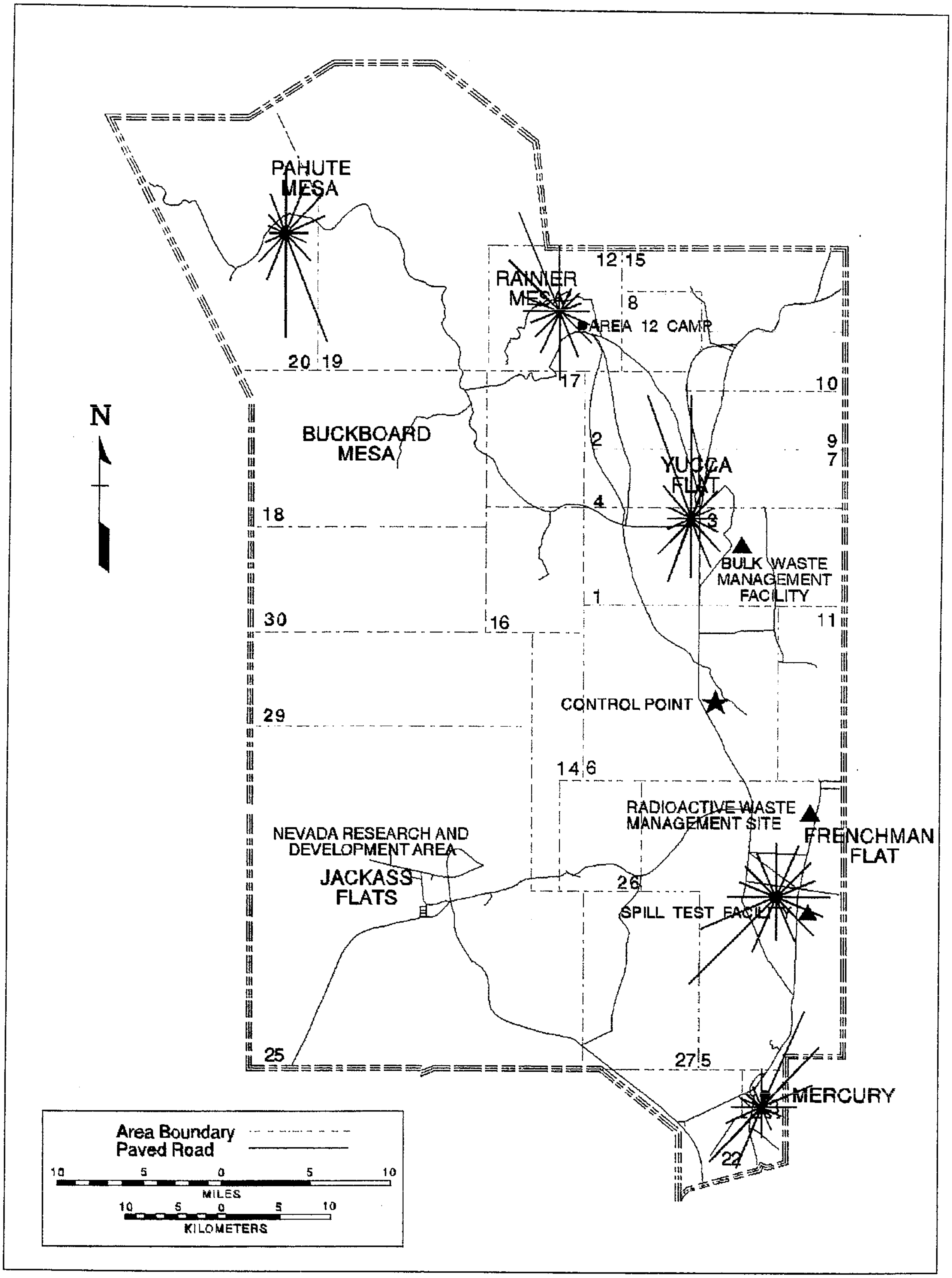


Figure 2.10 1992 Wind Rose Patterns for the NTS (Courtesy of Weather Services Nuclear Support Office, NOAA)

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 1220 and 1520 m (4000 and 5000 ft) in elevation in Yucca Flat, transitional associations are dominated by *Grayia spinosa-Lycium andersonii* (hopsage/desert thorn) associations, while the upper bajadas support *Coleogyne* types. Above 1520 m (5000 ft) the vegetation mosaic is dominated by sagebrush associations of *Artemisia tridentata* and *Artemisia arbuscula* subspecies *nova*. Above 1830 m (6000 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. Larger mammals include feral horses, burros, deer, mountain lions, bobcats, coyote, kit foxes, and rabbits. Reptiles include four species of venomous snakes. Bird species are mostly migrants or seasonal residents. Rodents are, in terms of distribution and relative abundance, the most important group of mammals on the NTS. Most nonrodent mammals have been placed in the "protected" classification by the state of Nevada.

In 1989 the desert tortoise, *Gopherus agassizii*, was placed on the endangered species list by the U.S. Department of Interior and was relisted as threatened in 1991. Tortoise habitats on the NTS are found in the southern third of the NTS outside the recent areas of nuclear test activities in Yucca Flat, Rainier Mesa, and Pahute Mesa.

2.1.9 ARCHAEOLOGICAL AND HISTORICAL VALUES

Human habitation of the NTS area ranges from as early as 10,000 B.C. to the present. Various aboriginal cultures occupied the NTS area over this extended period as evidenced by the presence of artifacts at many surface sites and more substantial deposits of cultural material in several rock shelters. This period of aboriginal occupation was sustained primarily by a hunting and gathering economy based on using temporary campsites and shelters. The area was occupied by Paiute Indians at the time of the first known outside contact in 1849.

Because readily available surface water was the most important single determinant governing the location of human occupation, historic sites are often associated with prehistoric ones, both being situated near springs. As a consequence of this superposition of historic occupation, disturbance of certain aboriginal sites by modern man occurred long before use of the area as a nuclear testing facility began. The larger valleys show little or no evidence of occupation. Together these areas comprise almost the entire floors of Yucca, Frenchman, and Jackass Flats. Thus, testing and associated operational activities have generally been most intense in those parts of the NTS valleys where archaeological and historic sites are absent. In contrast, there are many archeological sites on the Pahute and Rainier Mesas testing areas. Surveys of some of these NTS areas are documented in Reno and Pippin (1985) and Pippin (1986).

In addition to the archaeological sites, there are also some sites of historical interest on the NTS. The principal sites include the remains of primitive stone cabins with nearby corrals at three springs, a natural cave containing prospector's paraphernalia in Area 30, and crude remains of early mining and smelting activities.

2.1.10 DEMOGRAPHY

Figure 2.11 shows the population of counties surrounding the NTS, based on 1990 Bureau of Census estimates (Department of Commerce 1990). Excluding Clark County, the major population center (approximately 741,000 in 1990), the population density within a 150-km (90-mi) radius of the NTS is about 0.5 persons per square kilometer. In comparison, the 48 contiguous states (1990 census) had a population density of approximately 29 persons per square kilometer.

The offsite area within 80 km (50 mi) of the NTS Control Point 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 15,000, is about 80 km (50 mi) south of CP-1. The Amargosa Farm area, which has a population of about 950, 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 1500 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 5000 tourists and campers on any particular day during holiday periods in the winter months. As many as 30,000 are in the area during "Death Valley Days" in the month of November. 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 1991 population of 21,000. The Owens Valley, where numerous small towns are located, lies 50 km (31 mi) west of Death Valley. The largest town in the Owens Valley is Bishop, located 225 km (140 mi) west-northwest of the NTS, with a population of 3500.

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 1991 population of 29,000. The next largest town, Cedar City, with a population of 13,000, 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 1991 population estimate of 22,000, and Kingman, located 280 km (174 mi) southeast of the NTS, with a population of about 13,000.

2.1.11 SURROUNDING LAND USE

Figure 2.12 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 4400 m (14,500 ft) above MSL in the Sierra Nevada Range, including parts of two major agricultural valleys (the Owens and San Joaquin). 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 Valley and Moapa Valley, supporting

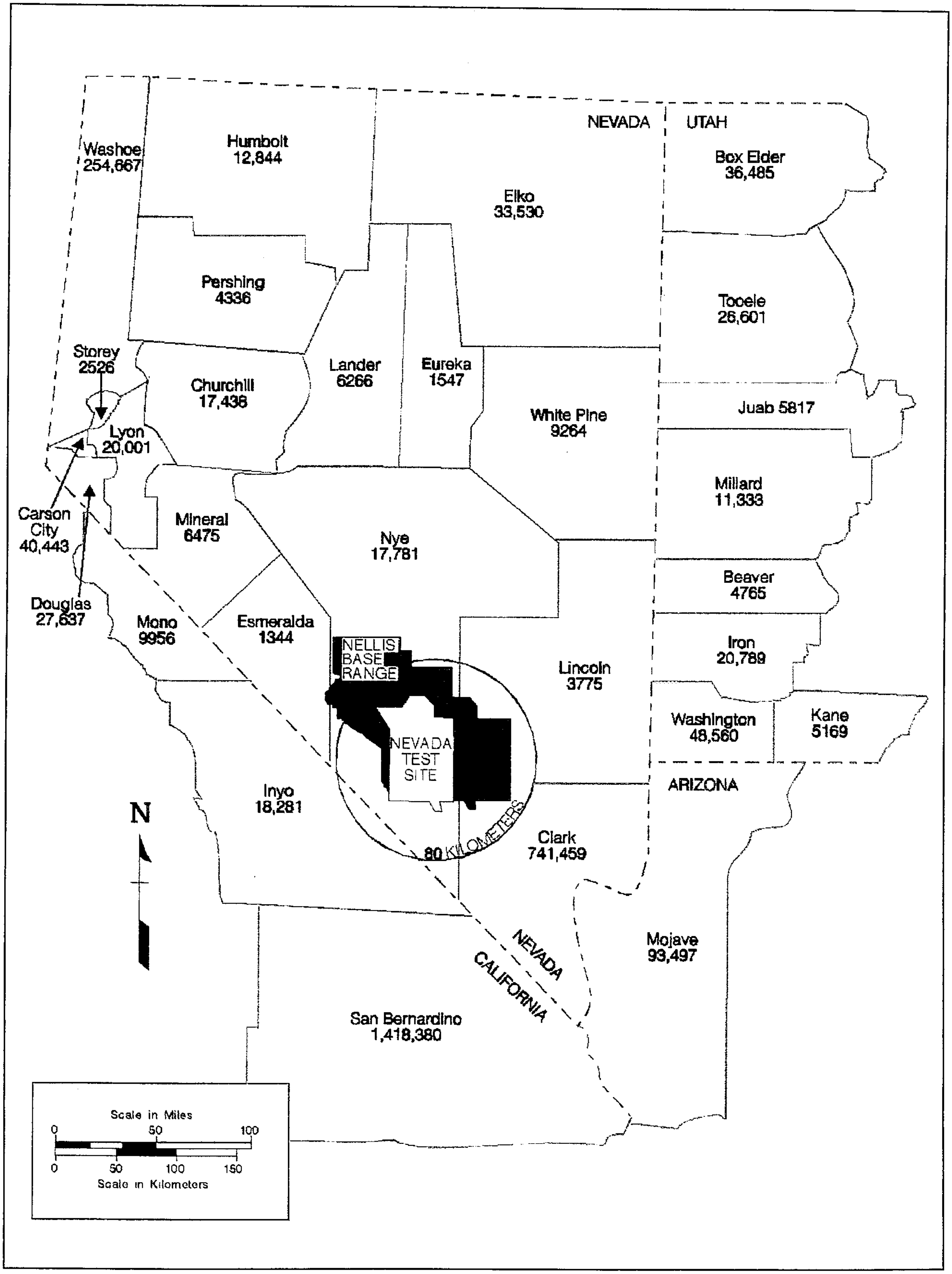


Figure 2.11 Population Distribution in Counties Surrounding the NTS (Based on 1990 Census Estimates)

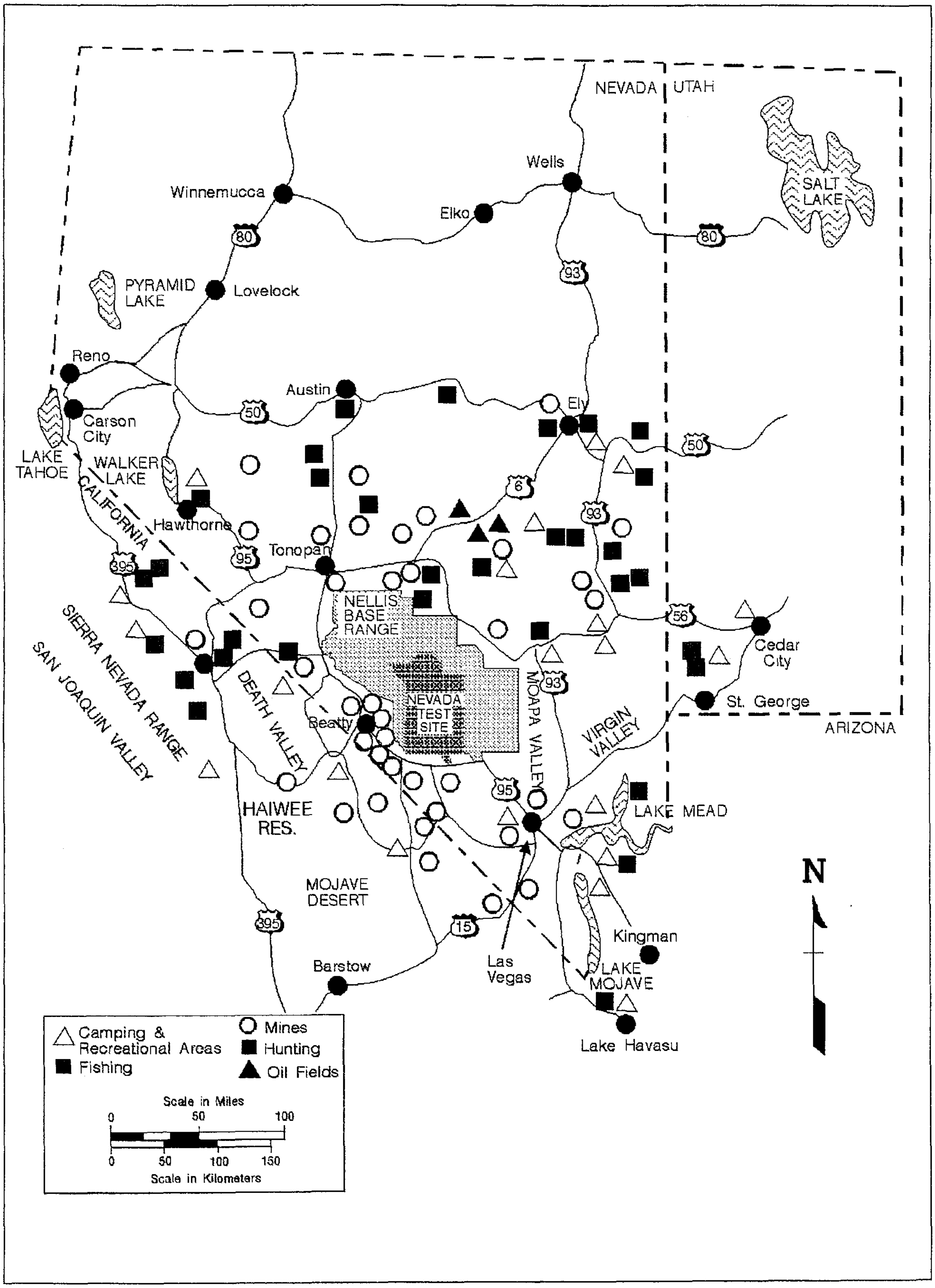


Figure 2.12 Land Use Around the NTS

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. Minor agriculture, primarily the growing of alfalfa hay, is found in this portion of the state within 300 km (180 mi) of CP-1. 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 northwest, north, and northeast of the NTS are utilized throughout the year except for the winter months. Camping and fishing locations to the southeast, south, and southwest are utilized throughout the year. The peak hunting season is from September through January.

2.2 NON-NTS FACILITIES

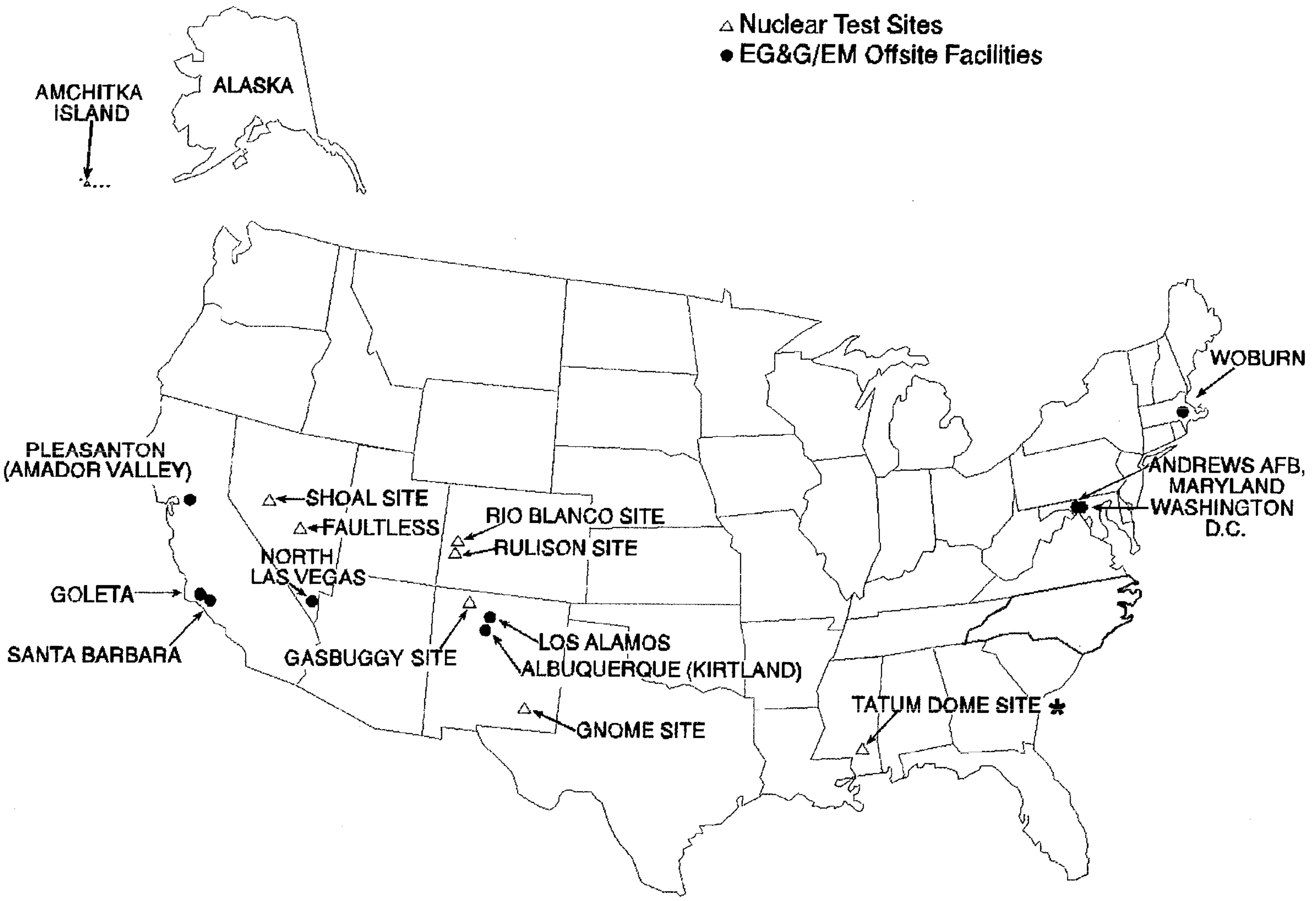
EG&G/EM has several offsite operations in support of activities at the NTS under a contract with the DOE/NV. These include the Amador Valley Operations, Pleasanton, California; Kirtland Operations that includes the Craddock Facility and facilities at Kirtland Air Force Base, Albuquerque, New Mexico; Las Vegas Area Operations that include the Remote Sensing Laboratory at the NAFB and North Las Vegas Complex in North Las Vegas, Nevada; Los Alamos Operations, Los Alamos, New Mexico; Santa Barbara Operations that includes the Robin Hill Road and Francis Botello Road Facilities, Goleta, California; Special Technologies Laboratory, Santa Barbara, California; Washington Aerial Measurements Department, Andrews Air Force Base, Maryland; and Woburn Cathode Ray Tube Operations, Woburn, Massachusetts. These locations are shown in Figure 2.13. Each of these facilities is located in a metropolitan area. City, county, and state regulations govern emissions, waste disposal, and sewage. No independent EG&G/EM 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 are possible during normal facility operations.

2.2.1 AMADOR VALLEY OPERATIONS (AVO)

The AVO facility in Pleasanton, California, occupies a 5520 m^2 (59,445 ft^2) two story combination office/laboratory building. AVO is located near the Lawrence Livermore National Laboratory (LLNL) in Livermore, California, to simplify logistics and communications associated with EG&G/EM support of LLNL programs. Most of the work is in support of NTS underground weapons testing, but AVO 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.

2.2.2 KIRTLAND OPERATIONS (KO)

KO at Kirtland Air Force Base (KAFB) and in Albuquerque, New Mexico, consists of a 5200 m^2 (56,000 ft^2) complex of prefabricated metal buildings located on 16 ha (39.5 acres) at KAFB, and a 3250 m^2 (35,000 ft^2) industrial facility, called the Craddock Facility, located near the Albuquerque International Airport. KO provides technical support to Sandia National Laboratories (SNL), the DOE, the Department of Defense (DOD), and other federal agencies. In conjunction with DOE work, KO provides significant support to a variety of ongoing safeguards and security programs. KO is also responsible for operation of the System Control and Receiving Station (SCARS), a part of the DOE Remote Seismic Test Network (RSTN). Areas of environmental interest include small solvent cleaning and painting operations.



*The Tatum Dome Site was the location of the Project Dribble tests SALMON and STERLING.

Figure 2.13 Locations of Non-NTS Operations and Underground Event Sites

2.2.3 LAS VEGAS AREA OPERATIONS (LVAO)

The LVAO includes the North Las Vegas facility at 2621 Losee Road and the Remote Sensing Laboratory on the Nellis Air Force Base (NAFB) in North Las Vegas, Nevada. These facilities provide technical support for the DOE/NV test program.

The North Las Vegas facility includes multiple structures totaling about 53,820 m^2 (585,000 ft^2). At the facility there are numerous areas of environmental interest, including metal finishing operations, a radiation source range, an X-ray laboratory, solvent and chemical cleaning operations, small amounts of pesticide and herbicide application, photo laboratories, and hazardous waste generation and accumulation.

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

2.2.4 LOS ALAMOS OPERATIONS (LAO)

The LAO resides in a facility of approximately 6040 m^2 (65,000 ft^2). It is a two-story combination engineering/laboratory/office complex located near the Los Alamos National Laboratory (LANL) facility to provide local support for LANL's programs. The work performed includes direct support of the LANL testing program, the DOE Research and Development (R&D) Program, and miscellaneous DOE cash-order work. LAO's primary activities are twofold: (1) the design, fabrication, and fielding of data acquisition systems used in underground nuclear testing diagnostics and (2) the analysis of data from underground and high-altitude experiments. In addition, two LAO operations build and field CORRTEX III recorders. Areas of environmental interest include small solvent cleaning, alodining, metal machining operations, and a small photo laboratory.

2.2.5 SANTA BARBARA OPERATIONS (SBO)

SBO occupies two facilities located in Goleta, California. The Robin Hill Road Facility, comprising 3700 m^2 (40,000 ft^2), includes a mercuric iodide crystal laboratory and a specialized radiation research building that houses the DOE-EG&G/EM linear accelerator (LINAC) with accompanying laboratories. Located at the Francis Botello Road Facility, 1130 m^2 (12,174 ft^2), is a small machine shop, laboratory buildings, and a source range.

In support of the DOE/NV, the SBO was established for R&D work in nuclear instrumentation and measurements with emphasis on radiation detectors, data acquisition systems, and fast pulse electronics. Through the years its facilities have been adapted to a wide range of R&D tasks. The SBO also describes and assesses the potential ecological impacts of various DOE projects on ecological systems of interest. Activities of environmental interest include a mercuric iodide laboratory (where mercuric iodide crystals are grown), minor solvent operations, and several fume hoods.

2.2.6 SPECIAL TECHNOLOGIES LABORATORY (STL)

The STL located in Santa Barbara, California, consists of approximately 3340 m^2 (36,000 ft^2) of secure combination office/laboratory area 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 and a small vapor degreaser.

2.2.7 WASHINGTON AERIAL MEASUREMENTS DEPARTMENT (WAMD)

The WAMD, located at Andrews Air Force Base, consists of a 186 m^2 (2000 ft^2) Butler building used as office space; a 1110 m^2 (12,000 ft^2) combination electronics laboratory, aircraft maintenance, and office complex; and a portion of a large aircraft hangar. WAMD operations provides an effective East Coast Nuclear Emergency Search Team (NEST) response capability and provides an eastern aerial survey capacity to the DOE/NV. Areas of environmental interest include small solvent cleaning operations and used fuels and oils.

2.2.8 WOBURN CATHODE RAY TUBE OPERATIONS (WCO)

The WCO in Woburn, Massachusetts, is comprised of a 1300 m^2 (14,000 ft^2) facility which is used to develop and manufacture advanced cathode-ray tubes and oscilloscopes in support of the DOE/NV LANL weapons test program. Areas of environmental interest include small solvent cleaning operations and several laboratory hoods, and a dry well for discharging uncontaminated, non-contact cooling water.

2.3 NON-NTS UNDERGROUND EVENT SITES

Previously, nuclear tests were conducted for a variety of purposes at eight different non-NTS sites in the U.S. These events and their locations appear in Figure 2.13 and Table 2.1. Activities at these locations generally are limited to annual sampling at over 200 wells, springs, and other sources at locations near sites where nuclear explosive tests were conducted. However, a Remedial Investigation/Feasibility Study has begun at the Mississippi test location which will include significant new characterization activities. Sampling results for these sites appear in Chapter 9 of this volume.

Table 2.1 Non-NTS Nuclear Underground Test Sites Studied in 1993

Event Name	Location	Date of Test
GNOME	Malaga, New Mexico	12/10/61
SHOAL	Fallon, Nevada	10/26/63
SALMON (Dribble)	Baxterville, Mississippi	10/22/64
STERLING (Dribble)	Baxterville, Mississippi	12/03/66
GASBUGGY	Gobernador, New Mexico	12/10/67
FAULTLESS	Blue Jay, Nevada	01/19/68
RULISON	Grand Valley, Colorado	09/10/69
RIO BLANCO	Rio Blanco, Colorado	05/17/73
LONG SHOT	Amchitka Island, Alaska	10/29/65
MILROW	Amchitka Island, Alaska	10/02/69
CANNIKIN	Amchitka Island, Alaska	11/06/71

3.0 COMPLIANCE SUMMARY

Colleen M. Beck, H. Bruce Gillen, Orin L. Haworth, and Cathy Wills

The predominant environmental compliance activities at the Nevada Test Site (NTS) during calendar year 1993 involved hazardous waste management associated with Resource Conservation and Recovery Act (RCRA) requirements. Clean Air Act compliance involved asbestos renovation projects, radionuclide emissions, and state air quality permit renewals and reporting. Toxic Substances Control Act (TSCA) compliance activities were concerned with polychlorinated biphenyl (PCB) management practices. 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. There were no activities requiring compliance with Executive Orders on Flood Plain Management or Protection of Wetlands.

Corrective actions are continuing as a response to the findings of the DOE "Tiger Team" during its October 1989 assessment of environmental compliance and program management. Throughout 1993 the NTS was subject to several formal compliance agreements with regulatory agencies, including: the American Indian Religious Freedom Act; a Programmatic Agreement with the Nevada Division of Historic Preservation and Archaeology and the Advisory Council on Historic Preservation; the United States Fish and Wildlife Service (USFWS) for protection of the desert tortoise; a Memorandum of Understanding with Nevada covering releases of radioactivity; Agreements in Principle with Nevada and Mississippi covering ES&H activities; and a Settlement Agreement to manage mixed TRU waste. No lawsuits have been identified that affect DOE/NV's program obligations. Emphasis on waste control and minimization at the NTS continued in 1993.

Compliance activities at DOE/NV non-NTS facilities operated by EG&G/Energy Measurements, Inc. (EG&G/EM), involved the permitting and monitoring requirements of: (1) the Clean Air Act for airborne emissions; (2) the Clean Water Act for wastewater discharges; (3) state Safe Drinking Water Act (SDWA) regulations; (4) RCRA disposal of hazardous wastes; (5) hazardous substance reporting. Waste minimization efforts continued at all EG&G/EM operations.

3.1 COMPLIANCE STATUS

3.1.1 NATIONAL ENVIRONMENTAL POLICY ACT

The National Environmental Policy Act (NEPA) of 1969 requires all federal facilities, including the NTS, to account for environmental impacts, and potential alternatives, in conducting and planning their operations.

In accordance with NEPA, DOE/NV activities, both NTS and non-NTS, are evaluated for their potential environmental impacts and to ensure the proper level of NEPA documentation is initiated. There are three general levels of NEPA documentation: (1) An Environmental Impact Statement (EIS) is a full discussion of the potential environmental impacts, and possible alternative, for a planned activity; (2) An Environmental Assessment (EA) is a brief discussion of a planned activity and its potential environmental impacts to determine if a full EIS is necessary; and (3) A Categorical Exclusion (CE) identifies an activity which based on past activities has been found to have no significant environmental impacts. In 1993 NEPA related activities included actions on two EISs, 17 EAs and 100 CEs. Of these, seven Environmental Assessments and 89 Categorical Exclusions were initiated in 1993. These NEPA documents are listed in chronological order in Appendix H, Table H.1, with the assigned number and their present status. The two EIS's were for the Space Nuclear Thermal Propulsion (SNTP) project and Environmental Restoration and Waste Management (ERWM) activities at the NTS. The EIS for the SNTP, a Department of Defense (DOD) project, evaluated several locations in the continental United States, including Area 14 of the NTS, for the testing of a nuclear propulsion system. The EIS for the ERWM activities will evaluate impacts for restoration and waste management activities at the NTS.

3.1.2 CLEAN AIR ACT

Clean Air Act and 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.

3.1.2.1 NTS NESHAP ASBESTOS COMPLIANCE

In January 1990 the state of Nevada, Division of Occupational Safety and Health, issued regulations (Nevada Revised Statutes [NRS] 618.760-805) requiring that all contractors intending to engage in asbestos abatement projects in Nevada, involving friable asbestos in quantities greater than or equal to 3 linear ft or 3 ft^2, submit a Notification Form. This form is required by the Division ten days before beginning any work at an asbestos abatement project site. Notifications are also required to be made to the EPA Region 9 for projects which disturb greater than 260 linear ft or 160 ft^2 of asbestos containing material in accordance with 40 CFR 61.145-146.

During 1993 one project was conducted at building 4015 in Area 25 which required NESHAP notification to EPA Region 9. Seven state of Nevada notifications were made for asbestos renovation and abatement projects in accordance with the requirements of NRS 618.760-805. A list of these notifications appears in Appendix H, Table H.2. Reynolds Electrical & Engineering Co., Inc. (REECo), collected and analyzed bulk, occupational, environmental, and clearance samples for these projects.

3.1.2.2 RADIOACTIVE EMISSIONS ON THE NTS

NTS operations were conducted in compliance with the NESHAP radioactive air emission standards of Subpart H of 40 CFR 61. In compliance with those requirements, DOE/NV provides reports to DOE/HQ on airborne radioactive effluents for submission to EPA.

There are three locations on the NTS where airborne radioactive effluents may be emitted from permanent stacks. These are air ventilation exhaust stacks (1) on the tunnels in Rainier Mesa, (2) on clothes dryers for the anti-contamination clothing laundry facility (although most of the radioactivity removed from this clothing is in the wash water), and (3) on the analytical laboratory hoods in the town of Mercury. Based on the amount of material handled, the exhausts from the laundry and the analytical laboratories are considered negligible compared to other sources on the NTS. Diffuse sources, which are difficult to monitor, include seepage of noble gases from the ground caused by barometric pressure variations, evaporation of tritiated water from containment ponds, diffusion of tritiated water vapor from the Radioactive Waste Management Site, Area 5 (RWMS-5), and resuspension of plutonium contaminated soil from safety and atmospheric test sites.

In the NESHAP report for airborne radioactive effluents emitted from the NTS during calendar year 1993 (Black 1994), the effluents from the tunnel ventilation systems were reported on the basis of operational measurements and calculations. The airborne emission of tritiated water vapor from the containment ponds was conservatively reported as if all the liquid discharge into the ponds during 1993 had evaporated and become airborne. For tritiated water vapor diffusing from the RWMS-5, plutonium particulate resuspension from Areas 3 and 9, and seepage of ^{85}Kr from Pahute Mesa, the airborne effluents were conservatively estimated as follows. For each situation, the 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 CAP88-PC software was used to determine what total activity would have to have been emitted from the geometric center of the region in question in order to produce that EDE.

In September of 1991, to assure compliance with 40 CFR 61.93 and in order to provide confirmatory data for the tunnel effluent calculations, an isokinetic sampling unit was installed in the ventilation duct near the portal of P Tunnel. This unit was in use during 1993 to monitor tritiated water vapor, noble gases, radioiodines and radioactive particulates.

Other emissions can occur from operational activities such as drillbacks into test cavities (to obtain diagnostic and other data) and purging of tunnel systems after nuclear tests (to facilitate re-entry activities). Because of the moratorium, there were no such activities in 1993.

Using these best estimates of air emissions in 1993 as input to the CAP88-PC computer software model, the maximum potential individual EDE would have been only 0.004 mrem, much less than the 10 mrem limit specified in 40 CFR 61.

Discussions with EPA Region 9 personnel have indicated that the NTS is in full compliance with the requirements of 40 CFR 61.

3.1.2.3 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. (See Table 4.5, Section 4.3.1 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 1992 Air Quality Permit Data Report was sent to the state of Nevada on March 17, 1993, to meet the annual reporting requirement. 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. Certification to perform visible emissions opacity evaluations is required by the state, with recertification required every six months. During 1993, eleven REECo Environmental Compliance Department (ECD) personnel and four operational personnel were certified and/or recertified. In 1993 these personnel performed, at a minimum, biannual visible emission evaluations of permitted air quality point sources. When visual evaluations determine that an emission exceeds the 20 percent opacity requirement, corrective action is initiated. Seven permitted equipment/processes, such as weapons event stemming operations, have been identified as routinely exceeding the 20 percent opacity requirement. In July 1992, The Mark Group made recommendations to correct these opacity exceedances. During 1993 their recommendations, or equivalent changes, were made to bring these sources into compliance. (see Section 3.2.1).

During 1993 state of Nevada personnel conducted several inspections of NTS equipment permitted under air quality operating permits or permits to construct. No findings or violations were issued. Three new air quality permits were issued by the state in 1993.

3.1.2.4 NON-NTS EG&G/EM OPERATIONS

There are no activities at any of the eight EG&G/EM operations with NTS projects that produce radioactive effluents. Clean Air Act issues involve only the nonradiological emissions covered by local permit requirements.

Air quality operating permits were required for three of the eight non-NTS, EG&G/EM operations. There were no effluent monitoring requirements associated with these permits. Compliance for each of these specific permits is discussed below.

Ninety-five emission units at the EG&G/EM, Las Vegas Area Operation (LVAO), which includes the North Las Vegas Facility (NLVF) and the Remote Sensing Laboratory (RSL), were regulated during 1993 under conditions of 28 permits issued by the Clark County Health District (CCHD), Las Vegas, Nevada. An air emissions update report was sent to DOE/NV on November 19, 1993, for submittal to the CCHD.

EG&G/EM, Amador Valley Operations (AVO) holds an operating permit issued by the Bay Area Air Quality Management District (BAAQMD) for two solvent cleaning operations. The permit conditions place limits on the annual quantity of materials used and impose record keeping requirements. Local air pollution regulations require businesses to discontinue use of aerosol spray paints containing more than 67 percent organics. Compliance has been maintained, and no routine monitoring activities have been required. On December 16, 1993, AVO was issued a notice of violation from the BAAQMD for exceeding the permitted 10 gallon annual use rate by 7.5 gallons.

The County of Santa Barbara, Air Pollution Control District (APCD), issued a permit to EG&G/EM, Special Technologies Laboratory (STL) to operate a vapor degreaser. Permit conditions include throughput limitations and record keeping requirements.

EG&G/EM, Woburn Cathode Ray Tube Operations (WCO) was required to limit use of 1,1,1-trichloroethane to no more than one ton per year pursuant to a "Plans Approval" certificate (not an operating permit) issued by the local regulatory authority. Compliance has been maintained, and no routine monitoring or reports have been required.

3.1.3 CLEAN WATER ACT

The Federal Water Pollution Control Act, as amended by the Clean Water Act, establishes ambient water quality standards and effluent discharge limitations which are generally applicable to facilities which discharge any materials onto the waters of the United States. 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 local permit requirements. A complete listing of applicable permits appears in Section 4.3. There are no National Pollutant Discharge Elimination System (NPDES) permits for DOE/NV facilities as there are no wastewater discharges to onsite or offsite surface waters.

3.1.3.1 NTS OPERATIONS

Discharges of wastewater are regulated by the state of Nevada under the Nevada Water Pollution Control Act. The state of Nevada also regulates the design, construction, and operation of sanitary sewage collection systems. Wastewater monitoring at the NTS was limited to sampling wastewater influents to sewage lagoons and containment ponds.

During 1993 two drafts of a general permit which will cover all sewage lagoon facilities were issued by the state. Both drafts were reviewed, and comments were submitted on new and more involved requirements. Vadose zone monitoring, groundwater monitoring, or lining of all impoundments has been proposed, along with increased monitoring of the influent flows and infiltration basin contents. A final draft was issued on December 17, 1993, and will take effect in early 1994 pending any appeal or changes made as a result of further negotiations.

Compliance with sewage lagoon discharge permit requirements was achieved with two exceptions. Second quarter pH readings of influent flows at all facilities were not obtained in July due to an oversight by the operational staff. Submittal of fixture unit counts, personnel counts and flow summaries for facilities served by seven lagoon systems were not performed until early 1994. Submittal of this information was not anticipated by the operational staff because the issuance of the general permit had been expected in 1993. Fixture unit and personnel count investigations are not included as requirements in the new general permit.

The state has recognized that facility usage is continually changing on the NTS, which often results in some primary lagoons not maintaining a three-foot minimum depth. The state recommends that reasonable attempts be employed to preserve the biomass, but extraordinary, costly, or labor intensive efforts are not required. The state also made recommendations for odor control.

In partial resolution of the Notice and Finding of Alleged Violation issued by the state of Nevada in 1991 for the improper modification of tunnel wastewater ponds at U-12n Tunnel, and the lack of a discharge permit for the same ponds, a 180 day temporary water pollution control permit was issued for the U-12n Tunnel discharge. This permit was followed by a 2-year individual water pollution control permit which became effective on November 12, 1992. Compliance with permit requirements was maintained throughout 1993. A revised compliance schedule was requested on November 5, 1993, and was granted by the state on November 15. The new schedule extended the timetable for implementation of the mothball plan until June 14, 1994. A preliminary plan for plume investigation of the vadose zone beneath the wastewater ponds was submitted to the state in November. An Operations and Maintenance Manual was submitted within the required time frame of 180 days after the effective date of the permit. Certain sampling requirements in the permit were relaxed by the state due to the reduced and intermittent volumes of wastewater being discharged.

A 180 day temporary water pollution control permit was issued by the state of Nevada for the Area 12 Fleet Operations Steam Cleaning Facility on July 15, 1992. It allowed the continued operation of the existing system under certain conditions and monitoring requirements. Steam cleaning activities under this permit ceased in August 1992, and the permit was allowed to expire in January 1993. During the period of the permit all specified compliance requirements were met.

State of Nevada compliance personnel routinely inspected the NTS sewage discharge lagoons and the U-12n Tunnel discharge ponds in 1993. No findings or notices of violation were issued for these permitted units.

3.1.3.2 NON-NTS EG&G/EM OPERATIONS

Permits for wastewater discharges were held for six non-NTS facilities. Monitoring and reporting were performed according to specific local requirements. EG&G/EM AVO's wastewater permit, which did not require effluent monitoring, was eliminated in 1993.

EG&G/EM, LVAO submitted self monitoring reports to local regulatory authorities for the NLVF and the RSL. A new wastewater discharge permit was issued for the NLVF by the city of North Las Vegas and for the RSL by the Clark County Sanitation district. The wastewater permit for the NLVF required biannual monitoring for 11 additional outfalls. RSL monitoring reports were submitted in June and December 1993. NLVF monitoring reports were submitted in July 1993 and January 1994.

EPA Region 9 inspected both the RSL and the NLVF during 1993. A draft inspection report was submitted on the RSL that noted no concerns or alleged violations. The draft inspection report on the NLVF submitted in September 1993, alleged EG&G/EM had violated federal categorical pretreatment standards in 1988, and failed to monitor processes EPA considered to be subject to federal standards for metal finishing operations. EPA also alleged they found evidence that dilution was occurring at the Anodize/Iridite Shop for the purpose of avoiding pretreatment. As requested in the draft inspection report, EG&G/EM submitted a response to the findings and inaccuracies of fact relating to the information used by EPA to support their findings. On December 28, 1993, EG&G/EM received a Notice of Violation and Order from EPA Region 9 that included a modified reiteration of the findings stated in the draft inspection report. Additional monitoring and reporting requirements for calendar year 1994 were stipulated. No fines were assessed.

Although EG&G/EM has reservations about the EPA findings, action was initiated to ensure that no requirements of the Order were violated. All wastewater discharges to the sewer identified in the Order were immediately discontinued. Until compliance procedures could be developed and implemented, EG&G/EM will submit a response to these findings in January, 1994, requesting clarification of issues in the Order, and reserving rights to contest the matters addressed in the Finding of Violation and Order.

EG&G/EM, SBO batch discharged wastewater three times during 1993 from the mercuric iodide laboratory. Each batch discharge was sampled and analyzed by the Goleta Sanitation District (GSD). SBO's facility effluent was sampled and analyzed twice by the GSD. SBO's wastewater discharges were found to be in full compliance with GSD requirements.

EG&G/EM, STL pretreated and batch discharged wastewater from a small printed circuit plating operation. Each batch was sampled and analyzed by the GSD. STL's facility effluent was sampled and analyzed twice by the GSD. STL's wastewater discharges were found to be in full compliance with GSD requirements.

EG&G/EM, AVO wastewater discharge permit number 3671-101 was eliminated in 1993 since AVO no longer had a regulated wastewater effluent.

EG&G/EM, WCO submitted self monitoring reports required by wastewater discharge permit conditions to the Massachusetts Water Resources Authority.

No wastewater permits were held for EG&G/EM Kirtland Operations, Los Alamos Operations, or Washington Aerial Measurements Facility in 1993.

3.1.4 SAFE DRINKING WATER ACT

3.1.4.1 NTS OPERATIONS

The Safe Drinking Water Act (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. The state also regulates daily system operations, such as operation and maintenance, water haulage, operator certification, permitting, and sampling requirements.

The number and location of NTS work force personnel serviced by permitted water distribution systems, as reported to the state of Nevada in 1991, is included in Appendix H, Table H.3. Due to programmatic cut-backs, this service population declined during 1993.

As required under state health regulations, potable water distribution systems at the NTS are monitored for residual chlorine content and for coliform bacteria. Monitoring results for these parameters are discussed in Section 7.1.1.1. The single incident in 1993 where analyses indicated the presence of coliform bacteria is discussed below. The state of Nevada was immediately notified of this positive coliform sample.

- In August 1993, the pump for Army Well No. 1 failed. After the pump was replaced and the lines were flushed, subsequent water samples indicated the well was positive for the presence of coliforms (fecal coliforms were negative). Continued flushing and chlorination did not solve the problem, and it was theorized that the contamination was in static water above the level of the pump. REECo developed a method of introducing super-chlorinated water above the level of the pump. After adequate contact time, the well was again flushed and coliform analysis results were then negative. During the time the Army Well No. 1 was not operating, water conservation notices were placed throughout Mercury.

NTS potable water distribution systems are also monitored for volatile organic compounds, inorganic compounds, and other water quality standards. Monitoring results for these parameters are discussed in Section 7.1.1. Volatile organic compounds were not detected in any NTS potable water distribution systems. Primary water quality standards were met for all parameters. Incidents where analyses indicated that a state of Nevada Secondary Standard was exceeded are discussed below:

- Previous samples from the NTS Area 25 water distribution system have had a fluoride level of over 2.0 ppm, which is the threshold limit for the state of Nevada Secondary Standard. Following 1990 sampling results which indicated elevated fluoride concentrations, the DOE petitioned the state of Nevada for a variance to fluoride requirements for the Area 25 distribution system. In January 1991 the state of Nevada approved a variance request with the caveat that the system be sampled on an annual basis to ensure that the fluoride level does not exceed the Primary Standard of 4.0 ppm, and that a notice of the elevated fluoride levels be posted for the user population. Sampling in 1993 indicated a fluoride level of 2.1 ppm which is well below the primary standard.

- Water from wells 5B and 5C, which serve the Mercury (Area 23) distribution system, are naturally high in pH. Normally water from these wells is blended with Army Well No. 1 water, and the resultant pH meets the state of Nevada pH standard. While Army Well No. 1 was inoperative, the water exceeded the Ph standard, and REECo posted notices as required by the state. All notices were removed after Army Well No. 1 was placed back in service and the pH declined. Design drawings for a carbon dioxide injection system to rectify the problem are currently under review.

During the September 1993 state inspection, the inspector collected the annual samples for organic and inorganic water quality. These samples were analyzed by the state, and the results are shown in Appendix I, Table I.2. The state did not issue any findings or notices of violation relating to drinking water quality during 1993.

3.1.4.2 NTS WATER HAULAGE

To accommodate the diverse, and often transient, field work locations at the NTS, a substantial water haulage program is used. To ensure potability of hauled water, the water is obtained from potable water fill stands, chlorinated in the truck, and then sampled for coliform bacteria.

The state of Nevada inspected the water hauling trucks in 1993 but no findings or notices of violation relating to potable water haulage were expected or issued.

3.1.4.3 NON-NTS EG&G/EM OPERATIONS

The EG&G/EM facility in Woburn, Massachusetts, has a dry well for discharging uncontaminated, noncontact cooling water into the ground. On January 4, 1993, the Massachusetts Department of Environmental Protection Division of Water Pollution Control issued a new permit for this effluent. Permit conditions include self monitoring and monthly reporting requirements. All parameters measured were found to be in compliance with permit conditions.

3.1.5 RESOURCE CONSERVATION AND RECOVERY ACT

The Resource Conservation and Recovery Act (RCRA) of 1976 and the Hazardous and Solid Waste Amendments (HSWA) of 1984 constitute the statutory basis for the regulation of hazardous waste and underground storage tanks. Under Section 3006 of RCRA, the EPA may authorize states to administer and enforce hazardous waste regulations. Several host states (e.g., Nevada) have received such authorization and act as the primary regulators 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. A discussion of actions regarding the FFCA at the NTS is given in section 3.1.6.

3.1.5.1 NTS RCRA COMPLIANCE

Compliance activities under state of Nevada hazardous waste management regulations during 1993 included submission of revisions to the RCRA Part A and B application, and response to state findings of alleged violation. The Nevada Division of Environmental Protection's (NDEP) Bureau of Federal Facilities staff routinely inspects NTS facilities and work sites.

As required under state of Nevada regulation, a Hazardous Waste Generator Report for Generator Identification Number NV3890090001 was sent to the state on March 30, 1992. As a result of a review of this document in January 1993, it was discovered that information on the thermal treatment of explosives at the Area 11 Explosive Ordnance Disposal (EOD) Unit was inadvertently omitted. A modification to the report was sent to the state on January 19, 1993. Recent changes to the state regulations now require submission of Generator Reports only on even calendar years. Accordingly, the next Generator Report will be transmitted in early 1994 and will summarize hazardous waste activities for the years of 1992 and 1993.

During 1993 Raytheon Services of Nevada (RSN) revised and updated the RCRA Part A and B permit applications. The application requested RCRA permits be issued for the management and operation of four activities in Area 5 and one in Area 11, NTS. The original application was submitted to the state in November 1992, and comments were given to DOE/NV in February 1993. In July 1993, the state sent technical comments concerning the Waste Analysis Plan. In December 1993, DOE/NV received the state's rebuttal to selective comments made in the February 1993 response. DOE/NV will provide revised packages in early 1994 to the state's comments. Of the activities considered, regulation of the TRU Waste Storage Pad has been addressed by a "Settlement Agreement for TRU Storage Issues at the Nevada Test Site" between NDEP and DOE/NV signed in June 1992.

The state issued two Findings of Alleged Violation (FOAV) jointly to the DOE/NV and REECo in 1993 for failure to comply with state laws and regulations for hazardous waste management and actions continued on a FOAV issued in 1992. These FOAV's are discussed below:

- On July 20 and 21, 1992, two EPA Region 9 RCRA inspectors performed an inspection of hazardous waste activities at NTS and evaluated the records at the RWMS-5, the Area 5 HWAS, and Area 11 EOD Unit. The results of this evaluation were sent to the state NDEP for action. In a letter, dated October 7, 1992, NDEP sent a transmittal of the EPA Compliance Evaluation Inspection report and requested a response by December 8, 1992 to the nineteen potential violations identified. Prior to December 8, DOE/NV and REECo had conversations with NDEP to clarify the concerns and resolve the alleged violations. Although the DOE/NV responded on December 7, 1992 and acknowledged six violations, NDEP issued a FOAV and Order on December 8, 1992 to the Department of Energy and REECo for allegedly violating fourteen provisions of NAC 444.8632 - Compliance with Federal Standards. On January 20, 1993, DOE/NV and REECo met with NDEP officials to discuss the alleged violations. Ten of the violations were held to be valid by NDEP, and a settlement agreement of $21,500 was reached on July 18, 1993.

- On February 23, 1993, the state issued a FOAV and Order to the Department of Energy and REECo for again violating the provisions of NAC 444.8632. The basis for issuing this

FOAV was that hazardous wastes had been improperly discharged during laboratory operations at Area 23 building 650. Specifically, it was alleged that wastewater containing solvents (FOO1 through FOO5 waste codes) and a pH of less than 2.0 was discharged to a leachfield after regulatory deadlines prohibiting such disposal. The position of DOE/NV and REECo is that the wastewater pH was greater than 2.0 and solvents were not improperly discharged. This leachfield had been previously identified as a RCRA mixed waste management unit. Discharge lines from building 650 into the leachfield influent line had been rerouted into the Mercury sewage lagoon prior to the November 8, 1992 regulatory deadline for loss of interim status for mixed waste management facilities. However, during 1993 one discharge line was discovered to have been missed. A meeting with the state of Nevada was conducted on March 26, 1993, to discuss this FOAV. As a result of this meeting, the state dropped the allegation that solvents were improperly discharged. The state requested additional information concerning an alleged material in an effluent sampling container which may have erroneously biased the pH reading to below 2.0. After reviewing the additional information supplied, the NDEP held that there were inadequate controls to demonstrate that acids had not been improperly discharged. A final settlement for $20,000 was reached on August 10, 1993. A plan to disconnect the last discharge line to the leachfield was approved by the state in 1993, and will be accomplished in 1994. The leachfield will undergo state approved closure.

- On March 2, 1993, the state conducted a formal inspection of the Area 23 Fleet Operations shops and yard areas. A March 3, 1993, letter from the state to DOE/NV requested additional information on eight drums observed during the inspection. This letter also stated that two instances of improper disposal of waste aerosol cans had been observed and that a FOAV would be issued for these violations following completion of the inspection report. On May 24, 1993, a FOAV was issued for a drum containing hazardous waste that had not been properly characterized and managed. A final settlement for $20,400 was reached on October 4, 1993.

No FOAV's resulted from the RCRA Annual Compliance Evaluation Inspection conducted at the NTS in November, 1993.

3.1.5.2 HAZARDOUS WASTE REPORTING FOR NON-NTS, EG&G/EM OPERATIONS

EG&G/EM, LVAO submitted to DOE/NV, for submission to the state of Nevada, the Hazardous Waste Generator biennial report for hazardous wastes generated at the North Las Vegas Facility under EPA ID Number NVD097868731.

3.1.5.3 UNDERGROUND STORAGE TANKS

NTS OPERATIONS

The NTS underground storage tank (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 state NDEP to satisfy state regulatory reporting requirements.

During 1993 five USTs were removed and one was upgraded in accordance with state and federal regulations (see Appendix H, Table H.4). The two boiler house tanks in Areas 12 and 27 had reportable hydrocarbon releases and will require remedial action. One fiberglass tank

(Area 6 helicopter pad) was upgraded with dual wall fiberglass pipes, leak detection, spill/overfill protection, and in-tank monitoring equipment. Soil samples were collected prior to or during the upgrade activities to evaluate whether past releases had occurred at the site. Results indicated contamination at the site did not exceed state regulatory levels. Characterization work (drilling and sampling) remains to be done at the Areas 12 and 23 gasoline stations and the Areas 25 and 26 power house tanks to evaluate site conditions and remediation options.

NON-NTS EG&G/EM OPERATIONS

Characterization began on January 1, 1992 at the RSL where 500 gallons of fuel were released April 25, 1991 into the area surrounding the underground storage tanks. The tanks were pulled and the soil was excavated down to 14 ft below grade. It was discovered that soil contamination extended beyond 22 ft and would require remediation by some means other than excavation. The site was characterized, and a draft site remediation plan utilizing vapor extraction was developed. The plan was approved and implemented during the last quarter of 1993.

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

Compliance activities under CERCLA/SARA for 1993 included SARA Section 312, Tier II reporting to the state of Nevada.

The possibility of listing the NTS on the National Priority List (NPL) of hazardous waste sites carries potential for extensive budget and operational impact. Although the NTS has not been listed on the NPL, planning for environmental mitigation and restoration continued (see Section 3.2.8). The state of Nevada has taken action to negotiate a formal agreement with DOE/NV rather than waiting for the EPA to list the NTS on the NPL. This agreement would clearly establish the state's role and authority over sites requiring evaluation and corrective actions, and establish agreed-upon tasks, time schedules, and funding commitments. DOE/NV met with the state on August 24, September 28, and October 28, 1993, to further negotiate a Federal Facilities Agreement (FFA). A draft FFA and negotiation strategy were provided to DOE/HQ on November 26, 1993. Final approval of this FFA is expected by March, 1994.

3.1.6.1 REPORTING OF UNDERGROUND TESTS TO THE NATIONAL RESPONSE CENTER

In 1987 a DOE/HQ task force determined that underground nuclear device testing areas are CERCLA sites. Under CERCLA all releases of hazardous or extremely hazardous substances (EHS) that exceed reportable quantities must be reported to the National Response Center (NRC). The DOE/NV began reporting nuclear tests to the NRC in 1989 in accordance with Section 103 of CERCLA and Section 304 of SARA. Following a test the NRC is notified of the test and of which typical test profile to reference. Due to the testing moratorium initiated in October 1992, there were no nuclear tests conducted during 1993.

3.1.6.2 TIER II REPORTING UNDER SARA TITLE III

In 1992, the state of Nevada combined the reporting requirements for the SARA Title III, Section 312 Tier II report to include information for the Nevada State Fire Marshall Division Uniform Fire Code Materials Report. The state renamed this document the Nevada Combined Agency Hazardous Substances Report. The 1992 report for the NTS was submitted to the state on April 12, 1993, and contained information on 28 different chemicals in 36 areas which were above the reporting threshold. The combined SARA Section 312, Tier II Report for the Area 5 Spill Test Facility and the EG&G/EM facilities in Areas 5 and 6 was submitted to DOE/NV in February 1993 and subsequently submitted to the state on April 23, 1993.

Non-NTS TIER II REPORTING UNDER SARA TITLE III

The Nevada Combined Agency Reports as described above, for EG&G/EM's LVAO were submitted to DOE/NV in February 1993 and subsequently submitted to the state on April 23, 1993. Reportable EHS at the NLVF were liquid nitrogen (91,776 lb) and lead (250,000 lb). Reportable EHS at the RSL was sulfuric acid (850 lb). Tier II reports for the EG&G/EM WCO and fuel tanks managed by the RSL were filed directly with the appropriate agencies.

3.1.7 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. This law requires the registration of highly hazardous substances above predetermined thresholds. On June 30, 1993, DOE/NV submitted a report for the NTS. The only reportable chemicals for the NTS were chlorine gas, which is used for chlorination of the potable water systems and at the Mercury swimming pool, and carbon dioxide used in testing conducted at the Area 5 Spill Test Facility. The amount of chlorine reported was 2200 pounds, which was a decrease from the 3600 pounds reported in 1992. The amount of carbon dioxide reported was 12,000 pounds.

3.1.8 TOXIC SUBSTANCES CONTROL ACT

State of Nevada regulations which implement the Toxic Substances Control Act require submission of an annual report describing polychlorinated biphenyl (PCB) control activities. The 1992 NTS PCB annual report was transmitted to EPA and the state of Nevada on June 30, 1993. The report included the quantity and status of PCB and PCB-contaminated transformers and electrical equipment at the NTS. Also reported were the number of shipments of PCBs and PCB-contaminated items from the NTS to an EPA approved disposal facility. Fifty-five (55) large PCB capacitors, and four small, low volume PCB capacitors, remain under the management of the Los Alamos National Laboratory in Area 27 of the NTS.

3.1.9 FEDERAL INSECTICIDE, FUNGICIDE, AND RODENTICIDE ACT

During 1993 the application of pesticides at the NTS was conducted under the supervision of a REECo sanitarian who was certified as a pesticide applicator with the state of Nevada. Pesticides were stored in an approved storage facility located in Area 23. 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 lagoons berms. All other pesticide applications were applied on an as-requested basis. General-use pesticides were used for most applications, although restricted-use herbicides and rodenticides were used upon occasion.

Records were maintained on all pesticides used, both general and restricted. These records will be held for at least three years. All applicators are provided the opportunity to receive state-sponsored training materials.

No unusual environmental activities occurred in 1993 at the NTS relating to the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)

Contract companies applied pesticides at all non-NTS facilities in 1993.

3.1.10 HISTORIC PRESERVATION

The National Historic Preservation Act requires federal agencies to take into account any impact their actions might have upon historic sites eligible for listing in the National Register of Historic Places (NR). Accordingly, DOE/NV conducts cultural resource surveys and other studies to assess any impacts NTS operations may have on cultural and archaeological sites at the NTS. When cultural resources eligible for the NR are found in a project area, and they cannot be avoided, plans are written for the recovery of data to mitigate the effects of operations on these sites. Technical reports are written on the results of these recovery programs. The responsibility for overseeing these studies belongs to the Desert Research Institute, University of Nevada.

In 1993, 42 cultural resource surveys were conducted for historical and archaeological sites on the NTS, and reports on the findings were prepared. These surveys identified 23 sites containing previously unknown archaeological information. One data-recovery project was undertaken in 1993 and Native American monitors were present during the fieldwork.

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 1989 the NTS AIRFA Compliance Program was established to assist DOE/NV in the development and implementation of a consultation plan designed to solicit Native American comments regarding the effects of DOE/NV activities on Native American historic properties and the expression of traditional Native American religions. In 1993, the draft technical report on this AIRFA Program was prepared and reviewed by all tribes and appropriate government agencies. This report includes the Native Americans' recommendations regarding the effects of DOE/NV's activities. The report will be finalized in 1994.

As part of the Programmatic Agreement with the State Historic Preservation Office and the Advisory Council on Historic Preservation, work continued on the Long Range Study Plan for Pahute and Rainier Mesas. The objective of the plan is to study a geographically representative sample of all cultural resources on Pahute and Rainier Mesas. In 1993, two data recovery projects were completed and the technical reports were issued for these projects and for two projects from the previous year. During 1993, DOE/NV, the State Historic Preservation Office, and the Advisory Council on Historic Preservation agreed to modify the agreement for the Long Range Study Plan. This modification, known as Attachment A, requires the summary and synthesis of existing archaeological data from the mesas and the preparation of three professional papers over a two to three year period. During the tenure of this agreement, no data recovery will be undertaken on the mesas.

In response to recent federal legislation, a multi-phase program is in progress to upgrade the NTS archaeological collection and archives. In 1993 a piece-by-piece inventory of the collection was initiated and will continue into the next year. In response to the Native American Graves Protection and Repatriation Act (NAGPRA), a summary of the NTS artifact collection was prepared and distributed to 17 Native American tribal groups for review. Under NAGPRA, federal agencies are required to consult with Native Americans regarding unassociated and associated funerary items and human remains. Few of these exist on the NTS.

3.1.11 ENDANGERED SPECIES PROTECTION

The Endangered Species Act (ESA) requires federal agencies to insure that their actions do not jeopardize the continued existence of federally listed endangered or threatened species or their critical habitat. The desert tortoise is the only threatened species on the NTS. DOE/NV consulted with the U.S. Fish and Wildlife Service (USFWS) and received non-jeopardy Biological Opinions for installation of a fiber-optic cable and activities proposed in the 5-year plan. USFWS also provided an incidental take authorization and specified terms and conditions that must be implemented to minimize take.

A total of 27 NTS project sites in desert tortoise habitat were surveyed and construction was monitored at these sites. Two reports documenting compliance actions taken during 1992 and 1993 were submitted to USFWS in the fall of 1993.

There are 21 species known or expected to occur on NTS that are being considered for listing under the ESA. DOE/NV is gathering information to help USFWS evaluate whether federal protection is really justified for any of the species. DOE/NV conducted 45 preactivity surveys at proposed disturbance sites to determine the presence of these species. Survey results and mitigation recommendations were documented in 38 survey reports. New populations of four Category 2 candidate plant species were found as a result of the 1993 preactivity surveys.

A report synthesizing the efforts to conserve the Category 1 candidate plant Beatley's milkvetch and to monitor its status was submitted to USFWS. Based on the information provided in the report, DOE/NV requested that the species be reclassified to Category 3C, which greatly reduces the likelihood that the species will be considered for federal protection in the near future. USFWS did not concur with DOE/NV's request and recommended that DOE/NV develop a new Conservation Agreement with USFWS for this species. Additional populations of nine other candidate plant species were located during field surveys. DOE/NV provided USFWS with an updated map of the distribution of all NTS candidate plants.

3.1.12 EXECUTIVE ORDER 11988, FLOODPLAIN MANAGEMENT

There were no projects in 1993 which required consultation for floodplain management. NTS design criteria does not specifically 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.

3.1.13 EXECUTIVE ORDER 11990, PROTECTION OF WETLANDS

There were no projects in 1993 which required consultation for protection of wetlands. NTS design criteria does not specifically address protection of wetlands, however, all projects are reviewed pursuant to the requirements of DOE Order 5400.1.

3.1.14 EXECUTIVE ORDER 12856, FEDERAL COMPLIANCE WITH RIGHT-TO-KNOW LAWS AND POLLUTION PREVENTION REQUIREMENTS

Actions taken to comply with the requirements of this executive order are discussed in Section 3.2.6.

3.2 CURRENT ENVIRONMENTAL COMPLIANCE ISSUES AND ACTIONS

There were numerous activities and actions relating to environmental compliance issues in 1993. These activities and actions are discussed below grouped by general area of applicability. There were no lawsuits identified in 1993 relating to environmental compliance issues that would affect DOE/NV program obligations.

3.2.1 CLEAN AIR ACT

A fugitive dust study of permitted equipment and surface disturbance operations was completed by The Mark Group in July, 1992 to identify means of improving NTS air quality emissions. Recommendations made by The Mark Group included the installation of an electrostatic precipitator at the Area 1 Shaker Plant and the installation of a cyclone separator at the Area 1 Rotary Dryer. It was also recommended that the Area 3 Portec Hopper, scheduled for relocation to the Area 1 Batch Plant, be outfitted with a cyclone separator. This same separator could also be used by the Area 1 Batch Plant. The Mark Group recommendations were either instituted or equivalent changes were made.

3.2.2 CLEAN WATER ACT

A NPDES permit may be issued for the NTS and the off-NTS EG&G/EM NLVF as part of the state implementation of the federal stormwater discharge regulations. Public hearings were held in December 1992 on the state of Nevada Stormwater Discharge General Permit to solicit public and industry comments prior to final state regulatory promulgation. The NDEP must determine if waters of the United States exist on the NTS and if requirements under federal stormwater discharge regulations are relevant to the NTS.

The federal stormwater regulations identify regulated facilities by their SIC code. Since there were no SIC codes that directly applied to the NLVF, similar SIC codes were identified and a survey conducted to assess the level of activity for each SIC code and establish a primary SIC code for the NLVF. This survey was conducted in accordance with guidance received from Region 9 EPA and the Office of Management and Budget. The survey revealed that the primary SIC code was not a regulated activity subject to the federal stormwater regulations. A survey report was prepared and submitted to the State of Nevada requesting a formal determination on the regulatory status of the NLVF. This determination is still pending.

A short solution for the treatment of septage and portable toilet waste was developed and approved by the state of Nevada. The state had asserted that addition of portable toilet waste into the Areas 6, 12, and 23 sewage lagoon systems significantly impacted the microbial breakdown efficiency in these lagoons. Information provided to the state demonstrated that breakdown efficiency was not impacted except during winter when portable toilet wastes have an antifreeze additive. Dewatering of septage and winter portable toilets within the Area 25 Engine Test Stand #1 and two of the Area 12 sewage lagoon secondary basins continued in

1993. The use of the Area 2 sewage lagoon secondary basin for this dewatering was initiated after verbal approval from DOE/NV on September 2, 1993. Future flows into the Area 2 secondary basin are not anticipated since Area 2 will be abandoned in 1994. The Areas 12 and 25 dewatering sites have been identified in the draft general permit for sewage lagoons.

Discharge from the Area 6 Decontamination Facility (DECON) into an evaporation pond was discontinued prior to the November 8, 1992 regulatory deadline since the pond and discharge pipeline had been identified for closure as a RCRA mixed waste management unit. Discharge of hazardous waste into this pond had been discontinued in 1988. A temporary decontamination effluent collection facility capable of transferring wastewater into three 79,500 L (21,000 gal) Baker Tanks was installed in January 1993. Wastewater will be stored until analytical results are evaluated to verify there are no RCRA wastes, and discharge to sewage lagoons is acceptable. The state has chosen to not issue a permit for this temporary facility, but a start-up operations manual was developed. Limited operation was started on May 17, 1993. RCRA samples are being collected to comply with a February 3, 1993, state letter. Construction for connection of the sewage line from the DECON to the Area 6 Yucca Lake sewage lagoons was initiated in October 1993.

An unauthorized discharge of sewage resulted from a blockage in a main line of the Area 12 collection system. Subsequently, the NDEP required the development of an action plan for the abandonment of inactive sewer lines and service laterals as well as procedures and a schedule for flushing and cleaning sewer lines and mains. This action plan was submitted to the state by DOE/NV on January 22, 1993, and approved on January 26, 1993. Field investigations, work plans, cost estimates and schedules of work have been completed for the Areas 6, 12 and 23 collection systems. Funding has been provided and six months has been estimated for completion of abandonment procedures after written approval by DOE/NV. An operations and maintenance manual will be prepared for NTS sewage collection systems upon completion of abandonment activities.

Clearing of a plugged effluent line at the Area 23 Fleet Operations Steam Cleaning Facility culminated in an unauthorized discharge of pollutants and hydrocarbons. To satisfy NDEP requirements, the visibly contaminated soils were sampled and removed for disposal, improvements in the line were installed, maintenance practices for the facility were reviewed and improved, and a schedule for the construction of a closed loop steam cleaning system was developed and submitted. The closed loop system was scheduled for completion in August 1993, but was delayed by the need to obtain a water system addition approval from the state. The completion of the closed loop system is now scheduled for early 1994. To satisfy the original due date to eliminate surface discharge, wastewater is being pumped from a collection sump into a nearby sewer drain.

The REECo Analytical Services Laboratory was granted certification to perform wastewater sample analysis of wastewater pH, total suspended solids (TSS), and Biochemical Oxygen Demand (BOD) by the state of Nevada in February 1993.

As part of planned actions for Tiger Team Finding SW/CF-3, an investigation was conducted to determine which abandoned septic tank systems at the NTS can be closed using state regulations and which systems need to be sampled for potential hazardous/radioactive contamination. Because these systems were abandoned, detailed knowledge of disposal activities is not available. SW/CF-3 listed 30 abandoned systems from a 1987 report. A total of 54 abandoned tank systems have now been identified. Procedures were finalized in October 1993 for closure of these systems. The procedures cover sampling of liquids and solids, process knowledge investigation, wastewater source documentation and the submittal of a notification report. DOE/NV Environmental Protection Division will be notified when a hazardous and/or radiological waste is discovered to determine immediate action and obtain proper direction on any long term closure activities.

An initial survey of active septic systems, completed in January 1991, in response to Tiger Team Finding SW/CF-5, revealed 37 active systems with state requirement deficiencies. A total of 48 systems have now been identified for corrective actions. Corrective actions have been assigned to responsible department managers.

A surface discharge of domestic wastewater originating from Quonset 800 and industrial wastewater from an adjacent steam cleaning facility into a drainage ditch was noted on September 28, 1993. Both flows were immediately terminated upon discovery. Three alternatives for permanent disposal of both waste streams are under evaluation.

3.2.3 SAFE DRINKING WATER ACT

An Operations and Maintenance Plan was developed to address standard operating procedures for water system operations at the NTS. A draft copy of the plan was submitted to the state for review in 1992. Comments from the state were incorporated into the Plan, and a formal transmittal was made during 1993. The state responded with additional comments, which are being incorporated into the final Plan for resubmission to the state in early 1994.

Engineering drawings for a new NTS water well, Well 4A, were submitted to the state of Nevada for review and approval. Well 4A will supplement the Area 6 water distribution system. The state of Nevada did not approve the plans for Well 4A and responded with a list of regulatory requirements that must be addressed on engineering drawings prior to state approval. Appropriate changes were made to the engineering drawings, and the state approved them during 1993. The connection to the Area 6 system has not been made, because of the declining work force supplied by this system. Prior to being placed in service, the state will need to sample Well 4A.

In February 1993, REECo completed a cross connection survey of all active, inactive, and sporadically used NTS buildings utilizing American Water Works Association certified Cross Connection Control Program Specialists. A report was sent to DOE/NV in 1993. A total of 72 facilities were identified in the survey reports as requiring internal or external cross connection prevention devices. Survey reports have been transmitted to RSN to initiate engineering design for the devices. Funding was approved in late 1993, and RSN has begun the design work.

The Las Vegas Valley Water District sponsored a training course for water system operator certification from January through March 1993. Two REECo employees received Water Distribution System Operator Grade 1 certifications.

The state of Nevada classified the NTS water systems as requiring a Grade II Water System Operator Certification. A REECo Water and Steam Section superintendent was granted a Grade II Certification in early 1993.

In March, 1992, a potential cross connection was identified in the draining system for the Area 6 water fill stand and the REECo Site Maintenance Department corrected the problem.

However, there was concern about the existing design. To correct this design concern, the Area 6 fill stand will be converted to a closed filling system with a backflow prevention assembly in-line. Engineering design for this system was completed and submitted to the state in mid 1992. The plans were approved in August 1993 and work began on the project.

The REECo Analytical Services Laboratory has applied for certification to analyze drinking water samples for coliform, volatile organic compounds (VOCs), heavy metals, and trace minerals. The laboratory received the certification for coliform on July 12, 1993, and discussions with the state indicate that the remaining certifications will probably be granted early in 1994.

3.2.4 COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT

In mid 1990 the state of Nevada requested assistance from REECo to clean up abandoned waste in Pahrump, Nevada. The site consisted of 780 containers of various size, most of them 55-gal. drums. A REECo stamp was found on three 5-gal buckets. Three other containers bore a Defense Logistics Agency stamp; the other containers bore no discernable labels to indicate ownership. Cleanup activities began in 1990 and were completed by year's end. A final report from REECo was submitted to DOE/NV in June, 1991, for transmittal to the state. Then in December 1992, REECo was notified by EPA of its potential liability for $48,608.63 in EPA-incurred costs for stabilization and assessment actions at the Pahrump Drum Removal Site, later revised in December of 1993 to more than $93,000. DOE/NV Office of Chief Counsel advised REECo on or about January 5, 1993, that DOE/HQ was not approving the payment, subject to further review. REECo was instructed to obtain further information and data supporting a possible offer/payment based on volumetric calculations. The appropriateness of this payment is being evaluated.

3.2.5 HISTORIC PRESERVATION

The Historic Structures Program continued in 1993. This is a multi-phase project focusing on assisting DOE/NV inventory and interpreting the cultural resources associated with NTS activities. During the first phase of this project, background research was conducted on structures associated with atmospheric testing with a one week field visit by an architectural historian. A draft technical report containing a preliminary inventory and evaluation of NTS structures was prepared and reviewed by DOE/NV. The final report will be issued in FY 1994.

Other efforts in 1993 included management of cultural resources on the NTS, preparing management objectives and plans, and promoting public relations and communications concerning the NTS archaeology and cultural resources program.

3.2.6 WASTE MINIMIZATION

3.2.6.1 NTS OPERATIONS

All NTS contractors and users have published implementation plans in accordance with the DOE/NV Waste Minimization and Pollution Prevention Awareness Plan. These plans are designed to reduce waste generation and possible pollutant releases to the environment. Some contractors have revised their plans, incorporating the most current waste minimization requirements or new Executive Orders (e.g., Executive Order 12856), and are establishing ongoing goals for further improvements. These ongoing efforts provide increased protection of public health and the environment, as well as:

- Reduced waste management and compliance costs.
- Reduced resource usage.
- Reduced inventories of chemicals that require reporting under the Superfund Amendments and Reauthorization Act (SARA), and the EPA 33/50 Pollution Prevention Program.
- Reduced exposure to civil and criminal liabilities under environmental laws.
- Reduced overhead costs and increased productivity through improved work processes and greater awareness.

The waste minimization program reflects DOE/NV goals and policies for waste minimization, pollution prevention and recycling, and represents an ongoing effort to make pollution prevention/waste minimization part of the NTS operating philosophy. In accordance with the Pollution Prevention Act of 1990 (PPA) and this DOE policy, the following hierarchical approach to waste reduction is practiced and applies to all waste streams: (1) Prevent or reduce waste at the source whenever feasible; (2) Recycle, in an environmentally acceptable manner, waste that cannot feasibly be prevented; (3) Treat waste that cannot feasibly be prevented or recycled; (4) Dispose of waste only as a last resort.

All DOE/NV quantitative goals and schedules were met or exceeded. Total NTS hazardous waste generation was reduced by 13 percent in 1993 over 1992 generated waste.

The NTS program recycles and returns to productive use significant quantities of materials. (see Appendix H, Table H.5).

The REECo Just-in-Time (JIT) supply system now provides most common use items, e.g., cleansers and lubricants, to all NTS agencies. This program has significantly reduced on-hand stores, thereby reducing administrative and handling costs, and virtually eliminating waste generation due to expiration of shelf life. All parties benefit in reduced waste disposal and increased productivity.

Chlorofluorocarbon (freon) recycling equipment is in place at all NTS service and maintenance centers. All freon is recovered and reused, eliminating ozone-depleting substance emissions into the atmosphere almost completely. Approximately 150 service personnel have been trained and certified in the operation of this equipment, nearly a year ahead of the EPA's required deadline.

The DOE/NV, its contractors, and other agencies and users serve as members of the DOE/NV Waste Minimization Task Force which conducts pollution prevention campaigns, reaching all employees as well as the surrounding community. The Task Force has developed a Pollution Prevention and Waste Minimization training course which has been concurred in by DOE/NV and is available to all DOE/NV contractors and users.

3.2.6.2 NON-NTS EG&G/EM OPERATIONS

Policies and Procedures

The EG&G/EM Waste Minimization and Pollution Prevention Awareness Implementation Plan was submitted to DOE/NV on December 20, 1991. A formalized system of waste minimization was developed through the implementation of EG&G/EM Policy No. 31-70.A," Waste Minimization and Pollution Prevention"; and Standard Operating Procedure 31-006.A, "Hazardous Waste Minimization Plan". During 1993, processes were evaluated for product substitution, cross-contamination control, or site treatment. Organizational Operating Procedure No. 31-C300-004.A, "Purchase Requisition Review" establishes the review requirements for the procurement of hazardous materials to ensure proper tracking and appropriate substitutes are identified.

Training

EG&G/EM employees and management are trained on company policies, procedures, and rules and are provided the opportunity to review waste minimization training videos. Fifteen Safety Specialists have completed the performance based training module entitled "Introduction to Waste Minimization Techniques." Over 783 employees received formal waste minimization training during 1993.

Product Substitution

EG&G/EM has made progress towards substituting chemicals that have a high stratospheric ozone depletion potential with chemicals that have a lower depletion potential. Most air conditioner refrigerants at EG&G/EM facilities have been substituted with HCFC-22 which has an ozone depletion potential of 0.05 as opposed to CFC-11 and CFC-12 which have an ozone depletion potential of 1.0. Substitutions for 1,1,1-trichloroethane have either been implemented or are in the trial phase. Planisol is being used as a replacement for gross non-critical cleaning. Irradicon is being used on a trial basis as a supercritical cleaner. New less hazardous janitorial chemicals have replaced existing stock to minimize variety and quantity of chemical used and stored onsite. Over 1100 chemicals at Kirtland Operations were evaluated and 338 were discontinued.

The sheet metal shop at EG&G/EM, North Las Vegas Facility has replaced solvent based paints with water base paints for most applications reducing the solvent waste stream from this facility by 250 gal per year.

Recycling

Freon recycling systems capable of capturing, cleaning and drying the freon for reuse are used for air conditioning systems EG&G/EM operates and maintains. EG&G/EM has also implemented a recycling program for HP Laser Jet II/III and Canon FAX toner cartridges. EG&G/EM recycled over 165,880 pounds of paper, 12,000 pounds of cardboard, 2,640 pounds of aluminum cans, and 576,000 pounds of scrap metal.

Treatment/Volume Reduction

The EG&G/EM, RSL has a photo laboratory which develops 850 ft^2 of film per day. The effluent from the laboratory processes is captured, neutralized, and the silver removed and recycled. The effluent is then discharged to a publicly owned treatment works. The effluent is tested 4 times a day to verify it is within the permitted discharge limits.

Reports

The annual SEN-37-92 Annual Waste Reduction Report on waste generation and minimization was submitted to DOE in February 1993 in accordance with the requirements of DOE Order 5400.1, "General Environmental Protection Program".

3.2.7 SOLID/SANITARY WASTE

During 1993 sanitary land fills were operated in Areas 9 and 23. The amount of material disposed in each is provided in Appendix I, Table I.8.

In November, 1993, the NDEP enacted new solid waste regulations, consistent with the EPA's federal solid waste program, which affect the NTS Solid Waste Program. These regulations require municipal landfills to meet more stringent location, design, monitoring, and operation requirements. Several actions have been taken to ensure compliance with these new regulations. One of the NTS sanitary landfills will be closed by October, 9, 1995. The other NTS landfill will be upgraded by the installation of a groundwater monitoring, or comparable, system by October 9, 1996.

Effective December 31, 1991, the state of Nevada restricted land disposal of soil contaminated with hydrocarbons at concentrations above 100 ppm of total petroleum hydrocarbons. Hydrocarbon contaminated soil predominately originates from spills or leaks of oil or other hydrocarbon based liquids onto soil. Following this disposal prohibition, hydrocarbon contaminated soil was stockpiled while alternative disposal means were under consideration by DOE/NV. In mid-1992, the state clarified requirements necessary for land disposal of hydrocarbon contaminated soil. Based on these clarified requirements, the inactive Area 6 sanitary landfill was proposed for soil disposal, and an Operations & Maintenance (O&M) plan was developed and provided to the state for review. The installation of neutron moisture monitoring wells at the Area 6 landfill was included in this plan. Final approval of the O&M plan was received in February 1993. The Area 6 landfill opened strictly for disposal of hydrocarbon contaminated soil in May 1993. Table I.8 in Appendix I gives the amount of soil disposed of in this landfill in 1993.

3.2.8 ENVIRONMENTAL RESTORATION/REMEDIATION ACTIVITIES

The NTS has an ongoing Environmental Restoration Program (ERP) for the characterization and restoration of contaminated facilities or areas. In 1993 characterization and restoration activities associated with the ERP included:

- Continuation of studies of the environmental impact on groundwater from nuclear testing. To date five wells designed for the groundwater characterization program have been completed out of an estimated 100 wells to be installed by the end of 1999.

- Inspection of 28 suspected abandoned underground storage tank (UST) sites located throughout the NTS: underground tanks were found at 12 of the sites. Five USTs were closed in 1993 with soil samples taken to document proper closure.

- Completion of closure activities for the five RCRA hazardous waste trenches at the Mercury Landfill in August 1993. Closure involved the placement of two covers totaling about 150,000 square feet. A Construction Quality Assurance Plan, an engineering study to identify the stability of the covers under seismic stress, and the Closure and Certification Report were also completed. The facility is being monitored monthly for soil moisture with monthly cover inspections as part of the post closure requirements.

- Responding to NDEP comments on the work plan for preliminary characterization of 19 abandoned septic tanks and leachfields. Sampling is to begin in 1994.

- Excavation and shipment of the soil mound at the Project CHARIOT Ogotoruk Valley site to the NTS. Additional soil containing low levels of contamination were also excavated and shipped. All assessment and remediation work was completed by late August. Public meetings were held at the beginning and the conclusion of this project.

Other characterization or restoration activities not associated with the ERP included:

- Completion of a Phase 1 site characterization of the Area 2 Pull Test Facility where lead in soil was identified. The site may require remediation. Additional sampling is planned, with the remedial method anticipated to be selected in 1994.

- Beginning closure of two injection wells located at the Area 1 Drilling Subdock. Additional sampling was required due to the unexpected presence of petroleum hydrocarbons identified during initial closure activities. The closure plan was amended with the new findings included and is anticipated to be approved by the NDEP in early 1994.

3.2.9 RADIATION PROTECTION

3.2.9.1 NTS OPERATIONS

Results of environmental monitoring on the NTS during 1993 indicated full compliance with the radiation exposure guidelines of DOE Order 5400.5, "Radiation Protection of the Public and the Environment" and the 40 CFR 141 National Primary Drinking Water Regulations. Onsite air monitoring results showed average annual concentrations ranging from 9×10^{-4} percent of the DOE Order 5400.5 guidelines for ^{85}Kr to 0.2 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 0.1 percent of the National Primary Drinking Water Regulation for tritium. Supply wells contained 0.01 percent of the DOE Order 5400.5 guideline for $^{239+240}$Pu. Comparisons were made to the guidelines for public consumption although the general public does not consume water from these supplies.

3.2.9.2 NON-NTS EG&G/EM OPERATIONS

There were no radioactive air emissions, no radioactive or nonradioactive surface water/liquid discharges, subsurface discharges through leaching, leaking, seepage into the soil column, well disposal, or burial at any of the EG&G/EM operations. Use of radioactive materials was primarily limited to sealed sources. Facilities which use radioactive sealed sources or radiation producing equipment, with the potential to expose the general population outside the property line to direct radiation, are: SBO during operation of the LINAC; STL during the operation of the sealed tube neutron generator; the RSL at Nellis Air Force Base; and the LVAO, NLVF A-1 Source Range. Sealed sources are tested periodically to assure there is no leakage of radioactive material. Fence line radiation monitoring was conducted at these facilities. At least two TLDs are at the fence line on each side of the facility. The TLDs are exchanged quarterly with an additional control TLD kept in a safe. The monitoring data were consistent with previous data indicating no exposures to the public from any of the monitored facilities.

3.2.10 ENVIRONMENTAL COMPLIANCE AUDITS

3.2.10.1 TIGER TEAM COMPLIANCE ASSESSMENT

The DOE Tiger Team Compliance Assessment of the NTS conducted from October 30 to December 1, 1989, was part of a 10-point initiative by the Secretary of Energy to conduct independent oversight compliance and management assessments of environmental, safety, and health programs at over 100 DOE operating facilities. The Tiger Team identified 149 deficiencies including 45 environmental "findings" in its assessment of the NTS, none of which reflected situations which presented an immediate risk to public health or the environment. Potential noncompliance findings included 35 irregularities with federal or state environmental regulations and/or DOE Orders. Ten findings represented conditions which were judged not to meet "best management practices," i.e., practices which could be improved through application of available or improved methods.

In response to the Tiger Team report, the DOE/NV developed an action plan to address each of the findings. In many cases the planned actions were straightforward and could be readily implemented. Others required or will require substantial funding and years to implement. A schedule for accomplishing all actions was established in 1990, and, dependent upon adequate funding, all work is planned to be completed by September 30, 1996.

The "most significant findings" identified by the environmental sub-team of the Tiger Team included:

- Incomplete waste characterization for wastes slated for disposal.
- Radioactive wastes being accepted at the Area 3 and Area 5 radioactive waste disposal sites from generators not approved in accordance with DOE/NV procedures.
- Various wastes generated on the NTS were managed with insufficient knowledge of hazardous waste-related components in the waste streams.

Work continues on responding to these issues. At the end of 1993, 145 of the 149 findings have been closed in accordance with the DOE/NV Procedure for Closure of Nevada Operations Office (NV) Action Plan, Revision No. 0, July 13, 1990. The remaining items require more funding or effort to close out. They include Environmental Impact Statements, standardization of training activities, and management of NTS electrical service.

3.2.10.2 NTS ENVIRONMENTAL SURVEYS

From March 8 to 24, 1993, an environmental compliance assessment was conducted by REECo of all active REECo facilities and work sites at the NTS. Numerous deficiencies were corrected at the time of the assessment. A deficiency is defined as a direct violation of an environmental requirement, such as an environmental regulation, or any REECo environmental company procedure or policy. Those deficiencies which were not correctable have been assigned a system deficiency number and are being formally tracked. The assessment identified approximately 55 of these system deficiencies. The majority of identified deficiencies can be classified in five general categories: (1) improper management of aerosol cans; (2) improper management of containers; (3) improper hazardous waste satellite accumulation area management; (4) unidentified hydrocarbon stains; (5) uncharacterized discharges. As of the end of 1993, six of the identified deficiencies remain open. As part of the Environmental Corrective Action Plan developed to prevent these problems from reoccurring, REECo line management is now required to perform monthly compliance inspections of their facilities, and to enter any deficiencies into REECo Automated Deficiency Tracking System for corrective action tracking.

3.2.10.3 NON-NTS EG&G/EM AUDITS

In 1991 the DOE Office of Environmental Audit, conducted an environmental audit of EG&G/EM Santa Barbara Operations, Special Technologies Laboratory, and Las Vegas Area Operations including the Remote Sensing Laboratory and the North Las Vegas Facility. There were 22 findings and 4 noteworthy practices. The findings were not considered to be indicative of significant programmatic failings. All findings were submitted for closure in 1993.

3.2.11 OCCURRENCE REPORTING

Occurrences are environmental, health, and/or safety-related events which are reported in several categories in accordance with the requirements of DOE Order 5000.3A, "Occurrence Reporting and Processing of Operations Information." A listing of the reportable occurrences for off-NTS support facilities and on-NTS locations appears in Appendix H, Tables H.6 and H.7. An analysis of occurrences for 1993 in DOE Order 5000.3B, "Trending and Analysis Report", showed that 57.1 percent of these occurrences were due to personnel error, with violation of procedures as the most common sub-group under this general root cause.

3.3 PERMIT SUMMARY

For facilities used in the operation and maintenance of the NTS and non-NTS facilities, the DOE/NV contractors providing such operation and support activities for the DOE/NV have been granted numerous permits by the appropriate regulatory authorities. In addition to the existing number of permits in 1993 (shown in Appendix H, Table H.8) portions of the RCRA Part B permit applications were in various stages of NDEP review for the different units requesting permission to construct or operate.

