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Offsite Environmental Monitoring Report

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#55

Radiation Monitoring Around United States Nuclear Test Areas, Calendar Year 1992

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RESEARCH AND DEVELOPMENT
ENVIRONMENTAL MONITORING SYSTEMS LABORATORY-LAS VEGAS
P.O. BOX 93478
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702/798-2100

April 20, 1995

Dear Reader:

Since 1954, the U.S. Environmental Protection Agency (EPA) and its predecessor the U.S. Public Health Service (PHS) has conducted radiological monitoring in the offsite areas around United States nuclear test areas. The primary objective of this monitoring has been the protection of the health and safety of residents in the unlikely event of release of radioactive material into public areas. Further, the Offsite Environmental Surveillance Program documents has provided independent verification of the safety of the U.S. Nuclear Weapons Testing Program.

The enclosed report documents EPA's monitoring activities for calendar year 1992, the last year of nuclear testing prior to the moratorium. Monitoring data are included so that you may evaluate the contribution, if any, of nuclear testing to man's radiation exposure. The total radiation exposure man receives includes external exposure from naturally occurring, manmade materials in our environment, and internal exposure from natural and manmade radioactive materials in the air we breathe, the water we drink, and the food we eat. In 1992, there was no radioactivity detected offsite by the various EPA monitoring networks and no exposure above natural background to the population living in the vicinity of the Nevada Test Site (NTS) that could be attributed to current NTS activities.

If you have any questions regarding EPA's monitoring of radiation in areas around U.S. nuclear test areas, please feel free to contact me at the above address.

Sincerely,

Paul J. Weeden
Director
Radiation Sciences Division

Enclosure

Offsite Environmental Monitoring Report:

Radiation Monitoring Around United States
Nuclear Test Areas, Calendar Year 1992

Contributors:

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Notice

Abstract

This report describes the Offsite Radiation Safety Program conducted during 1992 by the Environmental Protection Agency's (EPA's), Environmental Monitoring Systems Laboratory-Las Vegas. This laboratory operates an environmental radiation monitoring program in the region surrounding the Nevada Test Site and at former test sites in Alaska, Colorado, Mississippi, Nevada, and New Mexico. The surveillance program is designed to measure levels and trends of radioactivity, if present, in the environment surrounding testing areas to ascertain whether current radiation levels and associated doses to the general public are in compliance with existing radiation protection standards. In 1992, there were six events. The surveillance program additionally has the responsibility to take action to protect the health and well-being of the public in the event of any accidental release of radioactive contaminants. Offsite levels of radiation and radioactivity are assessed by sampling milk, water, and air; by deploying thermoluminescent dosimeters and using pressurized ion chambers; and by biological monitoring of animals, food crops, and humans. Personnel with mobile monitoring equipment are placed in areas downwind from the test site prior to each nuclear weapons test to implement protective actions, provide immediate radiation monitoring, and obtain environmental samples rapidly after any release of radioactivity.

Comparison of the measurements and sample analysis results with background levels and with appropriate standards and regulations indicated that there was no radioactivity detected offsite by the various EPA monitoring networks and no exposure above natural background to the population living in the vicinity of the NTS that could be attributed to current NTS activities. Annual and long-term (10 year) trends were evaluated in the Noble Gas, Tritium, Milk Surveillance, Biomonitoring, Thermoluminescent Dosimetry, Pressurized Ion Chamber networks, and the Long-Term Hydrological Monitoring Program. All evaluated data were consistent with previous data history. No radiation directly attributable to current NTS activities was detected in any samples. Monitoring network data indicate the greatest population exposure came from naturally occurring background radiation, which yielded an average exposure of 78 mrem/yr. Worldwide fallout accounted for about 0.088 mrem/yr. Calculation of potential dose to offsite residents based on onsite source emission measurements provided by the Department of Energy resulted in a maximum calculated dose of 0.012 mrem/yr. These were insignificant contributors to total exposure as compared to natural background.

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Abbreviations, Acronyms, Units of Measure, and Conversions

ABBREVIATIONS and ACRONYMS

AEC -- Atomic Energy Commission
ALARA -- As Low as Reasonably Achievable
ALI -- Annual Limit on Intake
ASN -- Air Surveillance Network
ANSI -- American National Standards Institute
BOC -- Bureau of Census
BOMAB -- Bottle Mannequin Absorber
CEDE -- Committed Effective Dose Equivalent
CFR -- Code of Federal Regulations
CG -- Concentration Guide
CP-1 -- Control Point One
CRMP -- Community Radiation Monitoring Program
DAC -- Derived Air Concentration
DCG -- Derived Concentration Guide
DOE -- U.S. Department of Energy
DOELAP -- Department of Energy, Laboratory Accreditation Program
DQO -- data quality objective
DRI -- Desert Research Institute
ECF --Element Correction Factor
EDE -- Effective Dose Equivalent
EML -- Environmental Monitoring Laboratory
EMSL-LV -- Environmental Monitoring Systems Laboratory-Las Vegas
EPA -- U.S. Environmental Protection Agency
FDA -- Food and Drug Administration
FRMAC -- Federal Radiological Monitoring and Assessment Center
GOES -- Geostationary Operational Environmental Satellite
GZ --Ground Zero
HTO -- tritiated water
HpGe -- High purity germanium
IAGs -- Interagency Agreements
ICRP -- International Commission on Radiological Protection
LGFSTF -- Liquefied Gaseous Fuels Spill Test Facility
LTHMP -- Long-Term Hydrological Monitoring Program
MDC -- minimum detectable concentration
MSL -- mean sea level
MSN -- Milk Surveillance Network
NCRP -- National Council on Radiation Protection and Measurements
NIST -- National Institute of Standards and Technology
NGTSN -- Noble Gas and Tritium Surveillance Network
NPDWR -- National Primary Drinking Water Regulation
NPS -- National Park Service
NTS -- Nevada Test Site
NRD -- Nuclear Radiation Assessment Division
ORSP -- Offsite Radiological Safety Program
PHS -- U.S. Public Health Service
PIC -- pressurized ion chamber
QA -- quality assurance
QC -- quality control
RAWS -- Remote Automatic Weather Station
RCF -- reference correction factor
RCRA -- Resource Conservation and Recovery Act
SASN -- Standby Air Surveillance Network
S.D. -- standard deviation
SGZ -- Surface Ground Zero
SMSN -- Standby Milk Surveillance Network
SOP -- standard operating procedure
STDMS -- Sample Tracking Data Management System
TLD -- thermoluminescent dosimetry
USGS -- U.S. Geological Survey
WSNSO -- Weather Service Nuclear Support Office

Abbreviations, Acronyms, Units of Measure, and Conversions (continued)

UNITS OF MEASURE

Bq	--	Becquerel, one disintegration per second
C	--	coulomb
•C	--	degrees centigrade
Ci	--	Curie
cm	--	centimeter, 1/100 meter
eV	--	electron volt
•F	--	degrees Fahrenheit
g	--	gram
hr	--	hour
keV	--	one thousand electron volts
kg	--	kilogram, 1000 grams
km	--	kilometer, 1000 meters
L	--	liter
lb	--	pound
m	--	meter
meV	--	one million electron volts
mg	--	milligram, 10^{-3} gram
min	--	minute
mL	--	milliliter, 10^{-3} liter
mo	--	month
mR	--	milliroentgen, 10^{-3} roentgen
mrem	--	millirem, 10^{-3} rem
mSv	--	millisievert, 10^{-3} sievert
pCi	--	picocurie, 10^{-12} curie
qt	--	quarter
R	--	roentgen
rad	--	unit of absorbed dose, 100 ergs/g
rem	--	dose equivalent, the rad adjusted for biological effect
Sv	--	sievert, equivalent to 100 rem
wk	--	week
yr	--	year
µCi	--	microcurie, 10^{-6} curie
µR	--	microroentgen, 10^{-6} roentgen
%	--	percent
±	--	plus or minus
<	--	less than
=	--	equals
≅	--	approximately equals

PREFIXES

a	atto	=	10^{-18}
f	femto	=	10^{-15}
p	pico	=	10^{-12}
n	nano	=	10^{-9}
µ	micro	=	10^{-6}
m	milli	=	10^{-3}
k	kilo	=	10^{3}

CONVERSIONS

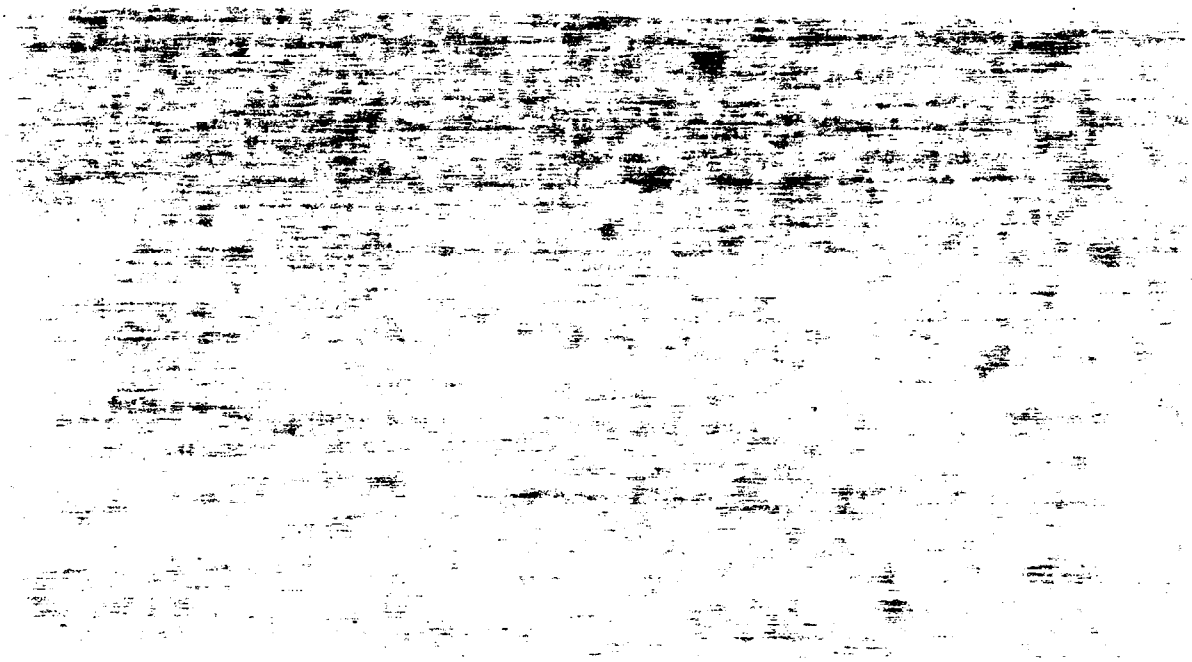
Multiply	by	To Obtain
Concentrations		
µCi/mL	10^{9}	pCi/L
µCi/mL	10^{12}	pCi/m^3
SI Units		
rad	10^{-2}	Gray (Gy=1 Joule/kg)
rem	10^{-2}	Sievert (Sv)
pCi	3.7×10^{-2}	Becquerel (Bq)
mR/yr	2.6×10^{-7}	Coulomb (C)/kg-yr

List of Elements

ATOMIC NUMBER	SYMBOL	NAME	ATOMIC NUMBER	SYMBOL	NAME
1	H	hydrogen	47	Ag	silver
2	He	helium	48	Cd	cadmium
3	Li	lithium	49	In	indium
4	Be	beryllium	50	Sn	tin
5	B	boron	51	Sb	antimony
6	C	carbon	52	Te	tellurium
7	N	nitrogen	53	I	iodine
8	O	oxygen	54	Xe	xenon
9	F	fluorine	55	Cs	cesium
10	Ne	neon	56	Ba	barium
11	Na	sodium	57	La	lanthanum
12	Mg	magnesium	58	Ce	cerium
13	Al	aluminum	59	Pr	praseodymium
14	Si	silicon	60	Nd	neodymium
15	P	phosphorus	61	Pm	promethium
16	S	sulfur	62	Sm	samarium
17	Cl	chlorine	63	Eu	europium
18	Ar	argon	64	Gd	gadolinium
19	K	potassium	65	Tb	terbium
20	Ca	calcium	66	Dy	dysprosium
21	Sc	scandium	67	Ho	holmium
22	Ti	titanium	68	Er	erbium
23	V	vanadium	69	Tm	thulium
24	Cr	chromium	70	Yb	ytterbium
25	Mn	manganese	71	Lu	lutetium
26	Fe	iron	72	Hf	hafnium
27	Co	cobalt	73	Ta	tantalum
28	Ni	nickel	74	W	tungsten
29	Cu	copper	75	Re	rhenium
30	Zn	zinc	76	Os	osmium
31	Ga	gallium	77	Ir	iridium
32	Ge	germanium	78	Pt	platinum
33	As	arsenic	79	Au	gold
34	Se	selenium	80	Hg	mercury
35	[illegible]	bromine	81	Tl	thallium
36	[illegible]	krypton	82	Pb	lead
37	[illegible]	rubidium	83	Bi	bismuth
38	[illegible]	strontium	84	Po	polonium
39	Y	yttrium	85	At	astatine
40	Zr	zirconium	86	Rn	radon
41	Nb	niobium	87	Fr	francium
42	Mo	molybdenum	88	Ra	radium
43	Tc	technetium	89	Ac	actinium
44	Ru	ruthenium	90	Tn	thorium
45	Rh	rhodium	91	Pa	protactinium
46	Pd	palladium	92	U	uranium

List of Elements (continued)

ATOMIC NUMBER	SYMBOL	NAME
93	Np	neptunium
94	Pu	plutonium
95	Am	americium
96	Cm	curium
97	Bk	berkelium
98	Cf	californium
99	ES	einsteinium
100	Fm	fermium
101	Md	mendelevium
102	No	nobelium
103	Lr	lawrencium



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1 Introduction

The U.S. Atomic Energy Commission (AEC) used the Nevada Test Site (NTS), between January 1951 and January 1975, for conducting nuclear weapons tests, nuclear rocket engine development, nuclear medicine studies, and for other nuclear and nonnuclear experiments. Beginning in mid-January 1975, these activities became the responsibility of the U.S. Energy Research and Development Administration. Two years later this organization was merged with other energy-related agencies to form the U.S. Department of Energy (DOE).

Atmospheric weapons tests were conducted periodically at the NTS from January 1951 through October 1958, followed by a test moratorium which was in effect until September 1961. Since then all nuclear detonations at the NTS have been conducted underground, with the expectation of containment, except the above-ground and shallow underground tests of Operation Sunbeam and cratering experiments conducted under the Plowshare program between 1962 and 1968.

Prior to 1954, an offsite radiation surveillance program was performed by personnel from the Los Alamos Scientific Laboratory and the U.S. Army. Beginning in 1954, and continuing through 1970, this program was conducted by the U.S. Public Health Service (PHS). When the U.S. Environmental Protection Agency (EPA) was formed in December 1970, certain radiation responsibilities from several federal agencies were transferred to it, including the Offsite Radiological Safety Program (ORSP) of the PHS. Since 1970, the EPA Environmental Monitoring Systems Laboratory-Las Vegas (EMSL-LV) has conducted the ORSP, both in Nevada and at other U.S. nuclear test sites, under interagency agreements (IAGs) with the DOE or its predecessor agencies.

Since 1954, the three major objectives of the ORSP have been:

- Assuring the health and safety of the people living near the NTS.
- Measuring and documenting levels and trends of environmental radiation or radioactive contaminants in the vicinity of atomic testing areas.
- Verifying compliance with applicable radiation protection standards, guidelines, and regulations.

Offsite levels of radiation and radioactivity are assessed by gamma-ray measurements using pressurized ion chambers (PICs) and thermoluminescent dosimeters (TLDs); by sampling air, water, milk, food crops, other vegetation, soil, and animals; and by human exposure and biological assay procedures.

Before each nuclear test at the NTS, EPA radiation monitoring technicians are stationed in offsite areas most likely to be affected by an airborne release of radioactive material. These technicians use trucks equipped with radiation detectors, samplers, and supplies and are directed by two-way radio from the control point at the NTS.

1.1 Program Description

The EPA EMSL-LV Nuclear Radiation Assessment Division (NRD) provides scientific and technical support to the DOE's nuclear weapons testing program at the NTS and other nuclear testing sites through an IAG. The primary objective of EPA's activities is protection of the health and safety of the offsite resident population. This objective is accomplished through monitoring and documentation of environmental levels of radiation in the areas around the NTS, monitoring of people in the offsite area, calculating committed effective radiation dose to offsite residents most likely to be exposed, maintaining emergency response capabilities, and fostering community involvement and education in radiation-related issues.

Emergency response capabilities are maintained in readiness for each nuclear weapons test conducted at the NTS. Monitoring technicians are deployed for each test and senior EPA personnel serve on the Test Controller's Scientific Advisory Panel. Tests are only conducted when meteorological conditions are such that any release would be carried towards sparsely populated, controllable areas. Should a release occur, EPA monitoring technicians would deploy mobile monitoring instruments, assist state and local officials in implementing protective actions, and collect samples for

prompt analysis. Hours before each test, Weather Service Nuclear Support Office personnel and, if requested, an instrumented aircraft gather meteorological data for use by the Test Controller's Advisory Panel in judging the safety of executing the test. A second aircraft carries radiation detectors. In the unlikely event of a significant release of radioactivity following a nuclear weapons test, the equipment on the aircraft would enable rapid sampling and analysis of a radioactive cloud. Data gathered by the aircraft are used to assist in deploying field monitoring technicians to downwind areas, to help determine appropriate protective actions, and to perform radiation monitoring and environmental sampling (EPA, 1988a).

The IAG also requires EPA monitoring technicians to conduct monitoring during tests conducted at the Liquefied Gaseous Fuels Spill Test Facility (LGFS-TF) located on the NTS. These spills involve non-radioactive hazardous materials.

Environmental radiation levels are continuously monitored and documented through an extensive environmental surveillance program conducted by EPA in the offsite areas surrounding the NTS. This program is an outgrowth of environmental surveillance activities conducted by the PHS before 1970. The original PHS surveillance program, initiated in 1954, was limited to offsite surveillance during testing activities. Since 1954, the program has grown and evolved to its present configuration. Many historical sampling locations have been retained, resulting in a continuous data record of three decades or longer.

The ORSP consists of several networks to monitor concentrations of radioactive materials (radioisotopes) in air, atmospheric moisture, milk, local foodstuffs, and surface and ground water. Ambient radiation levels are continuously monitored at selected locations using PICs and TLDs. Atmospheric monitoring includes air samplers, noble gas samplers, and atmospheric moisture (tritium-in-air) samplers. Milk, wildlife, domestic animals, and fruits and vegetables are routinely sampled and analyzed. Some residents in the offsite areas participate in TLD and internal dosimetry networks. Ground water on and in the vicinity of the NTS is monitored in the Long-Term Hydrological Monitoring Program (LTHMP); additional monitoring of surface and ground water is conducted under the LTHMP at sites of previous nuclear weapons tests in Alaska, Colorado, Nevada, New Mexico, and Mississippi. Results obtained from these networks are used to calculate an annual radiation dose to the offsite residents.

Another function of the ORSP is to conduct dairy animal and human population censuses. This type of information would be necessary in the unlikely event of a release from the NTS. A dairy animal and population census is continuously updated for areas within 240 miles north and east, and 125 miles south and west of Control Point One (CP-1). The location of CP-1 is shown in Figures 3 and 6, Section 2. The remainder of the Nevada counties and the western most Utah counties are scheduled for dairy animal and population census updates every two years. A partial census was done in 1992. The locations of processing plants and commercial dairy herds in Idaho and the remainder of Utah are obtained from the milk and food sections of the respective state governments.

Community information programs are an integral component of the EPA activities. Town hall meetings or presentations are held at the request of various civic groups. These meetings and 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. In addition, tours of the NTS are arranged for interested parties. In nineteen of the communities around the NTS, Community Radiation Monitoring Program (CRMP) stations have been established. The CRMP stations are established in prominent locations in the offsite communities and include samplers for several of the surveillance networks (PIC, TLD, and air samplers; many also include noble gas and tritium-in-air samplers). At each CRMP location, a local resident serves as the station manager. The CRMP is a collaborative effort of EPA EMSL-LV, the Desert Research Institute (DRI), the University of Utah, and DOE.

1.2 Report Description

Beginning with Operation Upshot-Knothole in 1953, a report summarizing the monitoring data obtained from each test series was published by the U.S. PHS. For the reactor tests in 1959 and the weapons and Plowshare tests in 1962, data were published only for the tests in which detectable amounts of radioactivity were measured in an offsite area. Publication of the summary data for each six-month period was initiated in 1964. In

1971, the Atomic Energy Commission implemented a requirement (AEC71), subsequently incorporated into Department of Energy Order 5484.1(DOE85), that each agency or contractor involved in major nuclear activities provide an annual comprehensive radiological monitoring report. In 1988, DOE Order 5484.1 was superseded by the General Environmental Protection Program Requirements (Order 5400.1) of the DOE (DOE88). Each annual report summarizes the radiation monitoring activities of the EPA in the vicinity of the NTS and at former nuclear testing areas in the United States. This report summarizes those activities for calendar year 1992.

Section 2 of this report contains a physical description of the NTS and the surrounding areas. Section 3 discusses the external ambient gamma monitoring networks, including the TLD Network, the PIC Network, and a comparison of the two monitoring technologies. Section 4 discusses the atmospheric monitoring networks including the Air Surveillance Network, the Tritium in Atmospheric Moisture Network, and the Noble Gas Sampling Network. Section 5 addresses foodstuffs that could be consumed by residents living close to the NTS. This includes the Milk Surveillance Network, the Animal Investigation Program, and a discussion of fruits and vegetables. Section 6 discusses the Internal Dosimetry Program. The LTHMP is discussed in Section 7. Each of the monitoring network sections includes a description of the network design, a discussion of the procedures, a presentation of the results, and a section on quality assurance/quality control (QA/QC) methods. Section 8 contains a calculation of potential radiation dose to residents living in the offsite area. Section 9 contains a discussion of the support the ORSP provides for weapons testing and liquefied gaseous fuels spill tests. Section 10 describes the CRMP and lists the town hall meetings and NTS tours conducted in 1992. A detailed description of the QA program including a discussion of data quality objectives and of QA data analysis, is provided in Section 11. Section 12 contains a discussion of the sample analysis procedures. Section 13 explains our training program. Section 14 contains radiation protection standards for external and internal exposure. Section 15 contains the summary and conclusions.

Although written to meet the terms of the IAG between the EPA and the DOE as well as the requirements of DOE Order 5400.1, this report also should be of interest and use to the citizens of Nevada, Utah, and California. State, federal, and local agencies involved in protecting the environment and the health and well-being of the public, and individuals and organizations concerned with environmental quality and the possible release of radioactive contaminants into the biosphere, also may find this report of interest.

2 Description of the Nevada Test Site

The principal activity at the NTS is the testing of nuclear devices to aid in the development of nuclear weapons, proof testing of weapons, and weapons safety and effects studies. The major activity of the EPA's ORSP is radiation monitoring around the NTS. This section provides an overview of the climate, geology, hydrology, and land uses in this generally arid and sparsely populated area of the southwestern United States (Figure 1). The information included should provide an understanding of the environment in which nuclear testing and monitoring activities take place, the reasons for the location of instrumentation, the weather extremes to which both people and equipment are subjected, and the distances traveled by field monitoring technicians in collecting samples and maintaining equipment.

2.1 Location

The NTS is located in Nye County, Nevada, with its southeast corner about 54 miles (90 km) northwest of Las Vegas (Figure 2). It occupies an area of about 1,350 square miles (3,750 square km), varies from 28 to 35 miles (46 to 58 km) in width (east-west) and from 49 to 55 miles (82 to 92 km) in length (north-south). This area consists of large basins or flats about 2,970 to 3,900 feet (900 to 1,200 m) above mean sea level (MSL) surrounded by mountain ranges rising from 5,940 to 7,590 feet (1,800 to 2,300 m) above MSL.

The NTS is surrounded on three sides by exclusion areas, collectively named the Nellis Air Force Base Range Complex, which provides a buffer zone between the test areas and privately owned lands. This buffer zone varies from 14 to 62 miles (24 to 104 km) between the test area and land that is open to the public. In the unlikely event of an atmospheric release of radioactivity (venting), two to more than six hours would elapse, depending on wind speed and direction, before any release of airborne radioactivity would reach private lands.

2.2 Climate

The climate of the NTS and surrounding area is variable, due to its wide range in altitude and its rugged terrain. Most of Nevada has a semi-arid climate characterized as mid-latitude steppe. Throughout the year, water is insufficient to support the growth of common food crops without irrigation.

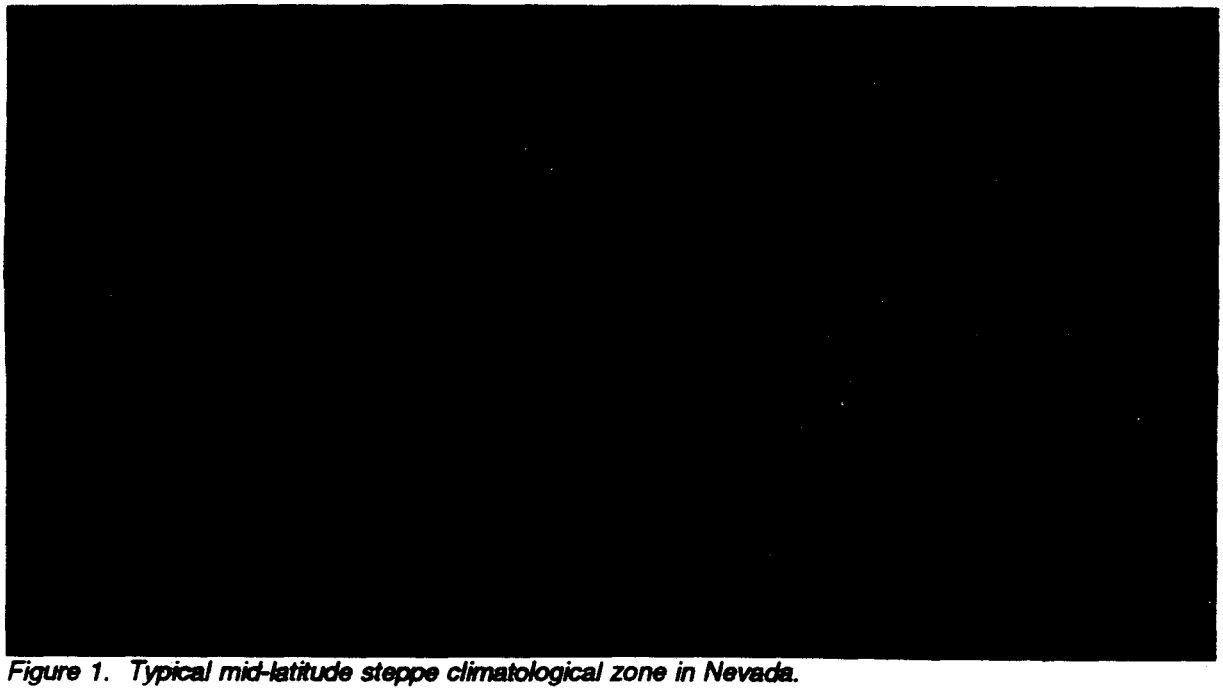

Figure 1. Typical mid-latitude steppe climatological zone in Nevada.