4.0 ENVIRONMENTAL PROGRAM INFORMATION

The environmental monitoring and compliance programs for the Nevada Test Site (NTS) and offsite EG&G Energy Measurements, Inc. (EG&G/EM), facilities consist of radiological monitoring, nonradiological monitoring, and environmental permits and operations compliance.

4.1 RADIOLOGICAL MONITORING

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There are two radiological monitoring programs associated with the NTS, one onsite and the other offsite. The onsite program is conducted by several organizations. Reynolds Electrical & Engineering Co., Inc. (REECo), the operating contractor at the NTS, is responsible for environmental surveillance and effluent monitoring. Several other organizations, such as the Lawrence Livermore National Laboratory (LLNL), Los Alamos National Laboratory (LANL), Desert Research Institute (DRI), the U. S. Environmental Protection Agency (EPA), and participants in the Basic Environmental Compliance and Monitoring Program (BECAMP) also make radiological measurements onsite. The offsite program is conducted by the EPA's Environmental Monitoring Systems Laboratory in Las Vegas, Nevada (EMSL-LV).

4.1.1 ONSITE MONITORING

At the NTS radiological effluents may originate from tunnels, from underground test event sites [at or near surface ground zeros (SGZs)], and from facilities where radioactive materials are either used, processed, stored, or discharged. All of these sources have the potential to or are known to discharge radioactive effluents into the environment. Monitoring these at the point of discharge is effluent monitoring. Another type of monitoring, environmental surveillance, is used to measure radioactivity in the general environment.

Table 4.1 is a summary of the routine environmental surveillance program. Air sampling is conducted for radioactive particulates, halogens, noble gases, and tritiated water vapor (see Figure 4.1 for sampling locations). Ambient gamma radiation monitoring is conducted throughout the NTS using TLDs (see Figure 4.2). Water from groundwater wells, spring water, well reservoirs, and waste disposal ponds is sampled for radioactivity (see Figures 4.3 and 4.4). These tasks make up the environmental surveillance program on the NTS.

4.1.1.1 CRITERIA

DOE Order 5400.1, "General Environmental Protection Program," published in November of 1988, established the onsite environmental protection program requirements, authorities, and

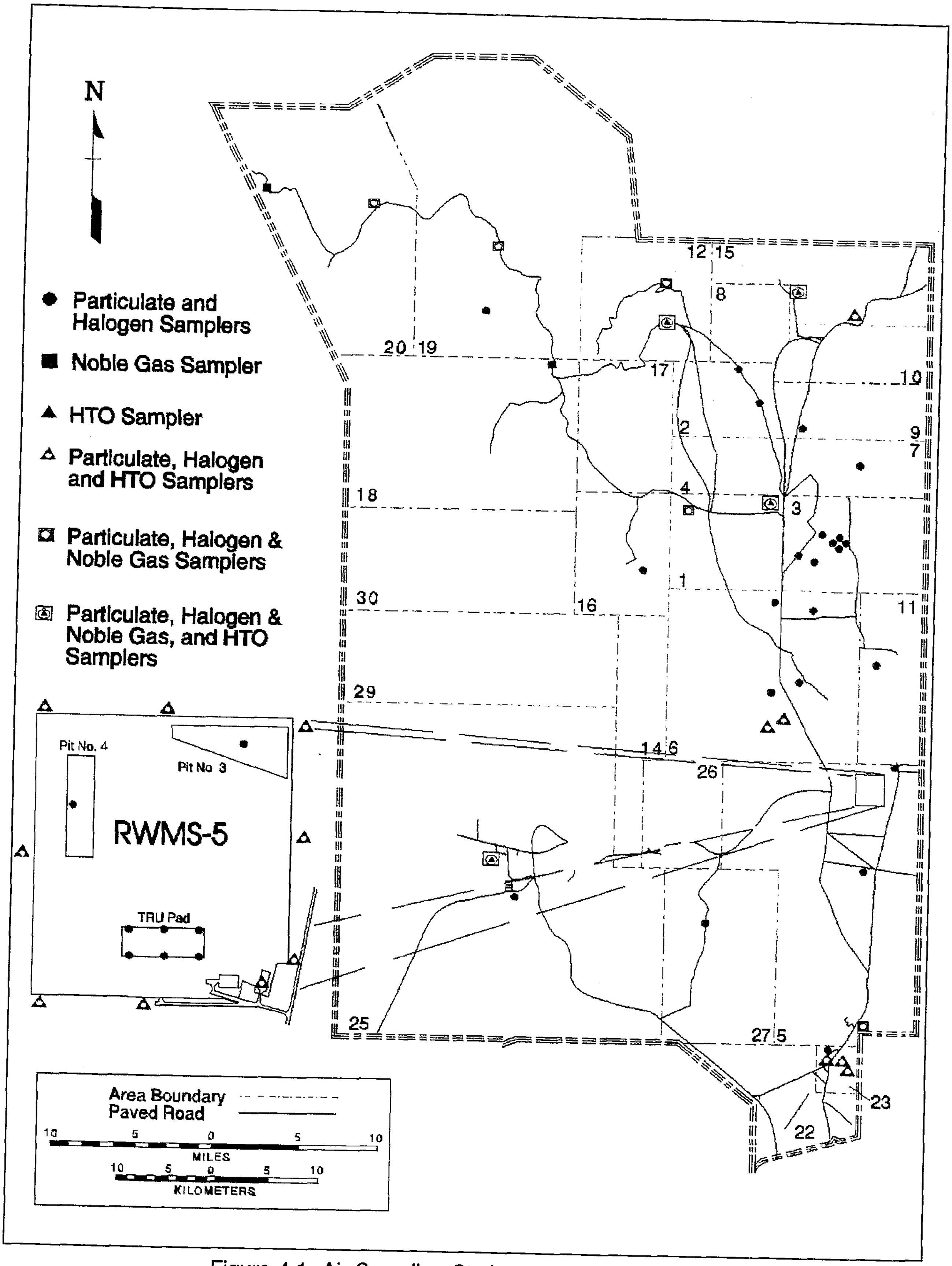


Figure 4.1 Air Sampling Stations on the NTS - 1993

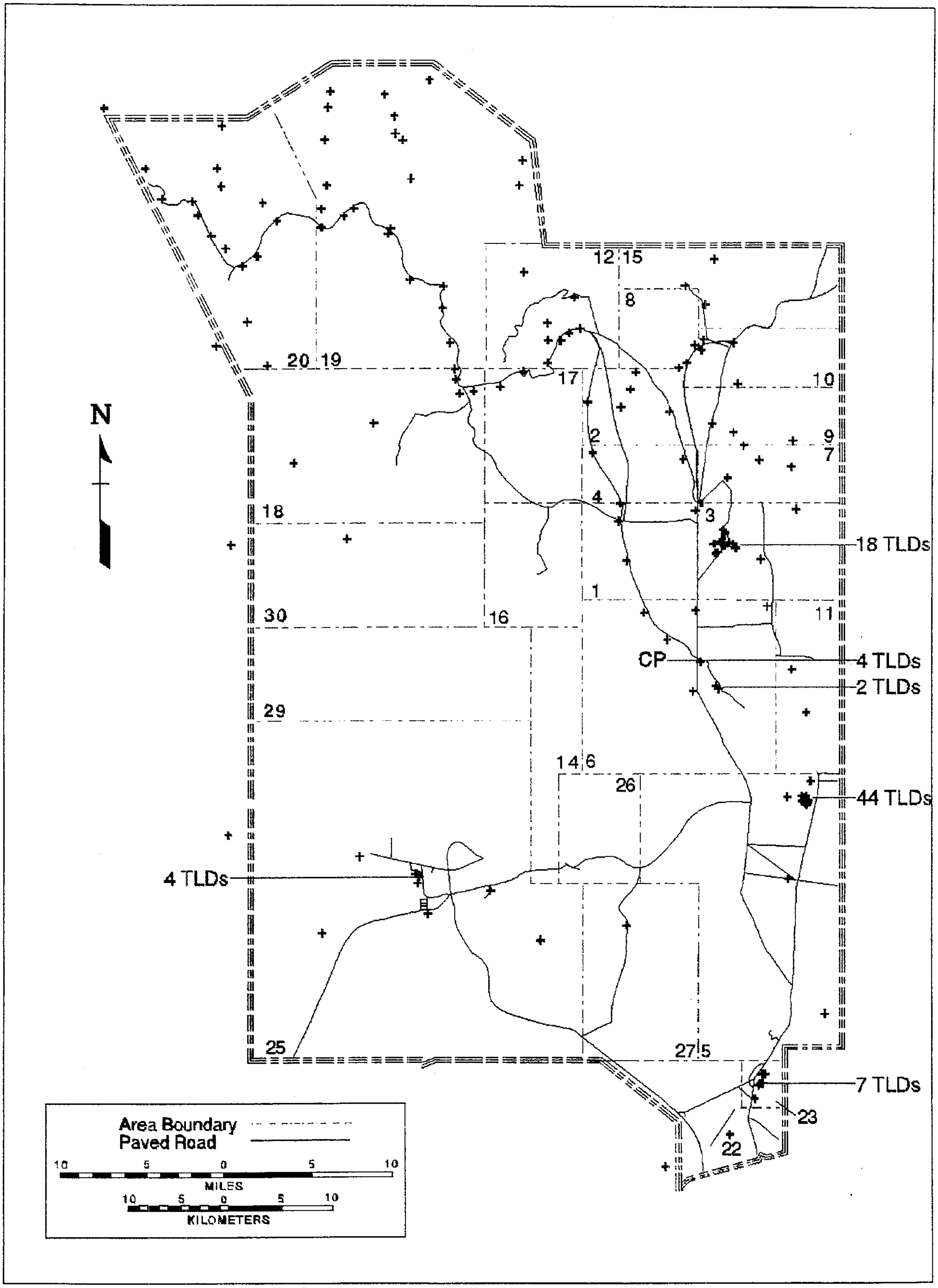


Figure 4.2 Thermoluminescent Dosimeter Stations on the NTS (+) - 1993

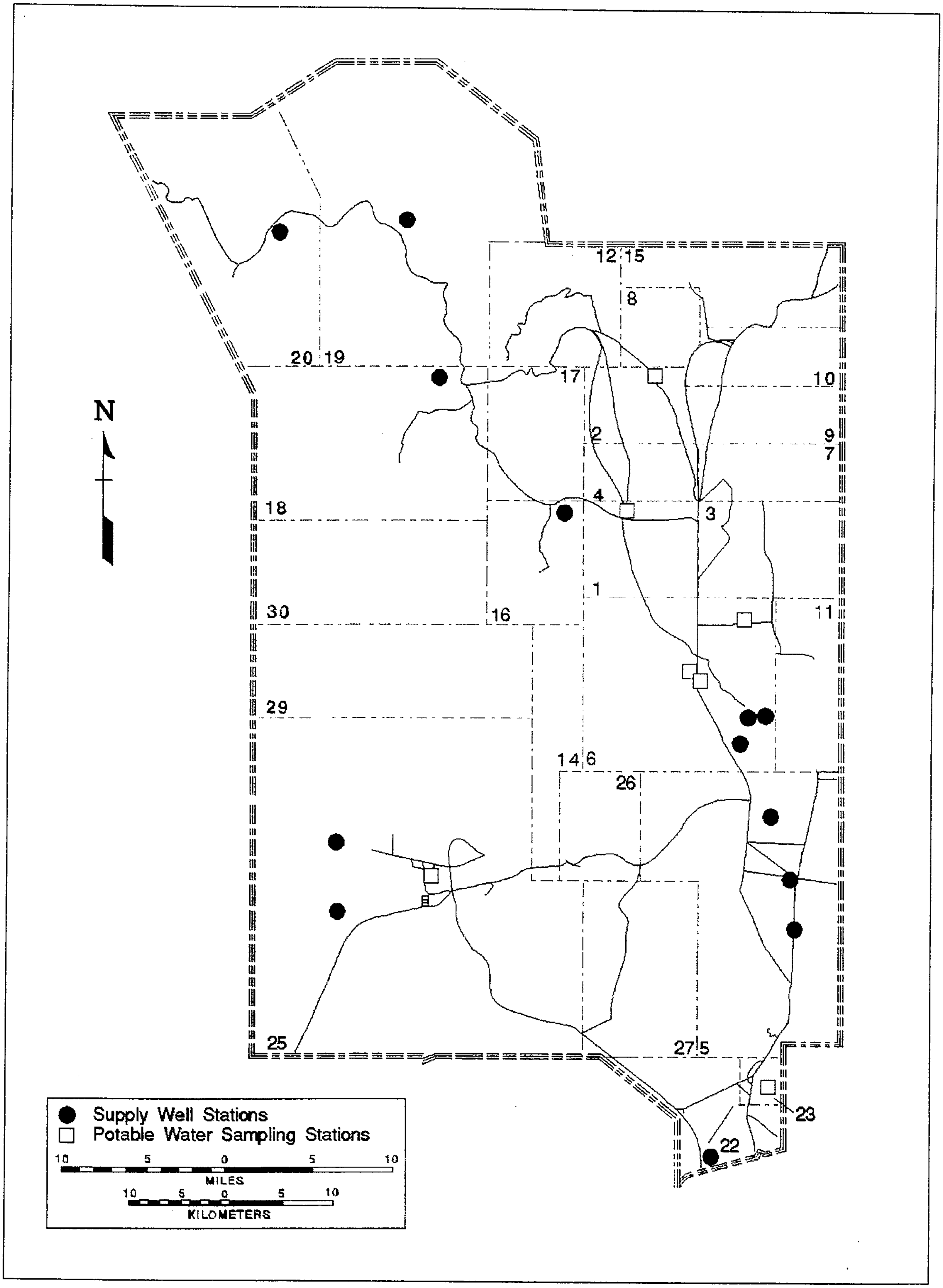


Figure 4.3 Supply Well and Potable Water Sampling Stations on the NTS - 1993

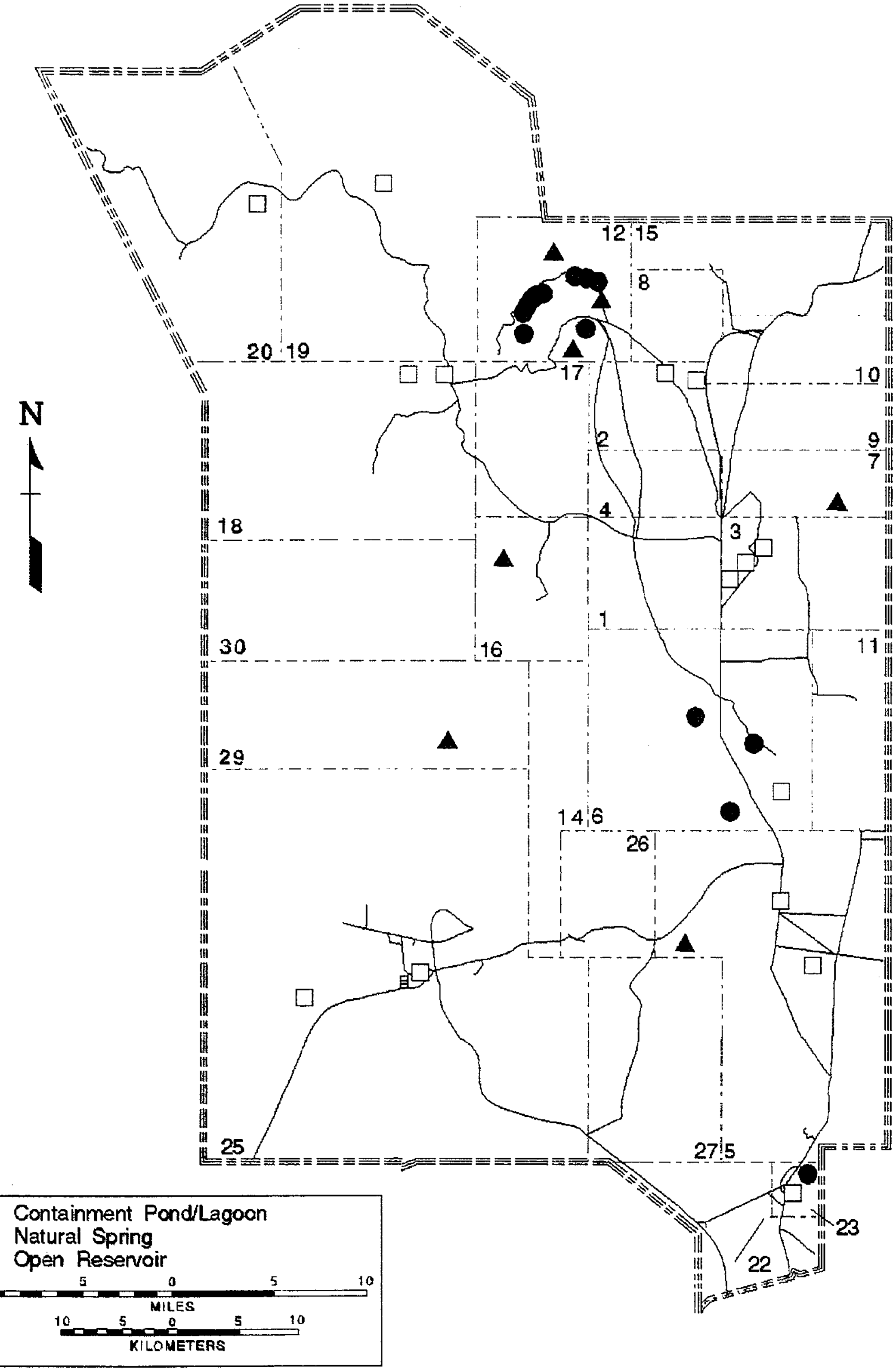


Figure 4.4 Surface Water Sampling Locations on the NTS - 1993

Table 4.1 Summary of Onsite Environmental Surveillance Program - 1993

Sample Type	Description	Collection Frequency	Number of Sampling Locations[(a)]	Type of Analysis
Air	Sampling through Whatman GF/A glass fiber filter and a charcoal cartridge	Weekly	52	Gamma spectroscopy, gross ß,(${}^{238,239+240}$Pu, monthly composite)
	Low-volume sampling through silica gel	Biweekly	17	HTO (tritium oxide)
	Low-volume sampling	Weekly	10	^{85}Kr and ^{133}Xe
Potable Water	Grab sample	Weekly	8	Gamma spectroscopy, gross ß, ^{3}H, (${}^{238,239+240}$Pu, gross α quarterly), (^{90}Sr annually)
Potable Supply Wells	Grab sample	Monthly	10	Gamma spectroscopy, gross ß, ^{3}H, (^{226}Ra, ${}^{238,239+240}$Pu, ^{3}H enrichment, gross α, ^{90}Sr quarterly)
Non-Potable Supply Wells	Grab sample	Monthly	2	Gamma spectroscopy, gross ß, ^{3}H, (${}^{238,239+240}$Pu, gross α, quarterly), (^{90}Sr annually)
Open Reservoirs	Grab sample	Monthly	15	Gamma spectroscopy, gross ß, ^{3}H, (${}^{238,239+240}$Pu quarterly), (^{90}Sr annually)
Natural Springs	Grab sample	Monthly	7	Gamma spectroscopy, gross ß, ^{3}H, (${}^{238,239+240}$Pu quarterly), (^{90}Sr annually)

(a) Not all of these locations were sampled because of inaccessibility or lack of water

Table 4.1 (Summary of Onsite Environmental Surveillance Program - 1993, cont.)

Sample Type	Description	Collection Frequency	Number of Sampling Locations[(a)]	Type of Analysis
Containment Ponds	Grab sample	Monthly	9	Gamma spectroscopy, gross ß, ^{3}H, ($^{238,239+240}$Pu quarterly), (^{90}Sr annually)
Sewage Lagoons	Grab sample	Quarterly	8	Gamma spectroscopy, gross ß, ^{3}H, ($^{238,239+240}$Pu quarterly), (^{90}Sr annually)
External Gamma Radiation Levels	UD-814AS thermoluminescent dosimeters	Quarterly	193	Total quarterly exposure

(a) Not all of these locations were sampled because of inaccessibility or lack of water

responsibilities for DOE operations. These mandates required compliance with applicable federal, state, and local environmental protection regulations. Other orders applicable to environmental monitoring include DOE Order 5480.11, "Radiation Protection for Occupational Workers"; DOE Order 5480.1B, "Environment, Safety, and Health Program for Department of Energy 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.

4.1.1.2 EFFLUENT MONITORING

During 1993, the effluent monitoring efforts at the NTS focused only on tunnel discharge waters and the Area 6 Decontamination Facility. Due to the continuation of the moratorium on nuclear testing throughout the year, no effluent monitoring for nuclear tests was required.

LIQUID EFFLUENT MONITORING

Radiologically contaminated water was discharged from N, T, and E Tunnels in the Rainier Mesa (Area 12) range. A grab sample was collected monthly from each tunnel's effluent discharge point and from each tunnel's contaminated water holding ponds. These samples were analyzed for tritium (^{3}H), gross beta, and gamma emitters. In addition, quarterly samples were analyzed for ^{238}Pu and $^{239+240}$Pu, and an annual sample was analyzed for ^{90}Sr. Tritium was the radionuclide most consistently detected at the tunnel sites. Other radionuclides were detected infrequently.

The liquid effluents from the tunnel were measured by equipment installed by the DRI, University of Nevada. The results of these efforts were used to quantify the total annual radiological effluent release. The quarterly average concentration of the radionuclide of interest in the effluent liquid was multiplied by the total quantity of liquid discharged from the tunnel during the quarter based on the average flow rate for the quarter. This value was calculated for each tunnel and summed to obtain the total liquid radiological effluent discharged from the facility.

On November 8, 1992, all liquid waste discharges from the Decontamination Facility into the Yucca Waste Pond were stopped. At that time operations at the Decontamination Pad were terminated, and the liquid wastes from the laundry were discharged into holding tanks, monitored for radioactivity, and discharged into the sewage lagoon if the concentrations of radioactivity were below established guidelines. The radioactivity discharged from the laundry into the sewage lagoon was calculated by multiplying the radioactivity concentrations by the volume of water discharged from the tanks.

Typical lower limits of detection for water analyses were:

- Gross α: 2×10^{-9} μCi/mL (7.4×10^{-2} Bq/L)
- Gross β: 3×10^{-9} μCi/mL (0.11 Bq/L)
- Gamma Spectroscopy: 0.1 to 20×10^{-7} μCi/mL (0.3 - 74 Bq/L) (Using a ^{137}Cs standard)
- Tritium (conventional): 5×10^{-7} μCi/mL (11 Bq/L)
- Tritium (enrichment): 1×10^{-8} μCi/mL (0.74 Bq/L)
- ^{90}Sr: 1×10^{-9} μCi/mL (0.037 Bq/L)
- ^{226}Ra: 1×10^{-9} μCi/mL (0.074 Bq/L)
- ^{238}Pu: 1×10^{-10} μCi/mL (3.7×10^{-3} Bq/L)
- $^{239+240}$Pu: 5×10^{-11} μCi/mL (1.8×10^{-3} Bq/L)

AIRBORNE EFFLUENT MONITORING

As the moratorium on nuclear testing was continued throughout the year, airborne effluent monitoring was not required on Pahute Mesa. To validate that the existing methods of determining effluents from tunnel activities comply with the periodic confirmatory requirements of 40 CFR 61, "National Emission Standards for Hazardous Air Pollutants: Radionuclides" and the DOE Regulatory Guide DOE/EH-0173T, an isokinetic sampling system was operated to continuously sample from the P tunnel ventilation pipe through August 10, 1993.

4.1.1.3 ENVIRONMENTAL SURVEILLANCE

Environmental surveillance was conducted onsite throughout the NTS. Equipment at several fixed, continuously sampling stations was used to monitor for radioactive materials in the air. Surface water and groundwater samples were routinely collected at pre-established locations.

AIR MONITORING

The environmental surveillance program maintained samplers designed to detect airborne radioactive particles, radioactive gases (including radioiodines and noble gases), and radioactive hydrogen (^3H) as water vapor in the form $^3H^3HO$ or ^3HHO.

Air sampling units were located at 52 stations on the NTS (see Figure 4.1) to measure radioactive particulates and halogens. All placements were chosen primarily to provide monitoring of radioactivity at sites with high worker population density. Access, geographical coverage, and availability of commercial power were also considered in site selection.

An air sampling unit consisted of a positive displacement pump drawing approximately 140 L/min (5 cfm) of air through a nine-centimeter diameter Whatman GF/A glass fiber filter for trapping particulates. This was followed by a charcoal cartridge for collecting radioiodines. The filter and cartridge were mounted in a plastic, cone-shaped sample holder. A dry-gas meter measured the volume of air sampled during the sampling period (typically seven days). The unit collected approximately 1400 cubic meters of air during the sampling period.

The filters were held for no less than five nor more than seven days prior to analysis to allow naturally occurring radon and its daughter products to decay. Gross beta counting was performed with a gas-flow proportional counter for 20 minutes. The lower limit of detection for gross beta, assuming typical counting parameters, was 2×10^{-15} µCi/mL (7.4×10^{-5} Bq/m^3) using a ^{90}Sr calibration source. Gamma spectroscopy of the filter and cartridge was accomplished using germanium detectors with an input to a 2000-channel spectrometer, calibrated at 1 kiloelectronvolt (keV) per channel from 0.02 to 2 megaelectronvolts (MeV) using a National Institute of Standards and Technology traceable mixed radionuclide source. The lower limit of detection for gamma spectroscopy is 5×10^{-15} µCi/mL (1.8×10^{-4} Bq/m^3).

Weekly air samples for a given sampling station were composited on a monthly basis and radiochemically analyzed for ^{238}Pu and $^{239+240}$Pu. This procedure incorporated an acid dissolution and an ion-exchange recovery on a resin bed. Plutonium was deposited by plating on a stainless steel disk. The chemical yield of the plutonium was determined with an internal ^{242}Pu tracer. Alpha spectroscopy was performed utilizing a solid-state silicon surface barrier detector. The lower limit of detection for ^{238}Pu and $^{239+240}$Pu was approximately 1×10^{-17} µCi/mL (3.7×10^{-7} Bq/m^3).

The radioactive noble gases ^{85}Kr and ^{133}Xe were continuously sampled at ten permanent locations. The noble gas samplers maintained a steady sampling flow rate of approximately 80 L/min. These sampling units were housed in a metal tool box with three metal air bottles attached to the sampling units with short hoses. A vacuum was maintained on the first bottle by pumping the sample into the other two bottles. The two collection bottles were exchanged weekly and contained a sample volume of about 400 liters each at standard conditions.

The noble gases were separated from the atmospheric sample by cryogenic gas fractionation. Water and carbon dioxide were removed at room temperature, and the krypton and xenon were collected on charcoal at liquid nitrogen temperatures. These gases were transferred to a molecular sieve where they were separated from any remaining gases and from each other.

The krypton and xenon were transferred to separate scintillation vials and counted on a liquid scintillation counter. The lower limits of detection for ^{85}Kr and ^{133}Xe were 3 x 10^{-12} and 14 x 10^{-12} µCi/mL (0.1 and 0.5 Bq/m^3), respectively.

Airborne tritiated water vapor was monitored at 19 permanent locations throughout the NTS. A small electronic pump drew air continuously into the sampler at approximately 0.6 L/min. The tritiated water vapor was removed from the air stream by a silica-gel drying column followed by a drierite column. These columns were exchanged every two weeks. Appropriate aliquots of condensed moisture were obtained by heating the silica gel. The tritium activity was then obtained by liquid scintillation counting. The lower limit of detection for tritiated water vapor analysis was 3 x 10^{-13} µCi/mL (0.011 Bq/m^3) of air.

AMBIENT GAMMA MONITORING

Ambient gamma monitoring was conducted at 193 stations within the NTS (see Figure 4.2) through use of thermoluminescent dosimeters (TLDs). A TLD emits light when it is heated after having been exposed to radiation, hence the term "thermoluminescent." The total amount of light given off by the TLD crystal is proportional to the amount of energy absorbed from the radiation. Therefore, the intensity of light emitted from the TLD crystal is directly proportional to the radiation exposure.

The dosimeter used was the Panasonic UD-814AS environmental dosimeter. It consists of four elements housed in an air-tight, water-tight, ultraviolet-light-protected case. The first 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 1000 mg/cm^2 of plastic and lead to monitor penetrating gamma radiation only. TLDs were deployed for a calendar quarter in a holder placed about one meter above the ground. Locations were chosen at the site boundary, and where operations or ground contamination occurred.

WATER MONITORING

Water samples were collected at various frequencies from selected potable tap-water points, water supply wells, natural springs, open reservoirs, sewage lagoons, and containment ponds. The frequency of collection was determined on the basis of a preliminary radiological pathways analysis. Potable tap-water was collected weekly; supply wells, springs, reservoirs, and containment ponds were sampled monthly; and sewage lagoons were sampled quarterly. Samples were collected in one-liter glass containers. All samples were analyzed for gross beta, tritium, and gamma-emitting radionuclides. Plutonium analyses were performed on a quarterly basis. Samples of potable well and end-point water were also analyzed on a quarterly basis for gross alpha. End-point water was analyzed annually for ^{90}Sr, potable well water for ^{226}Ra and tritium by the enrichment method. For the quarterly and annual analyses of water samples, an additional one liter sample was collected for non-potable water and an additional two liters for potable water. Sampling locations are shown on Figures 4.2 and 4.4.

A 500-mL aliquot was taken from the water sample, placed in a Nalgene bottle, and counted for gamma activity with a germanium detector. A 5-mL aliquot was used for ^{3}H analysis by liquid scintillation counting. The remainder of the original sample 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 samples for 100 minutes in a gas-flow proportional counter.

Tritium enrichment analyses were performed by concentrating the volume and tritium content of a 250 mL sample aliquot to 10 mL by electrolysis and analyzing a 5 mL portion of the concentrate by liquid scintillation counting. The ^{226,228}Ra concentrations were determined from low-background gamma spectrometry analyses of radium sulfate. The samples were prepared by adding a barium carrier and ^{225}Ra tracer to 800 mL of sample, precipitating the barium and radium as a sulfate, separating the precipitate, and counting for 500 minutes.

The radiochemical procedure for plutonium was similar to that previously described in this chapter under "Air Monitoring." Alpha spectroscopy was used to measure any ^{238}Pu and $^{239+240}$Pu present in the sample and the ^{242}Pu tracer.

WASTE MANAGEMENT SITE MONITORING

Environmental surveillance on the NTS included the Radioactive Waste Management Project sites. These sites are used for the disposal of low-level radioactive waste (LLW) from the NTS and from other DOE facilities. Shallow disposal in trenches, pits, and augured shafts, was accomplished at the Area 5 Radioactive Waste Management Site (RWMS-5) and in subsidence craters at the Area 3 RWMS (RWMS-3).

The RWMS-5 contains the LLW disposal unit, the transuranic waste storage cell, and the Greater Confinement Disposal Unit. The RWMS-3 accepts large packages of LLW, most of which is contaminated soil. The packages are deposited in subsidence craters (craters which result from surface ground collapse after underground nuclear detonations, see Chapter 2, Figure 2.5).

Ambient monitoring included 17 permanent air particulate/halogen sampling stations, nine permanent tritiated water vapor sampling stations placed on and around the RWMS-5, and 26 TLD stations. The RWMS-3 is monitored by four air particulate/halogen sampling stations with several TLD stations located nearby.

RADIONUCLIDE MIGRATION AND UPTAKE STUDIES

A series of studies on the potential of subsurface radionuclide migration were continued on the NTS by the DRI, USGS, LANL, and LLNL (See Sections 9.4.2 and 9.4.3). These studies included:

- Field research on contamination enhancement of groundwater by water drainage through subsidence craters.
- Study of precipitation recharge effects on Pahute Mesa groundwater recharge.
- Geologic formation fluid pressure studies in Area 3 and Area 4.
- Experiments on the role of colloidal transport of radionuclides in groundwater.

4.1.1.4 SPECIAL ENVIRONMENTAL STUDIES

The Basic Environmental Compliance and Monitoring Program (BECAMP) was involved in special studies at the NTS that focused on the movement of radionuclides through the environment and the resultant dose to man. BECAMP uses the past accomplishments of two former DOE/NV-sponsored programs at the NTS, the Nevada Applied Ecology Group (NAEG) and the Radionuclide Inventory and Distribution Program (RIDP), in ongoing efforts to design effective programs to assess changes over time in the radiological conditions on the NTS, update human dose-assessment models, and provide information to DOE/NV for site restoration projects and compliance with environmental regulations.

The main objective of one group in BECAMP (Task 1 - Movement of Radionuclides On and Around the NTS) is to determine the rate of movement of surface-deposited radionuclides in four categories: (1) horizontal movement; (2) water-driven erosional transport; (3) vertical migration; (4) and wind-driven resuspension. Efforts in 1993 included: (1) documenting an investigation into the water-driven migration of plutonium in a wash that passes through an area of plutonium-contaminated soil (Shinn eta al 1993a); (2) completing a study of plutonium concentrations in soil profiles from five safety shots on the NTS (Shinn et al 1993b); and (3) finishing a study on the influence of soil variability on the precision of *in situ* detector measurements of radionuclide activity (Shinn et al 1993c).

A second task in the BECAMP program (Task 2 - Human Dose Assessment Models) is to update the NAEG/NTS dose-assessment model in order to assess the human dose from radionuclides found in soil on the NTS. The NAEG model is used to estimate the dose, via ingestion and inhalation, to man from $^{239+240}$Pu. The BECAMP dose-assessment model is an expanded version of the NAEG model that has been updated to include all significant radionuclides in the NTS environs and all exposure pathways. Efforts in 1993 included: (1) completing the documentation of the dose-assessment model (an analysis of uncertainties in predicted radionuclide body burdens and doses from discrete and continuous radionuclide source terms) (Kercher and Robison 1993); and (2) publishing the results of a workshop conducted on the apparent different bioavailability of the plutonium isotopes ^{238}Pu and ^{239}Pu (Kercher and Gallegos 1993).

Occasionally, DOE/NV management requests special investigations and projects. In 1993, a history of the DOE Test Range Complex with summaries of NAEG and correlative programs research results was released (Friesen 1992). Another document released in 1993 presents the results of an earlier preliminary investigation into the occurrence and distribution of beryllium in soils of the NTS (Patton 1992).

4.1.2 OFFSITE MONITORING

Under the terms of an Interagency Agreement between DOE and EPA, the EPA EMSL-LV conducts the Offsite Radiation Safety Program (ORSP) in the areas surrounding the NTS. Personnel from EMSL-LV provide support for each nuclear weapons test conducted at the NTS as one component of the program. Another component is public information and community assistance activities. The third and largest component of EMSL-LV's program is routine monitoring of potential human exposure pathways.

As a result of the continuing moratorium on nuclear weapons testing, only simulated tests were conducted in 1993. Four simulated nuclear weapons test readiness exercises and one non-proliferation experiment using conventional (non-nuclear) explosives were conducted at the NTS. For each one, EMSL-LV senior personnel served on the Test Controller's Scientific Advisory Panel and on the EPA offsite radiological safety staff. To add as much realism as possible to the exercises, actual meteorological conditions were used and data flow was managed in the same manner as in a real test. Routine off-site environmental radiation monitoring continued throughout 1993 as in past years.

Town hall meetings and public information presentations provide a forum for increasing public awareness of NTS activities, disseminating radiation monitoring results, and addressing concerns of residents related to environmental radiation and possible health effects. This community education outreach program is discussed in Section 4.1.2.9. Community Radiation Monitoring Program (CRMP) stations have been established in prominent locations in a number of offsite communities. The CRMP stations contain samplers for several of the monitoring networks and are managed by local residents. The University of Utah and DRI are cooperators with EPA in the CRMP. The CRMP is discussed in Section 4.1.2.8.

Environmental monitoring networks, described in the following subsections, measure radioactivity in air, atmospheric moisture, milk, local foodstuffs, and groundwater. These networks monitor the major potential pathways of radionuclide transfer to man via inhalation, submersion, and ingestion. Direct measurement of offsite resident exposure through the external and internal dosimetry programs provides confirmation of the exposures measured in the monitoring networks. Ambient gamma radiation levels are continuously monitored at selected locations using Reuter-Stokes pressurized ion chambers (PICs) and Panasonic TLDs. Atmospheric monitoring equipment includes air samplers, noble gas samplers, and atmospheric moisture (tritium-in-air) samplers. Milk, game and domestic animals, and foodstuffs (fruits and vegetables) are routinely sampled and analyzed. Groundwater on and in the vicinity of the NTS is monitored in the Long-Term Hydrological Monitoring Program (LTHMP). Data from these monitoring networks are used to calculate an annual exposure dose to the offsite residents, as described in Chapter 6.

4.1.2.1 AIR MONITORING

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 NTS and non-NTS activities. Data from atmospheric monitoring can determine the concentration and source of airborne radioactivity and can project the fallout patterns and durations of exposure to man. Atmospheric monitoring networks include the Air Surveillance, Noble Gas, and Atmospheric Moisture (Tritium-in-Air) networks.

The Air Surveillance Network (ASN) is designed to monitor the areas within 350 km (220 mi) of the NTS, with some concentration of stations in the prevailing downwind direction. Station location is dependent upon the availability of electrical power and, at stations distant from the NTS, on a resident willing to operate the equipment. This continuously operating network is supplemented by a standby network encompassing the contiguous states west of the Mississippi River. Standby samplers are identical to those used at the active stations and are operated by state and municipal health department personnel or by other local residents.

During 1993 the ASN consisted of 30 continuously operating sampling stations (see Figure 4.5 for these locations) and 77 standby stations (Figure 4.6) that were scheduled to be activated one week per quarter.

Twenty-four standby stations were activated over a three week period during April 1993 immediately following the Russian TOMSK-7 incident. Only eleven standby stations were activated during the fourth quarter of 1993. The remaining sixty-six stations of the standby network were not activated during the fourth quarter due to budget restrictions.

The low-volume air sampler at each station is equipped to collect particulate radionuclides on fiber filters and gaseous radioiodines in charcoal cartridges. The filters and charcoal

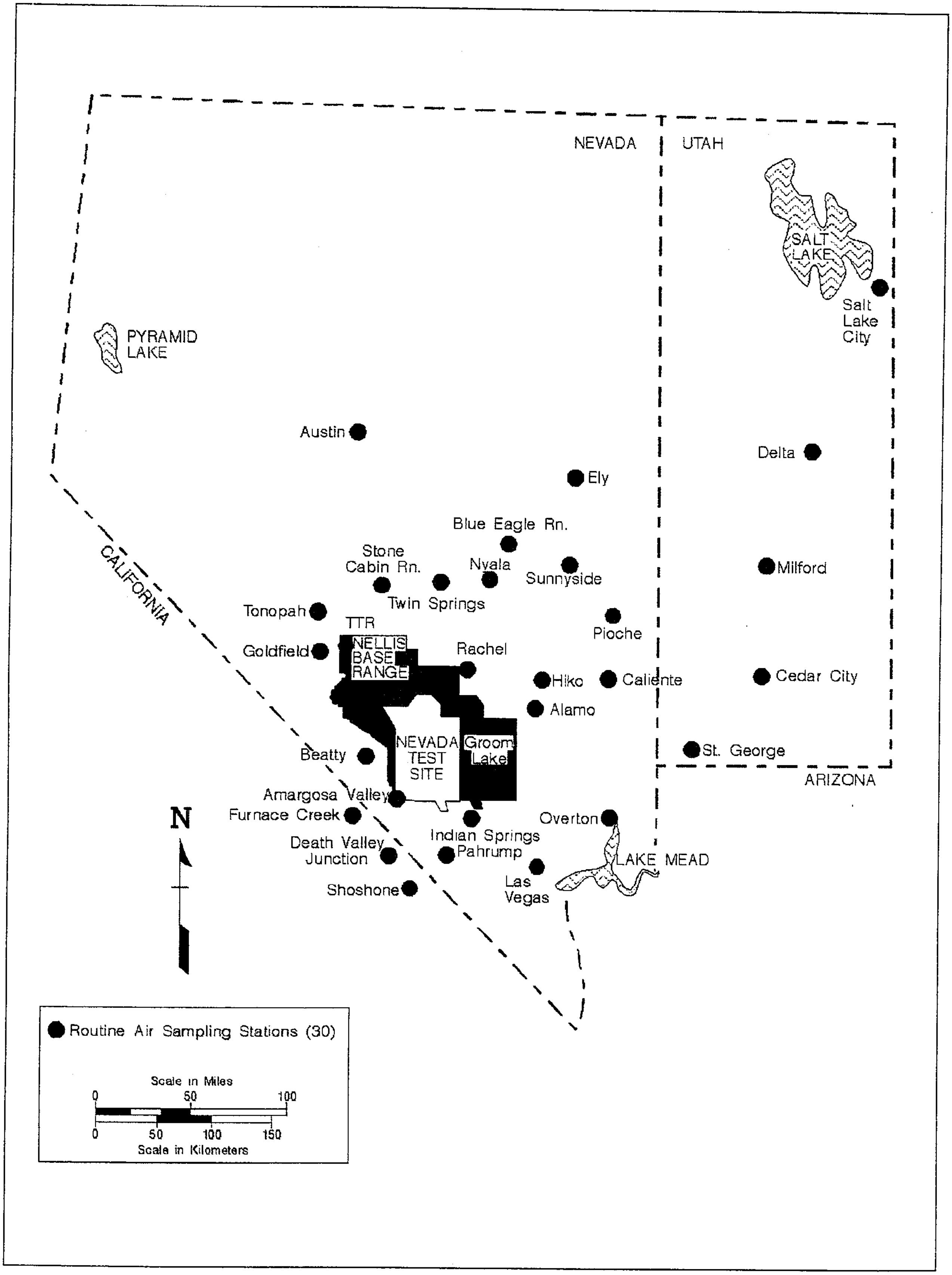


Figure 4.5 Air Surveillance Network Stations - 1993

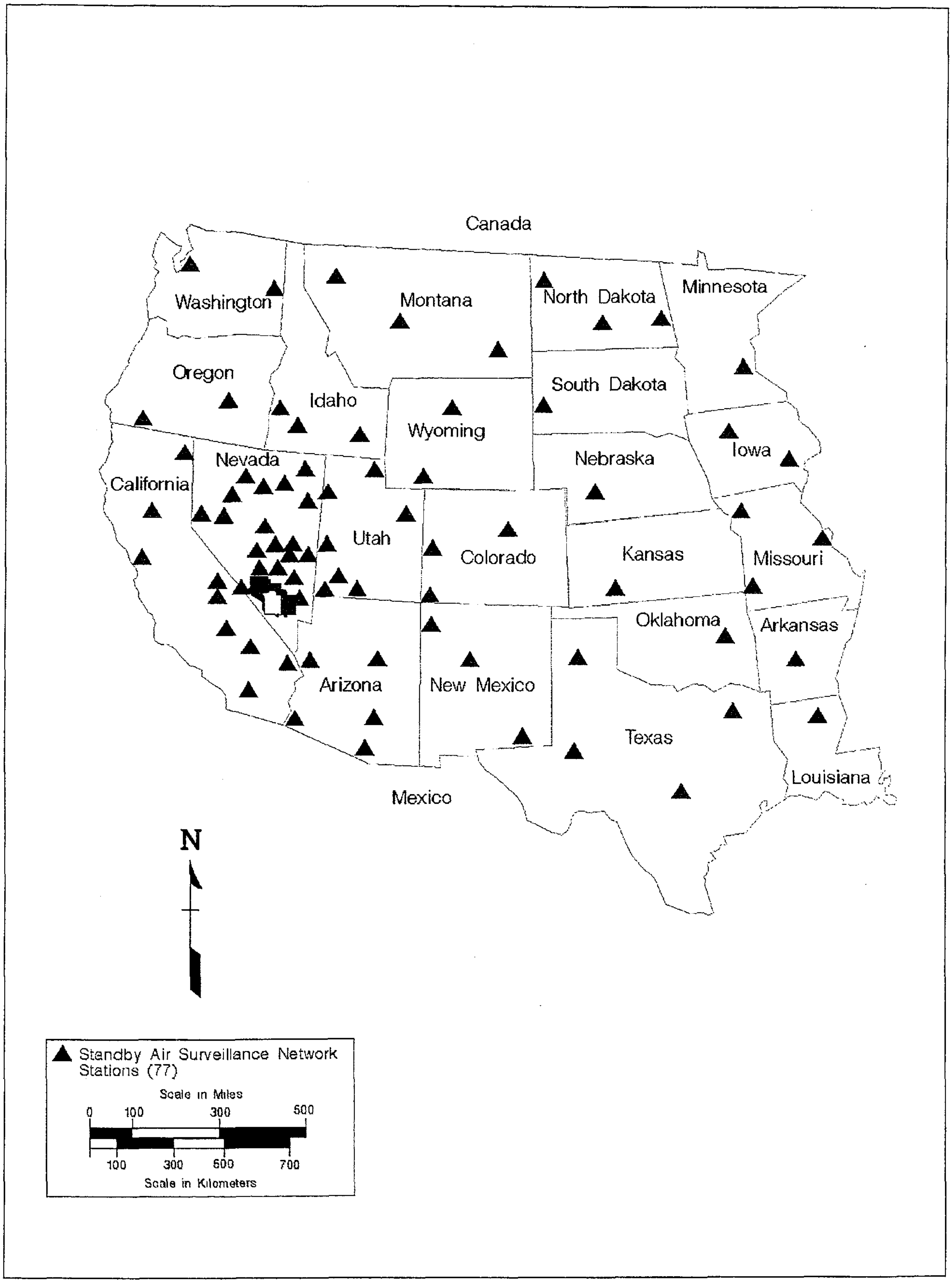


Figure 4.6 Standby Air Surveillance Network Stations - 1993

cartridges from all active stations and the filters from standby stations receive complete analyses at the EMSL-LV Radioanalysis Laboratory. The charcoal cartridges from standby stations are analyzed only if there is some reason to expect the presence of radioiodine. Duplicate air samples are collected from three routine ASN stations each week. The duplicate samplers operate at randomly selected stations continuously for three months and are then moved to a new location.

Samples of airborne particulates are collected at each active station on 5-cm (2.0-in.) diameter glass-fiber filters at a flow rate of about 80 m^3 (2800 ft^3) per day. Filters are changed after sampler operation periods of one week (approximately 560 m^3 or 20,000 ft^3). Activated charcoal cartridges placed directly behind the filters to collect gaseous radioiodine are changed at the same time as the filters.

At EMSL-LV, both the glass-fiber filters and the charcoal cartridges are initially analyzed by high-resolution gamma spectrometry. Each of the glass-fiber filters is then analyzed for gross alpha and gross beta activity. These gross analyses are performed on the glass-fiber filters 7 to 14 days after sample collection to allow time for the decay of naturally occurring radon-thoron progeny. Selected glass-fiber filters are then composited and analyzed for plutonium isotopes.

A second part of the EMSL-LV offsite air network is the Noble Gas and Tritium Surveillance Network (NGTSN). Noble gases may be released into the atmosphere from research and power reactor facilities, fuel reprocessing facilities, and from nuclear testing. Noble gases may also be released during drillbacks and tunnel purgings after a nuclear test.

The xenons, because of their short half-lives, decay before dispersing widely and so environmental levels are normally below the minimum detectable concentration (MDC). Krypton-85 is dispersed more or less uniformly over the entire globe because of its long half-life, 10.7 years, and the lack of significant sinks (NCRP 1975). Considering the amount released, ^{85}Kr results are expected to be detectable. Tritium is created by natural interactions in the upper atmosphere and is also emitted from nuclear reactors, reprocessing facilities (non-NTS facilities), and from nuclear testing.

The locations of the NGTSN stations are shown in Figure 4.7. The NGTSN is designed to detect any increase in offsite levels of xenon, krypton, or atmospheric tritium due to possible NTS emissions. Routinely operated network samplers are typically located in populated areas surrounding the NTS and standby samplers are located in communities at some distance from the NTS. In 1993, this network consisted of 13 routine noble gas and tritium-in-air samplers, plus eight on standby, located in the states of Nevada, Utah, and California. The stations on routine sampling status ring the NTS to detect any emissions of noble gases or atmospheric tritium which reach the population centers in the immediate offsite area. In addition, a tritium sampler is routinely operated near a nuclear research reactor in Salt Lake City, Utah.

Noble gas samples are collected by compressing air into storage tanks. The equipment continuously samples air over a seven-day period and stores approximately 0.6 m^3 (21 ft^3) of air in the tanks. The noble gas samplers consist of a four-bottle system. One bottle is filled over the entire sampling period. The other three bottles are filled consecutively over the same sampling period in 56-hour increments. Only the bottle containing samples from the entire sampling period is routinely analyzed. If xenons or levels of ^{85}Kr greater than normal background were detected in this sample, then the other three samples would be analyzed. The tanks are exchanged weekly and returned to the EMSL-LV Radioanalysis Laboratory for analysis. For the analysis, samples are condensed at liquid nitrogen temperature. Gas chromatography is then used to separate the various radionuclides. The radioactive gases are dissolved in liquid scintillation "cocktails," then counted in a liquid scintillation counter to determine activity.

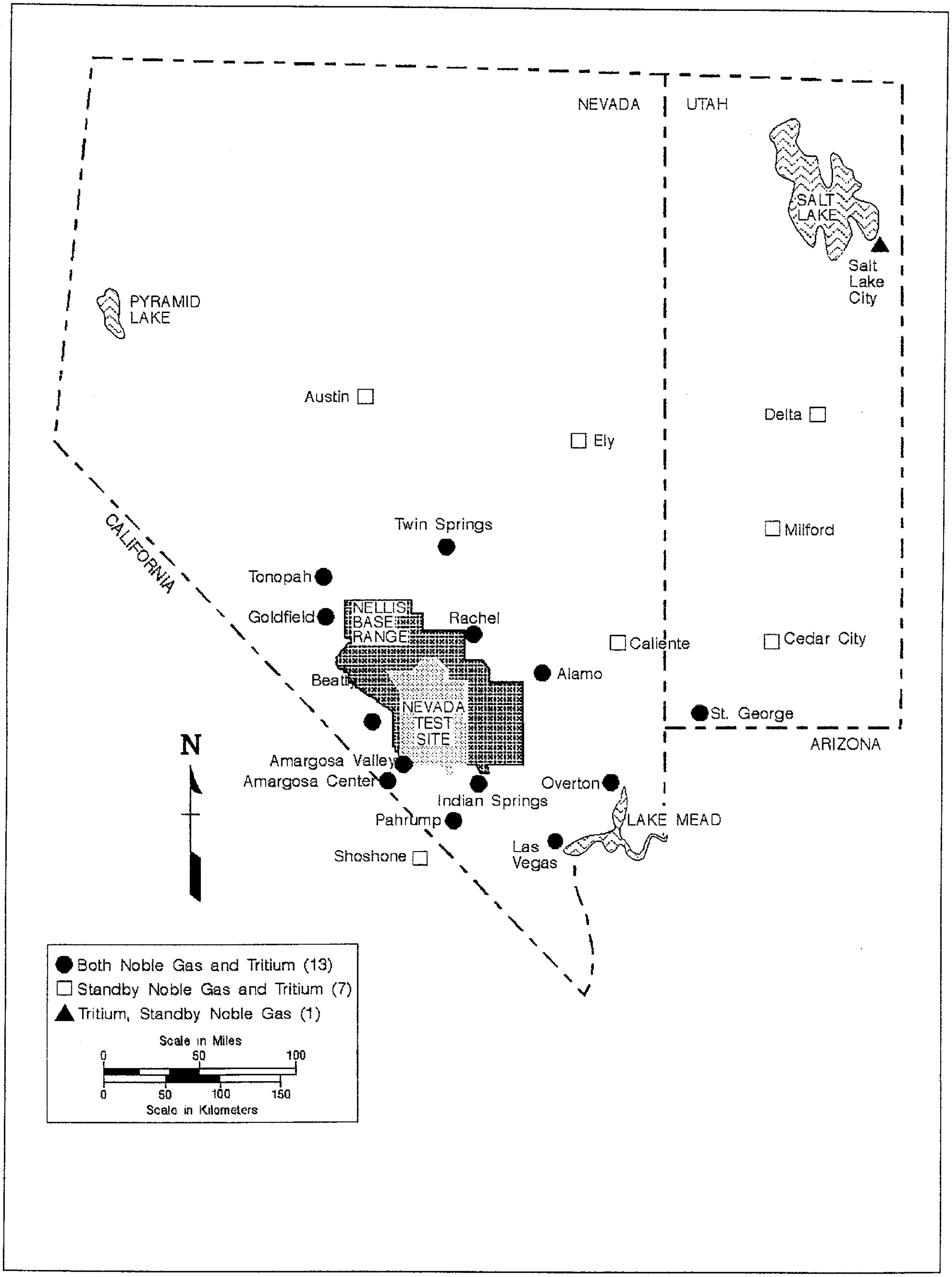


Figure 4.7 Offsite Noble Gas and Tritium Surveillance Network Stations - 1993

In tritium-in-air sample collection, a column filled with molecular sieve pellets is used to collect moisture from the air. Approximately 6 m^3 (212 ft^3) of air is drawn through the column during a typical 7-day sampling period. The water absorbed in the pellets is recovered and measured and the concentration of ^3H is determined by liquid scintillation counting. The volume of recovered water and the ^3H concentration is then used to calculate the concentration of HTO, which is the form of tritium most commonly encountered in the environment.

4.1.2.2 WATER MONITORING

As part of the LTHMP, EPA EMSL-LV scientists routinely collect and analyze water samples from locations on the NTS and from sites in the surrounding offsite areas. 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 of the drinking water supplies used by the offsite population are represented in the LTHMP samples. Results for the LTHMP samples are discussed in Chapter 9, Sections 9.5 and 9.6.

4.1.2.3 MILK SURVEILLANCE NETWORK

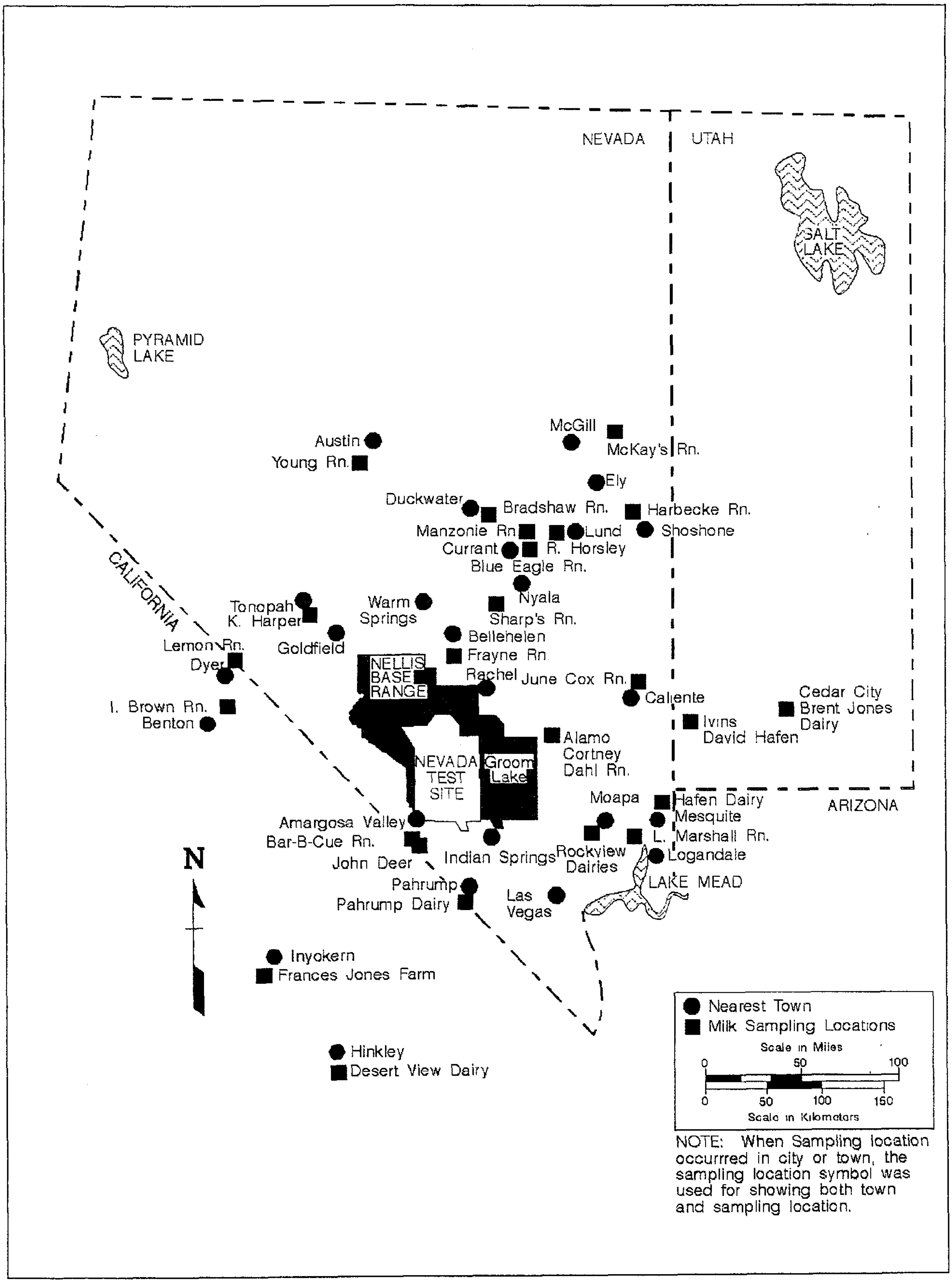
Milk is particularly important in assessing levels of radioactivity in a given area. It is one of the most universally consumed foodstuffs and certain radionuclides are readily traceable through the food chain from feed or forage to the consumer. This is particularly true of radioiodine isotopes, which, when consumed by children in sufficient quantities, can cause significant impairment of thyroid function. Because dairy animals consume vegetation representing a large area of ground cover and because many radionuclides are transferred to milk, analysis of milk samples may yield information on the deposition of small amounts of radionuclides over a relatively large area. Accordingly, milk is closely monitored by EPA EMSL-LV through the Milk Surveillance Network (MSN) and the Standby Milk Surveillance Network (SMSN). The third component of this monitoring network is a dairy animal and population census.

The MSN includes commercial dairies and family-owned milk cows and goats representing the major milksheds within 300 km (186 mi) of the NTS. The 24 locations comprising the MSN at the beginning of 1993 are shown in Figure 4.8. Samples were collected from 21 of these locations in 1993. Changes to the network in 1993 are summarized in Table 4.2.

The SMSN consists of dairies or processing plants representing all major milksheds west of the Mississippi River. The network is activated annually by contacting cooperating Food and Drug Administration (FDA) Regional Milk Specialists, who in turn contact State Dairy Regulators to enlist cooperating milk processors or producers. This annual activation permits trends to be monitored and ensures proper operation of the SMSN, should an emergency arise. The 115 locations comprising the SMSN in 1993 appear in Figure 4.9. Of these, 110 locations were sampled in 1993.

Raw milk is collected in 3.8-L (1-gal) Cubitainers and preserved with formaldehyde. Samples from the SMSN are mailed to the EMSL-LV Radioanalysis Laboratory.

All milk samples are analyzed by high-resolution gamma spectrometry to detect gamma-emitting radionuclides. One sample per quarter from each MSN location and samples from



NOTE: When Sampling location occurrred in city or town, the sampling location symbol was used for showing both town and sampling location.

Figure 4.8 Milk Surveillance Network Stations - 1993

Table 4.2 Milk Surveillance Network Sampling Location Changes - 1993

Location	Change	Effective Date	Reason for Change
Irene Brown Ranch, Benton, California	Deleted	04/15/93	Sold goats
Blue Eagle Ranch, Currant, Nevada	Deleted	10/03/93	Sold cow
Harbecke Ranch, Shoshone, Nevada	Deleted	07/06/93	Owner no longer wishes to participate
Frances Jones Farm Inyokern, California	Added	03/18/93	Added to network
Frayne Ranch Bellehelen, Nevada	Deleted	04/08/93	Moved No samples in 1993
Manzonie Ranch Currant, Nevada	Deleted	12/07/93	No samples in 1993

two locations in each state in the SMSN are analyzed for ^{3}H by liquid scintillation counting and for ^{89}Sr and ^{90}Sr by radiochemical separation and beta counting.

The dairy animal and population census is continually updated for those areas within 385 km (240 mi) north and east of CP-1 and within 200 km (125 mi) south and west of it. The remainder of the Nevada counties and the western-most Utah counties are surveyed approximately every other year. The locations of processing plants and commercial dairy herds in Idaho and the remainder of Utah can be obtained from the milk and food sections of the respective state governments.

4.1.2.4 BIOMONITORING

Ingestion is one of the critical transport pathways for radionuclides to humans. Food crops may absorb radionuclides from the soil in which they are grown. Radionuclides may be found on the surface of fruits and vegetables from atmospheric deposition, resuspension, or in particles of soil adhering to vegetable surfaces. Weather patterns, especially precipitation, can affect soil inventories of radionuclides. Grazing animals ingest radionuclides which may have been deposited on forage grasses and, while grazing, ingest soil which may contain radionuclides. Radionuclides may accumulate in certain organs in the grazing animal, such as liver and muscle, and human uptake may occur by consumption of meat or meat products.

The biomonitoring network includes the animal investigation program and monitoring of radionuclides in locally grown fruits and vegetables. The objective of the animal investigation program is to determine whether there is any potential for radionuclides to reach humans through the ingestion pathway. The program is based upon what is considered to be a worst-case scenario. Mule deer are migratory; the ranges of the herds which inhabit the NTS include lands, outside the federal exclusionary area, in which hunting is permitted.

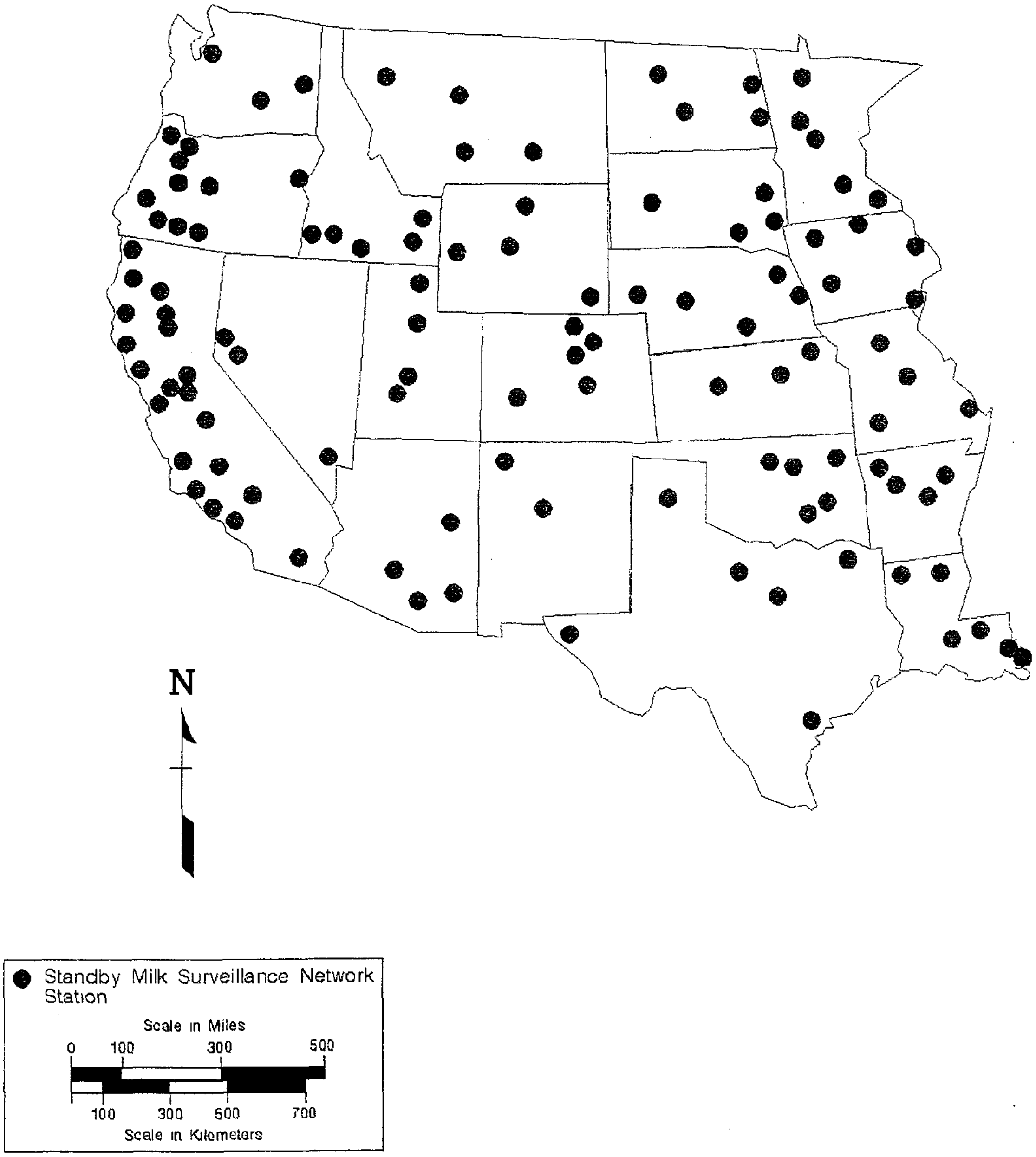


Figure 4.9 Standby Milk Surveillance Network Stations - 1993

Therefore, it is theoretically possible for a resident to consume meat from a deer which had become contaminated with radionuclides during its migration through the NTS. During the years of atmospheric testing, fission products were carried outside the boundaries of the NTS and deposited in the offsite area. Longer-lived radionuclides, particularly plutonium and strontium isotopes, are still detected in soil. Some of these radionuclides may be ingested by animals residing in those areas. Cattle are purchased from ranches where atmospheric tests are known to have deposited radionuclides. The continued monitoring of bighorn sheep provides a long-term history for examination of radioactivity trends in large grazing animals. The biomonitoring network also includes special studies, such as collection and analysis of forage and grains. No such special studies were conducted in 1993. The locations where animals were collected in 1993 are shown in Figure 4.10.

During the bighorn sheep season in November and December, licensed hunters in Nevada are asked to donate one leg bone and one kidney from each bighorn sheep taken. The location where the sheep was taken and any other available information are recorded on the field data form. The bone and kidney samples are weighed, sealed in labeled sample bags, and stored in a controlled freezer until processing. Weights are recorded on the field data form. After completion of the hunting season, a subset of the samples is selected to represent areas around the NTS. Kidney samples are delivered to the EPA EMSL-LV Radioanalysis Laboratory for analysis of gamma-emitting radionuclides and tritium. All bone samples are shipped in a single batch to a contract laboratory for ashing and analysis for plutonium isotopes and strontium. All results are reported in units of pCi/g of ash. The ash weight to wet weight ratios (percent ash) are also reported, to permit conversion of radionuclide activity to a wet weight basis for use in dose calculations.

Each year, attempts are made to collect four mule deer from the NTS, on a one per quarter schedule. Only three deer were collected from NTS in 1993 (see Figure 4.11). Several attempts were made to collect a deer during the fourth quarter, but were unsuccessful. In addition one deer was collected in Nye County in the Cherry Creek area to be used as a comparison as shown in Figure 4.10. A deer is hunted by personnel with a special permit to carry weapons on the NTS. The deer is usually dressed in the field, with precautions taken to minimize risk of contamination. The location of the deer, weight, sex, condition, and other information are recorded on a field data form. Organs are removed and sealed in labeled sample bags. Later, at the NTS Farm Facility, samples are placed in 350-mL sealed aluminum cans for gamma counting. Soft tissue organs, including lung, liver, muscle, and rumen contents are divided into two samples, one for analysis of gamma-emitting radionuclides and one for ashing prior to analysis for plutonium isotopes. Thyroid and fetus (when available), because of their small size, are analyzed only for gamma-emitting radionuclides. Samples of blood are analyzed for gamma-emitting radionuclides and tritium. Bone samples are shipped in a single batch each quarter to a contract laboratory for ashing and analyses for plutonium isotopes and strontium. All other analyses are completed in the EPA EMSL-LV Radioanalysis Laboratory.

Occasionally, additional animals are collected as part of special studies. In 1993, the DOE and the state of Nevada requested the collection of quail and chukar on the NTS. Three chukar were collected from the T Tunnel area, two chukar from Tub Spring, three chukar from Tippipah Spring, one chukar from Topopah Spring and one quail from White Rock Spring. This collection will be used to establish a baseline of possible radioactive contaminant levels in these game birds. In the future, chukar may be captured by the state of Nevada and relocated to other areas of the state to establish new breeding colonies. The locations of collection in 1993 are shown in Figure 4.11.

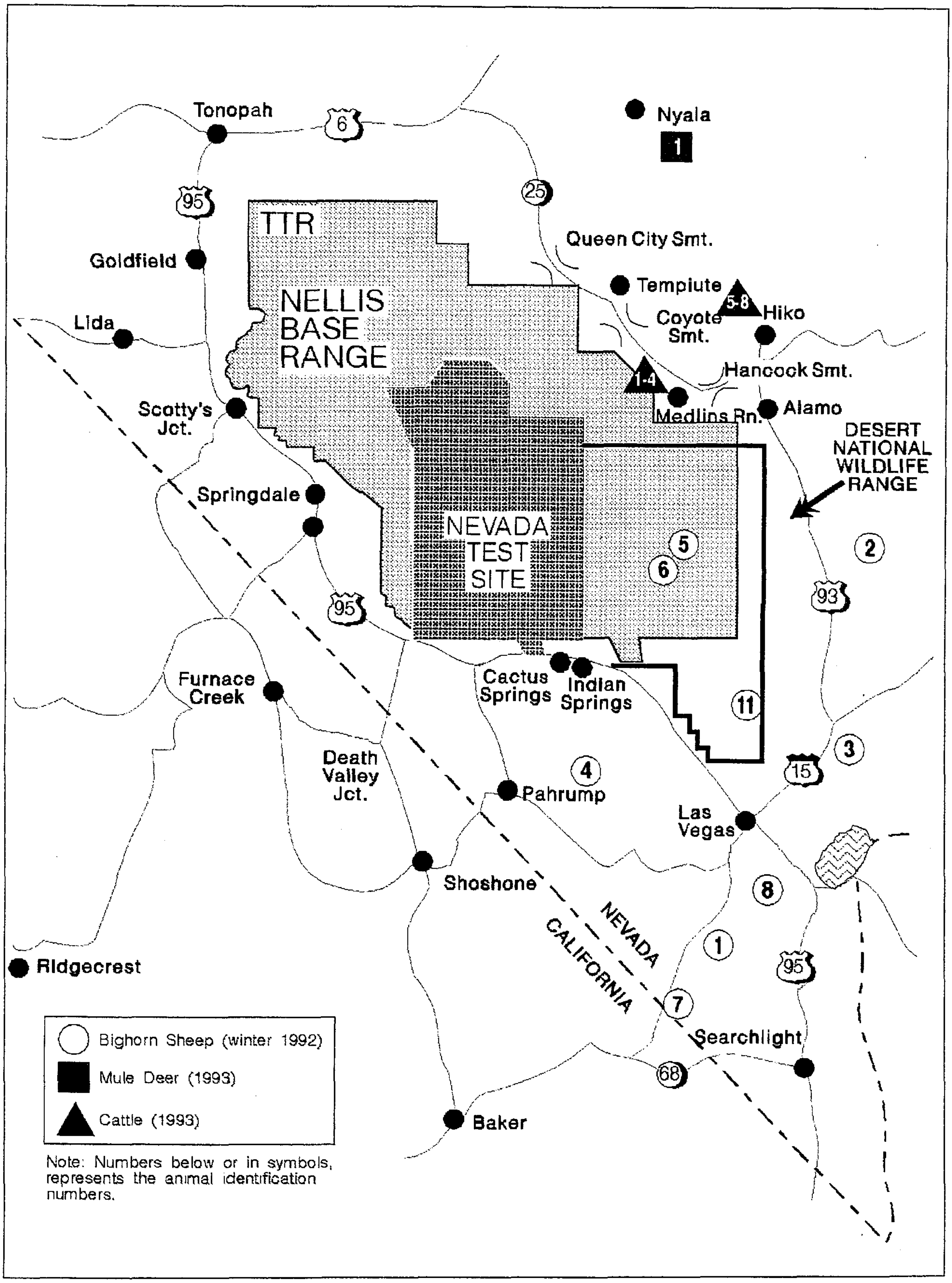


Figure 4.10 Offsite Collection Sites for Animals Sampled - 1993

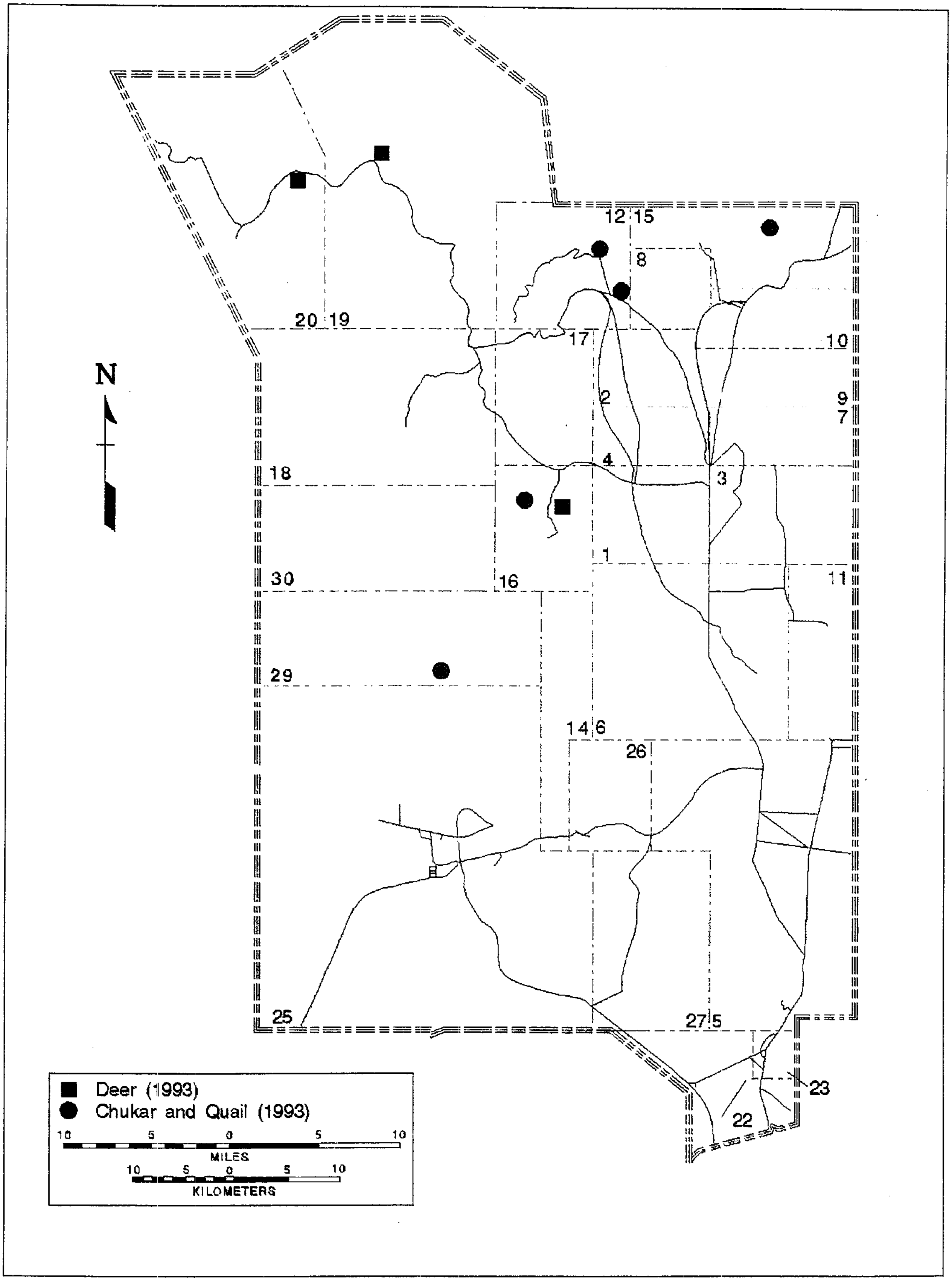


Figure 4.11 Onsite Collection Sites for Deer, Chukar and Quail Sampled - 1993

Four cattle are purchased each spring and fall from ranches in the offsite area around the NTS. In 1993, four cattle were purchased in the spring from the Medlin Ranch in Tikaboo Valley, Nevada and another four were purchased in the fall from the Nash Ranch at Hiko, Nevada. Generally, two adult cattle and two calves are acquired in each purchase. The NTS Farm Facility is used for the slaughter. This facility is designed to minimize risk of contamination. As with the bighorn sheep and mule deer, sampling information and sample weights are recorded on a field data form and samples are sealed in labeled sample bags. Samples of blood and soft tissues (lung, muscle, liver, thyroid, and kidney) are analyzed for gamma-emitting radionuclides; blood is also analyzed for tritium activity. A second liver sample and bone samples are sent to a contract laboratory for ashing. Ashed samples are analyzed for plutonium isotopes; bone ash samples are also analyzed for strontium. A sample of the water used in processing the samples is also collected and analyzed.

In addition to animals, samples of locally grown fruits and vegetables were obtained in the fall of 1993 by donation from residents of farms in Rachel, Nevada, (kohlrabi and broccoli), Complex I, Nevada, (carrots and red leaf lettuce), Twin Springs Ranch, Nevada, (turnips, carrots, and squash), Hiko, Nevada, (potatoes, apples, and squash), Alamo, Nevada, (carrots, onions and squash), Adaven, Nevada, (pears), and St. George, Utah, (cabbage and potatoes).

The samples are analyzed by gamma spectrometry, then ashed and analyzed by radiochemistry for ^{90}Sr, ^{238}Pu, and $^{239+240}$Pu.

4.1.2.5 THERMOLUMINESCENT DOSIMETRY NETWORK

The primary function of the EPA EMSL-LV environmental dosimetry program is to detect any increase in radiation levels in areas surrounding the NTS. This is accomplished by developing baseline information regarding ambient radiation levels from all radiation sources and looking for deviations from established trends. In addition to the environmental TLD program, EPA deploys personnel TLDs to individual volunteers living in areas surrounding the NTS. Information gathered from this program would help define possible exposures to residents in the event there were a release from the NTS. Basic philosophies for program development for the personnel TLD program are essentially similar to the environmental TLD program.

The current EPA TLD program utilizes the Panasonic Model UD-802 TLD for personnel monitoring and the UD-814 TLD for environmental monitoring. Each dosimeter is read by using the Panasonic Model UD-710A automatic dosimeter reader.

The UD-802 TLD incorporates two elements of $Li_2B_4O_7$:Cu and two elements of $CaSO_4$:Tm phosphors. With the use of different filtrations, a dose algorithm can be applied to look at ratios of the different elements. The resultant is the radiation type and energy which provides a mechanism for establishing a dose equivalent.

Environmental monitoring is accomplished using the UD-814 TLD which is made up of one element of $Li_2B_4O_7$:Cu and three elements of $CaSO_4$:Tm. An average of the corrected values for the three similar elements gives the total exposure for that TLD. Two UD-814 TLDs are deployed at each station per monitoring period.

In general terms, electrons in the TLD elements are moved to a higher energy state when exposed to ionizing radiation. After the exposure period, each TLD element is heated to induce the electrons to lose this additional energy by dropping from the higher energy state to the ground state. This energy loss is emitted in the form of light photons. These photons are then collected in a photomultiplier tube whose current output is proportional to the number of photons and thus to the initial deposited energy.

During 1993 a total of 127 offsite stations were monitored using TLDs. Figure 4.12 shows current fixed environmental monitoring locations. Total annual exposures were calculated by dividing each quarterly result by the number of days representing each deployment period. The quarterly daily rates were averaged to obtain an annual daily average. If a deployment period overlapped the beginning or end of the year a daily rate was calculated for that deployment period and multiplied by the number of days that fell within 1993. The total average daily rate is then multiplied by 365.25 to determine the total annual exposure for each station.

During 1993 a total of 69 offsite personnel were issued TLDs to monitor their annual dose equivalent. Locations of personnel monitoring participants are shown in Figure 4.13. Detailed results are displayed in Table D.9, Appendix D.

Total annual whole body dose equivalent was calculated by summing all available data for the year. All data were used that fell within the 1993 calendar year. If data gaps occurred all available data were summed and a daily rate was computed by dividing the sum by the number of days with available data. The daily rate was than multiplied by 365.25 days.

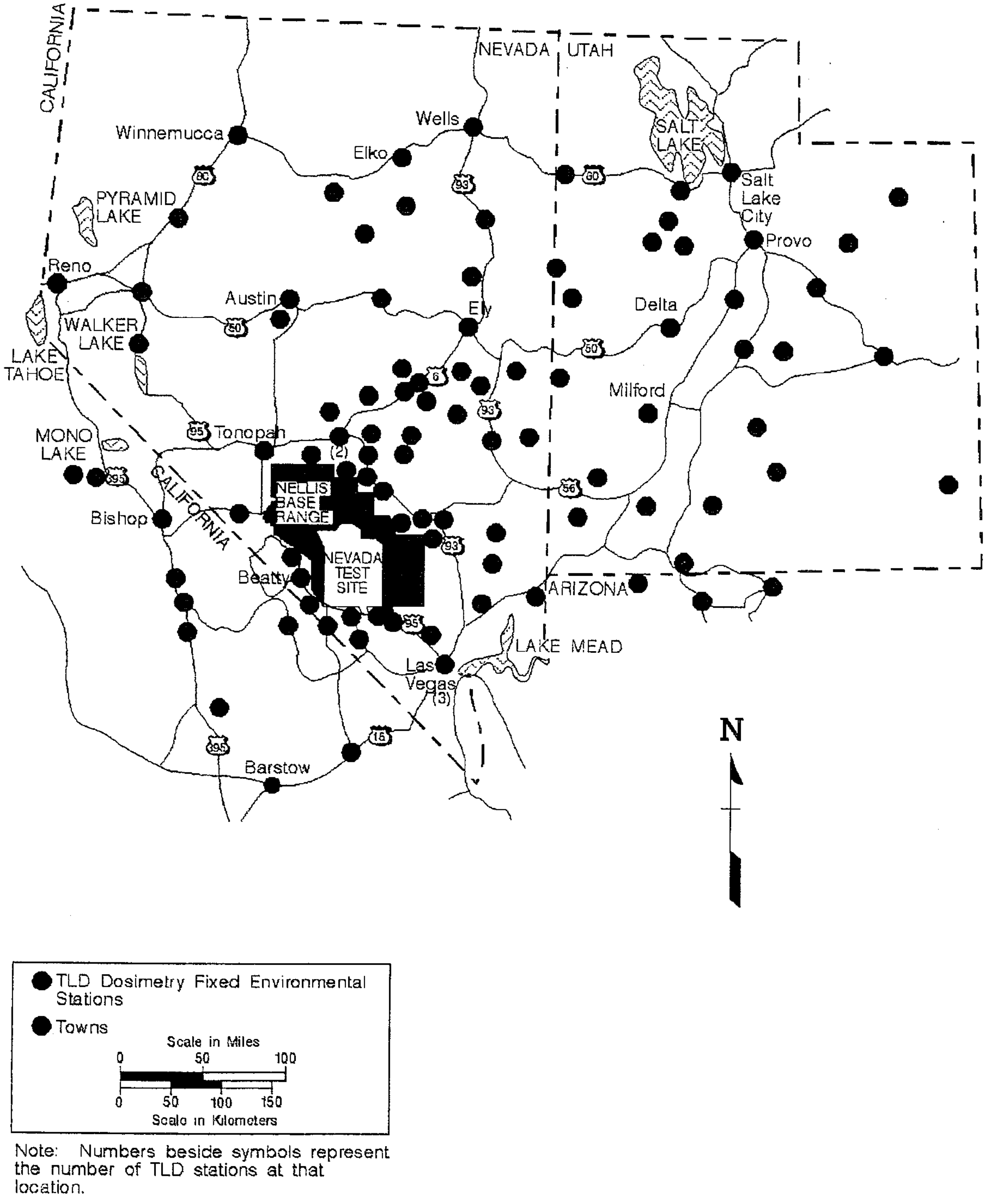
Transit control dosimeters accompany station TLDs during transit to the deployment location and during their return to the processing laboratory. Between 1988 and 1991 transit control TLDs were inappropriately subtracted from the station TLDs, thus reducing the deployment exposure. Operational techniques have since changed for defining these transit exposures to provide more correct data for measurements since 1992. A summary of current and past annual exposure data is provided in Figure 4.14.

4.1.2.6 PRESSURIZED ION CHAMBER (PIC) NETWORK

The PIC network continuously measures ambient 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 rates vary with altitude (cosmic radiation) and with radioactivity in the soil (terrestrial radiation). Ambient gamma radiation also varies slightly within a location due to weather patterns.

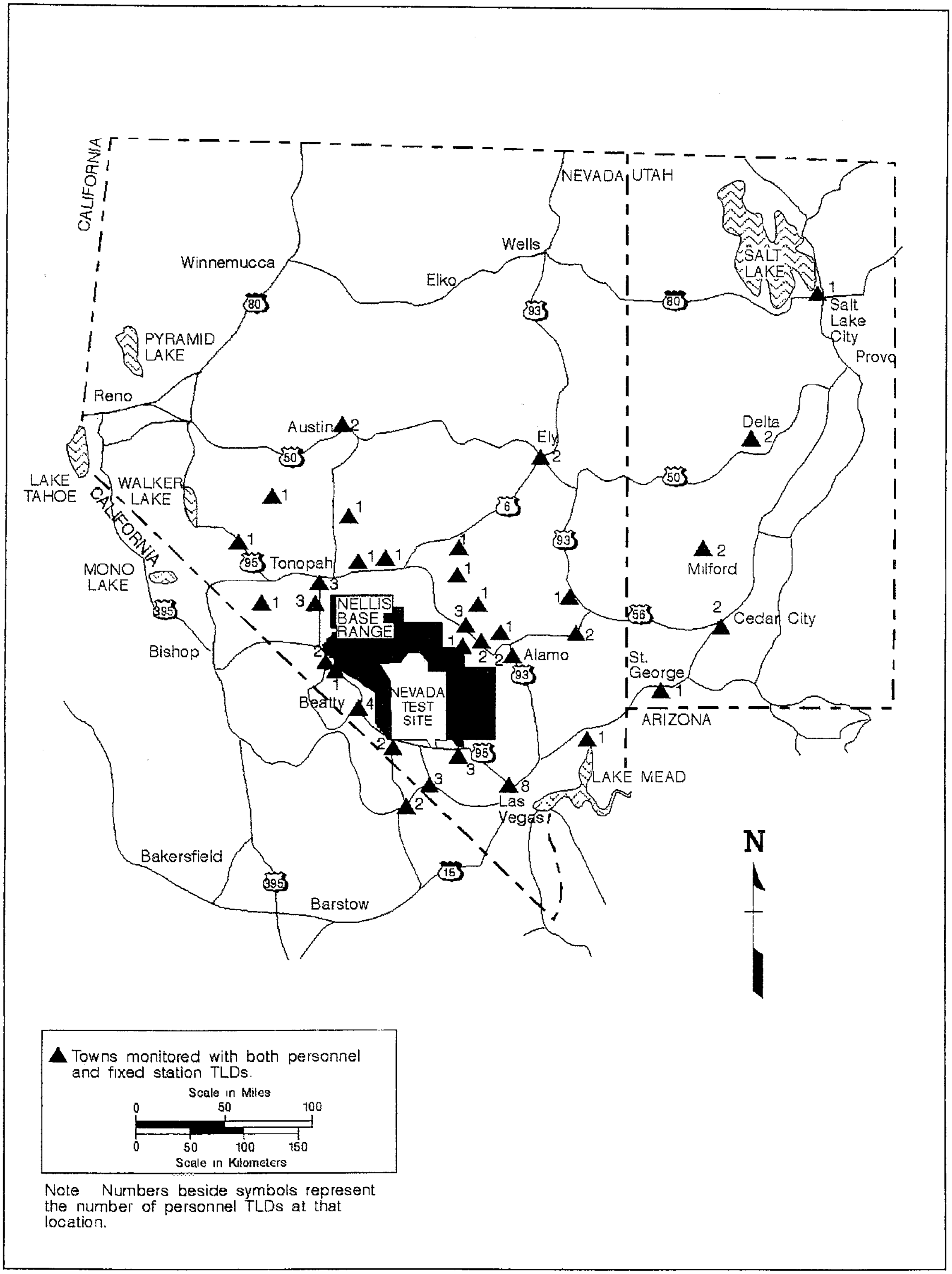
There are 27 PICs stationed in communities around the NTS which provide near real-time estimates of gamma exposure rates. In addition, stations located at Terrell's Ranch and Amargosa Valley Community Center which are part of the Yucca Mountain Project would, in the event of a release of radioactivity, be used to track emissions. The locations of the PICs are shown in Figure 4.15. Eighteen of the PICs are located at CRMP stations which are discussed in Section 4.1.2.8.

The PIC network uses Reuter-Stokes models 1011, 1012, and 1013 PICs. The PIC is a spherical shell filled with argon gas to a pressure 25 times that of the atmosphere. In the center of the chamber is a spherical electrode with a charge opposite to the outer shell. When gamma radiation penetrates the sphere, ionization of the gas occurs and the ions are collected by the center electrode. The electrical current generated is measured, and the intensity of the radiation field is determined from the magnitude of this current.



Note: Numbers beside symbols represent the number of TLD stations at that location.

Figure 4.12 Thermoluminescent Dosimetry Fixed Environmental Stations - 1993



Note Numbers beside symbols represent the number of personnel TLDs at that location.

Figure 4.13 Thermoluminescent Dosimetry Personnel Monitoring Participants - 1993

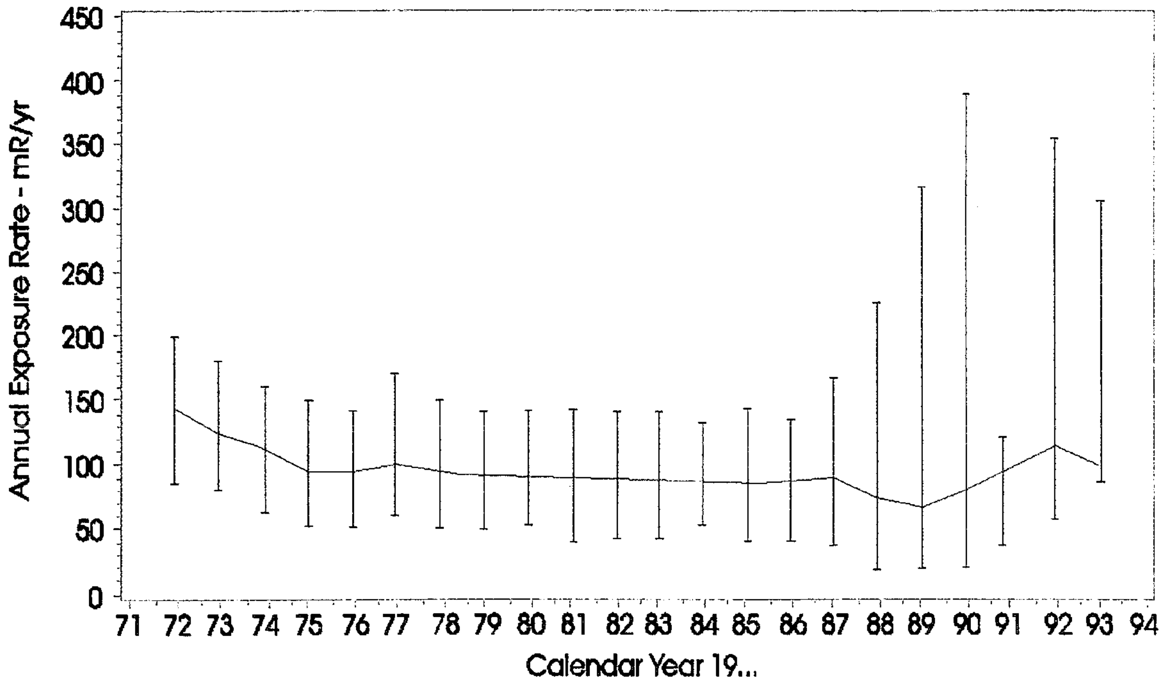


Figure 4.14 Summary of Annual TLD Data - 1993

Data are retrieved from the PICs shortly after measurements are made. The near real-time telemetry-based data retrieval is achieved by the connection of each PIC to a data collection platform which collects and transmits the data. Gamma exposure measurements are transmitted via the Geostationary Operational Environmental Satellite directly to a receiver earth station at the NTS and from there to EPA EMSL-LV by dedicated telephone line. Each station routinely transmits data every four hours unless the gamma exposure rate exceeds the currently established alarm threshold. When the threshold is exceeded for two consecutive 1-minute periods, the system goes into the alarm mode and transmits a string of nine consecutive 1-minute values every 2 to 15 minutes. Additionally, the location and status (i.e., routine or alarm mode) of each station are shown on a map display in the Control Point-One (CP-1) control room at the NTS and at EMSL-LV. Thus, immediate documentation of radioactive cloud passage can be obtained from the PIC network in the event of an accidental release from the NTS. The threshold limits are established at approximately two times background for each station location. These threshold values range from 16 µR/h for Pahrump, Nevada to 35 µR/h for Milford, Utah and Stone Cabin Ranch, Nevada. A significant improvement was made to the network during 1993. In previous years and in the first half of 1993, 4-hour average, 1-minute minimum, and 1-minute maximum values were the only values transmitted every four hours. During 1993, the software at the stations was upgraded to allow a string of 48 five-minute averages to be transmitted every four hours.

In addition to telemetry retrieval, PIC data are also recorded on both magnetic tapes and hardcopy strip charts at 24 of the 27 EPA stations and on magnetic cards for the other three

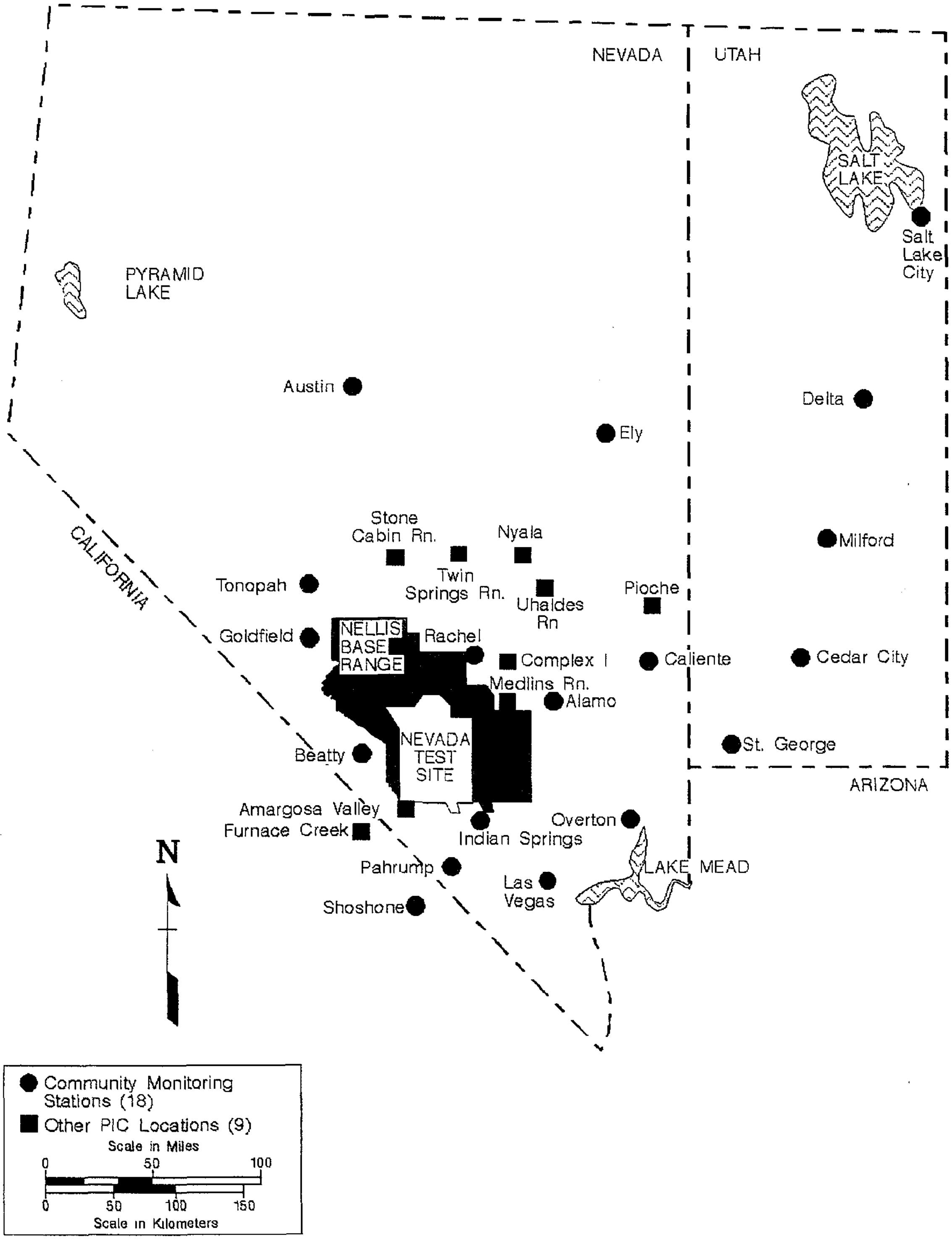


Figure 4.15 Pressurized Ion Chamber Network Station Locations - 1993

EPA stations. The magnetic tapes and cards, which are collected weekly, provide a backup to the telemetry data. The PICs also contain a liquid crystal display, permitting interested persons to note the current readings.

The data are evaluated weekly by EMSL-LV personnel. Trends and anomalies are investigated and equipment problems are identified and referred to field personnel for correction. Weekly averages are stored in Lotus files on a personal computer. These weekly averages are compiled from the telemetry data when available and from the 5-minute averages from the magnetic tapes or cards when the telemetry data are unavailable. Computer-generated reports of the PIC average data are issued weekly for posting at each station and are sent to state and federal personnel in the three states shown in Figure 4.12. These reports indicate average gamma exposure rate for the current week, the previous week, and for the year, plus the range of background levels in the U.S.

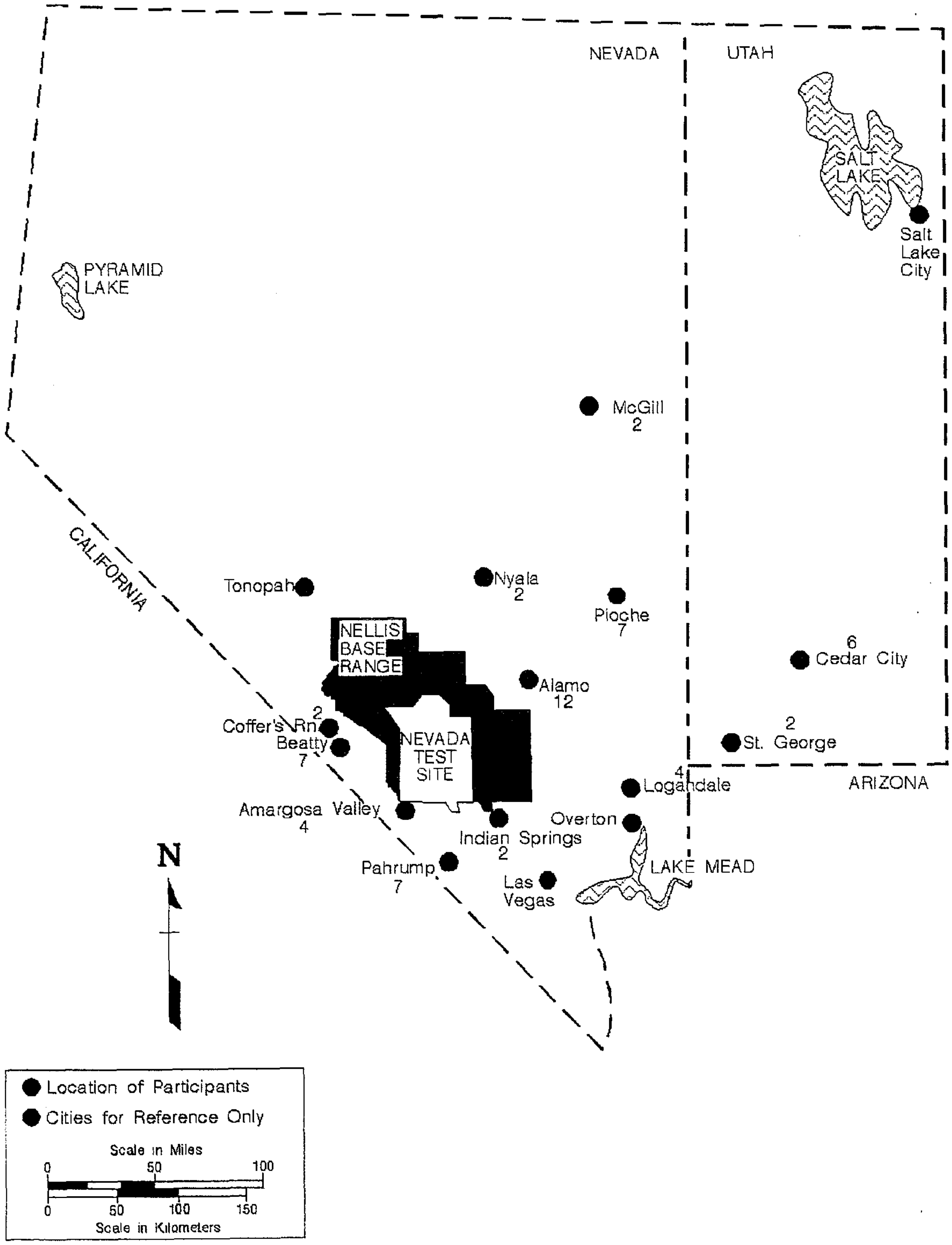
4.1.2.7 INTERNAL DOSIMETRY NETWORK

Internal radiation exposure is caused by radionuclides that are ingested, absorbed, or inhaled and retained within the body for varying amounts of time. The EMSL-LV Internal Dosimetry Program employs two methods to detect body burdens: whole body counting (including lung counting) and urinalysis.

The Whole Body Counting facility has been in operation at EMSL-LV since 1966. It is equipped with a large-volume semiconductor detector for entire body scans and an array of smaller volume detectors for scans of the lungs. The facility is equipped to determine the identity and quantity of gamma-emitting radionuclides which might have been inhaled or ingested by offsite residents and others who may have been exposed to releases of radioactivity. Routine measurement of radionuclides in a person consisted of a 2000-second count with a radiation detector placed next to the person reclining in one of the two shielded counting rooms. In the other shielded room, a detector array positioned over the lung area is used to determine the presence of radioactive actinides e.g., americium, plutonium, or uranium. Analysis of urine specimens is conducted at the EMSL-LV Radioanalysis Laboratory to determine concentrations of tritium.

The Internal Dosimetry Program was developed to monitor participants in the Offsite Dosimetry Network, the Radiological Safety Program, and as a public service to other concerned citizens. The Offsite Dosimetry Network was initiated in 1970 to monitor family members in communities and ranches surrounding the NTS. In 1993, there were a total of 54 families (158 individuals) in the program. Not all individuals participate in the program each year. The locations and number of individuals taking part in the program in 1993 are shown in Figure 4.16. Biannually, participants travel to EMSL-LV for a whole-body and lung count, and submission of a urine specimen. At 18-month intervals, a medical laboratory examination is performed and the participant is examined by a physician.

In 1993, internal dosimetry monitoring was also performed on participants in the Radiological Safety Program, which includes EPA employees, DOE contractor employees, and other workers who might have been occupationally exposed. In 1992 and 1993, by special request, whole body counting was performed on Desert Storm soldiers who were injured with shrapnel possibly containing depleted uranium. In addition, counts and urinalysis were performed on members of the public who contacted EMSL-LV with concerns about radiation exposures.



NOTE: Numbers denote offsite participants monitored in 1993.

Figure 4.16 Number and Location of Participants in the Offsite Dosimetry Program - 1993

4.1.2.8 COMMUNITY RADIATION MONITORING PROGRAM

Because of the successful experience with the Citizen's Monitoring Program during the purging of the TMI containment in 1980, the Community Radiation Monitoring Program (CRMP) consisting of 15 monitoring stations located in the states of California, Nevada and Utah was begun. Today there are 18 stations located in these three states (see Figure 4.15). The CRMP is a cooperative project of the DOE, EPA, DRI, and University of Utah.

The DOE sponsors the program. The EPA provides technical and scientific direction, maintains the instrumentation and sampling equipment, analyzes the collected samples and interprets and reports the data. The DRI administers the program by hiring the local station managers and alternates, securing rights-of-way, providing utilities and performing additional quality assurance checks of the data. The University of Utah provides detailed training twice a year for the station managers and alternates on all issues related to nuclear science, radiological health and radiation monitoring.

Each station is operated by a local resident, in most cases a high-school science teacher. Samples are analyzed at the EMSL-LV Radioanalysis Laboratory. Data interpretation is provided by DRI to the communities involved. All of the 18 CRMP stations have one of the samplers for the ASN, NGTSN, on either routine or standby status, and TLD networks. In addition a PIC and recorder for immediate readout of external gamma exposure and a recording barograph are located at the station.

All of the equipment is mounted on a stand at a prominent location in each community so the residents are aware of the surveillance and, if interested, can check the data. Also, computer-generated reports of the PIC data are issued weekly for each station as explained above.

4.1.2.9. COMMUNITY EDUCATION OUTREACH PROGRAM

DOE sponsors Public Information Presentations which are forums for increasing the public's awareness of NTS activities, disseminating radiation monitoring results, and addressing concerns of residents related to environmental radiation and possible health effects. These public information presentations were initiated in February of 1982 in the form of town hall meetings. Between 1982 and 1990, 95 town hall meetings were held in the communities surrounding the NTS in the states of Arizona, California, Nevada, and Utah.

In the fall of 1990 the focus of this outreach program was changed. Rather than a single subject presented at general town hall meetings, audiences from schools, service clubs and civic groups from the various communities were targeted and offered presentations on many different subjects. Table 4.3 lists the outreach presentations conducted in 1993. A list of presentation subjects is provided in Table 4.4. An annual report on the CRMP and outreach program is published by the DRI under the name "Community Radiation Monitoring Program Annual Report for FY 19xx," with a report number such as DOE/NV-10845-xx, which may be obtained from either DRI or DOE/NV.

Table 4.3 Community Radiation Monitoring Program Outreach Presentations - 1993

Date	Location	Audience	Subject	Attendance
01/16	Henderson, Nevada	Iota Chapter of Beta Sigma Phi	NTS Deer Migration Study	20
01/29	St. George, Utah	Utah State Teachers Assn.	NTS Activities and Related Matters	36
01/29	St. George, Utah	Utah State Teachers Assn.	ABC's of Radiation	20
02/25	Ely, Nevada	Ely Middle School	ABC's of Radiation	94
04/27	Beatty, Nevada	Beatty High School	Careers in Science and Engineering	22
06/13	Tonopah, Nevada	Tonopah Rotary Club	Consumer Electronic Product Radiation	22
11/17	Cedar City, Utah	Cedar City High School	Pack Rat Midden	38
11/17	Cedar City, Utah	Exchange Club	Pack Rat Midden	20
11/19	Alamo, Nevada	Alamo High School	Hydrology	94
11/23	Las Vegas, Nevada	Bonanza High School	Archaeology at the NTS	516
12/13	Beatty, Nevada	Beatty High School	Photography	21
			Attendance Total	903

Table 4.4 Community Radiation Monitoring Program Presentation Topics

ABC's of Radiation. Radiation explained in understandable terms; when it is dangerous and when it is not.

Testing Nuclear Weapons. How nuclear weapons are tested (safely) on the Nevada Test Site (NTS).

Joint Verification Experiment. Interaction with the USSR during exchange of weapons tests at the NTS and the USSR.

Downwind Radiation Exposures and Legislation. The different studies that have been done to calculate the radiation exposures to people who were living in the downwind area during atmospheric testing.

Offsite Radiation Monitoring and the Community Monitoring Program. The offsite monitoring program which is performed by the Environmental Protection Agency in areas and communities surrounding the NTS. The Community Radiation Monitoring Program details how science teachers and local residents in Nevada, California, and Utah have been and are involved in understanding activities on the NTS.

Hiroshima-Nagasaki Experience. Predicted radiation effects based on the Japanese data.

Environmental Restoration. Current environmental restoration programs on the NTS and those planned for the future.

Onsite Environmental Monitoring. The NTS onsite environmental monitoring program.

Consumer Electronic Product Radiation. Risks and benefits of safe usage of common household electronic products.

NTS Archaeology. Prehistory and cultural resources of the southern great basin and NTS that also includes studies of pack rat middens.

NTS Hydrology. Groundwater flow studies and subsurface contamination on the NTS and surrounding areas.

Surficial Radioactive Contamination. Occurrence of radioactive contamination on the NTS and surrounding area as a result of weapons testing.

NTS Deer Migration Study. Seven year deer tagging study to understand migration patterns.

Low Level Waste. A description of how low level waste is managed and controlled at the Low Level Waste Management Site on the NTS.

Emergency Response Training. The training program for Nevada policemen and firemen who are first-on-the-scene accident responders.

4.2 NONRADIOLOGICAL MONITORING

H. Bruce Gillen, Orin L. Haworth and Richard B. Hunter

The 1993 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. BECAMP conducted studies in 1993 that included wildlife surveys and vegetation trend assessments in disturbed and undisturbed areas of the NTS. Nonradiological monitoring was conducted in 1993 for 4 tests conducted at the Liquified Gaseous Fuels Spill Test Facility (LGFSTF) on the NTS.

Nonradiological monitoring of non-NTS DOE/NV facilities was conducted by EG&G/EM at three facilities. This monitoring was limited to wastewater discharges to publicly owned treatment works and into one dry well for returning uncontaminated, noncontact cooling water back to the ground.

4.2.1 NTS OPERATIONS MONITORING

4.2.1.1 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 operation activities. This included motor pool facilities; large equipment and drilling 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 Complex in Area 6. The LGFSTF in Area 5 is a source of potential release of nonradiological contaminants to the environment, depending on the individual tests conducted. In 1993 there were four tests all involving carbon dioxide conducted at this facility. Monitoring was performed to assure these contaminants did not move to offsite areas. Since these monitoring functions are performed by the EMSL-LV at the NTS boundary, monitoring functions for the LGFSTF are described below in Section 4.2.2, "Offsite Monitoring." Routine nonradiological environmental monitoring on the NTS in 1993 was limited to:

- Sampling of drinking water distribution systems and water haulage trucks for Safe Drinking Water Act and state of Nevada compliance.

- Sewage lagoon influent and N-tunnel discharge sampling for compliance with state of Nevada operating permit requirements.

- Sampling of electrical equipment oil, soil, water, surfaces, and waste oil for the presence of polychlorinated biphenyls (PCB) as part of Toxic Substance Control Act compliance.

- Asbestos sampling in conjunction with asbestos removal and renovation projects and in accordance with occupational safety and National Emission Standards for Hazardous Air Pollutants (NESHAP) compliance.

- Sampling of soil, water, sediment, waste oil, and other media for RCRA constituents.

4.2.1.2 ECOLOGICAL STUDIES

Studies conducted under DOE/NV-sponsored programs included monitoring the flora and fauna on the NTS to assess changes in ecological conditions over time and to provide information needed to document NTS compliance with environmental laws, regulations, and orders. The monitoring effort has been arranged into three interrelated phases of work: (1) a series of five non-disturbed study plots in test-impacted ecosystems that are monitored at one to five-year intervals to establish natural baseline conditions; (2) a series of study plots in representative disturbed areas that are monitored at three- to five-year intervals to determine impacts of disturbance, document site recovery, and investigate natural recovery processes; and (3) observations of birds and large mammals throughout the NTS. Monitoring and survey work includes: (1) sampling vegetation to determine health, recovery, and utilization of vegetation in disturbed and undisturbed areas; (2) rodent trapping to determine the condition of individual animals and the continuity and stability of resident populations; (3) sampling a ubiquitous lizard to determine changes in abundance and health due to natural and man-made disturbances; (4) surveys to obtain information concerning resident populations of desert tortoises, kit foxes, rabbits, deer, and feral horses; and (5) the maintenance and preservation of the NTS herbarium, biological data archives, and ecology library.

In 1993, the sixth full year of flora and fauna monitoring, surveys were conducted at 17 sites. Ephemeral plants were monitored at 14 locations, some with multiple plots. Perennial plants were measured at 10 sites, mammals at 10 sites, and reptiles at 8 sites. Many of these sites included paired disturbed/undisturbed plots. Three baseline sites were monitored and perennials and ephemerals were measured at all of them. Sites in disturbed areas are monitored on a three year cycle. In 1993 three burned areas and two roadside study sites were sampled. In addition, baseline measurements were made near the Device Assembly Facility under construction in Frenchman Flat.

Monitoring of feral horses continued for the fourth consecutive year. All horses, including foals, were individually identified. In addition, field observations were made of raptors, mule deer, and ravens in appropriate habitats throughout the NTS. Desert tortoises in the Rock Valley study enclosures were monitored in spring and fall, and free roaming tortoises were marked and measured when fortuitously encountered.

4.2.2 OFFSITE MONITORING

The LGFSTF 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 LGFSTF 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 down-wind gaseous concentrations, operating data, and close-in/down-wind meteorological data; and (3) provide a means to control and monitor these functions from a remote location.

DOE/NV provides the facilities, security, and technical support, but all costs are borne by the organization conducting the tests. In 1993 four tests were conducted involving carbon dioxide. The plans for each test series were examined by an Advisory Panel that consisted of DOE/NV and EMSL-LV professional personnel augmented by personnel from the organization performing the tests.

For each test the EMSL-LV provided 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 was deployed downwind of the test at the NTS boundary to measure chemical concentrations that may have reached the offsite area. Based on wind direction and speed, the boundary monitor was instructed to collect samples at the time of projected maximum concentration. Samples were collected with a hand-operated Dräger pump and sampling tube appropriate for the chemical being tested. Not all tests were monitored by EPA if professional judgement indicated that, based on previous experience with the chemical and the proposed test parameters, NTS boundary monitoring was unnecessary.

The EPA monitors at the NTS boundary, in contact by two-way radio, were always placed at the projected cloud center line at the time when the cloud was expected at the boundary, so the air samples would be collected at the time and place of maximum concentration. The exact location of the boundary monitor was adjusted during the test by use of two-way radio to ensure that monitoring was performed at the projected cloud center line.

4.2.3 NON-NTS FACILITY MONITORING

Although permits for the eight EG&G/EM non-NTS operations included 31 air pollution, 6 wastewater, one dry well for returning uncontaminated, non-contact cooling water back to the ground, and 3 local hazardous waste generator permits, effluent monitoring was limited to wastewater discharges (see below) at 3 sites. Four wastewater permits did not include effluent monitoring by EG&G/EM as a requirement. Reports on the quantities of hazardous materials used in production or disposed of were required by some of the various permits, but these quantities were gleaned from internal records on operating times or use rate, not from any specific routine monitoring effort. A description involving any unexpected emission was required for some permits, but again, monitoring was not required. All results from routine monitoring were within the permit limits, and monitoring activities were limited to the following:

- During 1993 EG&G/EM, Las Vegas Area Operation (LVAO), North Las Vegas Facility, was required to collect composite samples twice a year from the anodizing shop effluent. Analyses for pH, cyanide, metals and total toxic organics were made on each sample. On October 29, 1993, the wastewater discharge permit was modified to include biannual monitoring requirements from nine additional processes and two facility outfalls. Biannual monitoring reports were submitted to the city of North Las Vegas in July 1993 and January 1994 for discharges that occurred during 1993.

- EG&G/EM, Woburn Cathode Ray Tube Operation (WCO), was not required to sample and submit monitoring reports for wastewater discharge to the sewer during 1993. WCO was required to submit monthly monitoring reports to the state of Massachusetts, Department of Environmental Protection on the uncontaminated noncontact cooling water that was being discharged into a dry well. Monthly monitoring included measuring pH, temperature, and flow.

- EG&G/EM, LVAO, Remote Sensing Laboratory, was required to collect a composite sample twice a year from the photo laboratory effluent. Analyses for pH and silver were made on each sample. Biannual monitoring reports were submitted to the Clark County Sanitation District on June and December of 1993.

4.3 ENVIRONMENTAL PERMITS

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NTS environmental permits active during 1993 which were issued by the state of Nevada or Federal agencies included 43 air quality permits involving emissions from construction operation facilities, boilers, storage tanks, and open burning; five permits for onsite drinking water distribution systems; four permits for sewage discharges to lagoon collection systems; an N-Tunnel water pollution control permit; a temporary water pollution control permit for Area 12 steam cleaning operations; eight permits for septage hauling; and four endangered species and wildlife scientific collection permits. New revisions to the Resource Conservation and Recovery Act (RCRA) Part A and Part B permit applications were submitted to the state of Nevada in 1993.

Non-NTS EG&G/EM permits included 31 air pollution control permits, four sewage discharge permits and one injection well permit. Nine EPA Generator Identification (ID) numbers were issued to seven EG&G/EM operations, and three local RCRA-related permits were required at two EG&G/EM operations.

4.3.1 AIR QUALITY PERMITS

Air quality permits were required for numerous locations at the NTS and at two non-NTS facilities.

4.3.1.1 NTS AIR QUALITY PERMITS

Table 4.5 is a listing of state of Nevada air quality operating or construction permits active in 1993.

The expiration date indicated in the table for air quality permits to construct, identified with the prefix PC, is identified as "varies" because a permit to construct is generally valid until the time the state performs an inspection and an operating permit is issued.

For OP 94-14, the Nevada Air Quality Officer must be notified of each burn no later than five days following the burn, either by telephone or written communication. During 1993 no open burns of explosives-contaminated debris were conducted in Area 27. As the Part A and B RCRA permit applications did not include burning of explosives in Area 27, these burning activities were transferred to the Area 11 Explosive Ordnance Disposal (EOD) Area that is included within the Part A and B application.

For OP 93-16, the Air Quality Officer no longer must be notified by telephone at least two working days in advance of each training exercise for Class A flammables, with a written summary of each exercise submitted within 15 days following the exercise. This summary, which includes the date, time, duration, exact location, and amount of flammables burned, is now included in an annual report. During 1993, 16 burns were conducted for radiological emergency response training. No training burns were conducted by onsite fire protection services, and no controlled burns for Class A flammables were held in 1993.

Table 4.5 NTS Active Air Quality Permits - 1993

Permit No.	Facility or Operation	Expiration Date
OP 94-14[a]	Open burning, Area 27	11/28/94
OP 93-16[a]	Open burning fire rescue	02/25/94
OP 2187	York-Shipley boiler	11/01/95
OP 2230	Rex LO-GO Concrete Batch Plant	02/19/96
OP 2275	Storage tank, DF #2	02/25/96
OP 2276	Storage tank, unleaded fuel	02/25/96
OP 2277	Storage tank, unleaded fuel	02/25/96
OP 2278	Storage tank, DF #2	02/25/96
OP 2428	Aggregate Plant	02/12/97
OP 2625	LGFSTF	11/02/97
OP 2745[a]	Cafeteria boiler, Ajax boiler	03/23/98
OP 2746[a]	Cafeteria boiler, Ajax boiler	03/23/98
OP 2744[a]	Area 12 Cafeteria boiler, Ajax boiler	03/23/98
OP 2743[a]	Surface area disturbances	03/23/98
OP 1966	Cement storage equipment, Area 6	11/21/94
OP 1972	Shaker Plant	12/04/94
OP 1973	CMI rotary dryer	12/04/94
OP 1974	Cedarapids crusher	12/04/94
OP 1975	Stemming Facility	12/04/94
OP 1976	Stemming Facility	12/04/94
OP 1978	Ajax boiler WOFD-6500	12/04/94
OP 1979	Aggregate Mixing/Hopper Plant	12/04/94
OP 2555[a]	Incinerator	08/17/97
OP 2674	Portable Ammonia Refrigeration System	12/14/97
OP 2850[a]	Portable cement bins, Area 6	12/02/98
OP 2849[a]	Concrete Batch Plant	12/02/98
PC 2707	Portable compressor	Varies
PC 2709	Portable compressor	Varies
PC 2710	Portable compressor	Varies
PC 2711	Portable compressor	Varies
PC 2712	Portable compressor	Varies
PC 2823	Portable jaw crusher	Varies
PC 2824	Portable screen (C.R.)	Varies
PC 2825	Portable screen (Tel.)	Varies
PC 2826	Portable pugmill	Varies
PC 3061[b]	Portable stemming facility, Area 3	Varies
PC 3246	Area 3 Mud Plant	Varies
PC 3247	Area 20 Portable Mud Plant	Varies
PC 3248	Area 3 Portable Mud Plant	Varies
PC 2988	Area 3 Two-Part Epoxy Batch Plant	Varies
PC 3311[b]	Area 1 Sandbag Facility	Varies
PC 3312[b]	Area 1 Portable Kolberg Screen	Varies
PC 3518[b]	Area Commander Crushing Plant	Varies

(a) Permits reissued in 1993
(b) New permits issued in 1993

4.3.1.2 NON-NTS AIR QUALITY PERMITS

Twenty-eight air pollution control permits have been issued for emission units at EG&G/EM LVAO, one permit to operate for a vapor degreaser at the EG&G/EM Special Technologies Laboratory (STL), one permit to operate for two solvent cleaning operations at the EG&G/EM Amador Valley Operations (AVO) and one Plans Approval for a vapor degreaser at WCO. No expiration dates have been issued for the LVAO, STL, and WCO permits. Annual renewal is contingent upon payment of permit fees. No renewal is required for the WCO permit. Permits are amended and revised only if the situation under which the permit has been issued changes. For the other non-NTS, EG&G/EM operations, no permits have been required or the facilities have been exempted. Table 4.6 lists each of the required permits.

4.3.2 DRINKING WATER SYSTEM PERMITS

NTS drinking water permits issued by the state of Nevada as shown in Table 4.7 were renewed with new expiration dates as shown. Permit number NY-4097-12NC was cancelled following direction from the state as water which is used in the associated distribution system is provided by water haulage trucks instead of a water well. No drinking water systems were maintained by non-NTS facilities.

4.3.3 SEWAGE DISCHARGE PERMITS

Sewage discharge permits from the state of Nevada, Division of Environmental Protection (NDEP), are listed in Table 4.8 and require submission of quarterly discharge monitoring reports.

4.3.3.1 NTS SEWAGE HAULING PERMITS

Permits issued by the state of Nevada Division of Health for sewage hauling trucks for the NTS were renewed in November, 1993 and are listed in Table 4.9.

4.3.3.2 NON-NTS SEWAGE PERMITS

Sewage permits were required for six of the eight non-NTS EG&G/EM operations. This included two permits at the Las Vegas Area Operations facilities, two at the Santa Barbara Operations facility, one at the Special Technologies Laboratory, and one at the Woburn Cathode Ray Tube Operations facility as shown in Table 4.8. Each was issued by the county or community in which the facility was located.

4.3.4 N-TUNNEL WATER POLLUTION CONTROL PERMIT

On November 2, 1992, the NDEP issued a water pollution control permit, number NEV92033, for the operation and closure of the wastewater treatment ponds at N-tunnel on the NTS. This permit became effective on November 12, 1992, and expires on the same date in 1994. The permit specifies pond monitoring, quarterly reporting and management requirements.

Table 4.6 Active Air Quality Permits, Non-NTS Facilities - 1993

Permit No.	Facility or Operation
Las Vegas Area Operation[a]	
A06501	Process Equipment, Metal Sanding - Cyclone, Losee Road, NLV
A06502	Process Equipment, Anodizing, Losee Road, NLV
A06504	Diesel Power Generator, Losee Road, NLV
A06506	Process Equipment, Welding, Losee Road, NLV
A06507	Process Equipment, Spray Painting, Losee Road, NLV
A06509	Process Equipment, PC Board Plating, Losee Road, NLV
A06510	Process Equipment, Material Processing, Losee Road, NLV
A06511	Process Equipment, Chemical Processing, Losee Road, NLV
A06512	Cyclone and Stack, Abrasive Blast Facility, Losee Road, NLV
A38701	Emergency Generator, C-1 Complex, Losee Road, NLV
A38702	Process Equipment, Surface Coating, Paint Spraying Facilities, NLV
A38703	Exhaust, Soldering, Building C-1, Losee Road, NLV
A38704	Exhausts, Photo Processing, Building C-1, Losee Road, NLV
A34801	Fuel Burning Equipment, Boiler, NAFB
A34802	Fuel Burning Equipment, Boiler, NAFB
A34803	Fuel Burning Equipment, Boiler, NAFB
A34804	Fuel Burning Equipment, Water Heater, NAFB
A34805	Fuel Burning Equipment, Water Heater, NAFB
A34806	Emergency Generator, NAFB
A34807	Fume Hood, Battery Charging Equipment, NAFB
A34808	Photochemical Mixing & Photo Processing w/Vents, NAFB
A34809	Process Equipment, Paint Spray Booths, NAFB
A06513	Time Saver Ferrous Sander with Torit Dust Cyclone
A06514	Time Saver Aluminum Sander with Torit Dust Cyclone
A06515	Katolight and Kohler Diesel Standby Generators
A06516	Emergency Fire Control Equipment, Cummins Diesel Engine
A06517	Trinco Dry Blast with Dust Filters
A34810	Emergency Fire Control Equipment, Cummins Diesel Engine
Special Technologies Laboratory[a]	
8477	Permit to Operate a 12 Gallon Capacity Vapor Degreaser
Amador Valley Operations	
7586	Permit to Operate two small solvent cleaning tanks
Woburn Cathode Ray Tube Operations[a]	
MBR-88-IND-188	Approval of plans to install a vapor degreaser

(a) An annual fee is paid on these permits; there are no expiration dates

Table 4.7 NTS Drinking Water Supply System Permits - 1993

Permit No.	Area(s)	Expiration Date
NY-5024-12NC	Area 1	09/30/94
NY-4099-12C	Area 2 & 12	09/30/94
NY-360-12C	Area 23	09/30/94
NY-4098-12NCNT	Area 25	09/30/94
NY-5000-12NCNT	Area 6	09/30/94

Table 4.8 Sewage Discharge Permits - 1993

Permit No./Location	Areas	Expiration Date
	NTS Permits	
NEV87069	Area 2 (1), Area 6 (4)	02/28/94
NEV87076	Area 22, Area 23	02/28/94
NEV87060	Area 6 (1), Area 25 (4)	03/31/94
NEV87059	Area 12	02/28/94
	Off-NTS Permits	
Las Vegas Area Operations		
CCSD-032/Remote Sensing Laboratory[a]		
CLV-9/North Las Vegas Facility[a]		12/31/94
Santa Barbara Operations		
II-204/Goleta, California		
III-330/Goleta, California		12/31/95
Special Technologies Laboratory		
III-331/Santa Barbara, California		12/31/95
Woburn Cathode Ray[a] Tube Operations		
43 005 732-0		12/15/96

(a) Owner/Operator effluent monitoring required by permit

Table 4.9 NTS Septic Waste Hauling Trucks

Permit Number	Vehicle Identification Number	Expiration Date
NY-17-03310	Septic Tank Pumper E-104866	11/30/94
NY-17-03311	Septic Tank Pumper E-104573	11/30/94
NY-17-03312	Septic Tank Pumper E-104296	11/30/94
NY-17-03313	Septic Tank Pumper E-105293	11/30/94
NY-17-03314	Septic Tank Pumper E-105299	11/30/94
NY-17-03315	Septic Tank Pumper E-105919	11/30/94
NY-17-03317	Septic Tank Pumper E-105918	11/30/94
NY-17-03318	Septic Tank Pumping Subcontractor Vehicle	11/30/94

4.3.5 180-DAY TEMPORARY WATER POLLUTION CONTROL PERMIT FOR THE AREA 12 STEAM CLEANING FACILITY

On July 14, 1992, the NDEP issued 180-day temporary water pollution control permit for the discharge from the Area 12 Fleet Operations steam cleaning facility. The permit became effective on July 15, 1992, and was allowed to expire on January 11, 1993. This permit allowed continued discharge from the facility under certain conditions and monitoring requirements. In August 1992 steam cleaning operations at this facility ceased. A closed loop steam cleaning replacement system was to be in place by the expiration date of the permit. However, the construction of the replacement system was cancelled with the suspension of Area 12 facility operation.

4.3.6 INJECTION WELL PERMITS

Underground injection is not being used to dispose of industrial wastewater at the NTS. One injection well for uncontaminated noncontact cooling water at the EG&G/EM facility in Woburn, Massachusetts is subject to state overview. A discharge permit for this well was issued on January 4, 1993. WCO was required to submit monthly monitoring reports to the state of Massachusetts, Department of Environmental Protection on the uncontaminated noncontact cooling water that was being discharged into a dry well. Monthly monitoring included measuring pH, temperature, and flow.

4.3.7 RCRA PERMITS

4.3.7.1 NTS OPERATIONS

Hazardous waste generation activities at the NTS continue to be performed under EPA ID Number NV3890090001. A Part A and Part B RCRA permit application has been submitted to the state of Nevada for the following NTS operations: Pit 3 Mixed Waste Disposal Units (existing), the Mixed Waste Disposal Units (proposed), the Area 5 Hazardous Waste Storage Unit (proposed), and the Area 11 Explosive Ordnance Disposal Area (existing) (see Section 3.1.5.1). Both of the existing units have achieved interim status.

4.3.7.2 NON-NTS FACILITIES

Nine EPA Generator ID numbers have been issued to seven EG&G/EM operations. In addition, three local ID numbers were required at two EG&G/EM operations. Hazardous waste is managed at these locations using satellite accumulation areas and a less than 90-day waste accumulation area. All hazardous and industrial chemical wastes are transported offsite to RCRA-permitted facilities for approved treatment and/or disposal.

4.3.8 ENDANGERED SPECIES ACT/WILDLIFE PERMITS

Federal and state permits have been issued to NTS entities for study of endangered species and wildlife. (All EG&G/EM non-NTS facilities are located in existing metropolitan areas and are not subject to the Endangered Species Act.) These biological studies include ongoing research on the desert tortoise. Annual reports are filed as stipulated in the permits.

Desert tortoise studies at the NTS are performed under endangered species permit numbers PRT-744522 issued to REECo in 1990 (expiration date: December 31, 1994), and PRT-683011 issued to EG&G/EM in 1993 (expiration date: June 30, 1995). Both of these permits were issued by the U.S. Fish and Wildlife Service.

The state of Nevada Department of Wildlife issued a scientific collection permit, number S-9022, in 1993 for the collection and study of various species at the NTS. This permit expires on June 30, 1994.

The U.S. Fish and Wildlife Service issued REECo "Special Purpose Salvage" permit PRT-762816 on November 8, 1993. This permit allows for salvaging dead migratory birds and expires on December 31, 1995.

5.0 RADIOLOGICAL MONITORING RESULTS

Radiological environmental monitoring results from onsite environmental programs included effluent sampling results for airborne emissions and liquid discharges to containment ponds and environmental sampling results for onsite surveillance conducted by Reynolds Electrical & Engineering Co., Inc., (REECo). Offsite environmental surveillance was conducted by the EPA's Environmental Monitoring Systems Laboratory - Las Vegas (EMSL-LV). Onsite monitoring results indicated that environmental concentrations of radioactivity resulting from NTS air emissions were statistically no different than background except in the immediate vicinity of the emissions. These airborne emissions, and radioactive liquid discharges to onsite containment ponds, produced concentrations that were only a fractional percentage above background in terms of potential exposure of onsite workers. Offsite monitoring indicated that environmental radionuclide concentrations and exposure rates were statistically no different than background, with no measurable exposure of offsite residents from current NTS test operations. Small amounts of radioactivity were detected in animal samples collected onsite and in some garden vegetables collected offsite.

5.1 RADIOLOGICAL EFFLUENT MONITORING

Fred D. Ferate

Since no nuclear tests were performed at the Nevada Test Site during 1993, monitoring efforts for radioactive effluents consisted primarily of routine air sampling throughout the NTS, and of periodic sampling of liquid discharges to the Area 12 tunnel containment ponds. One drillback into an old test cavity was performed in 1993, but no radioactivity was released to the environment. Samples of air exhausted through the ventilation duct at the P Tunnel Portal indicated emissions of 3.7 Ci (137 GBq) of gaseous radioactivity in the form of tritiated water vapor in 1993, due to seepage within the tunnel from nuclear tests performed in previous years. Air samples collected in and around the Area 5 Radioactive Waste Management Site (RWMS-5) indicated that no measurable radioactivity was detectable away from the area, although trace amounts of tritium were detected at its boundary. Samples in Area 3 and at the Area 9 Bunker showed above-background levels of $^{239+240}$Pu. Measured ^{85}Kr levels on Pahute Mesa were about 2 pCi/m^3 (0.074 Bq/m^3) higher than the NTS average, due to atmospheric pumping from past nuclear tests. In each case, by using data from the station with the highest annual average, replacing the diffuse source with an equivalent point source, and using CAP88-PC, upper limits of 1.0 x 10^{-3} Ci (37 MBq) of $^{239+240}$Pu, 0.3 Ci (11 GBq) of ^{3}H and 160 Ci (5.9 TBq) of ^{85}Kr were estimated for airborne emissions from Area 3, from the RWMS-5, and from Pahute Mesa, respectively. Using a different model, an upper limit of 7.5 x 10^{-4} Ci (28

MBq) was estimated for airborne emissions of $^{239+240}$Pu from the Area 9 Bunker. The primary liquid effluents were Rainier Mesa tunnel seepage water collected in containment ponds at the tunnel mouths. Influent to these ponds essentially contained only tritium (^{3}H), with a total tunnel discharge of 710 Ci (26 TBq).

5.1.1 EFFLUENT MONITORING PLAN

As required by DOE Order 5400.1 (DOE 1990b), the NTS Environmental Monitoring Plan (DOE 1991c) was reviewed and updated in 1993. An important part of the Plan is the onsite Effluent Monitoring Plan, in which the Area 12 tunnels, the Area 6 Decontamination Facility, nuclear test sites, Radioactive Waste Management Sites, and all other potential effluent sites throughout the NTS have been assessed for their potential to contribute to the public dose.

Airborne radioactive effluents are the emissions on the NTS with the greatest potential for reaching members of the public. All radioactive liquid effluents from activities on the NTS are contained within its boundaries. For all activities on the NTS, the estimated effective dose equivalent to any member of the public from all airborne radionuclide emissions is much less than 0.1 mrem/year. Requirements of the National Emission Standards for Hazardous Air Pollutants (NESHAP) are set forth in 40 CFR 61.93(b)(4)(ii), and Regulatory Guide DOE/EH-0173T (DOE 1991d). Compliance with these requirements is achieved by periodic measurements of effluents to confirm the low dose levels. For consistency with past practices, the monitoring methods and procedures developed over the years are being continued with changes to be introduced as conditions warrant.

To meet 40 CFR 61 requirements, an isokinetic sampling system was installed in September 1991 near the entrance to P Tunnel in Area 12, for the purpose of making periodic confirmatory measurements of airborne effluents from the P Tunnel ventilation duct. With occasional gaps because of repairs, equipment exchanges, and shutdowns of airflow in the ventilation duct, this system was in operation during 1993. More details are given in Section 5.1.2.2 of this report.

5.1.2 AIRBORNE EFFLUENTS

No nuclear tests were performed during 1993 so there were no test-related effluents. The majority of radioactive air effluents at the NTS in 1993 originated from seepage of low concentrations of radioactive krypton and tritiated water vapor from Pahute Mesa and P Tunnel, respectively. (See Table 5.1 for a listing of onsite releases.) Samples of air from the ventilation duct at the P Tunnel Portal indicated emissions of 3.7 Ci (137 GBq) of gaseous radioactivity in the form of tritiated water vapor in 1993, due to seepage within the tunnel from nuclear tests performed in previous years. Based on environmental surveillance data, it was calculated that diffuse emissions contributed 0.001 Ci (37 MBq) of $^{239+240}$Pu from Area 3, 0.29 Ci (11 GBq) of ^{3}H from Area 5, 0.00075 Ci (28 MBq) of $^{239+240}$Pu from Area 9, and 160 Ci (5.9 TBq) of ^{85}Kr from Pahute Mesa to the monitored effluents (Black 1994). Effluent monitoring for a drillback into an old test cavity indicated that no radioactivity was released to the environment during this operation as described in section 5.1.2.1 below.

Table 5.1 NTS Radionuclide Emissions - 1993

Onsite Liquid Discharges

Containment Ponds	Curies(a)					
	Gross Beta	^{3}H	^{90}Sr	^{137}Cs	^{238}Pu	${}^{239+240}$Pu
Area 12, E Tunnel	2.8×10^{-3}	6.0×10^{1}	2.0×10^{-4}	7.8×10^{-4}	1.8×10^{-5}	1.6×10^{-4}
Area 12, N Tunnel		3.6×10^{-1}				2.6×10^{-7}
Area 12, T Tunnel	4.1×10^{-3}	6.5×10^{2}			3.9×10^{-7}	1.2×10^{-5}
TOTAL	6.9×10^{-3}	7.1×10^{2}	2.0×10^{-4}	7.8×10^{-4}	1.8×10^{-5}	1.7×10^{-4}

Airborne Effluent Releases

Facility Name (Airborne Releases)	Curies(a)		
	^{3}H(b)	^{85}Kr	${}^{239+240}$Pu
Area 3(c)			1.0×10^{-3}
Area 5, RWMS(c)	2.9×10^{-1}		
Area 9 Bunker(c)			7.5×10^{-4}
Area 12, P Tunnel Portal(d)	3.7×10^{0}		
Areas 19 and 20, Pahute Mesa(c)		$1.6 \times 10^{+2}$	
TOTAL	4.0×10^{-0}	$1.6 \times 10^{+2}$	1.8×10^{-3}

(a) Multiply by 3.7×10^{10} to obtain Bq. Calculated releases of transuranics from laboratory spills and losses are shown in Table 1.1.
(b) In the form of tritiated water vapor, primarily HTO.
(c) Calculated from air sampler data.
(d) From measurements of air exhausted through ventilation duct.

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, DOE Order 5400.5, and regulatory guide DOE/EH-0173T, as well as from EPA requirements in the National Emission Standards for Hazardous Air Pollutants, 40 CFR 61. 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, DOE/NV/10630-28, published in November 1991. This plan was updated in 1992 and 1993.

5.1.2.1 POSTSHOT DRILLBACK MONITORING

No nuclear tests were performed during 1993, and therefore no specific nuclear event monitoring was conducted at the NTS. However, one postshot drillback was carried out from May 3 through May 7, 1993, by the Los Alamos National Laboratory for the nuclear test GASCON which had taken place 7 years earlier in Area 4. Complete radiological safety coverage was provided during these activities which involved drilling into the vicinity of the nuclear detonation to acquire samples of test-associated material. There was a potential for releasing radioactive gases to the atmosphere. However, for containment of radioactive material during drillback, LANL utilized a pressurized recirculation system. Platform and cellar air samples were taken during the entire drillback operation. These air samples were analyzed for source characterization and operational safety as well as environmental monitoring purposes.

During the post-event drillback activities, REECo personnel maintained continuous environmental surveillance in the work area. Radiation detector probes were placed in strategic locations in the work areas and connected to recorders and alarms to warn of increases in radiation levels. Radiation monitoring personnel using portable instruments periodically checked work area radiation levels and issued protective equipment to, or were prepared to evacuate, area personnel if necessary.

Personnel equipped with specialized collection and measurement instruments were prepared to respond rapidly should an accidental release of airborne radioactive materials have occurred from the underground test cavity. As expected, during the entire postshot drillback operation, no radioactive emissions were detected.

5.1.2.2 TUNNEL COMPLEX EFFLUENT

Despite multiple problems associated with the microprocessor-controlled isokinetic sampling unit which had been installed at P Tunnel Portal in September of 1991, samples were collected through this unit from the P Tunnel ventilation duct during most of 1993, except when the ventilation was turned off, when sampling equipment was being exchanged, repaired, or tested, or when samples were lost because of sampling equipment malfunction.

Two sampling rakes with five probes each were situated along the diameter of the ventilation duct, perpendicular to the flow of air. Air from one rake was drawn through a particulate filter followed by an activated charcoal filter. Air from the other rake was drawn through another sampling tube, and some of the air from this tube was drawn through a silica gel column to extract moisture for tritiated water vapor measurements, while a separate portion was stored under pressure in an aluminum tank to be analyzed for the possible presence of radioactive noble gases. Sampler air flow was controlled to assure that the linear air speed within the sampling tubes was equal, within specified tolerances, to the airspeed in the duct.

Because of excessive dust loading, the particulate filter was exchanged every eight hours. A weekly composite was analyzed for gamma radiation and a monthly composite for ^{238}Pu and $^{239+240}$Pu. Weekly the charcoal filter was analyzed for gamma radiation, the moisture from the silica gel column was analyzed for tritium (HTO), and the compressed air was analyzed for ^{85}Kr and ^{133}Xe.

The principal emissions detected by these measurements were 3.7 Ci (137 GBq) of ^{3}H in the form of tritiated water vapor. This radioactive vapor is attributed to migration of tritium through tunnel walls due to tests from previous years. The amount emitted contributed a negligible effective dose equivalent to NTS workers or members of the general public.

5.1.2.3 RADIOACTIVE WASTE MANAGEMENT SITES (RWMS)

Two permanent particulate/halogen samplers were located within the disposal pits at the RWMS-5. As was the case in 1992, the 1993 annual average concentration of gross beta activity in samples taken within Pits 3 and 4 in Area 5 were 2.1 and 2.0 x 10^{-14} µCi/mL (0.78 and 0.74 mBq/m^{3}), respectively. The NTS 1993 annual average gross beta concentration was 2.0 x 10^{-14} µCi/mL (0.74 mBq/m^{3}). These results indicate that, except for trace amounts of tritium, the operations in the RWMS-5 are not contributing radiological effluents to the NTS environment. Average annual gross beta and plutonium results for 1993 from all the samples collected at the RWMS-5 facility are shown Figure 5.1.

Nine HTO samplers were located surrounding RWMS-5. These samplers are placed near the perimeter berm of the disposal site as seen in Figure 5.2. The 1993 annual average HTO concentration for the nine stations was 7.3 x 10^{-6} pCi/mL (0.27 Bq/m^{3}). This value is less than 0.08 percent of the Derived Concentration Guide for tritiated water vapor in air. The results indicate that the waste disposal operations at the RWMS-5 did not contribute significant levels of tritiated water vapor to the NTS environment. The 1993 annual average HTO concentrations from the samplers at the RWMS-5 facility are displayed in Figure 5.2.

The results from thermoluminescent dosimeters (TLDs) deployed surrounding the RWMS facility, as was the case for TLD measurements for most measured locations on the NTS, appeared to indicate that the gamma exposure rates measured in 1993 were somewhat higher than the levels measured in 1992. This is believed to be due to an artifact of the measuring process, and is discussed in Section 5.2.1.8. A discussion of historical trends of environmental gamma exposure as measured by environmental TLDs is given in Appendix G.

Although a statistical analysis shows that there are differences between NTS areas in levels of environmental exposure, there were not enough data to determine the pattern of the differences. Nevertheless, an examination of annual average exposure rates (see Table F.4, Appendix F) shows that the gamma exposure rates detected at the RWMS-5 perimeter are not atypical of gamma measurements taken at other locations on the NTS. The RWMS perimeter exposure rates in mR/day are shown in Figure 5.2. The statistical analysis is presented in Appendix F.

The Area 3 RWMS (RWMS-3) is used for disposal of radiologically contaminated waste in packages that are unsuitable for waste disposal in the Area 5 facility. This waste is buried in subsidence craters much like waste is buried at the RWMS-5. The RWMS-3 is surrounded by four permanent particulate/halogen samplers located approximately north, south, east, and west of the burial pit. Several TLDs were distributed at the RWMS-3 and surrounding areas.

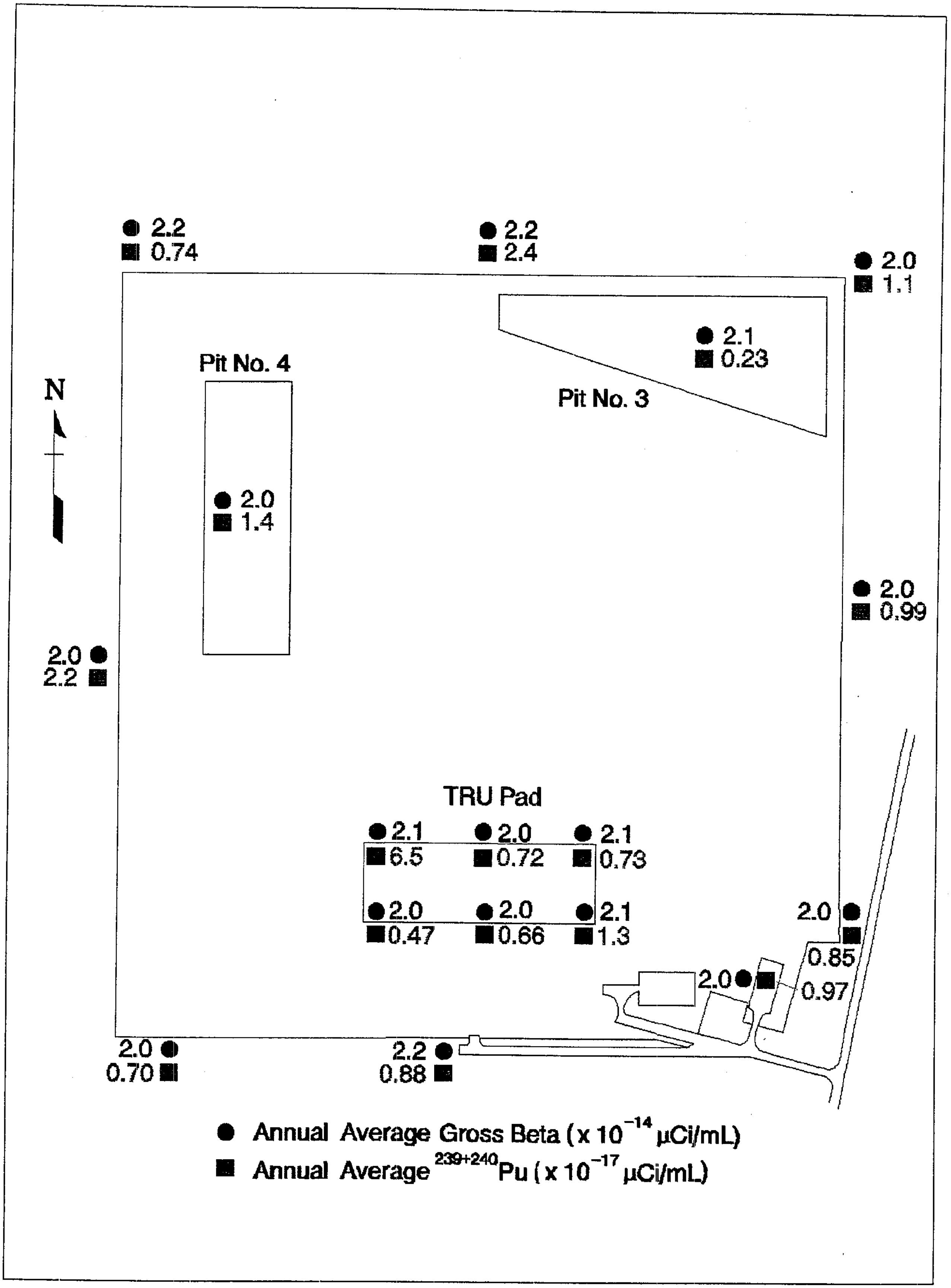

Figure 5.1 RWMS-5 Air Sampling Annual Average Results - 1993

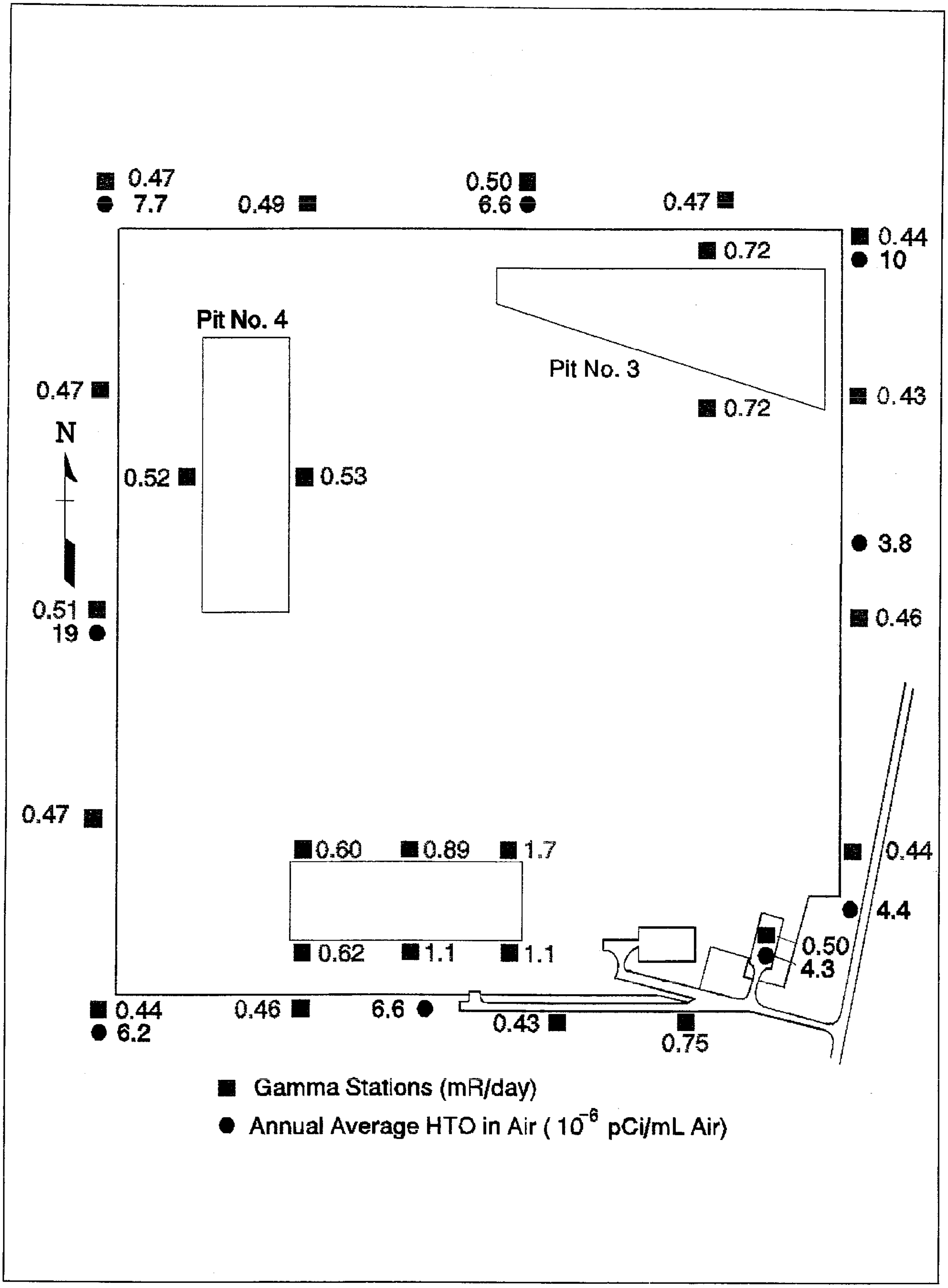

Figure 5.2 RWMS-5 HTO & TLD Annual Average Results - 1993

The gross beta 1993 annual average at the RWMS-3 of 1.9 x 10^{-14} µCi/mL was the same as the 1992 average, and was not statistically different at the five percent significance level from the site-wide average of 2.0 x 10^{-14} µCi/mL (0.74 mBq/m^3). However, $^{239+240}$Pu results indicated that levels of these radionuclides in the vicinity of the RWMS-3 were consistently above the NTS average (see Appendix A). Vehicular traffic and operational activities in Area 3 apparently resuspend plutonium that was deposited on the soil surface during earlier nuclear explosives testing. These elevated $^{239+240}$Pu levels indicated that Area 3 is a diffuse source of effluents. Air sampling results are displayed in Section 5.2.1.2, Tables 5.5 and 5.6, and TLD results are listed and discussed in Appendix F.

5.1.3 LIQUID DISCHARGES

The only radioactive liquid discharges at the NTS in 1993 originated from tunnel drainage. Typically, all liquid discharges within the NTS were held in containment ponds. Monthly grab samples were taken from each pond and, where possible, from the influent. Radioactive liquid effluents discharged to onsite ponds contained approximately 710 Ci (26 TBq) of ^{3}H during 1993. Radioactivity in liquid discharges released to the containment ponds was monitored to assess the efficacy of tunnel sealing and provide a quantitative and qualitative annual summary of the radioactivity released onsite.

5.1.3.1 TUNNELS

Rainier Mesa in Area 12 is the location where nuclear tests were conducted within tunnels by the DOD. Seepage water discharged from these tunnels was collected in containment ponds. This water was usually contaminated with radionuclides, mainly ^{3}H, generated during nuclear tests in previous years.

Liquid effluents were discharged during 1993 from three tunnels: N, T, and E. The liquid discharge from the tunnels decreased appreciably during 1993 compared to previous years. Intermittent flow was observed from N Tunnel during most of the year. The majority of the flow from T Tunnel was eliminated with the installation of a plug on May 5, 1993. The installation of a second plug on September 9, 1993, stopped the flow from T Tunnel almost completely. Only at E Tunnel was the 1993 flow comparable to that for previous years.
A monthly grab sample was taken from each containment pond and from the tunnel discharge. Monitoring results indicated that the water discharged from these tunnels contained measurable quantities of ^{3}H and small amounts of other radionuclides. Total quantities of ^{3}H, ^{238}Pu, $^{239+240}$Pu, ^{90}Sr, ^{137}Cs, and beta activity were determined for each liquid effluent source and are listed in Table 5.1.

Tunnel seepage was the only source of radioactive liquid discharges on the NTS. Onsite discharges to containment ponds contained about 710 Ci (26 TBq) of ^{3}H. Discharges of other radionuclides totaled approximately 8 mCi (296 MBq). No liquid effluents were discharged offsite.

During 1993 an estimated 1.4 x 10^7 L of water were discharged into the T Tunnel containment ponds. Sampling results from the tunnel effluent pipe indicated an average, over the nearly four months of observed flow, of 4.6 x 10^4 pCi/mL (1.7 x 10^6 Bq/L) of ^{3}H. Therefore, the total quantity of ^{3}H discharged out of the T Tunnel complex was calculated to be 650 Ci (24 TBq). Similar calculations were performed for the other tunnel effluents. A summary of the ^{3}H effluent data for the tunnels is found in Table 5.2.

Table 5.2 Tritium in NTS Onsite Liquid Discharges - 1993

Location	Discharge Volume (L)	Average ^3H Concentration (pCi/mL)	Total ^3H Discharge (Ci)$^{(a)}$
T Tunnel	1.4×10^7	4.6×10^4	650
N Tunnel	3.0×10^6	1.2×10^2	0.36
E Tunnel	3.3×10^7	1.8×10^3	60

(a) Multiply by 37 to obtain GBq

5.1.3.2 DECONTAMINATION FACILITY

The Decontamination Facility, located in Area 6, was not used during 1993 since no nuclear tests were conducted. One drillback was performed; the equipment for the drillback was isolated and still awaiting decontamination at the end of the year. On November 8, 1992, the containment pond was permanently isolated from the Decontamination Facility. Until a new lined containment pond is constructed, any effluent from that Facility is intended to be captured in holding tanks and held for disposal. At the end of 1993, the infrastructure to accomplish this was still under construction.

5.2 RADIOLOGICAL ENVIRONMENTAL SURVEILLANCE

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Onsite surveillance of airborne particulates, noble gases, and tritiated water vapor indicated concentrations that were generally not statistically different from background concentrations. Surface water samples collected from open reservoirs or natural springs and industrial-purpose water, exclusive of tunnel ponds, gave no indication of statistically significant contamination levels. External gamma exposure monitoring indicated that the gamma radiation environment within the NTS remained consistent among stations, although the site-wide average was 19 percent higher than last year. The reason for the increase is unknown but is being investigated. Special environmental studies included soil radionuclide transport studies and development of a NTS-specific dose assessment model. Results of offsite environmental surveillance by EPA EMSL-LV showed no NTS-related radioactivity was detected by the offsite monitoring network, and there were no apparent net exposures detectable by the offsite internal dosimetry network. Radionuclides were detectable in tissues from animals collected both on- and offsite and in some vegetables collected offsite at levels near the MDC.

5.2.1 ONSITE ENVIRONMENTAL SURVEILLANCE

The onsite radiological surveillance networks consist of 52 air sampling stations; 10 radioactive noble gas sampling stations; 17 tritiated water vapor sampling stations; surface water samples from 15 open water supply reservoirs, 7 springs, 9 wastewater containment ponds, and 3 sewage lagoons; groundwater samples from 10 potable and 2 non-potable supply wells and 8 drinking water consumption points; and 193 locations where TLDs measure gamma exposures. Additional radiological studies are conducted through the Basic Environmental Compliance and Monitoring Program (BECAMP), including: investigating the movement of radionuclides on and around the NTS through horizontal movement, water-driven erosion, vertical migration, and wind-driven erosional resuspension; development of a human dose-assessment model specific to the environmental and radiological conditions of the NTS; and preparation of a peer-reviewed publication that addresses an important issue related to the potential environmental impacts of past, present, and future activities on the NTS.

5.2.1.1 RADIOACTIVITY IN AIR

Fifty-two air sampling stations were operated continuously. At each of the stations, samples were collected weekly on glass fiber filters (for particulate) and charcoal cartridges (for halogens). The filters were counted for gamma and gross beta activity, composited monthly, and then analyzed for ^{238}Pu and $^{239+240}$Pu. The charcoal cartridge was counted for gamma activity each week. The individual gross beta, ^{238}Pu, $^{239+240}$Pu, and gamma sampling results are listed in Appendix A, Attachments A.1 through A.4.

Air monitoring for the noble gases ^{85}Kr and ^{133}Xe was performed at ten fixed locations. These air samples were also collected weekly. A distillation process separated the radioactive krypton and xenon from the sample for measurement. Tritiated water vapor was monitored continuously at 17 locations. Samples were collected every two weeks and analyzed for ^{3}H. Liquid scintillation counting was used for these measurements.

For the purpose of comparing measured quantities of airborne radioactivity to the Derived Air Concentrations (DAC), the guides for occupational exposures found in DOE Order 5480.11, and to the Derived Concentration Guides (DCG), the guides for exposures to members of the general public found in DOE Order 5400.5, the following assumptions were made:

- The chemical species of the radionuclides detected was unknown so the most restrictive DAC or DCG was used (almost always Class Y compounds which take on the order of years to clear from the respiratory system). The DCG and DAC values used are listed in Table 5.3.

- For air sampling results, all of the gross beta activity detected was assumed to be ^{90}Sr.

5.2.1.2 AIR (PARTICULATE AND HALOGEN GAS) SAMPLING RESULTS

During the year there were no changes in air sampling locations.

GROSS BETA

Figure 5.3 displays the average NTS gross beta results for 1993. Air particulate samples, except for Gate 200 in Area 5, were held for five to seven days prior to gross beta counting and gamma spectrum analysis to allow for the decay of radon and radon daughters. Samples collected at Gate 200 in Area 5 were not held for decay of radon daughters. The results from this station provided a useful indication of any site-wide anomalous concentrations. The statistical evaluation of gross beta results is presented in Appendix A. Table 5.4 presents the network arithmetic averages, minimums, and maximums for 1993 airborne gross beta sampling results.

All results exceeded the MDC. The network 1993 annual average gross beta concentration was 2.0×10^{-14} µCi/mL (0.74 mBq/m^3), the same as 1992. This concentration is 0.001 percent of the ^{90}Sr DAC listed in DOE Order 5480.11 and 2.2 percent of the DCG in DOE Order 5400.5 adjusted to an annual Effective Dose Equivalent (EDE) of 10 mrem (10 mSv). The statistical evaluation of the gross beta concentrations indicated that a lognormal distribution provides an adequate approximation to the true distribution. The network annual geometric mean and geometric standard deviation of the data were 1.9×10^{-14} µCi/mL and 1.4 (0.70 mBq/m^3 and 1.6).

Although the gross beta concentration average for all stations was the same as last year's, it was apparent that there was a slight increasing trend in concentrations throughout the year (see Figure A.9, Appendix A, Vol. II) that was observed at all stations . The shape of the curve resembled that for $^{239+240}$Pu all-station averages (see Table A.5, Appendix A).

Table 5.3 Derived Limits for Radionuclides in Air and Water

Radionuclide	DAC (air)[(a)] µCi/mL	DCG (air)[(b)] µCi/mL	DCG (water)[(c)] µCi/mL
^{3}H	2×10^{-5}	1×10^{-8}	9×10^{-5}
^{40}K	2×10^{-7}	6×10^{-11}	3×10^{-7}
^{85}Kr (d)	1×10^{-4}	6×10^{-7}	-
^{89}Sr	6×10^{-8}	3×10^{-11}	6×10^{-7}
^{90}Sr	2×10^{-9}	6×10^{-13}	3×10^{-8}
^{133}Xe	1×10^{-4}	5×10^{-8}	-
^{226}Ra	3×10^{-10}	3×10^{-13}	6×10^{-9}
^{238}Pu (a)	7×10^{-12}	3×10^{-15}	2×10^{-9}
$^{239+240}Pu$ (a)	6×10^{-12}	3×10^{-15}	1×10^{-9}

(a) DAC - The Derived Air Concentration used for limiting radiation exposures of workers. The values are based on either a stochastic effective dose equivalent of 5 rem or a nonstochastic organ dose of 50 rem, whichever is more limiting (DOE Order 5480.11). Class Y is used for plutonium.

(b) DCG - Derived Concentration Guides are reference values for conducting radiological protection programs at operational DOE facilities and sites. The DCG values are for an effective dose equivalent of 10 mrem (10 mSv) (inhalation) for a year as required by 40 CFR 61.92 and DOE Order 5400.5.

(c) The values listed for beta and photon emitters in the table are based on 4 mrem committed effective dose equivalent for the radionuclide taken into the body by ingestion of water during one year (730 L).

(d) Nonstochastic value.

PLUTONIUM

Monthly composite samples from each particulate sampling location were analyzed for ^{238}Pu and $^{239+240}Pu$. Figure 5.4 shows the airborne $^{239+240}Pu$ annual average results for each of the sampling locations. Tables 5.5 and 5.6 list the maximum, minimum, annual arithmetic mean, standard deviation, and the mean expressed as a percentage of the DCG for each sampling location, for $^{239+240}Pu$ and ^{238}Pu, respectively. The ranges in the annual mean concentrations for ^{238}Pu and $^{239+240}Pu$ for all stations were -0.012 to 0.91×10^{-17} µCi/mL and 0.071 to 48×10^{-17} µCi/mL (-0.044 to 3.4×10^{-7} and 0.26 to 178×10^{-7} Bq/m^3), respectively. The arithmetic mean and standard deviation of ^{238}Pu in air for all stations were $(1.1 \pm 3.1) \times 10^{-18}$ µCi/mL ($[4.1 \pm 11] \times 10^{-8}$ Bq/m^3). Most observed values of ^{238}Pu were well below the limit of detection. The arithmetic mean and standard deviation of $^{239+240}Pu$ in air for all stations were $(4.1 \pm 15) \times 10^{-17}$ µCi/mL ($[1.5 \pm 5.6] \times 10^{-6}$ Bq/m^3). The network arithmetic mean for $^{239+240}Pu$ was 65 percent of the 1992 mean concentration.

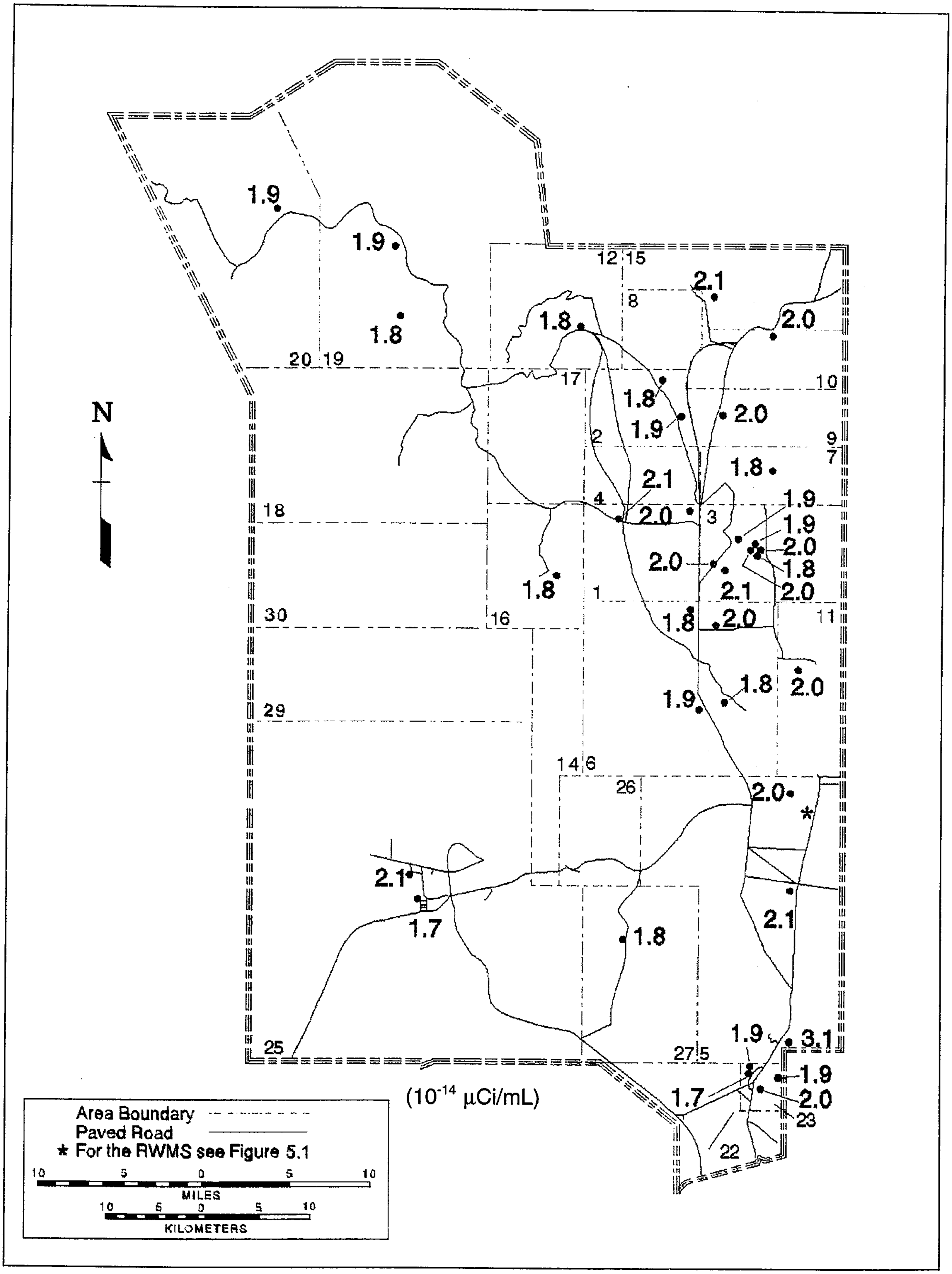


Figure 5.3 NTS Airborne Gross Beta Annual Average Concentrations - 1993

Table 5.4 Airborne Gross Beta Concentrations on the NTS - 1993

		Gross Beta Concentration (10^{-14} µCi/mL)				
Location	Number	Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as %DCG
Area 1, BJY	52	4.0	0.55	2.0	0.66	2.2
Area 1, Gravel Pit	52	6.9	0.44	2.1	0.93	2.3
Area 2, 2-1 Substation	52	3.4	1.0	1.9	0.59	2.1
Area 2, Complex	51	3.5	0.64	1.8	0.59	2.0
Area 3, Complex	52	4.1	0.64	2.0	0.73	2.2
Area 3, Complex No. 2	51	6.2	1.0	2.1	0.86	2.3
Area 3, Mud Plant	52	3.4	0.66	1.9	0.62	2.1
Area 3, U-3ah/at E	49	3.6	0.61	2.0	0.66	2.2
Area 3, U-3ah/at N	52	3.6	0.52	1.9	0.60	2.1
Area 3, U-3ah/at S	51	3.1	0.83	1.8	0.53	2.0
Area 3, U-3ah/at W	50	3.4	0.69	2.0	0.64	2.2
Area 5, Dod Yard	49	4.0	0.56	2.0	0.72	2.2
Area 5, Gate 200 S	49	9.3	0.90	3.1	2.0	3.4
Area 5, RWMS No. 1	52	3.7	0.91	2.0	0.65	2.2
Area 5, RWMS No. 2	51	3.9	0.80	2.0	0.72	2.2
Area 5, RWMS No. 3	50	4.5	0.84	2.0	0.74	2.2
Area 5, RWMS No. 4	51	5.3	0.77	2.0	0.84	2.2
Area 5, RWMS No. 5	52	3.9	0.81	2.2	0.72	2.4
Area 5, RWMS No. 6	51	4.4	0.97	2.2	0.85	2.4
Area 5, RWMS No. 7	52	3.8	0.98	2.1	0.70	2.3
Area 5, RWMS No. 8	52	4.0	0.78	2.1	0.74	2.3
Area 5, RWMS No. 9	52	4.0	0.96	2.2	0.76	2.4
Area 5, RWMS Pit No. 3	49	4.2	0.48	2.0	0.76	2.2
Area 5, RWMS Pit No. 4	50	3.8	0.88	2.0	0.76	2.2
Area 5, RWMS TP N	49	3.9	0.93	2.0	0.69	2.2
Area 5, RWMS TP NE	51	3.8	0.77	2.1	0.72	2.3
Area 5, RWMS TP NW	51	3.7	0.76	2.1	0.65	2.3
Area 5, RWMS TP S	50	3.3	0.67	2.0	0.61	2.2
Area 5, RWMS TP SE	51	4.3	0.88	2.1	0.71	2.3
Area 5, RWMS TP SW	51	3.6	0.94	2.0	0.66	2.2
Area 5, Well 5B	45	3.8	0.43	2.1	0.75	2.3
Area 6, Building 6-900	47	5.6	0.44	2.0	0.87	2.2
Area 6, CP-6	52	3.6	0.77	1.9	0.65	2.1
Area 6, Well 3 Complex	50	3.3	0.78	1.8	0.58	2.0
Area 6, Yucca Waste Pond	49	6.4	0.57	1.8	0.82	2.0
Area 7, Ue7ns	49	3.3	0.80	1.8	0.58	2.0
Area 9, 9-300 Bunker	51	3.6	0.96	2.0	0.60	2.2
Area 10, Gate 700	51	3.4	0.93	2.0	0.60	2.2
Area 11, Gate 293	49	3.5	0.67	2.0	0.67	2.3
Area 12, 12 Complex	52	3.2	0.86	1.8	0.52	2.0
Area 15, EPA Farm	52	3.7	0.96	2.1	0.62	2.3
Area 16, 3545 Substation	49	3.8	0.51	1.8	0.64	2.0
Area 19, Echo Peak	31	3.2	0.77	1.8	0.53	2.0
Area 19, Pahute Substation	35	3.4	1.2	1.9	0.53	2.1
Area 20, Dispensary	36	3.2	1.2	1.9	0.50	2.1
Area 23, Building 790	51	5.8	0.68	1.7	0.77	1.9
Area 23, Building 790 No. 2	52	3.7	0.54	1.9	0.70	2.1
Area 23, East Boundary	50	3.6	0.74	1.9	0.74	2.1
Area 23, H&S Building	51	4.0	0.58	2.0	0.68	2.2
Area 25, E-MAD North	51	3.9	0.46	2.1	0.76	2.3
Area 25, NRDS Warehouse	50	3.5	0.66	1.7	0.65	1.9
Area 27, Cafeteria	46	3.9	0.61	1.8	0.61	2.0

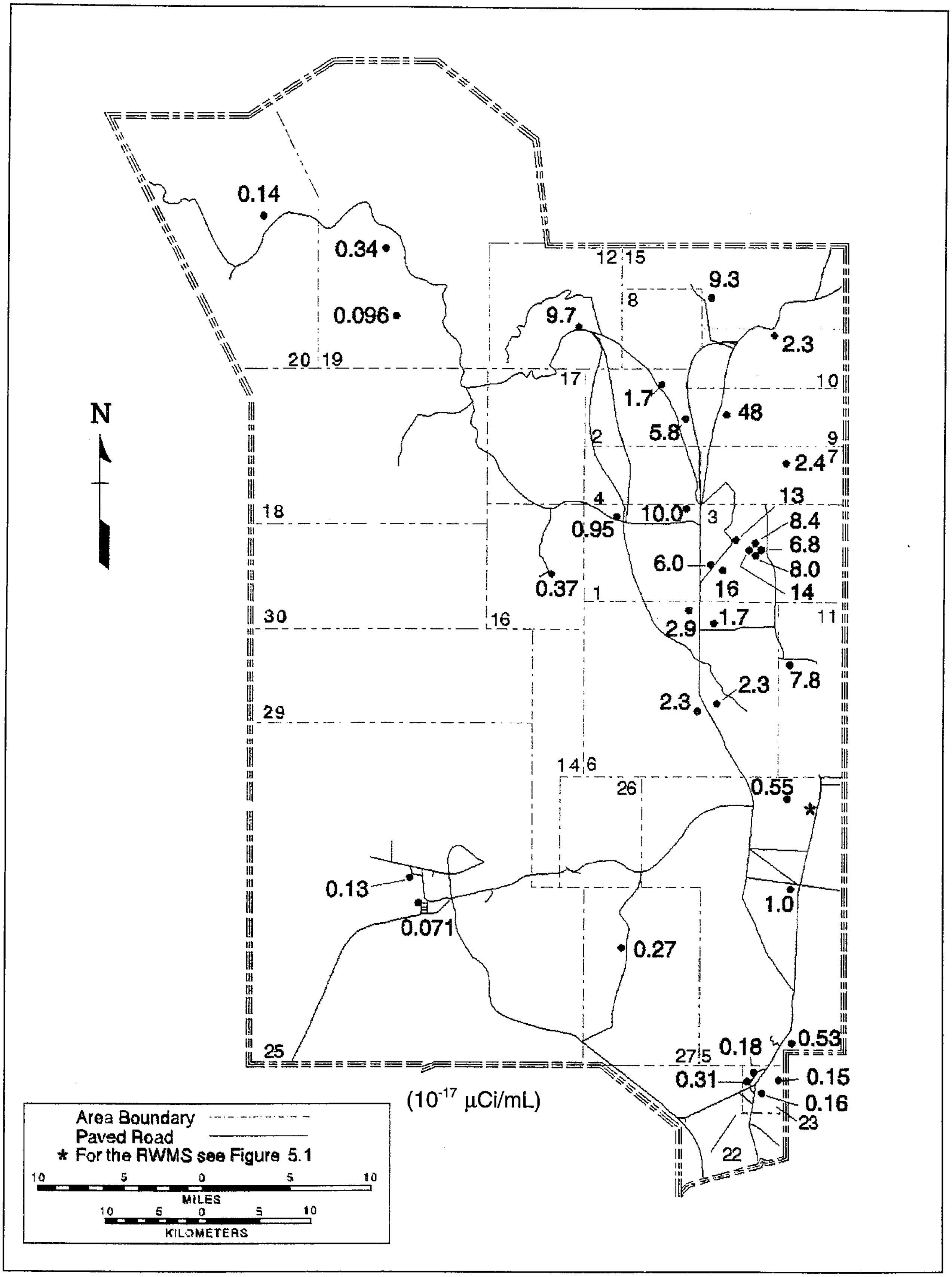


Figure 5.4 NTS Airborne $^{239+240}$Pu Annual Average Results - 1993

Table 5.5 Airborne $^{239+240}$Pu Concentrations on the NTS - 1993

		$^{239+240}$Pu Concentration (10^{-17} µCi/mL)				
Location	Number	Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as %DCG
Area 1, BJY	12	34.	0.15	10.	3.0	3.3
Area 1, Gravel Pit	12	6.5	0.0	0.95	0.51	0.32
Area 2, 2-1 Substation	12	47.	0.0	5.8	3.8	1.9
Area 2, Complex	11	4.9	0.13	1.7	1.9	0.56
Area 3, Complex	10	17.	0.10	6.0	5.1	1.9
Area 3, Complex No. 2	12	100.	0.58	16.	8.1	5.3
Area 3, Mud Plant	11	34.	0.34	13.	3.0	4.3
Area 3, U-3ah/at E	12	22.	0.33	6.8	1.7	2.2
Area 3, U-3ah/at N	12	26.	0.0	8.4	2.0	2.8
Area 3, U-3ah/at S	11	28.	0.14	8.0	2.6	2.6
Area 3, U-3ah/at W	11	50.	0.35	14.	4.7	4.6
Area 5, Dod Yard	11	1.4	0.0	0.55	0.16	0.18
Area 5, Gate 200 S	12	4.3	0.0	0.53	0.35	0.17
Area 5, RWMS No. 1	12	5.7	0.0	0.97	0.49	0.32
Area 5, RWMS No. 2	12	5.5	0.0	0.85	0.43	0.28
Area 5, RWMS No. 3	12	3.7	0.0	0.99	0.38	0.33
Area 5, RWMS No. 4	11	3.8	0.0	1.1	0.36	0.36
Area 5, RWMS No. 5	12	24.	0.0	2.4	2.0	0.79
Area 5, RWMS No. 6	12	1.7	0.0	0.74	0.16	0.24
Area 5, RWMS No. 7	11	13.	0.0	2.2	1.1	0.73
Area 5, RWMS No. 8	11	1.6	0.0	0.70	0.18	0.23
Area 5, RWMS No. 9	11	2.6	0.0	0.88	0.26	0.29
Area 5, RWMS Pit No. 3	12	0.76	0.0	0.23	0.069	0.08
Area 5, RWMS Pit No. 4	12	3.7	0.0	1.4	0.38	0.46
Area 5, RWMS TP N	11	2.7	0.0	0.72	0.24	0.24
Area 5, RWMS TP NE	12	3.4	0.0	0.73	0.30	0.24
Area 5, RWMS TP NW	12	68.	0.09	6.5	5.6	2.1
Area 5, RWMS TP S	11	1.9	0.0	0.66	0.19	0.22
Area 5, RWMS TP SE	10	6.8	0.0	1.3	0.64	0.43
Area 5, RWMS TP SW	10	2.0	0.0	0.47	0.19	0.16
Area 5, Well 5B	10	3.4	0.20	1.0	0.33	0.33
Area 6, Building 6-900	12	4.2	0.11	1.7	0.40	0.56
Area 6, CP-6	12	8.3	0.0	2.3	0.72	0.79
Area 6, Well 3 Complex	11	15.	0.06	2.9	1.3	0.92
Area 6, Yucca Waste Pond	12	8.3	0.20	2.3	0.77	0.79
Area 7, Ue7ns	11	7.8	0.0	2.4	0.76	0.79
Area 9, 9-300 Bunker	12	270.	1.2	48.	22.	16.
Area 10, Gate 700	12	17.	0.0	2.3	1.3	0.79
Area 11, Gate 293	11	42.	0.08	7.8	3.9	2.6
Area 12, 12 Complex	9	84.	-0.13	9.7	9.3	3.2
Area 15, EPA Farm	11	33.	0.22	9.3	3.4	3.0
Area 16, 3545 Substation	12	1.3	-0.11	0.37	0.14	0.12
Area 19, Echo Peak	8	0.36	-0.11	0.096	0.053	0.03
Area 19, Pahute Substation	9	0.77	0.0	0.34	0.079	0.11
Area 20, Dispensary	10	0.42	0.0	0.14	0.051	0.05
Area 23, Building 790	12	1.2	-0.25	0.31	0.11	0.11
Area 23, Building 790 No. 2	12	0.58	0.0	0.18	0.061	0.06
Area 23, East Boundary	10	0.29	0.0	0.15	0.032	0.05
Area 23, H&S Building	10	0.43	0.0	0.16	0.051	0.05
Area 25, E-MAD North	11	0.42	0.0	0.13	0.040	0.04
Area 25, NRDS Warehouse	12	0.26	-0.36	0.071	0.050	0.02
Area 27, Cafeteria	11	1.1	-0.14	0.27	0.11	0.09

Table 5.6 Airborne ^{238}Pu Concentrations on the NTS - 1993

		^{238}Pu Concentration (10^{-17} µCi/mL)				
Location	Number	Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as %DCG
Area 1, BJY	12	0.77	0.0	0.24	0.24	0.080
Area 1, Gravel Pit	12	0.28	0.0	0.066	0.092	0.022
Area 2, 2-1 Substation	12	0.75	0.0	0.12	0.22	0.040
Area 2, Complex	10	0.38	-0.16	0.067	0.15	0.022
Area 3, Complex	11	0.97	-0.22	0.26	0.36	0.087
Area 3, Complex No. 2	12	1.1	0.0	0.32	0.42	0.11
Area 3, Mud Plant	11	1.7	0.0	0.53	0.56	0.18
Area 3, U-3ah/at E	12	0.43	0.0	0.17	0.14	0.057
Area 3, U-3ah/at N	12	0.46	0.0	0.16	0.17	0.053
Area 3, U-3ah/at S	11	0.30	0.0	0.11	0.10	0.037
Area 3, U-3ah/at W	11	1.0	0.0	0.28	0.35	0.093
Area 5, Dod Yard	11	0.51	0.0	0.062	0.16	0.021
Area 5, Gate 200 S	12	0.35	0.0	0.069	0.13	0.023
Area 5, RWMS No. 1	12	0.48	0.0	0.12	0.18	0.040
Area 5, RWMS No. 2	12	0.098	0.0	0.020	0.037	<0.01
Area 5, RWMS No. 3	12	1.1	0.0	0.15	0.32	0.050
Area 5, RWMS No. 4	11	0.10	0.0	0.025	0.043	<0.01
Area 5, RWMS No. 5	12	0.83	0.0	0.12	0.25	0.040
Area 5, RWMS No. 6	12	0.85	0.0	0.081	0.24	0.027
Area 5, RWMS No. 7	11	0.41	0.0	0.13	0.16	0.043
Area 5, RWMS No. 8	11	0.19	0.0	0.051	0.077	0.017
Area 5, RWMS No. 9	11	0.18	0.0	0.038	0.068	0.013
Area 5, RWMS Pit No. 3	12	0.14	0.0	0.012	0.040	<0.01
Area 5, RWMS Pit No. 4	12	0.092	0.0	0.014	0.034	<0.01
Area 5, RWMS TP N	11	0.10	0.0	0.017	0.038	<0.01
Area 5, RWMS TP NE	12	0.30	0.0	0.039	0.095	0.013
Area 5, RWMS TP NW	12	1.30	0.0	0.19	0.36	0.063
Area 5, RWMS TP S	11	0.24	0.0	0.021	0.072	<0.01
Area 5, RWMS TP SE	10	0.74	0.0	0.13	0.22	0.043
Area 5, RWMS TP SW	10	0.082	0.0	0.022	0.036	<0.01
Area 5, Well 5B	10	0.26	0.0	0.053	0.096	0.018
Area 6, Building 6-900	12	0.14	0.0	0.020	0.047	<0.01
Area 6, CP-6	12	0.30	0.0	0.064	0.11	0.021
Area 6, Well 3 Complex	11	0.55	-0.26	0.068	0.21	0.023
Area 6, Yucca Waste Pond	12	0.34	0.0	0.11	0.12	0.037
Area 7, Ue7ns	11	1.4	0.0	0.17	0.41	0.057
Area 9, 9-300 Bunker	12	4.8	0.0	0.91	1.4	0.30
Area 10, Gate 700	12	0.76	0.0	0.11	0.22	0.37
Area 11, Gate 293	11	0.78	-0.27	0.21	0.28	0.070
Area 12, 12 Complex	9	0.97	-0.20	0.11	0.34	0.037
Area 15, EPA Farm	11	0.72	0.0	0.20	0.25	0.067
Area 16, 3545 Substation	12	0.077	-0.23	-0.012	0.071	NA
Area 19, Echo Peak	8	0.18	-0.22	0.0069	0.11	<0.01
Area 19, Pahute Substation	9	0.20	-0.40	0.0081	0.17	<0.01
Area 20, Dispensary	10	0.11	0.0	0.019	0.041	<0.01
Area 23, Building 790	12	0.14	-0.13	0.012	0.067	<0.01
Area 23, Building 790 No. 2	12	0.094	-0.12	0.0043	0.050	<0.01
Area 23, East Boundary	10	0.12	0.0	0.024	0.050	<0.01
Area 23, H&S Building	10	0.14	-0.20	-0.0055	0.082	NA
Area 25, E-MAD North	11	0.29	0.0	0.026	0.086	<0.01
Area 25, NRDS Warehouse	12	0.32	-0.36	-0.0053	0.15	NA
Area 27, Cafeteria	11	0.17	-0.28	-0.0057	0.12	NA

NA Not Available

Because many of the measured values from the ^{238}Pu analyses were negative after background subtraction, the geometric means and standard deviations were not calculated for this isotope. However, 86 percent of the $^{239+240}$Pu results were positive, therefore the geometric mean and standard deviation were determined to be 1.0 x 10^{-17}µCi/mL (3.7 x 10^{-7} Bq/m^3) and 5.3, respectively.