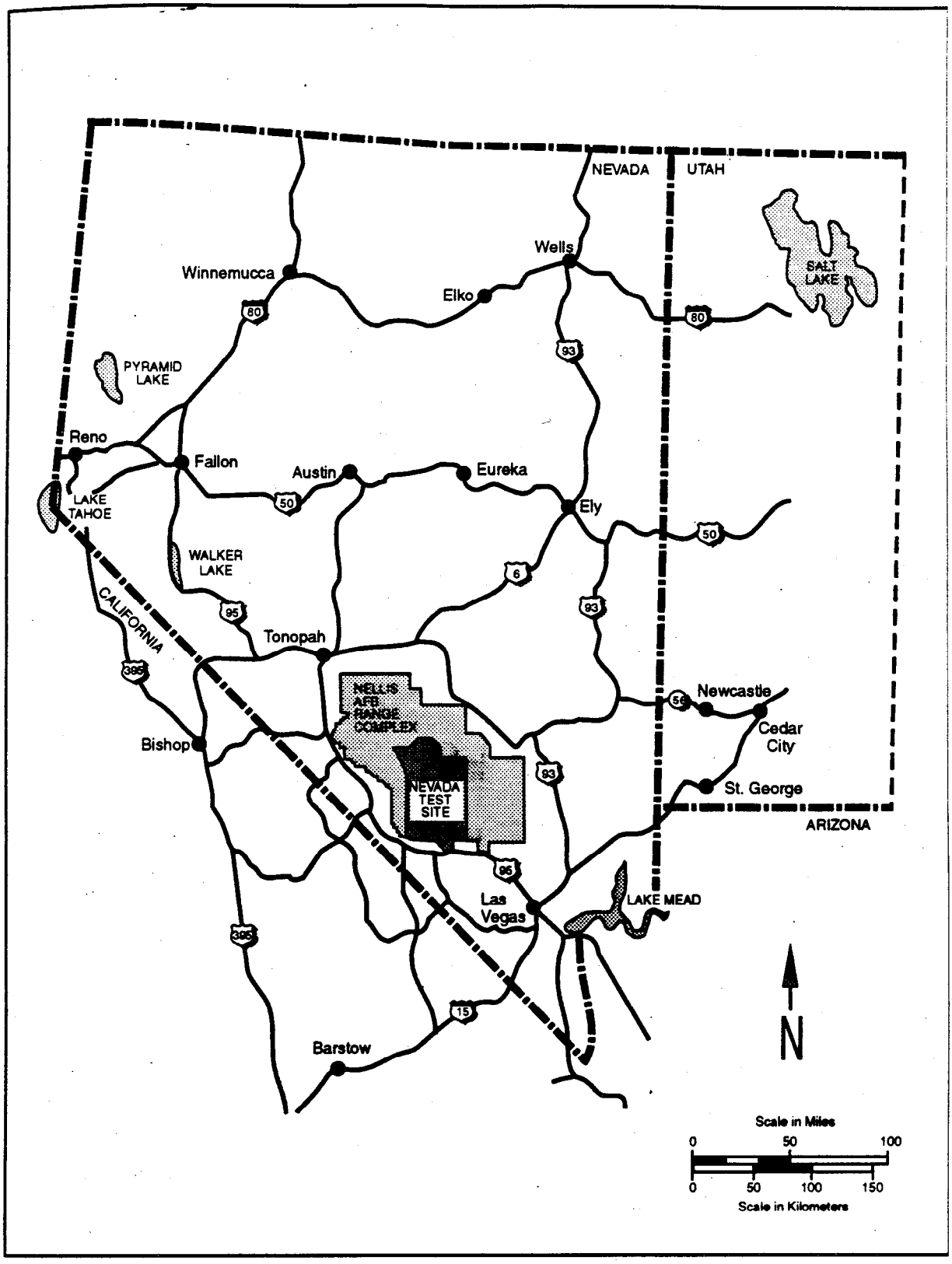

Figure 2. Location of the Nevada Test Site.

Climate may be classified by the types of vegetation indigenous to an area. According to *Nevada Weather and Climate* (Houghton et al., 1975), this method of classification developed by Köppen is further subdivided on the basis of "...seasonal distribution of rainfall and the degree of summer heat or winter cold." Table 1 summarizes the characteristics of climatic types for Nevada.

According to Quiring (1968), the NTS average annual precipitation ranges from about 4 inches (10 cm) at the lower elevations to around 10 inches (25 cm) at the higher elevations. During the winter months, the plateaus may be snow-covered for a period of several days or weeks. Snow is uncommon on the flats. Temperatures vary considerably with elevation, slope, and local air currents. The average daily temperature ranges at the lower altitudes are around 25 to 50°F (-4 to 10°C) in January and 55 to 95°F (13 to 35°C) in July, with extremes of -15°F (-26°C) and 120°F (49°C). Corresponding temperatures on the plateaus are 25 to 35°F (-4 to 2°C) in January and 65 to 80°F (18 to 27°C) in July with extremes of -30°F (-34°C) and 115°F (46°C).

The wind direction, as measured on a 98 ft (30 m) tower at an observation station approximately 7 miles (11 km) north-northwest of CP-1, is predominantly northerly except during the months of May through August when winds from the south-southwest predominate (Quiring, 1968). Because of the prevalent mountain/valley winds in the basins, south to southwest winds predominate during daylight hours of most months. During the winter months, southerly winds predominate slightly over northerly winds for a few hours during the warmest part of the day. These wind patterns may be quite different at other locations on the NTS because of local terrain effects and differences in elevation.

2.3 Hydrology

Two major hydrologic systems shown in Figure 3 exist on the NTS (U.S. Energy Research and Development Administration, 1977). Ground water in the northwestern part of the NTS (the Pahute Mesa area) flows at a rate of 6.6 to 600 feet (2 to 180 m) per year to the south and southwest toward the Ash Meadows discharge area in the Amargosa Desert. Ground water to the east of the NTS

Table 1. Characteristics of Climatic Types in Nevada (from Houghton et al. 1975)

Climate Type	Annual Temperature °F (°C) Winter	Summer	Precipitation inches (cm) Total*	Snowfall	Dominant Vegetation	Percent of Area
Alpine tundra	0 to 15 (-18 to -9)	40 to 50 (4 to 10)	15 to 45 (38 to 114)	Medium to heavy	Alpine meadows	--
Humid continental	10 to 30 (-12 to -1)	50 to 70 (10 to 21)	25 to 45 (64 to 114)	Heavy	Pine-fir forest	1
Subhumid continental	10 to 30 (-12 to -1)	50 to 70 (10 to 21)	12 to 25 (30 to 64)	Moderate	Pine or scrub woodland	15
Mid-latitude steppe	20 to 40 (-7 to 4)	65 to 80 (18 to 27)	16 to 15 (15 to 38)	Light to moderate	Sagebrush, grass, scrub	57
Mid-latitude desert	20 to 40 (-7 to 4)	65 to 80 (18 to 27)	3 to 8 (8 to 20)	Light	Greasewood, shadscale	20
Low-latitude desert	40 to 50 (-4 to 10)	80 to 90 (27 to 32)	2 to 10 (5 to 25)	Negligible	Creosote bush	7

* Limits of annual precipitation overlap because of variations in temperature which affect the water balance.

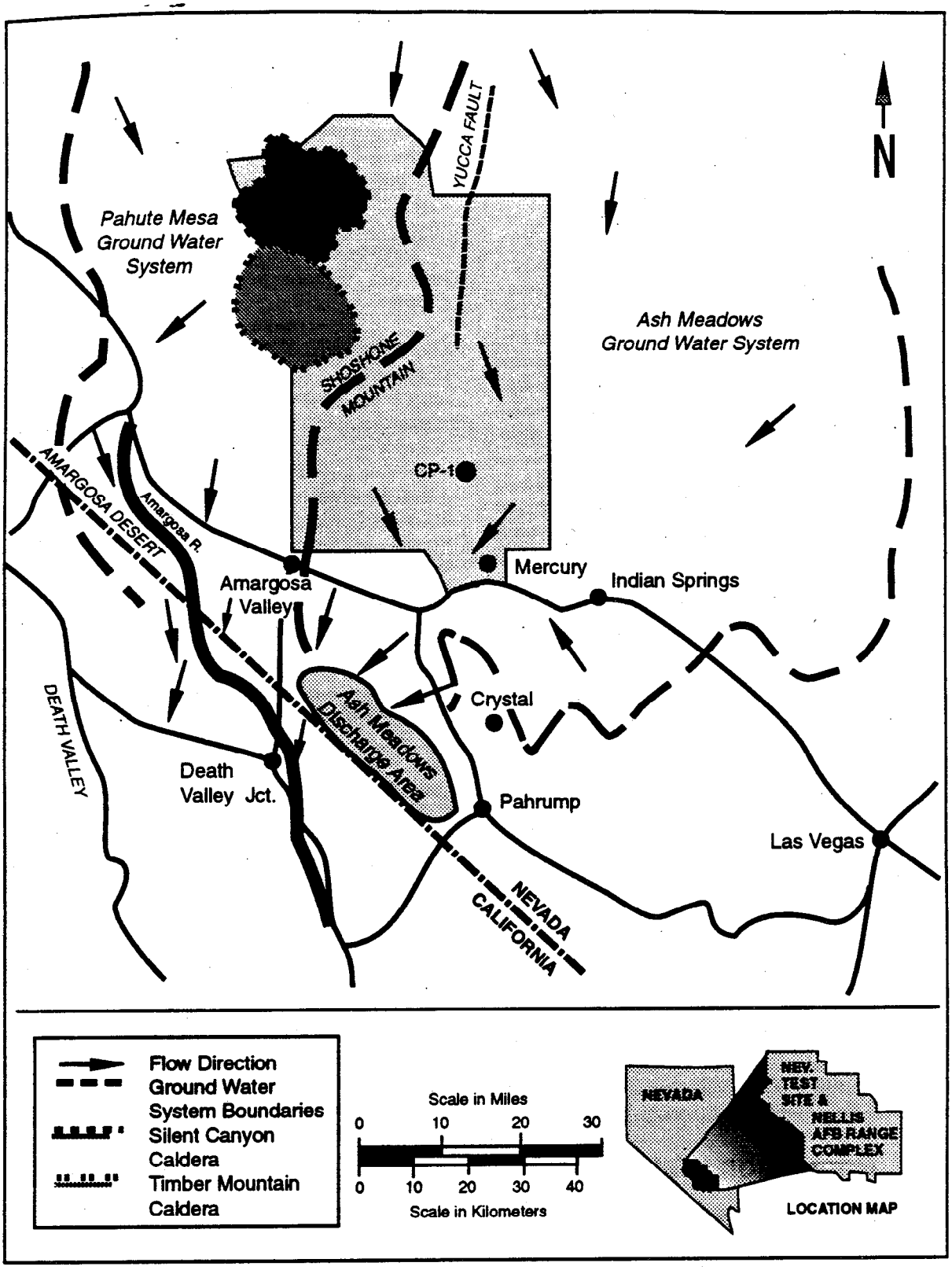

Figure 3. Ground water flow systems around the Nevada Test Site.

moves from north to south at a rate of not less than 6.6 feet (2 m) nor greater than 730 feet (220 m) per year. Carbon-14 analyses of this eastern ground water indicate that the lower velocity is nearer the true value. At Mercury Valley in the extreme southern part of the NTS, the eastern ground water flow shifts to the southwest, toward the Ash Meadows discharge area.

2.4 Regional Land Use

Figure 4 is a map of the off-NTS area showing a wide variety of land uses, such as mining, camping, fishing, and hunting within a 180-mile (300 km) radius of the NTS operations control center at CP-1 (the location of CP-1 is shown on Figures 3 and 6). West of the NTS, elevations range from 280 feet (85 m) below MSL in Death Valley to 14,600 feet (4,420 m) above MSL in the Sierra Nevada. Portions of two major agricultural valleys (the Owens and San Joaquin) are included. 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 the Moapa Valley, supporting irrigation for small-scale but intensive farming of a variety of crops. Grazing is also common in this area, particularly to 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 Nevada within 180 miles (300 km) of the CP-1. Many of the residents have access to locally grown fruits and vegetables.

Recreational areas lie in all directions around the NTS (Figure 4) 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 closed during winter months. Camping and fishing locations to the southeast, south, and southwest are utilized throughout the year. The peak of the hunting season is from September through January.

2.5 Population Distribution

Knowledge of population densities and spatial distribution of farm animals is necessary to assess protective measures required in the event of an accidental release of radioactivity at the NTS.

Figure 5 shows the population of counties surrounding the NTS based on the 1990 Bureau of Census (BOC) count (DOC, 1990). Excluding Clark County, the major population center (approximately 741,459 in 1990), the population density of counties adjacent to the NTS is about 0.7 persons per square mile (0.4 persons per square kilometer). For comparison, the population density of the 48 contiguous states was 70.3 persons per square mile (27 persons per square kilometer) (DOC, 1990). The estimated average population density for Nevada in 1990 was 10.9 persons per square mile (3.1 persons per square kilometer) (DOC, 1986).

The offsite area within 48 miles (80 km) of CP-1 (the primary area in which the dose commitment must be determined for the purpose of this report) is predominantly rural. Several small communities are located in the area, the largest being in Pahrump Valley. Pahrump, a growing rural community with a population of 7,425 (DOC, 1990), is located 48 miles (80 km) south of CP-1. The small residential community of Crystal, Nevada, also located in the Pahrump Valley, is several miles north of the town of Pahrump (Figure 3). The Amargosa farm area, which has a population of about 950, is located 30 miles (50 km) southwest of CP-1. The largest town in the near offsite area is Beatty, which has a population of about 1,500 and is located approximately 39 miles (65 km) 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 (NPS) estimated that the population within the Monument boundaries ranges from a minimum of 200 permanent residents during the summer months to as many as 5,000 tourists including campers on any particular day during the major holiday periods in the winter months, and as many as 30,000 during "Death Valley Days" in November (NPS, 1990). The largest populated area is the Ridgecrest, California area, which has a population of 27,725 and is located 114 miles (190 km) southwest of the NTS. The next largest town is Barstow, California, located 159 miles (265 km) south-southwest of the NTS, with a 1990 population of 21,472. The Owens Valley, where numerous small towns are located, lies 30 miles (50 km) west of Death Valley. The largest town in the Owens Valley is Bishop, California, located 135 miles (225 km) west-northwest of the NTS, with a population of 3,475 (DOC, 1990).

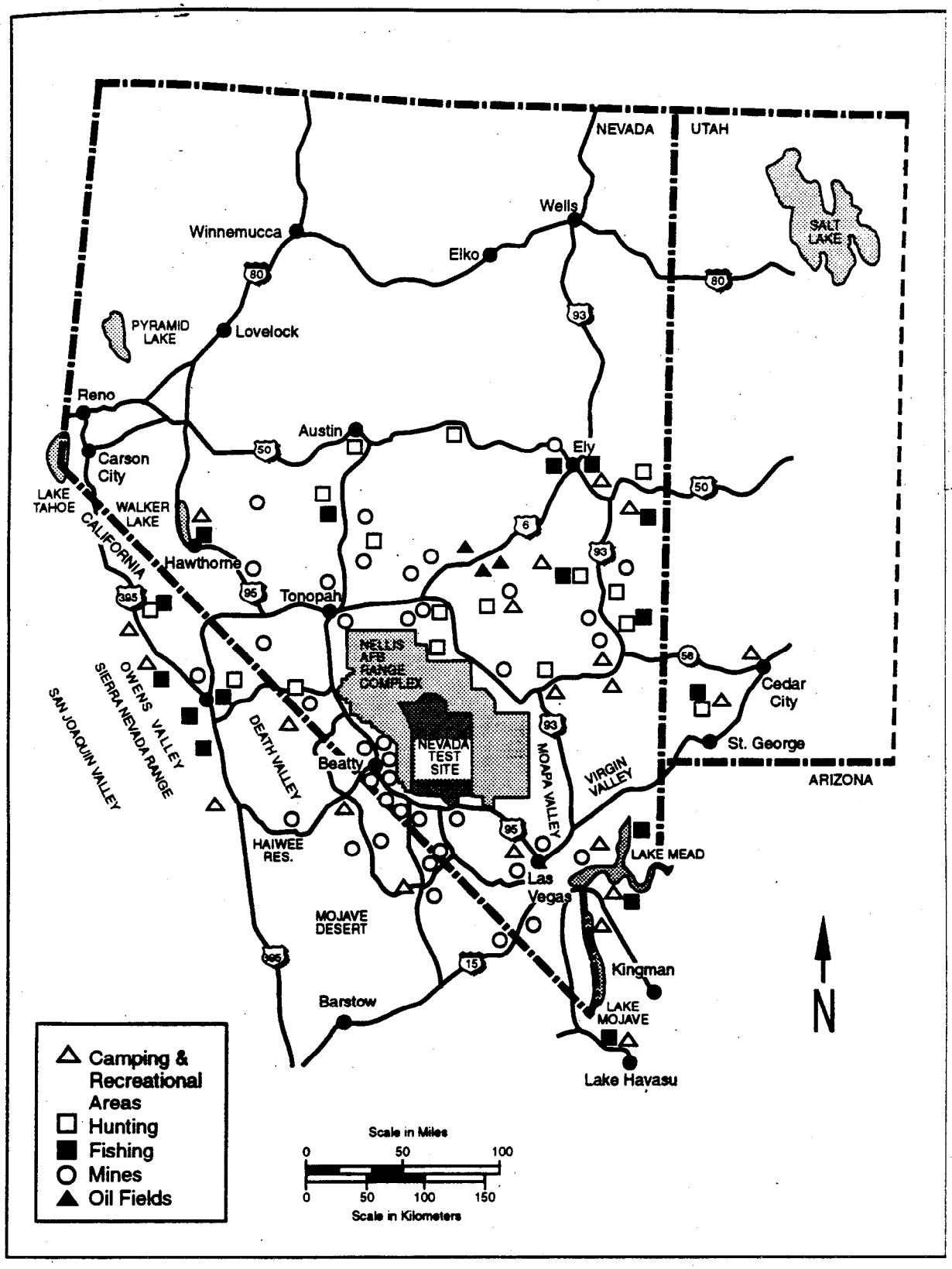

Figure 4. General land use within 180 miles (300 km) of the Nevada Test Site.

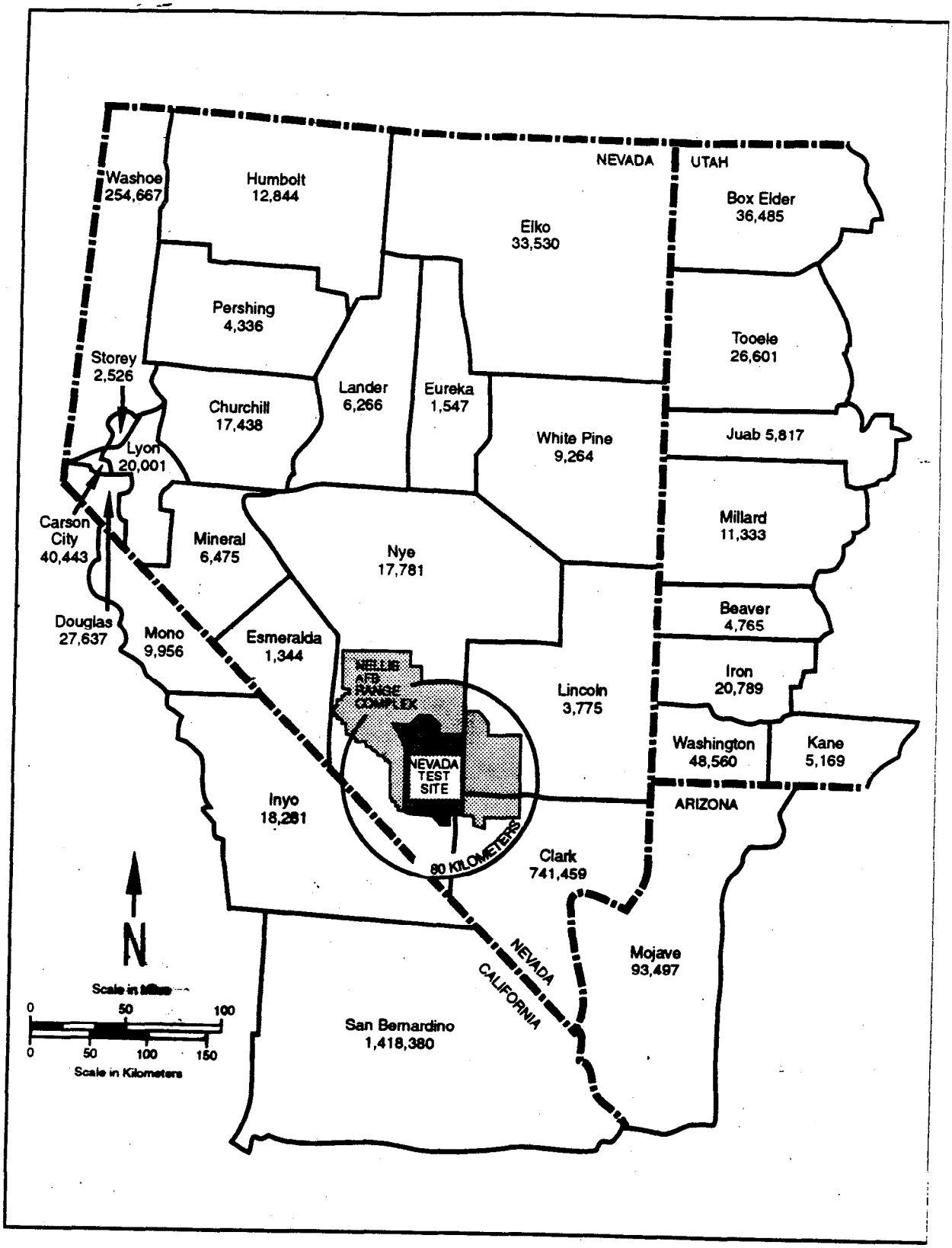

Figure 5. Population of Arizona, California, Nevada, and Utah counties near the Nevada Test Site.

The extreme southwestern region of Utah is more developed than the adjacent part of Nevada. The largest community is St. George, located 132 miles (220 km) east of the NTS, with a 1990 population of 28,502. The next largest town, Cedar City, with a population of 13,443, is located 168 miles (280 km) east-northeast of the NTS (DOC, 1990).

The extreme northwestern region of Arizona is mostly range land except for that portion in the Lake Mead National Recreation Area. In addition, several small communities lie along the Colorado River.

The largest towns in the area are Bullhead City, 99 miles (165 km) south-southeast of the NTS, with a 1990 population of 21,951 and Kingman, located 168 miles (280 km) southeast of the NTS, with a population of 12,722 (DOC, 1990).

Figures 6 through 9 show the most recent estimates of the domestic animal populations in the counties near the NTS. Domestic animal numbers are updated through interim surveys as part of routine monitoring and by periodic resurveys. The numbers given in Figure 6, showing distribution of family milk cows and goats, are determined from these interim surveys. The numbers in Figures 7 to 9 were compiled for Nevada and Utah from the Nevada Agricultural Statistics 1992 report (Nevada Agricultural Statistics Service, 1992) and from the 1992 Utah Agricultural Statistics report (Utah Agricultural Statistics Service, 1992). The numbers in Figures 7 to 9 pertaining to counties in California were received orally from personnel at the California Agricultural Statistics Service.

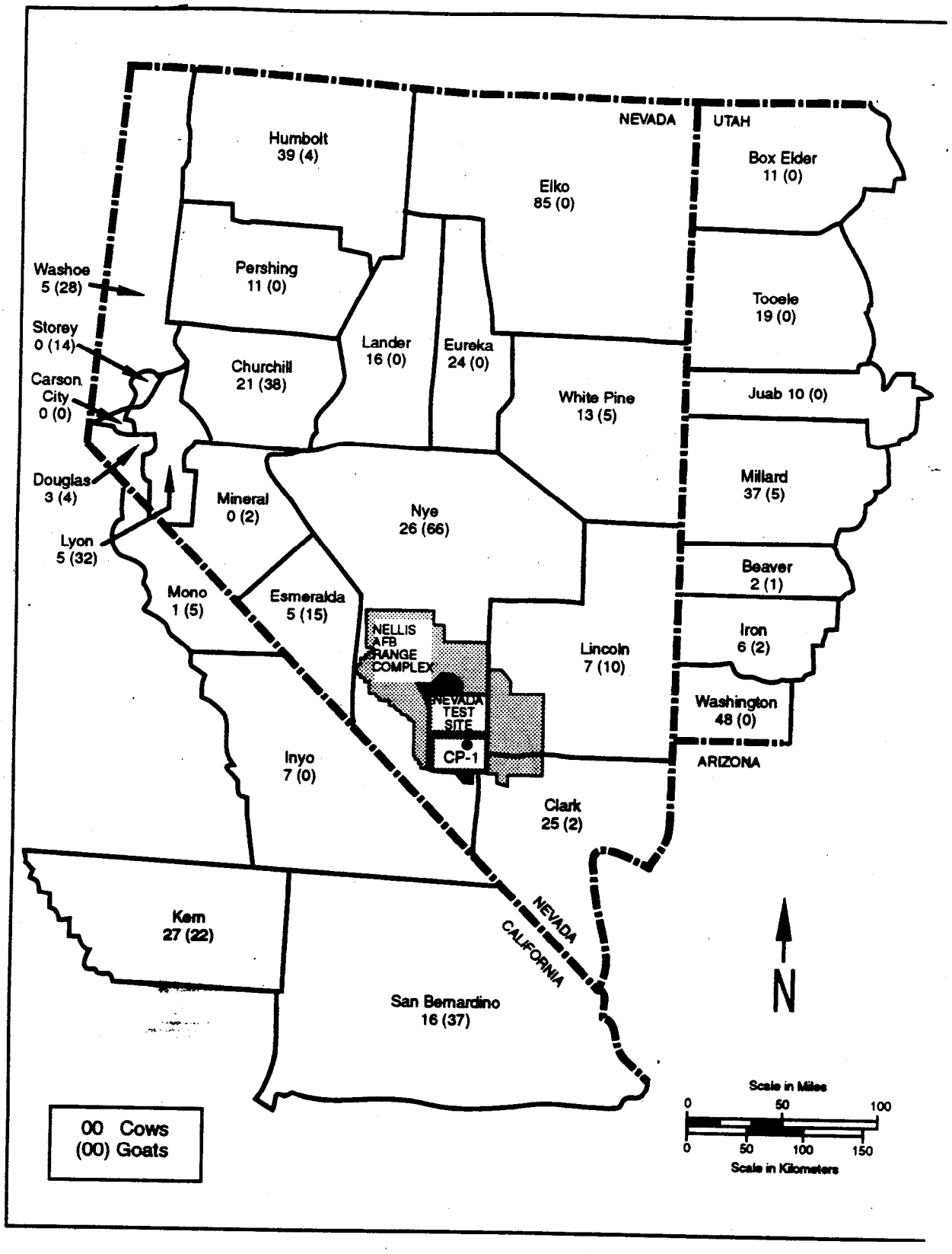

Figure 6. Distribution of family milk cows and goats, by county.

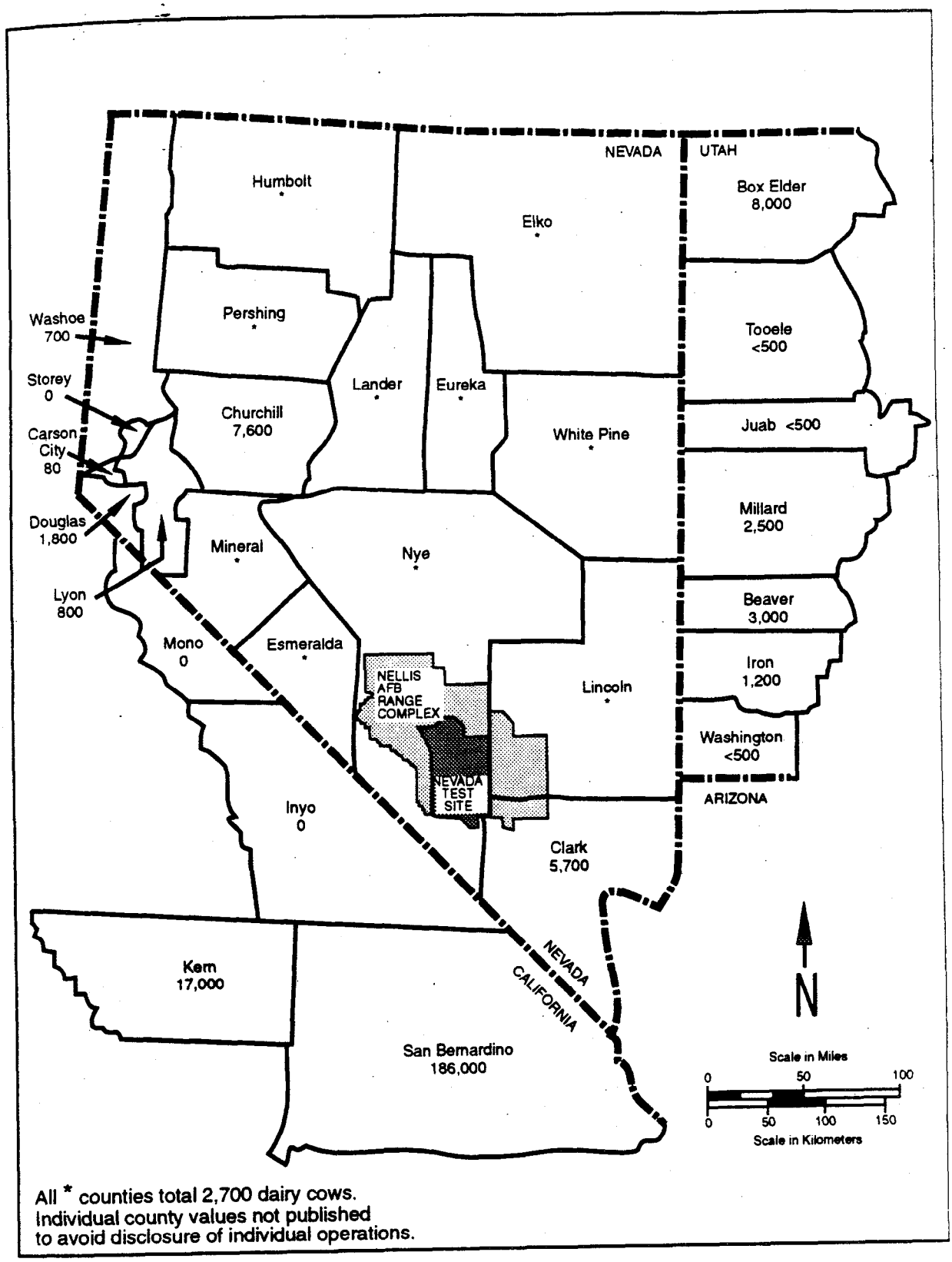

Figure 7. Distribution of dairy cows, by county.

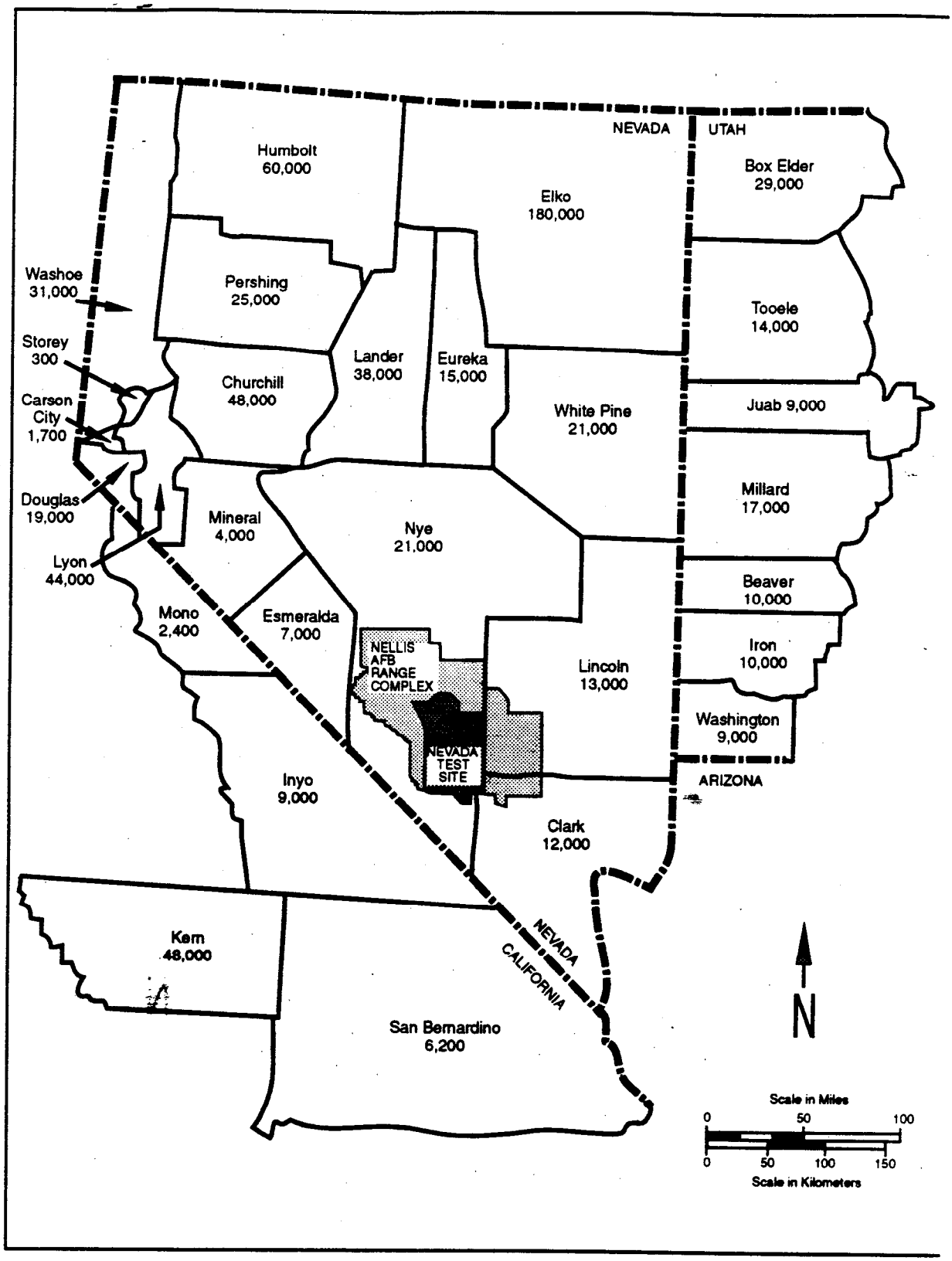

Figure 8. Distribution of beef cattle, by county.

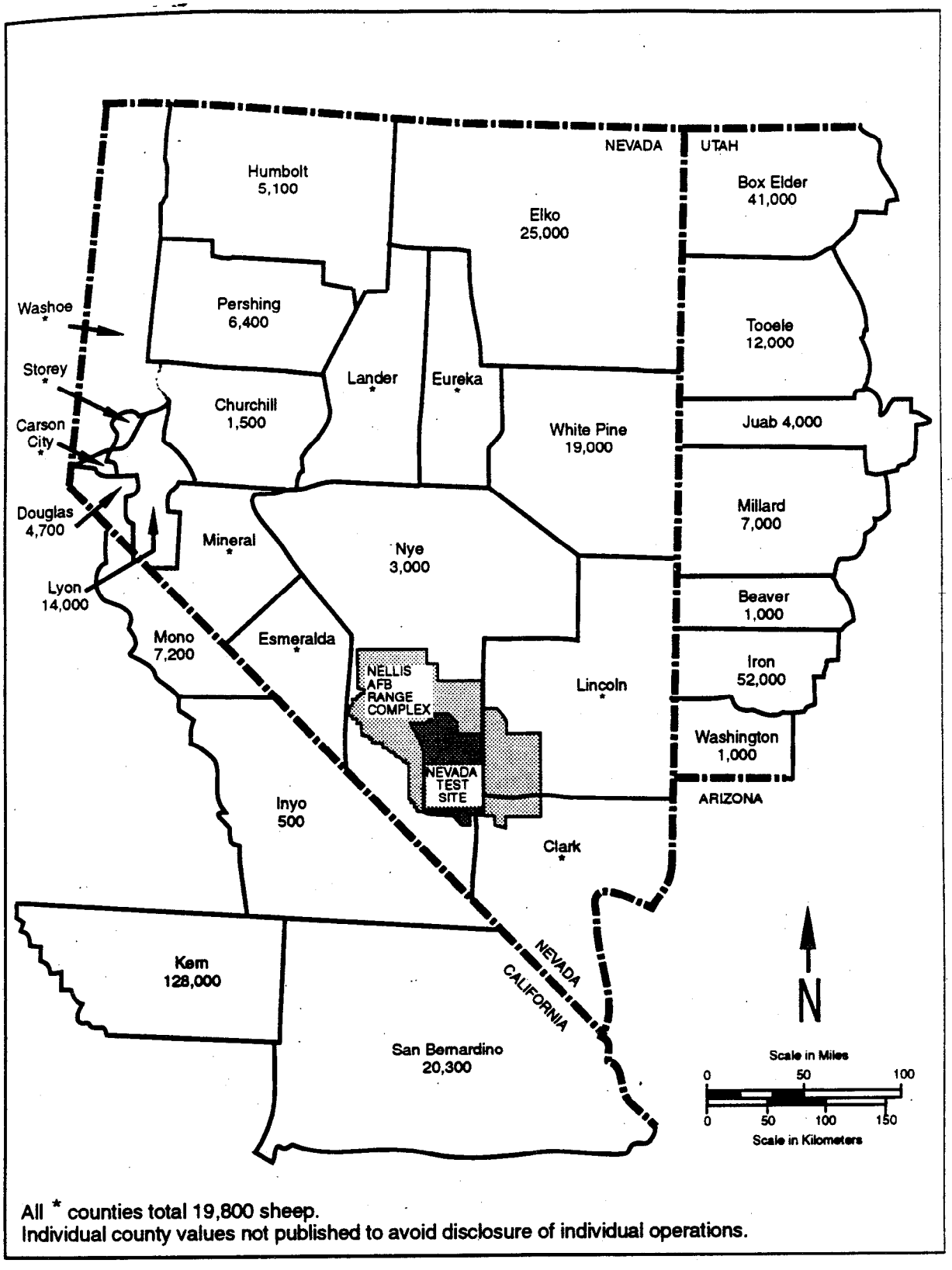

Figure 9. Distribution of sheep, by county.

3 External Ambient Gamma Monitoring

External ambient gamma radiation is measured by the Thermoluminescent Dosimetry (TLD) Network and also by the Pressurized Ion Chamber (PIC) Network. The primary function of the two networks is to detect changes in ambient gamma radiation. In the absence of nuclear testing, ambient gamma radiation rates naturally differ among locations since rates vary with altitude (cosmic radiation) and with radioactivity in the soil (terrestrial radiation). Ambient gamma radiation will also vary slightly at a location due to weather patterns.

3.1 Thermoluminescent Dosimetry Network

The primary function of the EPA EMSL-LV environmental dosimetry program is to define a mechanism for identifying 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 any deviations from data trends. In addition to the environmental TLD program, EPA deploys personnel TLDs to predefined individuals living in areas surrounding the NTS. Information gathered from this program would help define possible exposures to residents in the event of a release from the test site. Basic philosophies for program development for the personnel TLD program are essentially similar to the environmental TLD program.

3.1.1 Design

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 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. The phosphors are behind approximately 17, 300, 300, and 1000 mg/cm^2 of attenuation, respectively. With the use of different phosphors and filtrations, a dose algorithm can be applied to ratios of the different element responses. This process defines the radiation type and energy and provides a mechanism for assessing an absorbed 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. The $CaSO_4$:Tm elements are behind approximately 1000 mg/cm^{2}attenuation. An average of the corrected values for elements two through four gives the total exposure for each TLD. Two UD-814 TLDs are deployed at each station per monitoring period.

In general terms, TLDs operate by trapping electrons at an elevated energy state. After the collection period, each TLD element is heated. When heat is applied to the phosphor, the trapped electrons are released and the energy differences between the initial energies of the electrons and the energies at the elevated state are given off in the form of photons. These photons are then collected using a photomultiplier tube. The number of photons emitted, and the resulting electrical signal, is proportional to the initial deposited energy.

3.1.2 Results of TLD Monitoring

ENVIRONMENTAL DATA:

A network of environmental stations and monitored personnel has been established by EMSL-LV in locations encircling the NTS. Figure 10 shows fixed environmental monitoring locations. Total annual exposures were calculated by dividing all available data by the number of days representing each deployment period where data were available. 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 1992. The total average daily rate is then multiplied by 365 to show the total annual exposure for each station. Detailed results are shown in Appendix A, Table A-1.

Total annual exposures ranged from 57 mR at the station located on the campus of UNLV in Las Vegas, Nevada to 354 mR at the station in Warm Springs, Nevada with a mean annual exposure of 113 mR for all operating locations. The Warm Springs #2 station consistently shows exposure levels higher than all other locations due to the

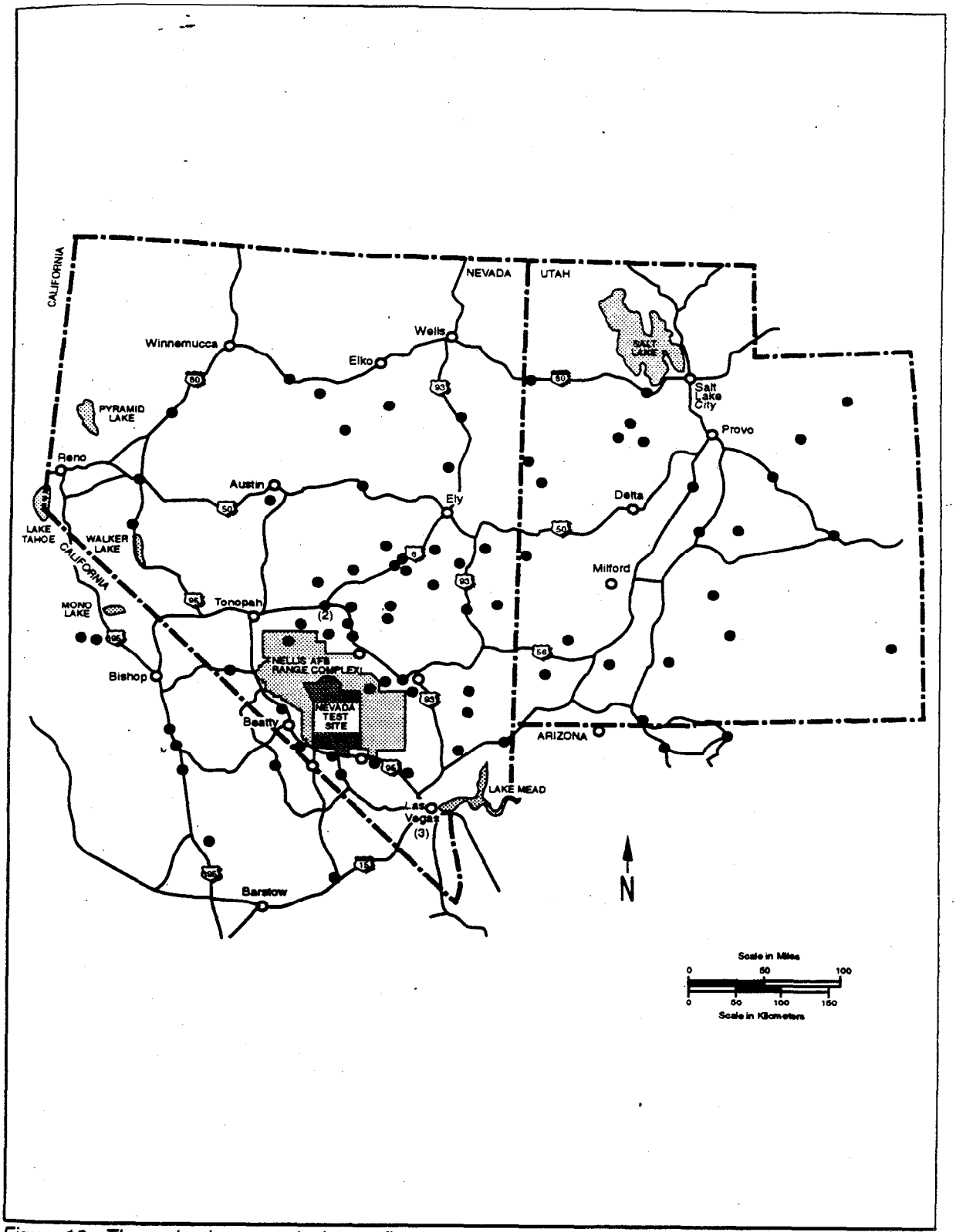

Figure 10. Thermoluminescent dosimetry fixed environmental stations - 1992.

elevated levels of naturally occurring radioactive materials present in the stream near the monitoring location. The next highest annual exposure was 182 mR at Hancock, NV.

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 TLD results were inappropriately subtracted from the station TLD results, reducing the deployment exposure. Operational techniques for defining these transit exposures have since changed to provide higher quality data. A summary of current and past annual exposure data is shown in Appendix A, Figure A-1.

PERSONNEL DATA:

During 1992, a total of 67 offsite personnel were issued TLDs to monitor their annual dose equivalent. Locations of program participants are shown in Figure 11. Detailed results are displayed in Appendix A, Table A-2. This table shows the following information:

- Personnel ID Number: This is a unique number given to each person participating in the program.
- Issue and Return Dates: The actual dates the TLD was issued to and retrieved from each individual.
- Shallow Dose: This represents the dose equivalent at the depth of 0.007 cm in a sphere of soft tissue of a density of 1 g/cm^3 and a diameter of 30 cm.
- Eye Dose: This represents the dose equivalent to the lens of the eye.
- Deep Dose: This represents the dose equivalent at the depth of 1.0 cm in a sphere of soft tissue of a density of 1 g/cm^3 and a diameter of 30 cm.
- Total annual whole body dose equivalent: This is calculated as the total cumulative deep dose over the calendar year.
- Data: This represents the percentage of data available for the year.
- Associated Station: This is the environmental station located nearest the participant's residence.

Total annual whole body absorbed dose equivalent was calculated by summing all available data for the year. All data were used from TLDs that were calibrated within ± 15 days of the beginning or end of the 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 then multiplied by 365 days.

Annual whole body dose equivalents ranged from a low of 103 mrem to a high of 391 mrem with a mean of 187 mrem for all monitored personnel.

3.1.3 Quality Assurance/ Quality Control

During 1992, two calibration instruments were available to support the program. One is a TLD irradiator manufactured by Williston-Felin housing a nominal 1.8 Ci ^{137}Cs source. This irradiator provides for automated irradiations of the TLDs. The second calibration instrument is a nominal 10 Ci ^{137}Cs well type irradiator. Unlike the Williston-Felin irradiators, this well type does not provide automated capabilities. TLD exposures accomplished with the well type irradiator are monitored using a Victoreen E-5000 precision electrometer whose calibration is traceable to the National Institute of Standards and Technology (NIST). The exposure rates of both irradiators have been confirmed by measurement using a precision electrometer which has a calibration traceable to NIST. Panasonic UD-802 dosimeters exposed by these irradiators are used to calibrate the TLD readers and to verify TLD reader linearity. Control dosimeters of the same type as field dosimeters (UD-802 or UD-814) are exposed and read together with the field dosimeters. This provides daily on-line process quality control checks in the form of irradiated controls.

Each magazine containing TLDs to be read normally contains three irradiated control TLDs that have been exposed to a nominal 200 mR at least 24 hours prior to the reading. After the irradiated controls have been read, the ratio of recorded exposure to delivered exposure is calculated and recorded for each of the four elements of the dosimeter. This ratio is applied to all raw element

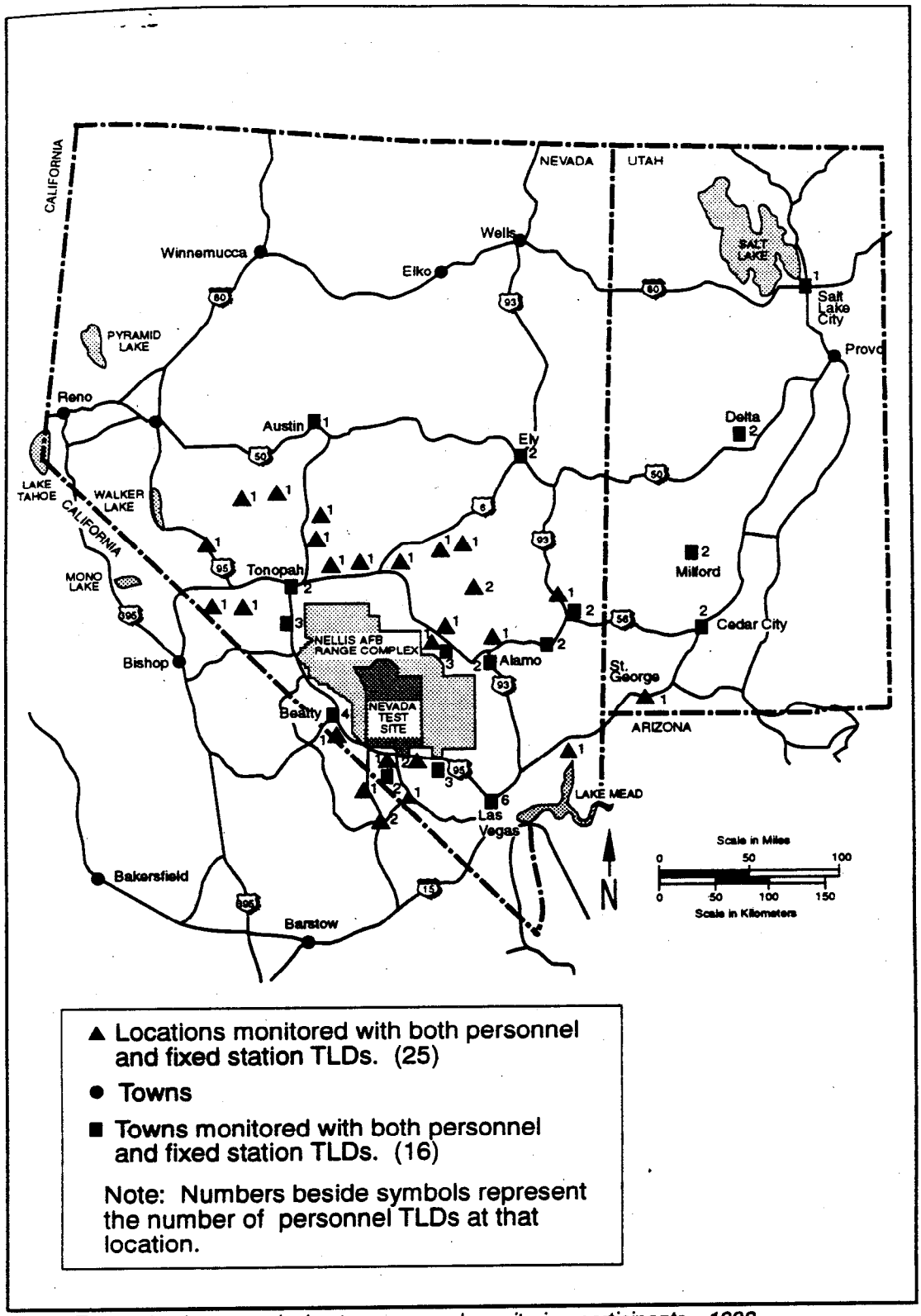

Figure 11. Thermoluminescent dosimetry personnel monitoring participants - 1992.

readings from field and unirradiated control dosimeters to automatically compensate for reader variations.

Prior to being placed in service, element correction factors are determined for all dosimeters. Whenever a dosimeter is read, the mean of the three most recent correction factor determinations is applied to each element to compensate for normal variability (caused primarily by the TLD manufacturing process) in individual dosimeter response.

In addition to irradiated control dosimeters, each group of TLDs is accompanied by three unirradiated control dosimeters during deployment and during return. These unirradiated controls are evaluated at the dosimetry laboratory to ensure that the TLDs did not receive any excess dose while either in transit or storage. The exposure received while either in storage or transit is typically negligible and thus is not subtracted.

An assessment of TLD data quality is based on the assumption that exposures measured at a fixed location will remain substantially constant over an extended period of time. A number of factors will combine to affect the certainty of measurements. The total uncertainty of the reported exposures is a combination of random and systematic components. The random component is primarily the statistical uncertainty in the reading of the TLD elements themselves. Based on repeated known exposures, this random uncertainty for the calcium sulfate elements used to determine exposure to fixed environmental stations is estimated to be approximately ± 3 to 5%. There are also several systematic components of exposure uncertainty, including energy-directional response, fading, calibration, and exposures received while in storage. These uncertainties are estimated according to established statistical methods for propagation of uncertainty.

Accuracy of the overall TLD deployment and processing cycle has been evaluated via the Department of Energy Laboratory Accreditation Program (DOELAP). This process concluded that procedures and practices utilized by the EPA EMSL-LV TLD Laboratory are adequate to detect dose equivalent to individuals greater than 3 mrem above background at the 95% confidence level. This is referred to as the lower limit of detectability. Tests using dosimeters exposed to known radiation levels both in-house and by external organizations have confirmed that the TLD readers exhibit linear performance from the lower limit of detectability through the accident range (500 rads).

3.1.4 Data Management

The TLD data base resides on a Digital Equipment Corporation MicroVAX II directly connected to the two Panasonic TLD readers. Samples are tracked using field data cards and an issue data base tracking system incorporated into the reader control software. Two major software packages are utilized by the TLD network. The first, a proprietary package written and supported by International Science Associates, controls the TLD readers, tracks dosimeter performance, completes necessary calculations to determine absorbed dose equivalent, performs automated QA/QC functions, and generates raw data files and reports. The second software package, locally developed, maintains privacy act information and the identifying data, generates reports in a number of predefined formats, and provides archival storage of TLD results dating to 1971.

3.2 Pressurized Ion Chambers

The Pressurized Ion Chamber (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 anthropogenic activities. In the absence of anthropogenic 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.

3.2.1 Network Design

Twenty-seven PICs are stationed in communities around the NTS and provide near real-time estimates of gamma exposure rates for the ORSP. (The stations located at Terrell's Ranch and Amargosa Valley Community Center became part of the Yucca Mountain Project in December 1991 and, therefore, are not included in this discussion.) The locations of the PICs are shown in Figure 12. Eighteen of the PICs are located at CRMP stations (Section 10.1).

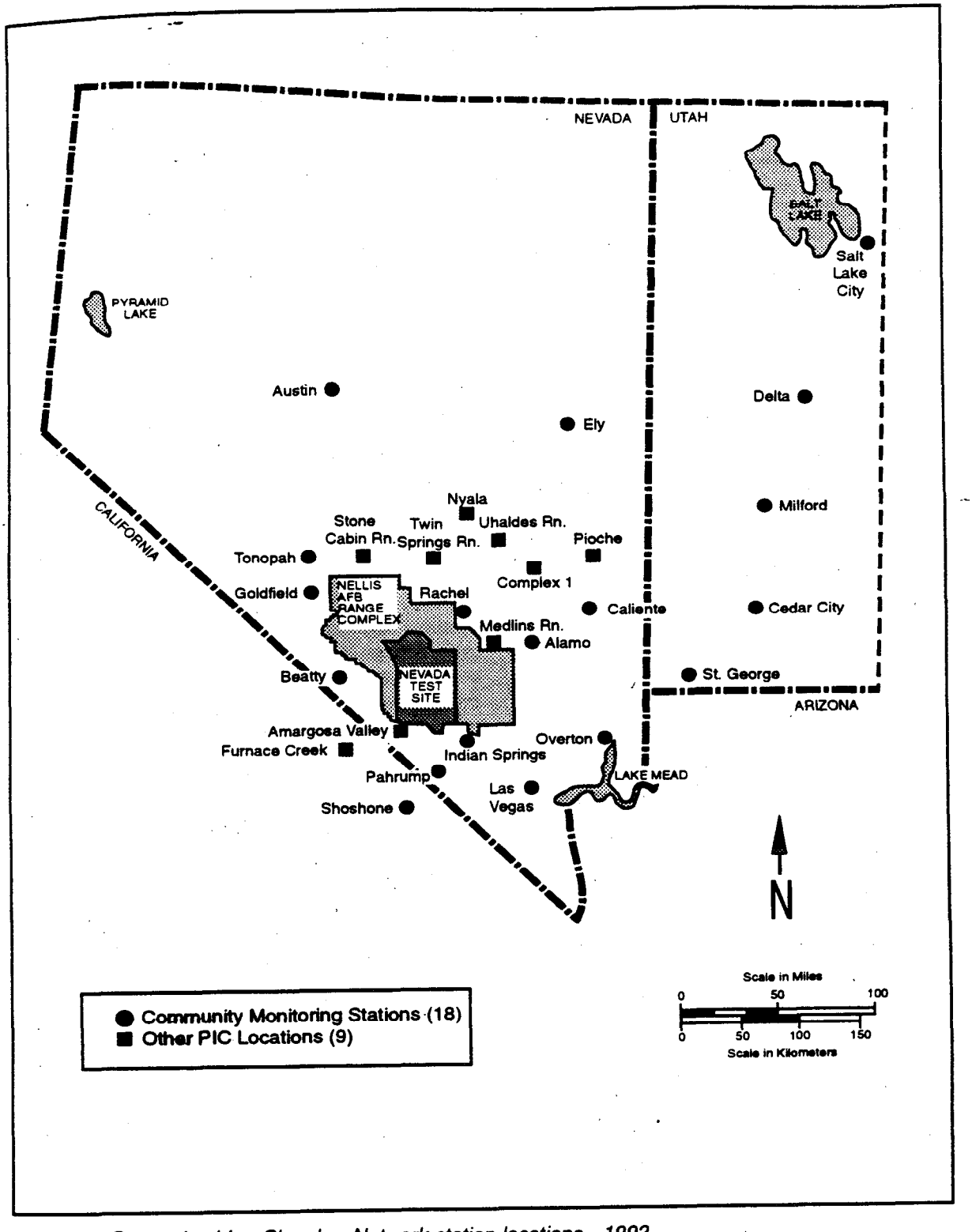

Figure 12. Pressurized Ion Chamber Network station locations - 1992.

3.2.2 Procedures

The PIC Network utilizes 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 atmospheric. 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.

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 (GOES) directly to a receiver earth station at the NTS and from there to the EMSL-LV by dedicated telephone line. Each station routinely transmits data every four hours (i.e., 4-hour average, 1-minute maximum, and 1-minute minimum values) unless the gamma exposure rate exceeds the currently established alarm threshold. When the threshold is exceeded for two consecutive 1-minute samples, 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 CP-1 control room at the NTS and at EMSL-LV. Thus, the PIC Network is able to provide immediate documentation of radioactive cloud passage in the event of an accidental release from the NTS.

In previous years and at the beginning of 1992, the alarm threshold limit was 50 μR/h. During March and April 1992, [illegible] were established for each station by multiplying the normal background rate by two. The new threshold limits range from 12 μR/h for Las Vegas, Nevada to 35 μR/h for Milford, Utah, and Stone Cabin Ranch, Nevada.