During 1993, the maximum annual average (mean) $^{239+240}$Pu concentration was found at the Area 9, 9-300 Bunker sampling location. Results from samples taken at that location averaged 48 x 10^{-17} µCi/mL (18 µBq/m^3) during 1993. This quantity was 0.008 percent of the DAC and 16 percent of the DCG adjusted to an annual EDE of 10 mrem. Historically, the highest concentrations of $^{239+240}$Pu have occurred in Areas 3 and 9. This is apparent from this year's averages for each of the areas; however, a statistical analysis (see Appendix A) of the $^{239+240}$Pu results indicated that due to the heterogeneity of the variances, the differences reported for the different areas are not statistically significant.

The presence of plutonium on the NTS is primarily due to atmospheric tests and tests in which nuclear devices were detonated with high explosives ("safety shots"). These latter tests spread low-fired plutonium in the eastern and northeastern areas of the NTS (see Chapter 2, Figure 2.3 for these locations). Two decades later, higher than normal levels of plutonium in the air are still detected in several areas on the NTS. Because of operational activities and vehicular traffic in Areas 3 and 9 some of the ^{238}Pu and $^{239+240}$Pu becomes airborne.

Gamma

The charcoal cartridges used to collect halogen gases and the glass fiber filters used to collect particulates were analyzed by gamma spectroscopy. The results from the gamma spectroscopy analyses are provided in Appendix A, Attachment A.4. All radionuclides detected by gamma spectroscopy were naturally occurring in the environment (^{40}K, ^{7}Be, and members of the uranium and thorium series). No nuclear event related radioactivity was detected in any of the air samples by the gamma spectroscopy analyses.

5.2.1.3 NOBLE GAS SAMPLING RESULTS

The locations at which compressed air samples were routinely collected throughout the year are shown in Figure 5.5 with the annual averages of the ^{85}Kr and ^{133}Xe analyses. All average concentrations were well below the DCG values of 3 x 10^{-7} µCi/mL (1.1 x 10^{4} Bq/m^3) for ^{85}Kr and 5 x 10^{-8} µCi/mL (1.8 x 10^{3} Bq/m^3) for ^{133}Xe. The samplers at the indicated locations were operated continuously throughout the year except for those at the Pahute Substation, Area 20 Camp, and DDZ77 Transformer. Due to the closing of Areas 19 and 20 during the winter months, these stations did not begin sampling until March and April 1993. Summaries of the results are listed in Tables 5.7 and 5.8. All individual results are listed in Appendix E.

As in the past, the levels of ^{85}Kr (half-life of 10.76 years) observed in the samples were from world-wide nuclear power and fuel processing operations, with some contribution of ^{85}Kr from underground nuclear tests at the NTS. Xenon-133 is not normally detected in the environment due to its short half-life of 5.27 days, so when any is detected it is usually attributed to nuclear testing operations at the NTS.

Krypton-85

A summary of all ^{85}Kr results appears in Table 5.7. Again this year the highest annual average concentration occurred at the Area 20 Dispensary, 28 x 10^{-12} µCi/mL (1.0 Bq/m^3),

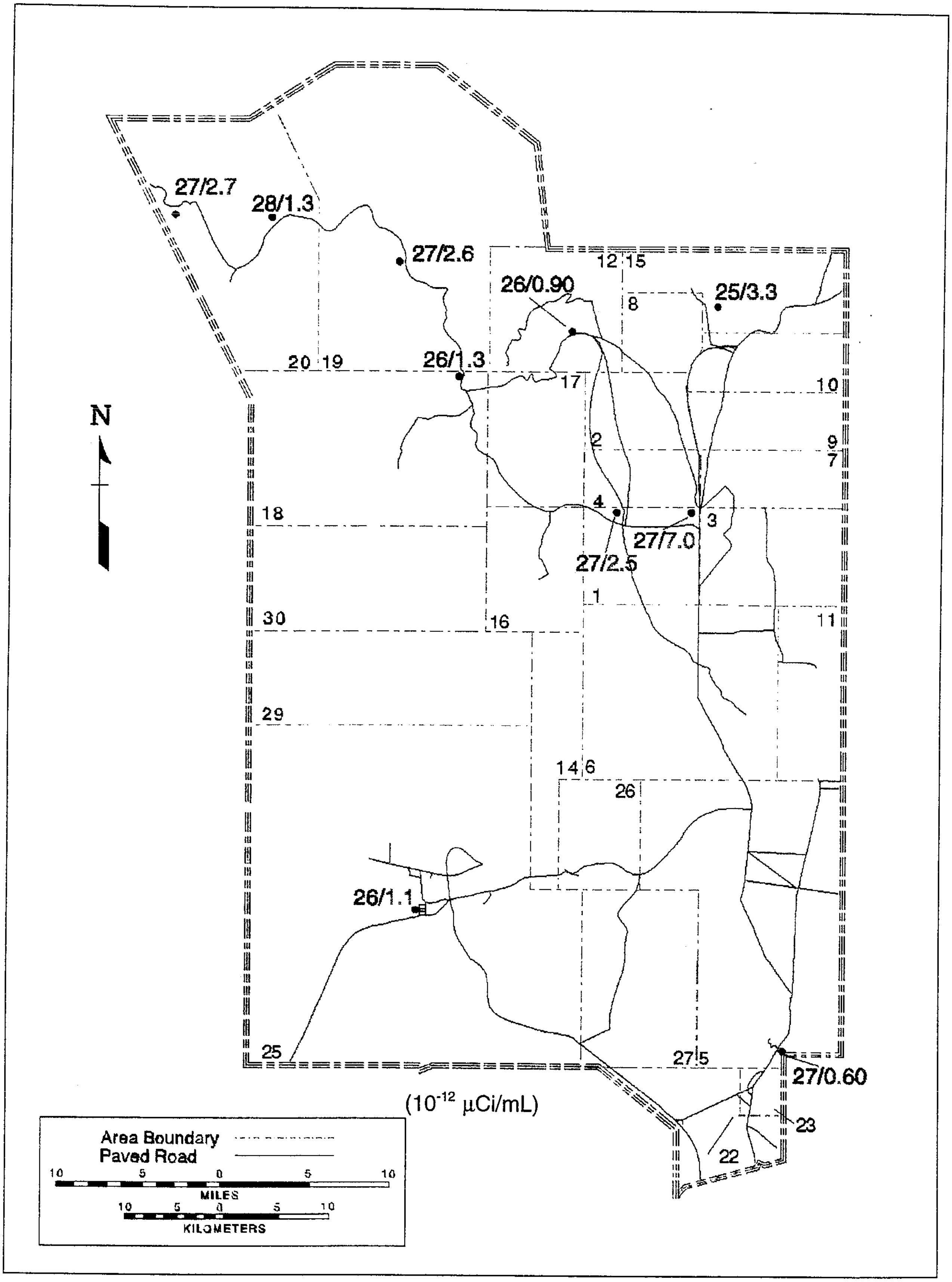


Figure 5.5 NTS ^{85}Kr/^{133}Xe Annual Average Concentrations - 1993

Table 5.7 Summary of NTS ^{85}Kr Concentrations - 1993

		^{85}Kr Concentration (10^{-12} µCi/mL)				
Location	Number	Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as % DCG
Area 1, BJY	39	38	20	27	4.4	<0.01
Area 1, Gravel Pit	37	47	18	27	6.0	<0.01
Area 5, Gate 200 S.	43	45	20	27	4.7	<0.01
Area 12, Camp	31	42	15	26	5.3	<0.01
Area 15, EPA Farm	37	32	18	25	3.5	<0.01
Area 18, Gate 400	38	40	16	26	4.8	<0.01
Area 19, Pahute Substation	25	44	14	27	7.9	<0.01
Area 20, Dispensary	27	40	17	28	5.7	<0.01
Area 20, DDZ77 Trans.	29	46	19	27	5.9	<0.01
Area 25, E-MAD	39	38	16	26	4.5	<0.01
All Stations	345	47	14	27	5.9	<0.01

Table 5.8 Summary of NTS ^{133}Xe Concentrations - 1993

		^{133}Xe Concentrations (10^{-12} µCi/mL)				
Location	Number	Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as % DCG
Area 1, BJY	31	90	-24	7.0	22	0.014
Area 1, Gravel Pit	29	31	-12	2.5	11	<0.01
Area 5, Gate 200	39	51	-23	0.60	17	<0.01
Area 12, Camp	30	26	-30	0.90	12	<0.01
Area 15, EPA Farm	33	46	-11	3.3	11	<0.01
Area 18, Gate 400	36	56	-63	1.3	24	<0.01
Area 19, Pahute Substation	22	100	-71	2.6	30	<0.01
Area 20, Dispensary	22	30	-66	1.3	21	<0.01
Area 20, DDZ77 Trans.	24	70	-54	2.7	23	<0.01
Area 25, E-MAD	33	67	-37	1.1	18	<0.01
All Stations	299	100	-71	2.3	24	<0.01

which is <0.01 percent of the DCG adjusted to an annual EDE of 10 mrem. The lowest annual average, 25 x 10^{-12} µCi/mL (0.93 Bq/m^3), occurred at the Area 15 Farm. The higher average for the samples collected at the Area 20 Dispensary was expected as it is in the northern portion of the NTS in the proximity of the sites where seepage of noble gases from the ground has been observed in the past.

Statistical evaluation of these data (see Appendix E) showed that the Area 20 Dispensary average concentration was not significantly higher than the other averages at the five percent significance level. Nevertheless, this station has been the highest for the last several years.

From the time series plots in Appendix E (Figures E.15 - E.25), no trend in concentrations was apparent. Each location had environmental levels of ^{85}Kr with occasional spikes attributed to seepage of noble gases from the Pahute Mesa area. All data since 1982 were evaluated for any trend in concentrations on the NTS (see Appendix E). From this evaluation the ^{85}Kr concentrations were found to have remained relatively constant over this period.

Xenon-133

Table 5.8 summarizes the ^{133}Xe results for samples collected at each location. The highest average concentration was 7.0 x 10^{-12} µCi/mL (0.26 Bq/m^3) at Area 1 BJY, which is in the northeastern portion of the test site. The lowest annual average was 6.0 x 10^{-13} µCi/mL (0.022 Bq/m^3) at Area 5 Gate 200. All average concentrations were below the minimum detectable concentration (MDC) of about 17 x 10^{-12} µCi/mL (0.63 Bq/m$^{3)}$), which is 0.034 percent of the DCG adjusted to an annual 10 mrem EDE.

A statistical evaluation of the ^{133}Xe data is contained in Appendix E. This evaluation showed that the differences in the annual average concentrations were not significant at the 5 percent significance level. The time series plots of the individual concentrations for each station showed no trend in concentrations. All of the concentrations varied around the MDC. Twenty-nine percent of the ^{133}Xe concentrations were slightly above the average MDC of 1.7 x 10^{-11} µCi/mL. However, these values were considered to be statistical anomalies and not due to any nuclear test. Since ^{133}Xe has a half-life of only 5.27 days, one would not expect any in the NTS environment because there have been no nuclear tests since 1992, and any xenon radioactivity from past tests would have decayed away.

5.2.1.4 TRITIATED WATER VAPOR SAMPLING RESULTS

The concentrations of tritiated water vapor determined from sampling conducted at 17 permanent sampling stations are summarized in Table 5.9. The individual results for each sample collected during the year are listed and plotted in Appendix B, which also includes a statistical evaluation of the data. As shown in Table 5.9, the location having the highest annual average tritium concentration was the Area 5 RWMS No. 7 Station with an average of 19 x 10^{-6} pCi/mL (0.70 Bq/m^3). This average was only 0.2 percent of the DCG for tritium adjusted for an annual EDE of 10 mrem. The annual average concentration at each station is shown on the map in Figure 5.6.

From the statistical evaluation, the data were found to be lognormally distributed, therefore the natural logarithms of the individual concentrations were used in a one-way analysis of variance to test for differences between station means (see Appendix B). This statistical

Table 5.9 Airborne Tritium Concentrations on the NTS - 1993

Location	Number	^{3}H Concentration (10^{-6} pCi/mL) Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as %DCG
Area 1, BJY	25	8.7	-0.66	1.7	2.4	0.02
Area 5, RWMS No. 1	24	19.	-3.3	4.3	4.6	0.04
Area 5, RWMS No. 2	23	11	-0.48	4.4	2.8	0.04
Area 5, RWMS No. 3	25	14	-0.23	3.8	3.4	0.04
Area 5, RWMS No. 4	20	68	-0.39	10	16	0.1
Area 5, RWMS No. 5	25	19	0.46	6.6	6.2	0.07
Area 5, RWMS No. 6	26	33	0.49	7.7	9.3	0.08
Area 5, RWMS No. 7	20	45	1.5	19.	15.	0.2
Area 5, RWMS No. 8	23	22	0.37	6.2	5.4	0.06
Area 5, RWMS No. 9	23	22	1.7	6.6	5.4	0.07
Area 10, Gate 700 South	24	7.9	-1.2	0.72	1.8	<0.01
Area 12, Complex	24	3.7	-0.93	0.42	1.1	<0.01
Area 15, EPA Farm	26	20	2.9	8.6	4.0	0.09
Area 23, Building 790 No. 2	23	3.9	1.8	0.78	1.5	<0.01
Area 23, East Boundary	26	1.5	-1.4	0.13	0.73	<0.01
Area 23, H&S Building	24	6.5	-1.0	0.36	1.6	<0.01
Area 25, E-MAD North	25	1.9	-2.2	0.17	0.99	<0.01
All Stations	406	68	-3.3	4.6	7.6	0.05

Average MDC ± 1 standard deviation was (1.6 ± 0.69) x 10^{-6} pCi/mL

testing also identified two separate groups. These groups are listed below in order of increasing median concentrations:

Lower Group	Higher Group
Area 23, H&S Building	Area 5, RWMS No. 3
Area 23, E. Boundary	Area 5, RWMS No. 1
Area 25, E-MAD North	Area 5, RWMS No. 2
Area 23, Building 790 No. 2	Area 5, RWMS No. 8
Area 1, BJY	Area 5, RWMS No. 6
Area 10, Gate 700 South	Area 5, RWMS No. 5
Area 12, Complex	Area 5, RWMS No. 4
	Area 5. RWMS No. 9
	Area 15, EPA Farm
	Area 5, RWMS No. 7

The lower group appears to include those locations where the majority of tritium concentrations were below the MDC. The higher group appears to represent those stations where concentrations were above the MDC. The highest and second highest annual averages were calculated from samples collected, respectively, at the Area 5 RWMS No. 7 and the Area 15 RWMS No. 4 locations.

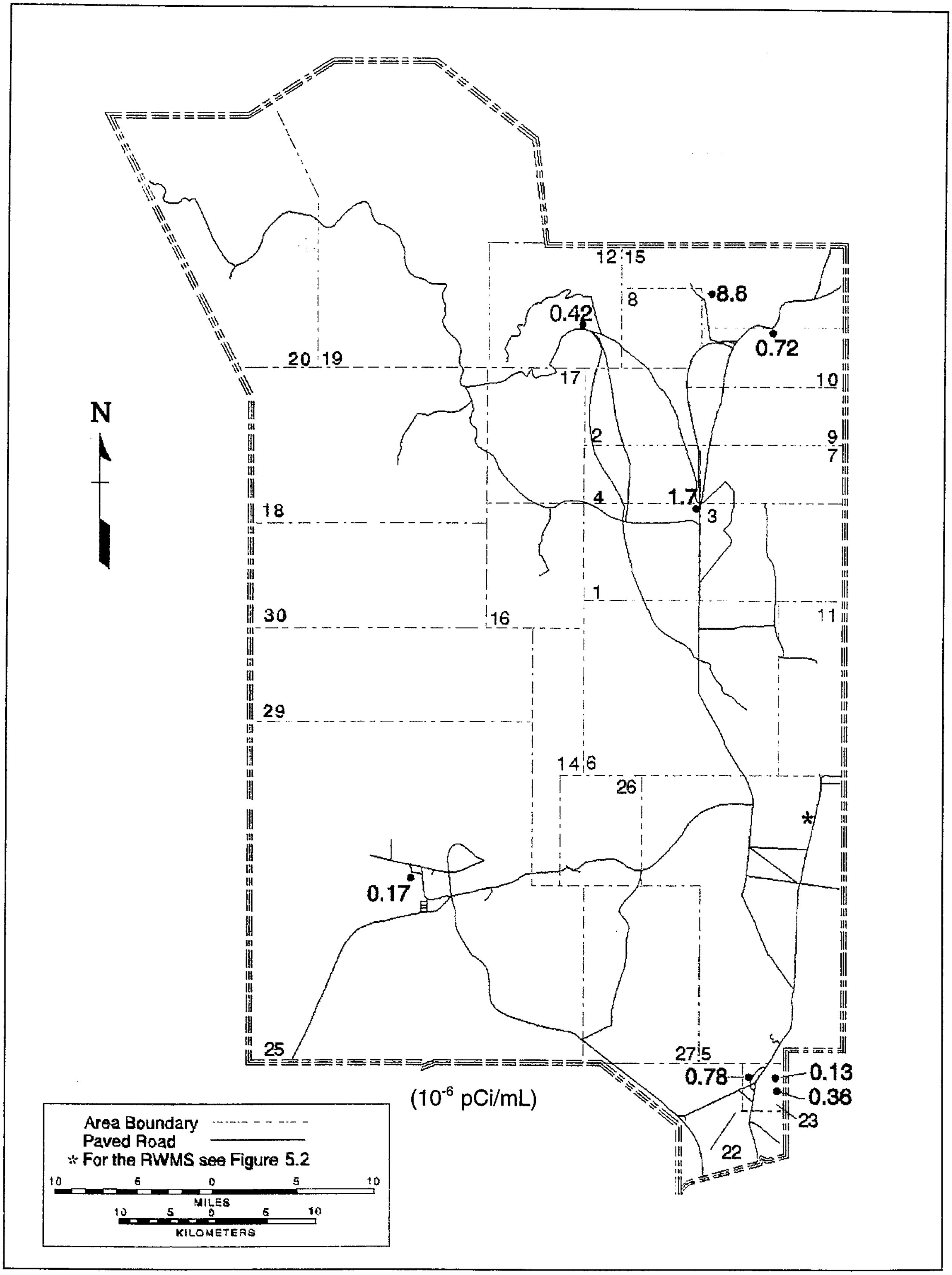


Figure 5.6 NTS Tritiated Water Vapor Annual Average Concentrations - 1993

A review of the historical trend in concentrations at the NTS (see Appendix B) over the years 1982 through 1993 was made. The review found that the average tritium concentration for all environmental stations showed an exponential decrease from about 1.4 x 10^{-4} pCi/mL in 1982 to about 4.0 x 10^{-5} pCi/mL in 1987, followed by a steady decrease to the current value, 4.6 x 10^{-6} pCi/mL. The same trend was observed at all environmental stations, including the RWMS stations, which implies that the RWMS, although emitting measurable tritium, may not be the major source of tritium at the NTS.

5.2.1.5 RADIOACTIVITY IN SURFACE WATER

Surface water sampling at the NTS was conducted at 15 open reservoirs, 7 natural springs, 9 containment ponds, 3 effluents, and 3 sewage lagoons. The locations of these sources are shown in Figure 4.4. When water was available and the weather permitted, a grab sample was taken each month from each surface water location. The sample was analyzed for ^{3}H, gross beta, and gamma activity. Each quarter an additional sample was collected and analyzed for ^{238}Pu and $^{239+240}$Pu, and in July a sample was collected for ^{90}Sr analysis. Surface water at the NTS was scarce during this year because of the continuing drought. Sources of surface water were, for the most part, man-made, created for or by NTS operations. There is no known human consumption of any surface water on the NTS. The data for all sampling locations are shown in Appendix C, Attachments C.1 through C.7.

The annual average for each radionuclide analyzed in surface waters is presented in Table 5.10, along with the results from analysis of tunnel effluents. The annual averages for open reservoirs and natural springs are compared to the DCGs for ingested water. Gamma results for all sample locations indicated that radionuclide levels were consistently below the detection limit except for samples from the containment ponds. All sampling results are presented in tabular form beginning with Appendix C, Attachment C.1. In each appendix table, the date of collection, the result, and its standard deviation (1s) counting error are presented.

With the exception of containment ponds, no annual average concentration in surface waters was found to be statistically different from any other at the five percent significance level. The analytical results from the Area 12 containment ponds showed measurable quantities of radioactivity and displayed identifiable trends.

OPEN RESERVOIRS

Open reservoirs have been established at various locations on the NTS for industrial uses. The annual average concentrations of radioactivity were compared to the DCGs for ingested water listed in DOE Order 5400.5, even though there was no known consumption of these waters. The appropriate data are shown in Table 5.11.

NATURAL SPRINGS

Of the nine natural springs found onsite, (i.e. spring-supplied pools located within the NTS) seven were consistently sampled. These springs were a source of drinking water for wild animals on the NTS. The annual average gross beta results for each spring are shown in Table 5.12 and compared to the ^{90}Sr DCG for drinking water; however, the water is not used for drinking. The highest result was for Reitman Seep which was still below the DCG.

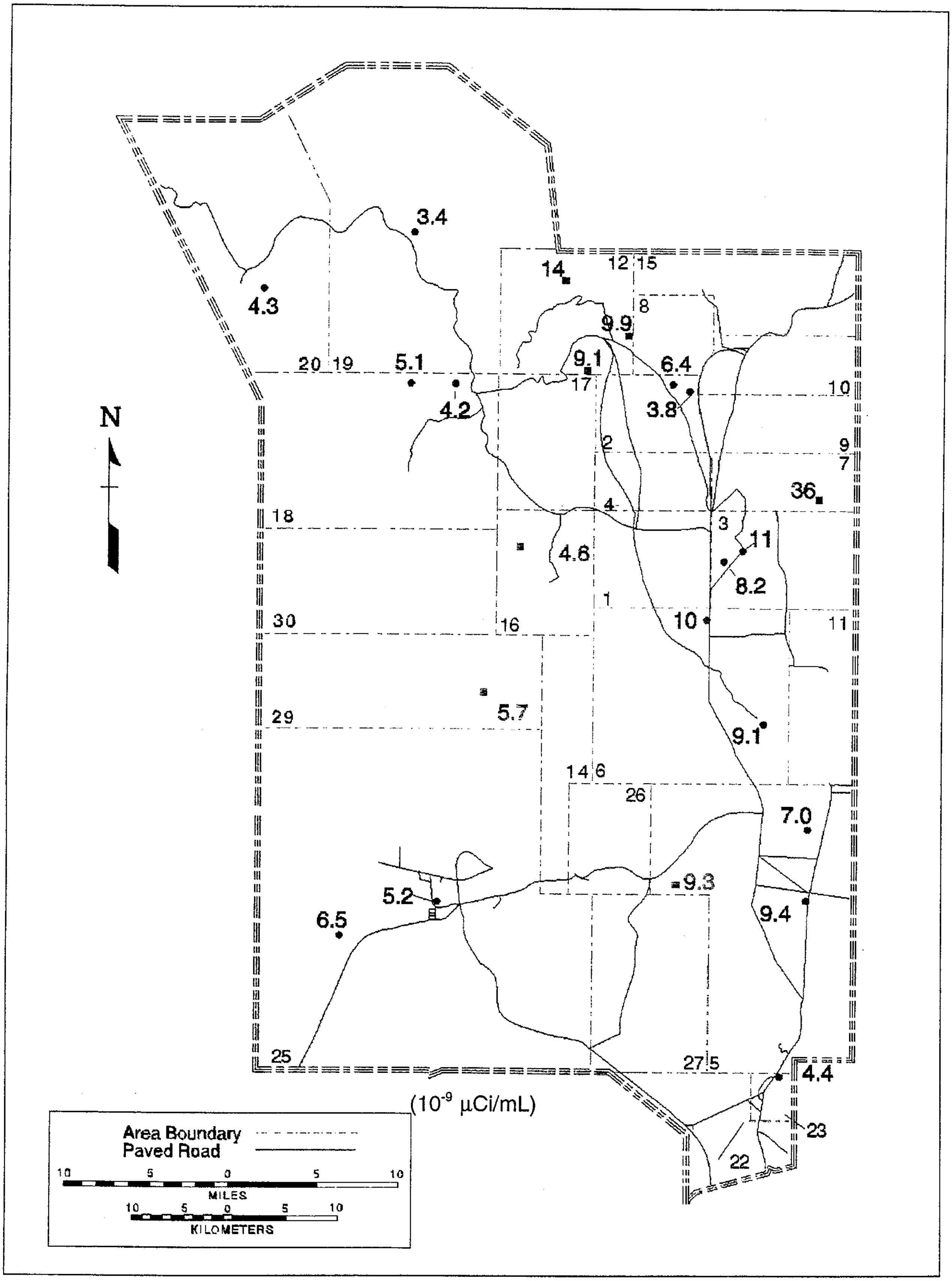


Figure 5.7 Annual Average Gross Beta in Open Reservoirs(•) and Natural Springs(■) - 1993

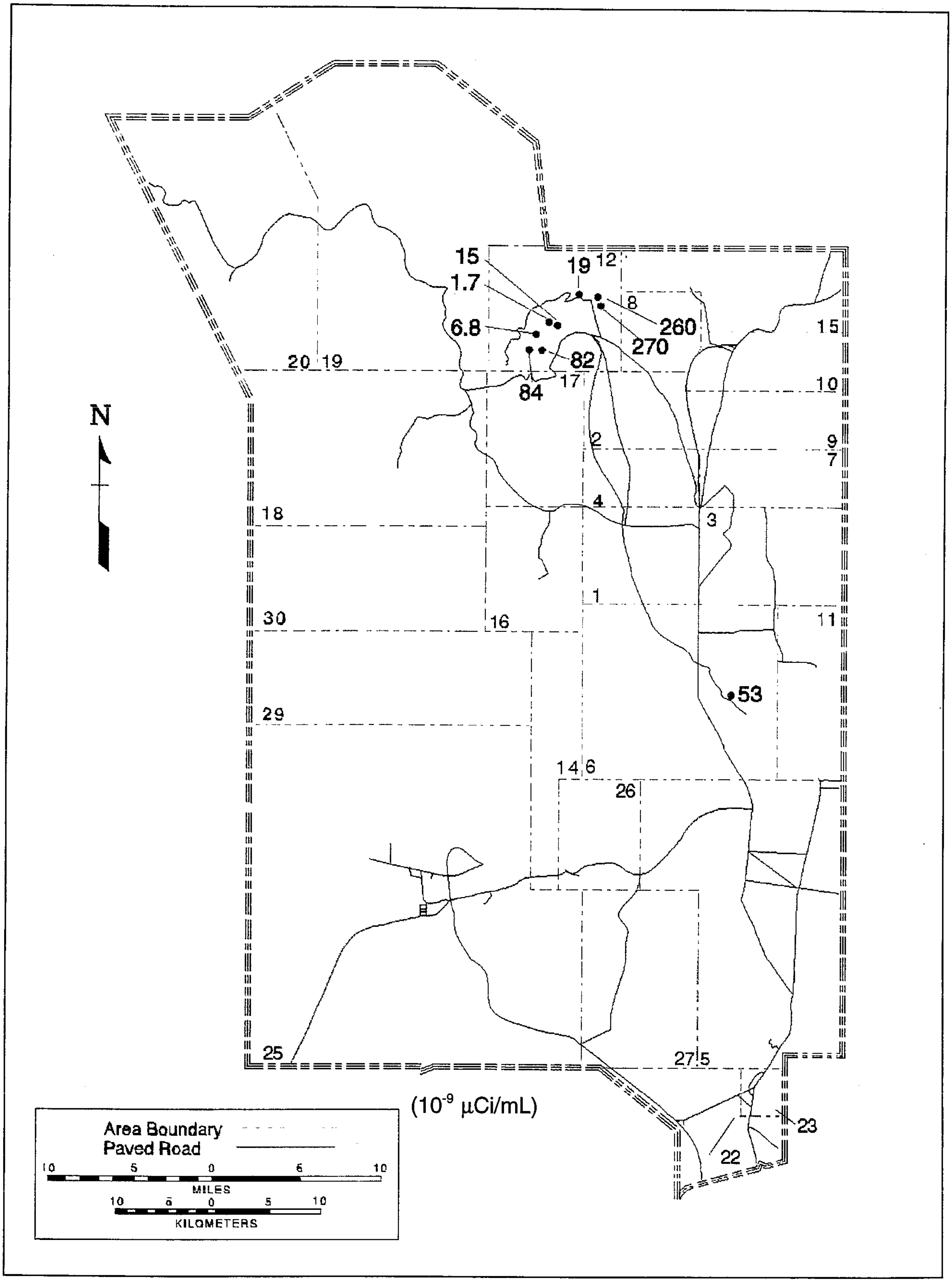


Figure 5.8 NTS Containment Pond Annual Average Gross Beta Concentrations - 1993

Table 5.10 Radioactivity in NTS Surface Waters - 1993

		(Annual Average Concentrations in units of 10^{-9} µCi/mL)					
Source of Water	Number of Locations	Gross β	Tritium	^{238}Pu	$^{239+240}$Pu	^{90}Sr[(a)]	% of DCG Range[(b)]
Open Reservoirs	15	5.7	-33	0.0011	0.20	0.13	0.069-24
Natural Springs	7	9.3	5.4	0.03	0.46	0.24	0.007-33
Containment Ponds							
T Tunnel	3	260.	3.1×10^7	0.028	0.81	NA	[(c)]
N Tunnel	3	5.3	2.2×10^5	0.00076	0.047	NA	[(c)]
E Tunnel	2	83	1.7×10^6	0.62	53	5.3	[(c)]
Decon Facility	1	53	1100	0.0	0.14	NA	[(c)]
Sewage Lagoons	3	24	67	0.0011	0.0082	0.13	[(c)]

(a) ^{90}Sr values are for one sample
(b) DCG based on value for drinking water (4 mrem EDE)
(c) Not a potable water source
NA Not analyzed

Table 5.11 NTS Open Reservoir Gross Beta Analysis Results - 1993

		Gross Beta Concentration (10^{-9} µCi/mL)				
Location	Number	Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as %DCG[(a)]
Area 2, Mud Plant Reservoir	12	9.7	1.4	3.8	2.1	9.5
Area 2, Well 2 Reservoir	12	12	4.0	6.4	2.2	16
Area 3, Mud Plant Reservoir	12	18	2.8	11	3.5	28
Area 3, Well A Reservoir	12	12	0.085	8.2	3.2	21
Area 5, UE-5c Reservoir	11	8.9	5.2	7.0	1.2	18
Area 5, Well 5B Reservoir	11	15	4.8	9.4	3.2	24
Area 6, Well 3 Reservoir	2	12	9.1	10	1.9	25
Area 6, Well C1 Reservoir	12	19	0.52	9.1	4.9	23
Area 18, Camp 17 Reservoir	11	8.7	2.8	4.2	1.6	11
Area 18, Well 8 Reservoir	3	6.1	3.8	5.1	1.2	13
Area 19, UE-19c Reservoir	10	12	1.4	3.4	3.0	8.5
Area 20, Well 20A Reservoir	7	12	1.1	4.3	3.6	11
Area 23, Swimming Pool	12	6.3	3.2	4.4	1.1	11
Area 25, Well J-11 Reservoir[(b)]	12	6.5	3.7	5.2	0.88	13
Area 25, Well J-12 Reservoir	12	9.5	4.8	6.5	1.6	16

(a) DCG based on ^{90}Sr value for drinking water (4 mrem EDE)
(b) Summary for this location excludes anomalous value of 4.5×10^{-7} µCi/mL

Table 5.12 NTS Natural Spring Gross Beta Analysis Results - 1993

		Gross Beta Concentration (10^{-9} μCi/mL)				
Location	Number	Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as %DCG(a)
Area 5, Cane Spring	12	24	2.0	9.3	6.3	23
Area 7, Reitmann Seep	12	100	19	36	23	90
Area 12, Captain Jack	8	18	5.0	9.1	4.1	23
Area 12, Gold Meadows	5	23	8.1	14	7.5	35
Area 12, White Rock Spring	12	13	7.0	9.9	1.9	25
Area 16, Tippipah Spring	12	7.3	3.2	4.6	1.1	12
Area 29, Topopah Spring	10	8.4	4.2	5.7	1.5	14

(a) DCG based on ^{90}Sr value for drinking water (4 mrem EDE)

CONTAINMENT PONDS

Nine sites related to containment ponds were sampled monthly. These were 5 ponds containing impounded waters from the tunnels, 3 liquid effluents discharged from the tunnels and a contaminated laundry pond. All active containment ponds were fenced and restricted access areas posted with radiological warning signs. The average gross beta concentration for each containment pond is shown in Figure 5.8. At each tunnel complex, a grab sample was taken from all active containment ponds and at the effluent discharge point. A grab sample was also taken monthly from the Area 6 Decontamination Facility containment pond. All samples taken from these sources were analyzed for ^{3}H, ^{90}Sr, ^{238}Pu, $^{239+240}$Pu, gross beta, and gamma activity in accordance with the schedule of Table 4.1.

The annual average of gross beta analyses from each sampling location is listed in Table 5.13 and compared to the DCG for ingested water; however, the water is not used for drinking. All data and statistical analyses are listed in Appendix C, Attachments C.1 to C.7.

AREA 6 DECONTAMINATION FACILITY POND

Since the closing of the Decontamination Facility on November 8, 1992, no wastewater has been discharged into the facility pond. As the water and soil in the area are contaminated, grab water samples were collected from the pond monthly when possible. As the water level has receded, sample collection has become difficult.

SEWAGE LAGOONS

As in the past, samples from Area 6, 12, and 23 sewage lagoons were collected quarterly during this year. During the month of November, sampling was expanded to include all sewage lagoons that are in use, which amounted to an increase of six lagoons. Each of the lagoons is part of a closed system used for evaporative treatment of sanitary waste. The lagoons are located in Areas 6, 12, 22, and 23. There was no known contact by the working population during the year. The annual gross beta concentration averages for the 3 lagoons ranged between 2.0 and 3.1 x 10^{-8} μCi/mL (0.7 to 1.1 Bq/L). The data for the new lagoons was similar. No radioactivity was detected above the MDCs for tritium and ^{238}Pu. Levels of ^{90}Sr slightly above the MDC were detected in samples collected at the Area 6 DAF Sewage

Table 5.13 NTS Containment Pond Gross Beta Analysis Results - 1993

Location	Number	Gross Beta Concentration (10^{-9} µCi/mL) Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as %DCG[(a)]
Area 6, Decontamination Facility Pond	7	83	33	53	20	130
Area 12, E Tunnel Effluent	12	170	51	84	34	210
Area 12, E Tunnel Pond No. 1	10	130	53	82	29	210
Area 12, N Tunnel Effluent	5	22	-1.4	6.8	9.2	17
Area 12, N Tunnel Pond No. 1[(b)]	-	-	-	-	-	-
Area 12, N Tunnel Pond No. 2	2	7.7	-4.3	1.7	8.5	4.3
Area 12, N Tunnel Pond No. 3	3	20	6.1	15	7.7	3.8
Area 12, T Tunnel Effluent	6	360	-3.9	19	160	48
Area 12, T Tunnel Pond No. 1[(b)]	-	-	-	-	-	-
Area 12, T Tunnel Pond No. 2	4	310	170	260	58	650
Area 12, T Tunnel Pond No. 3	4	330	180	270	69	680

(a) DCG based on ^{90}Sr value for drinking water (4 mrem EDE)
(b) Pond dry

Pond, the Area 6 Sewage Pond, and the Area 12 Sewage Pond. Levels of $^{239+240}$Pu were also detected slightly above the MDC in two samples collected from the Area 6 Sewage Pond. No event-related radioactivity was detected by gamma spectrometry analyses. The analytical results for individual samples can be found in Appendix C.

5.2.1.6 RADIOACTIVITY IN SUPPLY WELL 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 now consists of 12 supply wells (operation of wells UE-15d and UE-19c has ceased) 10 of which supply potable water to onsite distribution systems. The drinking water is pumped from the wells to the points of consumption. The supply wells are sampled on a monthly basis. Occasionally, some operational problems interrupt the sampling schedule. All drinking water is sampled weekly at end-points to provide a constant check of the radioactivity and to allow frequent end-use activity comparisons to the radioactivity of the water in the supply wells. In this section are presented the analytical results from samples taken at the 12 supply wells which furnished the water for consumption and industrial use at the NTS during 1993. Each well was sampled and analyzed in accordance with the schedule in Table 4.1.

The locations of the supply wells are shown in Figure 5.9. Water from these wells (10 potable and 2 non-potable) was used for a variety of purposes during 1993. Samples were collected from those wells which could potentially provide water for onsite human consumption. These data were used to help document the radiological characteristics of the NTS groundwater system. The sample results were maintained in a data base so that long-term trends and changes could be studied. Table 5.14 lists the potable and non-potable supply wells and their respective radioactivity averages; no event-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.

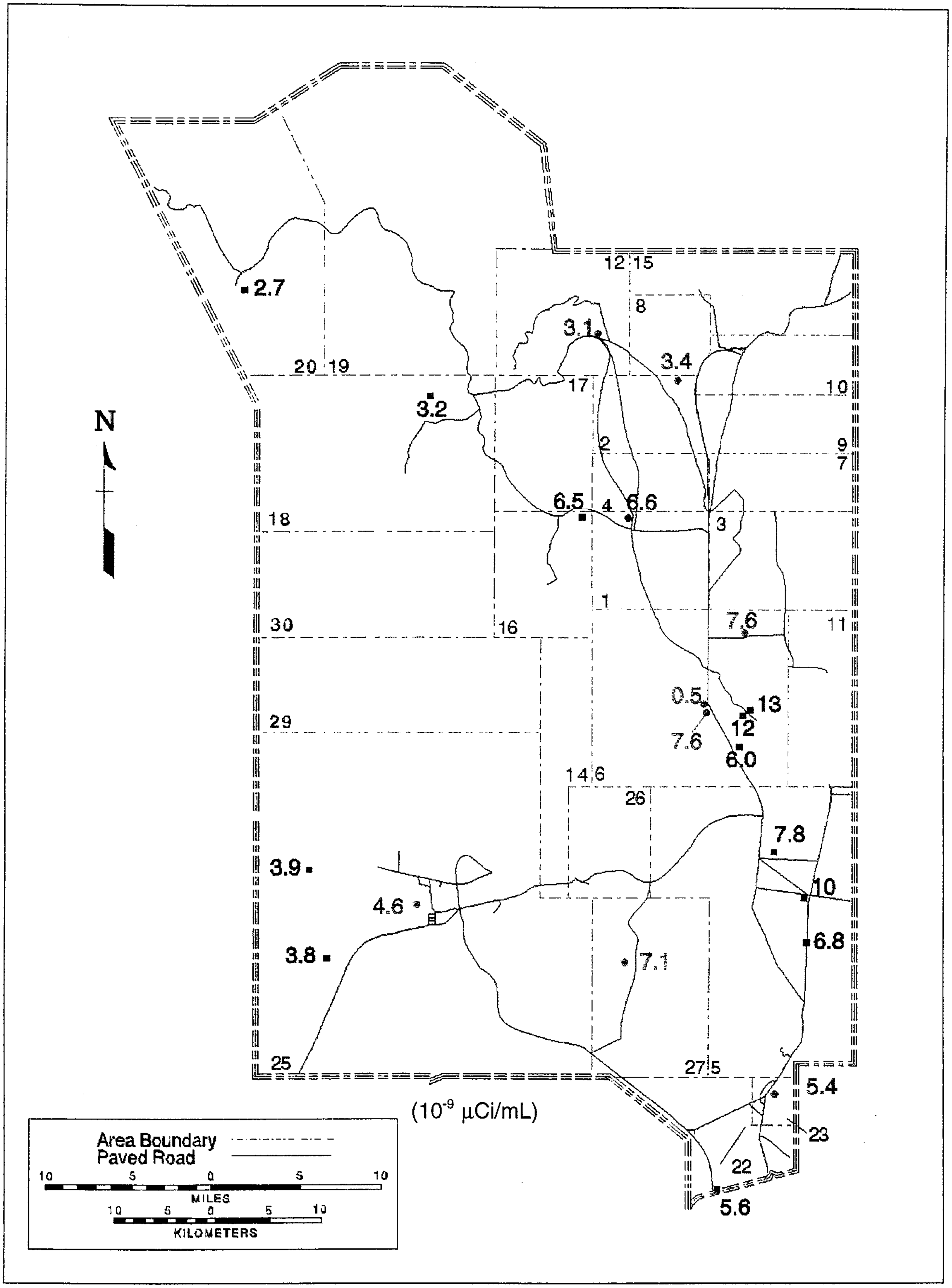


Figure 5.9 Annual Average Gross Beta in Supply Wells (■) and Potable Water (•) - 1993

Table 5.14 NTS Supply Well Radioactivity Averages - 1993

	µCi/mL					
Description	Gross Beta	^{3}H(a)	$^{239+240}$Pu	^{238}Pu	Gross Alpha	^{90}Sr(b)
Potable Water Supply Wells						
Area 5, Well 5C	6.8×10^{-9}	2.5×10^{-9}	-1.1×10^{-11}	-1.6×10^{-11}	1.1×10^{-8}	6.3×10^{-11}
Area 6, Well No. 4	6.0×10^{-9}	2.3×10^{-9}	-8.5×10^{-12}	-1.0×10^{-11}	9.7×10^{-9}	4.5×10^{-11}
Area 5, Well 5B(c)	1.0×10^{-8}	9.3×10^{-10}	1.7×10^{-12}	1.4×10^{-12}	5.7×10^{-9}	-4.3×10^{-11}
Area 6, Well C	1.3×10^{-8}	2.5×10^{-8}	-1.1×10^{-11}	-8.6×10^{-12}	9.3×10^{-9}	1.4×10^{-10}
Area 6, Well C1	1.2×10^{-8}	5.5×10^{-9}	-5.8×10^{-12}	3.5×10^{-12}	8.3×10^{-9}	1.0×10^{-10}
Area 16, Well UE-16d	6.5×10^{-9}	1.9×10^{-9}	-5.5×10^{-12}	-8.0×10^{-12}	8.7×10^{-9}	5.7×10^{-11}
Area 18, Well 8	3.2×10^{-9}	2.7×10^{-9}	-8.2×10^{-12}	-4.8×10^{-12}	6.2×10^{-10}	7.8×10^{-11}
Area 22, Army Well No. 1	5.6×10^{-9}	3.4×10^{-9}	-9.4×10^{-12}	-6.6×10^{-12}	4.5×10^{-9}	1.8×10^{-13}
Area 25, Well J-12	3.8×10^{-9}	2.7×10^{-9}	-7.0×10^{-12}	-1.0×10^{-11}	9.3×10^{-10}	1.1×10^{-10}
Area 25, Well J-13	3.9×10^{-9}	2.7×10^{-9}	-6.9×10^{-12}	-6.9×10^{-12}	2.2×10^{-9}	-2.6×10^{-11}
Non-Potable Water Supply Wells						
Area 5, Well UE-5c	7.8×10^{-9}	6.7×10^{-8}	3.4×10^{-12}	5.6×10^{-13}	NA	3.2×10^{-11}
Area 19, Well UE-19c(d)	-	-	-	-	-	-
Area 20, Well U-20	2.7×10^{-9}	1.2×10^{-7}	4.7×10^{-12}	4.7×10^{-12}	NA	5.2×10^{-10}
Median MDC	7.6×10^{-10}	4.5×10^{-7}	1.1×10^{-11}	1.1×10^{-11}	8.6×10^{-10}	1.4×10^{-10}

(a) Enrichment analysis (MDC ≈ 9×10^{-9} µCi/mL [0.33 Bq/L]) for ^{3}H in potable well water; for non-potable wells ^{3}H is by conventional analysis (MDC ≈ 4.5×10^{-7} µCi/mL [17 Bq/L])
(b) ^{90}Sr values for the non-potable supply wells are for one sample
(c) Only three samples collected; power unavailable; only one analyzed by tritium enrichment
(d) Pump broken down and no plans to repair
NA Not analyzed

For various operational reasons, samples could not be collected from each location every month. Due to the limited operation of the Area 5 Well 5b, only three water samples were collected during the year. In August 1993 Well 5b was also authorized for use as a potable water supply well. As the result of pump break-down and the closing of Area 20, only one sample was collected from Well U-20. Individual sampling results are presented in Appendix C, Attachments C.1 to C.7, and statistical discussions of the samples are found at the beginning of Appendix C.

Gross Beta

As shown in Table 5.14, the gross beta concentration averages for all the supply wells were above the median MDC of the measurement. The highest average gross beta activity for potable supply wells, occurring at Well C, was 1.3×10^{-8} µCi/mL (0.48 Bq/L), which was 4.3 percent of the DCG for ^{40}K and 33 percent of the DCG for ^{90}Sr based upon 4 mrem EDE per year. In previous reports (Scoggins 1983 and Scoggins 1984), it was shown that the majority of gross beta activity was attributable to naturally occurring ^{40}K. The gross beta annual averages are shown at their supply well sampling locations in Figure 5.9. All concentration averages were comparable to those reported last year.

Tritium

As shown in Table 5.14 the average tritium concentrations at all locations, except Well C, were below the average MDC of the measurement (note that the MDC was 9 x 10^{-9} µCi/mL for the tritium enrichment analyses performed on the potable supply wells samples but was 4.5 x 10^{-7} µCi/mL for the conventional analyses on the non-potable well samples).

Plutonium

All supply water samples analyzed for ^{238}Pu and $^{239+240}$Pu had concentrations below their respective MDCs of about 1.1 x 10^{-11} µCi/mL and 1.1 x 10^{-11} µCi/mL, which are 0.6 percent and 1.7 percent of their respective DCGs adjusted to a 4 mrem EDE per year. Table 5.14 lists the concentration averages for these nuclides for each location.

Gross Alpha

As shown in Table 5.14, the average gross alpha concentration for all of the supply wells, except for Well 8, was above the median MDC of 8.6 x 10^{-10} µCi/mL. The highest concentration occurred in samples from the Area 5 Well 5C, a source for potable water, and was 1.1 x 10^{-8} µCi/mL (0.41 Bq/L). This is acceptable according to the EPA drinking water standard as long as the combined concentration of ^{226}Ra and ^{228}Ra is less than 5 x 10^{-9} µCi/mL (0.18 Bq/L). The combined Ra concentration for this well was less than this at 2.4 x 10^{-10} µCi/mL (0.009 Bq/L).

Strontium

Beginning in 1993, ^{90}Sr analyses were performed quarterly instead of annually on samples collected from the potable supply wells. Note that the values for the ^{90}Sr analyses performed on the non-potable supply wells are for single samples and not an average. Concentrations of ^{90}Sr slightly above the MDC of the measurement were reported for samples collected from seven of the supply wells, however, as shown in Table 5.14, the average concentrations were below the median MDC of 1.4 x 10^{-10} µCi/mL (0.005 Bq/L) except for the single sample collected from the Area 20 Well U-20, which had the highest concentration, 5.2 x 10^{-10} µCi/mL (0.019 Bq /L). This high result is attributed to counting statistics as the standard deviation of the result due to counting error was 2.8 x 10^{-10}. This concentration value for Well U-20 was 1.3 percent of the DCG adjusted to a 4 mrem (0.04 mSv) EDE per year.

5.2.1.7 RADIOACTIVITY IN DRINKING WATER

As a check on any effect the water distribution system might have on water quality, eight end-points (labelled potable water in Figure 5.9) were sampled. In order to be certain that all of the water available for consumption was being considered, each drinking water system has been identified and sampled. The drinking water network at the NTS was found to consist of five drinking water systems. The components of the five are shown in Table 5.15. The five drinking water systems, fed by ten potable supply wells, are the source of the water for seven end-points. Water from the eighth end-point, Area 6 Bottled Water, is provided by a commercial vendor.

Table 5.15 NTS Drinking Water Sources - 1993

System	Supply Wells	End-point
No. 1	Wells C, C1, No. 4	Area 6, Cafeteria Area 6, Building 6-900
No. 2	Well 8	Area 2, Rest Room Area 12, Cafeteria (Closed in February 1993)
No. 3	Well UE-16d	Area 1, Building 101
No. 4	Wells 5B, Well 5C, and Army No. 1	Area 23, Cafeteria
No. 5	Wells J-12, J-13	Area 25, Building 4221
--	None	Area 6, Bottled Water

Table 5.16 lists the annual concentration averages for all the analyses performed on the samples collected from the end-use consumption points. The individual results for these analyses and for the gamma spectrometry analyses are listed in Volume II, Appendix C. No event-related radionuclides were detected by gamma spectrometry.

Gross Beta

As in previous years, the gross beta concentration averages for all end-points (except for Area 6, Bottled Water) were above the median MDC of the measurements. The highest annual average occurred in Area 6 Cafeteria and Building 6-900 samples, 7.6×10^{-9} µCi/mL (0.28 Bq/L). This annual average was 2.5 percent of the DCG for ^{40}K adjusted to an annual 4 mrem EDE. The locations and results for all potable water stations are shown in Figure 5.9.

To determine whether the average gross beta concentration for each end-point sampling location was greater than the average gross beta concentration of the supply well(s) providing the water to the end-point, a statistical evaluation was performed using a form of the Student's t-statistic which ignored time dependency and assumed independence of the wells. As certain end-points draw water from more than one supply well, the supply wells were assumed to contribute equally to the end-points to which they contribute. The results of this evaluation concluded that the end-point averages were not greater than the average of the supply well(s) at the 5 percent significance level except for the samples collected from Building 4221, Well J-12, and Well J-13, which failed the statistical evaluation. No explanation for this very small difference was found.

Tritium

The annual average tritium concentrations were all less than the median minimum detectable concentration of 4.5×10^{-7} µCi/mL provided that the anomalously high values, referred to in Table 5.16, are omitted from the calculation of the average for the Area 6 Bottled Water. As these high results are not corroborated by the results of samples collected before or after their collection dates, the values are not believed to be valid. The tritium concentrations for all end-point water samples are expected to be lower than the MDC because the levels of tritium in the potable supply wells were below or near the median tritium enrichment MDC of 9×10^{-9} µCi/mL (0.33 Bq/L). These MDC values of 4.5×10^{-7} and 9×10^{-9} µCi/mL are 0.5 percent and 0.01 percent, respectively, of the drinking water DCG adjusted to a 4 mrem (0.04 mSv) EDE per year.

Table 5.16 Radioactivity Averages for NTS End-Use Consumption Points - 1993

	μCi/mL					
Description	Gross Beta	^{3}H(a)	$^{239+240}$Pu	^{238}Pu	Gross Alpha	^{90}Sr(b)
Area 1, Building 101	6.6×10^{-9}	5.3×10^{-8}	0.0	1.2×10^{-12}	6.3×10^{-9}	6.8×10^{-11}
Area 2, Restroom	3.4×10^{-9}	1.1×10^{-8}	2.3×10^{-12}	8.0×10^{-12}	5.4×10^{-10}	-2.8×10^{-11}
Area 6, Bottled Water	4.5×10^{-10}	1.1×10^{-7}(c)	1.3×10^{-12}	1.0×10^{-12}	7.7×10^{-11}	6.2×10^{-12}
Area 6, Cafeteria	7.6×10^{-9}	6.0×10^{-8}(d)	2.3×10^{-12}	0.0	9.7×10^{-9}	3.0×10^{-10}
Area 6, Building 6-900	7.6×10^{-9}	-2.0×10^{-8}	7.2×10^{-13}	2.1×10^{-12}	1.0×10^{-8}	-1.7×10^{-10}
Area 12, Cafeteria	3.1×10^{-9}	6.8×10^{-8}	2.0×10^{-12}	0.0	5.3×10^{-10}	NA
Area 23, Cafeteria	5.4×10^{-9}	2.9×10^{-8}	2.1×10^{-12}	0.0	4.4×10^{-9}	2.1×10^{-10}
Area 25, Building 4221	4.6×10^{-9}	1.2×10^{-8}	9.6×10^{-13}	1.2×10^{-12}	1.4×10^{-9}	1.2×10^{-10}
Median MDC	7.6×10^{-10}	4.5×10^{-7}	1.1×10^{-11}	1.1×10^{-11}	8.6×10^{-10}	1.4×10^{-10}

(a) Analysis was by conventional method
(b) ^{90}Sr values are for one sample
(c) With two anomalous values omitted the mean concentration is 3.4×10^{-9} μCi/mL
(d) With two anomalous values omitted the mean concentration is -9.0×10^{-9} μCi/mL
NA Not analyzed

Plutonium

The annual averages of $^{239+240}$Pu and ^{238}Pu for each end-point were below the median MDC of the measurements, which were 1.1 and 0.6 percent of the DCG adjusted to an EDE of 4 mrem (0.04 mSv) per year. Normally, these radionuclides are not detected in drinking water.

Gross Alpha

In accordance with the National Primary Drinking Water Regulations (40CFR141), gross alpha measurements were made on quarterly samples from the drinking water systems, namely the potable supply wells reported in the previous section of this report. 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 samples from the end-points. As shown in Table 5.16, the annual concentration averages for gross alpha radioactivity in samples collected at three of the end-points exceeded the screening level at which ^{226}Ra analysis is required, 5×10^{-9} μCi/mL (5 pCi/L or 0.19 Bq/L). Samples from the supply wells were collected and analyzed for both ^{226}Ra and ^{228}Ra. As shown by the radium results in Table 5.17, the sum of the average concentrations for ^{226}Ra and ^{228}Ra were all less than 5 pCi/L. Therefore the onsite drinking water was in compliance with drinking water regulations.

Strontium

As indicated by Table 5.16, ^{90}Sr results for samples from two end-points had concentrations that were above the median MDC of the measurements. This is attributed to the uncertainty of the analysis, not the presence of ^{90}Sr, because the 2 standard deviation counting error for each measurement was about equal to the counting result. The highest concentration of ^{90}Sr, 3.0×10^{-10} μCi/mL (0.011 Bq/L) in a sample collected at the Area 6 Cafeteria, was 1.0 percent of the DCG adjusted to 4 mrem (0.04 mSv) EDE per year.

Table 5.17 Radium Analysis Results for NTS Drinking Water - 1993

Location	Number	Concentrations (10^{-9} µCi/mL) ^{226}Ra Arithmetic Mean	Standard Deviation	^{228}Ra Arithmetic Mean	Standard Deviation
Area 5, Well 5B	1	0.32	-	0.0	-
Area 5, Well 5C	2	0.16	0.85	0.082	0.24
Area 6, Well 4	3	0.12	0.49	0.33	0.083
Area 6, Well C	3	1.1	0.73	0.17	0.036
Area 6, Well C-1	2	1.1	1.6	0.50	0.51
Area 16, Well UE-16d	2	1.8	0.34	0.64	0.031
Area 18, Well 8	3	0.17	0.26	0.33	0.28
Area 23, Army Well No. 1	3	0.55	0.54	0.25	0.29
Area 25, Well J-12	3	0.38	0.59	-0.19	0.38
Area 25, Well J-13	3	-0.23	0.41	0.023	0.36

5.2.1.8 EXTERNAL GAMMA EXPOSURES - ONSITE AREA

TLDs were deployed at 193 locations throughout the NTS to measure ambient gamma radiation levels. These dosimeters were manufactured by Panasonic and designed to measure the typical levels of gamma radiation present in the environment, though not consistently. For example, the boundary stations average was 11 percent higher than last year, but the control stations were 29 percent higher.

The environmental TLD data presented herein should be viewed with caution since analysis has shown that the network average is 15 percent higher than it was last year. Since the annual averages for the past several years have remained fairly constant and since there was no nuclear testing or other activity that could have caused this increase, the results are suspect. The entire TLD procedure is being investigated, and a report of the findings will be included in the 1994 Annual Site Environmental Report (ASER).

The average levels of environmental gamma exposures recorded during 1993 were statistically different within different NTS areas, as has been noted previously, but a pattern of differences within areas cannot be elucidated because of vastly different numbers of TLDs from the areas involved. Using only environmental data, i.e., excluding atypical readings and readings from the vicinity of known radiation sources, it also appears that the overall exposure rates for the first three quarters are slightly lower than the overall rate for the fourth quarter. The reason for this difference is not apparent.

TLDs measured gamma exposures which ranged from 90 to 4313 mR/year. A plot of the data subsequent to removal of the obvious outlier data and the data from known radiation areas shows that the TLD results were normally distributed about a mean of 172 mR/year. The data that were removed ranged from 318 to 4313 mR/year.

Statistical analyses of the TLD data are presented in Appendix F. Table F.1 in that appendix contains a summary of the individual TLD results. Table 5.18 displays the results of gamma monitoring conducted at the NTS boundary. These locations were close to the NTS boundary and a few were reachable only via helicopter. The data collected at these locations were not statistically different from the control location data. The boundary TLDs for the second quarter of 1993 were collected but were inadvertently annealed so readout was impossible..

A group of locations which were not, to the best available knowledge, influenced by radiological contamination, served as controls for the NTS. The data from these locations are presented in Table 5.19. The overall network exposure range for the control locations for 1993 was 0.25 to 0.46 mR/day, with an average exposure rate of 0.36 mR/day or 131 mR/year.

An investigation of historical trends in onsite environmental gamma levels as measured by the TLD network showed no significant differences between years until 1993, except for data from 1987 (dosimetry system changed) and 1988 (due to a calibration problem). A description of this analysis is found in Appendix G.

5.2.2 OFFSITE ENVIRONMENTAL SURVEILLANCE

The primary purpose of the offsite environmental surveillance program operated by EMSL-LV is to detect any radioactivity related to current NTS activities which could potentially result in human exposure. Therefore, monitoring is concentrated on possible human exposure pathways and monitoring locations are generally in inhabited areas around the NTS. Monitoring sites are not designed to provide full spatial characterization of the offsite area, nor is the monitoring designed to detect all types of radioactivity arising from all natural and manmade sources. Possible exposure pathways monitored include air, water, milk, domestic and game animals, and locally grown fruits and vegetables. Alpha, beta, and gamma radiation in air are monitored in the Air Surveillance Network (ASN), comprised of 30 continuously operating stations around the NTS and 77 standby samplers (SASN) in states west of the Mississippi River. Custom-designed noble gas samplers and atmospheric moisture samplers are continuously operated at 13 locations around the NTS and identical samplers are maintained on standby status at another seven locations.. In Salt Lake City, atmospheric moisture is continuously monitored while a noble gas sampler is maintained on standby status. Groundwater and some surface water supplies are sampled regularly in the Long-Term Hydrological Monitoring Program (LTHMP). Water sampling locations include 37 wells on the NTS or immediately outside its borders and 32 locations in the offsite area. The Milk Surveillance Network (MSN) consists of 24 locations sampled monthly, including family-owned cows and goats and commercial dairies in the immediate offsite area. In addition, most major milksheds west of the Mississippi River, represented by 110 locations in 1993, are sampled annually through the Standby Milk Surveillance Network (SMSN). Cattle from ranches in the offsite area, mule deer from the NTS, and bighorn sheep hunted in Nevada are all included in the Biomonitoring Network, as are locally grown fruits and vegetables obtained by donation from residents.

In addition to the networks described above, external gamma radiation is monitored by the Pressurized Ion Chamber (PIC) Network and the Thermoluminescent Dosimeter (TLD) Network. The PIC network includes 27 stations, excluding two assigned to the Yucca Mountain Program, that are connected by satellite telemetry to the NTS for real-time data collection. Approximately 65 local residents voluntarily participate in the TLD network and another 127 TLDs are located at fixed environmental stations. In 1993, 56 offsite residents participated in the Offsite Dosimetry Network which includes an annual whole body and lung count and urinalysis. Internal dosimetry monitoring was also conducted for occupationally exposed workers under the Radiological Safety Program.

Table 5.18 NTS Boundary Gamma Monitoring Result Summary - 1993

Area	Location	First Quarter (mR/day)	Second Quarter (mR/day)	Third Quarter (mR/day)	Fourth Quarter (mR/day)	Average (mR/day)	1992 Annual Exposure (mR/yr)	1993 Annual Exposure (mR/yr)
3	Boundary TLD Station 358	0.28	(a)	0.33	0.23	0.28	88	102
15	Boundary TLD Station 356	0.52	(a)	0.24	0.45	0.40	172	147
10	Boundary TLD Station 357	0.43	(a)	0.35	0.26	0.35	102	127
11	Boundary TLD Station 359	0.53	(a)	0.67	0.44	0.55	172	200
5	Boundary TLD Station 360	0.25	(a)	0.32	0.22	0.26	77	96
12	Boundary TLD Station 355	0.31	(a)	0.47	0.33	0.37	117	135
20	Boundary TLD Station 352	0.35	(a)	0.44	0.29	0.36	117	131
19	Boundary TLD Station 353	0.48	(a)	0.49	0.43	0.46	150	170
19	Boundary TLD Station 354	0.40	(a)	0.50	0.44	0.45	154	163
20	Boundary TLD Station 350	0.62	(a)	0.83	0.52	0.66	205	240
20	Boundary TLD Station 351	0.51	(a)	0.49	0.47	0.49	187	179
22	Boundary TLD Station 346	0.25	(a)	0.32	0.21	0.26	81	100
25	Boundary TLD Station 347	0.35	(a)	(b)	(b)	0.35	117	128
30	Boundary TLD Station 349	0.42	(a)	0.74	0.44	0.53	179	195
25	Boundary TLD Station 348	0.49	(a)	(b)	0.41	0.45	172	164

(a) Results lost due to error in processing
(b) Missing or not collected TLD

Table 5.19 NTS TLD Control Station Comparison - 1987-1993

		Exposure Rate (mR/day)						
Area	Station	1987	1988	1989	1990	1991	1992	1993
5	Well 5B	0.32	0.43	0.36	0.34	0.37	0.31	0.40
6	CP-6	0.21	0.36	0.27	0.25	0.25	0.23	0.30
6	Yucca Oil Storage	0.30	0.29	0.32	0.32	0.33	0.31	0.37
23	Building 650 Dosimetry	0.14	0.26	0.19	0.20	0.19	0.18	0.26
23	Building 650 Roof	0.17	0.24	0.18	0.19	0.19	0.18	0.25
23	Post Office	0.24	0.29	0.23	0.23	0.24	0.23	0.30
25	HENRE Site	0.34	0.47	0.38	0.39	0.40	0.36	0.45
25	NRDS Warehouse	0.39	0.46	0.38	0.39	0.39	0.37	0.46
27	Cafeteria	0.38	0.49	0.32	0.40	0.42	0.39	0.46
Network Average		0.28	0.37	0.29	0.30	0.31	0.28	0.36

The results of monitoring conducted in 1993 are discussed in the following subsections for each of the environmental surveillance networks mentioned above but specifically described in Chapter 4. No major accidental releases of radionuclides from the NTS were reported in 1993, as has been the case since 1986.

5.2.2.1 AIR MONITORING NETWORKS

The following sections describe results for the ASN and its associated standby network (SASN), noble gas samplers, and atmospheric moisture samplers. The atmospheric monitoring networks measure the major radionuclides which could potentially be emitted from activities on the NTS, as well as naturally occurring radionuclides. Collectively, these networks represent the possible inhalation and submersion components of radiation exposure pathways to the general public.

AIR AND STANDBY AIR SURVEILLANCE NETWORKS

Gamma spectrometry was performed on all ASN and SASN samples. The majority of the samples were gamma-spectrum negligible (i.e., no gamma-emitting radionuclides detected). Naturally occurring ^{7}Be, averaging 3.0×10^{-13} µCi/mL, was infrequently detected. Alpha and beta results for 58 samples were not included in data analysis. These results were excluded because: total volume was less than 400 m^3, average flow rate was less than 2.9 m^3/hr or greater than 4.0 m^3/hr, or a power outage lasted more than one-third of sampling time. All remaining results were used in data analysis, including preparation of tables.

As in previous years, the gross beta results from both networks consistently exceeded the analytical minimum detectable activity concentration (MDC). The annual average gross beta activity was $1.5 \pm 0.6 \times 10^{-14}$ µCi/mL ($5.6 \pm 2.2 \times 10^{-4}$ Bq/m^3) for both the ASN and the SASN. Summary gross beta results for the ASN are in Table 5.20 and for the SASN in Table D.1, Appendix D. Samplers at 24 SASN stations were activated for 2 to 7 days following the TOMSK-7 incident in Russia. No beta radioactivity related to that event was detected.

Gross alpha analysis was performed on all samples. The average annual gross alpha activities were $9 \pm 3 \times 10^{-16}$ µCi/mL (33 ± 11 µBq/m^3) for the ASN and $8 \pm 2 \times 10^{-16}$ µCi/mL (30 ± 7 µBq/m^3) for the SASN. Summary gross alpha results for the ASN are presented in Table 5.21 and for the SASN in Table D.3, Appendix D. No alpha radioactivity related to the TOMSK event was detected.

Selected air prefilters were also analyzed for plutonium isotopes. This report contains results for samples collected during the first, second and third quarters of 1993, presented in Table 5.22 for the ASN and in Table D.5, appendix D, for the SASN. Due to the length of time required for analysis, the data for the fourth quarter are not available but will be included in the combined report for 1994. Although annual average values were essentially nondetectable, a few samples exceeded the Pu MDC within the ASN network. These were the June and July composites from Alamo, NV for ^{238}Pu analysis and the July sample from Rachel, NV for $^{239+240}$Pu analysis. The second quarter composite sample from the New Mexico standby stations exceeded the MDC for ^{238}Pu. The MDC for $^{239+240}$Pu was exceeded in four composite samples

Table 5.20 Gross Beta Results for the Offsite Air Surveillance Network - 1993

	Gross Beta Concentration (10^{-14} µCi/mL [0.37 mBq/m^3])				
Sampling Location	Number	Maximum	Minimum	Arithmetic Mean	Standard Deviation
Death Valley Junction, CA	48	3.30	0.50	1.50	0.70
Furnace Creek, CA	48	4.60	0.50	1.80	1.00
Shoshone, CA	52	3.50	0.50	1.70	0.70
Alamo, NV	51	3.30	0.60	1.50	0.50
Amargosa Valley, NV	49	3.00	0.50	1.50	0.60
Austin, NV	50	3.00	0.00	1.40	0.60
Beatty, NV	52	2.90	0.60	1.70	0.60
Caliente, NV	50	3.30	0.10	1.40	0.50
Clark Station, NV Stone Cabin Ranch	52	3.00	0.30	1.40	0.60
Currant, NV Blue Eagle Ranch	51	3.90	0.10	1.20	0.80
Ely, NV	52	3.40	0.40	1.40	0.50
Goldfield, NV	52	2.90	0.60	1.60	0.60
Groom Lake, NV	49	3.40	0.50	1.70	0.60
Hiko, NV	52	3.90	0.60	1.50	0.60
Indian Springs, NV	52	3.10	0.20	1.60	0.60
Las Vegas, NV	50	3.10	0.10	1.50	0.60
Nyala, NV	52	3.70	0.20	1.30	0.70
Overton, NV	51	3.50	0.10	1.70	0.70
Pahrump, NV	52	2.60	0.60	1.40	0.50
Pioche, NV	51	3.00	0.40	1.50	0.60
Rachel, NV	49	3.20	0.30	1.40	0.60
Sunnyside, NV	49	4.50	0.20	1.60	0.80
Tonopah, NV	50	3.10	0.60	1.60	0.60
Tonopah Test Range, NV	50	3.10	0.20	1.40	0.60
Twin Springs, NV Fallini's Ranch	51	4.40	0.80	1.90	0.80
Cedar City, UT	52	2.50	0.50	1.30	0.50
Delta, UT	48	4.70	0.30	1.80	0.90
Milford, UT	52	4.30	0.00	1.80	0.80
Salt Lake City, UT	51	4.20	0.40	1.60	0.70
St. George, UT	49	3.40	0.10	1.70	0.80

Mean MDC: 2.5×10^{-15} µCi/mL   Standard Deviation of Mean MDC: 3.2×10^{-16} µCi/mL

Table 5.21 Gross Alpha Results for the Offsite Air Surveillance Network - 1993

Sampling Location	Number	Gross Alpha Concentration (10^{-15} µCi/mL [37 µBq/m^3]) Maximum	Minimum	Arithmetic Mean	Standard Deviation
Death Valley Jct, CA	48	4.10	-0.40	1.40	1.00
Furnace Creek, CA	48	4.70	-0.70	1.20	1.10
Shoshone, CA	52	3.00	-0.10	1.00	0.70
Alamo, NV	51	2.80	0.00	1.10	0.60
Amargosa Valley, NV	49	3.30	-0.10	1.30	0.90
Austin, NV	50	3.40	-0.60	0.90	0.70
Beatty, NV	52	3.60	-0.30	1.20	0.80
Caliente, NV	50	1.80	-0.50	0.70	0.50
Clark Station, NV Stone Cabin Ranch	52	4.40	-0.40	1.30	0.90
Currant, NV Blue Eagle Ranch	51	2.10	-0.40	0.60	0.60
Ely, NV	52	1.60	-0.20	0.60	0.40
Goldfield, NV	52	1.90	-0.60	0.60	0.50
Groom Lake, NV	49	3.50	-0.20	1.50	0.70
Hiko, NV	52	2.40	-0.10	0.90	0.50
Indian Springs, NV	52	1.80	-0.20	0.70	0.50
Las Vegas, NV	50	2.60	-0.40	0.90	0.70
Nyala, NV	52	1.90	-0.60	0.60	0.50
Overton, NV	51	2.00	-0.60	0.70	0.50
Pahrump, NV	52	3.30	-0.40	0.90	0.80
Pioche, NV	51	1.80	-0.50	0.60	0.50
Rachel, NV	49	2.10	-0.60	0.60	0.50
Sunnyside, NV	49	3.20	-0.20	0.90	0.70
Tonopah, NV	50	1.90	-0.20	0.70	0.50
Tonopah Test Range, NV	50	2.60	-0.30	0.80	0.70
Twin Springs, NV Fallini's Ranch	51	2.70	-0.30	0.80	0.50
Cedar City, UT	52	2.20	0.10	1.10	0.50
Delta, UT	48	2.00	-0.50	0.60	0.50
Milford, UT	52	3.00	-0.60	0.90	0.70
Salt Lake City, UT	51	2.50	-0.80	0.60	0.60
St. George, UT	49	4.00	-0.30	1.20	0.90

Mean MDC: 8.1×10^{-16} µCi/mL   Standard Deviation of Mean MDC: 2.4×10^{-16} µCi/mL

Table 5.22 Offsite Airborne Plutonium Concentrations - 1993

		^{238}Pu Concentration (10^{-18} µCi/mL)				
Composite Sampling Location	Number	Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as %DCG
Alamo, NV	9	7.1	-1.3	1.8	3	0.6
Amargosa Valley, NV	9	29	-4.9	4.3	10	1.4
Las Vegas, NV	9	52	5.7	6.8	18	2.3
Rachel, NV	9	9.5	-4.0	1.4	4.4	0.5

Mean MDC: 16×10^{-18} µCi/mL Standard Deviation of Mean MDC: 9.9×10^{-18} µCi/mL

DCG Derived Concentration Guide; Established by DOE Order as 3×10^{-15} µCi/mL

		$^{239+240}$Pu Concentration (10^{-18} µCi/mL)				
Composite Sampling Location	Number	Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as %DCG
Alamo, NV	9	6.1	-0.9	1.5	2.6	0.7
Amargosa Valley, NV	9	12	0.0	3	4.7	1.5
Las Vegas, NV	9	12	-1.3	1.6	3.9	0.8
Rachel, NV	9	41	-8.2	3.7	14	1.8

Mean MDC: 12×10^{-18} µCi/mL Standard Deviation of Mean MDC: 8.8×10^{-18} µCi/mL

DCG Derived Concentration Guide; Established by DOE Order as 3×10^{-15} µCi/mL
To convert from µCi/mL to Bq/m^3 multiply by 3.7×10^{10} ([7.1×10^{-18}] x [37×10^{9}] = 26 µBq/m^3)

from the SASN; second quarter samples from New Mexico and Wyoming, and third quarter samples from Texas and Wyoming. Only 8 of 146 samples exceeded the MDC for Pu. Single SASN samples were analyzed for plutonium if the second prefilter was not received and three prefilters were analyzed when the sampler was operated more than once in a given quarter.

TRITIUM IN ATMOSPHERIC MOISTURE (HTO)

About five percent of the total number of samples collected were invalid due to malfunctioning equipment, power outages during collection, frozen lines, insufficient sample volumes, etc. Results exceeded the analysis MDC in three instances, but this could be due to simple counting statistics. The annual HTO network average was 3.0×10^{-7} pCi/mL (0.011 Bq/m^3). Summary results are given in Table 5.23 for the routine stations and in Table D.6, Appendix D, for the standby stations.

NOBLE GAS SAMPLING NETWORK

All samples were analyzed for ^{85}Kr and ^{133}Xe and the summary results are given in Table 5.24 for the routine stations. Eight standby stations were operated quarterly to ascertain

Table 5.23 Offsite Atmospheric Tritium Results for Routine Samplers - 1993

Sampling Location	Number	Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as %DCG
		HTO Concentration (10^{-6} pCi/mL)				
Alamo, NV	46	5.2	-2.3	0.6	1.6	0.006
Amargosa Valley, NV	52	23.0	-3.4	0.7	3.4	0.007
Amargosa Valley Community Center, NV	49	7.7	-5.3	0.5	2.2	0.005
Beatty, NV	44	3.2	-2.2	0.2	1.1	0.002
Goldfield, NV	48	3.4	-13.0	0.2	2.3	0.002
Indian Springs, NV	50	2.9	-1.8	0.3	0.9	0.003
Las Vegas, NV	51	3.2	-2.1	0.5	1.3	0.005
Overton, NV	52	4.5	-6.2	0.4	1.9	0.004
Pahrump, NV	49	4.8	-2.7	0.1	1.5	0.001
Rachel, NV	47	2.8	-2.6	0.1	1.1	0.001
Tonopah, NV	52	2.5	-4.5	0.2	1.1	0.002
Twin Springs, NV Fallini's Ranch	52	2.4	-2.7	0.3	1.0	0.003
Salt Lake City, UT	49	3.6	-2.9	0.3	1.4	0.003
St. George, UT	45	3.4	-5.1	0.3	1.6	0.003

Mean MDC: 3.66 x 10^{-6} pCi/mL Standard Deviation of Mean MDC: 2.10 x 10^{-6} pCi/mL

DCG Derived Concentration Guide; Established by DOE Order as 1 x 10^{-2} pCi/mL
MDC Minimum Detectable Concentration
Multiply table value by 37 to get mBq/m^3 (5.2 x 37 = 190 mBq/L)

operational status but the samples were not analyzed. Of the 676 samples collected in 1993, analyses were not performed on 63 samples (9.3 percent) due to either insufficient volume collected or sampler malfunction. As expected, all ^{85}Kr results exceeded the MDC and all ^{133}Xe results were below the MDC. The annual averages for the continuously operated samplers were 2.8 x 10^{-11} µCi/mL (1.0 Bq/m^3) for ^{85}Kr and -2.1 x 10^{-11} µCi/mL (-0.8 Bq/m^3) for ^{133}Xe. On February 9, the station at Las Vegas was relocated to the front of the EPA Executive Center. An anomalously high ^{85}Kr result of 2.5 x 10^{10} µCi/mL (9.2 Bq/m^3) occurred at this time.

5.2.2.2 WATER MONITORING

Environmental surveillance of water in the offsite areas around the NTS is conducted as part of the LTHMP. Results are discussed in Section 9.5.2 of Chapter 9, "Groundwater Monitoring."

5.2.2.3 MILK SURVEILLANCE NETWORK

For samples analyzed by gamma spectrometry, the average total potassium concentration derived from ^{40}K activity was 1.5 g/L, but manmade gamma-emitting radionuclides were not detected in any of the milk samples. Selected MSN and SMSN milk samples were analyzed for ^{3}H, ^{89}Sr, and ^{90}Sr, and the results are similar to those obtained in previous years; neither increasing nor decreasing trends are evident. Annual summary data are listed in Table 5.25. The numbers with detectable concentrations have, generally, decreased slightly. A summary of

Table 5.24 Offsite Noble Gas Results for Routine Samplers - 1993

		^{85}Kr Concentration (10^{-12} µCi/mL)				
Sampling Location	Number	Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as %DCG
Alamo, NV	44	32	21	27	2.2	0.004
Amargosa Valley, NV	49	31	24	28	1.9	0.005
Amargosa Valley Community Center, NV	41	32	23	27	2.1	0.004
Beatty, NV	48	33	23	27	2.3	0.004
Goldfield, NV	47	32	23	27	2.4	0.004
Indian Springs, NV	49	32	23	28	2.1	0.005
Las Vegas, NV	51	32	23	27	2.3	0.004
Overton, NV	50	32	22	27	2.3	0.004
Pahrump, NV	48	33	21	28	2.4	0.005
Rachel, NV	41	31	20	27	2.3	0.004
Tonopah, NV	48	31	22	27	2.1	0.004
Twin Springs, NV Fallini's Ranch	47	32	23	28	2	0.005
St. George, UT	46	33	21	27	2.7	0.004

Mean MDC: 5.7 x 10^{-12} µCi/mL Standard Deviation of Mean MDC: 1.1 x 10^{-12} µCi/mL

DCG Derived Concentration Guide; Established by DOE Order as 6 x 10^{-7} µCi/mL
Multiply table value by 0.037 to obtain Bq/m^3 (32 x 0.037 = 1.2 Bq/m^3)

		^{133}Xe Concentration (10^{-12} µCi/mL)				
Sampling Location	Number	Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as %DCG
Alamo, NV	44	8.6	-13.0	-1.6	4.5	NA
Amargosa Valley, NV	49	4.7	-10.0	-1.9	3.1	NA
Amargosa Valley Community Center, NV	41	8.6	-16.0	-2.8	5.1	NA
Beatty, NV	49	6.8	-14.0	-2.3	4.4	NA
Goldfield, NV	47	7.5	-11.0	-2.7	3.9	NA
Indian Springs, NV	50	11	-10.0	-1.5	4.2	NA
Las Vegas, NV	51	5.9	-8.1	-1.8	3.4	NA
Overton, NV	50	11	-20.0	-3.8	6.7	NA
Pahrump, NV	48	5.5	-13.0	-2.1	4	NA
Rachel, NV	41	8.4	-14.0	-2.4	5.4	NA
Tonopah, NV	49	12.0	-19.0	-1.4	6.1	NA
Twin Springs, NV Fallini's Ranch	47	12	-15.0	-2.7	5.3	NA
St. George, UT	47	19	-19.0	-0.9	7.2	NA

Mean MDC: 16.1 x 10^{-12} µCi/mL Standard Deviation of Mean MDC: 6.1 x 10^{-12} µCi/mL

DCG Derived Concentration Guide; Established by DOE Order as 5 x 10^{-8} µCi/mL
NA Not applicable, result is <MDC

Table 5.25 Summary of Radionuclides Detected in Milk Samples

	Milk Surveillance Network				Standby Milk Surveillance Network		
	No. of samples with results > MDC (Network average concentration in pCi/L)				No. of samples with results > MDC (Network average concentration in pCi/L)		
	1993	1992	1991		1993	1992	1991
^{3}H	0(120)	5(150)	2(150)	^{3}H	0(160)	6(160)	1(150)
^{89}Sr	0(-0.18)	4(-0.011)	1(0.30)	^{89}Sr	1(0.008)	4(0.38)	3(0.42)
^{90}Sr	2(0.55)	5(0.65)	4(0.55)	^{90}Sr	16(1.1)	17(0.99)	18(1.2)

the MSN results is in Tables 5.26 for ^{3}H, 5.27 for ^{89}Sr, and 5.28 for ^{90}Sr. The results for the annual SMSN samples analyzed for ^{3}H, ^{89}Sr, and ^{90}Sr are given in Table D.7, Appendix D. Samples analyzed by gamma spectrometry for the SMSN are listed in Table D.8, Appendix D.