In addition to telemetry retrieval, PIC data are also recorded on both magnetic tapes and hard-copy strip charts at 25 of the 27 EPA stations and on magnetic cards for the other two EPA stations. The magnetic tapes and cards, which are collected weekly, provide a backup to the telemetry data and are also useful for investigating anomalies because the data are recorded in smaller increments of time (5-minute averages). The PICs also contain a liquid crystal display, permitting interested persons to monitor 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 4-hour averages 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 weekly average data are issued weekly for posting at each station. These reports indicate the current week's average gamma exposure rate, the previous week's and year's averages, and the maximum and minimum background levels in the U.S.

3.2.3 Results

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 1992, with the exception of the weeks listed in Table 2. Data were unavailable during these weeks due to equipment failure.

Table 3 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 6.0 μR/hr at Las Vegas, Nevada to 19 μR/hr at Austin, Nevada. 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 1991. Total mR/yr measured by this network ranged from 53 mR/yr at Las Vegas to 169 mR/yr at Austin. 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 (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. Figure 13 shows the distribution of the weekly averages from each 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

Table 2. Weeks for which Pressurized Ion Chamber Data were Unavailable

Station	Week Ending	Station	Week Ending
Alamo, Nevada	July 15 July 22 July 28	Nyala, Nevada	February 25 March 11 November 17 November 24
Austin, Nevada	January 14	Pahrump, Nevada	June 16 November 11
Cedar City, Utah	May 12		November 24
Delta, Utah	May 26	Salt Lake City, Utah	February 4 February 18
Furnace Creek, California	June 2	St. George, Utah	February 25 May 12
Las Vegas, Nevada	January 21 January 28		June 16
Medlin's Ranch, Nevada	March 11	Twin Springs, Nevada	December 30

percentiles of the distribution of the weekly averages (i.e., 50 percent of the data fell 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 Goldfield, Nevada show the largest range. From October 1990 until the sensor unit was exchanged in February 1992, the PIC unit at this location had been underestimating the gamma exposure rate. The gamma exposure rates measured from February to December 1992 closely resemble those seen prior to October 1990.

3.2.4 Quality Assurance/Quality Control

Several measures are taken to ensure that the PIC data are of acceptable quality:

- The PICs are calibrated at least once every two years and usually once a year. The DOE requires that the PICs be calibrated every two years.
- Radiation monitoring technicians place a radioactive source of a known exposure on the PICs weekly to check the performance of the units.
- Source check calibration and background exposure rate data are evaluated weekly and compared to historical values.
- Data transmitted via the telemetry system are compared to the magnetic tape data on a weekly basis to check that both systems are reporting the same numbers. Whenever weekly averages from the two sets of numbers are not in agreement, the cause of the discrepancy is investigated and corrected.

A data quality assessment of the PIC data is given in Section 11, Quality Assurance.

3.3 Comparison of TLD Results to PIC Measurements

A comparison was conducted between the 1992 TLD data and the 1992 PIC data. This comparison showed only minor fluctuations between the two sets of data. PIC data compared to TLD data ranged from a low of a 10% difference at Overton, Nevada to a high of a 25% difference at Cedar City, Utah, with a mean deviation of +5%. A visual representation of this comparison is shown in Appendix A, Figure A-2.

In previous years, the comparison between the TLD and the PIC data showed a uniform under-response of the TLD results. It is now believed that this under-response was due to subtracting results from transit control dosimeters from the environmental TLD results. This process was discussed in Section 3.1.2.

Table 3. Summary of Weekly Gamma Exposure Rates as Measured by Pressurized Ion Chamber - 1992

Station	Number of Weekly Averages	Gamma Exposure Rate (µR/hr)					Total mR/yr	1991 Mean (µR/hr)
		Maximum	Minimum	Arithmetic Mean	Standard Deviation	Median		
Furnace Creek, CA	51	10.8	9.9	10.1	0.18	10.0	88	10.1
Shoshone, CA	52	12.5	11.5	11.9	0.24	12.0	105	11.8
Alamo, NV	49	14.1	13.1	13.7	0.30	13.7	120	13.4
Amargosa Valley, NV	52	16.6	13.7	14.4	0.54	14.2	126	14.0
Austin, NV	51	20.2	16.0	19.3	1.05	19.8	169	17.4
Beatty, NV	52	17.0	14.5	16.0	0.50	16.0	140	16.3
Caliente, NV	52	15.3	13.3	14.4	0.42	14.2	126	14.3
Complex I, NV	52	16.7	14.5	15.8	0.41	15.9	139	15.9
Ely, NV	52	13.4	11.9	12.6	0.41	12.5	110	12.3
Goldfield, NV	52	15.4	10.4	14.5	1.03	14.9	127	12.8
Indian Springs, NV	52	10.1	8.5	8.9	0.27	9.0	78	8.7
Las Vegas, NV	50	6.3	5.3	6.0	0.12	6.0	53	5.9
Medlin's Ranch, NV	51	16.0	15.0	15.8	0.28	15.9	138	15.8
Nyala, NV	48	12.7	11.2	11.9	0.36	11.9	104	12.4
Overton, NV	52	9.3	8.5	9.0	0.16	9.0	79	8.9
Pahrump, NV	48	8.1	7.0	7.7	0.39	7.9	67	7.9
Pioche, NV	52	12.9	10.8	12.0	0.35	12.0	105	11.8
Rachel, NV	52	16.9	15.0	16.2	0.37	16.1	142	15.9
Stone Cabin Ranch, NV	52	18.9	16.4	17.6	0.59	17.5	154	17.6
Tonopah, NV	52	17.8	15.0	16.9	0.51	17.0	148	16.7
Twin Springs, NV	51	17.6	16.2	16.7	0.37	16.6	146	16.7
Uhalde's Ranch, NV	52	18.8	14.6	17.4	1.15	18.0	152	17.0
Cedar City, UT	51	14.1	10.2	12.3	1.12	12.9	108	10.6
Delta, UT	51	12.8	11.3	12.1	0.24	12.0	106	11.9
Milford, UT	52	18.3	16.6	17.4	0.37	17.3	152	17.4
Salt Lake City, UT	50	11.2	10.4	11.0	0.15	11.0	96	10.9
St. George, UT	49	9.5	8.0	8.4	0.42	8.3	74	8.9

Note: Multiply µR/hr by 2.6×10^{-10} to obtain C/kg.hr

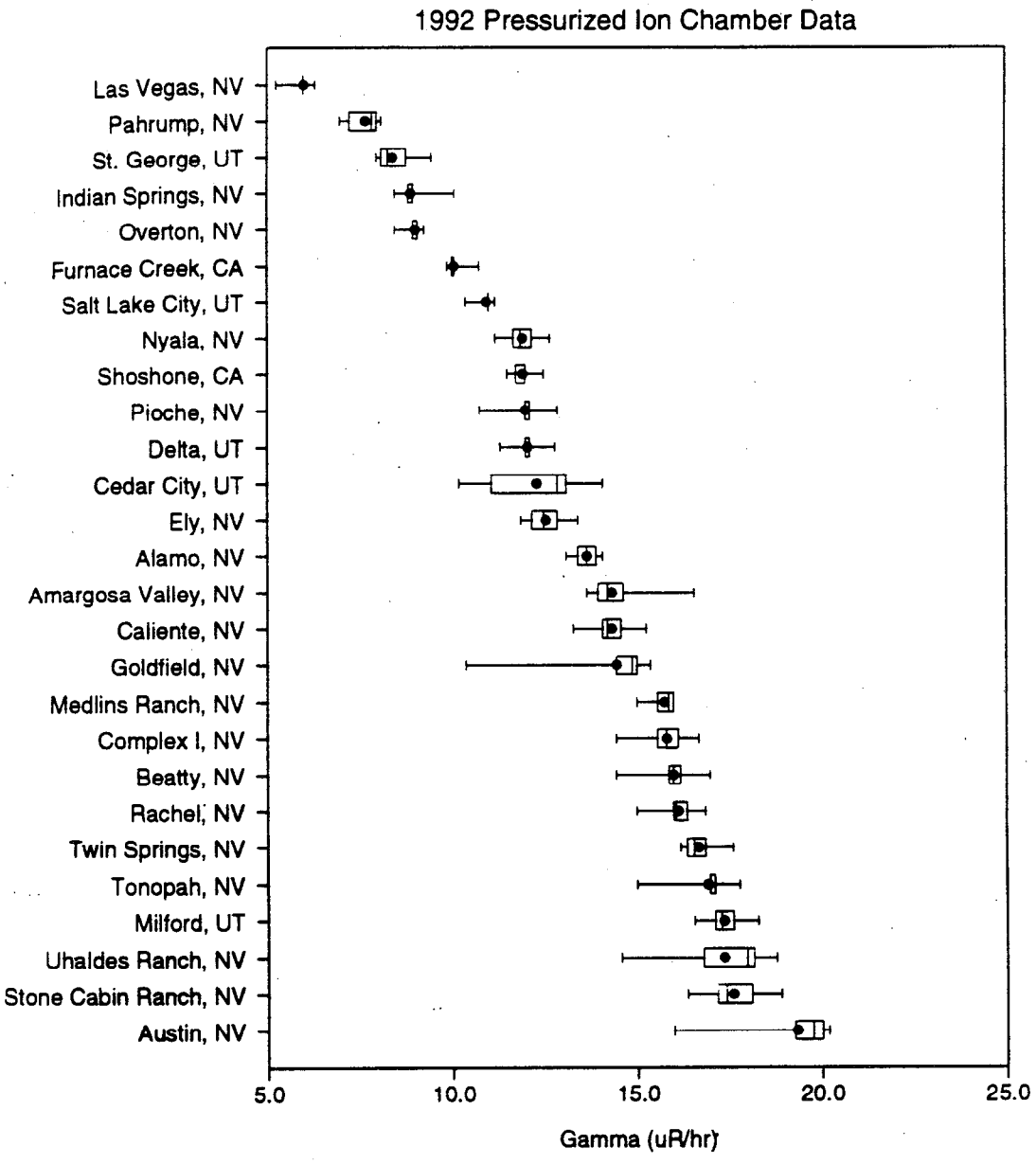

Figure 13. Distribution of the weekly averages from each Pressurized Ion Chamber Network station - 1992.

4 Atmospheric 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 radiation 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 atmospheric monitoring networks were designed to monitor the areas within 350 kilometers (210 miles) of the NTS. These continuously operating networks are supplemented by standby networks which cover the contiguous states west of the Mississippi River.

Many of the data collected from the atmospheric monitoring networks fall below the minimum detectable concentration (MDC). Averages of data presented in this chapter were calculated including measured results below MDCs. All of the data collected from the atmospheric monitoring networks reside on a VAX computer in the Sample Tracking Data Management System (STDMS).

4.1 Air Surveillance Network

4.1.1 Design

In 1992, the Air Surveillance Network (ASN) consisted of 30 continuously operating sampling stations located in areas surrounding the NTS (see Figure 14 for sampling locations). Complementing the ASN, the Standby Air Surveillance Network (SASN) consisted of 77 samplers located in contiguous states west of the Mississippi River (see Figure 15 for standby station locations). Each state had at least one standby sampler which was operated continuously for one week each quarter by local residents or state and municipal health department personnel. Locations of stations were dependent upon the availability of electrical power and the willingness of a local resident to operate the equipment at stations distant from the NTS.

There were no changes in the ASN in 1992; the last major network change was reassignment of three stations to the Yucca Mountain Program on December 1, 1991. The only change in the standby network was the reactivation of an air sampler in Lida, Nevada in the second quarter of 1992.

The air sampler at each station was equipped to collect particulate radionuclides on fiber prefilters and gaseous radioiodines in charcoal cartridges. Prefilters and charcoal cartridges collected from all ASN and prefilters collected from all SASN stations received complete analyses at EMSL-LV. Charcoal cartridges are collected from the SASN stations and would be available for analyses should the need arise.

4.1.2 Procedures

At each ASN station, samples of airborne particulates are collected as air is drawn through 5 cm (2.1 in) diameter, glass-fiber filters (prefilters) at a flow rate of about 80 m^3 (2800 ft^3) per day. Filters are exchanged after sampler operation periods of about one week (approximately 560 m^3 or 20,000 ft^3). Activated charcoal cartridges placed directly behind the filters to collect gaseous radioiodines are exchanged at the same time as the filters.

Duplicate air samples were obtained weekly from various stations. Four air samplers, which are identical to the ASN station samplers, were rotated between ASN stations for three to four week periods. The results of the duplicate field sample analyses are given in Section 11 as part of the data quality assessment.

At EMSL-LV, both the prefilters and the charcoal cartridges are initially analyzed by high resolution gamma spectrometry. Each of the prefilters is then analyzed for gross beta activity. Gross beta analysis is performed on the prefilters 7 to 14 days after sample collection to allow time for the decay of naturally occurring radon-thoron daughter products. Gross beta analysis is used to detect trends in atmospheric radioactivity since it is more sensitive than gamma spectrometry for this purpose. Selected prefilters are then composited (combined) and analyzed for plutonium isotopes. Additional information on the analytical procedures is provided in Section 12.

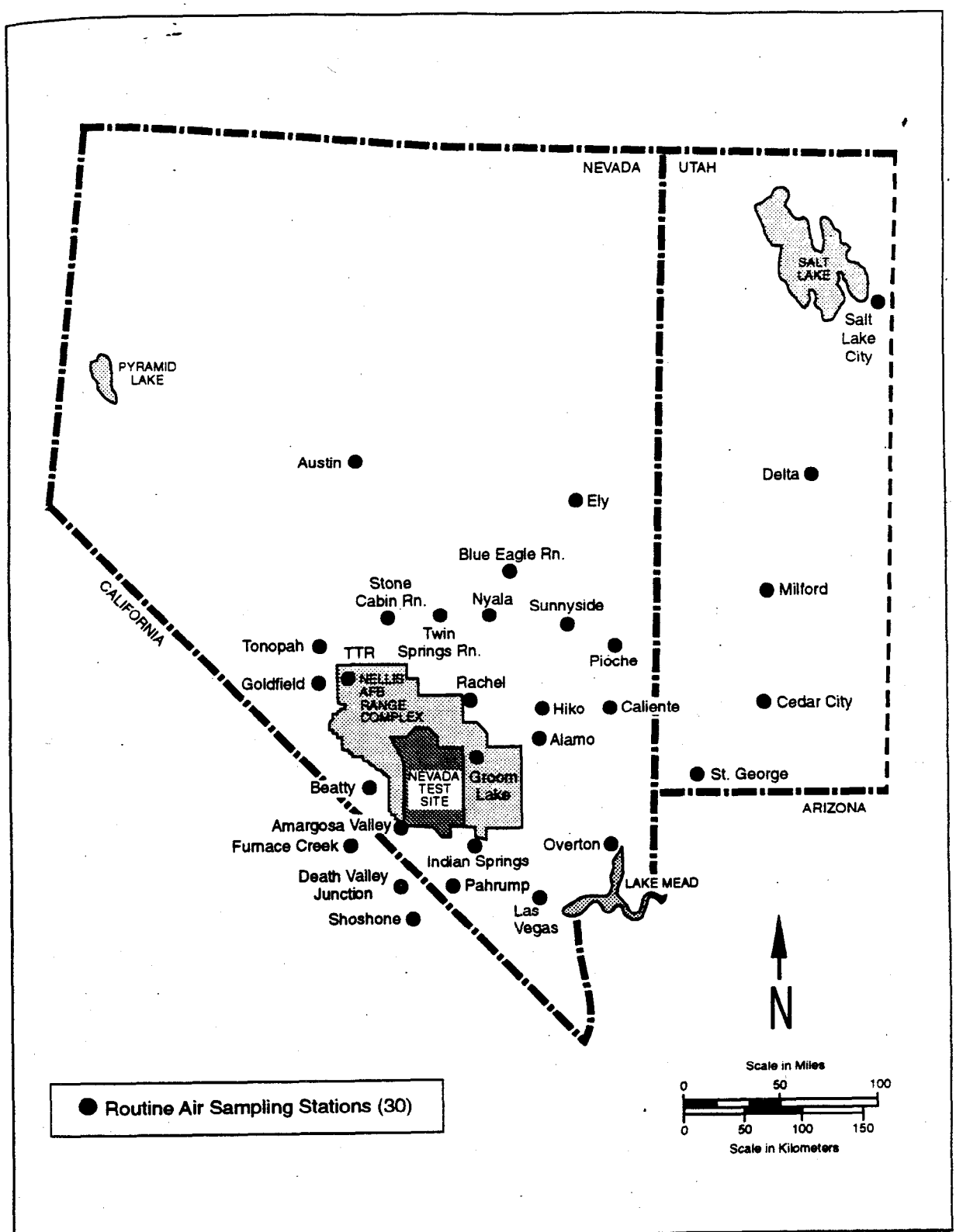

Figure 14. Air Surveillance Network stations - 1992.

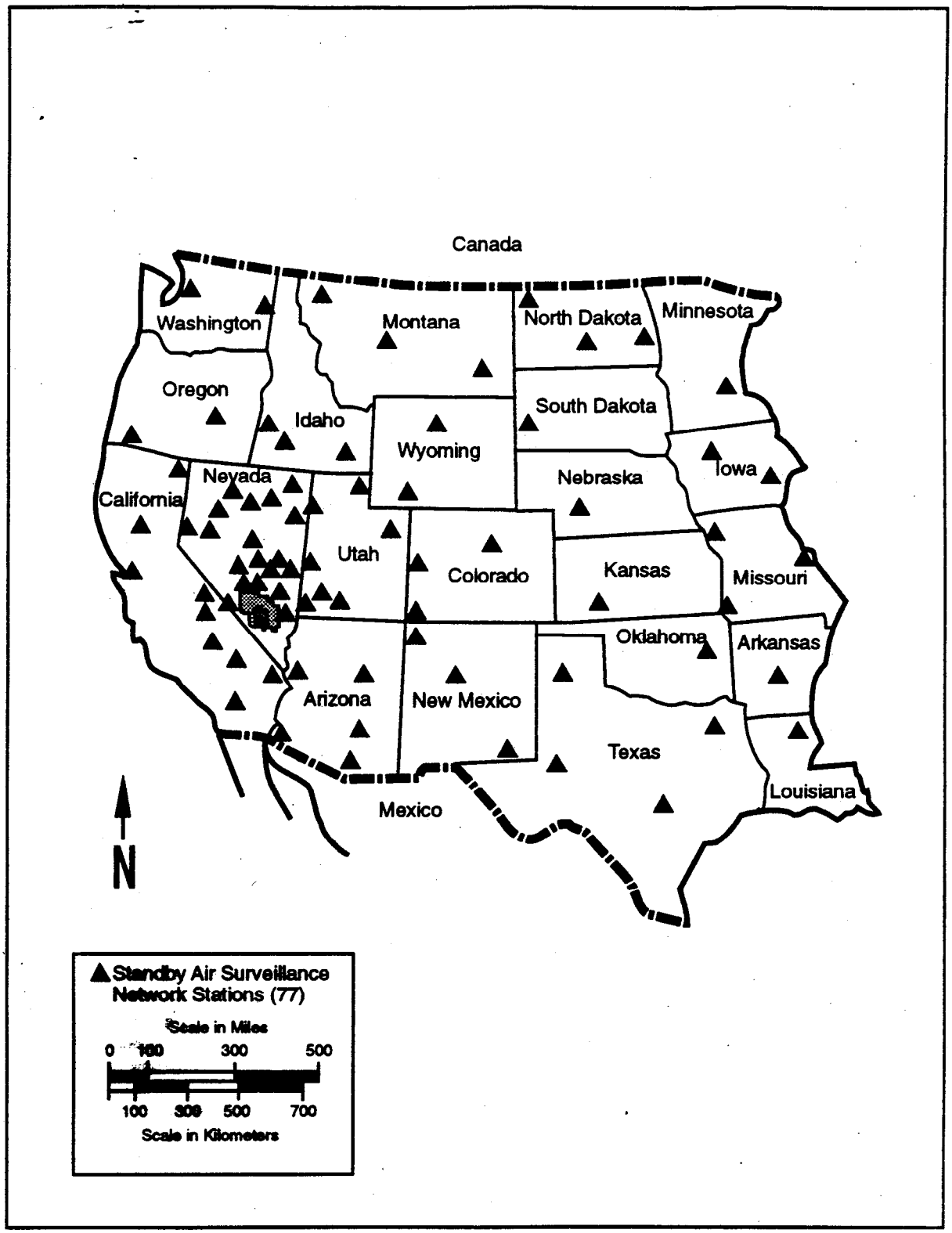

Figure 15. Standby Air Surveillance Network stations - 1992.

Selected air prefilters were also analyzed for plutonium isotopes. Prefilters are composited monthly for each of four ASN stations (Alamo, Amargosa Valley, Las Vegas, and Rachel, Nevada) and are composited quarterly for two SASN stations in each of 13 states: Arizona, California, Colorado, Idaho, Missouri, Montana, New Mexico, North Dakota, Oregon, Texas, Utah, Washington, and Wyoming. Beginning January 1, 1992, plutonium analyses of prefilters from the ASN sampler at Salt Lake City, Utah, were discontinued.

4.1.3 Results

The majority of ASN and SASN prefilters and cartridges analyzed by gamma spectrometry were gamma-spectrum negligible (i.e., no gamma-emitting radionuclides were detected). Naturally occurring ^{7}Be averaging 0.29×10^{-12} µCi/mL was the only radionuclide occasionally detected. The principal means of ^{7}Be production is from spallation (splitting) of ^{16}O and ^{14}N by cosmic rays in the atmosphere.

Alpha and beta results for 64 samples were not included in the data analysis. These results were excluded because they met one or more of the following criteria: sampling duration of greater than 14 days, total volume of less than 400 m^3, average flow rate less than 2.9 m^3/hr or greater than 4.0 m^3/hr, or power outage lasting more than one-third of sampling interval length. All remaining results were used in data analysis and are presented in tables in this report.

As in previous years, the gross beta results from both networks consistently exceeded the analysis MDC. The annual average gross beta activity was 1.64×10^{-14} µCi/mL for the ASN and 1.71×10^{-14} µCi/mL for the SASN. Summary gross beta results for the ASN are in Table 4 and for the SASN in Appendix B, Table B-1.

The average annual gross alpha activities for 1992 were 9.23×10^{-16} µCi/mL for the ASN and 1.11×10^{-15} µCi/mL for the SASN. These results indicate a slight decrease in alpha activity as compared to the only other alpha data available, which are for 1989. The average annual gross alpha activities in 1989 were 1.3×10^{-15} µCi/mL for the 14 ASN stations and 1.5×10^{-15} µCi/mL for the 21 SASN stations. Summary gross alpha results for the ASN are presented in Table 5 and for the SASN in Appendix B, Table B-2.

Figures 16, 17, 18, and 19 show the distribution of the gross beta values from each ASN station for 1989, 1990, 1991, and 1992 respectively. The stations are ordered by ascending means of the data values. The mean values are represented by the filled circles (black dots). The left and right edges of the box on the graph represent the 25th and 75th percentiles of the distribution of the values (i.e., 50% of the data falls within this region). The vertical line drawn inside the box represents the 50th percentile or the median value. The horizontal lines extend from the box to the minimum and maximum values. The averages of the quarterly gross beta values from the SASN stations are shown in Appendix B, Table B-1.

The ^{238}Pu and $^{239+240}Pu$ results from January through December 1992 for the ASN are in Table 6; those for the SASN are listed in Appendix B, Table B-3. The third quarter California composited sample was lost during analysis and no samples were received from the California SASN stations for the first quarter. The May, August, and October composited samples from Rachel, Nevada exceeded the MDC for ^{238}Pu. The fourth quarter composites for New Mexico and Wyoming exceeded the MDC of ^{238}Pu analysis. The only $^{239+240}Pu$ result greater than the analysis MDC was for the fourth quarter New Mexico sample, a single sample collected in Carlsbad. The plutonium results are consistent with data from previous years.

4.2 Tritium In Atmospheric Moisture

4.2.1 Design

Tritium is created by natural forces in the upper atmosphere and is also emitted from nuclear reactors, reprocessing facilities (non-NTS facilities), and worldwide nuclear testing.

At the beginning of 1992, the tritium network consisted of 14 continuously operated and seven standby stations. The routine stations are adjacent to the NTS to detect atmospheric tritium which could reach populated centers in the immediate offsite area. In addition, a tritium sampler is routinely operated near the nuclear research reactor in Salt Lake City, Utah. The following five stations were converted from routine to standby status effective with their last sampling collection

Table 4. Gross Beta Results for the Offsite Air Surveillance Network - 1992

		Gross Beta Concentration (10^{-14} µCi/mL)			
Sampling Location	Number	Maximum	Minimum	Arithmetic Mean	Standard Deviation
Death Valley Junction, CA	39	2.24*	0.37*	1.43	0.44
Furnace Creek, CA	49	3.77*	0.56*	1.79	0.62
Shoshone, CA	51	3.20*	0.40*	1.77	0.61
Alamo, NV	50	2.91*	0.58*	1.61	0.46
Amargosa Valley, NV	51	3.22*	0.48*	1.58	0.57
Austin, NV	43	5.71*	0.21*	1.66	0.84
Beatty, NV	52	3.12*	0.31*	1.70	0.53
Caliente, NV	48	2.90*	0.21	1.63	0.65
Clark Station, NV					
Stone Cabin Ranch	51	2.53*	0.29*	1.40	0.43
Currant, NV					
Blue Eagle Ranch	51	5.82*	0.28*	1.68	0.92
Ely, NV	52	2.00*	0.15	1.29	0.43
Goldfield, NV	52	3.39*	0.32*	1.68	0.53
Groom Lake, NV	43	3.68*	0.73*	1.79	0.60
Hiko, NV	51	2.88*	0.17	1.60	0.53
Indian Springs, NV	51	3.48*	0.38*	1.76	0.62
Las Vegas, NV	51	3.81*	0.43*	1.76	0.65
Nyala, NV	52	3.97*	0.16	1.39	0.63
Overton, NV	52	3.98*	0.45*	1.89	0.74
Pahrump, NV	52	3.05*	0.04	1.27	0.56
Pioche, NV	52	2.89*	0.09	1.55	0.53
Rachel, NV	50	4.67*	0.11	1.71	0.80
Sunnyside, NV	45	2.92*	0.28*	1.62	0.60
Tonopah, NV	52	2.57*	0.42*	1.48	0.44
Tonopah Test Range, NV	51	2.68*	0.19	1.50	0.44
Twin Springs, NV					
Fallini's Ranch	52	4.04*	0.36*	1.86	0.66
Cedar City, UT	52	2.69*	0.32*	1.40	0.47
Delta, UT	45	5.14*	0.86*	1.83	0.79
Milford, UT	48	5.03*	0.61*	1.93	0.82
Salt Lake City, UT	51	3.39*	0.79*	1.66	0.55
St. George, UT	52	4.10*	0.36*	1.81	0.70

Mean MDC: 2.53×10^{-15} µCi/mL Standard Deviation of Mean MDC: 3.15×10^{-16} µCi/mL

MDC = minimum detectable concentration.

* = result is greater than the MDC of analysis.

Table 5. Gross Alpha Results for the Offsite Air Surveillance Network - 1992

		Gross Alpha Concentration (10^{-15} µCi/mL)			
Sampling Location	Number	Maximum	Minimum	Arithmetic Mean	Standard Deviation
Death Valley Jct, CA	39	2.4*	0.1	0.96	0.57
Furnace Creek, CA	49	2.4*	0.1	0.95	0.57
Shoshone, CA	51	2.8*	-0.3	0.81	0.61
Alamo, NV	50	2.8*	0.1	1.1	0.58
Amargosa Valley, NV	51	2.7*	-0.1	1.0	0.68
Austin, NV	43	2.6*	0.0	1.1	0.59
Beatty, NV	52	2.5*	0.0	0.91	0.60
Caliente, NV	48	2.4*	-0.1	0.98	0.64
Clark Station, NV					
Stone Cabin Ranch	51	2.6*	-0.2	1.1	0.58
Currant, NV					
Blue Eagle Ranch	51	8.9*	-0.3	1.2	1.5
Ely, NV	52	1.9*	-0.2	0.73	0.45
Goldfield, NV	52	2.5*	0.1	0.80	0.50
Groom Lake, NV	43	5.2*	0.0	1.4	1.0
Hiko, NV	51	2.5*	-0.2	0.86	0.61
Indian Springs, NV	51	3.9*	0.0	0.83	0.70
Las Vegas, NV	51	3.1*	-0.2	0.89	0.75
Nyala, NV	52	2.5*	-0.2	0.66	0.52
Overton, NV	52	4.6*	-0.2	0.86	0.72
Pahrump, NV	52	2.2*	-0.4	0.68	0.60
Pioche, NV	52	2.4*	-0.2	0.60	0.48
Rachel, NV	50	2.5*	0.0	0.97	0.69
Sunnyside, NV	45	4.8*	0.0	1.2	0.85
Tonopah, NV	52	2.1*	-0.6	0.67	0.50
Tonopah Test Range, NV	51	2.8*	-0.1	1.0	0.72
Twin Springs, NV					
Fallini's Ranch	52	4.7*	0.0	1.0	0.80
Cedar City, UT	52	2.3*	0.0	0.98	0.55
Delta, UT	45	4.4*	-0.1	0.84	0.75
Milford, UT	48	2.9*	0.0	0.94	0.65
Salt Lake City, UT	51	1.5*	-0.3	0.65	0.39
St. George, UT	52	2.5*	0.0	0.77	0.55

Mean MDC: 8.07×10^{-16} µCi/mL Standard Deviation of Mean MDC: 2.36×10^{-16} µCi/mL

MDC = minimum detectable concentration.