5.2.2.4 BIOMONITORING

Sites where animals were collected in late 1992 and 1993 are shown in Chapter 4, Figure 4.10.

BIGHORN SHEEP

The sheep hunt takes place in November and December, hence, the data presented here are from animals hunted in late 1992. The kidney samples were analyzed for gamma-emitting radionuclides and for tritium. The bone samples were ashed prior to analysis of ^{90}Sr, ^{238}Pu, and $^{239+240}$Pu. A summary of results obtained from analysis of bighorn sheep bone and kidney is shown in Table 5.29. Other than naturally occurring ^{40}K, neither gamma-emitting radionuclides nor tritium were detected at concentrations greater than the MDC in any of the kidney samples. All of the bone tissue samples, however, yielded ^{90}Sr activities greater than the MDC of the analysis. The range and median values for ^{90}Sr, shown in Table 5.29, were similar to those obtained last year (DOE 1993). The average ^{90}Sr levels found in bighorn sheep bone ash since 1955 are shown in Figure 5.10. None of the bone samples yielded ^{238}Pu results greater than the MDC of the analysis and only one sample (Bighorn sheep No. 5) yielded a $^{239+240}$Pu result greater than the MDC. This animal was collected in Area 281, north of Indian Springs, Nevada, in the Pintwater Range. Medians and ranges of plutonium isotopes, given in Table 5.29, were similar to those obtained previously (DOE 1993).

MULE DEER

Blood samples are analyzed for gamma-emitting radionuclides and tritium. Soft tissue samples (lung, muscle, liver, thyroid, rumen contents, and fetus, when available) are analyzed for gamma-emitting radionuclides. Additionally, samples of soft tissues and bones were ashed and then analyzed for plutonium isotopes; ashed bone samples were also analyzed for ^{90}Sr. The average ^{90}Sr levels found in mule deer bone ash since 1955 are shown in Figure 5.11. Samples of thyroid and fetal tissue were not ashed due to their small size.

Table 5.26 Offsite Milk Surveillance ^{3}H Results - 1993

Sampling Location	Number	^{3}H Concentration (10^{-7} µCi/mL) Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as %DCG
Hinkley, CA						
Desert View Dairy	4	1.4	0.0	0.7	0.7	NA
Inyokern, CA						
Cedarsage Farm	4	1.5	-1.1	0.5	1.1	NA
Alamo, NV						
Cortney Dahl Ranch	4	3.3	-1.6	0.9	2.0	NA
Amargosa Valley, NV						
Bar-B-Cue Ranch	2	2.5	1.8	2.1	0.5	NA
John Deer Ranch	3	2.0	-1.4	0.1	1.8	NA
Austin, NV						
Young's Ranch	3	1.8	-0.4	0.8	1.1	NA
Caliente, NV						
June Cox Ranch	4	2.8	0.6	1.8	1.0	NA
Currant, NV						
Blue Eagle Ranch	1	-0.8	-0.8	-0.8		NA
Duckwater, NV						
Bradshaw's Ranch	4	3.2	-0.6	0.8	1.8	NA
Dyer, NV						
Ozel Lemon	4	3.8	-0.5	1.2	2.0	NA
Logandale, NV						
Leonard Marshall	2	2.3	1.2	1.8	0.8	NA
Lund, NV						
Ronald Horsley Ranch	4	1.9	0.9	1.3	0.4	NA
McGill, NV						
McKay's Ranch	3	2.3	-0.1	1.2	1.2	NA
Mesquite, NV						
Hafen Dairy	4	1.7	0.4	0.9	0.6	NA
Moapa, NV						
Rockview Dairies	4	3.0	-0.4	1.2	1.6	NA
Nyala, NV						
Sharp's Ranch	4	4.0	1.6	2.5	1.1	NA
Pahrump, NV						
Pahrump Dairy	5	3.9	-1.2	1.4	1.9	NA
Shoshone, NV						
Harbecke Ranch	1	1.3	1.3	1.3		NA
Tonopah, NV						
Karen Harper Ranch	4	2.0	0.0	1.0	0.9	NA
Cedar City, UT						
Brent Jones Dairy	4	3.7	1.0	2.4	1.1	NA
Ivins, UT						
David Hafen Dairy	4	2.2	0.4	1.4	0.8	NA

Mean MDC: 3.5×10^{-7} µCi/mL Standard Deviation of Mean MDC: 0.80×10^{-7} µCi/mL

DCG Derived Concentration Guide; Established by DOE Order as 9×10^{-5} µCi/mL
Multiply table value by 3.7 to obtain Bq/L (1.4 x 3.7 = 5.2 Bq/L)

NA Result is <MDC

Table 5.27 Offsite Milk Surveillance ^{89}Sr Results - 1993

		^{89}Sr Concentration (10^{-10} µCi/mL)				
Sampling Location	Number	Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as %DCG
Hinkley, CA6						
Desert View Dairy	2	8.0	-18.0	-4.9	18.0	NA
Inyokern, CA						
Cedarsage Farm	1	-7.6	-7.6	-7.6		NA
Alamo, NV						
Cortney Dahl Ranch	3	7.8	-8.8	-0.4	8.3	NA
Amargosa Valley, NV						
Bar-B-Cue Ranch	2	5.6	-8.1	-1.3	9.7	NA
John Deer Ranch	1	6.5	6.5	6.5		0.11
Caliente, NV						
June Cox Ranch	3	1.9	-9.7	-2.4	6.3	NA
Currant, NV						
Manzonie Ranch	1	0.0	0.0	0.0		NA
Duckwater, NV						
Bradshaw's Ranch	2	2.8	2.3	2.5	0.3	NA
Dyer, NV						
Ozel Lemon	2	0.4	-2.0	-0.9	1.8	NA
Logandale, NV						
Leonard Marshall	2	5.3	1.8	3.5	2.5	NA
Lund, NV						
Ronald Horsley Ranch	3	3.7	-6.2	-1.1	5.0	NA
McGill, NV						
McKay's Ranch	2	-0.9	-1.9	-1.4	0.7	NA
Mesquite, NV						
Hafen Dairy	2	4.9	-2.6	1.2	5.3	NA
Moapa, NV						
Rockview Dairies	2	12.0	-12.0	-0.3	17.0	NA
Nyala, NV						
Sharp's Ranch	2	-7.4	-10.0	-8.9	2.2	NA
Pahrump, NV						
Pahrump Dairy	3	6.7	-18.0	-2.1	14.0	NA
Tonopah, NV						
Karen Harper Ranch	2	-0.8	-10.0	-4.4	5.26	NA
Cedar City, UT						
Brent Jones Dairy	2	-2.4	-11.0	-6.8	6.2	NA
Ivins, UT						
David Hafen Dairy	2	2.1	-12.0	-5.0	10.0	NA

Mean MDC: 3.5×10^{-10} µCi/mL   Standard Deviation of Mean MDC: 0.8×10^{-10} µCi/mL

DCG Derived Concentration Guide; Established by DOE Order as 6×10^{-7} µCi/mL
Multiply table values by 0.0037 to obtain Bq/L (8.0 x 0.0037 = 30 mBq/L)

NA Result is <MDC

Table 5.28 Offsite Milk Surveillance ^{90}Sr Results - 1993

			^{90}Sr Concentration (10^{-10} µCi/mL)			
Sampling Location	Number	Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as %DCG
Hinkley, CA						
Desert View Dairy	4	7.0	-0.4	3.1	3.2	NA
Inyokern, CA						
Cedarsage Farm	4	6.9	0.1	3.3	3.2	NA
Alamo, NV						
Cortney Dahl Ranch	4	9.5	0.3	5.7	3.9	NA
Amargosa Valley, NV						
Bar B Cue Ranch	2	6.7	0.1	3.4	4.7	NA
John Deer Ranch	3	2.6	-0.8	0.5	1.8	NA
Austin, NV						
Young's Ranch	2	3.9	3.6	3.8	0.2	NA
Caliente, NV						
June Cox Ranch	3	8.5	2.1	6.3	3.7	NA
Currant, NV						
Manzonie Ranch	1	13.0	13.0	13.0		NA
Duckwater, NV						
Bradshaw's Ranch	3	7.3	2.9	4.6	2.3	NA
Dyer, NV						
Ozel Lemon	4	9.4	0.5	5.2	3.7	NA
Logandale, NV						
Leonard Marshall	2	1.8	1.2	1.5	0.4	NA
Lund, NV						
Ronald Horsley Ranch	4	4.7	1.0	3.7	1.8	NA
McGill, NV						
McKay's Ranch	3	6.4	4.3	5.3	1.0	NA
Mesquite, NV						
Hafen Dairy	4	9.4	1.7	4.5	3.6	NA
Moapa, NV						
Rockview Dairies	4	7.0	-0.5	3.4	3.8	NA
Nyala, NV						
Sharp's Ranch	4	12.0	3.1	8.8	3.9	NA
Pahrump, NV						
Pahrump Dairy	4	9.5	-0.1	4.3	4.1	NA
Shoshone, NV						
Harbecke Ranch	1	21.0	21.0	21.0		7.0
Tonopah, NV						
Karen Harper Ranch	4	22.0	6.7	12.0	6.9	NA
Cedar City, UT						
Brent Jones Dairy	4	12.0	0.9	7.1	4.9	NA
Ivins, UT						
David Hafen Dairy	4	12.0	-1.6	6.6	5.8	NA

Mean MDC: 14.2×10^{-10} µCi/mL Standard Deviation of Mean MDC: 1.1×10^{-10} µCi/mL

DCG Derived Concentration Guide; Established by DOE Order as 3×10^{-8} µCi/mL
Multiply table value by 0.0037 to obtain Bq/L (7.0 x 0.0037 = 26 mBq/L)

NA Result is <MDC

Table 5.29 Radiochemical Results for Animal Samples - 1993

Sample Type	Parameter	No.	Maximum	Minimum	Median$^{(a)}$	Standard Deviation	Median MDC ± std. dev.
Cattle Blood	^{3}H$^{(b)}$	8	3.16	–1.11	0.32	1.46	3.85 ± 0.93
Cattle Liver	% Ash	8	1.4	1.2	1.3	--	--
	^{238}Pu$^{(c)}$		2.54	–0.577	0.254	1.21	6.15 ± 3.42
	$^{239+240}$Pu$^{(c)}$		52.7*	2.88	5.72*	17.1	4.46 ± 2.20
Cattle Bone	% Ash	8	37.4	18.9	29.6	--	--
	^{90}Sr$^{(d)}$		1.6*	0.29*	0.89*	0.37	0.26 ± 0.01
	^{238}Pu$^{(c)}$		1.31	–0.838	0.327	0.64	2.56 ± 1.69
	$^{239+240}$Pu$^{(c)}$		16.5*	0.00	0.854	5.53	2.41 ± 1.41
Cattle Fetus	% Ash	1	--	--	2.4	--	--
	^{90}Sr$^{(d)}$		--	--	0.32*	--	0.28 ± --
	^{238}Pu$^{(c)}$		--	--	–1.63	--	4.29 ± --
	^{239}Pu$^{(c)}$		--	--	11.8*	--	0.885 ± --
Deer Blood	^{3}H$^{(b)}$	4	3.90	0.52	229	1.54	3.92 ± 1.59
Deer Liver	% Ash	4	1.4	1.3	1.3	--	--
	^{238}Pu$^{(c)}$		3.24	–0.0005	0.773	1.44	4.65 ± 4.73
	$^{239+240}$Pu$^{(c)}$		72.9*	8.06*	24.3*	28.7	1.79 ± 5.19
Deer Lung	% Ash	4	1.2	1.0	1.1	--	--
	^{238}Pu$^{(c)}$		2.33	–0.392	–0.392	1.47	4.21 ± 3.00
	$^{239+240}$Pu$^{(c)}$		130.*	0.640	10.7*	61.5	5.23 ± 3.16
Deer Muscle	% Ash	4	4.7	1.14	1.2	--	--
	^{238}Pu$^{(c)}$		3.73	–1.41	1.07	2.12	5.53 ± 3.63
	$^{239+240}$Pu$^{(c)}$		120.*	4.85*	13.8*	54.8	4.15 ± 5.29

* Result is greater than the minimum detectable concentration

(a) Median used instead of mean because small number of samples and large range

(b) Units are 10^{-7} µCi/mL

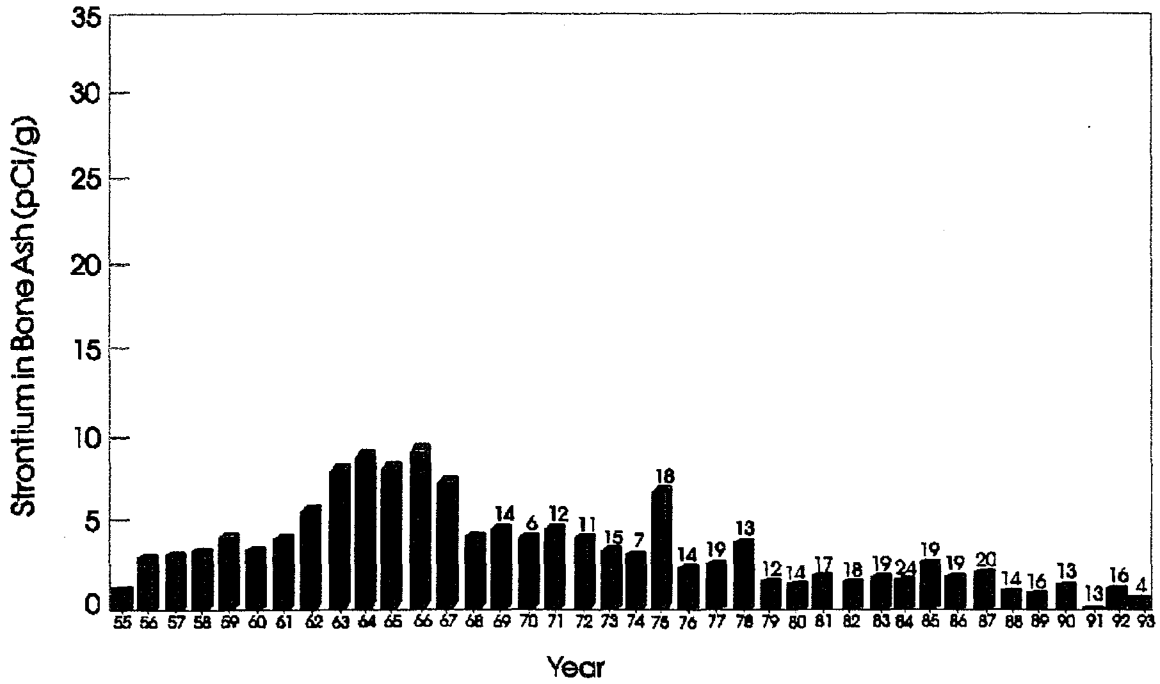
(c) Units are 10^{-3} pCi/g ash

(d) Units are pCi/g ash

Table 5.29 (Radiochemical Results for Animal Samples - 1993, cont.)

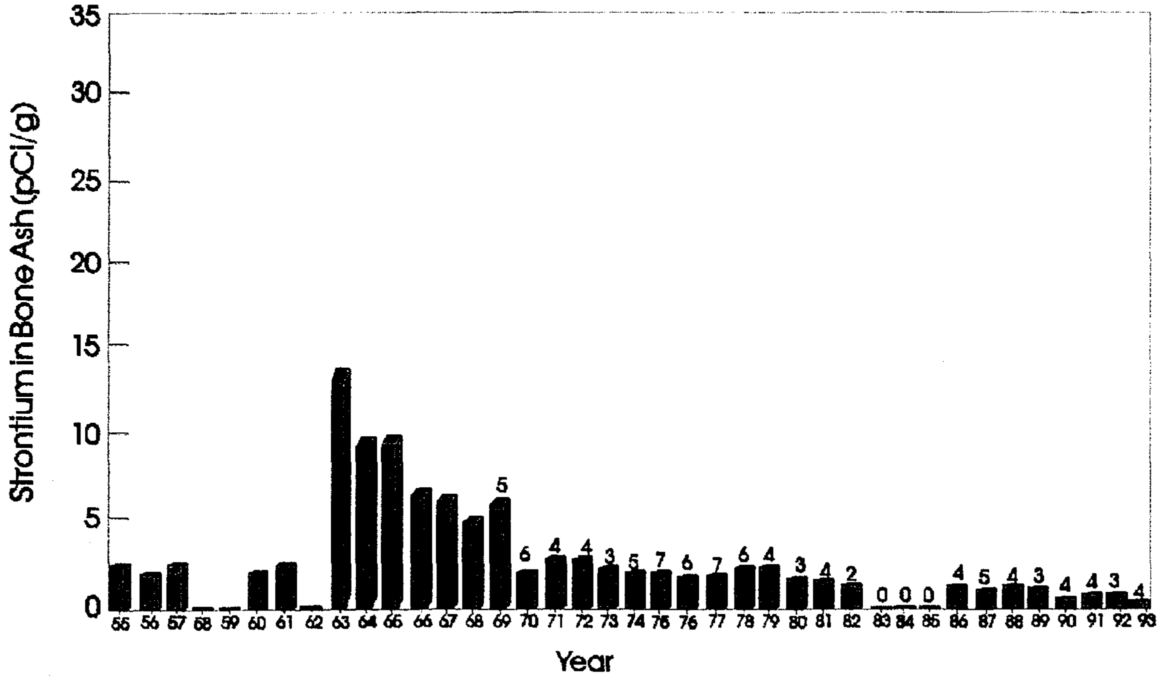
Sample Type	Parameter	No.	Maximum	Minimum	Median(a)	Standard Deviation	Median MDC ± std. dev.
Deer Rumen Content	% Ash	4	2.6	1.9	2.2	--	--
	^{238}Pu(c)		7.31*	−1.77	2.32	3.79	3.57 ± 2.41
	$^{239+240}$Pu(c)		98.7*	2.83	20.1*	42.96	4.83 ± 2.12
Deer Bone	% Ash	4	33.6	27.8	30.9	--	--
	^{90}Sr(d)		1.6*	0.59*	0.85*	0.48	0.28 ± 0.02
	^{238}Pu(c)		5.24*	−0.267	1.34	2.47	2.40 ± 1.00
	$^{239+240}$Pu(c)		2.94*	0.771	2.38*	0.98	1.90 ± 0.78
Bighorn Sheep Bone	% Ash	4	41.9	8.8	36.3	--	--
	^{90}Sr(d)		1.9*	0.67*	1.25*	0.50	0.26 ± 0.03
	^{238}Pu(c)		1.19	−0.308	0.443	0.71	2.04 ± 1.44
	$^{239+240}$Pu(c)		63.7*	0.444	1.05	31.4	2.04 ± 1.44
Bighorn Sheep Kidney	^{3}H(b)	7	2.38	−1.33	1.18	1.50	4.37 ± 2.02
Chukar Internal Organs	^{3}H(b)	4	38,700.*	−0.61	3.23	19,349	4.42 ± 0.04
Muscle	^{3}H(b)	4	32,800.*	1.33	3.64	16,398	4.36 ± 0.01
Chukar Bone	% Ash	3	19.0	4.2	5.8	--	--
	^{90}Sr(d)		3.5*	0.24	2.2*	1.64	0.35 ± 0.15
	^{238}Pu(c)		10.1*	1.30	2.46	4.78	3.21 ± 1.65
	$^{239+240}$Pu(c)		490.*	8.70*	20.7*	274.5	1.34 ± 0.27
Quail Whole Body	^{3}H(b)	1	--	--	556	--	439 ± --

* Result is greater than the minimum detectable concentration
(a) Median used instead of mean because small number of samples and large range
(b) Units are 10^{-7} µCi/mL
(c) Units are 10^{-3} pCi/g ash
(d) Units are pCi/g ash



Note: Nos. above bars represent No. of samples

Figure 5.10 Average Strontium Levels in Bighorn Sheep, 1955 - 1993



Note: Nos. above bars represent No. of samples

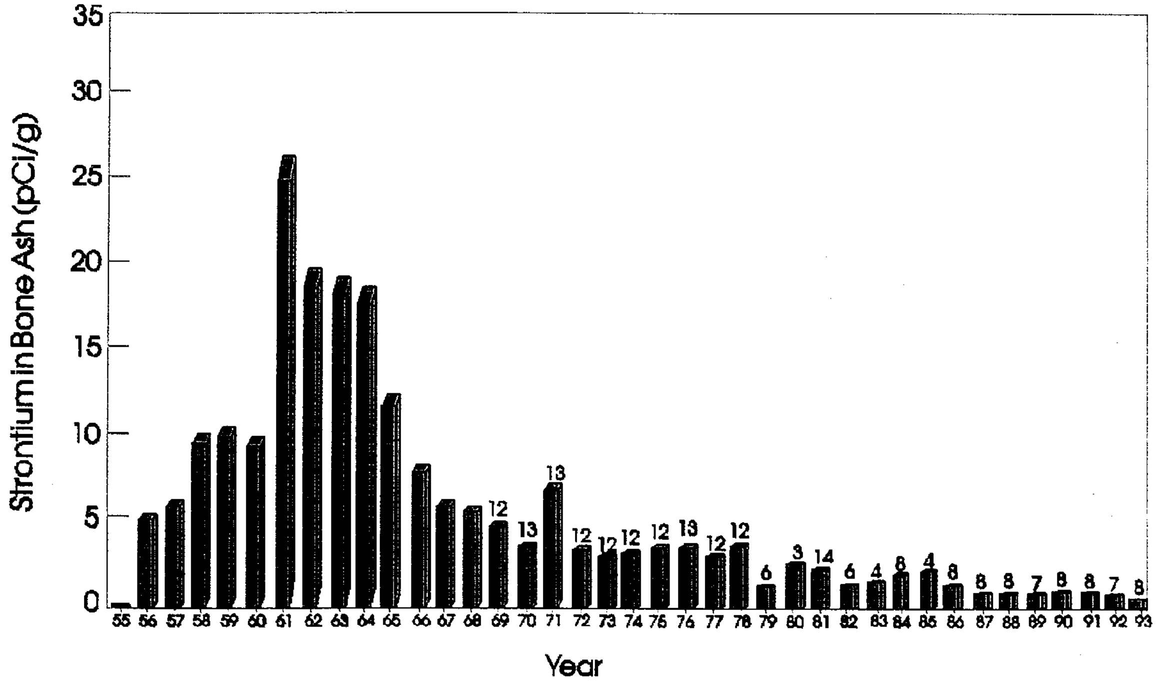
Figure 5.11 Average Strontium Levels in Mule Deer, 1955 - 1993

The mule deer collected in the first quarter of 1993 was a yearling female in fair to good condition. Collection was made in Area 16 about 1 1/2 miles east of U-16a site. The mule deer collected in the second quarter of 1993 was a mature male in good condition. Collection was made in Area 19 along the Pahute Mesa Road 1/2 mile north of U-19-ar. The mule deer collected in the third quarter of 1993 was a mature male in excellent condition. Collection was made in Area 20 along the Pahute Mesa Road 1/2 mile east of the Area 20 water reservoir. A female deer was collected offsite during the third quarter in the area of Cherry Creek Camp ground approximately three miles west of Adaven, Nevada. The deer was used as a control sample for the onsite collections. Attempts at collection were made in the 4th quarter but, due to sudden weather changes during this time, no collection was possible.

During the third quarter of 1993, Chukar and Quail were collected at the following locations on the NTS: in the area adjacent to the T Tunnel, Tub Spring, Tippipah Spring, White Rock Spring and Topopah Spring. Samples from each location were combined and the muscle and internal organs were checked for gamma-emitting radionuclides and ^{3}H. The bone samples were analyzed for ^{238}Pu, $^{239+240}$Pu and ^{90}Sr. Average tritium concentrations of 320 pCi/L (12 Bq/L) were found in the internal organs and 360 pCi/L (13 Bq/L)were found in the muscle of Chukar.

CATTLE

Blood and soft tissues (lung, muscle, liver, thyroid, kidney and fetal tissue, when available) are analyzed for gamma-emitting radionuclides; blood is also analyzed for tritium activity. Samples of liver, bone, and fetal tissue are ashed and analyzed for plutonium isotopes; bone and fetus samples are also analyzed for ^{90}Sr. The average ^{90}Sr levels found in cattle bone ash since 1955 are shown in Figure 5.12. Duplicate liver and bone samples from two animals in each group of four are prepared and analyzed.



Note: Nos. above bars represent No. of samples

Figure 5.12 Average Strontium Levels in Cattle, 1955 - 1993

The four cattle purchased in May 1993 in Tikapoo Valley, Nevada, had detectable concentrations of ^{90}Sr in bone ash samples ranging from 0.29 to 0.85 pCi/g (11 to 31 Bq/kg) ash. One bone sample contained 4.1 ± 3.1 fCi/g (0.15 ± 0.11 Bq/kg) ash of ^{238}Pu. The livers of all four cattle contained $^{239+240}$Pu ranging from 0.00211 to 0.0527 pCi/g (0.08 to 2.0 Bq/kg) ash. These cattle lived their entire life in the Tikapoo Valley area.

Analyses of samples are not yet completed for the four cattle purchased from the Orin Nash Ranch at Hiko, Nevada, in October 1993.

FRUITS AND VEGETABLES

In the fall of 1993, 16 samples of fruits and vegetables were donated by residents of Utah and Nevada. The samples included apples, potatoes, kohlrabi, turnips, carrots, pears, green onions and squash. All samples were analyzed for gamma-emitting radionuclides and only naturally occurring ^{40}K was detected. All samples were analyzed for tritium; two samples had results greater than the MDC: pears from Adaven, Nevada, and turnips from Warm Springs, Nevada. Samples were ashed and analyzed for ^{90}Sr, ^{238}Pu and $^{239+240}$Pu. Two samples were above the MDC: broccoli from Rachel and carrots with tops from Complex I. This is possibly due to the soil being trapped in the leafy portion of the vegetables. None of the smooth skinned crops or root crops without tops contained radionuclides above MDC. Results are listed in Table 5.30.

5.2.2.5 THERMOLUMINESCENT DOSIMETRY NETWORK

OFFSITE STATION NETWORK

Detailed results for both 1992 and 1993 data are set forth in Tables D.11 and D.12, Appendix D. There were 131 stations monitored in 1992 and 127 in 1993. Figure 4.12, Chapter 4, shows the current locations monitored with TLDs. Total annual exposures for 1992 ranged from 57 mR (0.57 mSv) for the UNLV station in Las Vegas to 354 mR (3.5 mSv) for the station at Warm Springs No. 2 with a mean of 113 mR (1.1 mSv)/yr for all stations. The Warm Springs station consistently has the highest exposure because of high levels of naturally occurring radionuclides in the nearby stream. The next highest exposure was 182 mR (1.8 mSv)/yr at Hancock Summit, Nevada. Data from 1988 to 1990 were slightly lower than the 1992 data due to differences in treatment of transit controls. Other than this inconsistency, the data are consistent with previous years' data, within the uncertainty of measurement.

Table 5.30 Detectable ^{3}H, ^{90}Sr, ^{238}Pu and $^{239+240}$Pu Concentrations in Vegetables

Vegetable	Collection Location	% Ash	^{3}H ± 1s pCi/L (MDC)	^{238}Pu ± 1s 10^{-3}pCi/g (MDC)	^{90}Sr ± 1s pCi/g ash (MDC)	$^{239+240}$Pu ± 1s 10^{-3} pCi/g ash (MDC)
Broccoli	Rachel, NV	.805			.60 ± .34 (.56)	
Carrots with tops	Complex I, NV	.52		2.34 ± 1.05 (2.18)		18.7 ± 13.3 (6.4)
Pears	Adaven, NV		525 ± 275 (443)			
Turnips	Twin Springs, NV		503 ± 138 (443)			

During 1993, annual exposures ranged from 55 mR (0.55 mSv) at Corn Creek, NV to 305 mR (3.0 mSv) at Warm Springs No. 2 with a mean exposure of 98 mR (0.98 mSv)/yr for the network. The next highest exposure occurred at Manhattan, NV: 175 mR (1.8 mSv)/yr.

OFFSITE PERSONNEL NETWORK

Detailed results for both 1992 and 1993 are shown in Appendix D, Tables D.9 and D.10. The number of personnel monitored with TLDs were 67 in 1992 and 69 in 1993. The locations of the personnel monitored in 1993 are shown on the map in Figure 4.13. The total annual EDE was calculated by summing the quarterly exposure data for the year. For 1992, all data that fell within 15 days of the beginning or end of the year were used. If data gaps occurred, an average daily exposure rate was calculated and used to obtain the mR/yr.

Annual whole-body absorbed dose equivalents ranged from a low of 121 mrem (1.2 mSv) to 370 mrem (3.7 mSv) with a network average of 186 mrem (1.9 mSv) during 1992. During 1993, the low was 61 mrem (0.61 mSv), the high was 190 mrem (1.9 mSv), and the mean was 106 mrem (1.1 mSv) for all monitored personnel.

5.2.2.6 PRESSURIZED ION CHAMBER NETWORK

The PIC data presented in this section are based on weekly averages of gamma exposure rates from each station. Weekly averages were compiled for every station, for every week during 1993 where available. Data were unavailable for a few weeks due to equipment failure.

Table 5.31 contains the number of weekly averages available from each station and the maximum, minimum, mean, standard deviation, and median of the weekly averages. The mean ranged from 7.5 μR/hr at Pahrump, NV to 19.0 μR/hr at Austin, NV or annual exposures from 66 to 166 mR (17 to 43 μC/kg). For each station, this table also shows the total mR/yr (calculated based on the mean of the weekly averages) and the average gamma exposure rate from 1992. Background levels of environmental gamma exposure rates in the U.S. (from the combined effects of terrestrial and cosmic sources) vary between 49 and 247 mR/yr (13 to 64 μC/kg-yr) (Committee on the Biological Effects of Ionizing Radiation, 1980). The annual exposure levels observed at each PIC station are well within these U.S. background levels. The ratio of PIC data to TLD data varies from a low of 1.19 at Nyala, Nevada to a high of 1.66 at Cedar City, Utah with a mean value of 1.32. Figure 5.13 shows the distribution of the weekly averages from each PIC station arranged by ascending means (represented by filled circles). The left and right edges of the box on the graph represent the 25th and 75th percentiles of the distribution of the weekly averages (i.e., 50 percent of the data falls within this region). The vertical line drawn inside the box represents the 50th percentile or median value. The horizontal lines extend from the box to the minimum and maximum values.

The data from the Las Vegas, Uhalde's Ranch, Rachel, and Austin stations show the greatest range and the most variability. The Las Vegas station was moved in February approximately 300 ft from one side of the parking lot to another. This caused an increase in the average exposure value from approximately 6.0 μR/hr to 9.0 μR/hr (1.5 to 2.3 nC/kg-hr). This increase is probably caused by moving the station from a relatively paved area to a less paved area where the detector is less shielded from terrestrial radiation. The data from the Austin station has historically shown natural fluctuations during the winter months (EPA 1993). The Uhalde

Table 5.31 Summary of Weekly Gamma Exposure Rates as Measured by Pressurized Ion Chamber - 1993

		Gamma Exposure Rate (µR/hr)						
Station	Number of Weekly Averages	Maximum	Minimum	Arithmetic Mean	Standard Deviation	Median	mR/yr	1992 Mean (µR/hr)
Furnace Creek, CA	50	10.8	9.8	10.1	0.20	10.0	88	10.1
Shoshone, CA	52	12.4	11.5	12.0	0.14	12.0	105	11.9
Alamo, NV	52	13.9	13.0	13.3	0.24	13.3	117	13.7
Amargosa Valley, NV	52	14.3	13.6	14.0	0.11	14.0	123	14.4
Austin, NV	52	20.6	14.9	19.0	1.72	19.9	166	19.3
Beatty, NV	51	17.9	15.9	16.5	0.64	16.2	145	16.0
Caliente, NV	50	15.2	14.1	14.6	0.30	14.5	128	14.4
Complex I, NV	51	17.5	13.9	15.5	0.67	15.6	136	15.8
Ely, NV	52	14.9	11.6	13.4	0.74	13.4	117	12.6
Goldfield, NV	52	16.1	13.8	14.9	0.35	15.0	131	14.5
Indian Springs, NV	52	12.1	10.0	11.0	0.51	11.0	97	8.9
Las Vegas, NV	49	10.1	6.0	9.5	1.20	10.0	83	6.0
Medlin's Ranch, NV	51	16.3	14.7	15.8	0.34	15.9	138	15.8
Nyala, NV	51	13.0	11.0	11.9	0.65	11.9	104	11.9
Overton, NV	50	9.9	8.9	9.1	0.23	9.0	80	9.0
Pahrump, NV	52	9.1	7.0	7.5	0.65	7.2	66	7.7
Pioche, NV	52	12.4	10.7	11.8	0.43	12.0	103	12.0
Rachel, NV	47	18.1	13.6	16.6	0.92	17.0	145	16.2
Stone Cabin Ranch, NV	52	18.5	14.8	17.3	0.87	17.4	152	17.6
Tonopah, NV	52	18.1	14.8	17.2	0.58	17.1	151	16.9
Twin Springs, NV	51	17.5	15.0	16.6	0.57	16.7	146	16.7
Uhalde's Ranch, NV	51	18.4	11.1	16.3	2.16	17.3	143	17.4
Cedar City, UT	52	14.1	11.4	13.1	0.74	13.3	115	12.3
Delta, UT	52	12.6	10.1	11.9	0.50	12.0	104	15.8
Milford, UT	51	18.5	17.0	17.6	0.38	17.5	154	17.4
Salt Lake City, UT	49	11.2	8.5	10.6	0.63	11.0	93	11.0
St. George, UT	41	9.0	8.0	8.3	0.30	8.2	73	8.4

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

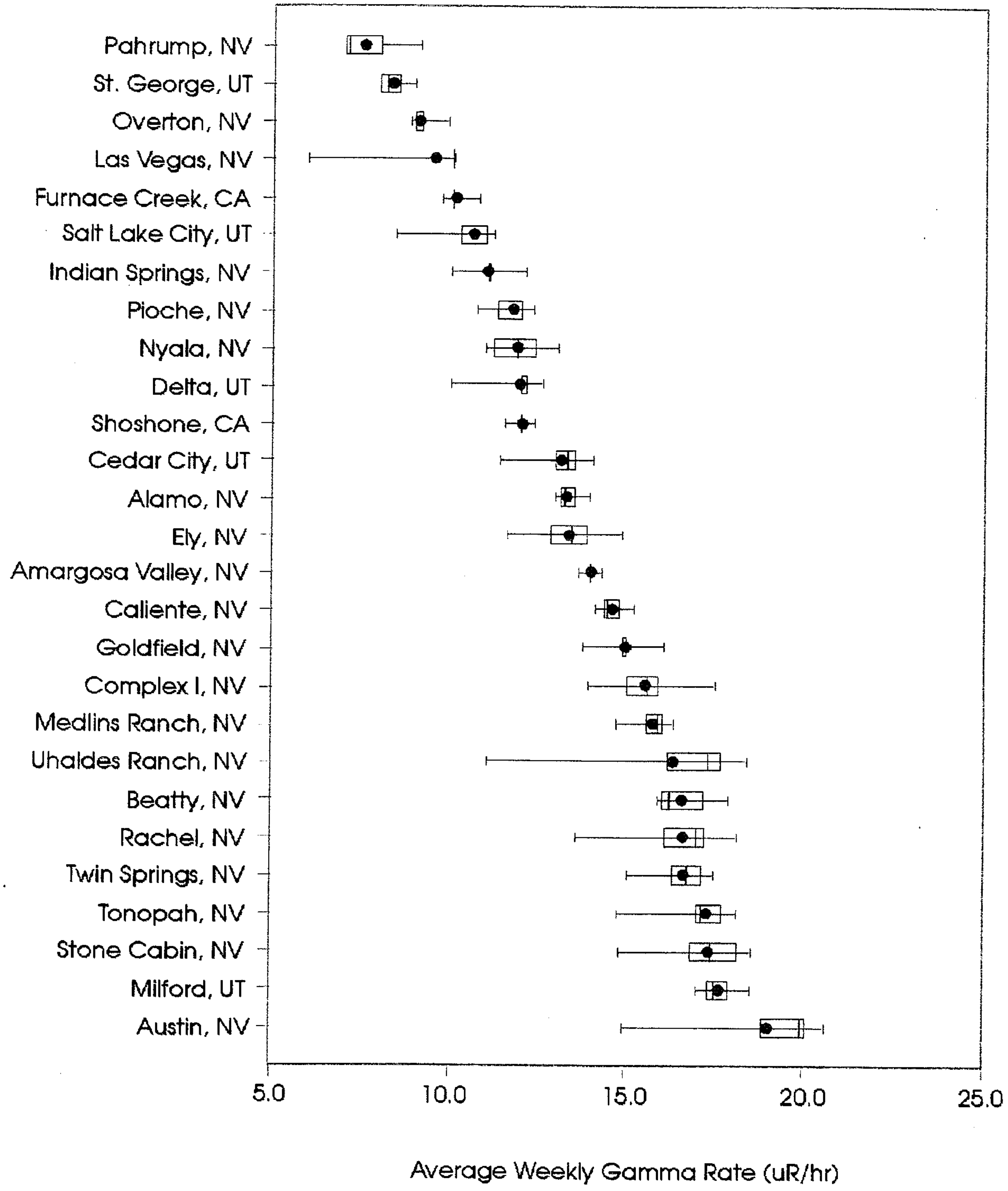


Figure 5.13 Distribution of Weekly Averages from Each PIC Network Station - 1993

Ranch and the Rachel stations experienced equipment problems that contributed to the variability in the data from these two stations. The mean exposure at the Indian Springs station increased from 8.9 μR/hr in 1992 to 11 μR/hr in 1993 (2.3 to 2.8 nC/kg-hr). This was due to landscaping changes made to the station in late 1992 and to the recalibration of the PIC which was done in November 1993.

5.2.2.7 INTERNAL DOSIMETRY NETWORK

In 1993, whole-body and lung counts were performed on 144 individuals, of whom 56 were participants in the Offsite Internal Dosimetry Network (see section 4.1.2.7). An additional 88 gamma-ray spectra were obtained for radiation workers, including EPA, DOE, and contractor personnel. In none of the spectra, which were collected for 2000 seconds each, were transuranic radionuclides detected. The spectra for the Offsite Dosimetry Network and Radiological Safety Program participants showed only low-level activities on the same order of intensity of those observed in normal background measurements. As in 1992, depleted uranium shrapnel was detected in participating Desert Storm soldiers, but the absolute amounts could not be determined by whole body counting alone.

Of the analytical results from urine samples available at the time of this publication, two showed tritium concentrations exceeding the MDC that were not related in location or collection time. The highest concentration was $8.3 \times 10^{-7} \pm 2.1 \times 10^{-7}$ μCi/mL (31 ± 8 Bq/L), which if assumed to be equal to the average intake concentration, corresponds to four percent of the 1979 drinking water regulation (2.0×10^{-5} μCi/mL or 740 Bq/L) for tritium (Table 5.32).

Table 5.32 Tritium in Urine, Offsite Internal Dosimetry Program - 1993

		^{3}H Concentration (10^{-7} μCi/mL)				
Location	Number	Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as % DCG
Alamo, NV	12	2.9	-0.7	1.1	1.1	NA
Amargosa Valley, Nv	4	0.6	-0.8	-0.1	0.6	NA
Beatty, NV	9	2.6	-1.0	0.4	1.1	NA
Indian Springs, NV	2	1.0	0.9	0.9	0.0	NA
McGill, NV	2	3.4	1.6	2.5	1.3	NA
Nyala, NV	2	-1.1	-1.7	-1.4	0.4	NA
Overton, NV	3	2.0	0.3	1.1	0.9	NA
Pahrump, NV	6	1.7	-0.2	0.9	0.7	NA
Pioche, NV	10	0.5	-1.1	-0.5	0.5	NA
Cedar City, UT	6	8.3	0.0	2.1	3.1	NA

Mean MDC: 3.0×10^{-7} μCi/mL Standard Deviation of Mean MDC: 0.39×10^{-7} μCi/mL

DCG Derived Concentration Guide; Established by DOE Order as 9×10^{-5} μCi/mL
NA Result is <MDC
To convert to Bq/L, multiple by 3.7 (2.9 x 3.7 = 10.7 Bq/L ≈ 11 Bq/L)

5.2.3 NON-NTS EG&G/EM FACILITY MONITORING

EG&G/EM facilities which use radioactive sealed sources or radiation producing equipment with the potential to expose the general population outside the property line to direct radiation are: Santa Barbara Operation during operation of the LINAC; the Special Technologies Laboratory during operation of the Sealed Tube Neutron Generator; the Remote Sensing Laboratory at Nellis Air Force Base; and the Las Vegas Area Operation's North Las Vegas Facility A-1 Source Range. Sealed sources are tested periodically to assure there is no leakage of radioactive material. The data from sealed source testing are kept in the EG&G/EM Radiation Protection Records.

Fence line radiation monitoring at these facilities was conducted during 1993 using Panasonic Type UD-814 TLDs. At least two TLDs were at the fence line on each side of the facility. TLDs were exchanged on a quarterly basis with an additional control TLD kept in a shielded safe. The monitoring data are in Table 5.33.

Table 5.33 EG&G/EM Boundary Line Monitoring Data - 1993

	1993 (mrem)				
LAVO ID#	4th Qtr	3rd Qtr	2nd Qtr	1st Qtr	Location Description
LV-01	26	22	22	17	Northwest Corner of Fence/Gate C-6
LV-02	*	25	24	16	North Fence -- Across from C-3
LV-03	24	24	24	16	North Fence -- West End of A-12
LV-04	*	24	27	18	North Fence -- East End of A-12
LV-05	*	20	24	*	North Fence -- North of A-9
LV-06	*	22	25	16	North Fence -- North of Substation
LV-07	24	22	*	16	North Fence -- West End of A-4
LV-08	23	19	23	18	Northeast Corner of Fence/Gate A-12
LV-09	*	19	21	18	East Fence -- North End of A-Complex
LV-10	24	22	26	21	East Fence -- Center of A-Complex
LV-11	*	21	25	17	East Fence -- South End of A-Complex
LV-12	24	20	23	16	East Fence -- North End of B-Complex
LV-13	*	20	24	16	East Fence -- Center of B-Complex
LV-14	23	19	23	15	East Fence -- South End of B-Complex
LV-15	*	21	23	16	South Fence -- East End of Fence
LV-16	25	21	23	16	South Fence -- Center of Fence/at Substation
LV-17	23	20	25	19	Southwest Corner/Gate C-1
LV-18	25	21	24	16	West Fence -- Gate C-3
LV-19	25	24	29	17	West Fence -- Between Gate C-3 and NLV-01
LV-20	*	*	*	19	North Park Lot Fence -- South of C-3
LV-21	29	26	28	24	C-1 West End Guard Gate
LV-22	*	21	24	15	Main Parking Lot Guard Gate/Gate C-8
LV-23	24	20	22	18	Northwest End of A-13/Double Gates
LV-24	*	18	23	*	Atlas Guard Station/Gate A-11

* Not analyzed

Table 5.33 (EG&G/EM Boundary Line Monitoring Data - 1993, cont.)

	1993 (mrem)				
LAVO ID#	4th Qtr	3rd Qtr	2nd Qtr	1st Qtr	Location Description
LV-25	*	*	*	15	A-2 South Side/Loading Dock/Gate A-7
LV-26	*	*	*	*	NLV Badge Office (A-7)/Gate A-2
Control	18	16	19	12	
RSL ID#					
RSL-01	28	27	25	27	Southeast Fence -- Near Gate
RSL-02	25	23	25	22	South Fence -- Center of Fence
RSL-03	22	20	22	22	Southwest Fence -- Near Gate
RSL-04	22	20	23	24	Northwest Fence -- Near Gate
RSL-05	26	26	25	19	North Fence -- Center of Fence
RSL-06	21	23	23	18	Northeast Fence -- Near Corner
Control	18	16	15	15	
SBO ID#					
SB105	26	22	28	20	Building 130 -- Northwest Post
SB110	26	22	*	23	Building 130 -- Center Post
SB112	28	25	56	23	Building 130 -- Front Fence
SB116	27	24	30	22	Building 130 -- Northeast Corner of Fence
SB117	27	25	29	22	Building 130 -- Southeast Corner of Fence
SB118	28	25	30	21	Building 130 -- South Fence
SB201	26	25	27	21	Building 226 -- Outside Window Sill
SB209	30	26	32	26	Building 227 -- North Fence
SB210	26	23	29	21	Building 2331 -- Rear Fence
SB215	*	23	31	21	Building 227 -- Northeast Corner of Fence
SB216	27	24	29	24	South Fence -- Behind Cf Shed
SB222	31	25	27	22	Building 227 -- East Fence
SB223	25	24	28	20	Building 227 -- Northeast Fence
SB224	26	23	28	21	Building 234 -- North Fence
SB225	25	23	28	21	Building 233 -- North Fence
SB226	26	23	28	21	Building 229-C -- Fence
SB228	28	24	30	21	Building 227 -- Southeast Corner of Fence
SB300	27	24	30	22	South Fence near Eyewash
SB314	25	22	29	21	North Fence -- Under Cover
SB315	27	23	*	21	Driveway Gate
SB316	*	24	31	22	East Fence -- Near Corner
SB317	33	23	29	22	East Fence -- Opposite X-ray Rooms
SB318	30	30	35	25	East Fence -- Opposite Portal
SB319	*	25	29	21	Southeast Corner -- Near Steps
Control	16	16	*	18	
Control	15	15	*	18	

* Not analyzed

6.0 DOSE ASSESSMENT

S. C. Black and D. M. Daigler

The extensive offsite environmental surveillance system operated around the NTS by EPA/EMSL-LV measured no radiation exposures that could be attributed to recent NTS operations. The potential Effective Dose Equivalent (EDE) to the maximally exposed offsite resident resulted in a maximum dose of 3.8 x 10^{-3} mrem (3.8 x 10^{-5} mSv) to a hypothetical resident of Indian Springs, NV located 54 km (32 mi) SE of the NTS control point. This value was based on onsite source emission measurements and estimates provided by DOE and calculated by EPA's CAP88-PC model. The calculated population dose (collective effective dose equivalent) to the approximately 21,750 residents living within 80 km (50 mi) from each of the NTS airborne emission sources was 1.2 x 10^{-2} person-rem (1.2 x 10^{-4} person-Sv). Monitoring network data indicated a 1993 dose of 97 mrem (0.97 mSv) from normal background radiation occurred in Indian Springs. The calculated dose to this individual from world-wide distributions of radioactivity as measured from surveillance networks was 0.054 mrem (5.4 x 10^{-4} mSv). An additional EDE of 0.56 mrem (5.6 x 10^{-3} mSv) would be received if edible tissues from a chukar and contaminated deer collected on the NTS were to be consumed. All of these maximum dose estimates are <1% of the most restrictive standard.

6.1 ESTIMATED DOSE FROM NEVADA TEST SITE ACTIVITIES

The potential Effective Dose Equivalent (EDE) to the offsite population due to NTS activities is estimated annually. Two methods are used to calculate 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 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) with documented assumptions and conversion factors to calculate the Committed Effective Dose Equivalent (CEDE). The sum of these methods provides an estimate of the EDE to a hypothetical individual continuously present outdoors at the location of interest. In addition, a Collective EDE is calculated by the first method for the total offsite population residing within 80 km (50 mi) of the NTS. 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 PIC network provides a measurement of background gamma radiation in the offsite area.

There are four pathways of possible radiation exposure to the population of Nevada that were monitored by EPA's offsite monitoring networks during 1993. These four pathways were:

- Background radiation due to natural sources such as cosmic radiation, radioactivity in soil, and ^{7}Be in air.

- Worldwide distributions of manmade radioactivity, such as ^{90}Sr in milk, ^{85}Kr in air, and plutonium in soil.

- Operational releases of radioactivity from the NTS, including those from drillback and purging activities.

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

Operational releases and other 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 treated in Section 6.1.2 below.

6.1.1 ESTIMATED DOSE USING REPORTED NTS EMISSIONS

Onsite source emission measurements, as provided by DOE, are listed in Chapter 5, Table 5.1, and include tritium, radioactive noble gases, and radioiodine. These are estimates of releases made at the point of origin. Meteorological data collected by the Weather Service Nuclear Support Office (WSNSO) were used to construct wind roses, indicating the prevailing winds for the following areas: Mercury, Area 12, Area 20, Yucca Flat, and the RWMS 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 Indian Springs, Nevada, 54 km (32 mi) SE of CP-1. The maximum dose to that individual would be 3.8×10^{-3} mrem (3.8×10^{-5} mSv). For comparison, data from the PIC monitoring network indicated a 1993 dose of 97 mrem (0.97 mSv) from background gamma radiation occurring in Indian Springs. The population living within a radius of 80 km (50 mi) from the airborne sources on the NTS was estimated to be 21,750 individuals, based on 1992 data. The collective population dose within 80 km (50 mi) from these sources was calculated to be 1.2×10^{-2} person-rem (1.2×10^{-4} 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, 3.4×10^{-3} mrem of the calculated EDE to the maximally exposed individual is due to tritium. The annual average HTO in air concentration that would cause this EDE is 14 times that actually measured in Indian Springs. Table 6.1 summarizes the annual contributions to the EDEs due to 1993 NTS operations as calculated by use of CAP88-PC and the radionuclides listed in Chapter 5, Table 5.1.

Input data for the CAP88-PC model include meteorological data from WSNSO and effluent release data reported by DOE. The effluent 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. Results obtained by using the CAP88-PC model are considered over-estimates of the dose to offsite residents since these results are much higher than exposures estimated with offsite monitoring results using the same radionuclides.

Table 6.1 Summary of Effective Dose Equivalents from NTS Operations during 1993

	Maximum EDE at NTS Boundary[(a)]	Maximum EDE to an Individual[(b)]	Collective EDE to Population within 80 km of the NTS Sources
Dose	4.8×10^{-3} mrem (4.8×10^{-5} mSv)	$3.8 \pm 0.57 \times 10^{-3}$ mrem (3.8×10^{-5} mSv)	1.2×10^{-2} person-rem (1.2×10^{-4} person-Sv)
Location	Site boundary 58 km SSE of NTS Area 12	Indian Springs, 80 km SSE of NTS Area 12	21,750 people within 80 km of NTS Sources
NESHAP[(c)] Standard	10 mrem per year (0.1 mSv per yr)	10 mrem per year (0.1 mSv per yr)	-----
Percentage of NESHAP	0.05	0.04	-----
Background	97 mrem (0.97 mSv)	97 mrem (0.97 mSv)	1747 person-rem (17.5 person Sv)
Percentage of Background	5.0×10^{-3}	4.0×10^{-3}	6.9×10^{-4}

(a) The maximum boundary dose is to a hypothetical individual who remains in the open continuously during the year at the NTS boundary located 60 km SSE from the Area 12 tunnel ponds.

(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 5.1 and assuming all tritiated water input to the Area 12 containment ponds was evaporated.

(c) National Emission Standards for Hazardous Air Pollutants.

6.1.2 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 1993. Actual results obtained in analysis are used; the majority of which are less than the reported MDC. Data quality objectives 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 6.2. The concentrations given in Table 6.2 are expressed in terms of activity per unit volume, weight, or time. These concentrations are converted to a dose by using the assumptions and

Table 6.2 Monitoring Networks Data used in Dose Calculations

Medium	Radionuclide	Concentration	Comment
Animals			
Beef Liver	$^{239+240}$Pu	6.8 x 10^{-4} pCi/g (2.5 x 10^{-5} Bq/g)	Concentrations are the maximum concentrations observed for each animal tissue type
Deer Muscle	$^{239+240}$Pu	1.44 x 10^{-3} pCi/g (5.3 x 10^{-5} Bq/g)	
Deer Liver	$^{239+240}$Pu	9.48 x 10^{-4} pCi/g (3.5 x 10^{-5} Bq/g)	
Chukar	^{3}H	3.3 x 10^{3} pCi/g (1.2 x 10^{5} Bq/g)	Maximum measured in one bird
Milk	^{90}Sr	0.55 pCi/L (0.020 Bq/L)	Concentration is the average of all network strontium results
	^{3}H	120 pCi/L (4.4 Bq/L)	Concentration is the average of all network tritium results
Drinking Water	^{3}H	1.2 pCi/L (0.04 Bq/L)	Concentration is the average of results from the two wells in Indian Springs, Nevada
Vegetables			
Broccoli	^{90}Sr	4.8 x 10^{-3} pCi/g (1.8 x 10^{-4} Bq/g)	Concentrations are maximum observed for each sample type
Carrots	$^{239+240}$Pu	1 x 10^{-4} pCi/g (3.7 x 10^{-6} Bq/g)	
Pears	^{3}H	0.52 pCi/g (0.019 Bq/g)	
Turnips	^{3}H	0.5 pCi/g (0.019 Bq/g)	
Air	^{3}H	0.3 pCi/m^{3} (0.011 Bq/m^{3})	Concentrations are average of all results from the air network
	^{7}Be	0.3 pCi/m^{3} (0.011 Bq/m^{3})	
	^{85}Kr	28 pCi/m^{3} (0.99 Bq/m^{3})	
	^{238}Pu	6.8 x 10^{-6} pCi/m^{3} (2.5 x 10^{-7} Bq/m^{3})	
	$^{239+240}$Pu	3.7 x 10^{-6} pCi/m^{3} (1.4 x 10^{-7} Bq/m^{3})	

dose conversion factors described below. The dose conversion factors assume continuous presence at a fixed location and no loss of radioactivity in meat and vegetables through storage and cooking.

- Adult respiration rate = 8400 m^3/yr (ICRP 1975)
- Milk intake for a 10 year old child = 164 L/yr (ICRP 1975)
- Consumption of beef liver = 0.5 lb/wk (11.5 kg/yr)
- An average deer has 100 lb (45 kg) of meat
- Water consumption = 2 L/day (ICRP 1975)
- Fresh vegetable consumption = 516 g/day (1.1 lb/day) for a four-month growing season (ICRP 1975)

The Effective Dose Equivalent (EDE) conversion factors are derived from EPA-520/1-88-020 (Federal Guidance Report No. 11). Those used here are:

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

- (3×10^{-1} pCi/m^3) x (8400 m^3/yr) x (6.4×10^{-8} mrem/pCi) = 1.61×10^{-4} mrem/yr

However, in calculating the inhalation CEDE from ^{3}H, the value is increased by 50 percent to account for absorption through the skin. The total dose in one year, therefore, is 1.61×10^{-4} mrem/yr x 1.5 = 2.4×10^{-4} mrem/yr. Dose calculations from ORSP data are in Table 6.3.

The dose from consumption of a mule deer and chukar collected on the NTS is not included in Table 6.3. The individual CEDEs from the various pathways added together give a total of 0.053 mrem/yr. The additional dose from ingestion of deer meat and liver containing the $^{239+240}$Pu activities given in Table 6.2 would be:

$$\{[(1.44 \times 10^{-3}\ \mathrm{pCi/g}) \times (4.5 \times 10^{4}\ \mathrm{g})] + [(9.48 \times 10^{-4}\ \mathrm{pCi/g}) \times (280\ \mathrm{g})]\} \times (3.7 \times 10^{-4}\ \mathrm{mrem/pCi}) = 2.41 \times 10^{-2}\ \mathrm{mrem}$$

Table 6.3 Dose Calculations from Monitoring Network Data

Medium	Route of Exposure	Radionuclide	Calculation	Dose (EDE) (mrem/yr)
Milk	Ingestion	^{90}Sr	(0.55 pCi/L) x (110 L/year) x (1.4 x 10^{-4} mrem/pCi)	8.5 x 10^{-3}
		^{3}H	(120 pCi/L) x (110 L/year) x (6.4 x 10^{-8} mrem/pCi)	8.4 x 10^{-4}
Water	Ingestion	^{3}H	(1.2 pCi/L) x 730 L x (6.4 x 10^{-8} mrem/pCi)	5.6 x 10^{-5}
Total from Liquid Ingestion				9.4 x 10^{-3}
Foodstuffs				
Beef Liver	Ingestion	^{238}Pu	(3.3 x 10^{-5} pCi/g) x (11.5 x 10^{3} g/yr) x (3.7 x 10^{-4} mrem/pCi)	1.4 x 10^{-4}
		$^{239+240}$Pu	(6.8 x 10^{-4} pCi/g) x (11.5 x 10^{3} g/yr) x (3.7 x 10^{-4} mrem/pCi)	2.9 x 10^{-3}
Broccoli[a]	Ingestion	^{90}Sr	(4.8 x 10^{-3} pCi/g) x (129 g/day) x (125 days/yr) x (1.4 x 10^{-4} mrem/pCi)	1.1 x 10^{-2}
Carrots[a]	Ingestion	$^{239+240}$Pu	(9.84 x 10^{-5} pCi/g) x (129 g/day) x (125 days/yr) x (3.7 x 10^{-4} mrem/pCi)	5.9 x 10^{-4}
Pears[a]	Ingestion	^{3}H	(0.52 pCi/g) x (129 g/day) x (125 days/yr) x (6.4 x 10^{-8} mrem/pCi)	5.4 x 10^{-4}
Turnips[a]	Ingestion	^{3}H	(0.50 pCi/g) x (129 g/day) x (125 days/yr) x (6.4 x 10^{-8} mrem/pCi)	5.2 x 10^{-4}
Total from Foodstuff Consumption				1.6 x 10^{-2}
Air	Submersion/ Inhalation	^{3}H	(3 x 10^{-1} pCi/m^3 x 8400 m^3/yr x 1.5 x 6.4 x 10^{-8} mrem/pCi)	2.4 x 10^{-4}
		^{7}Be	(0.3 pCi/m^3) x 8400 m^3/yr x (2.6 x 10^{-7} mrem/pCi)	6.6 x 10^{-4}
	Submersion	^{85}Kr	(2.8 x 10^{1} pCi/m^3 x 1.5 x 10^{-5} mrem/yr per pCi/m^3)	4.2 x 10^{-4}
	Inhalation	^{238}Pu	(6.8 x 10^{-6} pCi/m^3 x 8400 m^3/yr x 3.1 x 10^{-1} mrem/pCi)	1.8 x 10^{-2}
	Inhalation	$^{239+240}$Pu	(3.7 x 10^{-6} pCi/m^3 x 8400 m^3/yr x 3.1 x 10^{-1} mrem/pCi)	9.6 x 10^{-3}
Total from Air				2.9 x 10^{-2}
Total from Ingestion, Inhalation, Absorption and Submersion				5.4 x 10^{-2}

(a) The fruit and vegetable intake of 516 g/d was split between all fruits and vegetables and the number of days used for consumption was 125, slightly more than 4 months.

The weight of the liver (280 g) used in the above equation is the median weight of the livers from the three mule deer obtained in 1993. For the chukar, assume 250 g edible meat and 10 chukar consumed per individual during the hunting season. The CEDE would be:

$$3.3 \times 10^{3}\ \text{pCi/g} \times 250\ \text{g} \times 10 \times 6.4 \times 10^{-8}\ \text{mrem/pCi} = 0.53\ \text{mrem}$$

Total EDEs can be calculated based on different combinations of data. If an individual were interested in just one area, for example, the concentrations from those stations closest to that area could be substituted into the equation.

6.2 DOSE (EDE) FROM BACKGROUND RADIATION

In addition to external radiation exposure due to cosmic rays and gamma radiation from naturally occurring radionuclides in soil (e.g., ^{40}K, uranium and thorium daughters), 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 offsite surveillance network was 0.3 pCi/m^3. With a dose conversion factor for inhalation of 2.6×10^{-7} mrem/pCi, and an annual breathing volume of 8400 m^3/yr, this equates to a dose of 6.6×10^{-4} mrem as calculated in Table 6.3. This is a negligible quantity when compared with the PIC network measurements that vary from 66 to 166 mR/year, depending on location.

6.3 SUMMARY

The extensive offsite environmental surveillance system operated around the NTS by EPA EMSL-LV detected no radiological exposures that could be attributed to recent NTS operations, but a calculated EDE of 0.053 mrem can be obtained if certain assumptions are made. Calculation with the CAP88-PC model, using estimated or calculated effluents from the NTS during 1993, resulted in a maximum inhalation dose of 3.8×10^{-3} mrem (3.8×10^{-5} mSv) to a hypothetical resident of Indian Springs, NV, 54 km (32 miles) SE of the NTS CP-l. Based on monitoring network data, this dose is calculated to be 0.054 mrem. This latter EDE is about 14 times the dose obtained from CAP88-PC calculation, and is mostly due to inhalation of plutonium. If this individual were also to collect and consume a NTS deer such as the one discussed above, the estimated EDE would increase by another 2.4×10^{-2} mrem (2.4×10^{-4} mSv) to a total possible EDE of about 0.078 mrem (7.8×10^{-4} mSv), and consumption of 10 chukar with the maximum ^{3}H content would add 0.53 mrem for a total of 0.61 mrem. This maximum dose estimate is less than 1 percent of the International Commission on Radiological Protection (ICRP) recommendation that an annual effective dose equivalent for the general public not exceed 100 mrem/yr (ICRP 1985). The calculated population dose (collective effective dose equivalent) to the approximately 21,750 residents living within 80 km (50 mi) of each of the NTS airborne emission sources was 1.2×10^{-2} person-rem (1.2×10^{-4} person-Sv). Background radiation would yield a CEDE of 1747 person-rem (17.5 person-Sv).

Data from the PIC gamma monitoring indicated a 1993 dose of 97 mrem from background gamma radiation measured in Indian Springs. This gamma background value is derived from an average PIC field measurement of 8.9 µR/hr. The 0.054 mrem CEDE calculated from the monitoring networks and model as discussed above is a negligible amount by comparison.

The uncertainty (2σ) for the PIC measurement at the 97 mrem exposure level is approximately 6 percent. Extrapolating to the calculated annual exposure at Indian Springs, Nevada, yields a total uncertainty of approximately 4.5 mrem. Because the estimated dose from NTS activities is less than 1 mrem (the lowest level for which DQOs are defined, as given in Chapter 11) no conclusions can be made regarding the achieved data quality as compared to the DQO for this insignificant dose.

7.0 NONRADIOLOGICAL MONITORING RESULTS

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Nonradiological monitoring of NTS operations was confined to onsite monitoring as there were no nonradiological discharges to the offsite environment. Types of monitoring conducted included: (1) drinking water distribution systems for Safe Drinking Water Act compliance; (2) sewage influents to lagoons for state of Nevada permit requirements; (3) polychlorinated biphenyls (PCBs) as part of Toxic Substance Control Act compliance; (4) asbestos monitoring for asbestos removal and renovation projects; (5) environmental media for hazardous characteristics and constituents. Flora, fauna, and other environmental conditions were also monitored for population trends and impacts.

7.1 ENVIRONMENTAL SAMPLES

7.1.1 SAFE DRINKING WATER ACT

Water sampling was conducted for analysis of bacteria, volatile organic compounds (VOCs), inorganic constituents, and water quality as required by the Safe Drinking Water Act and state of Nevada regulations. Samples were taken at various locations throughout all drinking water distribution systems on the NTS by Reynolds Electrical & Engineering Co., Inc. (REECo). Common sampling points were rest room and cafeteria sinks. The sample collection points for water distribution systems on the NTS are shown in Chapter 4, Figure 4.3. All samples were collected according to accepted practices and sent to state approved laboratories for analysis. Analyses were performed in accordance with Nevada Administrative Code (NAC) 445 and 40 CFR Part 141. The water samples for organics and inorganics were collected by a state of Nevada inspector during his inspection in September 1993.

7.1.1.1 BACTERIOLOGICAL SAMPLING

During January through March the samples for analysis of coliform bacteria were submitted to the state-approved Associated Pathologists Laboratories in Las Vegas, Nevada. Beginning in April 1993, the REECo Analytical Services Department's (ASD) Analytical Chemistry Laboratory started performing the analyses for coliform bacteria. All water 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 consecutive samples must meet state requirements. The one incident of positive coliform bacteria results is discussed in Section 3.1.4.1.

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

Sample results for 1993 for coliform and RC are given in Appendix I, Table I.1, along with applicable state of Nevada permit numbers. The RC results are paired with the coliform results from each specific sample. The pH results for the distribution systems are given in Appendix I, Table I.2. The RC results were within state permit limits.

Samples from each truck which hauled potable water from NTS wells to work areas were analyzed for coliform bacteria. All truck samples were negative for coliforms in 1993.

7.1.1.2 Chemical Analysis

The results of chemical analyses of water samples are given in Appendix I, Table I.2. The Area 25 system slightly exceeded state secondary limits for pH and fluoride. The results for all other systems were within regulatory limits.

Volatile Organic Compound Analysis

Samples for volatile organic compounds (VOCs) were collected during each calendar quarter of 1993 from all NTS potable water wells. The samples were analyzed by Westech Laboratory Services of Phoenix, Arizona. These analyses did not indicate the presence of any VOCs above quantitation limits.

Inorganic Compound Analysis and Water Quality

Samples for inorganic compounds and water quality were collected in accordance with 40 CFR 141.11 and NAC 445 in September 1993 by the state inspector. The analytical results for these samples, including those mentioned above, are given in Appendix I, Table I.2.

7.1.2 CLEAN WATER ACT

7.1.2.1 NTS OPERATIONS

Routine influent sampling schedules have been established in accordance with state of Nevada operating permits (OPs) for the sewage lagoon systems on the NTS (OPs Nos. NV87059, NV87060, NV87069, and NV87076). Water parameters monitored included flow rate, pH, biochemical oxygen demand (BOD), and total suspended solids (TSS). The flow rate and pH were estimated or measured onsite, and the BOD and TSS were determined by a state approved laboratory, Atlas Chemical Testing, in Las Vegas, Nevada.

Continuous monitoring of flow rates was conducted at the Areas 6 (Yucca Lake), 12, and 23 lagoon systems. Flow rates for all other lagoon systems were determined by visual estimation (allowed by current permit requirements). The pH was determined with a pH meter. Measurements of the pH were performed every month for the Areas 22 and 23 lagoon systems and quarterly for all other systems. For BOD and TSS, the sewage lagoon system permits require biannual sampling at the Area 6 Yucca Lake and Area 25 Reactor Control lagoon system, quarterly sampling at the Area 12 lagoon system, and monthly sampling at the Area 23 lagoon system. The biannual BOD sampling could not be accomplished at Area 25 because the lagoon system was dry. The analysis results for NTS sewage lagoon systems influent sampling in 1993 are given in Appendix I, Table I.3. The pH and flow results were within state limits. There were no standards for BOD and TSS.

A water pollution control permit was issued for the U-12n Tunnel discharge effective November 12, 1992. This permit requires quarterly monitoring and reporting. The results of this monitoring in 1993 are given in Appendix I, Tables I.4 to I.7. None of the permit limits were exceeded during 1993.

7.1.2.2 NON-NTS SAMPLING RESULTS

Only the EG&G/EM, Las Vegas Area Operation (LVAO), was required by permit to sample and analyze wastewater effluent and submit monitoring reports. Effluent monitoring demonstrated that LVAO operations were in compliance with the limits specified in its permit.

7.1.3 NON-HAZARDOUS SOLID WASTE DISPOSAL

Monitoring of the three sanitary landfills was limited to recording daily refuse amounts by weight. The state has no permit system for these but did approve the O&M manuals. All waste disposed of in the Area 23 landfill was weighed at the Gate 100 weighing station. Weights indicated for the Area 9 landfill are estimations. About 12,600 tons of waste were disposed of in the Areas 6, 9, and 23 sanitary landfills as shown in Appendix I, Table I.8.

7.1.4 TOXIC SUBSTANCES CONTROL ACT (TSCA)

During 1993, a total of 204 samples were collected for PCB analyses: 39 were oil, 45 were wipes, 44 were water, 66 were soil, and 10 were miscellaneous matrices. All PCB samples were analyzed at the REECo ASD Analytical Chemistry Laboratory.

The sample analyses showed: (1) 33 oil samples did not contain detectable PCBs, 6 were between 5 and 500 ppm; (2) the 45 wipe samples ranged from <2.88 to 182 µg/wipe; (3) 43 water samples did not contain detectable PCBs, one contained PCBs at 3 ppm; (4) 57 soil samples did not contain detectable PCBs, 9 contained PCBs ranging from 4 to 223,000 ppm; (5) the 10 miscellaneous matrices did not contain detectable PCBs.

7.1.5 NATIONAL EMISSION STANDARDS FOR HAZARDOUS AIR POLLUTANTS

During 1993, 1,966 bulk or general air samples were collected and analyzed in conjunction with asbestos removal and renovation projects at the NTS. Of the 1300 bulk samples collected, 306 were positive for asbestos and 994 were negative. A total of 666 general area air samples were collected and analyzed, all were negative.

7.1.6 RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)

A total of 6115 analyses were performed in 1993 for waste management and environmental compliance activities at the NTS. Appendix I, Table I.9 gives a breakdown of these analyses by matrix and analysis type. Six hundred ninety-nine (74 percent) of the volatile organic analyses were performed by REECo ASD and the other 248 (26 percent) by outside commercial laboratories. Four hundred fifty (90 percent) of the semi-volatile organic analyses were performed by REECo ASD and the other 52 (10 percent) by outside commercial laboratories. One thousand eighty-nine (84 percent) of the ICP(a) metals analyses were performed by REECo ASD and the other 200 (16 percent) by outside commercial laboratories. Six hundred twenty six (60 percent) of the TCLP(b) metals analyses were performed by REECo ASD and the other 411 (40 percent) by outside commercial laboratories. All of the pH, flashpoint, TPH, and analyses indicated as "other" were performed by REECo ASD.

In addition to the analyses reported in this table 3190 (34 percent of total sample analyses) blank and spike samples were analyzed by the REECo ASD as part of the laboratory quality control program.

7.1.7 SPECIAL STUDIES

A total of 4 tests, all involving carbon dioxide, were conducted at the Liquified Gaseous Fuels Spill Test Facility (LGFSTF) in 1993. Pursuant to the agreement between LGFSTF and the state of Nevada, the EPA is invited to participate in spill test panels and field monitoring.

7.2 ECOLOGICAL CONDITIONS

Monitoring of flora and fauna on the Nevada Test Site (NTS) was conducted by the DOE/NV-sponsored Basic Environmental Compliance and Monitoring Program (BECAMP). Sampling included an annually monitored relatively undisturbed site, several intermittently monitored (e.g., every three years) DOE disturbed sites, and other baseline sites. Sampling activities included measurements on annual and perennial plants, reptiles, birds, rodents, deer, and feral horses. Complete data are assembled in five internal annual reports. The essence of the reports is summarized in the following sections.

In 1993, animal and ephemeral plant populations returned to pre-drought (i.e., prior to 1989) population levels or higher. Shrub populations remained at less than pre-drought cover and volume levels. Annual precipitation measured at Yucca Flat totaled 245 mm (9.6 in), the highest since 1984 (Appendix I, Table I.10). Precipitation was heaviest during winter, with 242 mm (9.54 in) falling between December 1992 and March 1993. Rainfall in central Yucca Flat did not exceed 18 mm (0.7 in) in any month from March through December 1993.

7.2.1 FLORA

A census of plant species on the Yucca Flat baseline plot is given in Appendix I, Table I.11. Significant growth of existing shrubs was noted in 1993. Shrub volume increased to the highest value since 1989, primarily due to increases in three species (Appendix I, Table I.12): *Atriplex canescens* (fourwing saltbrush), *Ceratoides lanata* (winterfat), and *Grayia spinosa* (spiny hopsage). *Atriplex canescens* increased to become the dominant species by volume (32 percent). Changes in 1993 represented a shift in dominance from long-lived, slow-growing species to disturbance-adapted, fast-growing species. This shift may be a continuing recovery pattern from the severe drought years that eliminated nearly half of the perennial plants and 40 percent of the total shrub live volume. Some of the long-lived species did continue recovery by resprouting both from below-ground and from low stems and crowns.

Densities of herbaceous perennials declined in 1993 probably due to death of seedlings in late summer 1992 (Appendix I, Table I.11). There was some germination of herbaceous perennials with *Oryzopsis hymenoides* (Indian ricegrass) numbers increasing slightly. Growth of surviving herbs was good.

Winter ephemeral densities increased ten-fold from 1992, but they dried up early so the biomass in mid-April was similar to the 1992 value. This high density reflected good reproduction in 1992 as well as favorable germination conditions. Native species made up 50 percent of the numbers, as opposed to only 3 percent in 1988. Little rain fell after early March and ephemerals dried up in late April, somewhat earlier than in 1992.

7.2.2 FAUNA

BECAMP uses the side-blotched lizard (*Uta stansburiana*) to monitor trends in reptile populations due to its widespread abundance on the NTS. Monitoring in 1993 continued to show no long term trend in side-blotched lizard numbers, indicating that human activities on the NTS have had no long term effect on this lizard population.

Nineteen marked tortoises inhabit three 9-ha fenced areas in Rock Valley. In the spring and/or autumn of 1993, 15 tortoises were captured, measured (length of plastron and carapace), weighed, and inspected to evaluate their general health. All tortoises showed positive growth in plastron length, but mean growth was low compared to other years of high winter precipitation. Mean growth in six males was significantly greater than in six females.

The number of small mammals captured at the Yucca Flat baseline plot in 1993 was the highest ever. Numbers of species (11) and species diversity (H=0.7090) were higher than in previous years. The chisel-toothed kangaroo rat (*Dipodomys microps*) was the most commonly captured rodent in 1993.

Blood from 58 deer mice (*Peromyscus maniculatus*) was tested for exposure to hantavirus in August 1993. Nine of 41 from Rainier Mesa and 4 of 17 from Pahute Mesa tested positive, indicating about 25 percent of NTS deer mice have been exposed. No other species tested positive.

The feral horse population declined by three in 1993. Two adult females were not observed in 1993 and another female died on 6 July near Area 2 camp, apparently from natural causes. The remaining observed adult (i.e., 2 years of age or older) population was 61 animals. Eleven foals were observed during 1993. Six were known to be missing and presumed dead, and the status of 5 was uncertain as of December 1993.

Fresh horse feces were collected from three horses in the north central part of the NTS during the summer and analyzed for tritium content. The results of these analyses were very low, ranging from 121 - 3770 pCi/L, with an average value of 1508 pCi/L. These values are more than ten-fold less than the Safe Drinking Water Act limit for tritium in water for human consumption. The possible source for these low levels of tritium was contaminated pond areas in Area 12.

Mule deer numbers on the NTS appeared to remain stable. During 1993 a potential source of sighting bias was evaluated by using a whistle stimulus during nighttime surveys. The number of deer per group was counted using spotlights both before and after blowing a whistle. Use of the whistle did not affect the mean deer count. Only 3 of 64 observations (4.7 percent) showed an increase in deer sighted, indicating deer do not avoid the spotlights during surveys.

Raven reproduction during 1993 appeared quite successful. Six of nine nests from Yucca and Frenchman Flats fledged young. Four of these nests were located on man-made structures in desert tortoise habitat. Most nests produced 4 or 5 young with an average of slightly more than 4 young per nest.

NTS raptors were recorded while driving along Mercury highway from Frenchman Flat through Yucca Flat finishing near the Area 12 camp. When first observed, 75 percent of the raptors were seen perched on poles along roadsides, with only 11 percent seen flying. Significantly greater numbers of raptors were seen along roadsides with poles than roadsides without poles. More raptors were seen on Yucca Flat than Frenchman Flat in the summer and fall, but not in the spring (Appendix I, Table I.13). Juveniles were abundant, indicating good reproduction. Common species observed were red-tailed hawk, American kestrel, and prairie falcon. Of special note were two sightings of Swainson's hawk in Frenchman Flat.

7.2.3 MONITORING OF DISTURBED AREAS

Disturbed areas on the NTS are monitored on a three year cycle. In 1993 four roadside areas were examined. One site in central Frenchman Flat (road 5-05) was studied for changes in small mammal, lizard, ephemeral plants, and perennial plants. Mammals and lizards were studied along a new road leading to the Device Assembly Facility (DAF) in northwestern Frenchman Flat. Perennial plants were studied along an abandoned roadside in Frenchman Flat (road 5-03). Weedy ephemeral plants were studied along Mercury Highway and Rainier Mesa Road, from Mercury through Frenchman and Yucca Flats. A summary of the results of these studies is given below.

7.2.3.1 EPHEMERAL PLANTS

Road 5-05: Overall ephemeral plant populations and biomass within 15 m of the edge of the road were very similar to those on the control area 500 m away. The total number of species on 1000 m^2 of roadside was 32, with 36 on the control area. Seven species were unique to the roadside, and 12 to the control area.

Mercury Highway: Eight common weeds were examined along Mercury Highway to determine if the roadway was enhancing their populations, and to determine the distance roadside populations were spreading into undisturbed vegetation. Only one species (*Erodium cicutarium*) was found more frequently on the roadside. Three species were seen more often on the undisturbed areas, and four were equally common on both roadside and undisturbed areas (Appendix I, Table I.14).

These results suggest that road construction and maintenance are not contributing to introduction or expansion of introduced plants on the NTS.

7.2.3.2 PERENNIAL PLANTS

Road 5-05: Total live cover and total live volume did not differ significantly between the control and roadside areas. The species composition did differ along the roadside compared with the control area. This difference can be attributed to altered conditions along the road, in particular, greater water resources for roadside vegetation.

Road 5-03: Average growth rates and percentage increase in total live volume were significantly greater in the control area compared with the roadside area. This was due principally to increases in the dominant species, *Ambrosia dumosa*. However, this increase was thought to be an artifact of the significantly greater decrease in this species in the control area during the drought years compared to the roadside area, with subsequent recovery in 1992 and 1993.

7.2.3.3 REPTILES

Road 5-05: There was no significant difference in the number of lizards seen per day in the total roadside area versus the control area, however, lizards were present in significantly greater numbers in the roadside berm versus scraped or paved road. The size and weight of the lizards sampled did not differ significantly between roadside and control areas. There was a significantly greater proportion of females in the control versus roadside area.

DAF Road: There was a significantly greater number of side-blotched lizards in the control versus roadside areas during the spring. However, in the summer no significant difference in numbers was observed. During the spring, females were present in significantly greater numbers in the roadside area. In the summer no sexual differentiation between roadside and control areas was observed.

Results from the two road sites suggest lizards are likely to be excluded from paved or scraped road areas, while roadside berm areas support higher lizard populations.

7.2.3.4 SMALL MAMMALS

Road 5-05: A greater proportion of juvenile females was present in the control versus roadside areas. *D. merriami* (Merriam's kangaroo rat) was the most common species, but *Chaetodipus formosus* (long-tailed pocket mouse) replaced *Perognathus longimembris* (little pocket mouse) as the second most common species.

DAF Road: The percentage of juvenile females in early June was higher in the control versus roadside area. However, by mid-July the percentage of juvenile females was higher in the roadside area.

8.0 RADIOACTIVE AND MIXED WASTE STORAGE AND DISPOSAL

Deron Linkenheil and John J. Mattick

Low-level radioactive wastes (LLW) are disposed of at two locations on the NTS. Packaged LLW from DOE and Department of Defense (DOD) facilities are disposed of at the Area 5 Radioactive Waste Management Site (RWMS-5) in shallow pits and trenches. In past years high specific activity, highly mobile, non-WIPP certifiable wastes were disposed of in deep augured shafts known as greater confinement disposal (GCD). Packaged LLW, low specific activity LLW packaged in large bulk waste containers, and unpackaged bulk wastes from the NTS are buried in selected subsidence craters at the Area 3 RWMS (RWMS-3).

Hazardous waste and transuranic (TRU) wastes are stored above ground in Area 5. Mixed TRU wastes are stored on a specially constructed RCRA pad. This waste will be characterized for proposed disposal at the Waste Isolation Pilot Plant (WIPP) in New Mexico. Uranium ore residues previously designated as strategic materials are stored north of the RWMS-5. Hazardous wastes generated on the NTS are accumulated at the Hazardous Waste Accumulation Site in Area 5 pending shipment to an offsite treatment, storage and disposal facility.

During 1993, air samples were collected at RWMS-3 and RWMS-5 for analysis of gross beta activity, photon emitting radionuclides, plutonium and tritium. The only airborne radionuclide detected attributed to disposal activities was tritium at the RWMS-5. All concentrations were well below derived concentration guides. Gamma radiation fields were monitored by thermoluminescent dosimeters (TLD). Gamma exposures greater than background were detected at the RWMS-5 gate and in areas where waste is stored above ground. Neutron radiation fields at the perimeter of the TRU waste storage pad were monitored by proton recoil dosimeters and results were well below occupational limits. Mixed waste cells were monitored for infiltration of rain water.

8.1 WASTE DISPOSAL OPERATIONS

Radioactive waste disposal was initiated at Area 5 on the NTS in 1961. By July 1976 six of nine developed trenches had been filled with LLW. In 1978 waste disposal operations were expanded when the DOE established the Radioactive Waste Management Project for the disposal of defense related LLW from the NTS, offsite DOE generators and DOD facilities. The state of Nevada granted the NTS interim status in 1987 for the disposal in Pit 3 of low-level mixed wastes. Mixed waste disposal was curtailed in 1990 by the DOE due to concerns about the presence of Land Disposal Restricted constituents in mixed waste. The state of Nevada later curtailed mixed waste disposal until DOE provides National Environmental Policy Act (NEPA) documentation and implements a state approved Waste Analysis Plan. No mixed wastes have been received or disposed of at the Areas 3 or 5 RWMSs since 1990.

The RWMS-3 has been used for the disposal of bulk atmospheric test debris, low-level radioactive waste, and non-standard packages of DOE and DOD wastes.

Wastes generated on the NTS that are regulated by the state of Nevada under the Resource Conservation and Recovery Act (RCRA) are shipped to offsite treatment, storage and disposal facilities. Hazardous chemical wastes are not accepted from offsite generators. Mixed wastes generated on the NTS may use Pit 3, RWMS-5, for disposal.

8.1.1 AREA 5 RADIOACTIVE WASTE MANAGEMENT SITE

The RWMS-5 occupies approximately 296 hectares (732 acres) and is located in the northern area of Frenchman Flat, approximately 26 km (16 mi) north of the NTS main gate. Currently, 37 hectares (92 acres) are posted radiological areas used for the disposal of LLW. Prior to 1968, Area 5 had been used for the testing of conventional weapons and both above and below ground testing of nuclear weapons.

The Frenchman Flat basin is bounded by the Massachusetts Mountains on the north, Black Ridge and Mt. Salyer to the west, the Buried Hills and Ranger Mountains to the east, and Mercury Ridge to the south. The general surface geology of the area is alluvial sediment interspersed with tuffaceous material. The basin is filled with up to 305 m (1000 ft) of alluvium from the surrounding mountain ranges. The disposal site is located on a gently sloping alluvial fan extending southward from the Massachusetts Mountains, which lie approximately 3.3 km (2 mi) to the north. The slope of the terrain is two percent in the vicinity of the disposal site, but increases to three percent to the west. Two shallow dry washes cross the site, from the northwest and from the northeast. An earthen dike has been constructed along the western, northern and eastern borders of the RWMS-5 to prevent water flow into the disposal area.

In the past LLW and mixed wastes have been managed by shallow land burial in trenches and pits at depths ranging from 4.6 m to 9.1 m (15 to 30 ft). Burial cells are temporarily covered by 2.8 m (9 ft) of soil which is the operational cap pending final design of a permanent closure cap. High specific activity, highly mobile, non-WIPP certifiable wastes have been managed by deep burial in augured shafts 36 m (120 ft) deep. The shafts have been backfilled with soil from a depth of 21 m (70 ft) to the surface. Wastes received at the RWMS-5 are transported and disposed of in approved Department of Transportation containers, generally 55-gallon steel drums or 4 ft x 4 ft x 7 ft steel and wooden boxes.

LLW is accepted for disposal from generators that have received DOE/HQ and DOE/NV approval. Prior to receiving approval, generators must submit an application detailing each waste stream's characterization and certification program that meets the requirements of NVO-325(Rev. 1), "Nevada Test Site Defense Waste Acceptance Criteria, Certification, and Transfer Requirements". Approval may be granted if an audit indicates that the waste characterization and certification plan has been satisfactorily implemented. Approved generator programs are reviewed and audited annually.

LLW amounting to 8,327 m^3 (2.9×10^5 ft^3) containing a total of 30 kCi (1.1 PBq) of radioactivity were received at the RWMS-5 from eight approved DOE and DOD generators in 1993. Tritium accounted for over 99.8 percent of this activity. ^{51}Cr, ^{60}Co, ^{14}C, ^{238}Pu, ^{234}U, ^{235}U and depleted uranium (^{238}U) account for the majority of the remaining activity. By the end of 1993 the RWMS-5 had disposed of an accumulative 1.7×10^5 m^3 (6.0×10^6 ft^3) of waste containing 9.8 MCi (360 PBq), neglecting radioactive decay from date of disposal.

LLW disposed of prior to 1986 may contain low levels of constituents that would be regulated as hazardous waste under RCRA. Mixed wastes had been previously disposed of in Pit 3 under RCRA Interim Status. In May 1990 mixed waste disposal operations in Pit 3 ceased due to EPA issuance of the Land Disposal Restrictions of RCRA. A Mixed Waste Management Unit (MWMU) is planned to be sited in the northeastern area of the RWMS-5. The MWMU will cover approximately 10 hectares (25 acres) and contain 8 landfill cells to be used for mixed waste disposal. Mixed waste disposal operations at the NTS will commence under interim status in Pit 3 upon completion of NEPA documentation and an approved state Waste Analysis Plan, and at the MWMU upon issuance of a state RCRA Part B Permit.

8.1.1.1 RWMS-5 GROUNDWATER MONITORING

In 1993 data collection was initiated for a study to characterize the hydrogeology of the vadose zone under the waste disposal cells at RWMS-5. The purpose of this study is to determine the hydrologic conditions of the vadose zone water quality conditions, and flow gradients. Sampling is being performed using three pilot wells drilled in 1992 into the uppermost aquifer under the LLW and Mixed LLW Disposal Cells in Area 5. Based on data analyzed to date, no chemical or radiological contaminants attributable to DOE weapons testing or waste management activities have been detected in the three wells. A detailed discussion of this study is given in Section 9.2.2.3.