* = result is greater than the MDC of analysis.

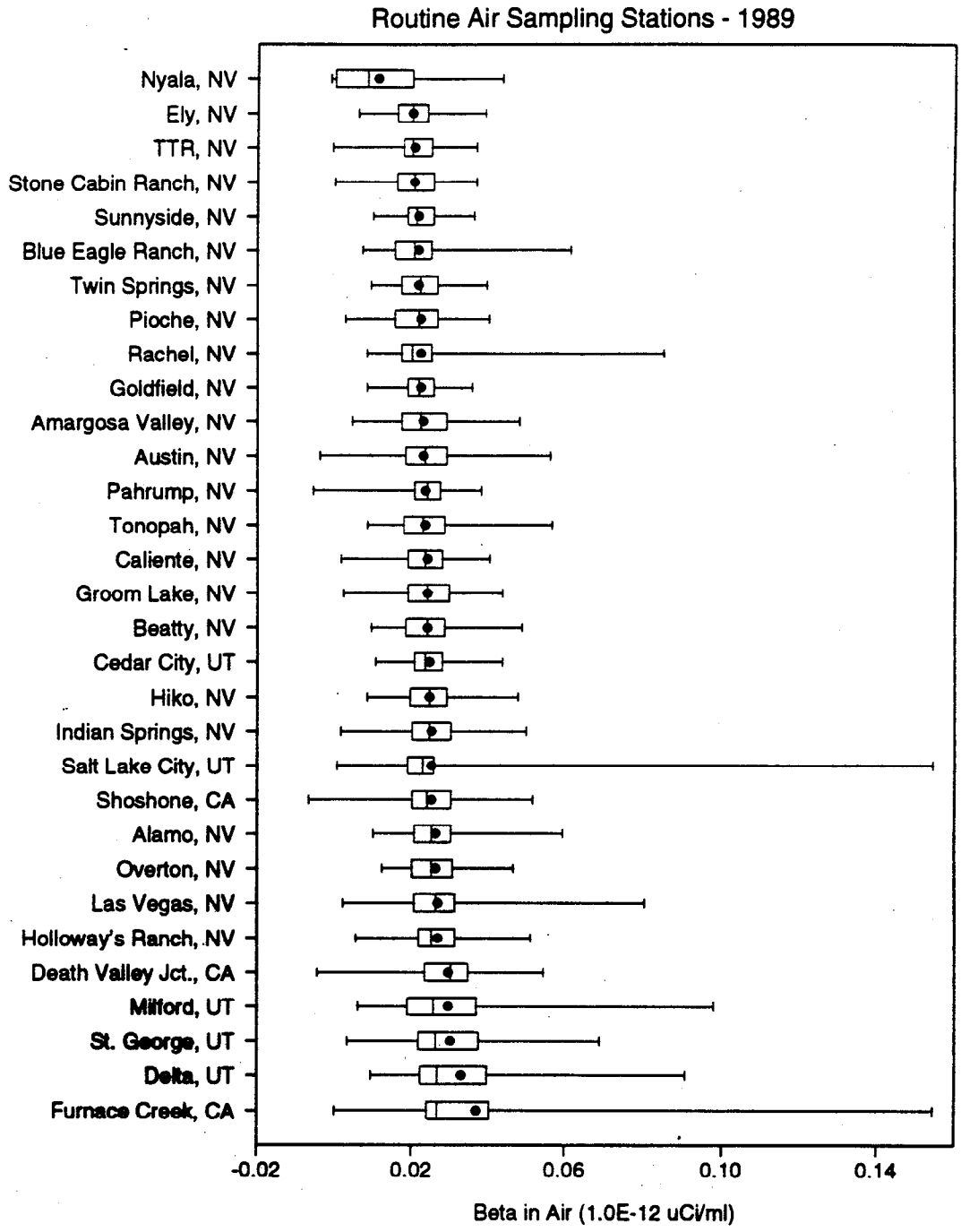

Figure 16. Distribution of gross beta values from Air Surveillance Network stations, 1989. Figure shows minimum, 25th percentile, mean, median, 75th percentile, and maximum values.

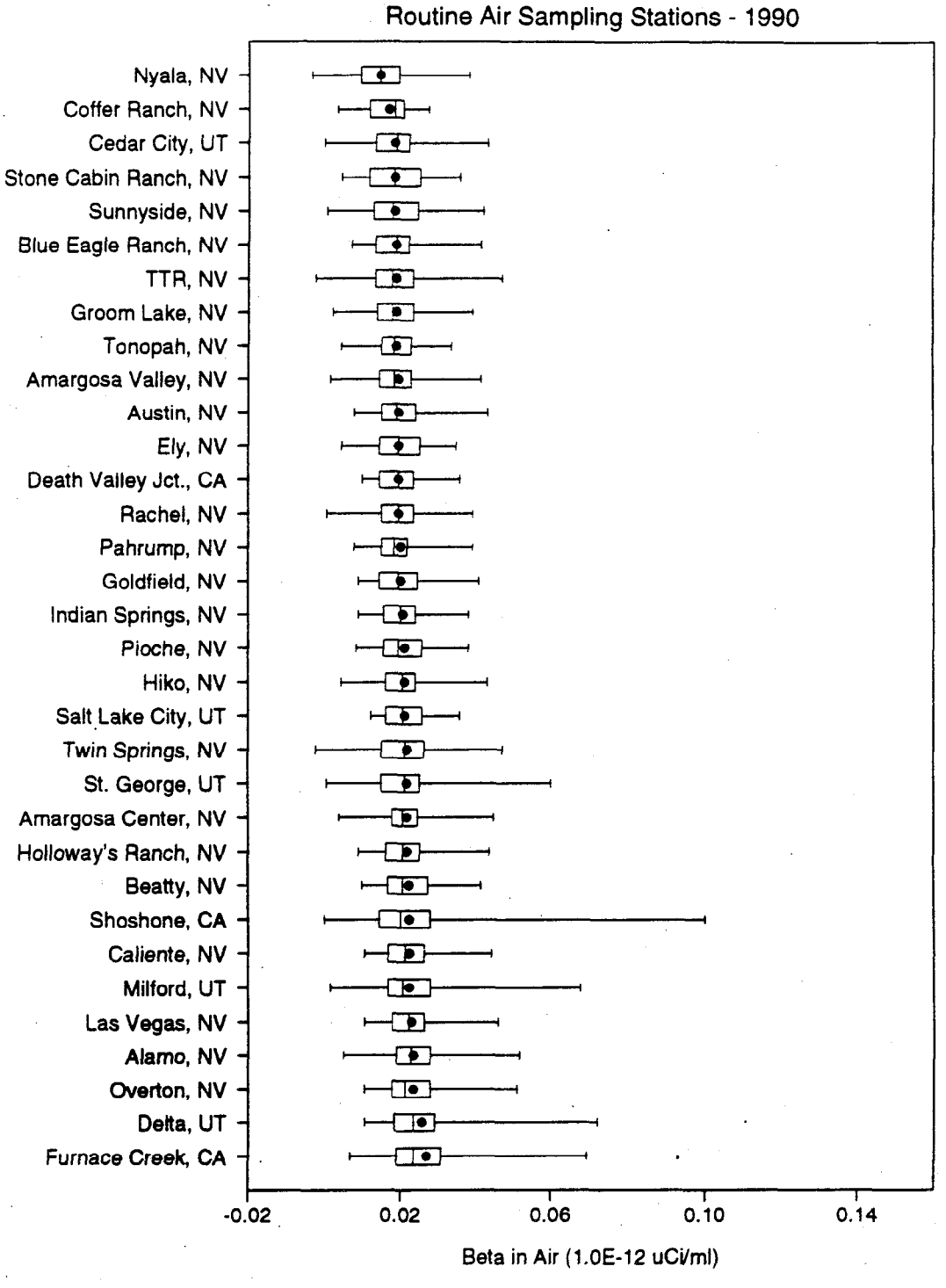

Figure 17. Distribution of gross beta values from Air Surveillance Network stations, 1990. Figure shows minimum, 25th percentile, mean, median, 75th percentile, and maximum values.

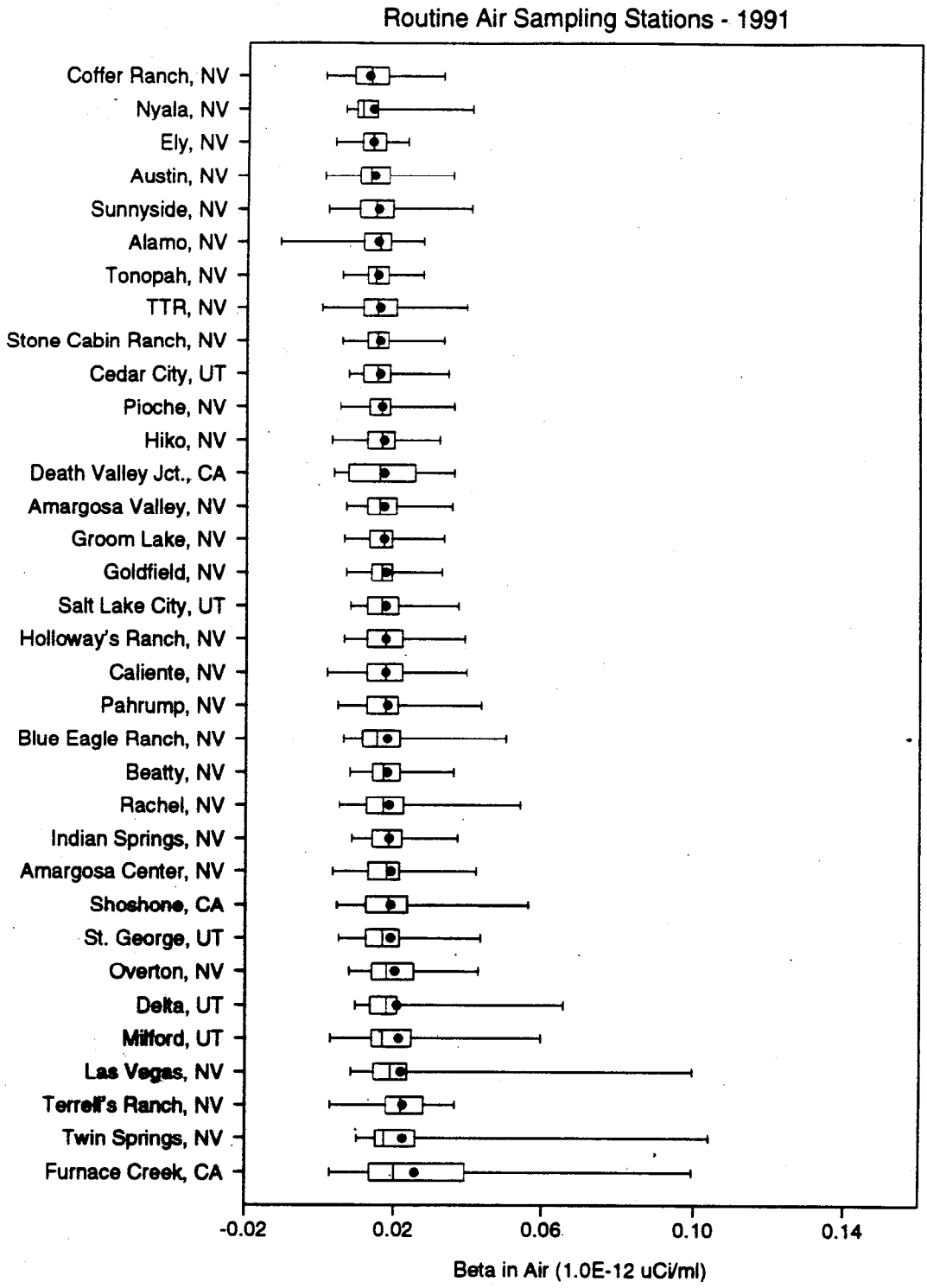

Figure 18. Distribution of gross beta values from Air Surveillance Network stations, 1991. Figure shows minimum, 25th percentile, mean, median, 75th percentile, and maximum values.

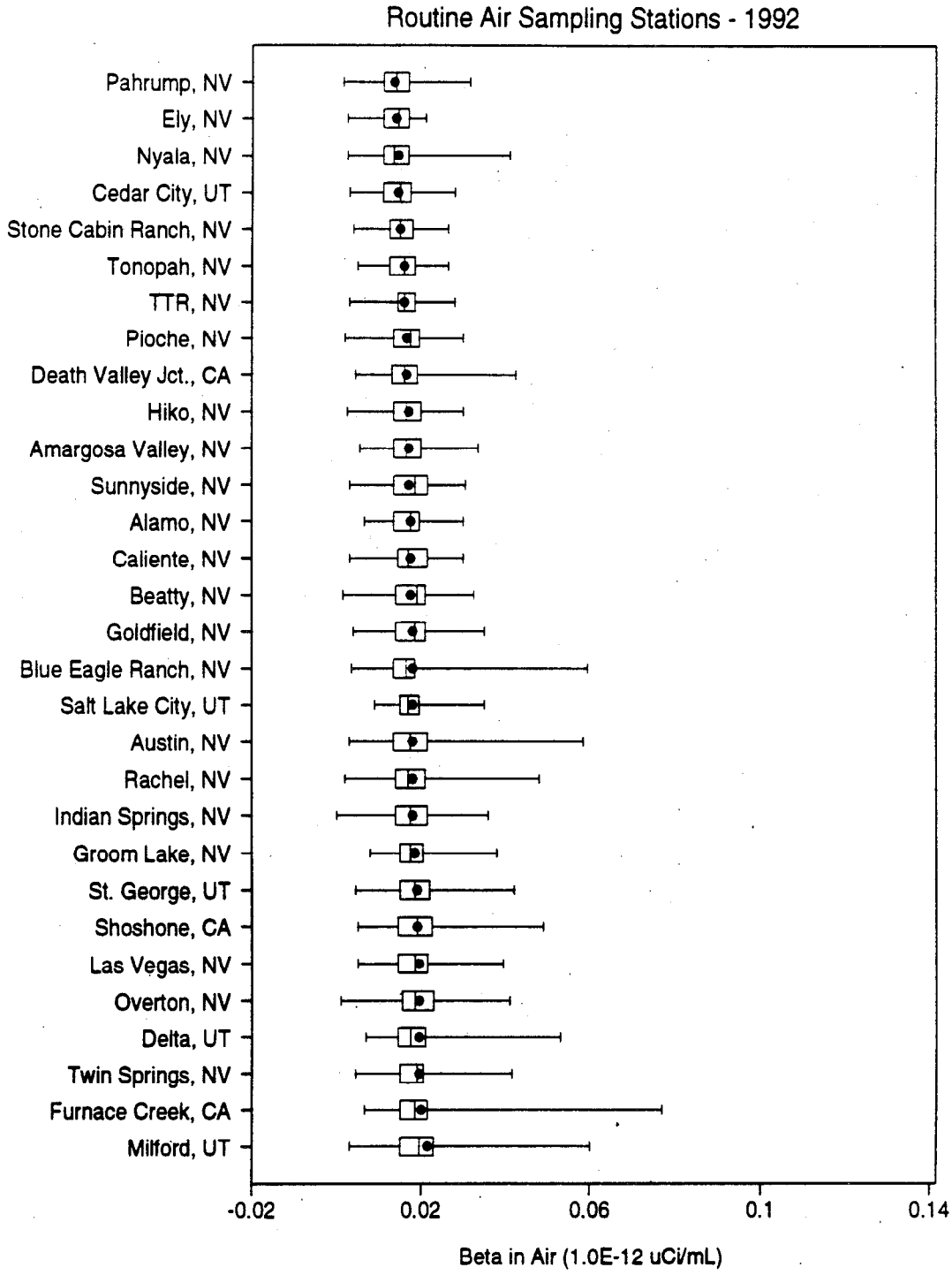

Figure 19. Distribution of gross beta values from Air Surveillance Network stations, 1992. Figure shows minimum, 25th percentile, mean median, 75th percentile and maximum values.

Table 6. Offsite Airborne Plutonium Concentrations - 1992

Composite Sampling Location	Number	^{238}Pu Concentration (10^{-18} µCi/mL) Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as %DCG
Alamo, Nevada	12	6.82	-2.95	1.98	3.00	0.07
Las Vegas, Nevada	12	7.40	-5.42	1.57	3.84	0.05
Amargosa Valley, Nevada	12	5.02	-8.77	-0.77	4.12	N/A
Rachel, Nevada	12	37.10*	-7.21	6.23	12.61	0.21

Mean MDC: 1.50×10^{-17} µCi/mL Standard Deviation of Mean MDC: 1.01×10^{-17} µCi/mL

DCG = derived concentration guide. Established by DOE Order as 3×10^{-15} µCi/mL.

Composite Sampling Location	Number	$^{239+240}$Pu Concentration (10^{-18} µCi/mL) Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as %DCG
Alamo, Nevada	12	4.97	-3.71	0.389	2.28	0.02
Las Vegas, Nevada	12	5.68	-4.39	-0.667	2.70	N/A
Amargosa Valley, Nevada	12	25.70	-15.10	0.002	9.49	<0.01
Rachel, Nevada	12	9.88	-7.42	3.512	4.74	0.18

Mean MDC: 1.35×10^{-17} µCi/mL Standard Deviation of Mean MDC: 1.05 µCi/mL

* = result is greater than the MDC of analysis.
DCG = derived concentration guide. Established by DOE Order as 2×10^{-15} µCi/mL.
MDC = minimum detectable concentration.
NA = not applicable.

periods in November 1991: Shoshone, California; Cedar City, Utah; and Austin, Ely, and Caliente, Nevada. Samples were collected approximately once a week from the routine stations and once a quarter from the standby stations. Figure 20 shows the locations of the tritium network sampling stations in conjunction with the noble gas sampling network stations.

4.2.2 Procedures

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 ^{3}H is determined by liquid scintillation counting. The volume of recovered water and the ^{3}H concentration is then used to calculate the concentration of HTO, the vapor form of tritium. HTO is the most common form of tritium encountered in the environment.

4.2.3 Results

Of the 716 routine and 15 standby samples collected in 1992, 15 samples were not analyzed: five because of broken sieves, three were lost, and seven contained insufficient sample (moisture). An additional seven samples were excluded from data analysis because of indications of operational malfunctions affecting data reliability. These included frozen lines, lack of pump flow, indications of leaks, and overextended sampling interval. Two samples exceeded the analysis MDC. Both samples were collected June 16 - 24; one from Las

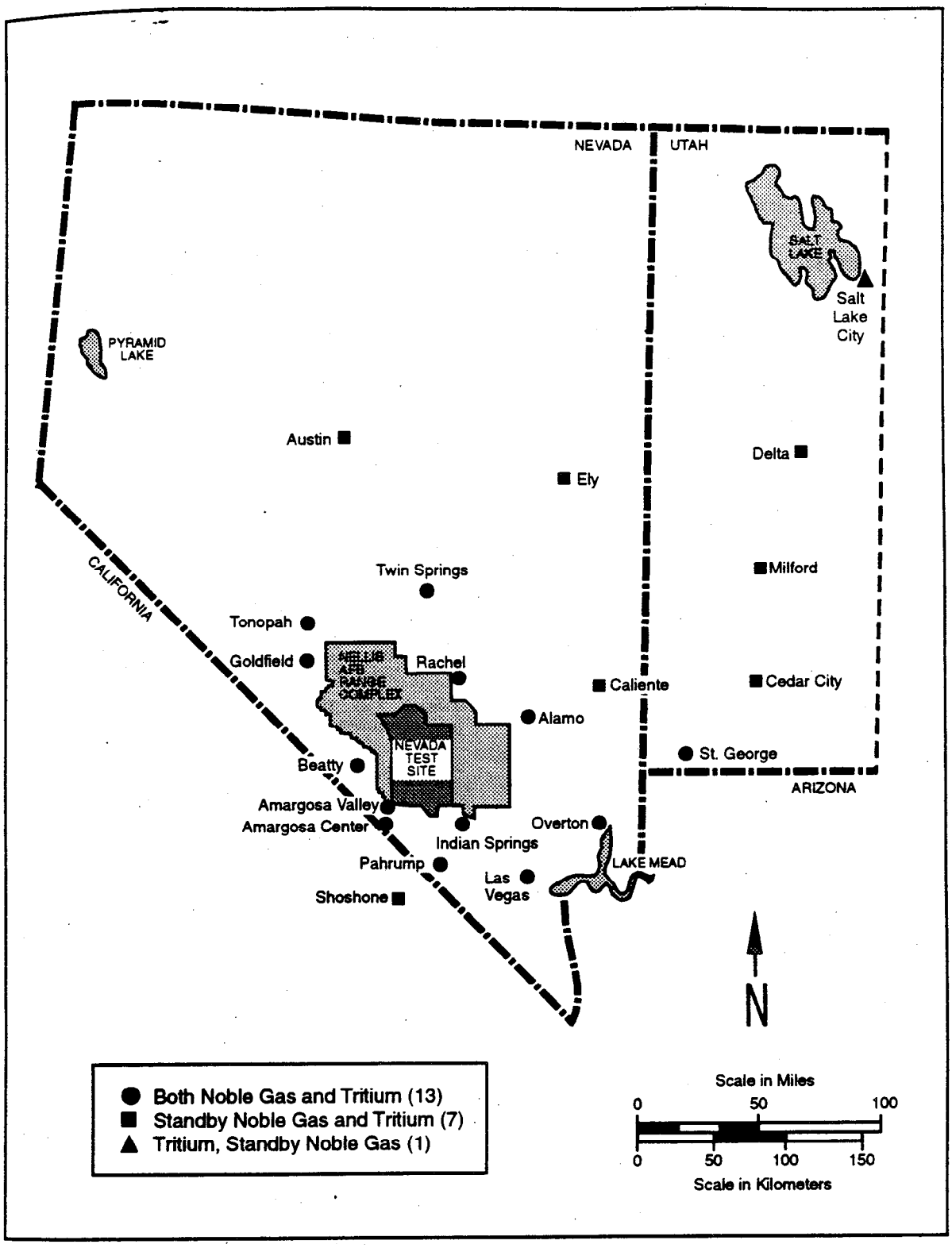

Figure 20. Offsite Noble Gas sampling and Tritium-in-Air Network stations - 1992.

Vegas and the other from Overton, Nevada. The average HTO concentration for the Las Vegas station, located near the EPA Radioanalysis Laboratory, was 1.5 x 10^{-6} pCi/mL. The annual HTO network average was 6.6 x 10^{-7} pCi/mL. Summary data results are given in Table 7 for the routine stations and in Table B-4, Appendix B, for the standby stations. The 1992 tritium data appear to be consistent with data from previous years.

4.3 Noble Gas Sampling Network

4.3.1 Design

At the beginning of 1992, the Noble Gas Sampling Network consisted of 13 routine (continuously operated) and 8 standby stations. In November 1991, the following 5 stations were converted from routine to standby status: Austin, Caliente, and Ely, Nevada; Shoshone, California; and Cedar City, Utah. Samples were collected approximately once a week from the routine stations and quarterly from the standby stations. Samples collected were analyzed for ^{85}Kr and ^{133}Xe. The locations of the noble gas sampling stations are shown in Figure 20 in conjunction with the tritium stations.

Noble gases may be released into the atmosphere from research and power reactor facilities, fuel reprocessing facilities, nuclear testing, and drill-backs and tunnel purgings which occur after nuclear tests. Environmental levels of the xenons, with their very short half-lives, are normally below the MDC. Krypton-85 disperses more or less uniformly over the entire globe because of its half-life, 10.7 years, and the lack of significant sinks (NCRP, 1975). For these reasons, ^{85}Kr results are expected to be slightly above the MDC.

4.3.2 Procedures

Noble gas samples are collected by compressing air into storage tanks (bottles). Air is continuously sampled over a 7-day period, collecting approximately 0.6 m^3 (21.2 ft^3) of air into 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. The bottle containing the sample from the entire sampling period is the only sample which is routinely analyzed. If xenons or abnormally high levels of ^{85}Kr were detected in this sample, then the other three samples would be analyzed. For the analysis, samples are condensed at liquid nitrogen temperature. Gas chromatography is then used to separate the gaseous radionuclide fractions. The radioactive gases are dissolved in liquid scintillation "cocktails," then counted to determine activity.

4.3.3 Results

Table 8 summarizes the ^{85}Kr and ^{133}Xe results for the routine stations and Table B-5, Appendix B, summarizes the results for the standby stations. The number of samples analyzed was less than 52 because samples were occasionally lost in analysis due to equipment failure or because the sample volume collected was insufficient to permit analysis. Of the 699 samples collected in 1992, analyses were not performed on 74 samples (10.6 percent) due to insufficient volume collected or sampler malfunctions. Twelve quarterly samples were collected from standby samplers; none were collected from Milford and Salt Lake City, Utah. 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 2.62 x 10^{-11} µCi/mL for ^{85}Kr and -1.77 x 10^{-11} µCi/mL for ^{133}Xe and for the standby samplers, 2.58 x 10^{-11} µCi/mL for ^{85}Kr and -2.74 x 10^{-11} µCi/mL for ^{133}Xe.

Figure 21 shows the distribution of the ^{85}Kr data from each routine sampling location arranged by ascending means. The graph, presented using the same conventions as in Figure 16, indicates that ^{85}Kr results are very consistent among stations. Figure 22 shows the annual average ^{85}Kr value from 1972 through 1992. The graph indicates that the levels of ^{85}Kr have remained consistent over the past several years. The results for ^{133}Xe are not graphed as all the values were below the MDC.

4.4 Quality Assurance/ Quality Control

General QA/QC guidelines for the atmospheric monitoring networks are as follows:

- All field sampling and laboratory instruments are calibrated and the date of calibration is marked on a decal affixed to the equipment.

Table 7. Offsite Atmospheric Tritium Results for Routine Samplers - 1992

Sampling Location	HTO Concentration (10^{-7} pCi/mL) Number	Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as %DCG
Alamo, NV	48	43.1	-35.3	6.52	17.4	0.01
Amargosa Valley, NV	51	50.3	-19.7	8.86	14.3	0.01
Amargosa Valley Community Center, NV	51	65.3	-44.7	5.48	19.1	0.01
Beatty, NV	51	18.7	-12.7	2.97	7.37	<0.01
Goldfield, NV	52	29.3	-27.0	4.93	11.7	<0.01
Indian Springs, NV	49	47.9	-43.2	7.41	17.6	0.01
Las Vegas, NV	52	94.9*	-49.4	15.3	30.1	0.02
Overton, NV	51	57.0	-42.1	8.53	19.7	0.01
Pahrump, NV	51	64.9	-22.4	10.4	19.9	0.01
Rachel, NV	48	22.6	-22.7	3.8	9.82	<0.01
Tonopah, NV	51	49.4	-24.2	5.50	15.6	0.01
Twin Springs, NV Fallini's Ranch	50	56.5	-39.5	4.38	17.1	<0.01
Salt Lake City, UT	38	24.0	-35.3	1.93	13.3	<0.01
St. George, UT	51	88.2	-79.4	6.86	32.7	0.01

Mean MDC: 5.52×10^{-6} pCi/mL Standard Deviation of Mean MDC: 2.75×10^{-6} pCi/mL

DCG = derived concentration guide. Established by DOE Order as 1×10^{-2} pCi/mL.
MDC = minimum detectable concentration.
* = result is greater than the MDC of analysis.

- Maintaining a file of calibration records, control charts, and log books.
- Assigning unique sample numbers.
- Obtaining laboratory supervisor approval of all analytical results before they are entered into the permanent data base.
- Maintaining files of QA data, which includes raw analytical data, intermediate calculations, and review reports.
- Performing analysis of blanks to verify method interferences caused by contaminants in solvents, reagents, glassware, and other sample processing are known and minimized.
- Estimating analytical accuracy with performance evaluation samples. For the gamma analysis of fiber filters, spiked samples should be within ± 10% of the known value. Gross beta analysis should be within ± 20%. Plutonium analysis of internal spikes should produce results within ± 20% of the known value. For the noble gases, spikedsamples should be within ± 20% of the known value.
- Estimating precision of laboratory analytical techniques and total precision for the entire system (both analytical and sampling error) using replicates. Field duplicate air samples as well as internal laboratory replicates are

Table 8. Offsite Noble Gas Results for Routine Samplers - 1992

^{85}Kr Concentration (10^{-11} µCi/mL)

Sampling Location	Number	Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as %DCG
Alamo, NV	48	3.03*	2.18*	2.62	0.21	0.01
Amargosa Valley, NV	44	3.01*	2.18*	2.59	0.20	0.01
Amargosa Valley Community Center, NV	35	3.05*	2.09*	2.64	0.23	0.01
Beatty, NV	50	3.08*	2.09*	2.62	0.24	0.01
Goldfield, NV	49	3.08*	2.13*	2.61	0.22	0.01
Indian Springs, NV	50	3.03*	2.17*	2.62	0.23	0.01
Las Vegas, NV	51	3.07*	2.08*	2.61	0.23	0.01
Overton, NV	52	3.12*	2.11*	2.63	0.22	0.01
Pahrump, NV	47	3.05*	2.23*	2.67	0.20	0.01
Rachel, NV	44	3.07*	2.04*	2.57	0.22	0.01
Tonopah, NV	45	3.09*	2.02*	2.63	0.19	0.01
Twin Springs, NV Fallini's Ranch	43	2.95*	2.21*	2.61	0.19	0.01
St. George, UT	49	3.14*	2.01*	2.59	0.26	0.01

Mean MDC: 5.55×10^{-12} µCi/mL Standard Deviation of Mean MDC: 1.25×10^{-12} µCi/mL

DCG = derived concentration guide. Established by DOE Order as 3×10^{-7} µCi/mL.

^{133}Xe Concentration (10^{-12} µCi/mL)

Sampling Location	Number	Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as %DCG
Alamo, NV	49	4.22	-18.4	-2.57	4.39	NA
Amargosa Valley, NV	44	7.19	-14.9	-2.09	3.59	NA
Amargosa Valley Community Center, NV	36	21.0	-17.3	-2.10	7.10	NA
Beatty, NV	51	6.01	-15.4	-2.11	4.59	NA
Goldfield, NV	48	12.9	-16.5	-1.36	4.95	NA
Indian Springs, NV	50	6.05	-12.0	-1.82	3.45	NA
Las Vegas, NV	51	4.55	-17.6	-1.49	4.67	NA
Overton, NV	52	8.22	-22.2	-2.63	5.58	NA
Pahrump, NV	47	5.75	-14.9	-1.10	3.53	NA
Rachel, NV	44	7.22	-15.4	-2.58	5.21	NA
Tonopah, NV	46	8.79	-15.5	-1.21	5.23	NA
Twin Springs, Fallini's Ranch	43	4.33	-13.0	-0.935	3.85	NA
St. George, UT	49	7.71	-11.1	-1.01	4.49	NA

Mean MDC: 1.40×10^{-11} µCi/mL Standard Deviation of Mean MDC: 5.41×10^{-12} µCi/mL

DCG = derived concentration guide. Established by DOE Order as 5×10^{-6} µCi/mL.
MDC = minimum detectable concentration.
* = result is greater than the MDC of analysis.
NA = not applicable.

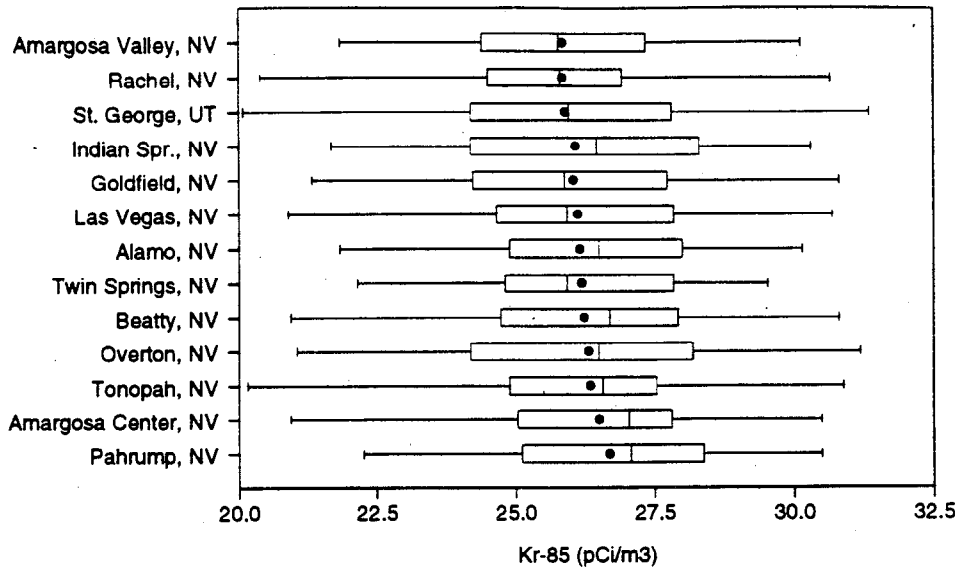

Figure 21. Distribution of krypton-85 data from routine sampling stations, 1992. Figure shows minimum, 25th percentile, mean, median, 75th percentile, and maximum values.

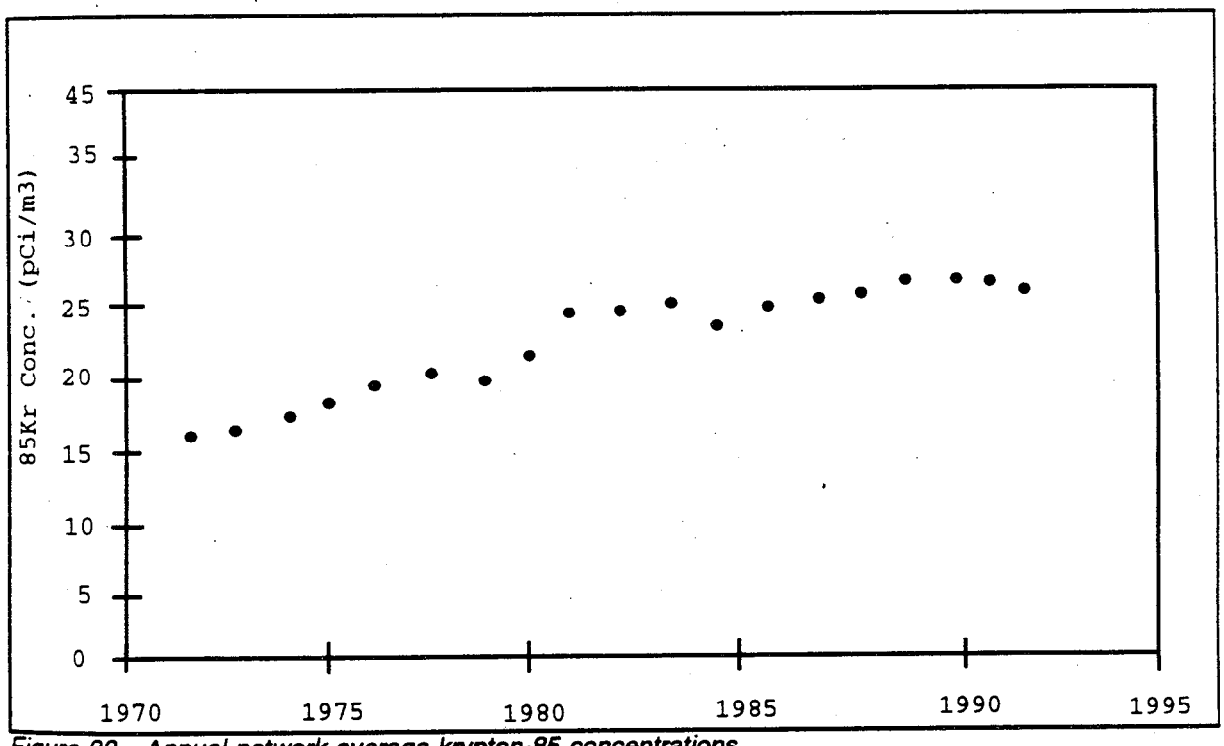

Figure 22. Annual network average krypton-85 concentrations.

analyzed for the ASN. Only internal laboratory replicates are analyzed for the noble gas and the HTO samples.

- Determining bias (the difference between the value obtained and the true or reference value) by participating in intercomparison studies.

Further discussion of the QA program and the data quality assessment is given in Chapter 11.

5.0 Foodstuffs

Ingestion is one of the critical exposure 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, vegetables, or food crops. The source of these radionuclides may be atmospheric deposition, resuspension, or adhering particles of soil. 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 could contain radionuclides.

Certain organs in the grazing animal, such as liver and muscle, may bioaccumulate radionuclides. These radionuclides are transported to humans by consumption of meat and meat products. In the case of dairy cattle, ingested radionuclides may be transferred to milk. Water is another significant ingestion transport pathway of radionuclides to humans (see Section 7).

To monitor the ingestion pathways, milk surveillance and biomonitoring networks are operated within the ORSP. The Milk Surveillance Network (MSN) includes commercial dairies and family-owned milk cows and goats representing the major milksheds within 186 miles (300 km) of the NTS. The MSN is supplemented by the Standby Milk Surveillance Network (SMSN) which includes all states west of the Mississippi. The biomonitoring network includes the Animal Investigation Program and monitoring of radionuclides in locally grown fruits and vegetables.

5.1 Milk Surveillance Network

Milk is particularly important in assessing levels of radioactivity in a given area and the exposure of the population as a result of ingesting milk or milk products. Milk 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, 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 EMSL-LV through the MSN and the SMSN. Records are kept of cow and goat locations.

5.1.1 Design

At the beginning of 1992, there were 24 MSN collection sites. Two sites were discontinued in July: Susie Scott's Ranch (Goldfield, Nevada) and Cedarsage Farm (Inyokern, California), which went out of business and moved to Idaho. McKay's Ranch (McGill, Nevada) was added to the MSN in February. These locations are shown in Figure 23. No samples were collected from Blue Eagle Ranch (Currant, Nevada) nor from Susie Scott's Ranch prior to its discontinuation.

The SMSN consists of dairies or processing plants representing 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. The annual activation permits trends to be monitored and ensures proper operation of the SMSN, should an emergency arise. The 115 locations sampled in 1992 appear in Figure 24. Changes in SMSN sampling locations are given in Table 9.

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 CP-1. The remainder of the Nevada counties and the western Utah counties are surveyed approximately every other year. A partial census, including all California counties contiguous to Nevada, Box Elder and Tooele counties in Utah, and half of Nevada, was performed in 1992. The locations of processing plants and commercial dairy herds in Idaho and the remainder of Utah can be obtained from the agriculture departments of the respective state governments.

5.1.2 Procedures

Raw milk is collected in 1-gallon (3.8 L) collapsible cubitainers and preserved with formaldehyde.

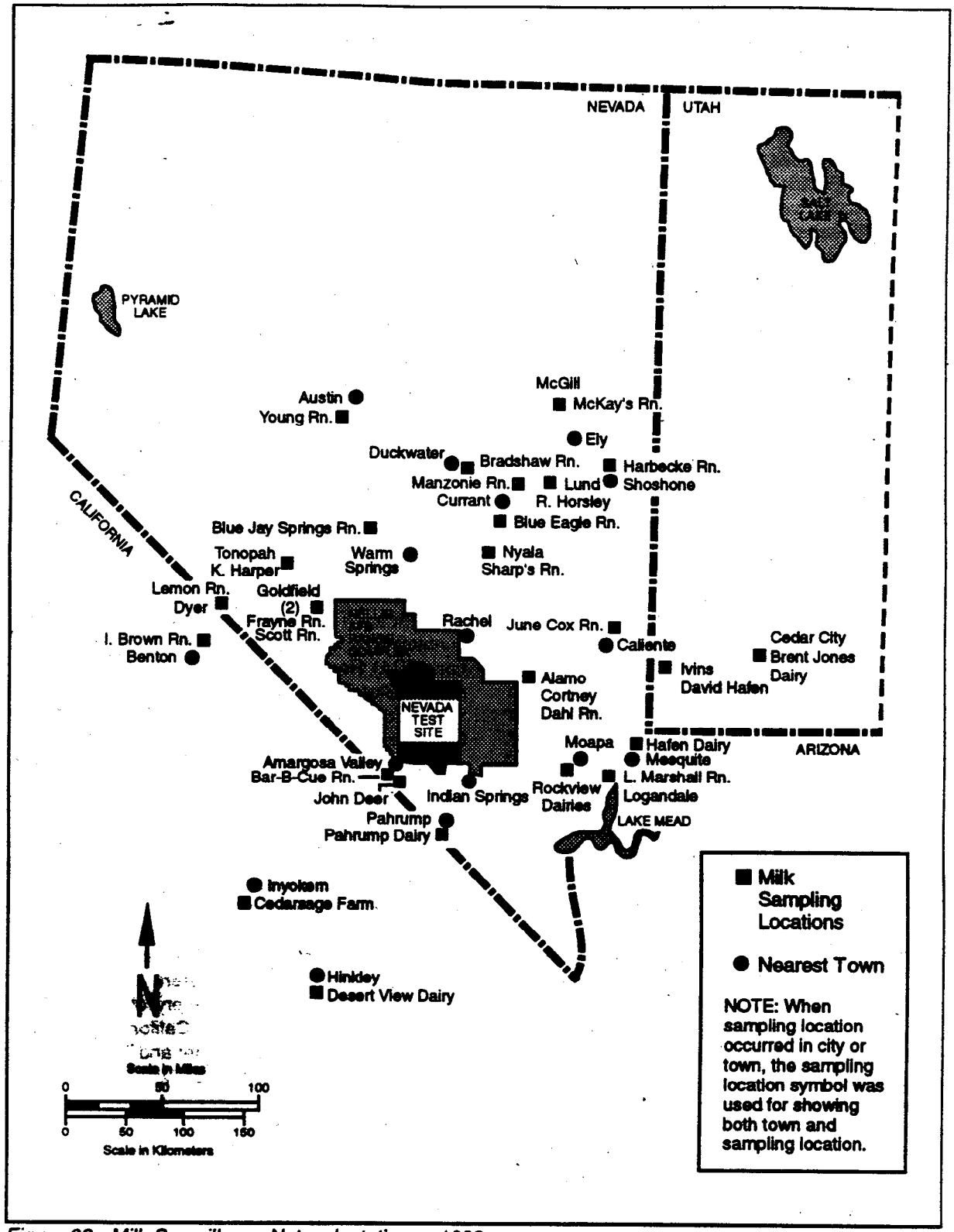

Figure 23. Milk Surveillance Network stations - 1992.

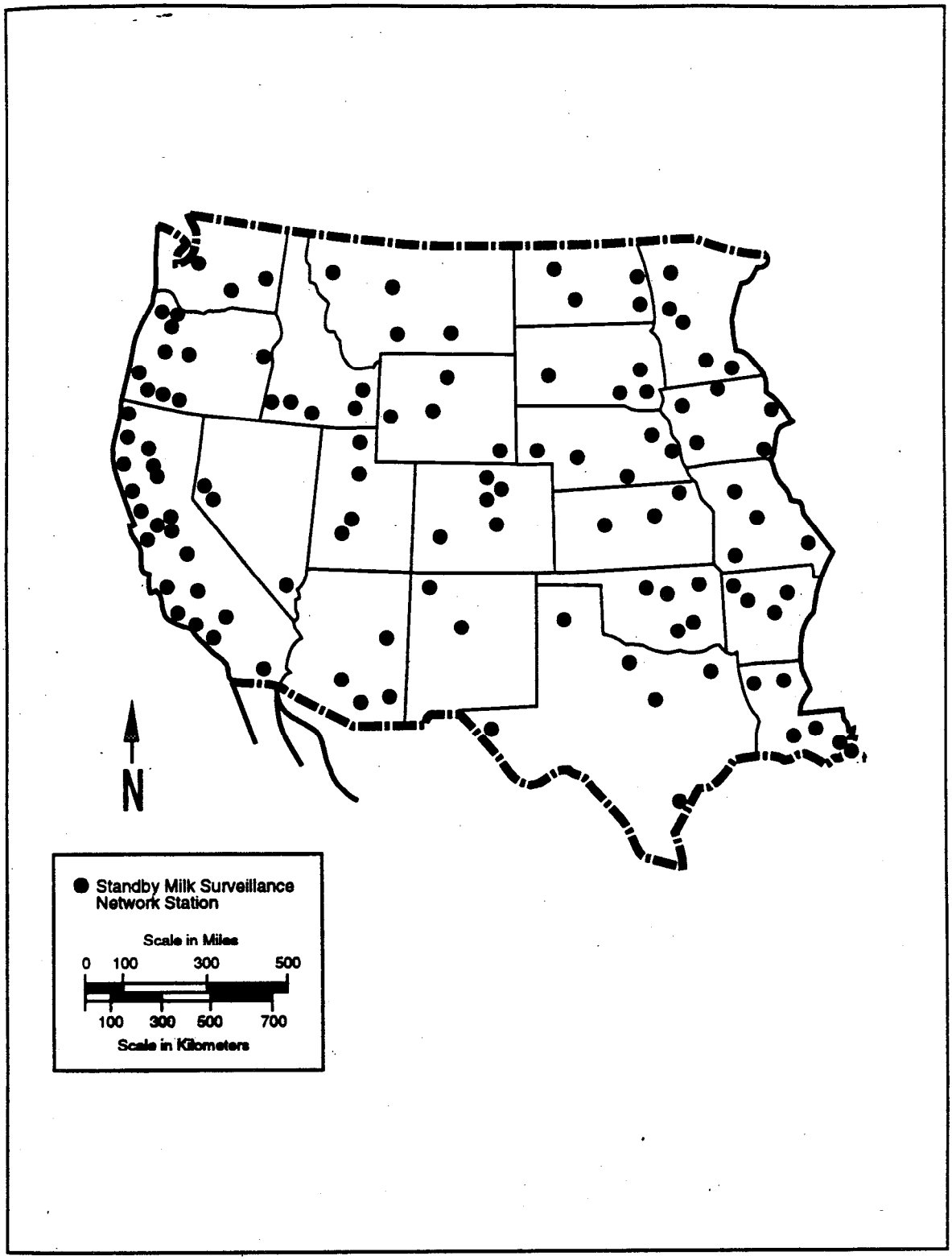

Figure 24. Standby Milk Surveillance Network stations - 1992.

Table 9. Standby Milk Surveillance Network Sampling Location Changes - 1992

City, State	Old Diary Name	City, State	New Dairy Name
Saugus, California	Wayside Honor Ranch	Long Beach, California	Paul's Dairy
North Powder, Oregon	Elmer Hill Dairy	Ontario, Oregon	Eastway Dairy
Logandale, Nevada	Nevada Dairy	Las Vegas, Nevada	Anderson Dairy
Corpus Christi, Texas	People's Baptist Church	Corpus Christi, Texas	Hygeia Milk Plant
Glen Rose, Texas	Daffan Family Dairy	Glen Rose, Texas	DeWayne Hankins Dairy (no replacement)
Ruston, Louisiana	Technical University Dairy		
		Coalgate, Oklahoma	Larry Krebs Dairy
Manteca, California	A & J Foods, Inc.	Manteca, California	Supremo Foods
Aurora, Missouri	Mid-America Dairymen, Inc.	Monett, Missouri	Mid-America Dairymen, Inc. (relocation)

Routine sampling is conducted monthly for the MSN and annually for the SMSN, or whenever local or worldwide radiation events such as the Chernobyl incident or nuclear testing by foreign nations suggest possible radiation concerns.

All samples are analyzed by high resolution gamma spectroscopy to detect gamma-emitting radionuclides. One sample per quarter from each MSN location and the annual samples from two of the SMSN locations in each western state (excluding Nevada) are evaluated by radiochemical analysis. These samples are analyzed for ^{3}H by liquid scintillation counting and for ^{89}Sr and ^{90}Sr by radiochemical separation and beta counting.

5.1.3 Results

The average total potassium concentration derived from ^{40}K activity was 1.6 g/L. Two SMSN samples indicated the presence of ^{137}Cs: the Tommy Rue Potts Dairy (Sulphur Springs, Texas) sample collected November 13 yielded 2.43 ± 0.86 pCi/L, and the Borden Velvet Dairy Products (New Orleans, Louisiana) sample collected April 9 yielded 3.46 [illegible] pCi/L. These values were below the MDC of the analysis, which was approximately 5 pCi/L. No other manmade gamma-emitting radionuclides were detected.

Selected MSN and SMSN milk samples were also analyzed for ^{3}H, ^{89}Sr, and ^{90}Sr, and the results are similar to those obtained in previous years; neither increasing or decreasing trends are evident. Although there was a slight increase in the number of samples whose results exceeded the MDC for ^{3}H, ^{89}Sr, and ^{90}Sr in 1992, as listed in Table 10, the average annual concentrations have, in general, decreased slightly. A summary of the MSN results are in Tables 11 for ^{3}H, 12 for ^{89}Sr, and 13 for ^{90}Sr. The results for the annual SMSN samples analyzed for ^{3}H, ^{89}Sr, and ^{90}Sr are given in Table B-6, Appendix B. Samples analyzed by gamma spectrometry for the SMSN are listed in Table B-7, Appendix B.

Time series distributions of the ^{90}Sr and ^{3}H data for the SMSN stations for 1982 through 1992 are provided in Appendix B, Figures B-1 through B-6. The information contained in these graphs is the same as that provided for Figures 16 - 19. The stations were divided into three regions for the graphs: the Midwest region including Louisiana, Texas, Arkansas, Illinois, Oklahoma, Missouri, Kansas, Iowa, Nebraska, Minnesota, South and North Dakota; the Mountain region including New Mexico, Arizona, Colorado, Utah, Wyoming, Idaho and Montana; and the Western region including California, Nevada, Washington, and Oregon. It should be noted that the data presented in these graphs include many values which are below the MDC. Values below the MDC were reported as measured.

In conclusion, the MSN and SMSN data are consistent with previous years and are not indicative of increasing or decreasing trends. No radioactivity directly related to current NTS activities was evident.

Table 10. 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)		
	1992	1991	1990	1992	1991	1990
^{3}H	5 (153)	2 (152)	0 (129)	^{3}H 6 (158)	1 (153)	1 (159)
^{89}Sr	4 (-0.01)	1 (0.30)	0 (0.18)	^{89}Sr 4 (0.38)	3 (0.42)	0 (-0.16)
^{90}Sr	5 (0.65)	4 (0.54)	4 (0.59)	^{90}Sr 17 (0.99)	18 (1.24)	17 (1.32)

5.1.4 Quality Assurance/Quality Control

Procedures for the operation, maintenance, and calibration of laboratory counting equipment, the control and statistical analysis of the sample, and the data review and records are documented in approved Standard Operating Procedures (SOPs). External and internal comparison studies were performed and field and internal duplicate samples were obtained for precision and accuracy assessments. Analytical results are reviewed for completeness and comparability. Trends are identified and potential risks to humans and the environment are determined based on the data. The data quality assessment is given in Section 11.

5.2 Animal Investigation Program

The primary purpose of the Animal Investigation Program is monitoring of the ingestion transport pathway to humans. Therefore, animals which are likely to be consumed by humans are targeted by the program. These are bighorn sheep, mule deer, and beef cattle.

A veterinarian retained through EPA EMSL-LV investigates any claims of damage to animals caused by radiation. No such claims were received in 1992.

5.2.1 Network Design

The objective of the animal investigation program is to determine whether there is potential for radionuclides to reach humans through ingesting wild game or meat from range cattle. To that end, 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. Therefore, it is theoretically possible for a resident to consume meat from a deer which had become contaminated with radionuclides while on 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 in the area. Some of these radionuclides may be ingested by animals. 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 collected animals are not selected to be representative of average radionuclide levels in animals residing in the offsite area, nor are they designed to be necessarily representative of the herd from which they are drawn. However, selection is not random. There is an inherent nonrandom selection in hunting and the ranchers select the cattle to be sold. Because the program is not statistically based, no conclusions can or should be

Table 11. Offsite Milk Surveillance ^{3}H Results - 1992

Sampling Location	Number	^{3}H Concentration (10^{-7} µCi/mL) Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as %DCG
Benton, CA						
Irene Brown Ranch	1	2.53*	2.53	2.53	--	0.32
Hinkley, CA						
Desert View Dairy	4	3.81	0.675	1.93	1.33	0.24
Inyokern, CA						
Cedarsage Farm	3	1.08	0.620	0.875	0.234	0.11
Alamo, NV						
Cortney Dahl Ranch	2	1.74	1.14	1.44	0.424	0.18
Amargosa Valley, NV						
Bar-B-Cue Ranch	4	1.64	-0.692	0.913	1.08	0.11
John Deer Ranch	2	2.26	1.46	1.86	0.564	0.23
Austin, NV						
Young's Ranch	4	2.65	0.519	1.33	0.937	0.17
Caliente, NV						
June Cox Ranch	4	1.04	0.433	0.816	0.288	0.10
Currant, NV						
Manzonie Ranch	4	2.63	1.42	1.77	0.572	0.22
Duckwater, NV						
Bradshaw's Ranch	4	1.20	0.292	0.852	0.418	0.11
Dyer, NV						
Ozel Lemon	3	3.97*	0.245	1.92	1.89	0.24
Goldfield, NV						
Frayne Ranch	3	2.42	0.944	1.71	0.739	0.21
Logandale, NV						
Leonard Marshall	4	1.94	-0.020	0.862	0.913	0.11
Lund, NV						
Ronald Horsley Ranch	3	1.56	1.05	1.31	0.255	0.16
McGill, NV						
McKay's Ranch	4	2.42	-0.186	1.48	1.15	0.19
Mesquite, NV						
Hafen Dairy	4	4.18*	0.090	1.89	1.95	0.24
Moapa, NV						
Rockview Dairies	4	2.51	0.377	1.82	1.00	0.23
Nyala, NV						
Sharp's Ranch	4	2.77	-0.200	1.14	1.53	0.14
Pahrump, NV						
Pahrump Dairy	4	2.61	1.02	1.91	0.662	0.24
Shoshone, NV						
Harbecke [illegible]	4	2.55	0.462	1.55	0.873	0.19
Tonopah, NV						
Karen [illegible]	3	4.76*	0.252	2.03	2.40	0.25
Cedar City, UT						
Brent Jones [illegible]	4	2.99	0.871	2.08	0.919	0.26
Ivins, UT						
David Hafen Dairy	4	2.64	0.900	2.07	0.789	0.26

Mean MDC: 2.85×10^{-7} µCi/mL Standard Deviation of Mean MDC: 5.70×10^{-6} µCi/mL

DCG = derived concentration guide. Established by DOE Order as 8×10^{-5} µCi/mL .
MDC = minimum detectable concentration.
* = result is greater than MDC of analysis.

Table 12. Offsite Milk Surveillance ^{89}Sr Results - 1992

Sampling Location	Number	^{89}Sr Concentration (10^{-10} µCi/mL) Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as %DCG
Benton, CA						
Irene Brown Ranch	1	5.10	5.10	5.10	--	0.06
Hinkley, CA						
Desert View Dairy	4	4.07	-7.60	-1.87	5.48	NA
Inyokern, CA						
Cedarsage Farm	3	4.57	-0.332	2.10	2.45	0.03
Alamo, NV						
Cortney Dahl Ranch	2	6.29	-14.8	-4.25	14.9	NA
Amargosa Valley, NV						
Bar-B-Cue Ranch	4	3.00	-19.4	-6.33	9.89	NA
John Deer Ranch	1	4.42	4.42	4.42	--	0.06
Austin, NV						
Young's Ranch	3	5.58	-8.09	0.177	7.27	<0.01
Caliente, NV						
June Cox Ranch	3	1.46	-15.8	-4.67	9.66	NA
Currant, NV						
Manzonie Ranch	4	6.79	-0.221	3.49	3.00	0.04
Duckwater, NV						
Bradshaw's Ranch	3	11.5*	-11.0	-3.37	12.9	NA
Dyer, NV						
Ozel Lemon	2	-3.25	-7.26	-5.26	2.84	NA
Goldfield, NV						
Frayne Ranch	2	3.51	-3.29	0.110	4.81	<0.01
Logandale, NV						
Leonard Marshall	4	4.38	-7.84	-1.64	5.45	NA
Lund, NV						
Ronald Horsley Ranch	3	1.12	-1.45	-0.309	1.31	NA
McGill, NV						
McKay's Ranch	4	-3.40	-9.13	-5.36	2.61	NA
Mesquite, NV						
Hafen Dairy	4	4.00	-7.66	-1.93	4.76	NA
Moapa, NV						
Rockview Dairies	3	11.0*	-3.57	2.48	7.59	0.03
Nyala, NV						
Sharp's Ranch	3	6.95	3.57	4.97	1.76	0.06
Pahrump, NV						
Pahrump Dairy	4	6.30	-2.42	1.83	3.74	0.02
Shoshone, NV						
Harbecke Ranch	4	8.25	0.770	4.71	3.49	0.06
Tonopah, NV						
Karen Harper Ranch	2	3.74	3.25	3.49	0.35	0.04
Cedar City, UT						
Brent Jones Dairy	4	9.74*	-5.26	1.85	6.15	0.02
Ivins, UT						
David Hafen Dairy	4	11.0*	-4.90	2.76	7.33	0.03

Mean MDC: 1.15×10^{-9} µCi/mL Standard Deviation of Mean MDC: 2.28×10^{-10} µCi/mL

DCG = derived concentration guide. Established by DOE Order as 8×10^{-7} µCi/mL.
MDC = minimum detectable concentration.
* = result is greater than the MDC of analysis.
NA = not applicable.