8.1.2 AREA 3 RADIOACTIVE WASTE MANAGEMENT SITE

The RWMS-3 lies at an elevation of 1230 m (4050 ft) and covers approximately 20 hectares (50 acres). It is located in the center of Yucca Flat approximately 8 miles north of the Yucca Playa Dry Lake Bed. The site is located on nearly 450 m (1500 ft) of alluvial and tuffaceous sediments. The climate and topography are similar to that of the RWMS-5. Atmospheric and underground nuclear tests have been conducted in several areas in Yucca Flat including Area 3. Safety tests have resulted in the dispersion of plutonium in surface soils in Area 3. Further details regarding the RWMS-3 are available in DOE report DOE/NV/10630-8 (Gonzalez 1989).

The RWMS-3 is used for the management of bulk debris from above ground nuclear tests and packaged low specific activity bulk wastes generated offsite. Subsidence craters formed by underground nuclear tests are used as disposal. The subsidence craters range in depth from 15 to 24 m (49 to 78 ft). The craters are filled by alternating layers of stacked waste packages and clean fill. A 2.5-m (8 ft) thick cap of clean soil extending 1.2 m (4 ft) above the grade has been used for temporary closure of the craters. A total volume of 292,056 m^3 (1.04×10^7 ft^3) of LLW originally containing 1528 Ci (56 Tbq) have been disposed of at the RWMS-3. Tritium accounts for approximately 87 percent of this activity. Fission products and depleted uranium account for the majority of the remainder. Two craters, U-3ax and U-3bl, have been filled to date. U-3ah/at is currently open and contains almost 47,464 m^3 (1,676,000 ft^3) of atmospheric testing debris. In 1993 the RWMS-3 received 9848 m^3 (3.5×10^5 ft^3) of waste containing 0.24 Ci (8.9 GBq) of activity. ^{234}U and ^{235}U account for approximately 43 percent and depleted uranium approximately 54 percent of the 1993 waste activity. The balance of the 1993 activity is related to fission products.

8.1.3 STRATEGIC MATERIALS STORAGE AREA

The strategic materials storage area is used for storage of residues from the processing of uranium ores from Mound Laboratory, Miamisburg, Ohio. On a mass basis this material consist primarily of ^{238}U and iron. On an activity basis the residues are highly enriched in ^{230}Th and ^{231}Pa and contain approximately 290 Ci (10.7 TBq) of total activity. The residues are considered potentially waste related materials and are stored in a controlled area pending a decision on their final disposition. The materials are packaged in steel drums in wooden boxes which are in turn stored in 28 steel cargo containers. The containers are stored on concrete pads inside a fenced radiological area. Opening of the cargo containers is controlled following established ALARA practices to minimize personnel exposure to external gamma radiation fields and potential internal radiation hazards. Periodic container integrity inspections are performed.

8.1.4 TRANSURANIC WASTE STORAGE

The TRU waste storage pad is located in the southeast corner of the RWMS-5. The pod is used for interim storage of TRU waste materials previously received from Lawrence Livermore National Laboratory (LLNL) that are suspected of being TRU mixed waste. The waste is stored in a controlled radiological area on a curbed asphalt pad surrounded by a security fence. The pod and waste storage configuration complies with RCRA requirements in 40CFR 265, Subpart I. TRU mixed waste is not currently accepted for storage or disposal at the NTS. The TRU inventory is awaiting permanent disposal in a deep geologic repository at the Waste Isolation Pilot Plant (WIPP). This waste does not currently meet WIPP waste acceptance criteria and will require characterization and certification before final disposal. A TRU Waste Certification Building to be located in Area 5 is in the engineering design phase. Completion of the building is planned for 1997.

Waste management personnel perform inspections of all TRU waste containers on a weekly basis. Rain water that accumulates on top of drums is removed after each rainfall. The drums are stored on wooden pallets to prevent contact with rain water that may accumulate on the pad. During 1992 all of the TRU waste in 55-gal drums were overpacked into steel drums with HEPA filter vents. Inspections of the TRU Waste Storage area were performed in 1993. Construction of a cover for the TRU waste storage pad will begin in February 1994 with completion scheduled for May of 1994.

8.2 ENVIRONMENTAL MONITORING AT WASTE STORAGE AND DISPOSAL SITES

The Reynolds Electrical & Engineering Co., Inc., (REECo) Analytical Services Department (ASD), Environmental Section is responsible for collection of samples and verifying sample results. The REECo ASD Radioanalytical Section is responsible for the analysis of the samples. Collection and analysis of samples is performed in accordance with approved operating procedures.

8.2.1 AIR MONITORING

Air sampling is conducted at nine sites along the perimeter of the RWMS-5 fence, at six sites along the perimeter of the TRU waste storage pod, and four sites along the perimeter of the U-3ah/at craters. The air samplers operate at an air flow rate of approximately 140 L (5.0 ft^3) per minute. The sampling media are a 10 cm (4 in) glass-fiber filter and a charcoal cartridge that are exchanged weekly. Each filter is analyzed for gross beta radiation and each filter and cartridge for photon emitting radionuclides. The filters are composited and analyzed monthly for ^{238}Pu and $^{239+240}$Pu. Samplers for tritium (HTO) are located with the particulate samplers. The tritium samplers consist of a column of silica gel, a pump for drawing air through the desiccant, and a dry-gas meter to measure the sample volume. Samples are collected every two weeks and represent approximately 12 m^3 (425 ft^3) of air.

Tritium, ^{238}Pu,$^{239+240}$Pu, and naturally occurring radionuclides were detected in air at the RWMS-5 in 1993. Airborne plutonium in Area 5 is most likely due to resuspension of contaminated soils and not attributable to waste disposal activities. The progeny of the primordial radionuclides ^{232}Th and ^{238}U, the naturally occurring radionuclide ^{40}K and the cosmogenic radionuclide ^{7}Be were also detected. No radioiodines were detected. Tritium is routinely detected at the RWMS-5 at activity concentrations slightly greater than the mean activity concentration for the NTS. The highest concentration detected was 1.9 X 10^{-11} µCi/mL (0.7 Bq/m^3) which is less than 0.1 percent of the derived concentration guide for HTO established in DOE Order 5400.5 for the protection of the public and the environment. In general tritium activity concentrations decreased from 1992 levels.

Naturally occurring radionuclides and traces of plutonium (^{238}Pu and $^{239+240}$Pu) were detected in air at all of the Area 3 samplers in 1993. The highest concentration of $^{239+240}$Pu detected was 1.6 x 10^{-16} µCi/ml (5.9 µBq/m^3) which is only 5 percent of the derived concentration guide for ^{239,240}Pu in DOE Order 5400.5. This airborne plutonium is most likely due to resuspension of soils contaminated by atmospheric weapons testing, and is therefore not attributable to waste disposal activities. The other radionuclides detected (^{40}K and ^{7}Be) are naturally occurring primordial or cosmogenic radionuclides.

8.2.2 EXTERNAL GAMMA EXPOSURES

Thermoluminescent dosimeters (TLDs) were deployed at 44 locations at the RWMS-5. Ten TLDs were placed within the perimeter which included six TLDs around the TRU Waste Storage Pad and two each in Pit Nos. 3 and 4 approximately 30 m (100 ft) from the waste stacks. Fifteen TLDs were located at the perimeter of the site and one was placed at the facility office. Another 18 TLDs are located around the Strategic Materials Storage Area (SMSA). All TLDs were exchanged and analyzed quarterly. TLDs placed at the perimeter of the RWMS-5 recorded 1993 exposures ranging from 156 mR to 273 mR. The highest value, 273 mR, was recorded at the East Gate, which is the main entrance to the disposal site, and is attributable to the passage of trucks delivering waste to the site. Exposures measured within Pits 3 and 4 fall within the range of values recorded for the facility perimeter. Exposures at the perimeter of the TRU waste storage pad were elevated and ranged from 217 to 631 mR for 1993. The TRU waste storage pad is located within a locked and fenced controlled radiological area which is not continuously occupied. Exposures at the perimeter of the SMSA ranged from 788 mR to 4313 mR for 1993. The SMSA is a fenced and posted area and is located in a remote, infrequently occupied area.

Exposure was monitored at the RWMS-3 at 19 sites located at the perimeter of the craters used for disposal. Exposures ranged from 175 to 1,051 mR for 1993. Much of the exposure at the RWMS-3 is attributable to contamination from weapons testing and safety tests.

All of the exposure ranges given above are elevated relative to 1992 exposures. As discussed in Section 5.2.1.8, there was an apparent positive bias (averaging ~ 19 percent) in NTS environmental surveillance TLDs in 1993 relative to 1992. Two other factors which could have contributed to these elevated exposure values are: (1) increased shipment of materials into the RWMS storage cells, and (2) suspended materials in the air created during heavy earthwork activities performed at the RWMS during 1993.

8.2.3 NEUTRON DOSE EQUIVALENTS

Neutron dose equivalents were measured at six locations at the perimeter of the TRU waste storage cell. Dose equivalents for 1993 ranged from 44 to 133 mrem (0.44 to 1.3 mSv). The perimeter of the TRU waste storage cell is not routinely occupied.

8.2.4 VADOSE ZONE MONITORING FOR MIXED WASTE DISPOSAL

Travel times of contaminants from waste disposal cells to the groundwater is expected to be tens of thousands of years because groundwater recharge and infiltration is believed to be nearly zero at the RWMS-5. Therefore conventional groundwater monitoring is not an effective and timely method to detect the migration of contamination. (See additional discussion in Section 9.2.2.3.)

A vadose zone monitoring program has been implemented to allow earlier detection of potential contaminant migration from the mixed waste disposal cell (Pit 3) at the RWMS-5. Gas sampling and in situ monitoring have been conducted in access tubes placed in a 24-ft grid. Each tube extends 4 m (13 ft) beneath the floor of the pit and has gas sampling ports at the top, middle and bottom of the waste stack and a sealed port 4 m (13 ft) beneath the floor. During 1993 only neutron moisture logging was performed. Because water movement through the waste is a potential mechanism for the transport of waste components, soil moisture content has been used to assess disposal unit performance. Soil gas sampling and analysis will begin in 1994. Because of the low water content of the vadose zone, vapor transport of volatile organic compounds is the most likely migration mechanism. Analysis of vadose zone soil air samples will provide early detection of the presence and concentration of volatile organic compounds. Gamma spectroscopy, which will be used to identify migrating radionuclides in the soil, is scheduled to be funded in FY 1995.

Baseline soil moisture data are currently being obtained by fast neutron scattering at 24 stations in Pit No. 3, i.e., the interim status mixed waste cell. Data collected through 1993 indicate that rain fall does not infiltrate below 2.4 m (8.0 ft) and does not contact waste packages. As in previous years (CY 1991 and 1992) the June 1993 data package indicates a significant increase in moisture near the ground surface compared to other times of the year. Although site specific precipitation data is not available for this time period, data from nearby weather stations indicate that total precipitation was significantly greater for this period than for the winter and spring of 1992-1993. As in previous years the evaporative demand during the summer months will remove this added moisture before it can penetrate significantly (i.e., more than 2.4 m [8 ft]). Although the winter and spring precipitation levels reached higher numbers than in previous years the logs indicate that the moisture is adsorbed and retained near the surface until it is evaporated.

A second neutron logging effort was scheduled and completed in October 1993. The data have been compiled, but the report has not yet been issued to substantiate decreased moisture content in the areas above the eight foot penetration depth.

The data discussed above will be used in computer model studies for the design of future vadose zone monitoring systems.

8.2.5 TRITIUM MIGRATION STUDIES AT THE RWMS-5

Subsurface tritium migration studies of four sites at the RWMS-5 to test package integrity are being conducted by personnel from the University of California, Berkeley (UCB) (Schulz, et al. 1991). In the past, various types of packaging have been used for transport and containment of tritiated waste being shipped to the NTS for disposal in RWMS-5. During placement and burial of the waste packages, a number of sampling lines were secured to the outside of the packages which lead to the UCB sample control trailer. Soil pore gas samples and vegetation samples are routinely collected by UCB personnel at the RWMS-5. Sampling was suspended during most of 1992 due to the unavailability of laboratory facilities. Sampling was resumed in August of 1992. Tritium migration study results are the subject of separate reports prepared by UCB. No reports are available for 1993 studies.

9.0 GROUNDWATER PROTECTION

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The primary mission of the DOE/NV at the Nevada Test Site (NTS) has been the testing of nuclear devices and their components. The DOE/NV's Environmental Protection Policy Statement outlines a general policy of preventing pollutants from reaching groundwater, but it also recognizes that some options for groundwater protections are precluded by an increased risk of atmospheric environmental releases and potential violation of international agreements. Therefore, the DOE/NV groundwater protection policy represents a balance between strict compliance with atmospheric release agreements and minimization of groundwater impacts. 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 is implemented by various programs that address compliance with regulatory requirements, minimization of waste streams, closure and monitoring of waste facilities, remedial investigations, groundwater monitoring, and environmental research.

An extensive program of well drilling at the NTS for groundwater characterization continued in 1993. This program will continue until the location, quantity, and movement of groundwater and contaminants are sufficiently understood to support a Remedial Investigation and Feasibility Study (RI/FS). The RI/FS will evaluate potential groundwater contaminant transport pathways, risks associated with these pathways, and possible remedial actions. Approximately 100 new wells are planned and a number of existing wells will be recompleted to obtain characterization data. Current wells being drilled are positioned to maximize the geologic and hydrologic data obtained for each major underground testing area.

DOE/NV instituted a Long-Term Hydrological Monitoring Program (LTHMP) in 1972 to be operated by the EPA under an Interagency Agreement. Groundwater was monitored on and around the NTS, at six sites in other states, and at two off-NTS locations in Nevada in 1993 to detect any radioactivity that may be related to previous nuclear testing activities. In 1965 tritium escaped from the LONG SHOT test on Amchitka Island and contaminated the groundwater, and, during cleanup and disposal operations, shallow groundwater at the Tatum Dome Test Site in Mississippi was contaminated by tritium. The tritium levels in these wells at both these sites are decreasing and were well below the National Primary Drinking Water Regulation levels during 1993. NTS supply wells were monitored for gross alpha and beta activity as well as tritium levels.

9.1 EXISTING GROUNDWATER CONDITIONS

9.1.1 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 variously 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 150 m (approximately 500 ft) below the land surface and is often more than 300 m (approximately 1000 ft). The hydrogeologic units at the NTS occur in three groundwater subbasins in the Death Valley Groundwater Basin (see Chapter 2, Figure 2.9, for a diagram of these systems). The actual subbasin boundaries are poorly defined, but 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 discharge 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 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 (Waddell 1982).

9.1.2 HYDROGEOLOGY OF NON-NTS UNDERGROUND EVENT SITES

The following descriptions of the hydrology of non-NTS underground event sites are summarized from Chapman and Hokett 1991.

9.1.2.1 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 that are separated by clay aquitards. Groundwater flow velocities through the granite to the alluvial aquifers of Fairview Valley are calculated to be very slow (Chapman and Hokett 1991).

9.1.2.2 BLUE JAY, NEVADA

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.

9.1.2.3 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.

9.1.2.4 RIO BLANCO, COLORADO

Project RIO BLANCO is located in the Fort Union and Mesa Verde Sandstones in the Piceance Creek Basin. Three aquifers comprise the majority 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.

9.1.2.5 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.

9.1.2.6 BAXTERVILLE, MISSISSIPPI

Project DRIBBLE and the Miracle Play Program were conducted in the Tatum Salt Dome. The Tatum 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 result in uncertainties in groundwater flow directions.

9.1.2.7 GOBERNADOR, 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 meters per year.

9.1.2.8 MALAGA, 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.

9.1.3 AREAS OF POSSIBLE GROUNDWATER CONTAMINATION AT THE NTS

A preliminary assessment of underground and surface contamination at the NTS was conducted by the DOE in 1987 and submitted to the Environmental Protection Agency (EPA) Region 9. The survey delineated known and potential sources of groundwater contamination at the NTS including underground nuclear testing areas and surface facilities (Figure 9.1). Information from this document and from DOE/NV's "Site Specific Plan for Environmental Restoration and Waste Management, Five Year Plan," was used to describe the possible areas of groundwater contamination at the NTS. Table 9.1 is a listing of routine sampling locations at NTS and off-NTS sites where in 1993 groundwater samples contained levels of man-made radioactivity greater than 0.2 percent of the standards in the National Primary Drinking Water Regulations.

To date, over 1050 announced nuclear tests have been conducted at the NTS with the majority of them occurring in Yucca Flat, Frenchmen Flat, Pahute Mesa, Rainier Mesa, and Shoshone Mountain. 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 may have contaminated the local groundwater with radionuclides, principally tritium.

Surface activities associated with underground testing and other NTS activities such as disposal of low-level radioactive and mixed wastes, spill testing of hazardous liquified gaseous fuels, and testing 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, hydrocarbons, and residues from plastics, epoxy, and drilling muds. A wide variety of surface facilities, such as injection wells, leach fields, sumps, waste storage facilities, tunnel containment ponds and muck piles, and storage tanks, may have contaminated the soil and shallow unsaturated zone of the NTS.

Because of the great depths to groundwater and the arid climate, the potential for mobilization of surface and shallow subsurface contamination is minimal. However, contaminants entering carbonate bedrock from Rainier Mesa tunnel ponds, contaminated wastes injected into deep wells, underground tests near the water table, and wastes disposed into subsidence craters have the potential to reach groundwater.

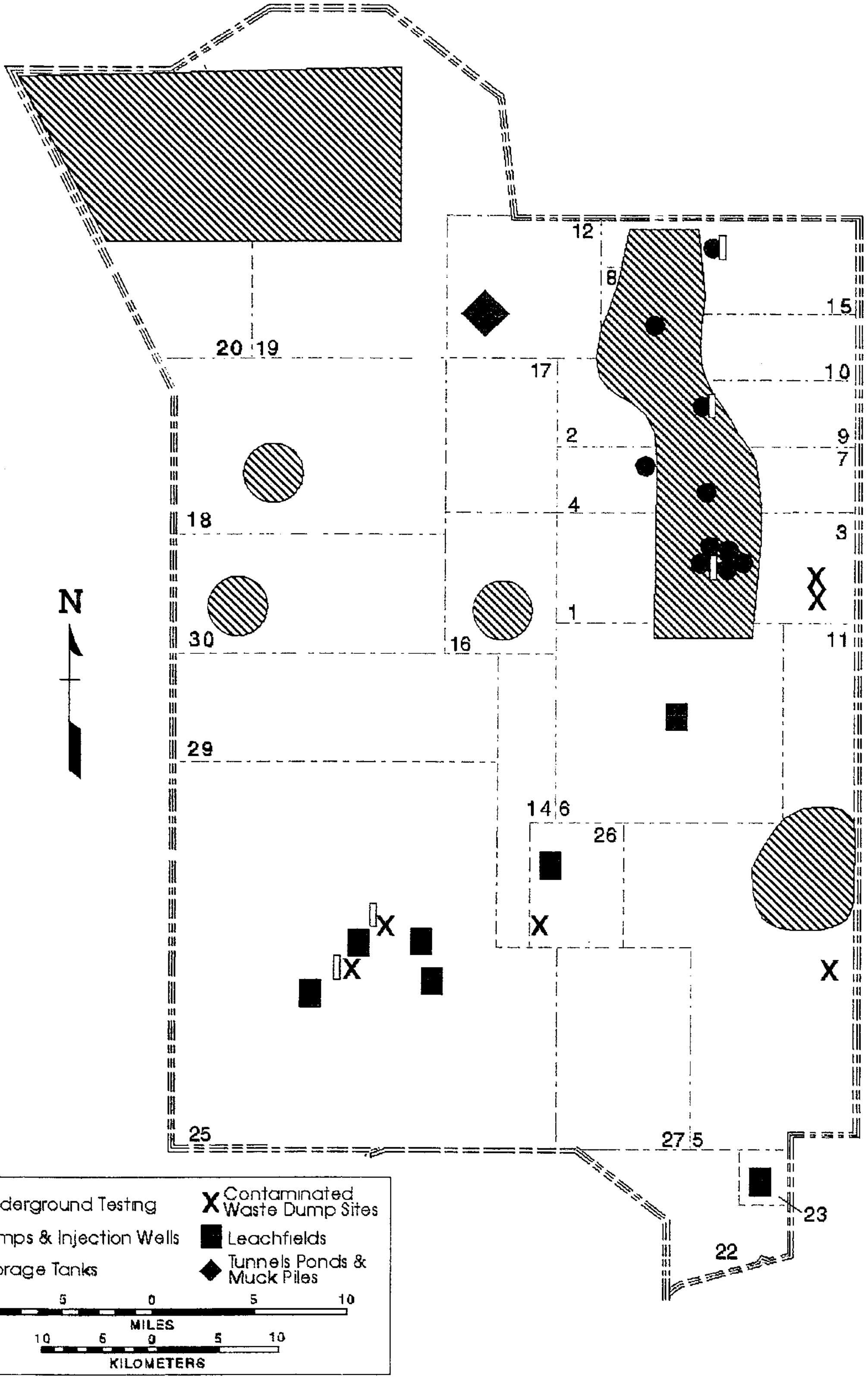

Figure 9.1 Areas of Potential Groundwater Contamination on the NTS

Table 9.1 Locations With Detectable Man-Made Radioactivity in 1993[a]

Sampling Location	Radionuclide	Concentration x 10^{-9} μCi/mL
NTS Onsite Network		
Well PM-1	^3H	220
Well UE-7ns	^3H	300
Project DRIBBLE, Mississippi		
Well HMH-1	^3H	3.3×10^3
Well HMH-2	^3H	7.8×10^3
Well HMH-5	^3H	3.0×10^3
Well HM-L	^3H	660
Well HM-S	^3H	5.8×10^3
Half Moon Creek	^3H	490
Half Moon Creek Overflow	^3H	490
Project GASBUGGY, New Mexico		
Well EPNG 10-36	^3H	330
	^{137}Cs	16
Project GNOME, New Mexico		
Well DD-1	^3H	7.4×10^7
	^{90}Sr	1.7×10^4
	^{137}Cs	8.2×10^5
Well LRL-7	^3H	7.3×10^3
	^{137}Cs	112
Well USGS-4	^3H	1.4×10^5
	^{90}Sr	4.0×10^3
Well USGS-8	^3H	8.8×10^4
	^{90}Sr	2.4×10^3
	^{137}Cs	59
Project LONG SHOT, Alaska		
Stream East-Longshot	^3H	180
Well GZ No. 1	^3H	1.4×10^3

(a) Only ^3H concentrations equating to greater than 0.2 percent of the National Primary Drinking Water Regulation Standard of 4 mrem using DCGs from ICRP-30 are shown {i.e., greater than 1.8×10^{-7} μCi/mL [180 pCi/L](7 Bq/L)}. Detectable levels of other man-made radioisotopes are also shown.

9.2 GROUNDWATER PROTECTION

Groundwater protection activities contained within DOE/NV programs are described below.

9.2.1 GROUNDWATER PROTECTION FOR UNDERGROUND NUCLEAR TESTS

The DOE/NV standard operating procedure "Protection of Groundwater at Nuclear Test Locations" (NTS-SOP 5417) 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 Environmental Restoration and Waste Management Division (AMEM) to show compliance with these criteria, which are:

- Future testing should utilize previously used areas of testing.
- Minimize tests with working points at or below the water table. 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 meters of the NTS boundary where groundwater leaves the NTS.
- Emplacement holes which extend more than two cavity radii or 30 meters, whichever is greater, beneath the working point should be plugged to prevent the open borehole from becoming a preferential pathway for groundwater contamination.

The Hydrologic Resources Management Program (HRMP) reviews the emplacement hole documentation for technical content and the DOE/NV Environmental Protection Division (EPD) reviews the documentation for environmental compliance. Based on recommendations by AMEM, HRMP, and EPD, the proposed location will either be approved or modifications recommended. If groundwater levels encountered during drilling of the emplacement holes are substantially different than predicted, the acceptability of the emplacement hole will be re-evaluated.

9.2.2 GROUNDWATER PROTECTION FOR SURFACE FACILITIES

Because of the large distance from the surface to groundwater, there is a minimal risk of groundwater contamination from surface activities at the NTS. Nonetheless, provisions for groundwater protection from surface activities have been established in several programs: (1) Waste Minimization and Pollution Prevention Awareness; (2) Decontamination and Decommissioning; and (3) Waste Treatment, Storage and Disposal.

9.2.2.1 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, increasing the protection of employees and the public. All DOE/NV contractors and NTS users that 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 1993 activities is given in Section 3.2.6.

9.2.2.2 DECONTAMINATION AND DECOMMISSIONING PROGRAM

The Decontamination and Decommissioning Program identifies inactive contaminated facilities, assesses the extent of contamination, minimizes its spread, and ensures that facilities are maintained in a safe manner pending determination of final disposition. Eight facilities at the NTS have been identified for decontamination and decommissioning. In 1993, an initial assessment of structural conditions, roof conditions, and asbestos contamination of these facilities was conducted. Results of this assessment were not available for this year's report.

9.2.2.3 WASTE TREATMENT, STORAGE AND DISPOSAL

DOE/NV currently operates two disposal facilities in Areas 3 and 5 at the NTS for low-level radioactive waste (LLW) generated by DOE and DOD facilities. The Area 5 Radioactive Waste Management Site (RWMS-5) also serves as a temporary storage area for Lawrence Livermore National Laboratory (LLNL) transuranic wastes which will be shipped, upon final certification, to the Waste Isolation Pilot Plant in New Mexico for disposal. 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. Uranium-ore residues designated as strategic materials are stored north of the RWMS-5. The RWMS-3 is used for the disposal of non-standard packaged radioactive low-level waste from offsite and unpackaged bulk wastes from the NTS.

Mixed waste disposal facilities are presently operating under the Resource Conservation and Recovery Act (RCRA) interim status pending completion of the RCRA permitting process. Site characterization activities are being performed in support of the RCRA Part B permit application and will evaluate the potential for the release and migration of waste from the waste disposal activities. Because of the great depth to groundwater at the NTS, vadose zone studies and monitoring are also being conducted to detect the migration of contaminants from the waste facilities.

Using data developed prior to 1992 from eight wells in Area 5, the water table elevation beneath the RWMS-5 has been estimated by a Dupuit-Forchiemer approximation to be approximately 244 m (800 ft) below the surface. This value is consistent with resistivity measurements and water measurements from pilot wells drilled in 1992-93. Preliminary modeling studies have shown the travel time from the surface to the water table to be in the tens of thousands of years. This modeling, based on data from pilot wells and other measurements is described in "Site Characterization and Monitoring Data from Area 5 Pilot Wells, Nye County, Nevada" published as report DOE/NV11432-74 in February 1994.

During 1992, three pilot wells (UE5PW-1, UE5PW-2, and UE5PW-3) were drilled through the vadose zone into the uppermost aquifer under the RWMS-5. The principle purpose of these wells was to characterize the hydrogeology of the vadose zone under the waste disposal cells at RWMS-5. This characterization of the uppermost aquifer is consistent with the leakage detection requirements for interim treatment, storage and disposal (TSD) facilities required by EPA (EPA 1993) and the state of Nevada.

In accordance with 40 CFR 265 - Subpart F, operators of interim status TSDs are required to collect quarterly samples for one year from one upgradient and three down gradient wells for characterization of background water quality. The first collections of these characterization data were performed in 1993. In subsequent (1994 and beyond) years the sampling frequency will be reduced to annual and results will be statistically compared with the initial characterization data. The analyses performed for these samples are given in Table 9.2. The first two quarters of data for 1993 have been compiled with work continuing on the last two quarters of data. These pilot wells are also used to provide supplemental radiological monitoring and parameters established to comply with DOE environmental monitoring requirements for LLW disposal sites (DOE 1988b).

Sampling protocols for the 1993 characterization data collection were based on the RCRA Groundwater Monitoring Technical Enforcement Guidance Document (EPA 1986). Groundwater elevation was measured prior to each sampling event. Water was withdrawn from each well with dedicated submersible double piston pumps for the purpose of purging and sample collection. Temperature, pH, specific conductance, and Eh were monitored during purging and sampling. Dissolved oxygen and turbidity were also measured during purging and at the conclusion of sampling. Samples were collected and analyzed in accordance with written procedures that specified sample collection methodology, sample preservation, sample shipment, analytical procedures and chain of custody control. Samples for analyses requiring separation into dissolved and total fractions (metals, gross alpha, gross beta, and gamma-emitting radionuclides) were filtered in the field. Preservative measures were applied in the field to all samples at the time of removal from each well.

Laboratory results for samples collected during the first two calendar quarters of 1993 are largely complete. Full statistical analyses of the data will be performed when a complete data set for 1993 is available. Routine annual and semi-annual monitoring is scheduled to continue in 1994. The list of supplemental parameters will be reduced in 1994 if no contaminates are detected during the 1993 characterization period.

Based on data received to date, the uppermost aquifer beneath the RWMS-5 disposal cells is suitable for use as drinking water or for agricultural purposes. No chemical or radiological contaminants attributable to DOE weapons testing or waste management activities have been detected in the three wells. The available data indicate that the aquifer has not been contaminated with hazardous chemical constituents.

Although several Toxicity Characteristic Leaching Procedure (TCLP) metals were detected in the aquifer, analysis of core samples collected during well drilling showed that these metals occur at readily detectable concentrations in the alluvial sediments that form the basin. In all instances the dissolved and total concentrations of metals As, Ba, Cd, Cr, Pb, Se, Hg, and Ag, were less than applicable Safe Drinking Water Act (SDWA) standards. The pesticide Lindane had been detected (September 1992 - Well UE5PW-1) at a mean concentration of 0.22 µg/L,

Table 9.2 First Year Groundwater Monitoring Parameters for Establishing Background Water Quality at the RWMS-5

Parameters Determining Suitability of Groundwater

Total and Dissolved Metals - As, Ba, Cd, Cr, Hg, Ag, Pb, Se
Anions- Fluoride, Nitrate
Pesticides
Herbicides
Radium
Total and Dissolved Gross Alpha/Beta
Coliform Bacteria

Parameters Establishing Water Quality

Chloride
Total and Dissolved Fe, Mn, Na
Phenols
Sulfate

Indicators of Contamination

pH
Conductivity
Total Organic Carbon
Total Organic Halogen

Additional Selected Parameters

Alkalinity
Volatile Organics (8270)
Oil and Grease
Cyanide
Total Dissolved Solids
Total and Dissolved Gamma-Emitting Radionuclides
Tritium
^{90}Sr
^{99}Tc
^{238}Pu
$^{239, 240}$Pu
Total Uranium
^{131}I

which is less than 5 percent of the applicable primary SDWA standard. This level may have been due to contamination introduced during the initial sampling and analysis. This contaminant has not been detected in 1993 samples for which analysis has been completed. Toluene (Well UE5PW-1) at 5.5 µg/L, chloromethane (Well UE5PW-2) at 8.0 µg/L, acetone (Well UE5PW-2) at 13.0 µg/L, and a semi-volatile compound, di-n-butylphthalate (Well UE5PW-2) at 51.0 µg/L were detected in samples collected on March 24, 1993. Toluene, chloromethane, and acetone were also detected in second quarter 1993 samples. These chemicals were identified as common laboratory contaminants. The di-n-butylphthalate is related to possible plastics contamination which may have occurred in either the sampling or analytical processes.

The maximum contaminant levels for the first two quarters of 1993 data showed that gross alpha activity concentration was 15.0 pCi/L excluding radon and uranium. Dissolved and gross alpha activity concentrations measured to date in the pilot wells range from 4.7 pCi/L to 7.2 pCi/L. Current regulations for drinking water standards set a limit of 5 pCi/L for ^{226}Ra and ^{228}Ra. The limited number of ^{226}Ra and ^{228}Ra results received and compiled for the first two quarters of 1993 have all been less than the minimum detectable concentration as listed in Chapter 4, Sec. 4.1.1.2. The high sulfate concentration of the aquifer limits the potential for significant concentrations of dissolved radium. The concentrations of dissolved barium and sulfate are very near the ($BaSO_4$) solubility limit. The only alpha emitting radionuclide detected was uranium.

Measured activity concentrations of dissolved and total gross beta in the pilot wells range from 4.5 pCi/L to 6.2 pCi/L. Analyses have been performed for specific radionuclides including ^{3}H, ^{90}Sr, ^{99}Tc, ^{131}I, ^{228}Ra, and gamma-emitting radionuclides. Tritium samples were enriched by the alkaline electrolysis method giving a minimum detectable concentration of 15.0 pCi/L. Only naturally occurring radionuclides have been detected in the analyses thus far completed.

9.3 ENVIRONMENTAL RESTORATION

The Nevada Environmental Restoration Project (NV-ERP) was established to assess past hazardous and radioactive waste contamination that may have occurred as a result of operations at DOE facilities. For those sites that could pose a threat to human health, welfare, and/or the environment, remedial actions consistent with the National Oil and Hazardous Substances Pollution Contingency Plan are developed. The NV-ERP has been designed to ensure DOE/NV compliance with federal laws such as RCRA; Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); and the Superfund Amendments and Reauthorization Act (SARA). CERCLA and SARA are the primary legislative acts governing remedial action at former hazardous waste disposal sites. These acts require the development of a Remedial Investigation and Feasibility Study (RI/FS) to assess the potential risks present at a site and to develop and evaluate remedial actions. The ERP has been modified to include a RI/FS for all former DOE/NV hazardous waste disposal and expended nuclear test sites. As an initial action a site characterization is conducted to determine the type of contamination present, the extent and concentration of contaminants, and to identify and delineate potential contaminant transport pathways.

9.3.1 UNDERGROUND NUCLEAR TESTING SITES

The hydrogeologic regime in the vicinity of the NTS is not well enough understood to ensure compliance with DOE/NV's objectives. Under the NV-ERP, the Groundwater Characterization

Project (GCP) was designed to gain a better understanding of the location, quantity, and movement of groundwater and contaminants at the NTS. Knowledge gained from the GCP was to be used in developing a RI/FS. In 1993, the GCP was officially incorporated into the Underground Testing Areas (UGTA) RI/FS which will evaluate potential groundwater contaminant transport pathways, the risks associated with those pathways, and possible remedial actions. The UGTA RI/FS is administered by IT Corporation for the NV-ERP and includes: (1) Program Planning, (2) Technology Development, and (3) Field Investigations.

Program Planning develops program objectives, workplans and schedules and is a joint effort between IT, LLNL, Los Alamos National Laboratory (LANL), Defense Nuclear Agency, U. S. Geological Survey (USGS), Desert Research Institute (DRI), Raytheon Services of Nevada, and Reynolds Electrical and Engineering Co., Inc. (REECo). Technology Development develops innovative technologies to address hydrogeologic problems unique to the NTS. In 1993, such technologies included: (1) design and procurement of a slim downhole pump; (2) a logging suite to monitor cement placement in a well; (3) a time-domain refractometer moisture detection system to locate the water table during drilling; and (4) development of a new cement port collar to stem well casing in small diameter boreholes. In Field Investigations, wells are drilled to obtain geologic and hydrologic information for each major underground testing area. Geologic information gained during drilling will be used to optimize testing of different hydrologic units and to determine well-screen intervals. Hydrogeologic information will be used to determine the directions and rates of groundwater flow in three dimensions, determine spatial and temporal variations in the directions and rates of groundwater flow, and quantify parameters that control these factors. In 1993, five new groundwater wells were drilled, and hydrologic testing and sampling of two wells were conducted.

9.3.2 SURFACE FACILITIES

Because of the arid climate and the great depths to groundwater, any contaminants found in the near-surface environment are unlikely to migrate to or contaminate groundwater. However, liquid wastes distributed to leachfields, unlined ponds, and subsidence craters could introduce contaminants into the unsaturated zone and supply the mechanisms necessary to transport contaminants to the local groundwater table. Injection of liquid wastes into wells also greatly increases the potential for contamination of groundwater by shortening the pathway to the water table and supplying a medium of transport. Corrective actions, RI/FS's, and RCRA closures are planned for various NTS leachfields, ponds, subsidence craters, and injection wells.

9.3.2.1 RAINIER MESA TUNNEL PONDS

Nuclear devices have been tested in horizontal tunnels mined into Rainier Mesa at the NTS. The tests are conducted in zeolitized volcanic tuffs which act as a perching layer for water infiltrating from the mesa surface. During normal mining operations, fractures containing water are intercepted creating artificial springs in the tunnels. Periodically these waters contain radionuclides from underground nuclear tests, and are drained out of the tunnels into unlined evaporation ponds. Mining and related operations may also release organic compounds and heavy metals to the tunnel effluent. N Tunnel effluent is covered under a discharge permit. A list of options to eliminate effluent discharge to the soil column from N, T, and E Tunnels was submitted to the state of Nevada in 1992. In the interim, drainage has been reduced and liquid effluent is analyzed for radionuclides. Samples are also analyzed to identify metals and organic compounds, and to observe temporal variations in discharge volumes and chemical constituents. The data are expected to support the design of treatment or remediation measures as part of an RI/FS for the tunnel evaporation ponds. Tunnel ponds effluent monitoring and results for 1993 are discussed in Chapters 5 and 7.

9.3.2.2 SURFACE OPERATIONAL SUPPORT FACILITIES

NTS operational support facilities such as ponds, sumps, lagoons, leachfields, and injection wells have been identified for assessment of contamination. Corrective actions, RI/FS's, and RCRA closures are being conducted to bring facilities into compliance with current regulations, characterize and remediate contaminated facilities, and close disposal sites.

Corrective actions being taken at NTS sewage lagoons, steam-cleaning pads and lagoons, and decontamination facilities include: (1) building of concrete pads with drains; (2) oil/water separators; (3) permitting of disposal systems; and (4) lining of ponds and lagoons. RI/FS's are planned for 18 NTS sumps and injection wells and for eight NTS leachfields. In 1993, preparation of RI/FS workplans for some facilities was initiated. As part of the RCRA site closure process, discharges of liquid wastes to injection wells, leachfields, and subsidence craters are being eliminated. NTS facilities with RCRA closure plans are shown in Table 9.3.

9.4 HYDROLOGIC RESOURCES MANAGEMENT PROGRAM

The Hydrology/Radionuclide Migration Program has previously provided information and support on radionuclide and hazardous substance source terms, near-field hydrology, site hydrology, and contamination transport. Many of this program's historic work elements, in particular, source characterization and subsurface transport of contaminants, have been assumed by AMEM and the UGTA Operable Unit. Accordingly, the name, mission, and objectives of this program have been redefined. The Hydrologic Resources Management Program (HRMP) is now responsible for groundwater stewardship, hydrology and radionuclide characterization for operations support, and integrated monitoring.

HRMP activities are conducted by agencies such as LLNL, LANL, USGS, and DRI with expertise in sciences required to study the subsurface effects of the weapons testing program. Program organization is divided into four broad categories: (1) Program Management; (2) Operational Support; (3) Groundwater Protection; and (4) Groundwater Monitoring.

9.4.1 PROGRAM MANAGEMENT

Each participating agency provides program planning and coordination of work conducted by individual investigators. However, program management is necessary for many activities not specifically related to research projects such as: (1) reviewing documents; (2) attending program planning, review, and coordination meetings; (3) planning and budgeting of future tasks; (4) writing progress reports; and (5) providing support services to DOE/NV.

9.4.2 OPERATIONAL SUPPORT

A number of studies and activities relating to hydrology at the NTS require operational support as discussed in the following subsections.

Table 9.3 NTS Facilities with RCRA Closure Plans

Area	Designation
Area 2	Bitcutter Shop & LLNL Postshot Shop
Area 2	U-2bu Subsidence Crater
Area 3	U-3fi Injection Well
Area 6	Decontamination Facility Evaporation Pond
Area 6	Steam Cleaning Effluent Pond
Area 23	Building 650 Leachfield
Area 23	Hazardous Waste Trenches
Area 27	Explosive Ordnance Disposal Facility

9.4.2.1 WATER-LEVEL ALTITUDES

The USGS collects water-level elevation measurements in wells, emplacement holes, and test holes to support operations at the NTS. These data along with other hydrogeologic data are maintained in a computerized database. Both historical and current data are used to produce water-table altitude maps to estimate the depth to water at proposed weapons testing sites.

9.4.2.2 YUCCA FLAT HYDROLOGY

Unusually high hydraulic pressures observed in Yucca Flat present problems with respect to nuclear testing by increasing engineering and material costs and causing concern for radionuclide migration. A Yucca Flat groundwater altitude map was updated based on historic and current groundwater levels to aid in estimating the depth to water at proposed weapons testing sites. Hydraulic information necessary to understand and to mitigate problems caused by the high pressure zone in Yucca Flat is being collected. Fluid levels in existing holes UE-3e#4, UE-4t, U-4ups2a, U-7cd, and U-7cd1 are being monitored. A new postshot hole, U-4tps3a, was drilled in 1993 to investigate whether radioactive material from a test had been injected into fractures extending outward from the test cavity and to evaluate drilling equipment and procedures. In addition to evaluating equipment and procedures, personnel were trained, core material was recovered for analysis of alteration, radioanalyses were performed, and a sampling point was established. Research continued in using mathematical modeling to determine the origin of Yucca Flat high hydraulic pressure. A simple analytic solutions model of transient water-level increases at the Project FAULTLESS site in central Nevada was used as a simple analog to the more complicated hydrologic setting in Yucca Flat. Analytic solutions to the Project FAULTLESS site suggest that observed hydrologic behavior can be modeled successfully and results from this study may be applicable to Yucca Flat's high hydraulic pressures. A video describing the conceptual model of the hydrogeology of the Project FAULTLESS site was produced.

9.4.2.3 PAHUTE MESA GROUNDWATER LEVELS

During drilling at Pahute Mesa, water is often encountered in emplacement holes well above the predicted elevation of the local groundwater table. These waters may be perched groundwater or fluids that are introduced during drilling. A tracer was added to drilling fluids during drilling of an emplacement hole in 1991 to evaluate the origin of this water. Analysis of tracer concentration in water in the emplacement hole after drilling suggests that this water originates from perched groundwater that lies above the bottom of the borehole. The long-term lack of decline in tracer content indicates that only a small reservoir of perched water is drained into and remains stagnant in the bottom of the borehole. Initial numerical computer modeling of infiltrated drilling fluids and seepage from a perched aquifer also suggest that this anomalous water originates from perched aquifers.

9.4.2.4 NEAR-FIELD HYDROLOGIC STUDY

The near-field hydrologic system controls the transfer of water and radionuclides from the shot cavity to the regional hydrologic system; therefore, it can strongly affect the environmental impact of underground testing. Theoretical studies have been made on the near-field hydrologic environment of below water-table tests. A conceptual model and analytic solutions were used to estimate a tritium plume given an idealized view of the U20c site at Pahute Mesa. The study suggests that tritium migration from that site is possible, however, the analytic solutions used were highly simplified and were intended only to illustrate the essence of groundwater transport for the conceptual model. Input parameter uncertainty and the theoretical nature of the study suggest that further theoretical numerical modeling is needed to better understand the possible transport mechanisms involved.

9.4.2.5 AMARGOSA TRACER CALIBRATION SITE STUDY

The USGS Amargosa Tracer Calibration Site south of the NTS was used for three radioactive tracer tests within the Lower Carbonate Aquifer between 1971 and 1975. In 1993, simple analytic solutions were used to make a reconnaissance assessment of possible migration of tritium left over from the tracer studies. Solutions indicate that very low but detectable concentrations might migrate downgradient from the site. However, the solutions do not consider dilution which probably occurred, making it highly unlikely that any injected tracer would be detectable in the aquifer.

9.4.3 GROUNDWATER PROTECTION

Under the HRMP a number of groundwater protection studies are being conducted. They are discussed briefly in the following subsections.

9.4.3.1 RADIONUCLIDE TRANSPORT STUDIES

When released to the groundwater system, radionuclides and toxic metals can react with various components of the groundwater, host rock, groundwater colloids, and organic compounds to form insoluble phases, solution species, and soluble complexes that can control radionuclide and metal migration behavior. Laboratory-scale studies examining the transport of radionuclides by colloids in groundwater are continuing at LANL. Presently, research is focused on developing techniques and models to describe the transport of silica colloids through columns of glass beads. The next stages will include labeling of colloids with radioactive materials, and passing colloid-containing fluids through crushed volcanic tuffs and simulated fractures.

Another approach for studying groundwater transport of tritium from the U-20c site is to use a stochastic approach and numerical simulations. The hydrologic system was modeled as a horizontal two-dimensional fractured-rhyolite aquifer intersected by a nuclear test rubble chimney extending upward from the resulting test cavity. The chimney is considered more permeable than the surrounding rocks and is thought to act as a conduit for flow of water from the cavity to the aquifer. Modeling results suggest that non-uniform flow conditions in the chimney greatly increase dispersion of a tritium plume and increases velocity of the plume in the direction of regional groundwater flow. A component of upgradient movement of the idealized tritium plume is also suggested.

9.4.3.2 WELLHEAD PROTECTION

A wellhead protection program is being developed for water-supply wells at the NTS. This program incorporates the travel time approach in modeling the transport of a solute particle from an input zone to the water-supply well. Wellhead protection areas for each water-supply well will be delineated. Capture zones for each well were delineated in 1993. Because of the large uncertainties associated with hydrologic input parameters such as hydraulic conductivity for each well, a probabilistic approach was used that takes into account these uncertainties. Capture zones were generated for 50, 90, 95, and 99 percent reliability levels. The width of each capture zone was influenced by the uncertainties in the magnitude and direction of the regional groundwater flow.

9.4.3.3 RISK ASSESSMENT OF GROUNDWATER RADIONUCLIDE TRANSPORT

A preliminary assessment of the potential health risk to individuals in the future, who may drink radioactively contaminated groundwater from the NTS, was conducted. Two scenarios were considered: loss of institutional control of the NTS after 100 years and migration offsite of contaminated groundwater. Potential human health risk was calculated for an individual ingesting contaminated groundwater over 70-years. Despite the large uncertainties in data used to estimate risk in this study, several conclusions were suggested by the assessment: (1) tritium would be the most likely radionuclide contributing to dose and risk for humans; (2) offsite migration of radionuclides does not appear to pose a serious concern for human exposure and risk; (3) risk would be greatly increased by onsite consumption of contaminated groundwater; and (4) a contingency plan may need to be developed for continuing institutional control of the NTS beyond 100 years in the future (Daniels et al. 1993).

9.4.4 GROUNDWATER MONITORING

Groundwater monitoring activities of the HRMP in 1993 included sampling of wells, emplacement holes, and postshot holes. An evaluation of the present routine monitoring programs at the NTS was also conducted.

9.4.4.1 GROUNDWATER SAMPLING

Groundwater samples from the NTS obtained under the HRMP were collected and analyzed for radionuclides by LLNL, LANL, and the USGS (tritium analysis of USGS samples was done by the EPA's Environmental Monitoring Systems Laboratory in Las Vegas, Nevada (EMSL-LV). The results of these analyses for well samples are given in Tables 9.4 and 9.5. Besides tritium, the only other radionuclide detected was 6.94 pCi/L of ^{226}Ra in well UE-20bh1. The results of analyses for samples from emplacement holes and postshot holes are given in Table 9.6. Well PM-2, located at Pahute Mesa, was drilled in 1964, but was sampled for the first time in 1993. Analytical results (Table 9.7) for these samples were positive for several

Table 9.4 Tritium Results for Samples Collected from Wells by HRMP in 1993

Well	Sample Date	Tritium (pCi/L)	Laboratory
UE-1h	05/26/93	10.9 ± 1.9	LLNL
Test Well D	06/08/93	3.8 ± 1.3	LLNL
Well 5C	05/20/93	0.64 ± 0.64	LLNL
UE-5c	05/13/93	0.64 ± 0.64	LLNL
UE-5n	05/24/93	9850. ± 520	LLNL
UE-5PW-1	05/26/93	0.32 ± 0.64	LLNL
UE-5PW-2	05/25/93	0.64 ± 0.64	LLNL
UE-5PW-3	05/26/93	3.84 ± 0.96	LLNL
Well C	05/19/93	11.5 ± 1.6	LLNL
Well 4	05/20/93	0.96 ± 0.64	LLNL
UE-16d	06/02/93	63.4 ± 38.4	LLNL
UE-17a	06/09/93	1.6 ± 0.96	LLNL
Well 8	06/02/93	1.6 ± 0.96	LLNL
UE-20bh#1	06/20/93	0.96 ± 0.64	LLNL
Army Well 1	05/12/93	1.28 ± 0.64	LLNL
J-12	05/13/93	0.64 ± 0.64	LLNL
J-13	05/13/93	0.64 ± 0.64	LLNL
J-11	06/21/93(a)	-22. ± 227	USGS(e)
J-11	06/21/93(b)	195. ± 227	USGS(e)
Army 2	06/16/93(c)	105. ± 224	USGS(e)
Army 2	06/16/93(d)	89. ± 227	USGS(e)
Army 3	06/17/93	38. ± 227	USGS(e)
Army 6A	06/21/93	-70. ± 224	USGS(e)

(a) 331 Meters Sampling Depth
(b) 353 Meters Sampling Depth
(c) 155 Meters Sampling Depth
(d) 189 Meters Sampling Depth
(e) Analyzed by EPA's EMSL-LV

Table 9.5 Groundwater Samples Collected and Analyzed for Certain Radionuclides

NTS Well Name	Radionuclide
UE-1c, Test Well D, Test Well B, UE-10j, U-12s, UE-20bh1*	^{60}Co, ^{99}Tc, ^{125}Sb, ^{137}Cs, ^{226}Ra
UE-1a, UE-1b, UE-5n, UE-17a, Test Well 1, UE-18r, UE-19h	^{60}Co, ^{99}Tc, ^{125}Sb, ^{137}Cs
UE-1h, Well 5c, UE-5c, UE-5pw1, UE-5pw2, UE-5pw3, Well C, Well 4, UE-16d, Well 8, Army Well 1, J-12, J-13	^{99}Tc

* 6.94 pCi/L of ^{226}Ra detected in UE-20bh1
Note: All Analytical Results Were <MDC (Collection and Analysis by LLNL in 1992 and 1993)

Table 9.6 Analytical Results of NTS Groundwater Samples Collected from Emplacement and Postshot Holes by HRMP in 1993 (pCi/L = 10^{-9} µCi/mL)

Hole	Date	Tritium (pCi/L)	^{60}Co (pCi/L)	^{125}Sb (pCi/L)	^{137}Cs (pCi/L)	^{226}Ra (pCi/L)	^{85}Kr (pCi/L)	Lab
UE-2ce	08/25/93	1.3×10^5	<0.304	<0.860	<0.280	6.60		LLNL
		1.5×10^5					4,200	LANL
UE-3e#4	08/25/93	9.4×10^6	<0.27	<0.77	<0.28	3.2		LLNL
U-4t		3.9×10^4	<0.33	<0.88	<0.34	<0.65		LLNL
U-4u		48×10^5	10.2	1530	20.2	<0.56		LLNL
RNM-1	09/14/93		<0.33	<0.97	68	<0.74		LLNL
RNM-2s	09/14/93		<0.22	<0.68	<0.24	1.7		LLNL
UE-7ns	08/24/93	460	<0.24	<0.58	<0.25	<0.50		LLNL
		<1000					380	LANL
U-19vps	09/28/93		<0.32	<0.84	<0.39	<0.70		LLNL
		17×10^6					4,000	LANL
		24×10^6					1.4×10^5	LANL
U-2gk	07/02/93	560 ± 230						USGS[(a)]
U-4ups2a	08/31/93	6.0×10^6						LLNL
		5.9×10^6						LLNL
		5.8×10^6						LLNL
		5.3×10^6					1.9×10^6	LANL
U-4tps3a	08/31/93	2.9×10^4						LLNL
		1,100					<1.0	LANL
UE-3e4	08/25/92	9.8×10^6					5,000	LANL
		4.8×10^5					160	LANL
	08/26/93	5.4×10^4					12	LANL
U-19bh	08/09/93	51 ± 260						USGS[(a)]

(a) Analyzed by EPA's EMSL-LV

Table 9.7 Radionuclides in Groundwater From Well PM-2 at Pahute Mesa Collected by HRMP in 1993

Depth (meters)	Date	Tritium (pCi/L)	^{125}Sb (pCi/L)	^{137}Cs (pCi/L)	^{85}Kr (pCi/L)	Lab
258	08/17/93	8,500 ± 320				USGS[(a)]
305	08/17/93	8,600 ± 320				USGS[(a)]
610	08/17/93	55,000 ± 1,600				USGS[(a)]
765	08/17/93	635,000 ± 1,700				USGS[(a)]
305	09/27/93	11,300 ± 340				USGS[(a)]
610	09/27/93	747,000 ± 1,900				USGS[(a)]
765	09/27/93	494,000 ± 1,500				USGS[(a)]
1,067	09/27/93	567,000 ± 1,600				USGS[(a)]
305	11/30/93	15,000	None Detected	None Detected	14	LANL
610	11/30/93	73,000	None Detected	Trace	<1	LANL
823	11/30/93	69,000	5.4	65	<1	LANL

(a) Analysis by EPA's EMSL-LV

radionuclides. This radioactivity is thought to have originated from a 1968 Plowshare test close to PM-2. Research is planned for 1994 to investigate the origin of this radioactivity.

9.4.4.2 GROUNDWATER MONITORING PROGRAMS REVIEW

Groundwater monitoring is conducted by REECo and EMSL-LV in accordance with state of Nevada and federal regulations, and DOE Orders. REECo's onsite monitoring network includes seven springs, ten potable water supply wells, two non-potable water supply wells, and eight drinking water consumption points. The EMSL-LV conducts the Long-Term Hydrologic Monitoring Program (LTHMP) which is a radiological groundwater monitoring network on and around the NTS, and at other U. S. locations where nuclear weapons tests have been conducted.

A review of these monitoring programs was conducted by the HRMP in 1993. This review found that these programs have not been administered under a comprehensive approach. Specific findings were: (1) redundancy in both sampling locations and constituents analyzed; (2) more frequent sampling than required by regulations; and (3) analysis of constituents not required by regulations. Recommendations to eliminate redundancy and unnecessary sampling and analysis were made.

9.5 LONG-TERM HYDROLOGICAL MONITORING PROGRAM

The Long-Term Hydrological Monitoring Program (LTHMP) was established in 1972 by the Nevada Operations Office of the AEC, the predecessor agency to DOE/NV. The EPA's EMSL-LV is responsible for operation of the LTHMP, including sample collection, analysis, and data reporting. From the early 1950s until implementation of the LTHMP, monitoring of ground and surface waters was done by the U.S. Public Health Service (PHS), the USGS, and AEC contractor organizations. The LTHMP was instituted because the AEC (later affirmed by DOE/NV) acknowledged its responsibility for obtaining and disseminating data acquired from all locations where nuclear devices have been tested for the purposes of:

- Assuring public safety.
- Informing the public, news media, and scientific community about any radiological contamination.
- Documenting compliance with existing federal, state, and local requirements.

The LTHMP conducts routine radiological monitoring of specific wells on the NTS and of wells, springs, and surface waters in the offsite area around the NTS. In addition, sampling is conducted at other locations in the U.S. where nuclear weapons tests have been conducted including sites in Nevada, Colorado, New Mexico, Mississippi, and Alaska.

9.5.1 SAMPLING AND ANALYSIS PROCEDURES

Under standard operating procedures three samples are collected from each source. Two samples are collected in 500-mL glass bottles to be analyzed for tritium. The results from one of these samples are reported while the other sample serves as a backup in case of loss or as a duplicate sample. The third sample is collected in a 3.8-L plastic container (cubitainer). At LTHMP sites other than the NTS and vicinity, two cubitainer samples are collected. One of these is analyzed by gamma spectrometry and the other is stored as a backup or for duplicate analysis. At a few locations, because of limited water supply, only 500-mL samples for tritium analysis are collected.

For wells with operating pumps, the samples are 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 three-liter samples from wells as deep as 1800 meters. At the normal sample collection sites, the pH, conductivity, water temperature, and sampling depth are measured and recorded when the sample is collected.

The first time samples are collected from a well, ^{89,90}Sr, $^{238,239+240}$Pu, and uranium isotopes are determined by radiochemistry. Prior to 1979, the first samples from a new location were also analyzed for 15 stable elements; anions, nitrates, ammonia, silica; and ^{226}Ra. Most of these analyses can still be completed by special request. At least one of the cubitainer samples from each site is analyzed by gamma spectrometry, using a 100-minute counting time. If conventional tritium analysis results are close to or less than the minimum detectable concentration (MDC) (approximately 400 to 700 pCi/L), the sample is concentrated by electrolysis (i.e., enrichment) and reanalyzed. This enrichment reduces the MDC to approximately 5 to 7 pCi/L.

9.5.2 ACTIVITIES ON AND AROUND THE NEVADA TEST SITE

9.5.2.1 NEVADA TEST SITE MONITORING

The present sample locations on the NTS, or immediately outside its borders on federally owned land, are shown in Figure 9.2. All sampling locations are selected by DOE and primarily represent drinking water supplies. Sixteen wells are scheduled to be sampled monthly and twenty wells at approximately six month intervals. Of these 36 sampling locations, eight could not be sampled at any time in 1993 (see Table 9.8). In the fall of 1992, DOE elected to restrict access and reduce maintenance to certain portions of the NTS. As part of this cost-saving measure, Well UE-19c has been temporarily shut down, i.e., power to the pump disconnected and the lines drained. The last sample from this well was taken in October 1992.

All samples are analyzed by gamma spectrometry and for tritium by the enrichment method. No gamma-emitting radionuclides were detected in any of the samples collected in 1993. Summary results of tritium analyses are given in Table 9.8. The highest tritium activity was 317 pCi/L in a sample from Well UE-7ns. This activity is less than 1 percent of the Derived Concentration Guide (DCG) for tritium established in DOE Order 5400.5, "Radiation Protection of the Public and the Environment", for comparison with the dose limit (4 mrem) in the National Primary Drinking Water Regulations. Three of the monthly sampled wells and nine of the wells sampled semiannually yielded tritium results greater than the MDC (approximately 5 to 7 pCi/L) in one or more samples. Two of the monthly sampled wells, Test Well B and water Well C, have consistently shown detectable tritium over their sampling history. The 1993 average for Test Well B was 98.0 ± 9.0 pCi/L (range 82.0 to 111 pCi/L; 0.09 to 0.12 percent of the DCG), and for Well C 12.0 ± 5.3 pCi/L (range 5.5 to 25.0 pCi/L; 0.01 to 0.03 percent of the DCG). Figure 9.3 shows a decreasing trend in Test Well B[1].

Both of the semiannual samples collected from the following wells showed tritium results above the MDC: Wells C-1, HTH #1, UE-7ns, UE-16f, P.M. Exploratory #1, and UE-18t. Four

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[1] In the time series plots used as figures in this section and the one that follows, the filled circles represent the result value, the error bars indicate ± one standard deviation of the analysis, and the (x) represents the MDC value.

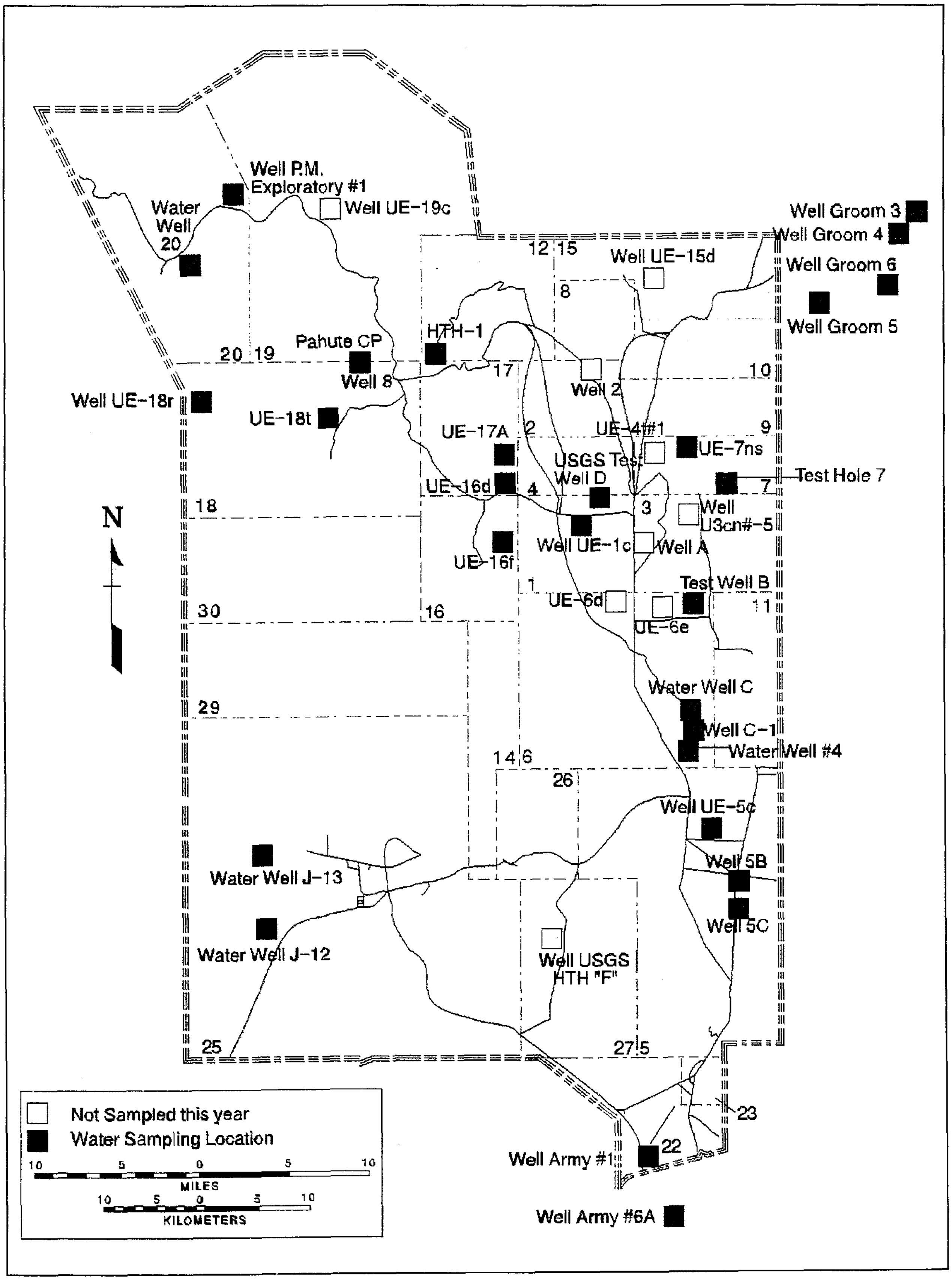

Figure 9.2 Wells on the NTS Included in the LTHMP

Table 9.8 Long-Term Hydrological Monitoring Program Summary of Tritium Results for Nevada Test Site Network, 1993

	Tritium Concentration (pCi/L)					
Location	Number	Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as %DCG
Test Well B	11	111.0	82.0	98.0	9.0	0.11
Test Well D	2	3.9	2.5	3.2	1.0	NA
Test Well 7	2	6.6	4.3	5.5	1.6	<0.01
Well Army #1	12	2.5	-3.7	-0.5	1.6	NA
Well Army #6A	2	3.0	0.1	1.5	2.0	NA
Water Well C	12	25.0	5.5	12.0	5.3	0.01
Well C-1	2	11.0	8.2	9.8	2.2	0.01
Well Groom 3	12	3.3	-1.0	1.0	1.3	NA
Well Groom 4	12	4.0	-2.0	0.1	2.1	NA
Water Well #4	12	3.2	-3.9	-0.3	2.2	NA
Well Groom 5	12	1.5	-3.0	-0.2	1.5	NA
Well 5B	3	1.4	-2.4	-1.0	2.1	NA
Water Well 5C	10	3.8	-2.5	0.1	2.0	NA
Well Groom 6	12	0.3	-2.2	-0.7	0.9	NA
Well HTH #8	12	5.5	-2.0	0.0	2.1	NA
Water Well 20	2	2.1	-1.0	0.6	2.2	NA
Well HTH #1	2	13.0	10.0	12.0	2.2	0.01
Well J-12	12	3.0	-2.9	-0.5	1.8	NA
Well J-13	12	1.7	-3.8	-0.5	1.9	NA
Well P.M. Expl. #1	2	221.0	215.0	218.0	4.2	0.24
Well UE-1c	2	7.4	2.8	5.1	3.2	NA
Well UE-5c	3	1.8	-3.7	-1.7	3.0	NA
Well UE-7ns	2	317.0	273.0	295.0	31.0	0.33
Well UE-16d	2	2.6	2.3	2.4	0.2	NA
Well UE-16f	2	6.2	6.0	6.1	0.2	<0.01
Well UE-17a	2	2.4	1.5	1.9	0.7	NA
Well UE-18r	2	5.4	-0.3	2.5	4.0	NA
Well UE-18t	2	166.0	156.0	161.0	7.0	0.18
Well A	Well inactivated by DOE, last sampled October 1988					
Water Well 2	Well shut down, last sampled December 1990					
Well USGS HTH "F"	Not sampled in 1993, last sampled February 1980					
Well U-3cn #5	Well shut down, last sampled December 1981					
Well UE-4t #1	Instrument in well, couldn't sample 1993					
Well UE-6e	Drill rig over hole, couldn't sample 1993					
Well UE-15d	Pump inoperative, last sampled 1992					
Well UE-19c	Road closed, (winter), pump inoperative, couldn't sample 1993					

Mean MDC: 5.38 pCi/L Standard Deviation of Mean MDC: 0.72 pCi/L

DCG Derived Concentration Guide; established by DOE Order as 90,000 pCi/L

NA Not applicable; percent of concentration guide is not applicable as the tritium result is less than the MDC or the water is know to be nonpotable

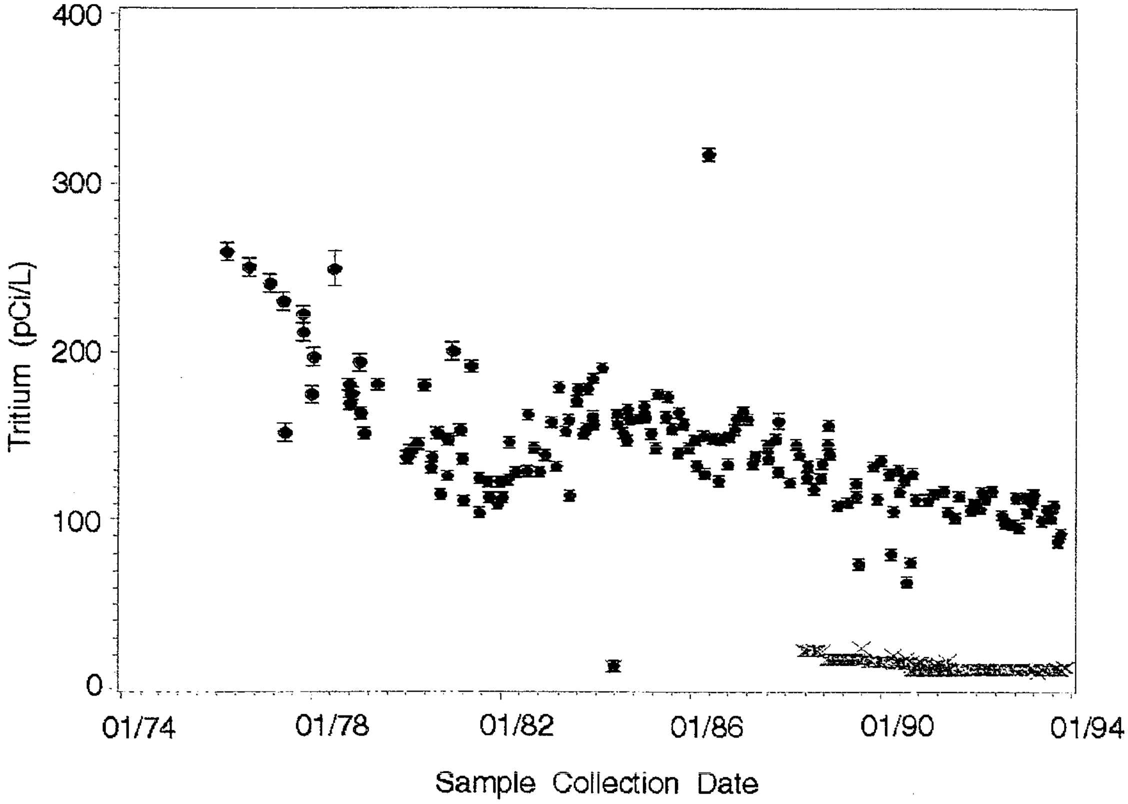

Figure 9.3 Tritium Concentration Trends in Test Well B on the NTS

of these sampling locations do not have sufficient data to discern any trends, as they have been added to the sampling network in recent years. Well UE-7ns was routinely sampled between 1976 and 1987. Sampling at Well UE-7ns was discontinued in 1988, and reinitiated in 1992. An increasing trend in tritium activity was seen, in excess of 2500 pCi/L at the time sampling ceased in September 1987. The results for 1992 and 1993 have shown a decrease from these previous results. Results obtained from Well C-1 indicate a decreasing trend in tritium concentration over the period from 1970 through 1979. Since 1979, tritium concentrations have been generally stable.

9.5.2.2 OFFSITE MONITORING IN THE VICINITY OF THE NEVADA TEST SITE

The monitoring sites in the offsite area around the NTS are shown in Figure 9.4. Most of the sampling locations represent drinking water sources for rural residents or public drinking water supplies for most of the communities in the area. The sampling locations include 23 wells, seven springs, and two surface water sites. Thirty of the locations are routinely sampled monthly. The remaining two sites, Penoyer Well 13 and Penoyer Wells 7 and 8, are in operation only part of the year, and samples are collected whenever the wells are in operation. One sampling location, the Johnnie Mine Well in Johnnie, Nevada, was deleted from the network when the mine was sold in August, 1993. This site had been sampled since 1989. The only tritium result for this location greater than the MDC was a concentration of

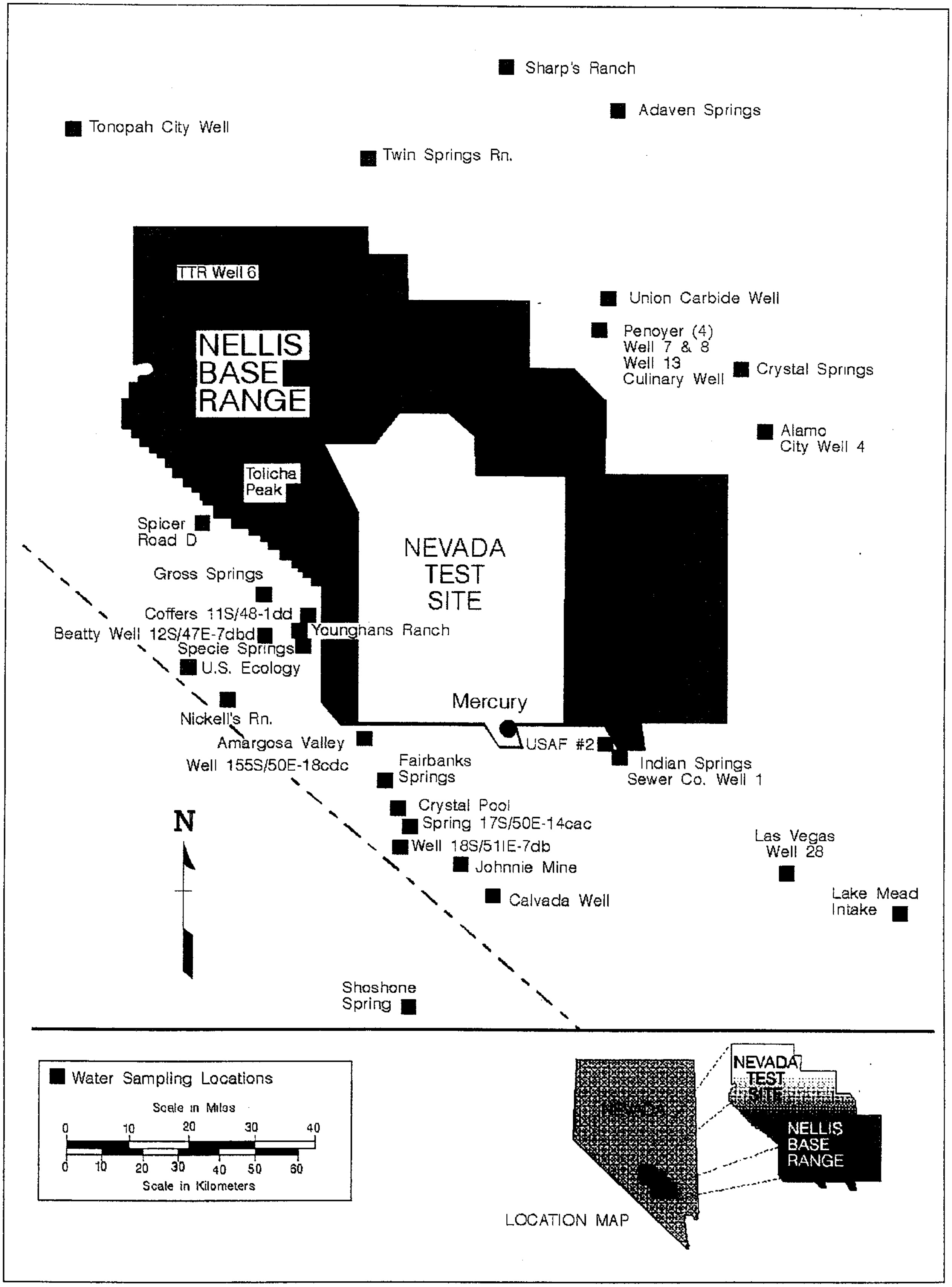

Figure 9.4 Wells Outside the NTS Included in the LTHMP

6.0 ± 1.7 pCi/L measured in 1992. Water samples are collected monthly for gamma spectrometric analysis. Tritium analyses are performed on a semiannual basis. In the past one of these analyses was done by the conventional method; the other analysis was done by the enrichment method. In April 1993 the procedure was changed so that both samples are analyzed using the enrichment method.

Over the last decade, only three sites have consistently shown detectable tritium activity: (1) Lake Mead Intake (Boulder City); (2) Adaven Spring (Adaven); and (3) Specie Springs (Beatty). In all three cases, the tritium activity represents environmental levels that have been generally decreasing over time.

In 1993, none of the samples analyzed for tritium using the conventional method had results above the MDC. Five of the samples analyzed for tritium by the enrichment method yielded detectable tritium activities. The January result for Adaven Spring of 31 ± 2.0 pCi/L and the July result of 36 ± 2.0 pCi/L were consistent with tritium levels noted in recent years as shown in Figure 9.5. The September result for Lake Mead Intake was 54 ± 2.0 pCi/L, similar to 1992 results as shown in Figure 9.6. This surface water site may be impacted by rainfall containing scavenged atmospheric tritium to a greater extent than well and spring sites. The July and December samples from Species Springs had tritium results of 18 ± 1.6 pCi/L and 20 ± 1.9 pCi/L, respectively. Tritium results for all samples are given in Table D.13, Appendix D. No gamma-emitting radionuclides were detected in any 1993 samples.

9.6 LTHMP AT OFF-NTS NUCLEAR DEVICE TEST LOCATIONS

The LTHMP conducts sampling at sites of past nuclear device testing in other parts of the U.S. to ensure the 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 and ground waters 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 Project DRIBBLE site in Mississippi. Sampling is conducted in odd numbered years, including 1993, on Amchitka Island, Alaska, site of Projects CANNIKIN, LONG SHOT, and MILROW. Analytical results for all samples are provided in Tables D.14 - 21 Appendix D.

The sampling procedure is the same as that used for sites on the NTS and offsite areas (described in Section 9.5.1), with the exception that two 3.8-L samples are collected in Cubitainers. The second sample serves as a backup or as a duplicate sample.

Because of the variability noted in past years in samples from the shallow monitoring wells near Project DRIBBLE ground zero (GZ), the sampling procedure was modified several years ago. A second sample is taken after pumping for a specified period of time or after the well has been pumped dry and permitted to refill with water. These second samples may be more representative of formation water, whereas the first samples may be more indicative of recent area rainfall.

9.6.1 PROJECT FAULTLESS

Project FAULTLESS was a "calibration test" conducted on January 19, 1968, in a sparsely populated area near Blue Jay Maintenance Station, Nevada. The test had a yield of less than 1 megaton (Mt) and was designed to test the behavior of seismic waves and to determine the

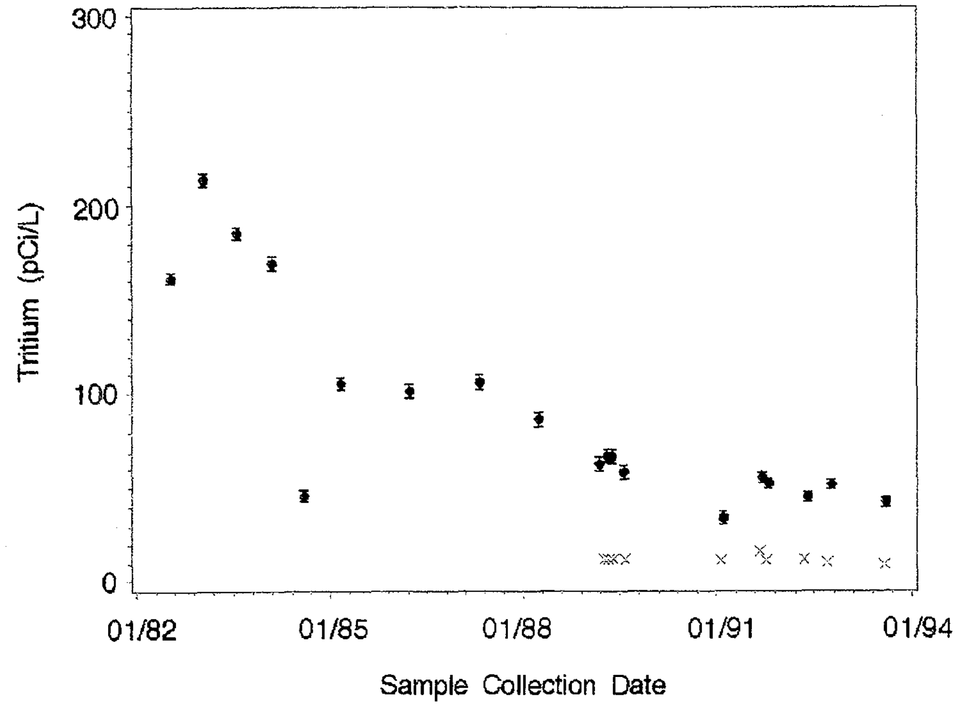

Figure 9.5 Tritium Results in Water from Lake Mead, Nevada

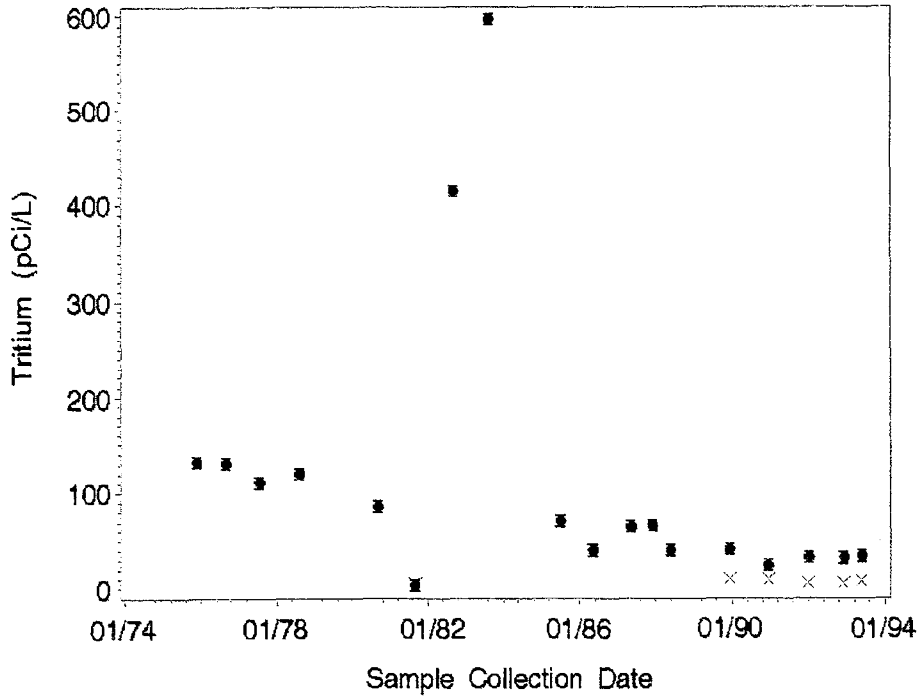

Figure 9.6 Tritium Results in Water from Adaven Spring, Nevada

usefulness of the site for high-yield tests. The emplacement depth was 975 m (3199 ft). A surface crater was created, but as an irregular block along local faults rather than as a saucer-shaped depression.

Sampling was conducted on March 16, 17, and 23, 1993 at locations shown in Figure 9.7. Routine sampling locations include one spring and five wells of varying depths. Six Mile Well was not sampled due to a missing pump motor. All of these locations are being used as, or are suitable for, drinking water supplies. At least two wells (HTH-1 and HTH-2) are positioned to intercept potential migration from the test cavity (Chapman and Hokett, 1991). All samples yielded negligible gamma activity. The only sample with tritium activity (7.3 ± 1.8 pCi/L; less than 0.01 percent of the DCG) above the MDC was from Blue Jay Maintenance Station (see Table D.14, Appendix D). These results are consistent with results obtained in previous years, and indicate that migration of radioactivity into the sampled wells, and into the area drinking water supplies, has not occurred.

9.6.2 PROJECT SHOAL

Project SHOAL, a 12-kiloton (kt) test emplaced at 365 m (1198 ft), was conducted on October 26, 1963, in a sparsely populated area near Frenchman Station, Nevada. The test, part of the Vela Uniform Program, was designed to investigate detection of a nuclear detonation in an active earthquake zone. The working point was in granite and no surface crater was created.

Samples were collected on February 24 and 25, 1993. The routine sampling locations (see Figure 9.8) include one spring, one windmill, and four wells of varying depths. Five of these six sampling locations were sampled. Spring Windmill was plugged. Well H-2 has been reworked and will be sampled next year. At least one location, Well HS-1, should intercept radioactivity migrating from the test cavity (Chapman and Hokett, 1991).

No gamma activity was detected in any of the samples. A tritium result of 62 ± 2.1 pCi/L, 0.07 percent of the DCG, was detected in the water sample from Smith/James Spring (see Table D.15, Appendix D). All of the remaining samples yielded tritium results less than the MDC. The result for Smith/James Springs is consistent with values obtained in previous years, as shown in Figure 9.9. The most probable source of this tritium is assumed to be rainwater infiltration, not the Project SHOAL cavity.

9.6.3 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 Rifle, Colorado on September 10, 1969, consisted of a 40-kt nuclear explosive emplaced at a depth of 2568 m (8425 ft). Production testing began in 1970 and was completed in April 1971. Cleanup was initiated in 1972 and wells were plugged in 1976. Some surface contamination resulted from decontamination of drilling equipment and fallout from gas flaring. Soil was removed during the cleanup operations.

Sampling was completed on June 16, 1993, with collection of nine samples in the area of Grand Valley and Rulison, Colorado. Routine sampling locations, shown in Figure 9.10, include the Grand Valley municipal drinking water supply springs, water supply wells for five local ranches, and three sites in the vicinity of GZ, including one test well, a surface-discharge spring, and a surface sampling location on Battlement Creek. An analysis of the sampling locations performed by DRI indicated that none of the sampling locations are likely to detect migration of radionuclides from the test cavity (Chapman and Hokett, 1991).