Table 13. Offsite Milk Surveillance ^{90}Sr Results - 1992

Sampling Location	Number	^{90}Sr Concentration (10^{-10} µCi/mL) Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as %DCG
Benton, CA						
Irene Brown Ranch	1	-1.23	-1.23	-1.23	--	NA
Hinkley, CA						
Desert View Dairy	4	5.65	1.13	3.57	2.11	0.89
Inyokern, CA						
Cedarsage Farm	3	3.74	1.04	2.28	1.36	0.57
Alamo, NV						
Cortney Dahl Ranch	2	6.94	-1.83	2.55	6.20	0.64
Amargosa Valley, NV						
Bar B Cue Ranch	4	14.2	-0.872	4.99	6.60	1.25
John Deer Ranch	2	1.88	-0.094	0.89	1.34	0.22
Austin, NV						
Young's Ranch	4	13.1	5.18	9.60	3.28	2.40
Caliente, NV						
June Cox Ranch	3	8.60	2.59	5.00	3.18	1.25
Currant, NV						
Manzonie Ranch	4	16.0*	3.24	7.68	5.85	1.92
Duckwater, NV						
Bradshaw's Ranch	4	13.7	1.24	8.27	5.21	2.07
Dyer, NV						
Ozel Lemon	3	10.6	5.46	8.55	2.72	2.14
Goldfield, NV						
Frayne Ranch	3	9.29	7.55	8.14	0.99	2.04
Logandale, NV						
Leonard Marshall	4	6.92	1.75	4.39	2.69	1.10
Lund, NV						
Ronald Horsley Ranch	3	7.51	2.25	4.01	3.03	1.00
McGill, NV						
McKay's Ranch	4	8.70	5.12	7.18	1.69	1.80
Mesquite, NV						
Hafen Dairy	4	10.4	3.48	6.44	2.99	1.61
Moapa, NV						
Rockview Dairies	3	6.82	-0.819	3.51	3.92	0.88
Nyala, NV						
Sharp's Ranch	4	9.59	4.30	6.77	2.20	1.69
Pahrump, NV						
Pahrump Dairy	4	8.60	1.11	4.87	4.18	1.22
Shoshone, NV						
Harbecke Ranch	4	19.6*	6.80	14.1	5.51	3.52
Tonopah, NV						
Karen Harper Ranch	3	22.9*	11.7	16.8	5.68	4.19
Cedar City, UT						
Brent Jones Dairy	4	7.78	2.58	5.49	2.16	2.74
Ivins, UT						
David Hafen Dairy	4	11.1	2.27	5.85	3.94	2.92

Mean MDC: 1.45×10^{-9} µCi/mL Standard Deviation of Mean MDC: 1.52×10^{-10} µCi/mL

DCG = derived concentration guide. Established by DOE Order as 4×10^{-8} µCi/mL.
MDC = minimum detectable concentration.
* = result is greater than MDC of analysis.
NA = not applicable.

drawn regarding average concentrations of radionuclides in animals in the offsite area, nor should any conclusions be drawn regarding average radionuclide ingestion by humans. The collection sites for the bighorn sheep, deer, and cattle analyzed in 1992 are shown in Figure 25.

5.2.2 Sample Collection and Analysis Procedures

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. The kidney is divided into two samples. One kidney sample is delivered to the EPA EMSL-LV Radioanalysis Laboratory for analysis of gamma-emitting radionuclides. The second kidney sample and all bone samples are shipped in a single batch to a contract laboratory for ashing. Upon completion of ashing, both the kidney and the bone samples are analyzed for plutonium isotopes and the bone samples are additionally analyzed for 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. If a deer is killed on the road, that animal is used. If road kills are not available, a deer is hunted by personnel with a special permit to carry weapons on the NTS. The deer is usually sampled 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, weighed, and sealed in labeled sample bags. Soft tissue organs, including lung, liver, muscle, and rumen contents are divided into two samples, one for analysis of gamma-emitting radionuclides and one which is ashed 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 ashed and analyzed for plutonium isotopes and strontium. The samples requiring ashing are shipped in a single batch each quarter to a contract laboratory. Analyses are completed in the EPA EMSL-LV Radioanalysis Laboratory.

Four cattle are purchased from ranches in the offsite area around the NTS each spring and another four are purchased each fall. In 1992, four cattle were purchased in the spring from G.L. Coffer's Fleur de Lis Ranch located north of Beatty, Nevada and another four were purchased in the fall from the Cortney Dahl ranch in Delamar Valley (east of Alamo, Nevada). Generally, two adult cattle and two calves are acquired in each purchase. The facility at the old EPA farm on the NTS 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 kidney sample and bone samples are sent to a contract laboratory for ashing. Ashed kidney samples are analyzed for plutonium isotopes; bone ash samples are analyzed for plutonium isotopes and strontium. A sample of the water used in processing the samples is also collected and analyzed.

5.2.3 Sample Results for Bighorn Sheep

The sheep hunt takes place in November and December, hence, the data presented here are from animals hunted in late 1991. The kidney samples and one lung sample were analyzed for gamma-emitting radionuclides and for tritium. The bone samples were ashed prior to analysis for ^{90}Sr, ^{238}Pu, and $^{239+240}Pu$. A summary of results obtained from analysis of bighorn sheep bone and kidney are shown in Table 14. Other than naturally occurring ^{40}K, gamma-emitting radionuclides were not detected, nor was tritium detected, at activities greater than the MDC in any of the kidney or lung 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 14, were similar to those obtained last year (DOE, 1991). The average ^{90}Sr levels

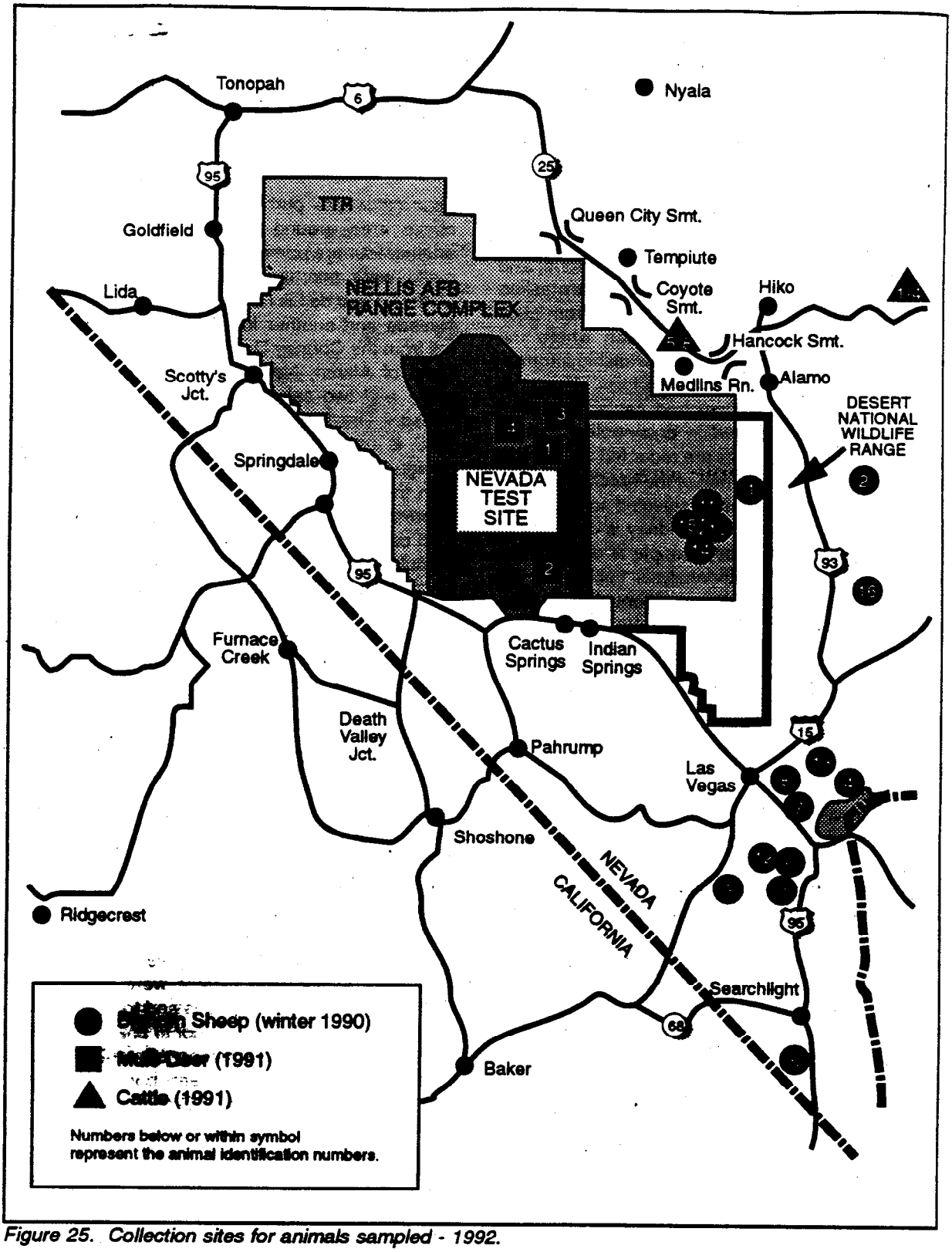

Figure 25. Collection sites for animals sampled - 1992.

Table 14. Radiochemical Results for Animal Samples - 1992

Sample Type	Parameter	Number	Maximum	Minimum	Median[a]	Standard Deviation	Median MDC ± std. dev.
Cattle Blood	^{3}H[b]	8	2.65	-0.62	0.99	1.00	3.15 ± 0.95
Cattle Liver	% Ash	8	1.42	1.10	1.31		
	^{238}Pu[c]		7.63*	-1.13	0.592	2.76	4.76 ± 3.11
	$^{239+240}Pu$[c]		15.4*	-0.954	10.2*	5.78	2.65 ± 2.65
Cattle Bone	% Ash	8	34.3	14.4	24.8		
	^{89}Sr[d]		0.72*	-0.46	-0.08	0.54	0.36 ± 0.03
	^{90}Sr[d]		0.88*	0.27	0.45*	0.22	0.20 ± 0.08
	^{238}Pu[c]		2.15	-0.854	0.244	0.955	1.75 ± 1.12
	$^{239+240}Pu$[c]		18.2*	-0.279	0.415	6.34	1.68 ± 1.13
Cattle Fetus	% Ash	2	10.4	2.1	6.2		
	^{90}Sr[d]		0.22	0.079	0.15	0.10	0.47 ± 0.32
	^{238}Pu[c]		-1.19	-1.52	-1.35	0.23	4.35 ± 0.04
	$^{239+240}Pu$[c]		5.05*	1.14	3.09	2.76	2.22 ± 1.19
Deer Blood	^{3}H[b]	3	1.80	-0.17	1.69	1.11	4.84 ± 184
Deer Liver	% Ash	3	1.30	1.25	1.26		
	^{238}Pu[c]		0.000216	-2.58	0.0000297	1.49	7.12 ± 3.64
	$^{239+240}Pu$[c]		51.8*	1.78*	17.1*	25.6	3.32 ± 1.83
Deer Lung	% Ash	3	1.18	0.92	1.12		
	^{238}Pu[c]		2.70	-3.47	1.62*	3.80	1.51 ± 4.78
	$^{239+240}Pu$[c]		30.6*	8.09	10.7*	12.3	1.51 ± 4.78
Deer Muscle	% Ash	3	1.19	0.90	0.99		
	^{238}Pu[c]		0.724	-0.0000325	0.542	0.377	1.52 ± 1.77
	$^{239+240}Pu$[c]		96.5*	5.86*	11.8*	50.7	1.52 ± 0.73
Deer Rumen Content	% Ash	3	1.98	1.50	1.85		
	^{238}Pu[c]		2.45*	1.26	1.82*	0.60	1.90 ± 2.37
	$^{239+240}Pu$[c]		37.3*	17.4*	28.1*	9.96	1.90 ± 0.67
Deer Bone	% Ash	3	32.5	32.2	32.4		
	^{89}Sr[d]		0.39*	--	--	--	0.31 ± --
	^{90}Sr[d]		1.4*	0.68*	0.74*	0.40	0.36 ± 0.13
	^{238}Pu[c]		0.826	-0.521	-0.386	0.742	2.43 ± 0.89
	$^{239+240}Pu$[c]		7.85*	0.386	1.04	4.13	2.43 ± 1.32
Bighorn Sheep Bone	% Ash	16	39.2	19.3	32.6		
	^{90}Sr[d]		2.7*	0.37*	1.0*	0.68	0.17 ± 0.05
	^{238}Pu[c]		0.848	-4.08	-0.0000255	0.372	2.20 ± 1.48
	$^{239+240}Pu$[c]		6.23*	-0.57	0.14	1.60	1.53 ± 1.35
Bighorn Sheep Kidney	^{3}H[b]	17	2.97	-1.30	0.75	1.12	3.53 ± 0.01

[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.
MDC = minimum detectable concentration.
* = result is greater than the MDC of analysis.

found in bighorn sheep bone ash since 1955 are shown in Figure 26. None of the bone samples yielded ^{238}Pu results greater than the MDC of the analysis and only one sample (Bighorn sheep No. 6) yielded a $^{239+240}Pu$ result greater than the MDC. This animal was collected in Area 268, near Buffington Pockets Spring south and west of Moapa, Nevada near the Valley of Fire. Medians and ranges of plutonium isotopes, given in Table 14, were similar to those obtained previously (DOE, 1991).

5.2.4 Sample Results for Mule Deer

Blood samples were analyzed for gamma-emitting radionuclides and tritium. Soft tissue samples (lung, muscle, liver, thyroid, rumen contents, and fetus, when available) were analyzed for gamma-emitting radionuclides and plutonium isotopes. Samples of bones were ashed and then analyzed for plutonium isotopes and for ^{90}Sr. Samples of thyroid and fetal tissue were not ashed due to their small size.

No deer was collected in the first quarter of 1992, although two hunting trips were conducted. The mule deer collected in the second quarter of 1992 was a buck in good condition obtained by hunting in Area 18 of the NTS, near Buckboard Mesa road. No gamma-emitting radionuclides other than naturally occurring ^{40}K were detected in soft tissues, however, $^{239+240}Pu$ was detected in the lungs, liver, and muscle. The rumen content contained ^{238}Pu and $^{239+240}Pu$. Values for $^{239+240}Pu$ were 0.031 ± 0.006 pCi/g ash in the lungs, 0.017 ± 0.004 pCi/g ash in the liver, 0.006 ±0.001 pCi/g ash in the muscle, and 0.0174 ± 0.003 pCi/g ash in the rumen. The bone sample contained 0.74 ± 0.13 pCi/g ash of ^{90}Sr. There was no detectable ^{3}H in the blood above the MDC of 1.82×10^{-7} µCi/mL.

The mule deer collected in the third quarter was a young buck in fair condition obtained by hunting in Area 19 of the NTS. The blood sample did not contain ^{3}H above the MDC of 4.84×10^{-7} µCi/mL, and there were no gamma-emitting radionuclides other than ^{40}K in the soft tissues. Plutonium-238 was found in the lung and rumen content. Bone contained only ^{90}Sr, 1.4 ± 0.2 pCi/g ash. All soft tissue samples contained $^{239+240}Pu$; the lungs contained 0.011 ± 0.002 pCi/g ash, the liver 0.002 ± 0.0001 pCi/g ash, and the muscle 0.012 ± 0.002 pCi/g ash.

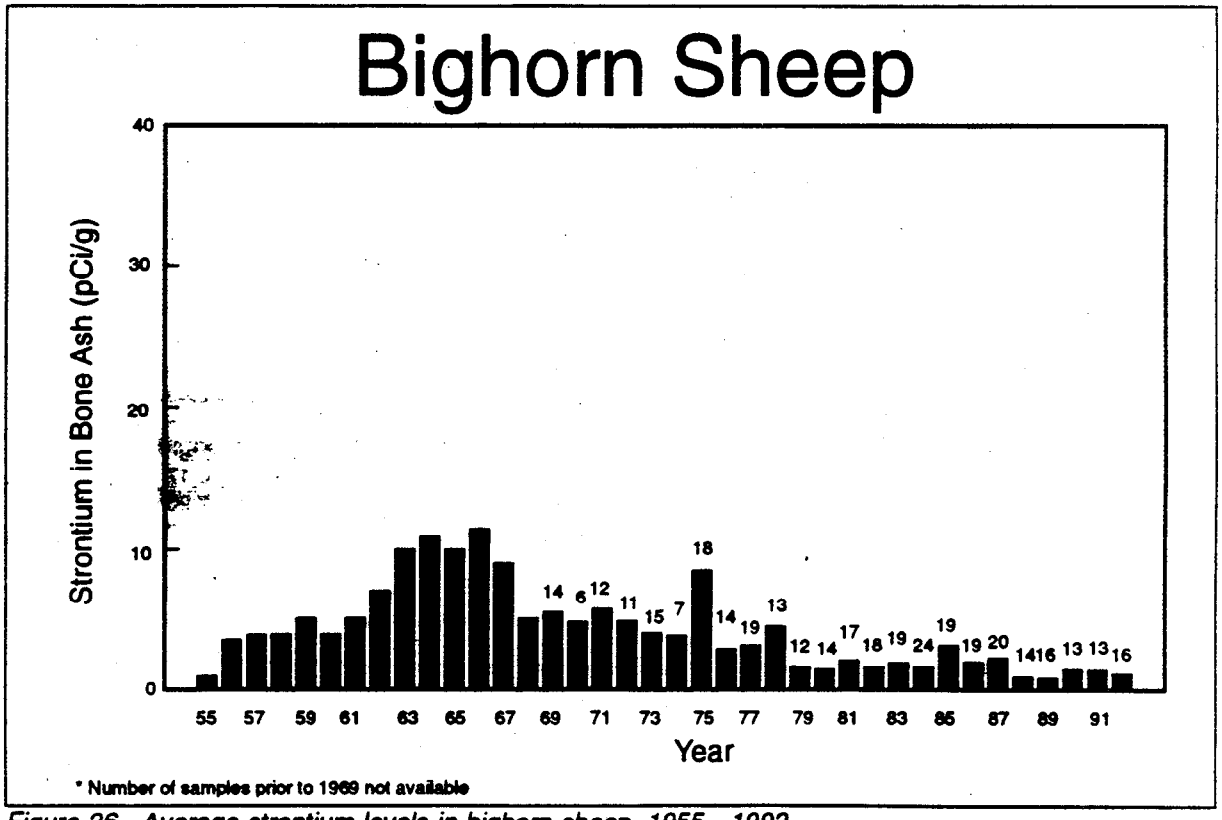

Figure 26. Average strontium levels in bighorn sheep, 1955 - 1992.

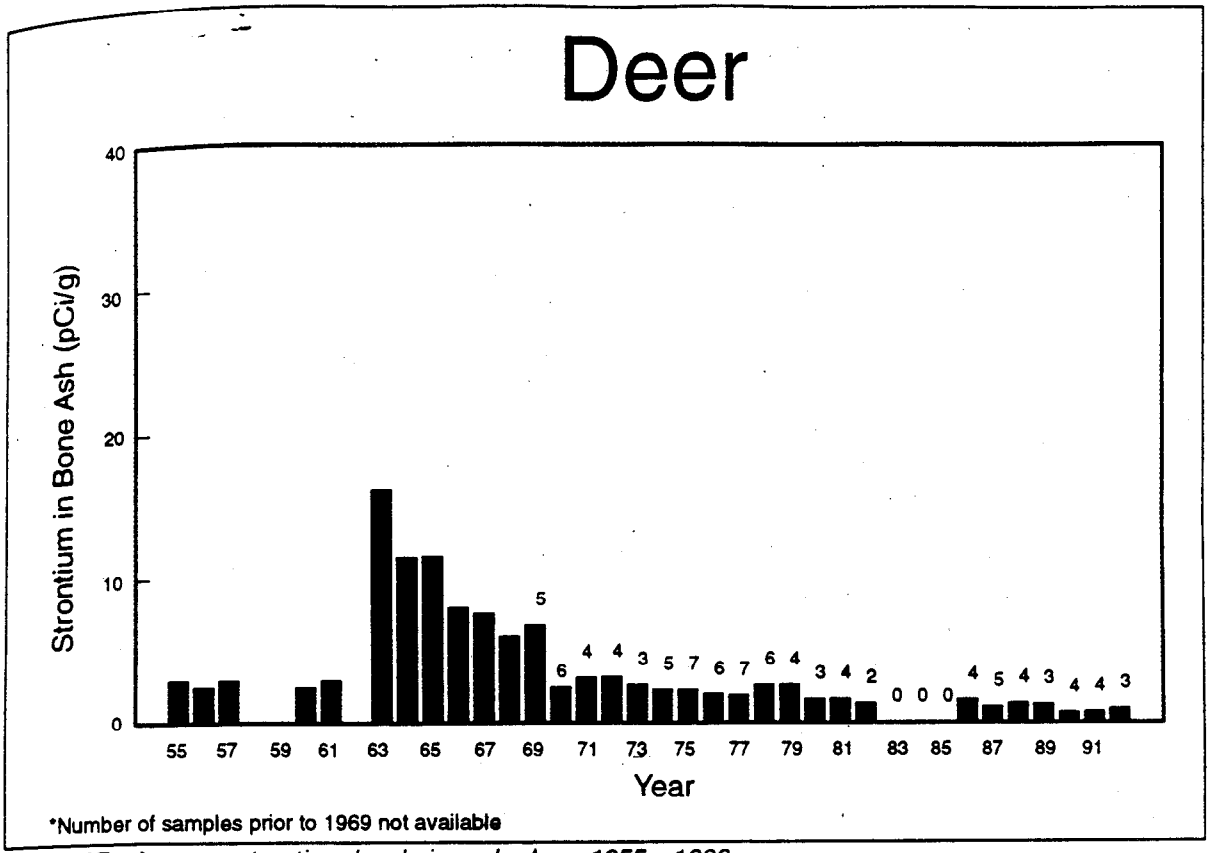

Figure 27. Average strontium levels in mule deer, 1955 - 1992.

The final deer killed in the fall was a nonlactating doe in good condition located in Area 19 of the NTS on Pahute Mesa Road. There was no ^{3}H found in the blood above the MDC of 5.16×10^{-7} µCi/mL, and no gamma-emitting radionuclides other than ^{40}K were detected in soft tissue or rumen content. Liver, muscle, and rumen contained $^{239+240}Pu$: 0.052 ± 0.008 (liver), 0.097 ± 0.008 (muscle), and 0.037 ± 0.005 (rumen) pCi/g ash. Bone contained 0.008 ± 0.001 pCi/g ash $^{239+240}Pu$, 0.39 ± 0.32 pCi/g ash of ^{89}Sr, and 0.68 ± 0.07 pCi/g ash of ^{90}Sr.

The medians and ranges of the 1992 mule deer analyses, presented in Table 14, are similar to those reported for mule deer collected in 1991 for bone tissue analyses and ^{238}Pu analyses in all tissues (DOE, 1991). The average ^{90}Sr levels found in mule deer bone ash since 1955 are shown in Figure 27. Marked differences between years are observed in the medians of tritium activity in blood and $^{239+240}Pu$ in ashed soft tissues. These differences are due to the fact that two contaminated animals were collected in 1991. In past years, none, or at most one, of the mule deer have shown evidence of radioactive contamination and, thus, a contaminated sample had no impact on the median.

5.2.5 Sample Results for Cattle

Blood and soft tissues (lung, muscle, liver, thyroid, kidney, and fetal tissue, when available) were analyzed for gamma-emitting radionuclides; blood was also analyzed for tritium activity. Samples of liver, bone, and fetal tissue were ashed and analyzed for plutonium isotopes; bone and fetus samples were also analyzed for ^{90}Sr. Duplicate liver and bone samples from two animals in each group of four were prepared and analyzed.

The four cattle purchased in May 1992 from the G.L. Coffer Fleur de Lis Ranch of Beatty, Nevada had detectable concentrations of ^{90}Sr in bone ash samples ranging from 0.27 ± 0.08 to 0.75 ± 0.13

pCi/g ash. One bone sample contained, 0.001 ± 0.001 pCi/g ash of ^{238}Pu and 0.003 ± 0.001 pCi/g ash of $^{239+240}$ Pu. One of the cows was pregnant. The fetal bone contained no ^{90}Sr above the detectable concentration of 0.70 pCi/g ash. The average ^{90}Sr found in cattle bone ash since 1955 is shown in Figure 28. All liver samples from the adult cattle contained $^{239+240}$Pu, ranging from 0.004 ± 0.001 pCi/g ash to 0.015 ± 0.004 pCi/g ash. No ^{3}H was detected above the MDC. These animals had ranged from Beatty into the NTS in the Beatty Wash area.

Four cattle were purchased in September 1992 from the Cortney Dahl ranch in Delamar Valley (near Alamo, Nevada). The livers of three of the animals contained $^{239+240}$Pu ranging from 0.010 ± 0.004 to 0.014 ± 0.002 pCi/g ash and one liver contained 0.008 ± 0.003 pCi/g ash of ^{238}Pu. Only one bone sample contained $^{239+240}$Pu, 0.018 ± 0.002 pCi/g ash, but all four contained ^{90}Sr ranging from 0.34 ± 0.06 to 0.88 ± 0.07 pCi/g ash. One bone sample also contained ^{89}Sr, 0.72 ± 0.36 pCi/g ash. One cow was pregnant and the fetus contained 0.005 ± 0.001 pCi/g ash of $^{239+240}$Pu. No ^{3}H was detected above the MDC. Medians and ranges, given in Table 14, are similar to those reported for animals collected in 1991 (DOE, 1991).

5.2.6 Quality Assurance/Quality Control

Standard operating procedures detail sample collection, preparation, storage, analysis, and data review procedures to ensure comparability among operators. Field personnel complete a standardized necropsy protocol form to ensure that all relevant information is recorded, such as date and location of collection, history and condition of the animals and tissues, sample weights, and assigned identification numbers. Standardized forms accompany each shipment of samples sent to the contract laboratory for ashing and are also used for analyses conducted in the Radioanalysis Laboratory. All information entered into the data base

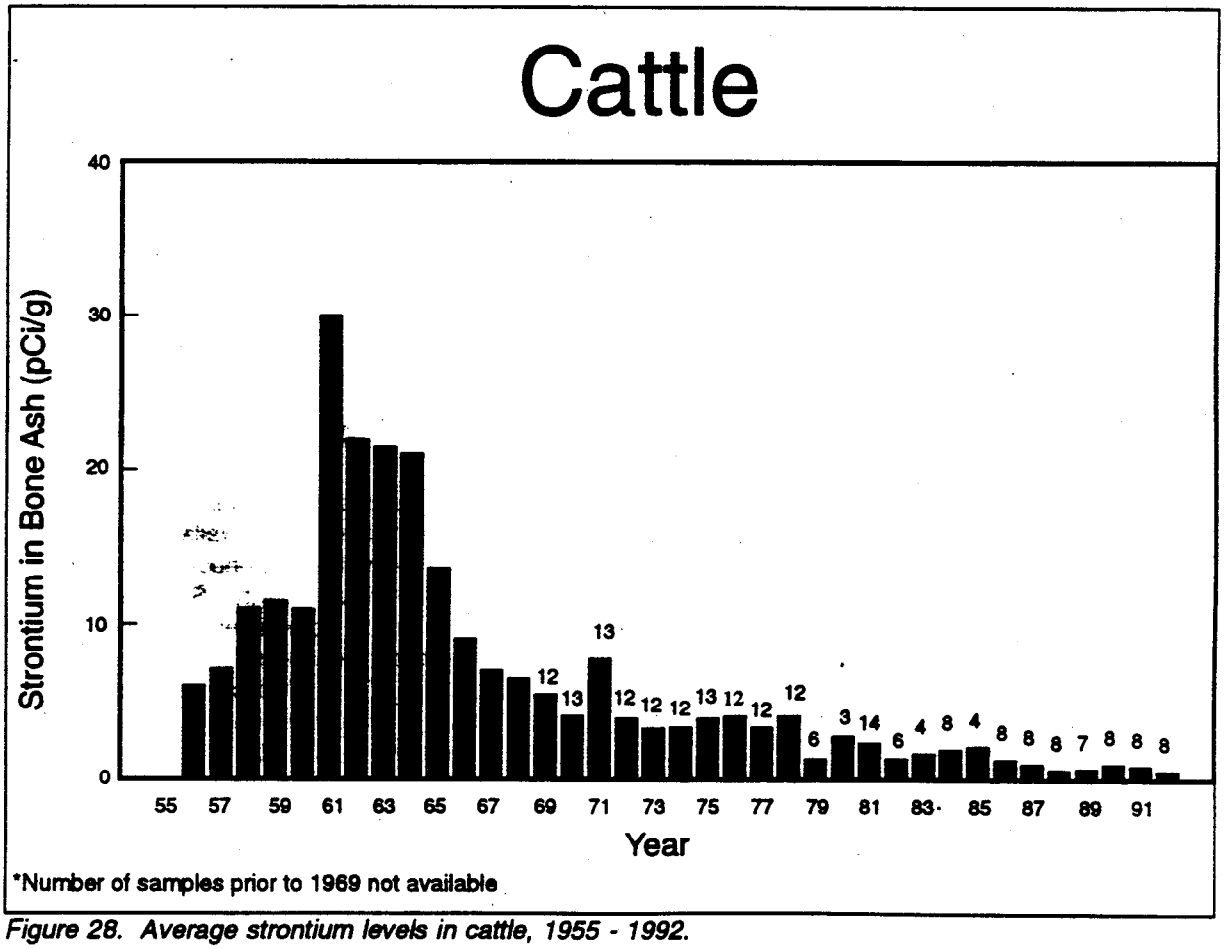

Figure 28. Average strontium levels in cattle, 1955 - 1992.

management system by Sample Control and the radioanalysis chemists is checked and verified by the Group Leader and assigned media expert.