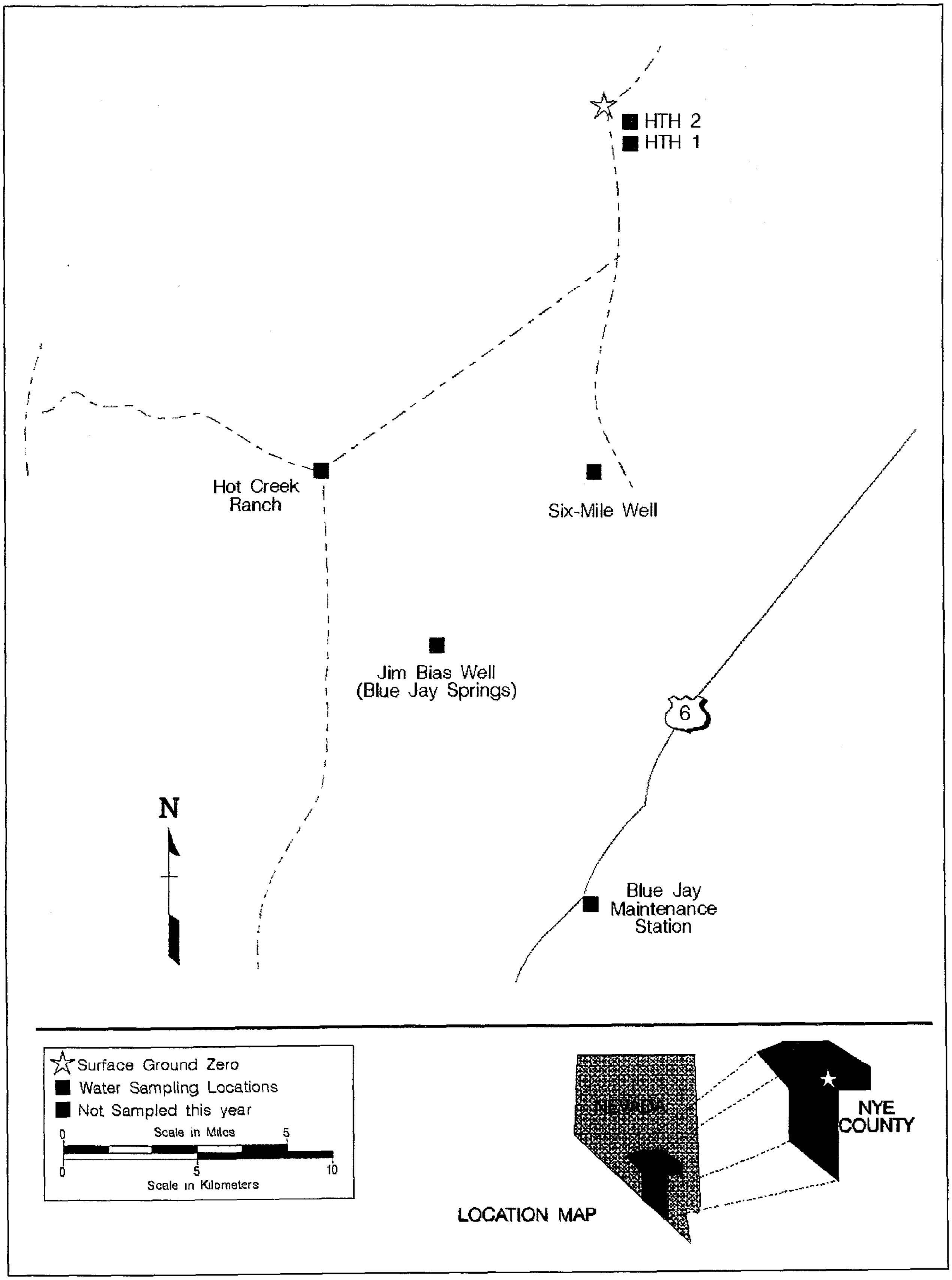

Figure 9.7 LTHMP Sampling Locations for Project FAULTLESS - 1993

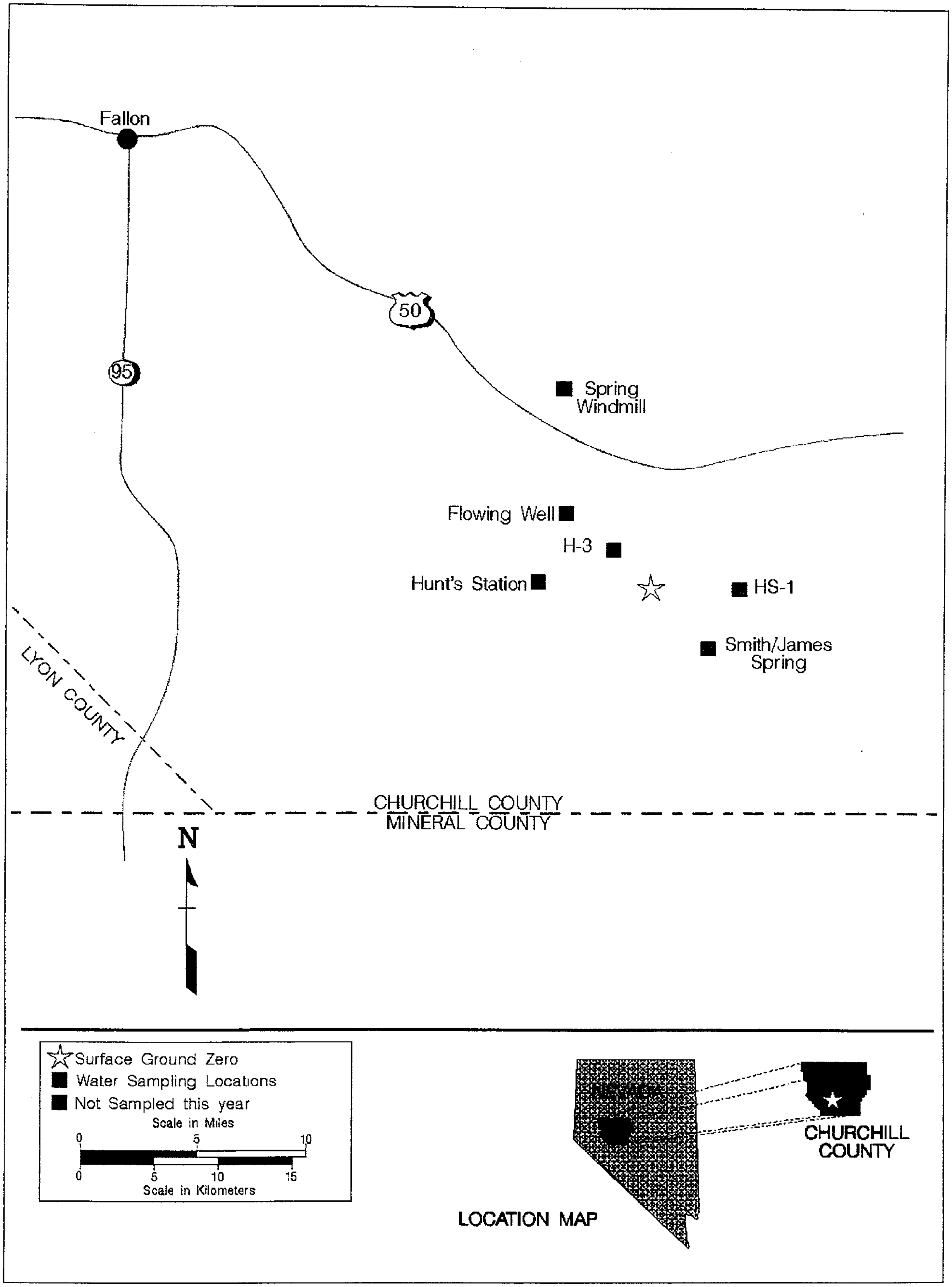

Figure 9.8 LTHMP Sampling Locations for Project SHOAL - 1993

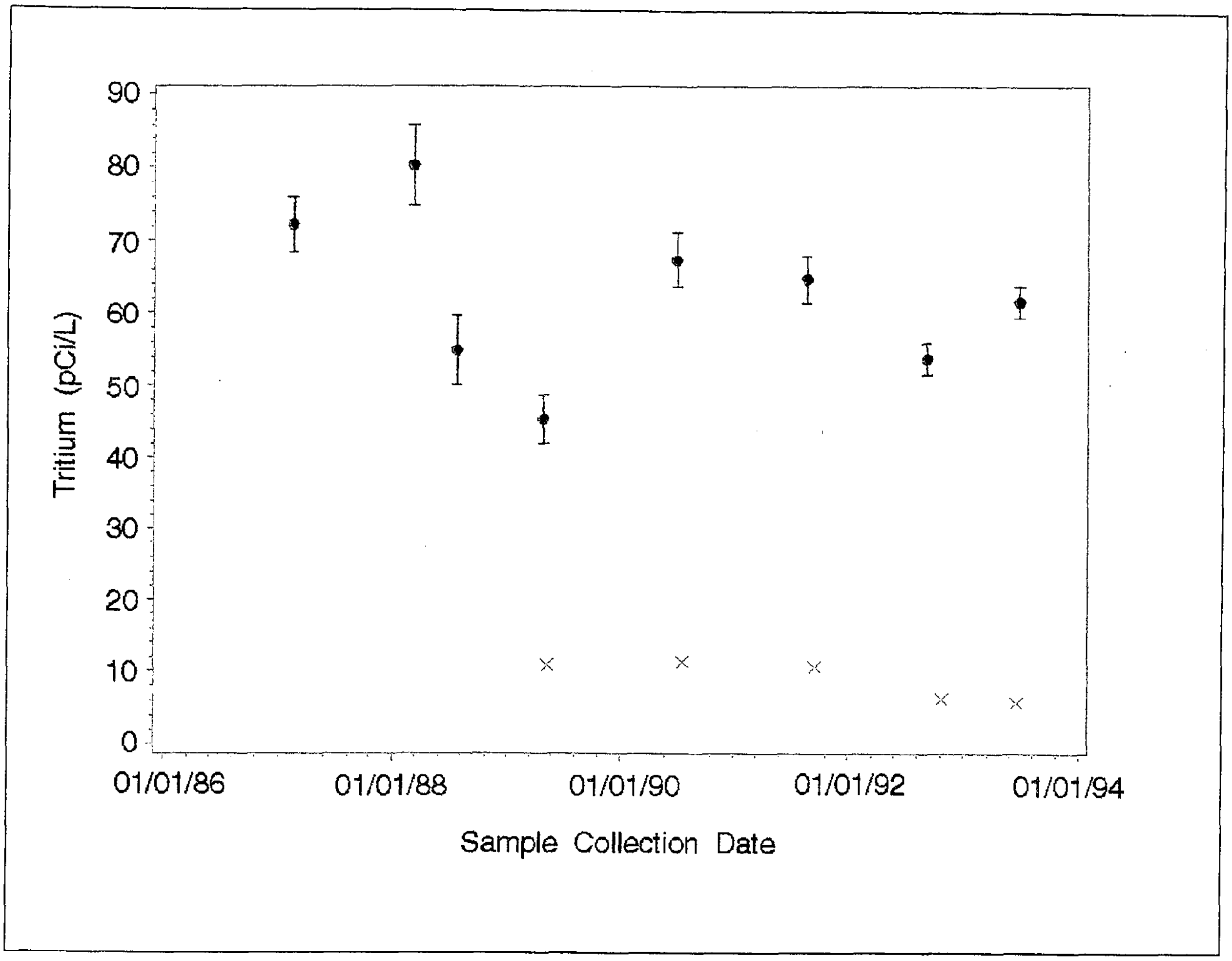

Figure 9.9 Tritium Results for Water from Smith/James Spring, Nevada

Tritium has never been observed in measurable concentrations in the Grand Valley City Springs. The sample from Potter's Ranch was invalidated following analysis. 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 the 1993 samples was from 49 ± 1.9 pCi/L at Battlement Creek to 116 ± 3 pCi/L at Lee Hayward Ranch (see Table D.16, Appendix D). All values were less than one percent of the DCG. The detectable tritium activities are probably a result of the high natural background in the area. This is supported by the DRI analysis, which indicated that most of the sampling locations are shallow, drawing water from the surficial aquifer which is unlikely to become contaminated by any radionuclides arising from the Project RULISON cavity (Chapman and Hokett, 1991). Figure 9.11 displays data for the last 20 years for Lee Hayward Ranch. The low value obtained in 1990 was attributed to analytical bias and was observed consistently for all Project RULISON sampling locations.

9.6.4 PROJECT RIO BLANCO

Like Project RULISON, Project RIO BLANCO was a joint government-industry test designed to stimulate natural gas flow and was conducted under the Plowshare Program. The test was conducted on May 17, 1973, at a location between Rifle and Meeker, Colorado. Three explosives with a total yield of 99 kt were emplaced at 1780-, 1920-, and 2040-m (5840-,

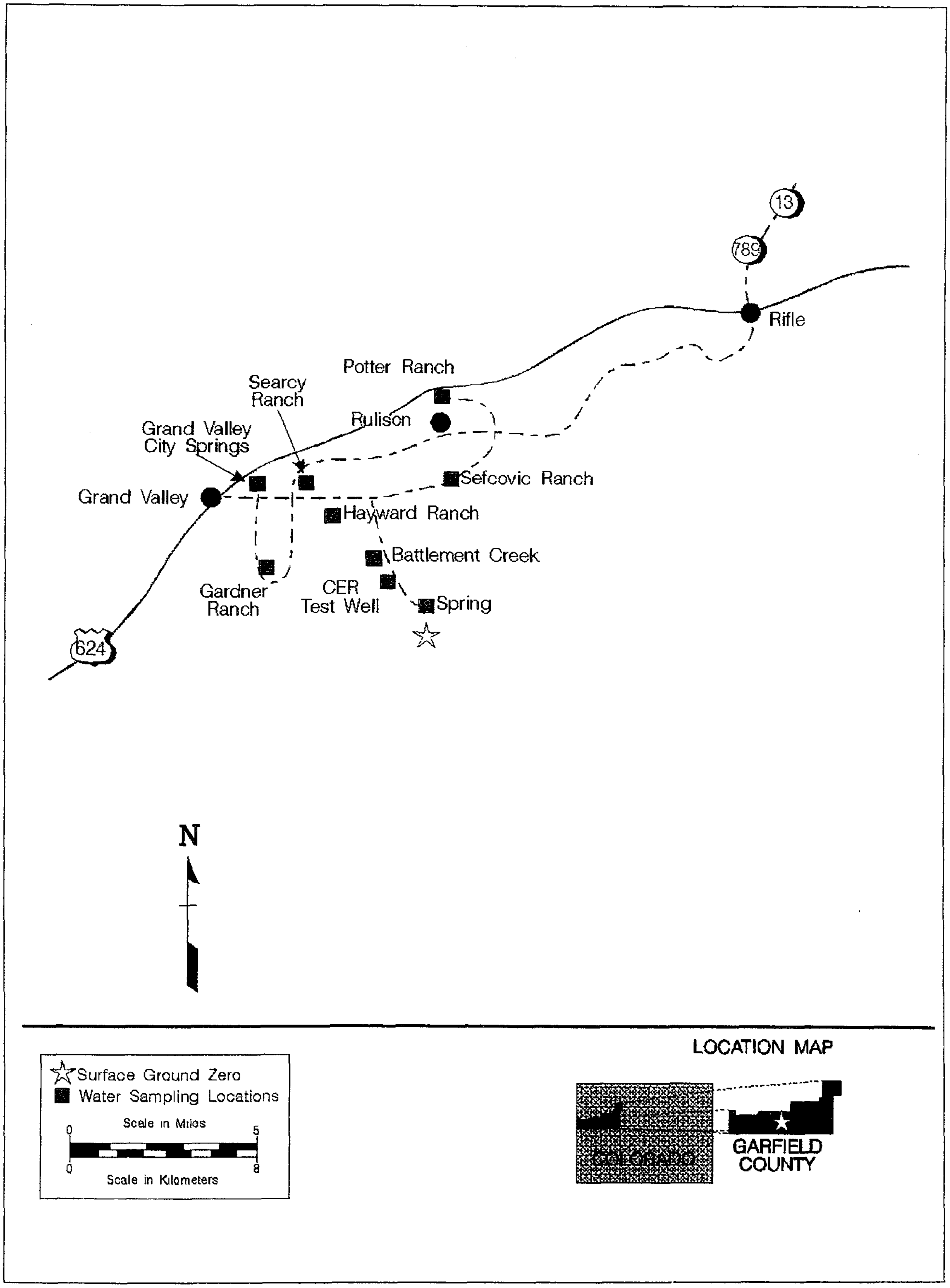

Figure 9.10 LTHMP Sampling Locations for Project RULISON - 1993

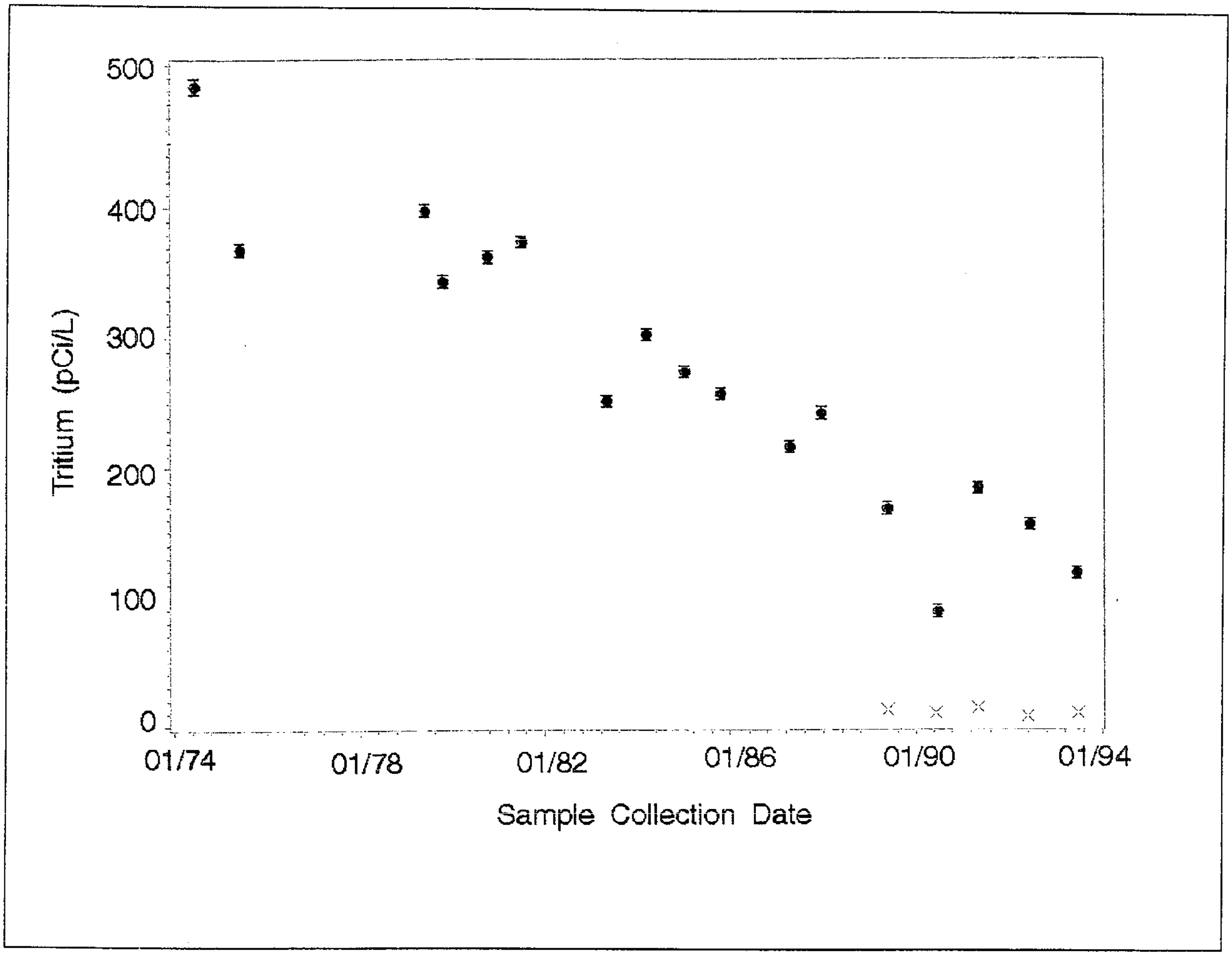

Figure 9.11 Tritium Trends in Groundwater, Hayward Ranch, Colorado

6299-, and 6693-ft) depths in the Ft. Union and Mesa Verde formations. Production testing continued to 1976. Tritiated water produced during testing was injected to 1710 m (5610 ft) in a nearby gas well. Cleanup and restoration activities were completed by November 1976.

Samples were collected June 17 and 18, 1993. The sampling sites, shown in Figure 9.12, include two shallow domestic water supply wells, six surface water sites along Fawn Creek, three springs, and three monitoring wells located near the cavity. At least two of the monitoring wells (Wells RB-D-01 and RB-D-03) are suitable for monitoring possible migration of radioactivity from the cavity. Tritium activity in the three springs ranged from 49 ± 1.9 to 58 ± 2.5 pCi/L, less than 0.1 percent of the DCG (see Table D.17, Appendix D). A generally decreasing trend in tritium activity, as depicted in Figure 9.13, is evident in the three springs. Only one of the two shallow domestic wells located near the Project RIO BLANCO site yielded detectable tritium activity: 7.0 ± 2.0 pCi/L from the Brennan Windmill sample. Two of the Fawn Creek surface sites were analyzed by the conventional tritium method, yielding results less than the MDC. The remaining four sites, analyzed using the enrichment method, yielded tritium activities ranging from 28 ± 1.7 to 39 ± 2.2 pCi/L, less than 0.1 percent of the DCG. There is no statistically significant difference between sites located upstream and downstream of the cavity area. There was no detectable tritium in the three monitoring wells, indicating migration from the test cavity has not been detected. No gamma activity was detected in any sample.

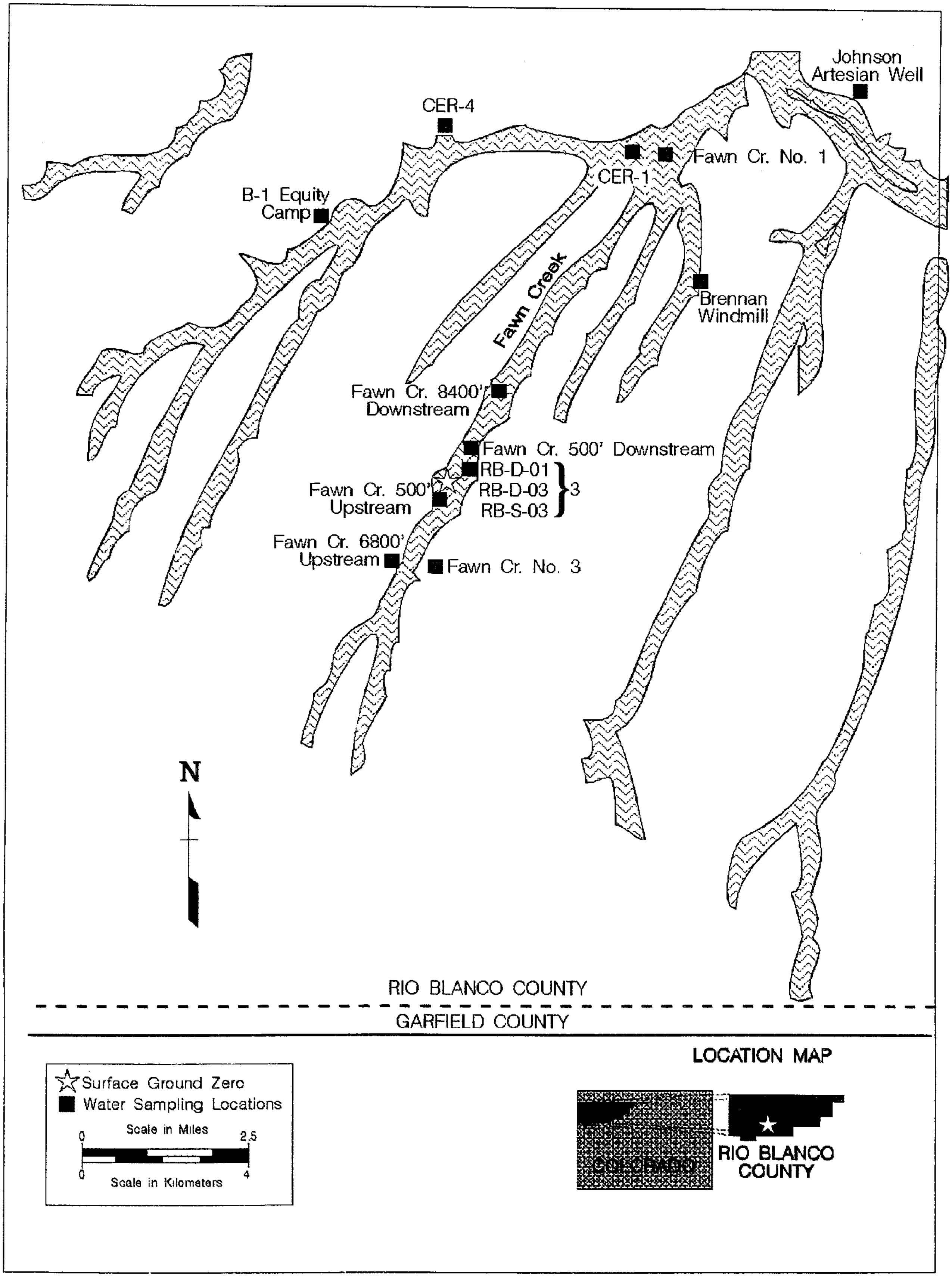

Figure 9.12 LTHMP Sampling Locations for Project RIO BLANCO, Colorado

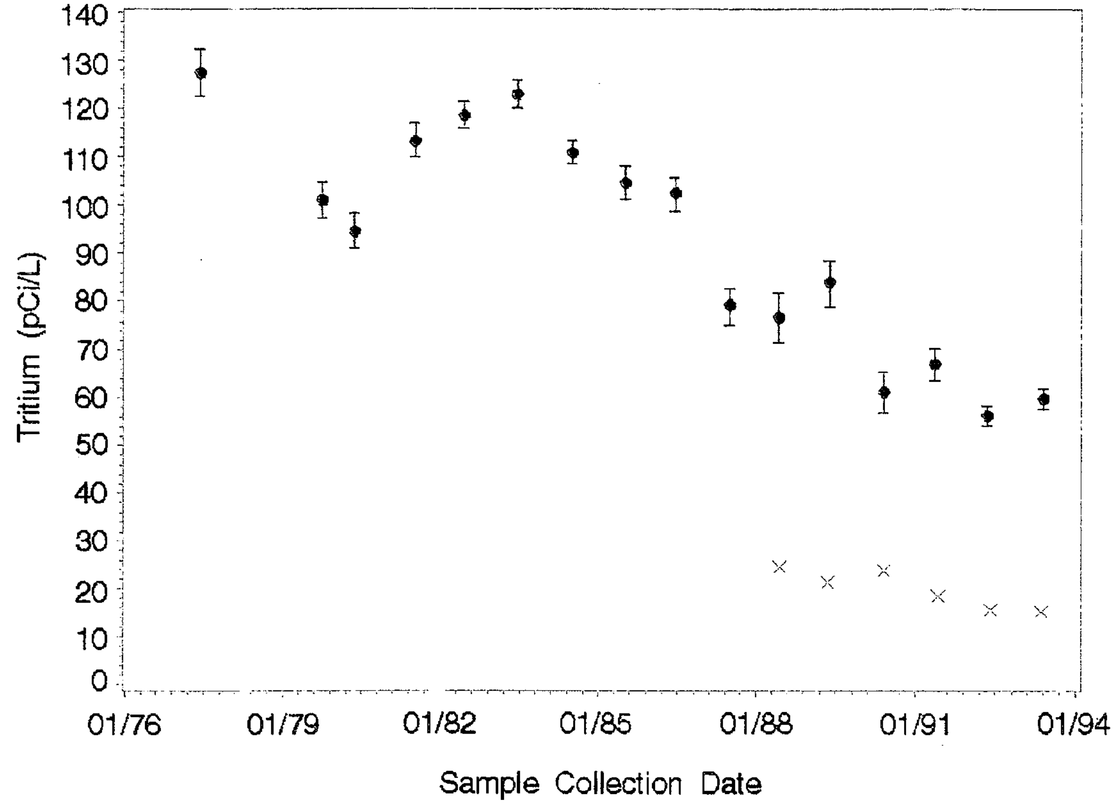

Figure 9.13 Tritium Results in Water from CER No. 4, RIO BLANCO, Colorado

9.6.5 PROJECT GNOME

Project GNOME, conducted on December 10, 1961, near Carlsbad, New Mexico, was a multipurpose test performed in a salt formation. A slightly more than 3-kt nuclear explosive was emplaced at 371 m (1217 ft) depth 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 into Well USGS-8 and pumping water from Well USGS-4. During remediation activities in 1968-69, 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 completed between June 26 and 28, 1993. The routine sampling sites, depicted in Figure 9.14, include nine monitoring wells in the vicinity of GZ, and the municipal supplies at Loving and Carlsbad, New Mexico. The Pecos River Pumping Station well is no longer sampled. A new sampling location, the J. Mobley Ranch located near Loving, New Mexico, was added in 1993. This sampling site is a 50 m (165 ft) deep well used to supply drinking water. No tritium activity above the MDC was detected in the

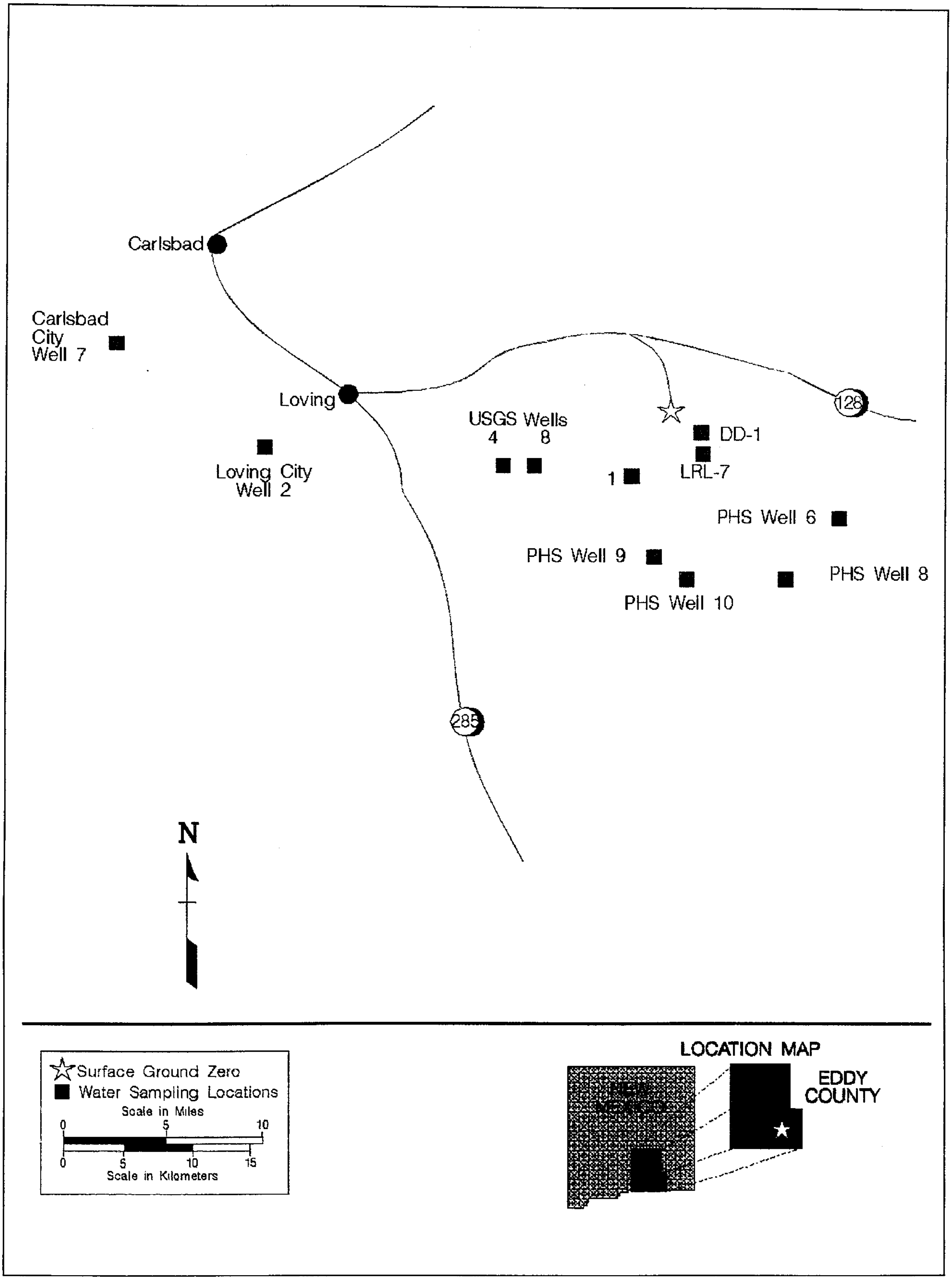

Figure 9.14 LTHMP Sampling Locations for Project GNOME - 1993

Carlsbad municipal supply. Tritium activities of 9.1 ± 1.7 pCi/L in the Loving municipal supply, and 4.9 ± 1.5 pCi/L in the J. Mobley Ranch well were detected. An analysis by DRI (Chapman and Hokett, 1991) indicates these three municipal sampling locations, located on the opposite side of the Pecos River from the Project GNOME site, are not connected hydrologically to the site and, therefore, could only become contaminated by Project GNOME effluents via surface pathways.

Tritium results greater than the MDC were detected in water samples from six of the nine sampling locations in the immediate vicinity of GZ. Tritium activities in Wells DD-1, LRL-7, USGS-4, and USGS-8 ranged from 7300 ± 150 pCi/L in Well LRL-7 to $7.4 \times 10^7 \pm 3.2 \times 10^5$ pCi/L in Well DD-1. Well DD-1 collects water from the test cavity, Well LRL-7 collects water from a sidedrift, and Wells USGS-4 and -8 were used in the radionuclide tracer study conducted by USGS. None of these wells supply potable water. In addition to tritium, ^{137}Cs concentrations ranging from 59 ± 5 pCi/L to 821,000 ± 39,800 pCi/L were observed in samples from Wells DD-1, LRL-7, and USGS-8, while ^{90}Sr activity ranging from 2400 ± 10 pCi/L to 17,000 ± 1400 pCi/L was detected in Wells DD-1, USGS-4 and USGS-8 (see Table D.18, Appendix D). With the exception of Well DD-1, the concentrations of these radionuclides decreased from 1992 results (see Figure 9.15). The remaining two wells with detectable tritium concentrations were PHS wells 6 and 8, with results of 30 ± 1.8 pCi/L and 9.0 ± 1.7 pCi/L, respectively, less than 0.04 percent of the DCG. No tritium was detected in the remaining Project GNOME samples, including Well USGS-1, which the DRI analysis (Chapman and Hokett, 1991) indicated is positioned to detect any possible migration of radioactivity from the cavity.

9.6.6 PROJECT GASBUGGY

Project GASBUGGY was a Plowshare Program test co-sponsored by the U.S. Government and El Paso Natural Gas. Conducted near Gobernador, 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 was conducted June 20 through June 25, 1993. Samples were collected from the 12 routine sampling locations. The Old School House Well, first sampled in 1991, was sealed by the state of New Mexico, thus ending plans to add this station to the routine sampling directory. The routine sampling locations include six wells, one windmill, three springs, and two surface water sites, depicted in Figure 9.16. The two surface water sampling sites yielded tritium activities of 36 ± 1.8 pCi/L and 41 ± 1.8 pCi/L, 0.04 and 0.05 percent of the DCG, respectively. The three springs yielded tritium activities ranging from 20 ± 1.9 pCi/L to 49 ± 1.9 pCi/L, less than 0.1 percent of the DCG, similar to the range seen in previous years. Tritium activities in three shallow wells which were sampled this year varied from less than the MDC to 40 ± 1.9 pCi/L, 0.04 percent of the DCG. The sample from the windmill was less than the MDC. Analytical results are given in Table D.19 Appendix D.

Well EPNG 10-36, a gas well located 132 m (435 ft) northwest of the test cavity with a sampling depth of approximately 1100 m (3600 ft), had yielded tritium activities between 100 and 560 pCi/L in each year since 1984, except 1987. The sample collected in 1993 yielded

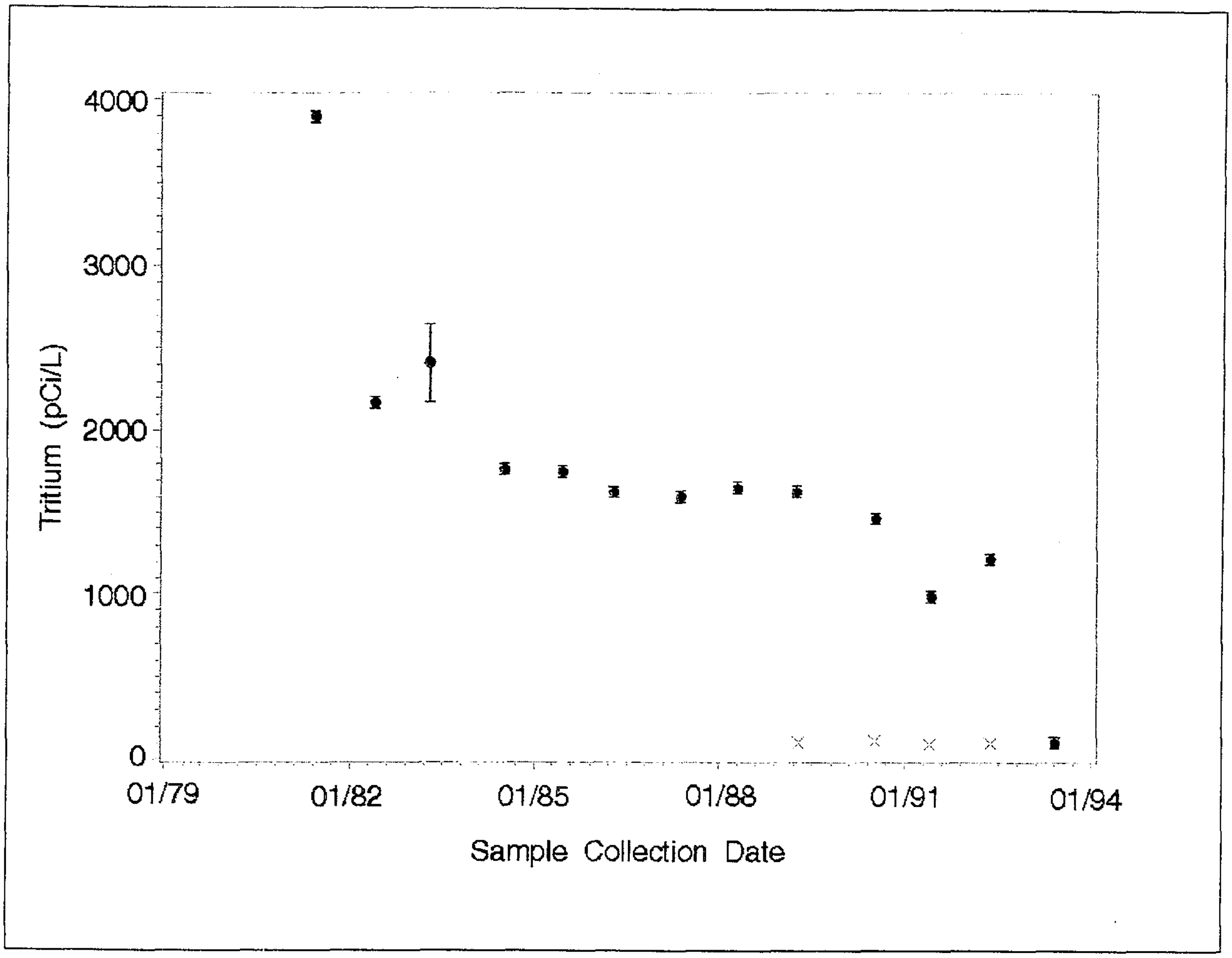

Figure 9.15 Tritium Results in Water from Well LRL-7 near Project GNOME, New Mexico

a tritium activity of 327 ± 3.5 pCi/L and a ^{137}Cs activity of 16 ± 3.9 pCi/L. The tritium activity is roughly the same as observed in 1992, but the ^{137}Cs activity is an increase over results from previous years.

The presence of fission products in samples collected from EPNG 10-36 confirms that migration from the Project GASBUGGY cavity is occurring. The migration mechanism and route are not currently known, although an analysis by DRI indicated two feasible routes, one through the Painted Cliffs sandstone and the other through the Ojo Alamo sandstone, one of the principal aquifers in the region (Chapman and Hokett, 1991). In either case, fractures extending from the cavity may be the primary or a contributing mechanism.

9.6.7 PROJECT DRIBBLE

Project DRIBBLE was comprised of two nuclear and two gas explosive tests, conducted in the SALMON Test Site area of Mississippi under the Vela Uniform Program. The purpose of Project DRIBBLE was to study the effects of decoupling on seismic signals produced by explosives tests. The first test, SALMON, was a nuclear device with a yield of about 5 kt, detonated on October 22, 1964, at a depth of 826 m (2710 ft). This test 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, conducted on

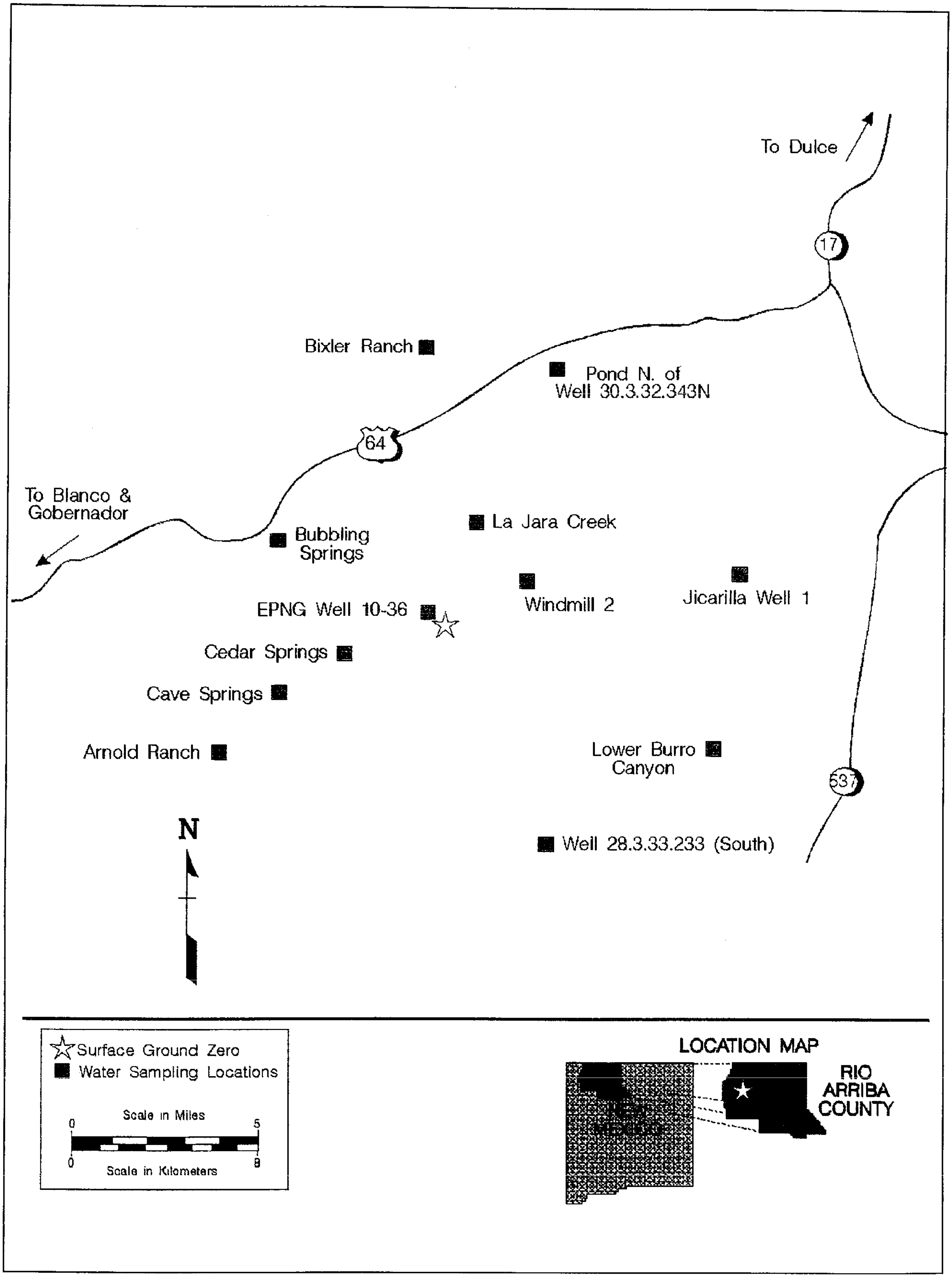

Figure 9.16 LTHMP Sampling Locations for Project GASBUGGY - 1993

February 2, 1969, and HUMID WATER, conducted 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. Shallow wells, labeled HMH wells on Figure 9.17, have been added to the area near surface GZ to monitor this contamination. In addition to the monitoring wells surrounding GZ, extensive sampling is conducted in the nearby offsite area. Most private drinking water supply wells are included, as shown in Figure 9.18.

Sampling on and in the vicinity of the SALMON Test Site was conducted between April 18 through 22, 1993. A total of 109 samples was collected; two of these were from new sampling locations in Lumberton, Mississippi. One offsite resident withdrew from the sampling program (Johnny Hudson Quail house), and one residence changed owners (the B. Chambliss location is now identified as Billy Hibley).

In the 52 samples collected from offsite sampling locations, tritium activities ranged from less than the MDC to 37 ± 1.8 pCi/L, 0.04 percent of the DCG. These results do not exceed the natural tritium activity expected in rainwater in the area. In general, results for each location were similar to results obtained in previous years. Long-term decreasing trends in tritium concentrations are evident only for a few locations, such as the Baxterville City Well, depicted in Figure 9.19. Low levels of uranium isotopes were detected in the two new sampling locations, ranging from 0.019 to 0.049 pCi/L of ^{235}U and 0.032 to 0.048 pCi/L of ^{238}U (see Table D.20, Appendix D). These low levels are probably of natural origin.

Due to the high rainfall in the area, the normal sampling procedure is modified for the shallow onsite wells. Following collection of a first sample, the well is pumped for a set period of time or until dry and a second sample is collected the next day. The second samples are thought to be more representative of the formation water. Of the 32 locations sampled onsite (7 sites sampled once, the remainder sampled twice) 26 yielded tritium activities greater than the MDC in either the first or second sample. Of these, 11 yielded results higher than normal background (approximately 60 pCi/L). Overall, tritium activities ranged from less than the MDC to 7.8×10^3 ± 150 pCi/L, as shown in Table D.20, Appendix D. The locations where the highest tritium activities were measured generally correspond to areas of known contamination. Decreasing trends were noted for the wells where high tritium activities have historically been noted, such as Well HM-S depicted in Figure 9.20. Results of sampling related to Project DRIBBLE are discussed in greater detail in *Onsite and Offsite Environmental Monitoring Report: Radiation Monitoring around SALMON Test Site, Lamar County, Mississippi, April 1993* (Max G. Davis, in press).

9.6.8 AMCHITKA ISLAND, ALASKA

Three nuclear weapons tests were conducted on Amchitka Island in the Aleutian Island chain of Alaska. Project LONG SHOT, conducted on October 29, 1965, was an 80-kt test under the Vela Uniform Program, designed to investigate seismic phenomena. Project MILROW, conducted on October 2, 1969, was an approximately 1-Mt "calibration test" of the seismic and environmental responses to the detonation of large-yield nuclear explosives. Project CANNIKIN, conducted on November 6, 1971, was a proof test of the Spartan antiballistic missile warhead with less than a 5-Mt yield. Project LONG SHOT resulted in some surface contamination, even though the chimney did not extend to the surface.

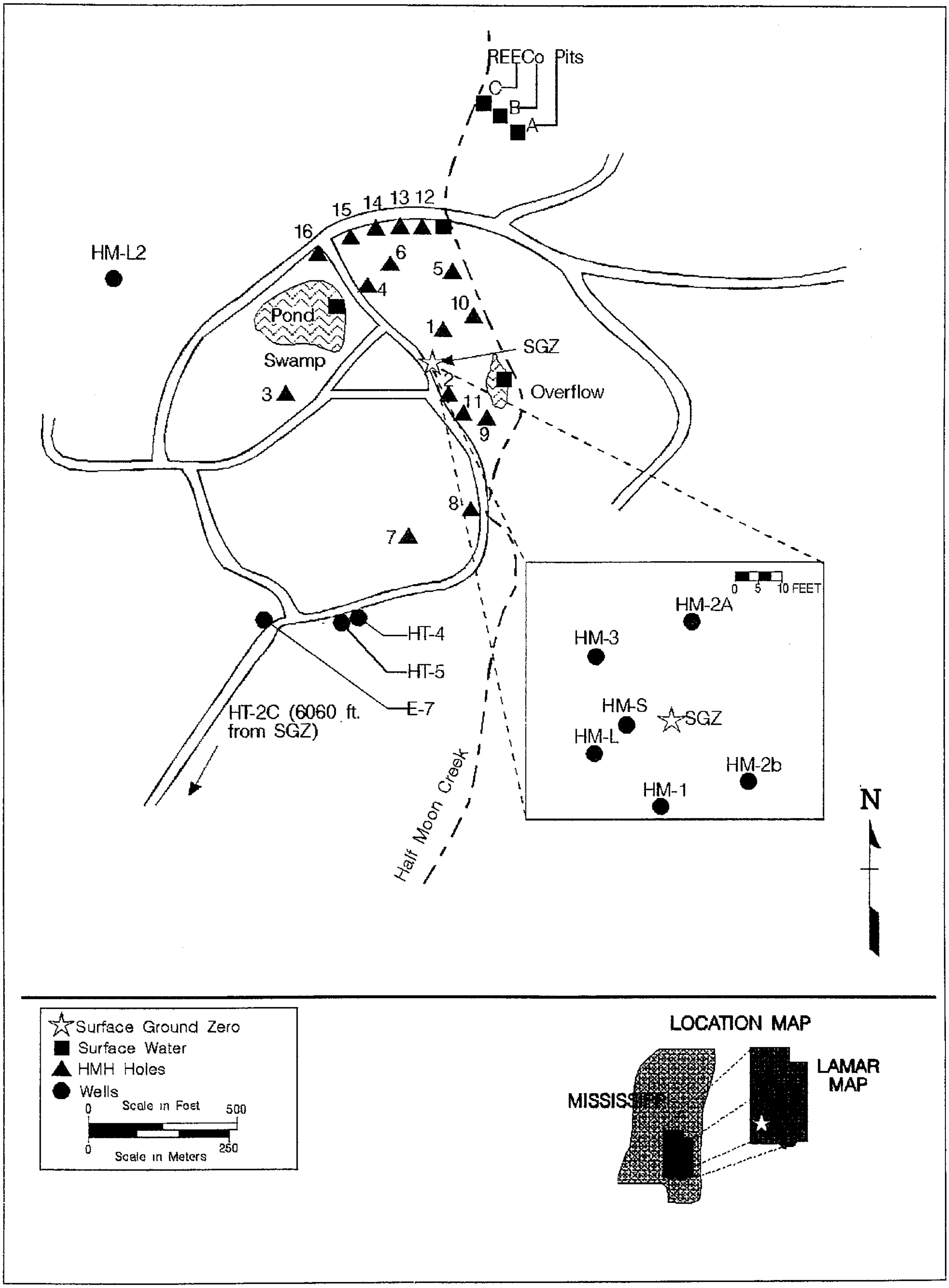

Figure 9.17 LTHMP Sampling Locations for Project DRIBBLE, Near Ground Zero - 1993

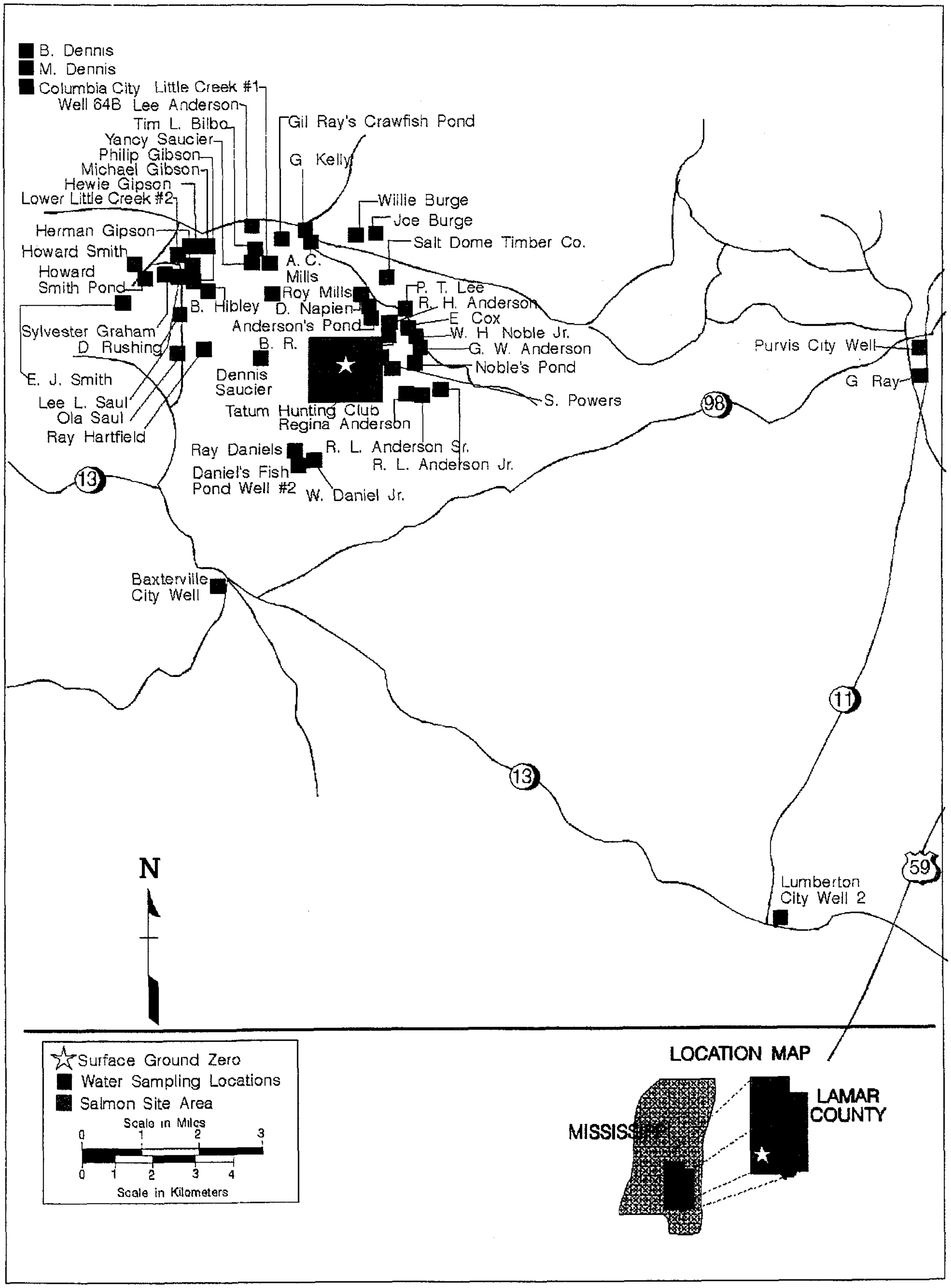

Figure 9.18 LTHMP Sampling Locations for Project DRIBBLE, Towns and Residences - 1993

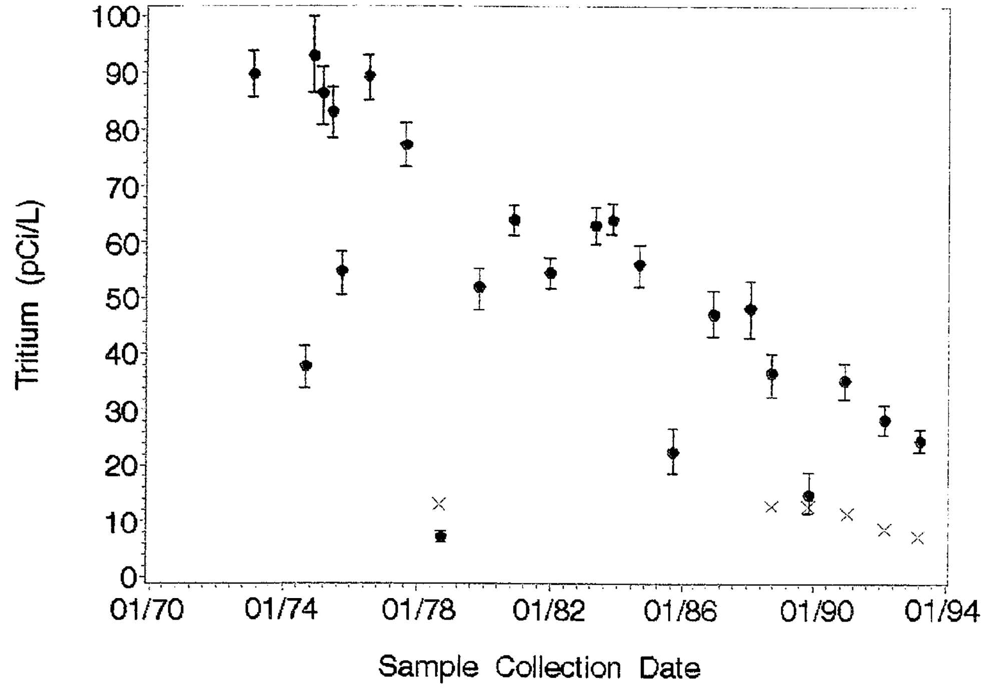

Figure 9.19 Tritium Result Trends in Baxterville, MS Public Drinking Water Supply - 1993

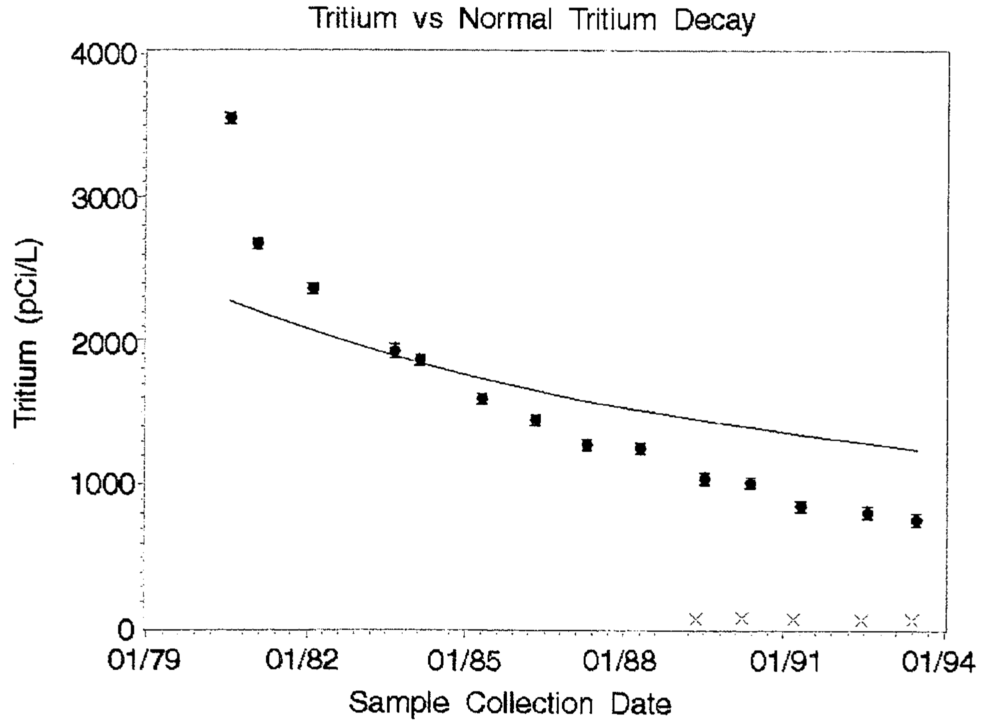

Figure 9.20 Tritium Results in Well HM-S, Tatum Salt Dome, Project DRIBBLE

Sampling on Amchitka Island, Alaska, is conducted every other year. Samples were collected from July 29 to August 1, 1993. The results from these samples are given in Table D.21, Appendix D. All samples were above the MDC for tritium.

The highest tritium concentrations were observed in samples from the Project LONG SHOT site, ranging from 10 ± 1.1 pCi/L to 1.4 x 10^3 ± 130 pCi/L, 0.01 to 1.6 percent of the DCG. The highest tritium result was obtained from well GZ No. 1, located near the Project LONG SHOT cavity. The tritium concentration in this well has been decreasing (see Figure 9.21), and, since this is the deepest well, suggests no continuing contribution from the test cavity.

The background sites had tritium concentrations ranging from 4.5 ± 1.7 pCi/L at the Base Camp to 30 ± 1.7 pCi/L at Constantine Spring Pump House, equivalent to 0.01 to 0.03 percent of the DCG (Figure 9.22). Samples from the Project CANNIKIN site yielded tritium concentrations ranging from 16 ± 1.6 pCi/L to 23 ± 1.8 pCi/L, 0.02 to 0.03 percent of the DCG (Figure 9.23). Project MILROW samples yielded tritium concentrations ranging from 13 ± 1.6 pCi/L to 36 ± 2.0 pCi/L, 0.01 to 0.04 percent of the DCG (Figure 9.24).

An analysis of the monitoring locations by DRI indicated that none of the sites are suitable for detection of migration from the test cavities (Chapman and Hokett, 1991). Migration from the Project MILROW cavity would likely discharge to the Pacific Ocean, while migration from the Projects LONG SHOT and CANNIKIN would likely discharge to the Bering Sea.

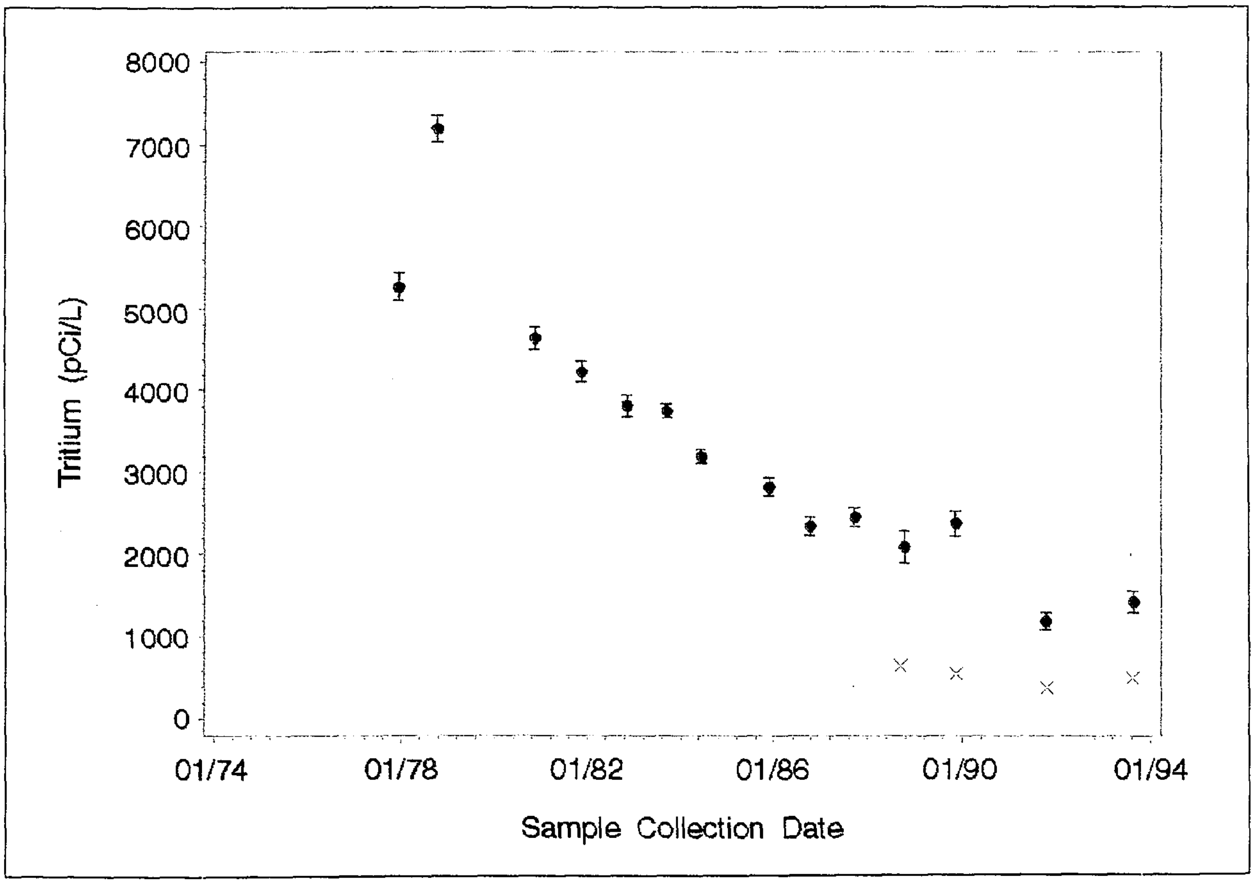

Figure 9.21 HTO Trend in Water from Well GZ No. 1, Project LONGSHOT

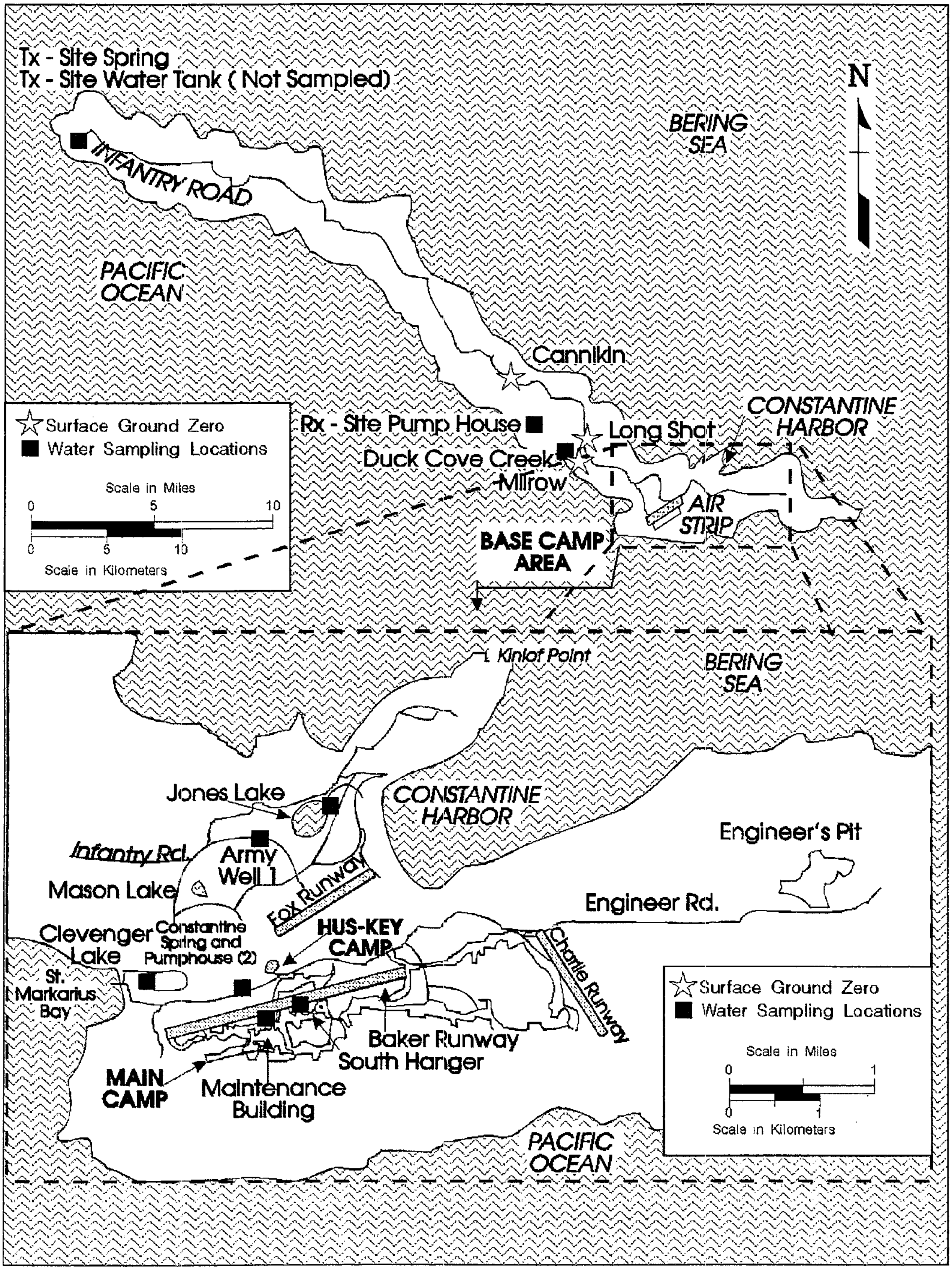

Figure 9.22 Amchitka, Alaska, Background Sampling Locations

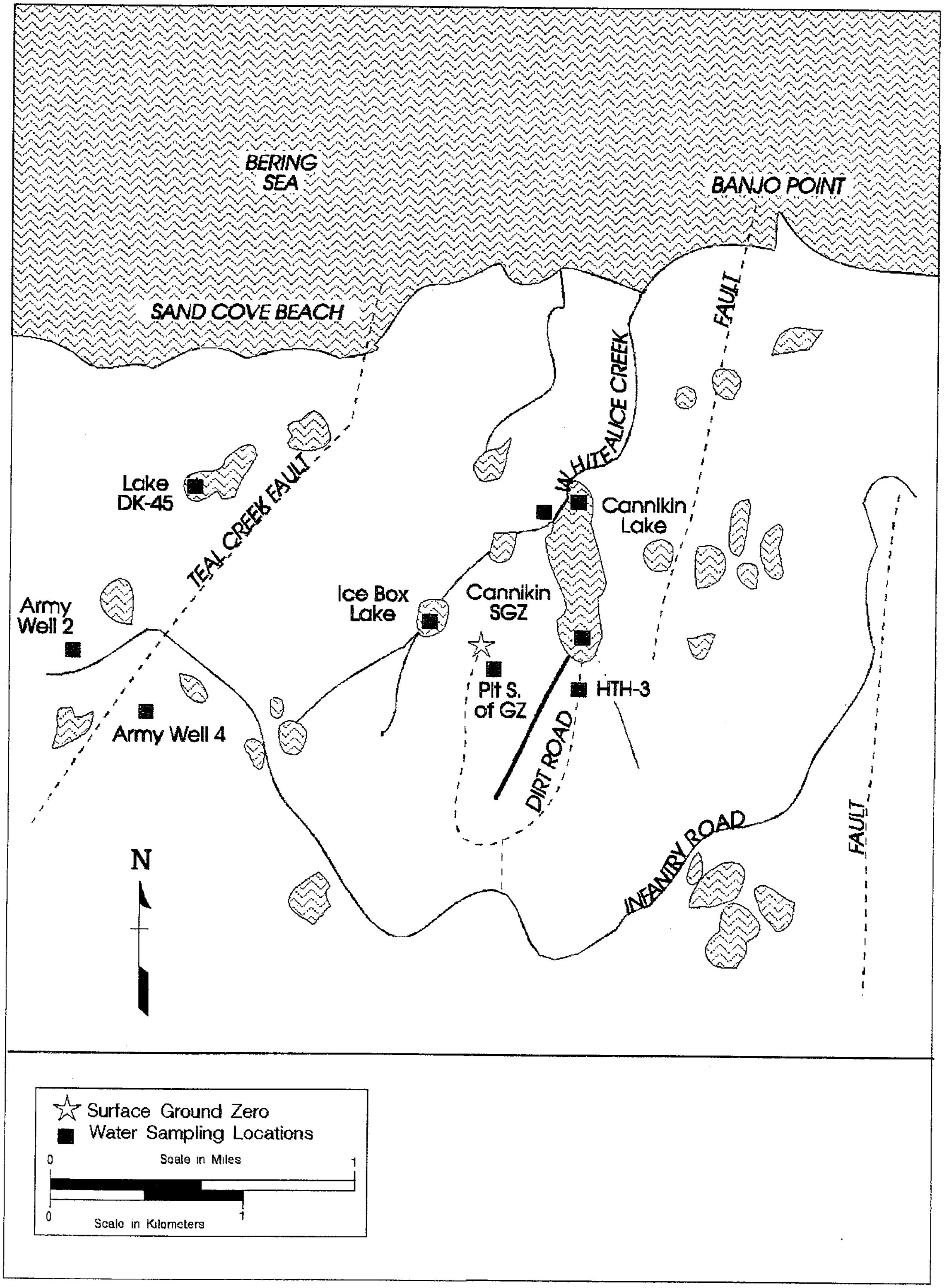

Figure 9.23 Sampling Locations for Project CANNIKIN

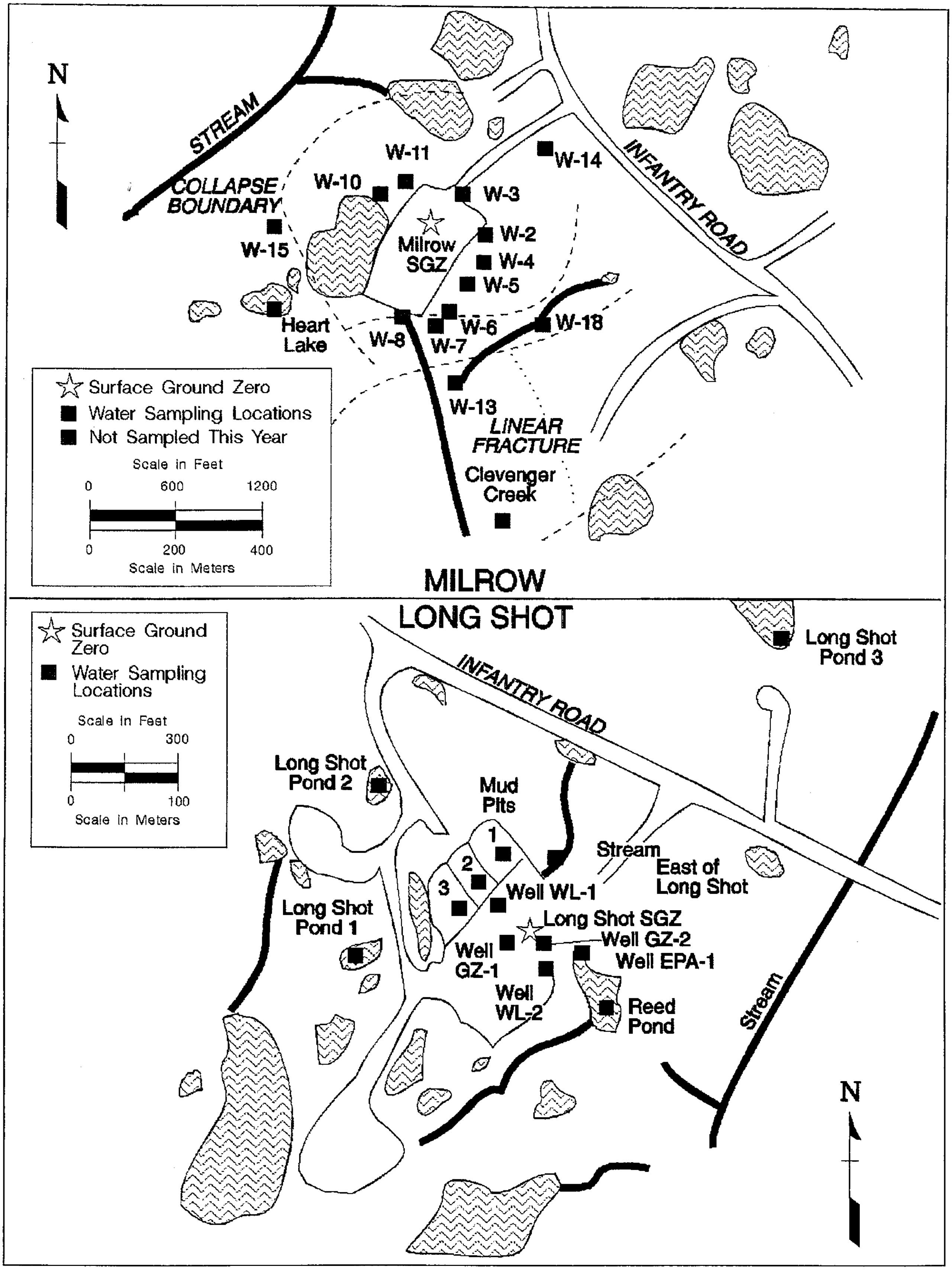

Figure 9.24 Sampling Locations for Projects MILROW and LONG SHOT

10.0 ONSITE LABORATORY QUALITY ASSURANCE

Yvonne Booker, Fred Ferate and Raymond Karrenbauer,III

The quality assurance program for radiological and nonradiological analyses ensures that data produced by the Analytical Services Department meets customer and regulatory defined requirements. Data quality is assured through process-based quality assurance, procedure-specific quality assurance, data quality objectives, and performance evaluation programs. The external quality assurance intercomparison program for radiological data quality assurance consists of participation in the Department of Energy (DOE) Quality Assessment Program (QAP) administered by the DOE Environmental Measurements Laboratory (EML); the Nuclear Radiation Assessment and Cross Check Program (NRACC) conducted by the EPA's Environmental Monitoring Systems Laboratory in Las Vegas (EMSL-LV); and the quality assessment program sponsored by the International Reference Center for Radioactivity (IRCR) of the World Health Organization (WHO). The radiological external quality assurance program also consists of participation in several pilot studies including the Mixed Analyte Performance Evaluation Program (MAPEP), being developed by the Radiological and Environmental Sciences Laboratory (RESL), in conjunction with the Laboratory Management Division (EM-563) of the Office of Technology Development; the DOE Laboratory Accreditation Program (DOELAP) Radiobioassay In-Vitro study administered by DOE; the Oak Ridge National Laboratories (ORNL) radiobioassay study conducted by ORNL in Oak Ridge, Tennessee; and the Tritium Enrichment program sponsored by the DOE/EPD. The external quality assurance intercomparison program for nonradiological data quality assurance consists of participation in the National Institute of Occupational Safety and Health (NIOSH) Proficiency Analytical Testing (PAT) Program; the American Industrial Hygiene Association (AIHA) Asbestos Analysts Registry (AAR) Program; the AIHA Bulk Asbestos Analysis Program, National Voluntary Laboratory Accreditation Program (NVLAP) Bulk Asbestos Fiber Analysis Program; the College of American Pathologists (CAP) Analysis of Lead in Blood Program; the Environmental Lead Proficiency Analytical Testing program administered by the American Industrial Hygiene Association; and the state of Nevada water pollution and water supply laboratory performance evaluation programs. Participation in the nonradiological external quality assurance pilot programs include the Mixed Analyte Performance Evaluation Program; and the Round Robin (RR) Analysis program for asbestos administered by Health Science Associates.

10.1 OVERVIEW OF LABORATORY QUALITY ASSURANCE PROGRAM

The Reynolds Electrical & Engineering Co., Inc. (REECo) Analytical Services Department (ASD) implements the requirements of DOE Order 5700.6C, "Quality Assurance" through integrated quality procedures. Table 10.1 lists the ASD quality procedures and the DOE Order 5700.6C criteria they implement.

The ASD uses a two-level approach to the quality assurance of analytical data. The quality of data and results is assured through both process-based and procedure-specific quality assurance.

Procedure-specific quality assurance begins with the development and implementation of standard operating procedures (SOPs) 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 National Institute of Standards and Technology (NIST) or the Environmental Protection Agency (EPA) are required. Quality control samples, e.g. spikes, blanks, and replicates, are included for each analytical procedure. Compliance to analytical procedures is measured through procedure specific assessments or surveillances.

An essential component of process-based quality assurance 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. Data checks are made for internal consistency, proper identification, transmittal errors, calculation errors, and transcription errors. 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 process are documented on data discrepancy reports (DDRs). DDRs are reviewed and compiled quarterly to discern systematic problems.

Process-based quality assurance programs also includes 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 quality assurance program is determined through systematic assessments of analytical activities. Systematic problems are documented and corrective actions tracked through System Deficiency Reports.

10.2 DATA AND MEASUREMENT QUALITY OBJECTIVES

10.2.1 DATA QUALITY OBJECTIVES

Data quality objectives delineate the circumstances under which measurements are made, and define the acceptable variability in the measured data. Data quality objectives describe 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

Table 10.1 Matrix of DOE Order 5700.6C, "Quality Assurance" Criteria vs Analytical Services Department Quality Procedures

DOE Order 5700.6C Criterion	ASD Quality Procedure Number(s)	ASD Quality Procedures
1. Program	AAHzz.B.01.00	ASD Operations Implementing Procedure
	AAHzz.B.02.00	Organization
2. Personnel Training Qualifications	AAHzz.B.03.00	Personnel Training and Qualifications
3. Quality Improvement		REECo Company Quality Improvement Procedures
4. Documents and Records	AAHzz.B.06.00	Documents and Records
5. Work Processes	AAHzz.B.07.00	Verification of Computer Software
	AAHzz.B.08.01	QC Samples and Control Charts
	AAHzz.B.08.02	Data Discrepancies and Corrective Actions
	AAHzz.B.12.01	Sample Traceability
	AAHzz.B.12.02	Standards Traceability
	AAHzz.B.12.03	Operational Check Requirements
	AAHzz.B.12.04	Calibration Requirements
	AAHzz.B.12.05	Reagents Verification
	AAHzz.B.12.06	ASD Analytical Logbooks
	AAHzz.B.12.07	Verification of Pipettes
6. Design	AAHzz.B.10.00	Planning and Scoping
	AAHzz.B.11.00	Design of Data Collection Operations
7. Procurement	AAHzz.B.05.00	Procurement of Services and Items
8. Data Acceptance and Review	AAHzz.B.13.00	Assessment of Data Usability
9. Management Assessment	AAHzz.B.04.00	Management Assessment
10. Independent Assessment	AAHzz.B.14.00	Independent Assessment

calculations will be performed on the measurement data to arrive at the final desired result(s). Associated measurement quality objectives, which define acceptable variability in the measured data, are established to ensure the quality of the measurements.

10.2.1.1 DECISION TO BE MADE

The primary decisions 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) 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 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 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 due to 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).

10.2.1.2 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. Work place and personnel monitoring to determine possible worker exposures is conducted by Health Protection Department (HPD) Industrial Hygienists and Health Physicists.

10.2.1.3 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 using Environmental Protection Agency (EPA) approved methods, such as, EPA Method No. 1311, Toxicity Characteristic Leaching Procedure; EPA Method No. 6010, Inductively Coupled Plasma Analysis for Inorganic Analytes; and EPA Method No. 8270, Analysis of Semivolatile Organic Compounds. Methods and procedures used to measure possible worker exposures to nonradiological hazards are defined by Occupational Safety and

Health Administration (OSHA) or National Institute of Occupational Safety and Health (NIOSH) protocols. Typical contaminants for which HPD 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.

10.2.1.4 SAMPLING LOCATIONS

The locations of routine radiological environmental surveillance sampling on the NTS are described in Chapters 4 and 5 of this Report. Sampling methodologies are described in REECo's Environmental Section SOPs. The locations of nonradiological environmental sampling are determined through site remediation and characterization activities.

10.2.1.5 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. To do this for all potential isotopes, pathways, and locations of interest would require an inordinate number of sampling stations and would be prohibitively expensive. 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.

10.2.1.6 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.

10.2.2 MEASUREMENT QUALITY OBJECTIVES

Measurement quality objectives 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.

10.2.2.1 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. 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 input into the model. An environmental monitoring plan for the NTS (DOE/NV/10630-28, "Environmental Monitoring Plan, Nevada Test Site and Support Facilities") 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, effects of wind and weather, extensive historical meteorological data, geological, hydrological, and topographical data, and locations of human populations.

10.2.2.2 COMPARABILITY

Comparability refers to the degree of confidence and consistency we have in our analytical results. To achieve comparability in measurement data, sample collection and handling, laboratory analyses, and data analysis and validation are performed in accordance with established SOPs. 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 quality assurance measures are used for all analytical processes. REECo ASD laboratories participate in several intercomparison programs where results can be compared with those of the sponsor laboratory and those of other participating laboratories.

10.2.2.3 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 REECo Environmental Section completeness objectives for all samples and analyses have been set at 90 percent for sample collection and 85 percent for analyses.

Completeness for inorganic and organic analyses is based on a comparison to hold time. Hold times are regulatory defined times within which organic and inorganic extractions or analyses must be performed. Hold times are analyte specific, i.e., twenty-four hours for a pH analysis, fourteen days for volatile organic compounds, or six months for inorganic analytes. Sample analyses which are performed outside the regulatory-defined hold times are considered invalid.

10.2.2.4 PRECISION

Precision refers to the degree of agreement in results if the same analysis were to be performed repeatedly on the same sample under the same analytical conditions. 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 Environmental Section 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 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 divided by their mean, expressed as a percent. The smaller the value of the %RSD, the greater is the precision of the measurement. The REECo Environmental Section precision objectives are shown in Table 10.2. They are a function of the concentration of radioactivity in the samples.

Table 10.2 Precision Objectives Expressed as Percents

Analysis	Conc. > 10 MDC	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.

10.2.2.5 ACCURACY

Accuracy refers to how well we can measure the true value of a given quantity. For practical purposes, assessments of accuracy for REECo ASD are done by performing measurements on special quality assurance 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 ASD staff until several months after the measurements are made and the results sent back to the quality assurance laboratory. Additionally, quality control samples with known values are submitted to the Radioanalytical and Analytical Chemistry Laboratories by the ASD Quality Support Group. 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., 100 - % accuracy. The smaller the percent bias, the more accurate are the measurements. Table 10.3 shows the REECo Environmental Section accuracy objectives.

The REECo ASD laboratories participate in several interlaboratory performance evaluation (PE) programs. The ASD Radioanalytical Section participates in the DOE/EML, EPA/EMSL-LV, World Health Organization (WHO), and two bioassay programs, DOELAP and ORNL.

Table 10.3 Accuracy Objectives Expressed as Percent Bias

Analysis	Conc. > 10 MDC	4 MDC ≤ Conc. ≤ 10 MDC
Gross Alpha	±20	±50
Gross Beta	±20	±50
Gamma Spectrometry	±20	±50
Scintillation Counting	±20	±50
X-Spectrometry	±20	±50
Noble Gas Analysis	±30	±60

Note: The accuracy objective for TLDs is 20 percent for exposures < 10 mR and 10 percent for exposures ≥ 10 mR.

The ASD Analytical Chemistry Section participates in the NIOSH PAT, AIHA AAR, CAP, ELPAT, NVLAP, DOELAP, Round Robin, and the state of Nevada water pollution (WP) and water supply (WS) programs. These PE programs provide an independent check of the accuracy of REECo analytical measurements.

10.3 RESULTS FOR COMPLETENESS, PRECISION, AND ACCURACY

10.3.1 COMPLETENESS

The analysis completeness data for calendar year 1993 are shown in Table 10.4. 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 compared to the total analyses expected from the samples scheduled for the year.

10.3.2 PRECISION

From replicate samples collected throughout the year, the %RSD was calculated for several types of analyses and sampling media. The results of these calculations are shown in Table 10.5.

Table 10.4 Analysis Completeness Data for Calendar Year 1993

Analysis	Medium	Completeness,%
Gross Beta	Particulate Air Filter	96.0
Plutonium	Particulate Air Filter	97.4
Gamma Spectrometry	Particulate Air Filter	96.0
Gamma Spectrometry	Charcoal Air Filter	96.0
Tritiated Water	Air	90.8
Krypton-85	Air	70.0
Xenon-133	Air	67.0
Gross Beta	Potable Water Endpoints	99.4
Gamma Spectrometry	Potable Water Endpoints	99.4
Tritiated Water	Potable Water Endpoints	99.4
Plutonium(a)	Potable Water Endpoints	97.2
Gross Beta	Wells, Reservoirs, Springs, Ponds	94.2
Plutonium	Wells, Reservoirs, Springs, Ponds	97.5
Gamma Spectrometry	Wells, Reservoirs, Springs, Ponds	94.2
Tritiated Water	Wells, Reservoirs, Springs, Ponds	94.2
Strontium-90	Wells, Reservoirs, Springs, Ponds	93.0
Gross Alpha	Potable Wells and Endpoints	97.2

(a) Not included in previous ASER

Table 10.5 Precision Estimates from Replicate Sampling

Analysis	Number of Replicate Analyses	Precision Estimate % RSD
Gross Beta in Air	40	22
Tritium in Air	15	19
^{85}Kr in Air	39	32
Gross Alpha in Water	27	61
Gross Beta in Water	50	17
Tritium in Water	50	4.9
TLDs	488	10

10.3.3 ACCURACY

The ASD accuracy objectives were measured through participation in interlaboratory comparison and quality assessment programs in 1993.

10.3.3.1 RADIOLOGICAL PERFORMANCE EVALUATION RESULTS

The external radiological PE program consisted of participation in the QAP conducted by DOE/EML and NRACC conducted by EPA/EMSL-LV. These programs serve to evaluate the performance of the radiological laboratory and identify problems requiring corrective actions.

Summaries of the 1993 results of the interlaboratory comparison and quality assessment programs conducted by the EPA/EMSL-LV and DOE/EML are provided in Tables 10.6 and 10.7. The last column in each table (Ratio of REECo/other organization) is the accuracy of analysis and can be expressed as percent accuracy by multiplying by 100.

10.3.3.2 NONRADIOLOGICAL PERFORMANCE EVALUATION RESULTS

The external nonradiological performance evaluation program consisted of participation in the NIOSH PAT program, CAP Lead in Blood Program, and AIHA AAR program. These programs serve to evaluate the performance of the nonradiological laboratory and identify problems requiring corrective actions.

Summaries of the 1993 results of the interlaboratory comparison and quality assessment programs conducted by the NIOSH PAT, CAP, and AIHA AAR are provided in Tables 10.8, 10.9, and 10.10.

10.3.3.3 CORRECTIVE ACTIONS IMPLEMENTED IN RESPONSE TO PERFORMANCE EVALUATION PROGRAMS

REECo 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. Corrective actions included a new process for preparing and including quality control samples, training of analysts, the use of an internal standard for solvents, and an improved tracking system for performance evaluation samples.

Table 10.6 Results of EPA/EMSL-LV Nuclear Radiation Assessment and Cross Checks - 1993

Analysis/	Water Samples, pCi/L			Ratio of
Date	REECo(a)	EPA/EMSL-LV-(b)	Control Limits(c)	REECo/ EMSL-LV
Gross Alpha				
01/29/93	No Data(d)	34. ± 9.0	18. - 50.	-----
04/20/93	75. ± 2.6	95. ± 24.	53. - 137.	0.79
07/23/93	10. ± 2.3	15. ± 5.0	6.3 - 24.	0.67
10/19/93	34. ± 1.5	40. ± 10.	23. - 57.	0.85
10/29/93	14. ± 1.1	20. ± 5.0	11. - 29.	0.70
Gross Beta				
01/29/93	No Data (d)	44. ± 5.0	35. - 53.	-----
04/20/93	114. ± 16.(e)	177. ± 27.	130. - 224.	0.64
07/23/93	28. ± 6.7(e)	43. ± 6.9	31. - 55.	0.65
10/19/93	45. ± 2.6	58. ± 10.	41. - 75.	0.77
10/29/93	15. ± 1.1	15. ± 5.0	6.0 - 24.	1.00
^{3}H				
06/04/93	9463. ± 374.	9844. ± 984.	8137. - 11551.	0.96
11/05/93	6927. ± 293.	7398. ± 740.	6114. - 8682.	0.94
^{60}Co				
04/20/93	42. ± 2.6	39. ± 5.0	30. - 48.	1.1
06/11/93	17. ± 1.0	15. ± 5.0	6.3 - 24.	1.1
10/19/93	11. ± 1.5	10. ± 5.0	1.3 - 19.	1.1
11/12/93	32. ± 3.8	30. ± 5.0	21. - 39.	1.1
^{65}Zn				
06/11/93	111. ± 3.5	103. ± 10.	86. - 120.	1.1
11/12/93	177. ± 10.(e)	150. ± 15.	124. - 176.	1.2
^{89}Sr				
01/15/93	11. ± 0.58	15. ± 5.0	6.3 - 24.	0.73
04/20/93	31. ± 6.1(e)	41. ± 5.0	32. - 50.	0.76
07/16/93	29. ± 2.1	34. ± 5.0	25. - 43.	0.85
10/19/93	9.7 ± 0.58	15. ± 5.0	6.3 - 24.	0.65
^{90}Sr				
01/15/93	9. ± 1.0	10. ± 5.0	1.3 - 19.	0.90
04/20/93	25. ± 2.9	29. ± 5.0	20. - 38.	0.86
07/16/93	22. ± 0.58	25. ± 5.0	16. - 34.	0.88
10/19/93	11. ± 2.1	10. ± 5.0	1.3 - 19.	1.1
^{106}Ru				
06/11/93	129 ± 42.	119 ± 12.	98. - 140.	1.1
11/12/93	211. ± 17.	201 ± 20.	166. - 236.	1.0

(a) Average value (± 1s) reported by REECo
(b) The known value (± 1s) reported by EPA/EMSL-LV
(c) The control limits determined by EPA/EMSL-LV
(d) No data provided
(e) The value is outside the control limits determined by EPA/EMSL-LV
(f) Outliers

Table 10.6 (Results of EPA/EMSL-LV Nuclear Radiation Assessment and Cross Checks - 1993, cont.)

Analysis/ Date	Water Samples, pCi/L *(cont.)*			Ratio of REECo/ EMSL-LV
	REECo(a)	EPA/EMSL-LV(b)	Control Limits(c)	
^{133}Ba				
06/11/93	105. ± 4.2	99. ± 10.	82. - 116.	1.1
11/12/93	75. ± 3.2	79. ± 8.0	65. - 93.	0.95
^{134}Cs				
04/20/93	26. ± 1.7	27. ± 5.0	18. - 36.	0.96
06/11/93	6.0 ± 1.0	5.0 ± 5.0	0.0 - 14.	1.2
10/19/93	9.7 ± 1.5	12. ± 5.0	3.3 - 21.	0.81
11/12/93	55. ± 0.58	59. ± 5.0	50. - 68.	0.93
^{137}Cs				
04/20/93	35. ± 0.58	32. ± 5.0	23. - 41.	1.1
06/11/93	6.7 ± 1.5	5.0 ± 5.0	0.0 - 14.	1.3
10/19/93	12. ± 1.5	10. ± 5.0	1.3 - 19.	1.2
11/12/93	47. ± 4.2	40. ± 5.0	31. - 49.	1.2
^{226}Ra				
03/05/93	2.4 ± 0.12(f)	9.8 ± 1.5	7.2 - 12.	0.24
04/20/93	No Data (d)	25. ± 3.7	18. - 31.	----
09/17/93	15. ± 3.1	15. ± 2.2	11. - 19.	1.00
10/19/93	14. ± 3.9(e)	9.9 ± 1.5	7.3 - 12.	1.4
^{228}Ra				
03/05/93	4.9 ± 0.21(f)	18. ± 4.6	10. - 26.	0.27
04/20/93	No Data (d)	19. ± 4.8	11. - 27.	----
09/17/93	22. ± 3.4	20. ± 5.1	12. - 29.	1.1
10/19/93	14. ± 1.1	12. ± 3.1	7.1 - 18.	1.2
^{239}Pu				
01/22/93	16. ± 0.60	20. ± 2.0	16. - 23.	0.80
^{131}I				
02/05/93	No Data (d)	100. ± 10.	83. - 117.	----
10/08/93	145. ± 15.(e)	117. ± 12.	96. - 138.	1.2
^{Nat}U				
02/12/93	5.0 ± 0.25	7.6 ± 3.0	2.4 - 13.	0.66
04/20/93	19. ± 5.9(e)	29. ± 3.0	24. - 34.	0.65
08/13/93	25. ± 0.01	25. ± 3.0	20. - 30.	1.0
10/19/93	19. ± 5.3	15. ± 3.0	10. - 20.	1.3

(a) Average value (± 1s) reported by REECo
(b) The known value (± 1s) reported by EPA/EMSL-LV
(c) The control limits determined by EPA/EMSL-LV
(d) No data provided
(e) The value is outside the control limits determined by EPA/EMSL-LV
(f) Outliers

Table 10.6 (Results of EPA/EMSL-LV Nuclear Radiation Assessment and Cross Checks - 1993, cont.)

Analysis/ Date	Air Filters, pCi/Filter			Ratio of REECo/ EMSL-LV
	REECo[a]	EMSL-LV[b]	Control Limits[c]	
Gross Alpha				
08/27/93	20. ± 0.0	19. ± 5.0	10. - 28.	1.0
Gross Beta				
08/27/93	56. ± 1.5	47. ± 5.0	38. - 56.	1.2
^{90}Sr				
08/27/93	16. ± 0.58	19. ± 5.0	10. - 28.	0.84
^{137}Cs				
08/27/93	9.0 ± 1.0	9.0 ± 5.0	0.3 - 18.	1.0

(a) Average value (± 1s) reported by REECo
(b) The known value (± 1s) reported by EPA/EMSL-LV
(c) The control limits determined by EPA/EMSL-LV
(d) No data provided
(e) The value is outside the control limits determined by EPA/EMSL-LV
(f) Outliers

Table 10.7 Results of the DOE/EML Quality Assessment Program - 1993

Analysis/ Date	Air Filters, Bq/Filter			Ratio of REECo/ EML
	REECo[a]	DOE/EML[b]	Mean[c]	
^{7}Be				
03/93	34. ± 24.0%	27. ± 2.0%	27.	1.3 ± 0.31
^{54}Mn				
03/93	16. ± 1.0%	12. ± 2.0%	12.	1.3 ± 0.04
09/93	19. ± 3.0%	15. ± 4.0%	15.	1.3 ± 0.07
^{57}Co				
03/93	3.2 ± 4.0%	2.7 ± 3.0%	2.4	1.2 ± 0.07
09/93	22. ± 3.0%	17. ± 4.0%	15.	1.3 ± 0.07

(a) Average value (± 1s) reported by REECo
(b) The known value (± 1 standard error of the mean [sem]) reported by DOE/EML
(c) The mean value was computed from all reported results, which are in the range of 0.5 to 2.0 times of the DOE/EML known value

Table 10.7 (Results of the DOE/EML Quality Assessment Program - 1993, cont.)

Analysis/ Date	Air Filters, Bq/Filter *(cont.)* REECo[(a)]		DOE/EML[(b)]		Mean[(c)]	Ratio of REECo/ EML	
^{60}Co							
03/93	2.0 ±	1.0%	1.7 ±	6.0%	1.7	1.2 ±	0.08
09/93	25. ±	3.0%	20. ±	4.0%	19.	1.2 ±	0.06
^{90}Sr							
03/93	0.19 ±	4.0%	0.15 ±	7.0%	0.18	1.3 ±	0.10
09/93	0.76 ±	3.0%	0.76 ±	4.0%	0.80	1.0 ±	0.06
^{125}Sb							
09/93	22. ±	6.0%	17. ±	5.0%	17.	1.3 ±	0.11
^{134}Cs							
03/93	2.1 ±	8.0%	2.0 ±	4.0%	2.0	1.0 ±	0.10
09/93	16. ±	15.0%	12. ±	3.0%	12.	1.3 ±	0.21
^{137}Cs							
03/93	4.3 ±	7.0%	3.1 ±	4.0%	3.1	1.4 ±	0.13
09/93	23. ±	6.0%	19. ±	4.0%	18.	1.2 ±	0.09
^{144}Ce							
03/93	22. ±	4.0%	19. ±	2.0%	16.	1.2 ±	0.06
09/93	60. ±	3.0%	40. ±	4.0%	34.	1.5 ±	0.08
^{238}Pu							
03/93	0.022 ±	52.0%	0.036 ±	4.0%	0.034	0.61 ±	0.32
09/93	0.107 ±	6.0%	0.129 ±	3.0%	0.122	0.83 ±	0.06
^{239}Pu							
03/93	0.021 ±	9.0%	0.023 ±	7.0%	0.023	0.91 ±	0.10
09/93	0.080 ±	5.0%	0.080 ±	3.0%	0.080	1.0 ±	0.06
^{234}U							
09/93	0.067 ±	3.0%	0.065 ±	4.0%	0.064	1.0 ±	0.06
^{238}U							
09/93	0.066 ±	5.0%	0.065 ±	7.0%	0.065	1.0 ±	0.10

(a) Average value (± 1s) reported by REECo
(b) The known value (± 1 standard error of the mean [sem]) reported by DOE/EML
(c) The mean value was computed from all reported results, which are in the range of 0.5 to 2.0 times of the DOE/EML known value

Table 10.7 (Results of the DOE/EML Quality Assessment Program - 1993, cont.)

Analysis/ Date	Soil Samples, Bq/kg			Ratio of REECo/ EML
	REECo[(a)]	DOE/EML[(b)]	Mean[(c)]	
^{40}K				
03/93	247. ± 1.0%	321. ± 4.0%	330.	0.77 ± 0.04
09/93	41. ± 3.0%	29. ± 7.0%	30.	1.41 ± 0.11
^{90}Sr				
09/93	7.6 ± 19.0%	5.4 ± 4.0%	5.3	1.41 ± 0.28
^{137}Cs				
03/93	748 ± 0.0%	923 ± 1.0%	998	0.81 ± 0.02
09/93	13. ± 4.0%	11. ± 2.0%	12.	1.18 ± 0.06
^{239}Pu				
03/93	8.1 ± 8.0%	12. ± 7.0%	11.	0.70 ± 0.08
09/93	2.0 ± 16.0%	1.5 ± 21.0%	1.6	1.3 ± 0.36
^{234}U				
09/93	22. ± 47.0%	25. ± 3.0%	18.	0.88 ± 0.42
^{238}U				
09/93	22. ± 43.0%	25. ± 4.0%	19.	0.88 ± 0.38
	Vegetation Samples, Bq/kg			
^{40}K				
09/93	914. ± 3.0%	842. ± 3.0%	958.	1.1 ± 0.05
^{90}Sr				
03/93	258. ± 16.0%	237. ± 15.0%	220.	1.1 ± 0.25
^{137}Cs				
03/93	33. ± 18.0%	25. ± 4.0%	27.	1.3 ± 0.25
09/93	99. ± 3.0%	89. ± 2.0%	96.	1.1 ± 0.05
^{238}Pu				
03/93	0.559 ± 59.0%	1.14 ± 50.0%	1.2	0.50 ± 0.38
^{239}Pu				
03/93	0.404 ± 50.0%	0.323 ± 5.0%	0.35	1.2 ± 0.63
^{60}Co				
09/93	9.3 ± 3.0%	6.4 ± 2.0%	7.1	1.4 ± 0.06

(a) Average value (± 1s) reported by REECo
(b) The known value (± 1 standard error of the mean [sem]) reported by DOE/EML
(c) The mean value was computed from all reported results, which are in the range of 0.5 to 2.0 times of the DOE/EML known value

Table 10.7 (Results of the DOE/EML Quality Assessment Program - 1993, cont.)

Analysis/ Date	Water Samples, Bq/kg			Ratio of REECo/ EML
	REECo[a]	DOE/EML[b]	Mean[c]	
^{3}H				
03/93	107. ± 8.0%	97. ± 3.0%	96.	1.1 ± 0.10
09/93	258. ± 1.0%	170. ± 4.0%	206.	1.5 ± 0.07
^{54}Mn				
03/93	110. ± 2.0%	105. ± 0.0%	110.	1.1 ± 0.03
09/93	118. ± 3.0%	109. ± 1.0%	116.	1.1 ± 0.04
^{60}Co				
03/93	48. ± 2.0%	45. ± 2.0%	48.	1.1 ± 0.04
09/93	109. ± 3.0%	100. ± 0.0%	105.	1.1 ± 0.04
^{90}Sr				
03/93	1.3 ± 15.0%	1.0 ± 9.0%	1.2	1.3 ± 0.23
09/93	2.3 ± 9.0%	2.5 ± 3.0%	2.6	0.92 ± 0.09
^{134}Cs				
03/93	45. ± 2.0%	42. ± 4.0%	46.	1.1 ± 0.05
09/93	58. ± 3.0%	56. ± 0.0%	59.	1.0 ± 0.04
^{137}Cs				
03/93	56. ± 3.0%	51. ± 1.0%	55.	1.1 ± 0.04
09/93	82. ± 3.0%	75. ± 1.0%	80.	1.1 ± 0.04
^{144}Ce				
03/93	93. ± 6.0%	84. ± 1.0%	87.	1.1 ± 0.08
09/93	181. ± 3.0%	173. ± 0.0%	178.	1.0 ± 0.04
^{238}Pu				
03/93	0.415 ± 4.0%	0.494 ± 3.0%	0.505	0.84 ± 0.05
09/93	1.0 ± 5.0%	1.1 ± 0.0%	1.1	0.91 ± 0.05
^{239}Pu				
03/93	0.756 ± 2.0%	0.828 ± 3.0%	0.845	0.91 ± 0.04
09/93	0.308 ± 5.0%	0.338 ± 5.0%	0.331	0.91 ± 0.07
^{234}U				
09/93	1.3 ± 20.0%	1.1 ± 5.0%	1.0	1.2 ± 0.26
^{238}U				
09/93	1.2 ± 12.0%	1.1 ± 2.0%	1.0	1.1 ± 0.14

(a) Average value (± 1s) reported by REECo
(b) The known value (± 1 standard error of the mean [sem]) reported by DOE/EML
(c) The mean value was computed from all reported results, which are in the range of 0.5 to 2.0 times of the DOE/EML known value

Table 10.8 NIOSH PAT Program Interlaboratory Comparison - 1993

Analysis and Date	REECo Result	Reference Value(a)	Ratio(b)	Performance Limits(a)
Cd (in mg)				
02/25/93	0.0055	0.0059	0.93	0.0050 - 0.0068
	0.0083	0.0088	0.94	0.0077 - 0.0099
	0.0175	0.0186	0.94	0.0164 - 0.0207
	0.0119	0.0128	0.93	0.0114 - 0.0143
05/21/93	0.0113	0.0118	0.96	0.0100 - 0.0135
	0.0047	0.0049	0.96	0.0042 - 0.0056
	0.0077	0.0079	0.97	0.0069 - 0.0089
	0.0165	0.0166	0.99	0.0144 - 0.0187
08/19/93	0.0082	0.0088	0.93	0.0076 - 0.0100
	0.0150	0.0156	0.96	0.0137 - 0.0175
	0.0152	0.0167	0.91	0.0146 - 0.0187
	0.0063	0.0068	0.93	0.0060 - 0.0077
11/18/93	0.0160	0.0177	0.90	0.0156 - 0.0198
	0.0102	0.0108	0.94	0.0097 - 0.0119
	0.0064	0.0069	0.93	0.0060 - 0.0078
	0.0129	0.0137	0.94	0.0119 - 0.0155
Cr (in mg)				
02/25/93	0.0855	0.0868	0.98	0.0699 - 0.1037
	0.1197	0.1208	0.99	0.0936 - 0.1479
	0.2110	0.2161	0.98	0.1805 - 0.2517
	0.1433	0.1472	0.97	0.1175 - 0.1769
08/19/93	0.2106	0.2094	1.00	0.1736 - 0.2452
	0.1189	0.1177	1.01	0.0981 - 0.1373
	0.0530	0.0543	0.98	0.0456 - 0.0629
	0.0924	0.0936	0.99	0.0768 - 0.1103
Pb (in mg)				
02/25/93	0.0722	0.0761	0.95	0.0661 - 0.0861
	0.0291	0.0316	0.92	0.0270 - 0.0363
	0.0539	0.0580	0.93	0.0500 - 0.0661
	0.0218	0.0235	0.93	0.0201 - 0.0269
05/21/93	0.0807	0.0861	0.94	0.0753 - 0.0969
	0.0417	0.0443	0.94	0.0391 - 0.0494
	0.0214	0.0222	0.96	0.0189 - 0.0255
	0.0491	0.0511	0.96	0.0459 - 0.0563
08/19/93	0.0298	0.0314	0.95	0.0274 - 0.0354
	0.0506	0.0525	0.96	0.0467 - 0.0584
	0.0880	0.0936	0.94	0.0822 - 0.1050
	0.0692	0.0735	0.94	0.0635 - 0.0834
11/18/93	0.0187	0.0214	0.87	0.0178 - 0.0250
	0.0856	0.0931	0.92	0.0816 - 0.1045
	0.0256	0.0281	0.91	0.0243 - 0.0318
	0.0624	0.0676	0.92	0.0586 - 0.0767

(a) Value provided by the NIOSH PAT Program
(b) Ratio = REECo Result/Reference Value
(c) Solvent abbreviations: CTC=Carbon Tetrachloride, DCE=1,2 Dichloroethane, MCM=1,1,1-Trichloroethane, PCE=Tetrachloroethylene, OXY=o-Xylene, TCE=Trichloroethylene, CFM=Chloroform, BNZ=Benzene, TOL=Toluene

Table 10.8 (NIOSH PAT Program Interlaboratory Comparison - 1993, cont.)

Analysis and Date	REECo Result	Reference Value[a]	Ratio[b]	Performance Limits[a]
Zn (in mg)				
05/21/93	0.0729	0.0765	0.95	0.0604 - 0.0925
	0.1245	0.1263	0.98	0.1127 - 0.1399
	0.1689	0.1703	0.99	0.1499 - 0.1906
	0.0965	0.0960	1.00	0.0847 - 0.1074
11/19/93	0.1277	0.1407	0.91	0.1224 - 0.1590
	0.0798	0.0849	0.94	0.0732 - 0.0967
	0.0588	0.0628	0.94	0.0542 - 0.0714
	0.1656	0.1753	0.94	0.1493 - 0.2013
Silica (in mg)				
02/25/93	0.0880	0.0841	1.05	0.0209 - 0.1473
	0.0700	0.0712	0.98	0.0219 - 0.1205
	0.1301	0.1267	1.03	0.0339 - 0.2195
	0.1104	0.1075	1.03	0.0425 - 0.1724
05/21/93	0.0339	0.0899	0.38	0.0284 - 0.1513
	0.0480	0.0766	0.63	0.0232 - 0.1301
	0.1221	0.1025	1.19	0.0361 - 0.1688
	0.1789	0.1609	1.11	0.0479 - 0.2739
08/19/93	0.0219	0.0545	0.40	0.0059 - 0.1150
	0.1038	0.1183	0.88	0.0230 - 0.2135
	0.0839	0.0935	0.90	0.0382 - 0.1487
	0.1156	0.1145	1.01	0.0376 - 0.1914
11/18/93	0.1265	0.1257	1.01	0.0362 - 0.2152
	0.0520	0.0653	0.80	0.0080 - 0.1226
	0.0733	0.0756	0.97	0.0175 - 0.1337
	0.0602	0.0822	0.73	0.0284 - 0.1360
Asbestos (in fibers/mm^2)				
02/25/93	374	293	1.28	163 - 461
	429	333	1.29	172 - 546
	1110	894	1.24	547 - 1326
	844	708	1.19	387 - 1126
05/21/93	728	551	1.32	201.8 - 1070.7
	365	253	1.44	94.3 - 488.2
	234	193	1.21	69.8 - 378.1
	561	489	1.15	177.4 - 954
08/19/93	248	245	1.01	115 - 423.4
	1231	957	1.29	589.1 - 1415
	490	446	1.10	243.7 - 708.5
	689	548	1.26	323.6 - 830.1
11/18/93	726	532	1.36	236.9 - 944.8
	674	515	1.31	222.6 - 927
	272	217	1.25	87.7 - 404.1
	389	260	1.50	99.1 - 496.9
		Solvents[c]		
MCM (in mg)				
02/25/93	0.4707	0.4426	1.06	0.3866 - 0.4987
	0.9727	0.9198	1.06	0.8200 - 1.0195
	0.9137	0.8742	1.04	0.7864 - 0.9620
	1.3490	1.3010	1.04	1.1449 - 1.4570

(a) Value provided by the NIOSH PAT Program

(b) Ratio = REECo Result/Reference Value

(c) Solvent abbreviations: CTC=Carbon Tetrachloride, DCE=1,2 Dichloroethane, MCM=1,1,1-Trichloroethane, PCE=Tetrachloroethylene, OXY=o-Xylene, TCE=Trichloroethylene, CFM=Chloroform, BNZ=Benzene, TOL=Toluene

Table 10.8 (NIOSH PAT Program Interlaboratory Comparison - 1993, cont.)

Solvents[c] *(cont.)*

Analysis and Date	REECo Result	Reference Value[a]	Ratio[b]	Performance Limits[a]
PCE (in mg)				
02/25/93	1.0097	0.9711	1.04	0.8408 - 1.1014
	0.8427	0.8100	1.04	0.7145 - 0.9055
	1.2507	1.2159	1.03	1.0605 - 1.3713
	0.5690	0.5572	1.02	0.4856 - 0.6289
TCE (in mg)				
02/25/93	0.5290	0.5182	1.02	0.4630 - 0.5733
	0.9517	0.9277	1.02	0.8345 - 1.0209
	1.1833	1.1666	1.01	1.0592 - 1.2739
	1.3720	1.3559	1.01	1.2254 - 1.4864
11/18/93	1.4265	1.3881	1.03	1.2014 - 1.5748
	1.1380	1.1161	1.02	0.9543 - 1.2779
	0.6110	0.6049	1.01	0.5078 - 0.7021
	0.9290	0.9124	1.02	0.7963 - 1.0285
CFM (in mg)				
05/21/93	0.8818	0.8613	1.02	0.7422 - 0.9804
	1.4038	1.3682	1.03	1.1671 - 1.5693
	1.0240	0.9853	1.04	0.8385 - 1.1321
	0.4880	0.4776	1.02	0.3954 - 0.5598
CTC (in mg)				
05/21/93	0.9530	0.9549	1.00	0.8236 - 1.0862
	0.5085	0.5135	0.99	0.4300 - 0.5969
	1.4214	1.3766	1.03	1.1805 - 1.5728
	1.6787	1.6350	1.03	1.4163 - 1.8537
11/18/93	0.9280	0.8860	1.05	0.7638 - 1.0083
	0.6590	0.6013	1.09	0.5150 - 0.6877
	1.7750	1.7813	1.00	1.5631 - 1.9996
	1.1845	1.1986	0.99	1.0795 - 1.3178
DCE (in mg)				
05/21/93	1.4755	1.4336	1.03	1.2870 - 1.5802
	0.9399	0.9111	1.03	0.8222 - 1.0001
	1.1111	1.0610	1.05	0.9475 - 1.1745
	0.5696	0.5507	1.03	0.4952 - 0.6062
11/18/93	1.0270	1.0188	1.01	0.8604 - 1.1773
	1.6000	1.5863	1.01	1.4148 - 1.7577
	1.3685	1.3786	0.99	1.2005 - 1.5566
	0.7080	0.7085	1.00	0.6150 - 0.8021
BNZ (in mg)				
08/19/93	0.4355	0.4295	1.01	0.3902 - 0.4687
	0.2235	0.2181	1.02	0.1951 - 0.2411
	0.1015	0.0938	1.08	0.0786 - 0.1090
	0.3590	0.3574	1.00	0.3208 - 0.3940
OXY (in mg)				
08/19/92	1.9515	1.9439	1.00	1.6655 - 2.2222
	0.6331	0.6207	1.02	0.5437 - 0.6977
	1.3675	1.3459	1.02	1.1801 - 1.5116
	1.1040	1.1074	1.00	0.9473 - 1.2675
TOL (in mg)				
08/19/93	0.5810	0.5816	1.00	0.5148 - 0.6483
	1.7055	1.7180	0.99	1.5319 - 1.9041
	1.0800	1.0811	1.00	0.9813 - 1.1809
	0.8660	0.8841	0.98	0.7830 - 0.9852

(a) Value provided by the NIOSH PAT Program
(b) Ratio = REECo Result/Reference Value
(c) Solvent abbreviations: CTC=Carbon Tetrachloride, DCE=1,2 Dichloroethane, MCM=1,1,1-Trichloroethane, PCE=Tetrachloroethylene, OXY=o-Xylene, TCE=Trichloroethylene, CFM=Chloroform, BNZ=Benzene, TOL=Toluene

Table 10.9 CAP Program Interlaboratory Comparison - 1993

Analysis and Date	REECo Result	Reference Value(a)	Ratio(b)	Performance Limits(a)
Blood Pb (in µg/dL)				
01/22/93	33.6	30.53	1.10	Not Reported
	21.4	19.34	1.11	15.3 - 23.4
	14.4	9.78	1.47(c)	5.7 - 13.8
	25.4	19.35	1.31	Not Reported
	12.2	9.53	1.28	5.5 - 13.6
04/03/93	43.8	42.87	1.02	Not Reported
	50.0	48.84	1.02	Not Reported
	33.0	31.26	1.05	Not Reported
	9.2	10.46	0.88	6.4 - 14.5
	20.8	19.91	1.04	Not Reported
08/18/93	12.2	15.13	0.81	11.1 - 19.2
	93.4	107.64	0.87	Not Reported
	15.0	15.42	0.97	11.4 - 19.5
	.8	1.17	0.68	0.0 - 5.2
	19.4	19.45	1.00	Not Reported
12/18/93	27.7	23.35	1.19	Not Reported
	72.8	58.05	1.25	Not Reported
	20.5	16.08	1.27(c)	12.0 - 20.1
	10.2	4.95	2.06(c)	0.9 - 9.0
	37.7	26.18	1.44	Not Reported

(a) Value provided by the CAP Blood Lead Survey Program
(b) Ratio = REECo Result/Reference value
(c) Outlier

Table 10.10 AAR Program Interlaboratory Comparison - 1993

Analysis and Date	REECo Result(a)	Reference Value(b)	Ratio(c)	Performance Limits(b)
Quantitative Asbestos (in fibers/mm^2)				
01/21/93	206	318	0.65	159 - 636
	399	318	1.25	159 - 636
	388	318	1.22	159 - 636
	432	430	1.00	215 - 861
	484	430	1.12	215 - 861
	531	430	1.23	215 - 861
	196	168	1.17	84 - 337
	204	168	1.21	84 - 337
	367	168	2.18(d)	84 - 337
	372	470	0.79	235 - 941
	556	470	1.18	235 - 941
	500	470	1.06	235 - 941
04/19/93	477	486	0.98	243 - 972
	700	486	1.44	243 - 972
	799	486	1.64	243 - 972
	120	175	0.68	88 - 351

(a) Individual analyst results reported by REECo
(b) Value(s) provided by AAR
(c) Ratio = REECo Result/Reference Value
(d) Outlier

Table 10.10 (AAR Program Interlaboratory Comparison - 1993, cont.)

Analysis and Date	REECo Result	Reference Value(a)	Ratio(b)	Performance Limits(a)
		Quantitative Asbestos, fibers/mm^2 *(cont.)*		
04/19/93	196	175	1.12	88 - 351
	177	175	1.01	88 - 351
	387	371	1.04	185 - 741
	529	371	1.42	185 - 741
	466	371	1.26	185 - 741
	392	308	1.27	154 - 616
	489	308	1.59	154 - 616
	435	308	1.41	154 - 616
07/19/93	251	378	0.66	189 - 756
	396	378	1.05	189 - 756
	364	378	0.96	189 - 756
	417	352	1.18	176 - 703
	408	352	1.16	176 - 703
	364	352	1.03	176 - 703
	481	434	1.11	217 - 867
	555	434	1.28	217 - 867
	637	434	1.47	217 - 867
	233	203	1.15	101 - 406
	251	203	1.24	101 - 406
	314	203	1.55	101 - 406
10/22/93	263	186	1.41	93 - 372
	197	186	1.06	93 - 372
	400	371	1.08	185 - 741
	295	371	0.79	185 - 741
	828	623	1.33	311 - 1245
	862	623	1.38	311 - 1245
	554	555	1.00	278 - 1111
	546	555	0.98	278 - 1111

(a) Individual analyst results reported by REECo
(b) Value(s) provided by AAR
(c) Ratio = REECo Result/Reference Value
(d) Outlier

11.0 OFFSITE LABORATORY QUALITY ASSURANCE

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The policy of the U.S. Environmental Protection Agency (EPA) requires participation in a centrally managed quality assurance (QA) program by all EPA organizational units involved in environmental data collection. The QA program developed by the Nuclear Radiation Assessment Division (NRD) of the Environmental Monitoring Systems Laboratory, Las Vegas (EMSL-LV) for the Offsite Radiological Safety Program (ORSP) meets all requirements of EPA policy, and also includes applicable elements of the Department of Energy (DOE) QA requirements and regulations. The ORSP QA program defines data quality objectives (DQOs), which are statements of the quality of data a decision maker needs to ensure that a decision based on that data is defensible. Achieved data quality may then be evaluated against these DQOs. This chapter describes the DQOs and the achieved data quality for the ORSP in 1993.

11.1 POLICY

One of the major goals of the U.S. Environmental Protection Agency (EPA) is to ensure that all EPA decisions which are dependent on environmental data are supported by data of known quality. Agency policy initiated by the Administrator in memoranda of May 30, 1979, and June 14, 1979, requires participation in a centrally managed Quality Assurance (QA) Program by all EPA Laboratories, Program Offices, Regional Offices, and those monitoring and measurement efforts supported or mandated through contracts, regulations, or other formalized agreements. Further, by EPA Order 5360.1, Agency policy requires participation in a QA Program by all EPA organizational units involved in environmental data collection.

The QA policies and requirements of EPA's Environmental Monitoring Systems Laboratory in Las Vegas (EMSL-LV) are summarized in the *Quality Management Plan* (EPA, 1993a). Policies and requirements specific to the Offsite Radiological Safety Program (ORSP) are documented in the *Quality Assurance Program Plan for the Nuclear Radiation Assessment Division Offsite Radiation Safety Program* (EPA, 1992a). The requirements of these documents establish a framework for consistency in the continuing application of quality assurance 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 (SOP). It is NRD policy that achievement of quality measurements is of the highest priority in the conduct of the ORSP and that quality is the responsibility of all personnel. All personnel are required to adhere to the requirements of the QA Plan and of all SOPs applicable to their duties to ensure that all environmental radiation monitoring data collected by EPA EMSL-LV in support of the ORSP are of adequate quality and properly documented for use by DOE, EPA, and other interested parties.

11.2 DATA QUALITY OBJECTIVES

Data quality objectives (DQOs) are statements of the quality of data a decision maker needs to ensure that a decision based on that data is defensible. Data quality objectives are defined in terms of representativeness, comparability, completeness, precision, and accuracy. Representativeness and comparability are generally qualitative assessments while completeness, precision, and accuracy may be quantitatively assessed. In the ORSP, representativeness, comparability, and completeness objectives are defined for each monitoring network. Precision and accuracy are defined for each analysis type or radionuclide.

Achieved data quality is monitored continuously through internal QC checks and procedures. In addition to the internal quality control procedures, NRD participates in intercomparison programs. One such intercomparison program is managed and operated by a group within EPA EMSL-LV. These external performance audits are conducted as described in and according to the schedule contained in "Environmental Radioactivity Laboratory Intercomparison Studies Program" (EPA 1992a). The analytical laboratory also participates in the DOE Environmental Measurements Laboratory (EML) Quality Assurance Program in which real or synthetic environmental samples that have been prepared and thoroughly analyzed are distributed to participating laboratories. Periodically (every two or three years) external systems and performance audits are conducted for the TLD network as part of the certification requirements for DOE's Laboratory Accreditation Program (DOELAP).

11.2.1 REPRESENTATIVENESS, COMPARABILITY, AND COMPLETENESS OBJECTIVES

Representativeness is defined as "the degree to which the data accurately and precisely represent a characteristic of a parameter, variation of a property, a process characteristic, or an operation condition" (Stanley and Verner, 1985). In the ORSP, representativeness may be considered to be the degree to which the collected samples represent the radionuclide activity concentrations in the offsite environment. Collection of samples from all media which are possible pathways to human exposure as well as direct measurement of offsite resident exposure through the TLD and internal dosimetry monitoring programs provides assurance of the representativeness of the calculated exposures.

Comparability is defined as "the confidence with which one data set can be compared to another" (Stanley and Verner, 1985). Comparability of data is assured by use of SOPs for sample collection, handling, and analysis; use of standard reporting units; and use of standardized procedures for data analysis and interpretation. In addition, comparability is attained through comparison of external performance audit results to those achieved by other participating laboratories. Use of SOPs, maintained under a document control system, is an important component of comparability, ensuring that all personnel conform to a unified set of procedures.

Completeness is defined as "a measure of the amount of data collected from a measurement process compared to the amount that was expected to be obtained under the conditions of measurement" (Stanley and Verner, 1985). Data may be lost due to instrument malfunction, sample destruction, loss in shipping or analysis, analytical error, or unavailability of samples. Additional data values may be deleted due to unacceptable precision, accuracy, or detection limit or as the result of application of statistical outlier tests. The completeness objective for all networks except the LTHMP is 90 percent. The completeness objective for the LTHMP is 80 percent.

11.2.2 PRECISION AND ACCURACY OBJECTIVES OF RADIOANALYSES

Precision is defined as "the degree of mutual agreement characteristic of independent measurements as the result of repeated application of the process under specified conditions" (Taylor, 1987). In the ORSP, total system precision is estimated from analytical results for field duplicates or, where collection of field duplicates is impractical, from sample splits. Results of repeated analyses of QC samples provide an estimate of laboratory or instrument precision.

Accuracy is defined as "the degree of agreement of a measured value with the true or expected value of the quantity of concern" (Taylor, 1987). Intercomparison study performance audit samples and matrix spike samples are used to estimate accuracy in the ORSP. Objectives for both precision and accuracy are given below.

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. Precision to a 95 percent confidence interval, monitored through analysis of duplicate samples, must be within ± 10 percent for activities greater than ten times the minimum detectable concentration (MDC) and ± 30 percent for activities greater than the MDC but less than ten times the MDC. There are no precision requirements for activity concentrations below the MDC, which by definition, cannot be distinguished from background at the 95 percent confidence interval. 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.

At concentrations greater than ten times the MDC, precision is required to be within ± 10 percent for:

- Conventional Tritium Analyses
- Uranium
- Thorium (all media)
- Strontium (in milk)

and within ± 20 percent for:

- Enriched Tritium Analyses
- Strontium (except in milk)
- Noble Gases
- Plutonium

At concentrations less than ten times the MDC, both precision and accuracy are expressed in absolute units, not to exceed 30 percent of the MDC for all analyses and all media types.

11.2.3 QUALITY OF EXPOSURE ESTIMATES

The allowable uncertainty of the effective dose equivalent (EDE) to any human receptor is ± 0.1 mrem annually. This objective is based solely upon the precision and accuracy of the data produced from the surveillance networks and does not apply to uncertainties in the model used, effluent release data received from DOE, or dose conversion factors. Generally, EDEs must have an accuracy (bias) of no greater than 50 percent for annual exposures ≥1 mrem but <5 mrem and no greater than 10 percent for annual exposures greater than or equal to 5 mrem. See Chapter 6, Sec. 6.7 for a discussion of 1993 data.

11.3 DATA VALIDATION

Data validation is defined as "A systematic process for reviewing a body of data against a set of criteria to provide assurance that the data are adequate for their intended use. Data validation consists of data editing, screening, checking, auditing, verification, certification, and review" (Stanley et al, 1983). Data validation procedures are documented in SOPs. All data are reviewed and checked at various steps in the collection, analysis, and reporting processes.

The first level of data review consists of sample tracking; e.g., that all samples planned to be collected are collected or reasons for non-collection are documented, that all collected samples are delivered to Sample Control and are entered into the appropriate data base management system, and that all entered information is accurate. Next, analytical data are reviewed by the analyst and by the laboratory supervisor. Checks at this stage include verifying that all samples received from Sample Control have been analyzed or reasons for non-analysis have been documented, that data are "reasonable" (e.g., within expected range), and that instrumentation operational checks indicate the analysis instrument is within permissible tolerances. Discrepancies indicating collection instrument malfunction are reported to the Monitoring and Assessment Branch. Analytical discrepancies are resolved; individual samples or sample batches may be reanalyzed if required.

Raw data are reviewed by a designated media expert. A number of checks are made at this level, including:

- Completeness - all samples scheduled to be collected have, in fact, been collected and analyzed or the data base contains documentation explaining the reasons for non-collection or non-analysis.

- Transcription errors - checks are made of all manually entered information to ensure that the information contained in the data base is accurate.

- Quality control data - field and analytical duplicate, audit sample, and matrix blank data are checked to ensure the collection and analytical processes are within specified QC tolerances.

- Analysis schedules - lists of samples awaiting analysis are generated and checked against normal analysis schedules to identify backlogs in analysis or data entry.

- Anomalous results - sample results and diagnostic graphics of sample results are reviewed for reasonableness; conditions indicative of instrument malfunction are reported to Field and/or Laboratory Operations.

Once the data have been finalized, they are compared to the DQOs. Completeness, accuracy, and precision statistics are calculated. The achieved quality of the data is reported annually, at a minimum. If data fail to meet one or more of the established DQOs, 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. Only specified personnel have change access; others have read access only.

All sample results exceeding the traditional natural background activity range are investigated. If data are found to be associated with a non-environmental condition, such as 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 (for example, higher-than-normal activities were observed for several radionuclides following the Chernobyl accident). When activities exceeding the expected range are observed for one network, the data for the other networks at the same location are checked. For example, higher-than-normal-range PIC values are compared to data obtained by the air, noble gas, TLD, and tritium-in-air samplers at the same location.

Data are also compared to previous years' data for the same location using trend analysis techniques. Other statistical procedures may be employed as warranted to permit interpretation of current data as compared to past data. Future trends may also be predicted. Trend analysis is made possible due to the length of the sampling history which, in some cases, is 30 years or longer.

Data from the offsite networks are used, along with NTS source emission estimates prepared by DOE, to calculate or estimate annual committed effective dose equivalents to offsite residents. Surveillance network data are the primary tools for the dose calculations. Additionally, CAP88-PC is used with local meteorological data to predict doses to offsite residents from NTS source term estimates. An assessment of the uncertainty of the dose estimate is made, based on analytical uncertainty, and reported with the estimate.

11.4 QUALITY ASSESSMENT OF 1993 DATA

Data quality assessment is associated with the regular QA and QC practices within the radioanalytical laboratory. The analytical quality control plan, documented in SOPs, describes specific procedures used to demonstrate that data are within prescribed requirements for accuracy and precision. Duplicate samples are collected or prepared and analyzed in the exact manner as the regular samples for that particular type of analysis. Data obtained from duplicate analyses are used for determining the degree of precision for each individual analysis. Accuracy is assessed by comparison of data from spiked samples with the "true" or accepted values. Spiked samples are either in-house laboratory blanks spiked with known amounts of radionuclides or performance audit samples prepared by other organizations in which data are compared among multiple laboratories.

On an annual basis, achieved data quality statistics are compiled. This data quality assessment is performed as part of the process of data validation, described in Section 11.3. The following subsections describe the achieved data quality for 1993.

11.4.1 COMPLETENESS

Completeness is calculated as:

$$\%C = \left(\frac{V}{n}\right)100$$

where
%C = percent completeness
V = number of measurements judged valid
n = total number of measurements

The percent completeness of the 1993 data is given in Table 11.1. Reasons for sample loss include instrument malfunction, inability to gain site access, monitoring technician error, or laboratory error. Completeness is not applicable to the Internal Dosimetry Network, as all individuals who request a whole body or lung count receive a valid one, resulting in a completeness of 100 percent, by definition.

The achieved completeness of over 93 percent for the LTHMP exceeds the DQO of 80 percent. If the wells shut down by DOE were included, the completeness becomes 85 percent overall but only 75 percent for onsite wells.

Overall completeness for the routine air surveillance network was greater than 97 percent, exceeding the DQO of 90 percent. Individually, all stations exceeded 95 percent data recovery and 4 stations achieved completeness of 100 percent. Plutonium analyses, conducted on composited filters from selected routine and standby air stations, were over 97 percent complete, exceeding the DQO of 90 percent.

Overall, the noble gas network met the DQO of 90 percent completeness. On an individual station basis, data recovery was over 90 percent for nine routine sampling locations, and greater than 79 percent for another four routine sampling locations. The achieved completeness for the atmospheric moisture network was 88 percent, slightly below the DQO of 90 percent.

Overall data recovery for the routine milk network was less than the DQO of 90 percent. Many of the milk sampling locations consist of family-owned cows or goats and can provide milk only when the animal is lactating. Seventy-five percent of the total possible number of samples were collected from six ranches: Dahl (Alamo, Nevada), Lemon (Dyer, Nevada), John Deer (Amargosa Valley, Nevada), Frayne (Goldfield, Nevada), Brown (Benton, California), and Blue Eagle (Currant, Nevada). Annual means for these locations individually cannot be considered to be representative of the year. However, the milkshed may be adequately represented because an alternate location in the area was sampled when the primary station could not supply milk.

All of the animals scheduled for collection in the Animal Investigation Program (AIP) were collected, with the exception of a mule deer from the NTS in the fourth quarter. No deer were found that could be collected on two separate hunting trips. Overall completeness exceeded the DQO of 90 percent.

The achieved completeness of 98 percent for the PIC network exceeds the DQO of 90 percent. The redundant data systems used in the PIC network (i.e., satellite telemetry, magnetic tape or card data acquisition systems, and strip charts) are responsible for the high rates of recovery. Gaps in the satellite transmissions are filled by data from the magnetic tape or card media.

Table 11.1 Data Completeness of Offsite Radiological Safety Program Networks[(a)]

Network	Number of Sampling Locations	Total Samples Possible	Valid Samples Collected	Percent Completeness
LTHMP[(b)]	271	479	447	93.3
Air Surveillance	30	10,950 days[(c)]	10,666	97.4
	17 ($^{238,\ 239+240}Pu$)[(d)]	75	73	97.3
Noble Gas	13[(e)]	676	613	90.7
Atmospheric Moisture	21[(f)]	756	665	88.0
Milk Surveillance	24	304	228	75.0
Animal Investigation	[(g)]	101	92	91.1
PIC	27[(h)]	52 (weeks)	1370	98.0

(a) The Data Quality Objectives (DQO) for completeness for monitoring networks summarized in this table are 90 percent.

(b) Does not include wells which were shut down by DOE for part or all of the year (see Section 9.5.2), nor unoccupied residences in Mississippi (see Section 9.6.7).

(c) Continuous samplers with samples collected at intervals of approximately one week. Days used as units to account for differences in sample interval length.

(d) Includes three quarters (January 1993 through September 1993) of data for 13 standby network locations and 4 routine sampling locations.

(e) Thirteen stations are operated on a routine basis and another eight are operated 1 week per quarter.

(f) Fourteen stations are operated on a routine basis and another seven are operated 1 week per quarter.

(g) Includes 4 mule deer (3 from the Nevada Test Site and 1 from offsite) and 8 cows (4 from each of two locations). Does not include bighorn sheep, fruits and vegetables, and other animals which are "samples of opportunity."

(h) Continuous samplers with data summarized on a weekly basis.

11.4.2 PRECISION

Precision is monitored through analysis of duplicate samples. Field duplicates (e.g., a second sample collected at the same place and time and under the same conditions as the routine sample) are collected in the ASN, LTHMP, and Milk Surveillance networks. For the ASN, a duplicate sampler is collocated with the routine sampler at randomly selected sites for a period of one to three months to provide the field duplicate. A total of four samplers are used; these second samplers are moved to various site locations throughout the year. Noble gas and atmospheric moisture samples are split to provide duplicate samples for analysis; the number of duplicates is limited by the number of routine samples which contain sufficient volume to permit division into two samples. In 1993, an experiment was conducted to see if a composite sample composed of the three noble gas bottles collected over 56-hour increments could be used as a "duplicate" sample for comparison to the fourth bottle, collected over the entire one-week sampling period. Animal tissue, vegetable, and bioassay (urine) samples are also split after processing, if the volume of material is sufficient. Two TLDs, each with three identical phosphors, are deployed to each fixed station, providing a total of six replicates. In lieu of field duplicates, precision for the PICs is determined by the variance of measurements over a specific time interval when only background activities are being measured. Precision may also be determined from repeated analyses of routine or laboratory spiked samples. The spiked QC samples are generally not blind to the analyst; e.g., the analyst both recognizes the sample as a QC sample and knows the expected (theoretical) activity of the sample.

Precision is expressed as percent relative standard deviation (%RSD), calculated by:

$$\%RSD = \left(\frac{std.\ dev.}{mean}\right)100$$

The %RSD (also called Coefficient of Variation) is not reported for duplicate pairs in which one or both results are less than the MDC of the analysis. For most analyses, the DQOs for precision are defined for two ranges: values greater than or equal to the MDC but less than ten times the MDC and values equal to or greater than ten times the MDC. The %RSD is partially dependent on statistical counting uncertainty so it is expected to be more variable for duplicate analyses of samples with low activities.

Figure 11.1 displays %RSDs for LTHMP field and spiked sample duplicate pairs analyzed by the conventional tritium method. This figure includes one matrix spike sample pair with a mean equal to or greater than ten times the MDC and 54 pairs of matrix spike samples and two field duplicate pairs with means equal to or greater than the MDC but less than ten times the MDC. The %RSD for the one pair with mean equal to or greater than 10 times the MDC was less than one percent, well within the DQO of ten percent. All pairs with means greater than the MDC but less than ten times the MDC yielded %RSDs of less than 15 percent; the DQO for precision of samples in this activity range is 30 percent.

Figure 11.2 displays %RSDs for duplicate pairs analyzed by the enriched tritium method. All 31 matrix spike sample duplicate pairs had means equal to or greater than ten times the MDC; all %RSDs were within the DQO of 20 percent. In addition, eight field duplicate pairs had means equal to or greater than ten times the MDC. The %RSDs of these pairs were all less than 8 percent. Of 19 field duplicate pairs with means equal to or greater than the MDC but less than ten times the MDC, all were within the DQO of 30 %RSD, and only two %RSDs were greater than 20 percent.

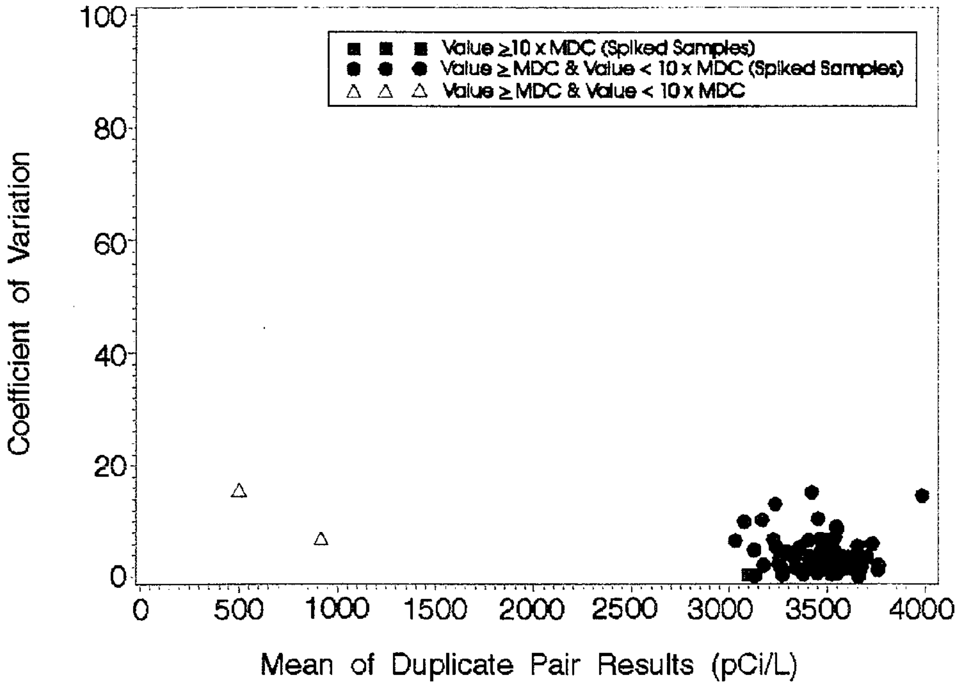

Figure 11.1 Precision Results for Conventional Method Tritium

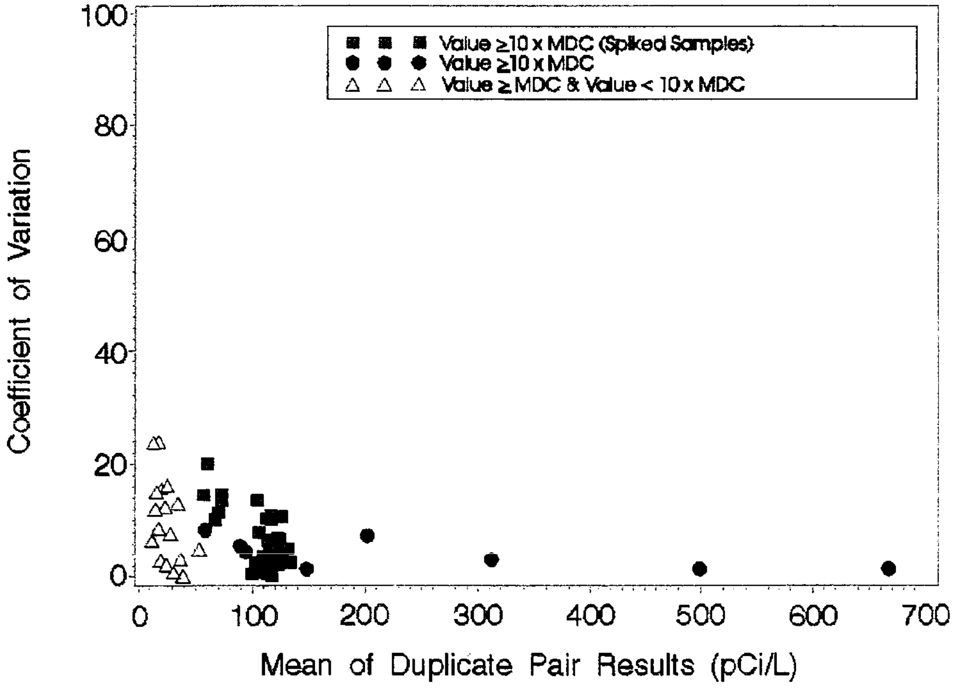

Figure 11.2 Precision Results for Enriched Method Tritium in Water

In the ASN, field duplicate pairs are analyzed for gross alpha, gross beta, and gamma-emitting radionuclides. Figure 11.3 shows the %RSD distribution for gross alpha field duplicate analyses. Of 52 field duplicate pairs with means greater than or equal to the MDC but less than ten times the MDC, 44 pairs had %RSDs of less than 40 percent. Figure 11.4 displays %RSDs for gross beta analyses of the 17 field duplicate pairs with means equal to or greater than ten times the MDC and the 125 field duplicate pairs with means equal to or greater than the MDC but less than ten times the MDC. All but one of the pairs with means equal to or greater than ten times the MDC yielded %RSDs of less than 20 percent. Of the 125 pairs with means equal to or greater than the MDC but less than ten times the MDC, the %RSDs for 113 pairs was less than 30 percent. Of the 9 field duplicate pairs with ^{7}Be activities greater than or equal to 10 MDC, all yielded %RSDs less than 20 percent and, of these, all but one were less than 10 %RSD.

In addition to analysis of field duplicate pairs, selected routine sample filters are analyzed twice for gross alpha, gross beta, and gamma-emitting radionuclides. Of 80 duplicate analyses for gross alpha with results greater than or equal to MDC but less than 10 MDC, 68 yielded %RSDs of less than 40 percent. Of 168 duplicate analyses for gross beta with means greater than or equal to MDC but less than 10 MDC, all but five yielded %RSDs of less than 20 percent. In addition, 9 duplicate analyses for gross beta yielded means greater than or equal to 10 MDC; the %RSDs for these pairs were all less than 10 percent. Seven duplicate gamma spectrometry analyses yielded ^{7}Be results with means greater than or equal to 10 MDC and the %RSDs for these pairs were less than 20 percent.

In 1993, precision estimates for noble gas samples were made by two methods. As an experiment, the three bottles collected over consecutive 56-hour increments were composited; results were compared to the results obtained for Bottle 4 which collected samples over the entire 1-week sampling period. As in previous years, estimates of precision were obtained from sample splits. The range of %RSDs for the 44 composited sample pairs was 0.1 to 20.3 percent while the range for the 23 split sample pairs was 0.8 to 19.5 percent. All duplicate sample pairs had means greater than or equal to MDC but less than 10 MDC. The DQO for this activity range is 30 percent; all %RSDs for both methods were well within this DQO. Figure 11.5 displays the %RSDs for the composited sample pairs and Figure 11.6 displays %RSDs for the split sample pairs.

All split samples analyzed for the atmospheric moisture network yielded means that were less than the MDC. By definition, no DQOs are established for activities less than the MDC.

None of the field duplicate pairs from the MSN and SMSN analyzed for tritium or ^{90}Sr yielded results equal to or greater than the MDC. Total potassium was measured at concentrations ≥10 MDC in 68 field duplicate pairs and in 39 duplicate analyses. All but one pair had %RSD of less than 25 percent and 93 pairs yielded %RSD of less than 10 percent. The %RSD results for the field duplicate pairs are shown in Figure 11.7. The DQO for these is ≤10%.

Duplicate samples of mule deer and cattle bone and cattle liver were prepared and analyzed to estimate precision for the AIP. The bone and liver ash samples were analyzed for ^{238}Pu and $^{239+240}$Pu; bone ash samples were additionally analyzed for ^{90}Sr. None of the 3 mule deer bone ash sample pairs, 4 cattle bone ash, or 4 cattle liver ash samples yielded results greater than or equal to MDC in both samples for ^{238}Pu. One mule deer bone, 2 cattle liver, and 1

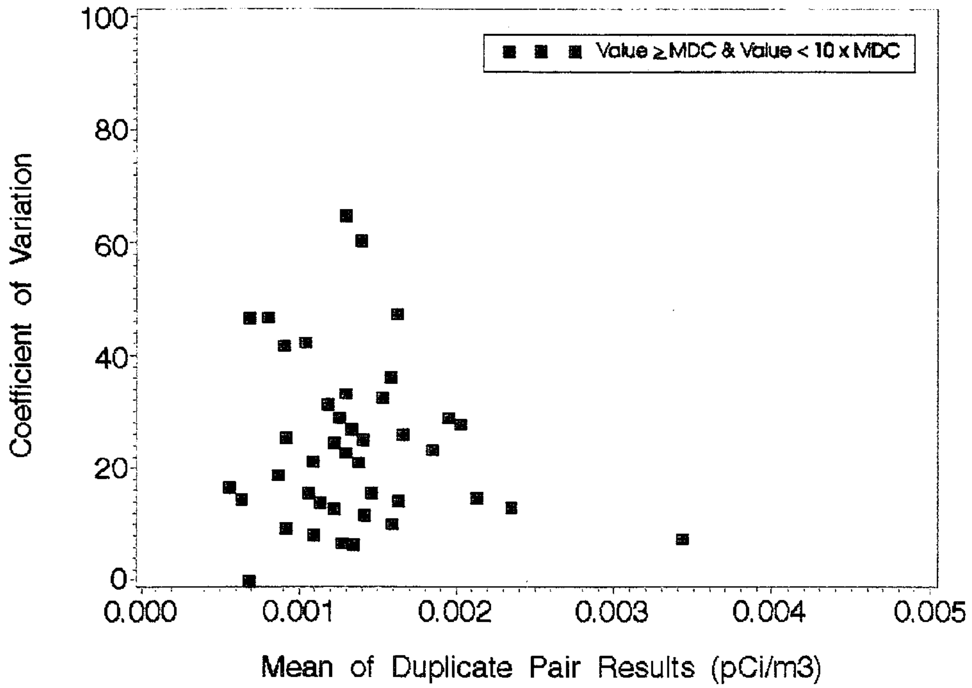

Figure 11.3 Precision Results for Alpha in Air

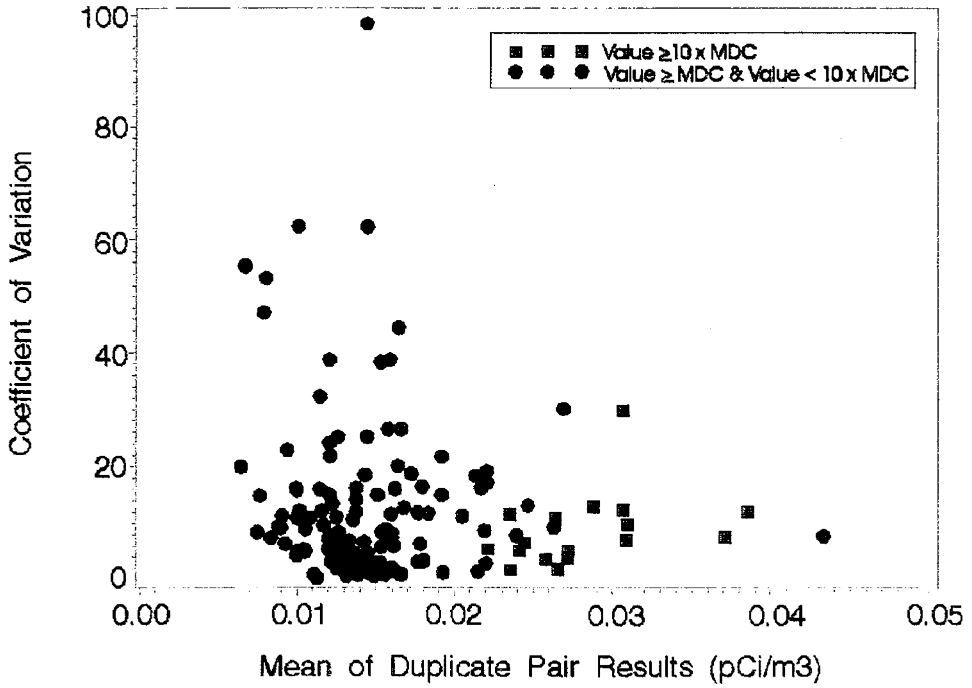

Figure 11.4 Precision Results for Beta in Air

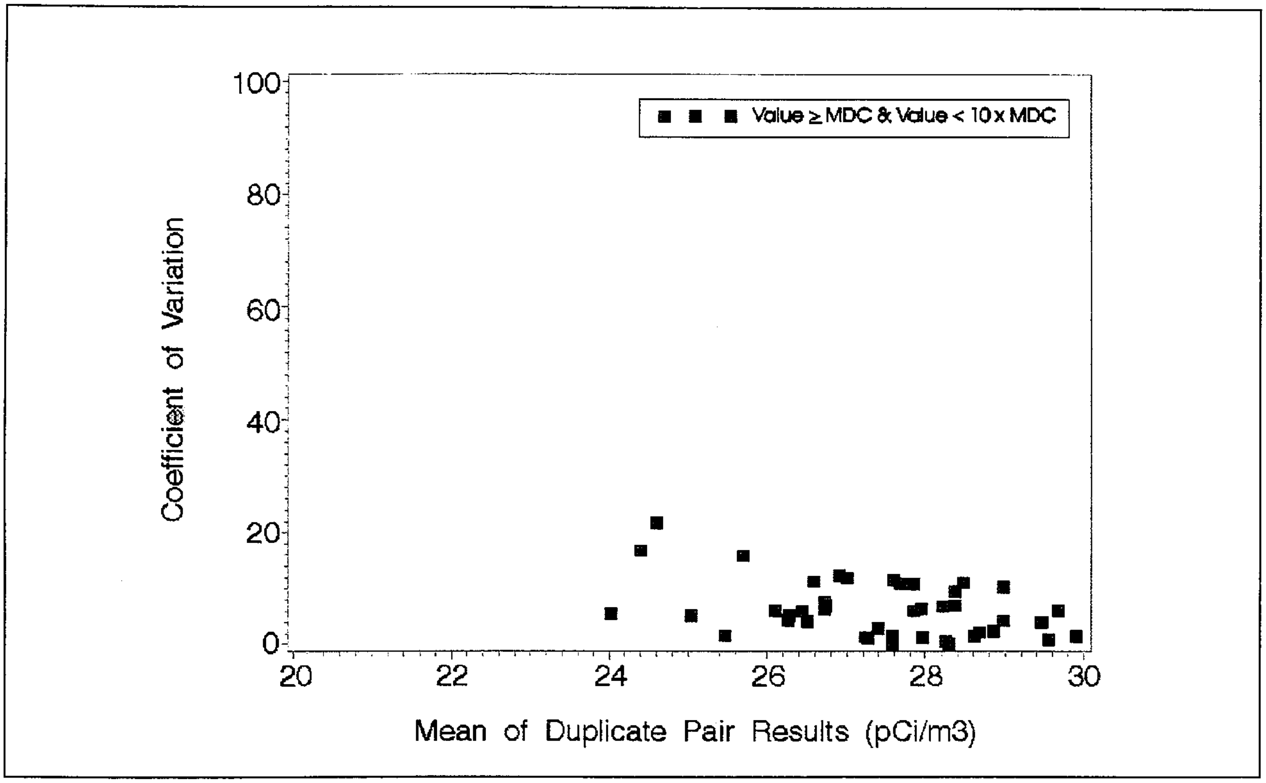

Figure 11.5 Precision Results from Composite Samples for ^{85}Kr in Noble Gas

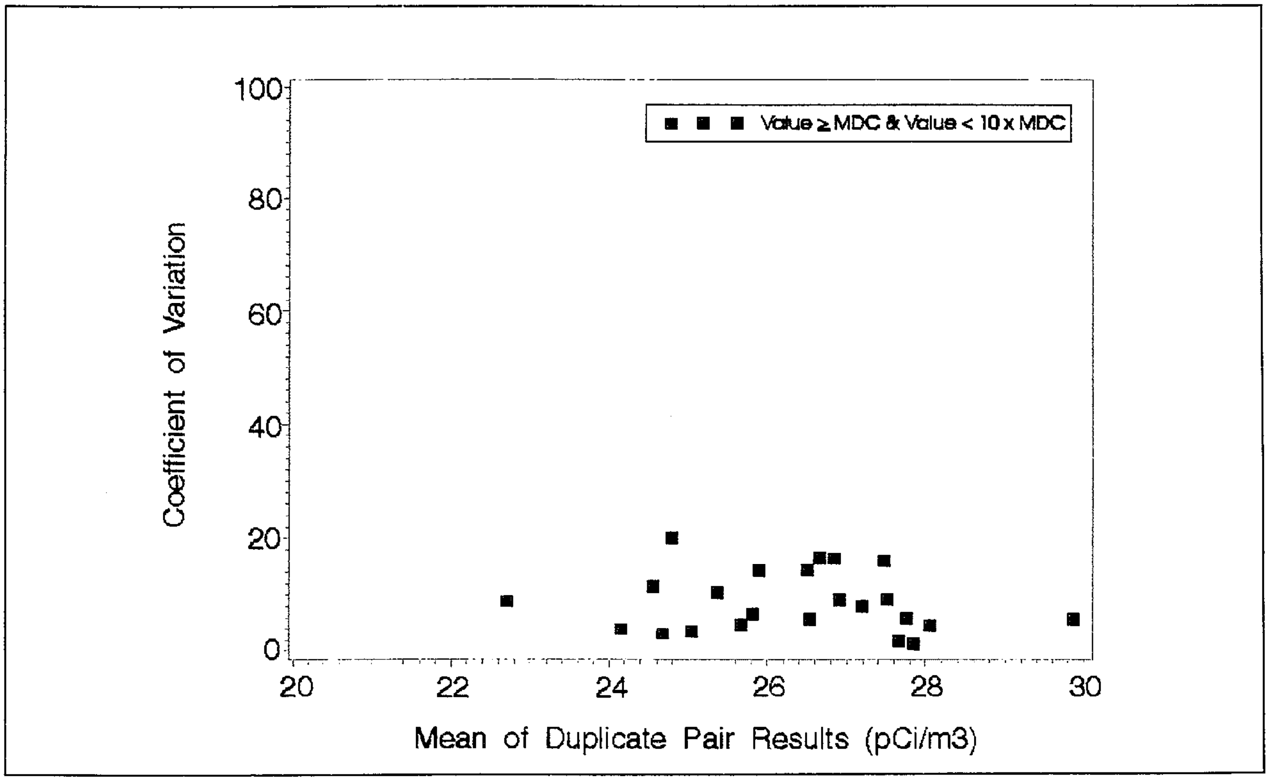

Figure 11.6 Precision Results from Split Samples for ^{85}Kr in Noble Gas

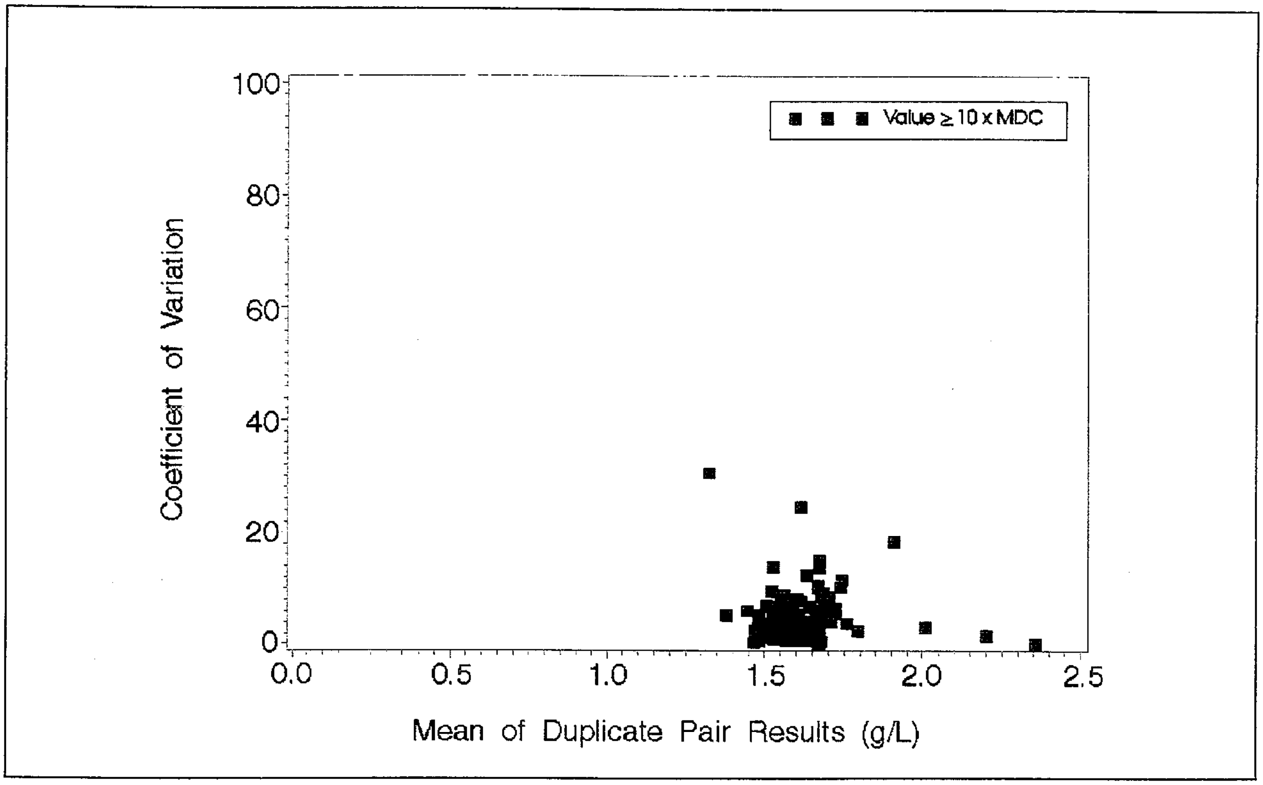

Figure 11.7 Precision Results for K (total) in Milk

cattle bone ash samples yielded valid results for $^{239+240}$Pu that were greater than or equal to MDC but less than 10 MDC in both samples; the %RSD was less than 10 percent for each pair. Except for one mule deer bone ash sample, all of the bone ash duplicate sample pairs yielded results greater than or equal to MDC but less than 10 MDC for ^{90}Sr. The %RSDs for these pairs were all less than the DQO of 30%, and all but one were less than 20%. There were no splits of vegetable samples analyzed in 1993.

Seven bioassay samples were split for duplicate tritium analysis; all yielded results less than the MDC by conventional method.

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. Table 11.2 presents the pooled data and estimates of overall precision. The pooled standard deviations and %RSD indicate the estimated achieved precision for 1993 samples.

11.4.3 ACCURACY

The accuracy of all analyses is controlled through the use of approved or NIST-traceable standards in instrument calibrations. Internal checks of instrument accuracy may be periodically performed, using spiked matrix samples. These internal QC procedures are the only control of accuracy for whole body and lung counts and PICs. For spectroscopic and radiochemical analyses, an independent measurement of accuracy is provided by participation in intercomparison studies using samples of known activities. The EPA EMSL-LV Radioanalysis Laboratory participates in two such intercomparison studies. An independent

Table 11.2 Overall Precision of Analysis

Network	Analysis	Sample Type	Range	n	Pooled Standard Deviation	%RSD
LTHMP	Conv. Tritium	Spiked	≥MDC, <10x MDC	54	176	5.1
	Conv. Tritium	Field	≥MDC, <10x MDC	2	69	9.6
	Conv. Tritium	Spiked	≥10x MDC	1	5.0	0.2
	Enrich. Tritium	Field	≥MDC, <10x MDC	19	2.0	8.5
	Enrich. Tritium	Spiked	≥10x MDC	31	7.3	6.8
	Enrich. Tritium	Field	≥10x MDC	8	7.7	3.0
ASN	Gross Alpha	Field	≥MDC, <10x MDC	52	0.0003	26.1
	Gross Alpha	Lab Dup	≥MDC, <10x MDC	80	0.0004	28.3
	Gross Beta	Field	≥MDC, <10x MDC	125	0.0028	19.6
	Gross Beta	Lab Dup	≥MDC, <10x MDC	168	0.0017	12.1
	Gross Beta	Field	≥10x MDC	17	0.0032	11.1
	Gross Beta	Lab Dup	≥10x MDC	9	0.0011	3.9
	^{7}Be	Field	≥10x MDC	9	0.0599	18.6
	^{7}Be	Lab Dup	≥10x MDC	7	0.0641	19.3
Noble Gas	^{85}Kr	Comp.	≥MDC, <10x MDC	44	1.84	6.7
	^{85}Kr	Split	≥MDC, <10x MDC	23	2.56	9.7
Milk	Potassium (total)	Field	≥10x MDC	68	0.12	7.8
	Potassium (total)	Lab Dup	≥10x MDC	39	0.12	7.3

verification of the accuracy of the TLDs is performed every two or three years by DOELAP. This involves a three-part, single blind, performance testing program followed by an independent onsite assessment of the overall program.

In the EPA EMSL-LV Intercomparison Study program, samples of known activities of selected radionuclides are sent to participating laboratories on a set schedule throughout the year. Water, milk, and air filters are used as the matrices for these samples. Results from all participating laboratories are compiled and statistics computed comparing each laboratory's results to the known value and to the mean of all laboratories. The comparison to the known value provides an independent assessment of accuracy for each participating laboratory.

Table 11.3 presents accuracy (referred to therein as Percent Bias) results for these intercomparison studies. Comparison of results among all participating laboratories provides a measure of comparability, discussed in Section 11.4.4. Approximately 70 to 290 laboratories participate in any given intercomparison study. 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*

Table 11.3 Accuracy of Analysis from EPA Performance Evaluation

Nuclide	Month	Known Value (pCi/L)(a)	EPA Average (pCi/L)(a)	Percent Bias
		Water Performance Evaluation Studies		
Alpha	Jan	34	37	8.8
Alpha	Apr(b)	95	110	15.8
Alpha	Jul	15	17	13.3
Alpha	Oct	20	17	-15.0
Alpha	Oct(b)	40	41	2.5
Beta	Jan	44	44	0.0
Beta	Apr(b)	177	166	-5.5
Beta	Jul	43	41	-4.7
Beta	Oct	15	18	20.0
Beta	Oct(b)	58	52	-10.3
^{89}Sr	Jan	15	11	-26.7
^{89}Sr	Apr(b)	41	26	-36.6
^{89}Sr	Jul	34	37	8.8
^{89}Sr	Oct(b)	15	17	13.3
^{90}Sr	Jan	10	9	-10.0
^{90}Sr	Apr(b)	29	26	-10.3
^{90}Sr	Jul	25	26	4.0
^{90}Sr	Oct(b)	10	10	0.0
^{239}Pu	Jan	20	19	-5.0
^{131}I	Feb	100	95	-5.0
^{131}I	Oct	117	114	-8.3
U-Nat	Apr(b)	29	28	-3.4
U-Nat	Aug	25	26	4.0
U-Nat	Oct	15	15	0.0
^{3}H	Jun	9800	9300	-5.1
^{3}H	Nov	7400	7000	-5.4
^{60}Co	Apr(b)	39	39	0.0
^{60}Co	Jun	15	14	-6.7
^{60}Co	Oct(b)	10	8	-20.0
^{60}Co	Nov	30	32	6.7
^{134}Cs	Apr(b)	27	24	-11.1
^{134}Cs	Jun	5	5	0.0
^{134}Cs	Oct(b)	12	9	-25.0
^{134}Cs	Nov	59	58	-1.7
^{137}Cs	Apr(b)	32	31	-3.1
^{137}Cs	Jun	5	5	0.0
^{137}Cs	Oct(b)	10	11	10.0
^{137}Cs	Nov	40	45	12.5
^{65}Zn	Jun	103	112	10.0
^{65}Zn	Nov	150	173	13.3
^{106}Ru	Jun	119	107	-8.3
^{106}Ru	Nov	201	190	-5.0
^{133}Ba	Jun	99	94	-6.0
^{133}Ba	Nov	79	82	3.8

(a) The grand average of all participating laboratories that are non-outliers.
(b) Refers to Blind Performance Evaluation (PE) Study.

Table 11.3 (Accuracy of Analysis from EPA Performance Evaluation, cont.)

Nuclide	Month	Known Value (pCi/L)[a]	EPA Average (pCi/L)[a]	Percent Bias
		Air Filter Performance Evaluation Studies		
Alpha	Aug	19	19	0.0
Beta	Aug	47	47	0.0
^{137}Cs	Aug	9	12	33.3
		Milk Performance Evaluation Studies		
^{89}Sr	Sept	30	24	-20.0
^{90}Sr	Sept	25	23	-8.0
^{131}I	Sept	120	117	-2.5
^{137}Cs	Sept	49	50	2.0
K(total)	Sept	1679	1452	-13.5

(a) The grand average of all participating laboratories that are non-outliers
(b) Refers to Blind Performance Evaluation (PE) Study

With the exception of ^{89}Sr in January and in the April blind PE water sample, ^{134}Cs in the October blind PE water sample, and ^{137}Cs in the single air filter intercomparison study sample, the achieved accuracy was better than ± 20 percent. For most analyses, the DQOs are ± 20 percent for values greater than ten times the MDC and ± 30 percent for results greater than the MDC but less than ten times the MDC.

The other intercomparison study in which the EPA EMSL-LV Radioanalysis Laboratory participates is the semiannual DOE QA Program conducted by EML in New York, NY. Approximately 20 laboratories participate in this performance evaluation program. Sample matrices include water, air filters, vegetation, and soil. Results for these performance audit samples are given in Table 11.4. The DQOs for accuracy were exceeded for ^{90}Sr and ^{60}Co in the March air sample, ^{144}Ce in the September air sample, $^{239+240}$Pu in the September soil sample, and ^{90}Sr in the March water sample.

In addition to use of irradiated control samples in the processing of TLDs, DOELAP monitors accuracy as part of the accreditation program. As with the intercomparison studies, samples of known activity are submitted as single blind samples. The designation "single blind" indicates the analyst recognizes the sample as being other than a routine sample, but does not know the concentration or activity contained in the sample. Individual results are not provided to the participant laboratories by DOELAP; issuance of the accreditation certificate indicates acceptable accuracy has been achieved as one of the accreditation criteria. No DOELAP samples were received in 1993.

11.4.4 COMPARABILITY

The EPA Performance Evaluation Program provides results to each laboratory participating in each study that includes a grand average for all values, excluding outliers.

Table 11.4 Accuracy of Analysis from DOE Performance Evaluation Studies

Nuclide	Month	EML Value[(a)]	EPA Value	Percent Bias
		Air Intercomparison Studies		
^{7}Be	March	28.	27	-3.6
^{54}Mn	March	12	12	0
^{54}Mn	September	16	15	-6.2
^{57}Co	March	2.6	2.7	3.8
^{57}Co	September	16	17	6.2
^{60}Co	March	.94	1.7	81
^{60}Co	September	21	20	-4.8
^{90}Sr	March	.54	.76	41
^{134}Cs	March	2.2	2	-9.1
^{134}Cs	September	13	12	-7.7
^{137}Cs	March	3.4	3.1	-8.8
^{137}Cs	September	19	19	0
^{144}Ce	March	18	19	5.6
^{144}Ce	September	28	40	43
^{238}Pu	March	.033	.036	9.1
^{238}Pu	September	.12	.13	8.3
$^{239+240}$Pu	March	.022	.023	4.5
^{239240}Pu	September	.072	.080	11
U-Nat	September	.15	.14	-6.7
		Soil Intercomparison Studies		
^{239240}Pu	March	11	11	9.1
^{239240}Pu	September	2.2	1.5	–32
U-Nat	March	42	50.3	19
		Vegetation Intercomparison Studies		
^{90}Sr	March	280.	240	–14
^{90}Sr	September	200.	220.	10
^{238}Pu	March	1.2	1.1	-8.3
^{238}Pu	September	.42	.46	9.5
^{239240}Pu	March	0.33	0.32	-3.00
^{239240}Pu	September	0.91	0.96	5.5
		Water Intercomparison Studies		
^{3}H	March	110	97	-12
^{3}H	September	260	270	3.8
^{54}Mn	March	110	100	-9.1

(a) Values were obtained from the Environmental Measurements Laboratory (EML) with all values rounded to two significant figures. Units are Bq/filter for air, Bq/L for water, and Bq/Kg for the remaining matrices.

Table 11.4 (Accuracy of Analysis from DOE Performance Evaluation Studies, cont.)

Nuclide	Month	EML Value[(a)]	EPA Value	Percent Bias
		Water Intercomparison Studies		
^{54}Mn	September	120	110	-8.3
^{60}Co	March	47	45	-4.2
^{60}Co	September	100	100	0
^{90}Sr	March	1.5	1.0	-33
^{90}Sr	September	2.7	2.5	-7.4
^{134}Cs	March	48	42	-12
^{134}Cs	September	63	56	-11
^{137}Cs	March	55	51	-7.3
^{137}Cs	September	83	76	-8.4
^{144}Ce	March	91	84	-7.7
^{144}Ce	September	170	170	0
^{238}Pu	March	0.48	0.49	2.1
^{238}Pu	September	1.1	1.1	0
^{239240}Pu	March	0.84	0.83	-1.2
^{239240}Pu	September	0.32	0.34	6.2
U-Nat	September	2.2	2.1	-4.5

(a) Values were obtained from the Environmental Measurements Laboratory (EML) with all values rounded to two significant figures. Units are Bq/filter for air, Bq/L for water, and Bq/kg for the remaining matrices.

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. Table 11.5 displays data from the 1993 intercomparison studies for all variables measured. There were three instances in which the EPA EMSL-LV Radioanalysis Laboratory results deviated from the grand average by more than three standard normal deviate units. These were the gross alpha in the January and ^{89}Sr in the April water intercomparison study samples and total potassium in the single milk intercomparison study sample. The gross alpha and total potassium results were within the DQO for accuracy. All other analyses were within three standard normal deviate units of the grand mean. This indicates acceptable comparability of the Radioanalysis Laboratory with the 73 to 262 laboratories participating in the EPA Intercomparison Study Program.

11.4.5 REPRESENTATIVENESS

Representativeness cannot be evaluated quantitatively. Rather, it is a qualitative assessment of the ability of the sample to model the objectives of the program. The primary objective of the ORSP is to protect the health and safety of the offsite residents. Therefore, the DQO of representativeness is met if the samples are representative of the radiation exposure of the resident population. Monitoring stations are located in resident population centers. Siting criteria specific to radiation sensors are not available for many of the instruments used. Existing siting criteria developed for other pollutants are applied to the ORSP sensors as

Table 11.5 Comparability of Analysis from EPA Performance Evaluation Studies[(a)]

Nuclide	Month	Known Value pCi/L	EPA Lab Average pCi/L	Grand Average pCi/L	Expected Precision	Normalized Dev. of EPA Average from Grand Average	Normalized Dev. of EPA Average from Known Value
			Water Performance Evaluation Study				
Alpha	Jan	34	37	17	9.0	3.8	0.58
Alpha	Apr[(b)]	95	110	97	24.0	0.92	1.0
Alpha	Jul	15	17	12	5.0	1.6	0.58
Alpha	Oct	20	17	14	5.0	1.1	-0.92
Alpha	Oct[(b)]	40	41	41	10.0	-0.02	0.12
Beta	Jan	44	44	42	5.0	0.58	-0.12
Beta	Apr[(b)]	177	166	155	27.0	0.67	-0.71
Beta	Jul	43	41	38	6.9	0.75	-0.58
Beta	Oct	15	18	17	5.0	0.34	1.0
Beta	Oct[(b)]	58	52	53	10.0	-0.18	-0.98
^{89}Sr	Jan	15	11	15	5.0	-1.2	-1.4
^{89}Sr	Apr[(b)]	41	26	38	5.0	-4.0	-5.2
^{89}Sr	Jul	34	37	34	5.0	1.1	1.2
^{89}Sr	Oct[(b)]	15	17	14	5.0	1.1	0.69
^{90}Sr	Jan	10	9	10	5.0	-0.23	-0.35
^{90}Sr	Apr[(b)]	29	26	28	5.0	-0.63	-1.0
^{90}Sr	Jul	25	26	24	5.0	0.69	0.35
^{90}Sr	Oct[(b)]	10	10	10	5.0	-0.09	0.0
$^{239+240}$Pu	Jan	20	19	19	2.0	0.18	-1.1
^{131}I	Feb	100	95	101	10.0	-1.2	-0.92
^{131}I	Oct	117	114	118	12.0	-0.53	-0.43
U-Nat	Apr[(b)]	29	28	28	3.0	0.34	-0.38
U-Nat	Aug	25	26	25	3.0	0.55	0.33
U-Nat	Oct	15	15	14	3.0	0.25	-0.17
^{3}H	Jun	9800	9300	9600	984.0	-0.51	-0.96
^{3}H	Nov	7400	7000	7200	740.0	-0.60	-1.3
^{60}Co	Apr[(b)]	39	39	39	5.0	-0.24	-0.12
^{60}Co	Jun	15	14	15	5.0	-0.20	-0.23
^{60}Co	Oct[(b)]	10	8	10	5.0	-0.72	-0.58
^{60}Co	Nov	30	32	30	5.0	0.91	0.81
^{134}Cs	Apr[(b)]	27	24	25	5.0	-0.37	-0.92
^{134}Cs	Jun	5	5	5	5.0	-0.13	0.0
^{134}Cs	Oct[(b)]	12	9	10	5.0	-0.27	-1.0
^{134}Cs	Nov	59	58	54	5.0	1.2	-0.35
^{137}Cs	Apr[(b)]	32	31	33	5.0	-0.44	-0.23
^{137}Cs	Jun	5	5	6	5.0	-0.15	0.12
^{137}Cs	Oct[(b)]	10	11	11	5.0	0.02	0.35
^{137}Cs	Nov	40	45	42	5.0	.99	1.7
^{65}Zn	Jun	103	112	108	10.0	0.71	1.5
^{65}Zn	Nov	150	173	156	15.0	2.0	2.7
^{106}Ru	Jun	119	107	104	12.0	.50	-1.7
^{106}Ru	Nov	201	190	175	20.0	.88	-1.4
^{133}Ba	Jun	99	94	97	10.0	-0.48	0.87
^{133}Ba	Nov	79	82	76	8.0	1.1	0.58

(a) The grand average of all participating laboratories that are non-outliers
(b) Refers to Blind Performance Evaluation (PE) Study
(c) pCi/filter
(d) mg/liter

Table 11.5 (Comparability of Analysis from EPA Performance Evaluation Studies, cont.)[(a)]

Nuclide	Month	Known Value pCi/L	EPA Lab Average pCi/L	Grand Average pCi/L	Expected Precision	Normalized Dev. of EPA Average from Grand Average	Normalized Dev. of EPA Average from Known Value
			Air Filter Performance Evaluation Study[(c)]				
Alpha	Aug	19	19	20	5.0	-0.46	-0.12
Beta	Aug	47	47	49	5.0	-0.69	0.12
^{137}Cs	Aug	9	12	10	5.0	-0.69	1.0
			Milk Performance Evaluation Study				
^{89}Sr	Sep	30	24	24	5.0	-0.11	-2.0
^{90}Sr	Sep	25	23	20	5.0	1.2	-0.58
^{131}I	Sep	120	120	120	12.0	-0.40	-0.38
^{137}Cs	Sep	49	50	50	5.0	-0.12	0.23
K[(d)] (Total)	Sep	1679	1452	1674	84.0	-4.6	-4.7

(a) The grand average of all participating laboratories that are non-outliers
(b) Refers to Blind Performance Evaluation (PE) Study
(c) pCi/filter
(d) mg/liter

available. For example, siting criteria for the placement of air sampler inlets are contained in Prevention of Significant Deterioration guidance documents (EPA 1976). Inlets for the air samplers at the ORSP stations have been evaluated against these criteria and, where necessary, relocated to meet the criteria. Guidance or requirements for handling, shipping, and storage of radioactivity samples are followed in program operations and documented in SOPs. Standard analytical methodology is used and guidance on the holding times for samples, sample processing, and results calculations are followed and documented in SOPs.

In the LTHMP, the primary objectives are protection of drinking water supplies and monitoring of any potential cavity migration. Sampling locations are primarily "targets of opportunity", i.e., the sampling locations are primarily wells developed for other purposes than radioactivity monitoring. Guidance or requirements developed for CERCLA and RCRA regarding the number and location of monitoring wells has not been applied to the LTHMP sampling sites. In spite of these limitations, the samples are representative of the first objective, protection of drinking water supplies. At all of the LTHMP monitoring areas, including on and around the NTS, most potentially impacted drinking water supplies are monitored, as are many supply sources with virtually no potential to be impacted by radioactivity resulting from past or future nuclear weapons testing. The sampling network at some locations is not optimal for achieving the second objective, monitoring of any migration of radionuclides from the test cavities. An evaluation conducted by DRI describes, in detail, the monitoring locations for each LTHMP location and the strengths and weaknesses of each monitoring network (Chapman and Hokett, 1991). This evaluation is cited in the discussion of the LTHMP data in Section 9.6.

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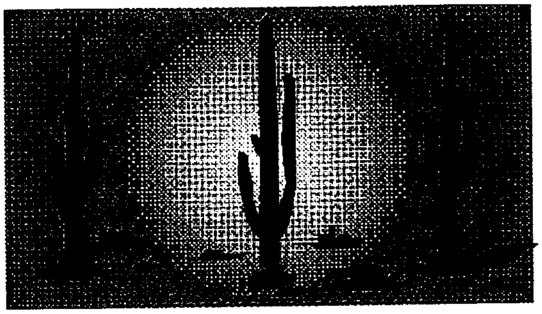

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