An estimate of system precision is obtained from results of duplicate samples. Matrix spike samples are used to verify analytical accuracy. Matrix blank samples monitor any contamination resulting from sample preparation and analysis. The entire sample set analyzed in any given year is quite small (usually four or five sample batches) and, as a consequence, the QA/QC sample results set contains fewer values than is considered minimal for statistical uses. Therefore, the results of QA/QC samples are considered to provide only an indication or estimate of true precision and accuracy. This is considered adequate because the Animal Investigation Program itself is not statistically based.

Prior to 1991, analyses of animal tissue samples were performed by a contract laboratory. The EPA EMSL-LV Radioanalysis Laboratory assumed responsibility for sample analysis beginning with the results contained in this report. The change of laboratories raised concerns about comparability of analyses, so a special QA review was conducted. The procedures used by each laboratory are comparable, as are results of matrix spike samples. Generally, the result ranges obtained in 1991 were similar to those obtained in previous years when samples were analyzed by the contract laboratory. Finally, results of QA/QC samples, with the exception of one routine duplicate pair, were within established control limits. Although a direct comparability study was not undertaken (i.e., analysis of replicate samples by both laboratories), the results of the QA review indicate the data obtained for 1992 analyses are comparable to data obtained in previous years.

The QA review also resulted in recommendations for some changes in the animal investigation program that were implemented in 1992. These recommendations included preparation of a large stock of matrix spike and blank sample material and addition of a system blank. The single stock of matrix spike sample material permit an additional estimate of precision, in this case analytical precision, to be obtained. The system blank was a bone sample known to contain no detectable concentrations of radionuclides (with the possible exception of strontium). It was processed with each tissue sample batch to provide a check of possible contamination during the ashing and sample preparation processes.

5.3 Fruits And Vegetables Monitoring

Another possible pathway of radionuclide ingestion is through produce: fruits, vegetables, and grains. Commercial farming, other than alfalfa, is not a major industry in the offsite area around the NTS. Therefore, monitoring is limited to fruits and vegetables grown in local gardens for family consumption. In the event of a release of radioactivity from the NTS, monitoring of produce would be extended to include alfalfa, forage grasses, and feed grain supplies. No extensive monitoring was required in 1992.

5.3.1 Network Design

Like the Animal Investigation Program, fruit and vegetable monitoring is based on a worst-case scenario. Local residents living in areas known to have received fallout from past atmospheric testing are asked to donate produce from their family gardens. These areas which received fallout are also the areas in the preferred downwind direction during current underground testing. As sample collection is not statistically based, no inference should be drawn regarding the representativeness of the sampled materials to concentrations of radionuclides in produce as a whole, nor should any conclusions be drawn regarding the average consumption of radionuclides from produce.

5.3.2 Sample Collection and Analysis Procedures

Fruit and vegetable contribution of samples is voluntary by the offsite residents. Sampling is done only once per year, in the late summer. Fruits and vegetables harvested at that time generally include root crops (onions, carrots, potatoes), melons and squash, and some leafy vegetables (e.g., cabbage).

Samples are processed by washing the material as it would be done by residents prior to eating or cooking. This washing procedure introduces an element of variability, as the thoroughness of washing varies by individual. Potatoes and carrots are not peeled. Further processing generally includes cutting the material into small pieces

and/or blending in a mixer or food processor. Splits are prepared for analysis of gamma-emitting radionuclides and tritium. Other sample splits are ashed and analyzed for ^{90}Sr, ^{238}Pu, and $^{239+240}Pu$.

5.3.3 Sample Results

In the fall of 1992, eight samples of locally grown fruits and vegetables were donated by offsite residents in Utah and Nevada. Fruits and vegetables sampled included apples, broccoli, cabbage, carrots, and summer squash. All samples were analyzed for gamma-emitting radionuclides and only naturally occurring ^{40}K was detected. All samples were analyzed for tritium; no results greater than the MDC of the analysis were obtained. Samples were then ashed and analyzed for ^{90}Sr, ^{238}Pu, and $^{239+240}Pu$. Results which were greater than the MDC of the analysis are listed in Table 15. Four vegetable samples from Nevada (cabbage, broccoli, and two samples of carrots with tops) contained ^{90}Sr greater than the MDC of the analysis. The source of the ^{90}Sr may have been soil particles adhered to the vegetable. No ^{238}Pu was found in any of the samples. Concentrations of $^{239+240}Pu$ greater than the analysis MDC were found in all carrots with tops. None of the smooth-skinned surface crops contained these radionuclides.

5.3.4 Quality Assurance/Qualtiy Control

The fruits and vegetables are considered to be a batch within the Animal Investigation Program. The same QA/QC samples are used, including matrix spikes and matrix blanks (animal bone ash is the matrix). If sufficient material is received, at least one of the samples may be analyzed in duplicate; however, in many years not enough of any one type of material is received from any one source to permit preparation of duplicates. As with the Animal Investigation Program, the QA/QC samples provide only an estimate or indication of the analytical precision and accuracy.

Table 15. Detectable ^{90}Sr and $^{239+240}Pu$ Concentrations in Vegetables

Vegetable	Collection Location	% Ash	$^{90}Sr \pm 1\sigma$ pCi/g ash (MDC)	$^{239+240}Pu \pm 1\sigma$ 10^{-3} pCi/g ash (MDC)
Broccoli	Rachel, NV	0.45	2.0 ± 0.49 (1.4)	
Cabbage	Rachel, NV	0.31	0.78 ± 0.18 (0.62)	
Carrots with tops	Alamo, NV	1.61	0.34 ± 0.05 (0.12)	1.26 ± 0.47 (0.833)
	Rachel, NV	1.03	0.82 ± 0.22 (0.68)	3.40 ± 1.46 (2.26)
	LaVerkin, UT	1.21		0.772 ± 0.409 (0.719)

MDC = minimum detectable concentration

6.0 Internal Dosimetry

Internal exposure is caused by ingested, absorbed, or inhaled radionuclides that remain in the body either temporarily or for longer periods of time because of storage in tissues. At EMSL-LV, two methods are used to detect body burdens: whole-body counting and urinalysis.

6.1 Network Design

The Internal Dosimetry Program consists of two components, the Offsite Internal Dosimetry Program and the Radiological Safety Program.

The Offsite Internal Dosimetry Program is designed to (1) measure radionuclide body burdens in a representative number of families who reside in areas that were subjected to fallout during the early years of nuclear weapons tests, and (2) provide a biological monitoring system for present nuclear testing activities. A few families who reside in areas not affected by fallout were selected for comparative study. Members of the general public concerned about possible exposure to radionuclides are also counted periodically as a public service.

The program was initiated in December 1970 to determine levels of radionuclides in some of the families residing in communities and ranches surrounding the NTS. For these families, counting is performed in the spring and fall of each year. This program started with 34 families (142 individuals). In 1992, 54 families (158 individuals) were eligible for the program. Locations of the 27 families monitored in 1992 are shown in Figure 29. The number of individuals participating in the program varies as children leave home to attend school or obtain employment. Although most families are able to come into the laboratory as scheduled, some are unable to participate in a particular year due to distance, weather, or family commitments. All families currently in residence would presumably be available following any accidental release of radioactivity.

The Radiological Safety Program is designed to assess internal exposure for EPA employees, DOE contractor employees, and by special request, employees of companies or government agencies who may have had an accidental exposure to radioactive material. Individuals with potential for occupational exposure are counted at the request of their employers. Counting is done routinely for DOE contractors. EPA personnel in radiation programs or those who work with radioactive materials undergo a whole body count and a urinalysis annually.

6.2 Procedures

The whole-body counting facility has been maintained at EMSL-LV since 1966 and is equipped to determine the identity and quantity of gamma-emitting radionuclides that may have been inhaled, absorbed, or ingested. Routine examinations consist of a 2,000 second count in each of the two shielded examination vaults. In one vault, a single intrinsic germanium coaxial detector positioned over an adjustable chair allows detection of gamma radiation with energies ranging from 60 keV to 2.0 meV in the whole body. The other vault contains an adjustable chair with six intrinsic germanium semiplanar detectors mounted above the chest area. The semiplanar array is designed to detect gamma- and X-ray-emitting radionuclides with energy ranges from 10 to 300 keV. Specially designed software allows individual detector spectra to be analyzed to obtain a summation of left- or right-lung arrays and of the total lung area. This provides much greater sensitivity for the transuranic radionuclides while still maintaining the ability to pinpoint "hot spots." Custom-designed detector mounts allow maximum flexibility for the placement of detectors in various configurations for skull, knee, ankle, or other geometries.

To complete the evaluation, a urine sample is collected for ^{3}H analysis. Not all participants in the Radiological Safety Program submit urine samples for ^{3}H analysis.

Before the Offsite Internal Dosimetry Program participants leave the facility, results of the whole-body and lung counts are made available and are discussed with the subjects. Results of the urine ^{3}H analysis are reported later if the result is abnormal. At 18-month intervals, a physical exam, health history, and the following are performed: complete urinalysis, complete blood count, serology, chest X-ray (three-year intervals), sight screen-

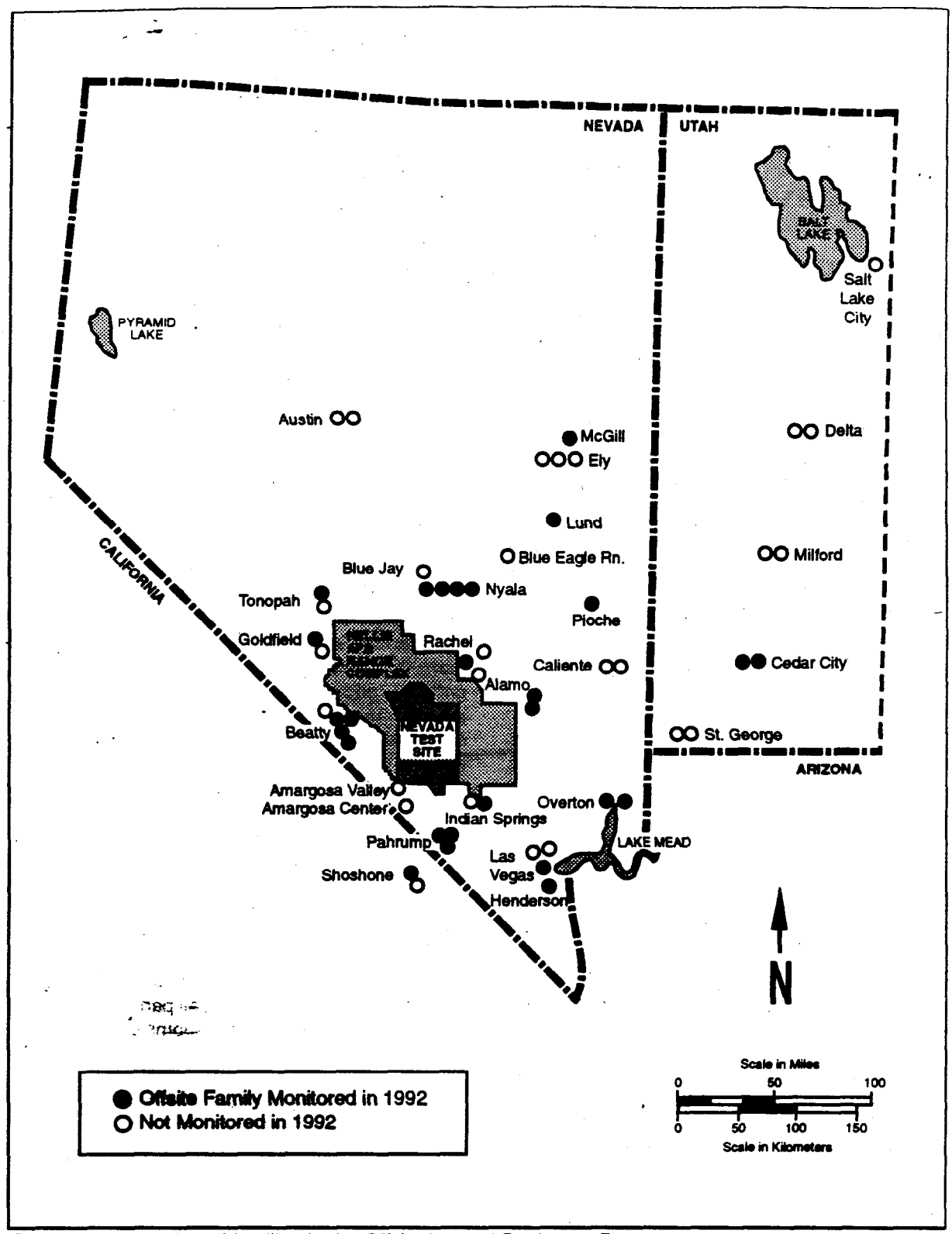

Figure 29. Location of families in the Offsite Internal Dosimetry Program - 1992.

ing, audiogram, vital capacity, EKG (for individuals over 40 years old), and thyroid panel. The results of the examination can be requested for use by the individual's family physician.

6.3 Results

During 1992, EPA performed whole-body and lung counting on 281 individuals, of whom 107 were participants in the Offsite Internal Dosimetry Network. An additional 118 gamma spectra were obtained for radiation workers, including EPA, DOE, and contractor personnel. Special study whole-body counts were performed for Utah State University volunteers participating in an ^{59}Fe uptake study, the U.S. Army, the U.S. Navy, and concerned citizens. No transuranic radionuclides were detected in any lung counts. All of the whole-body gamma spectra for the Offsite Internal Dosimetry Network and Radiological Safety Program participants were representative of normal background and showed only naturally occurring ^{40}K. The Utah State University volunteers, as expected, showed uptake of ^{59}Fe. The U.S Army specialist, wounded by an antitank missile during Operation Desert Storm, was found to have depleted uranium shrapnel imbedded in his legs and in one hand. An attempt was made to determine the amount of ^{235}U and ^{238}U present in the embedded shrapnel, but the depth of most of the shrapnel was unknown as was the self-absorption by the metal itself, so an accurate determination was impossible.

Bioassay results for single urine samples collected from participants in the Offsite Internal Dosimetry Network showed only five samples at random times with tritium concentrations greater than the MDC. The greatest tritium concentration detected was $3.43 \times 10^{-7} \pm 2.99 \times 10^{-7}$ µCi/mL, which is 0.4 percent of the annual limit of intake for the general public. Table 16 provides a summary of bioassay results. Two participants from McGill, Nevada did not participate in the bioassay portion of the program this year.

As reported in previous years, medical examinations of the offsite families revealed a generally healthy population. The blood examinations and thyroid profiles showed no symptoms which could be attributed to past or present NTS testing operations.

6.4 Quality Assurance/Quality Control

Quality Assurance procedures consist of daily equipment operations checks using QA software obtained specifically for this facility. Some of the parameters monitored daily include energy calibration of each detector using a NIST-traceable point source to check for zero, gain shift, and resolution over a wide range of energies. A background measurement is also taken once or twice daily depending on the count schedule.

The whole-body detector efficiency is calibrated annually using a Bottle Mannequin Absorber (BOMAB) phantom containing a NIST-traceable mixed radionuclide source. The lung counter is also calibrated annually with a male realistic lung phantom. A separate set of efficiency calibration data is kept for each combination of sample shape/organ geometry.

The following MDCs were calculated after recalibration of the lung counting system in February 1992: ^{241}Am, 0.2 µCi; ^{238}Pu, 18 µCi; and ^{239}Pu, 130 µCi. There were no significant differences from previous MDC's. These were calculated for a standard chest wall thickness of 3 cm. The MDAs for the whole-body counting system for 1991 were as follows: ^{60}Co, 10 nCi; ^{137}Cs, 14 nCi; ^{134}Cs, 11 nCi; and ^{131}I, 13 nCi.

All efficiency curves are generated by the vendor-supplied whole-body counting and lung counting software. QA software is used to monitor the systems by performing out-of-range tests for predetermined parameters. Results are plotted and reports are generated daily and monthly. All data are stored in the computer. Replicate counting of the standard BOMAB phantom provides a measure of consistency. Replicate counts of blind intercalibration phantoms and of people counted previously in other facilities provide additional measurements of precision and accuracy. Verification and validation are completed before results are entered into a data base. Calculation of internal dose is done utilizing software based on the International Commission on Radiological Protection (ICRP) methodology (ICRP, 1979).

Table 16. Tritium in Urine, Offsite Internal Dosimetry Program - 1992

		^{3}H Concentration (10^{-7} µCi/mL)				
Location	Number	Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as %DCG
Shoshone, CA	3	-0.0145	-1.07	-0.418	0.574	NA
Alamo, NV	10	1.81	-0.592	0.941	0.731	0.10
Beatty, NV	10	3.07*	-0.573	0.967	1.24	0.11
Goldfield, NV	2	2.73	1.65	2.19	0.764	0.24
Henderson, NV	2	1.29	0.756	1.02	0.381	0.11
Indian Springs, NV	2	1.32	0.741	1.03	0.407	0.11
Las Vegas, NV	2	2.33	1.38	1.85	0.669	0.21
Lund, NV	2	1.49	1.41	1.45	0.0551	0.16
Nyala, NV	9	3.43*	0.0432	1.45	1.05	0.16
Overton, NV	11	2.00	0.839	1.39	0.424	0.15
Pahrump, NV	23	2.52	0.000	1.01	0.773	0.11
Pioche, NV	10	1.68	0.306	0.803	0.546	0.09
Rachel, NV	4	2.09*	1.19	1.67	0.373	0.19
Tonopah, NV	4	3.02*	-0.642	1.66	1.60	0.18
Cedar City, UT	11	1.65	-0.792	0.908	0.714	0.10

Mean MDC: 2.46 x 10^{-7} µCi/mL Standard Deviation of Mean MDC: 5.29 x 10^{-8} µCi/mL

DCG = derived concentration guide. Established by DOE Order as 9 x 10^{-5} µCi/mL.
MDC = minimum detectable concentration.
* = result is greater than the MDC of analysis.
NA = not applicable.

Dose calculation is verified using ICRP and National Council on Radiation Protection and Measurements (NCRP) guidelines (NCRP, 1989). Preventive maintenance and repair of analytical equipment are done by the vendor service representative. Data are retained permanently. Subject confidentiality and data security are maintained through well-established procedures. EPA whole-body counting technicians participate in DOE and EPA QA training programs.

7.0 Long-Term Hydrological Monitoring Program

One of the concerns of underground nuclear weapons testing is the possibility of radionuclide contamination of groundwaters. Underground nuclear weapons tests are currently conducted only on the NTS, but between 1961 and 1973, eleven tests were conducted in eight other locations in the United States. The initial ground and surface water monitoring program was established by the PHS in the early 1950s. Pretest and posttest monitoring for the locations off the NTS was conducted by the PHS, the U.S. Geological Survey (USGS), and Teledyne Isotopes, Inc. In 1972, the LTHMP was established by the Nevada Operations Office of the AEC. Through an interagency agreement between AEC (later DOE) and the EPA, responsibility for operation of the LTHMP was assigned to the EMSL-LV. The LTHMP is only one component of the total surface and ground water monitoring program conducted under the auspices of DOE/NV.

The LTHMP conducts routine monitoring of specific wells on the NTS and of wells, springs, and surface waters in the offsite area around the NTS. In addition, sampling for the LTHMP is conducted at other sites in Nevada, Colorado, New Mexico, Mississippi, and Alaska locations where nuclear weapons tests have been conducted.

7.1 Network Design

The LTHMP was instituted because the AEC acknowledged its responsibility for obtaining and disseminating data acquired from all locations where nuclear devices have been tested. The three objectives originally established for the LTHMP were to:

- Assure public safety.
- Inform the public, news media, and scientific community about any radiological contamination.
- Document compliance with existing federal, state, and local antipollution requirements.

Another objective which has been incorporated into the LTHMP is to, where possible, detect trends in radionuclide activities which may indicate migration from test cavities.

The primary radionuclide analyzed in the LTHMP is tritium. As a product of nuclear weapons testing, tritium is found at high levels in test cavities. Because tritium can be incorporated into water molecules, it is expected to be the first radionuclide to migrate from a test cavity. Therefore, tritium serves as an indicator of radionuclide migration. Atmospheric tritium may also be deposited into water, primarily by precipitation scavenging. Tritium from this source is primarily found in surface waters, surficial aquifers, and springs closely connected to surficial aquifers.

7.1.1 Sampling Locations

In order to meet the objective of assuring public safety, EMSL-LV monitors drinking water supply wells and springs around the NTS and in the vicinity of surface ground zero (SGZ) at the other locations. The majority of these sampling sites are privately owned and participation in the LTHMP is voluntary. Municipal drinking water supplies are also represented. Regardless of the number of individuals served by a particular water supply, the National Primary Drinking Water Regulation[1] (NPDWR) pertaining to radioactivity is used as the compliance standard[2] (see notes at the end of this section).

All of the nuclear weapons tested at locations other than the NTS were emplaced at depths of greater than 1,200 feet. Nuclear weapons tested on the NTS are also emplaced at great depths, with the exception of some shallow underground tests conducted in the early 1960s. Most of the drinking water supply wells tap shallow aquifers, and consequently do not represent groundwater in the geologic strata containing the test cavities. Therefore, wherever possible, deep wells are included in the monitoring program. These wells include some which were drilled soon after a nuclear test specifically to monitor activities in or near the test cavity and others which can be considered only as "targets of opportunity"; e.g., existing wells for which sampling permission has been obtained. Most of the deep wells tap non-potable water sources. Monitoring design standards, such as

those in the Resource Conservation and Recovery Act (RCRA), did not become available until long after the LTHMP deep wells had been drilled. Cost has delayed emplacement of new wells, although a program to drill more than 90 new wells on the NTS was initiated in 1990. The sampling locations not associated with the NTS are defined by DOE as inactive hazardous waste sites and are exempt from the RCRA monitoring design requirements.

7.1.2 Sampling and Analysis Procedures

At nearly all LTHMP locations, the standard operating procedure is to collect three samples from each source. Two samples are collected in 500-mL glass bottles to be analyzed for tritium. The results from analysis of one of these samples are reported while the other sample serves as a backup in case of loss or as a duplicate sample. The remaining 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 are collected for tritium analysis.

For wells with operating pumps, samples are collected at the nearest convenient outlet. If the well has no pump, a truck-mounted sampling rig is used. With this rig it is possible to collect 3-L samples from wells as deep as 1,800 meters. At the normal sample collection sites, the pH, conductivity, water temperature, and sampling depth are measured when the sample is collected.

When samples are first collected from a well, $^{89,90}Sr$, $^{238,239}Pu$, and uranium isotopes are determined by radiochemistry. Prior to 1979, the first samples from a new location were analyzed for 15 stable elements, anions, nitrates, ammonia, silica, uranium, plutonium, and strontium isotopes; 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. One of the 500-mL samples from each site is analyzed for tritium. When sample results are close to or less than the MDC for the conventional tritium analysis (approximately 400 to 700 pCi/L), the sample is concentrated by electrolysis. The MDC for this method (referred to as the enrichment method in the following text) is approximately 5 to 7 pCi/L. Most of the LTHMP samples are analyzed by the enrichment method, unless past years' data have indicated activities are within the detectable range of the conventional method. Additionally, semiannually sampled wells on and in the vicinity of the NTS are analyzed once per year by the enrichment method and once per year by the conventional method.

7.1.3 Quality Assurance/Quality Control Samples

Sample collection and analysis procedures are described in SOPs. Data base management and data analysis activities are described in the Quality Assurance Plan (EPA, 1992). Use of standardized procedures ensures comparability of operations and data among monitoring locations and across temporal intervals.

Annual data quality assessments of precision, accuracy, and comparability are based on the results of QA/QC samples. The data quality assessment results for 1992 are given in Section 11. Overall system precision is estimated from the results of field duplicates. A field duplicate is a second sample collected from a sampling location immediately following collection of the routine sample using identical procedures. Field duplicates are collected from sampling locations on the NTS and in the vicinity of the NTS according to a schedule established by the LTHMP Technical Leader. Generally, all samples from the other locations are collected in duplicate; the second sample may be used as a duplicate or may be used as a replacement for the routine sample, if necessary.

Accuracy is estimated from results of intercomparison study samples. These samples are spiked samples (i.e., a water sample to which a known amount of particular radionuclide(s) have been added). Intercomparison study programs managed by EMSL-LV and DOE's Environmental Measurements Laboratory (EML) both include water matrix samples. The EMSL-LV intercomparison study samples are also used for an estimate of comparability. Generally, 60 to more than 300 laboratories participate in a given intercomparison study. Results for each laboratory are reported, as are pooled results (mean, standard deviation). Comparison of the EMSL-LV Radioanalysis Laboratory result to the mean for all

laboratories provides an estimate of the comparability of results.

In addition to the above-described QA/QC samples which are used in annual data quality assessments, the Radioanalysis Laboratory employs a number of internal QC samples and procedures to ensure data quality on a day-to-day basis. Internal QC samples include blanks, regular calibrations, matrix spike samples, and duplicate analyses (gamma spectroscopy only). If results of these internal QC samples fall outside prescribed control limits, corrective actions are implemented; analysis is stopped until the cause of the discrepant data is found and resolved.

7.1.4 Data Management and Analysis

In the spring of 1991, the LTHMP was selected as the pilot program to test the use of bar code sample labels. Bar code labels were prepared prior to each sampling excursion. Upon receipt of samples in Sample Control, the bar code label was read and the information transferred into the Sample Tracking Data Management System (STDMS), along with information from the field data card. This pilot program was extremely successful and is being continued for the LTHMP and expanded to other monitoring networks.

Analysis data were entered into the STDMS after they had been generated and reviewed by the analyst and Group Leader. Special software written in Fortran (referred to as "Chemistry Programs") was used for a majority of the radiochemical data reduction. The Chemistry Programs were used for calculating final data such as activity per unit volume, MDC, and 2-sigma error terms. All hand-entered data were checked for transcription errors. Once data had been entered and checked, they were transferred from a "review" data base to a permanent data base, where further changes may be made only by authorized personnel.

Periodically, the assigned media expert reviewed the data base and checked for completeness of sample collection, transcription errors, completion of sample analysis and QA/QC samples, and accuracy of information input. All discrepancies were resolved and corrected. Once the data base was complete for a given location, time series plots were generated. Any discernable trends were discussed at an annual data review attended by management and scientific personnel. Another data review of the LTHMP was held with DOE and DRI hydrology personnel. The time series plots which indicated consistent data trends are included as figures in the subsections which follow. The filled circles on the time series plots represent the result values, the error bars indicate ± one standard deviation of the result, and the (x) represents the MDC value.

7.2 Nevada Test Site Monitoring

The present structure of the LTHMP for the NTS onsite network, which includes sample locations on the NTS and immediately outside its borders on federally owned land, is displayed in Figure 30. All sampling locations are selected by DOE and primarily represent drinking water supplies. All samples are analyzed by gamma spectrometry and for tritium by the enrichment method. Sixteen wells are sampled monthly and 21 wells are sampled twice per year, at approximately six-month intervals. No gamma-emitting radionuclides were detected in any of the samples collected in 1992. The greatest tritium activity measured in the LTHMP NTS network in 1992 was 448 ± 4 pCi/L in a sample from Well UE-7ns. This activity is 0.5 percent of the derived concentration guide (DCG).[3]

Of the 37 sampling locations assigned to the LTHMP, six could not be sampled at any time in 1992: Water Well 2, where the pump has been inoperative since December 1990; Water Well A, which was deactivated by DOE in October 1988; Well USGS HTH "F", which was last successfully sampled in 1980; Well U3cn#5, which was shut down throughout 1992 and was last sampled in December 1981; Well UE-6d, which has never been successfully accessed for sampling; and Well UE-15d where the pump was found to be inoperative during a sampling visit in April and had not been repaired as of the end of 1992. One new sampling location was added, Well P.M. Exploratory #1, and sampling was resumed at two locations in 1992: Well 5B, which was last sampled in July 1988, and Well UE-7ns, which had last been sampled in September 1987. Additional analyses were performed on the first samples collected from the new location and from the two wells with a long break in sampling. The May 1992 sample from Well P.M. Exploratory #1 and

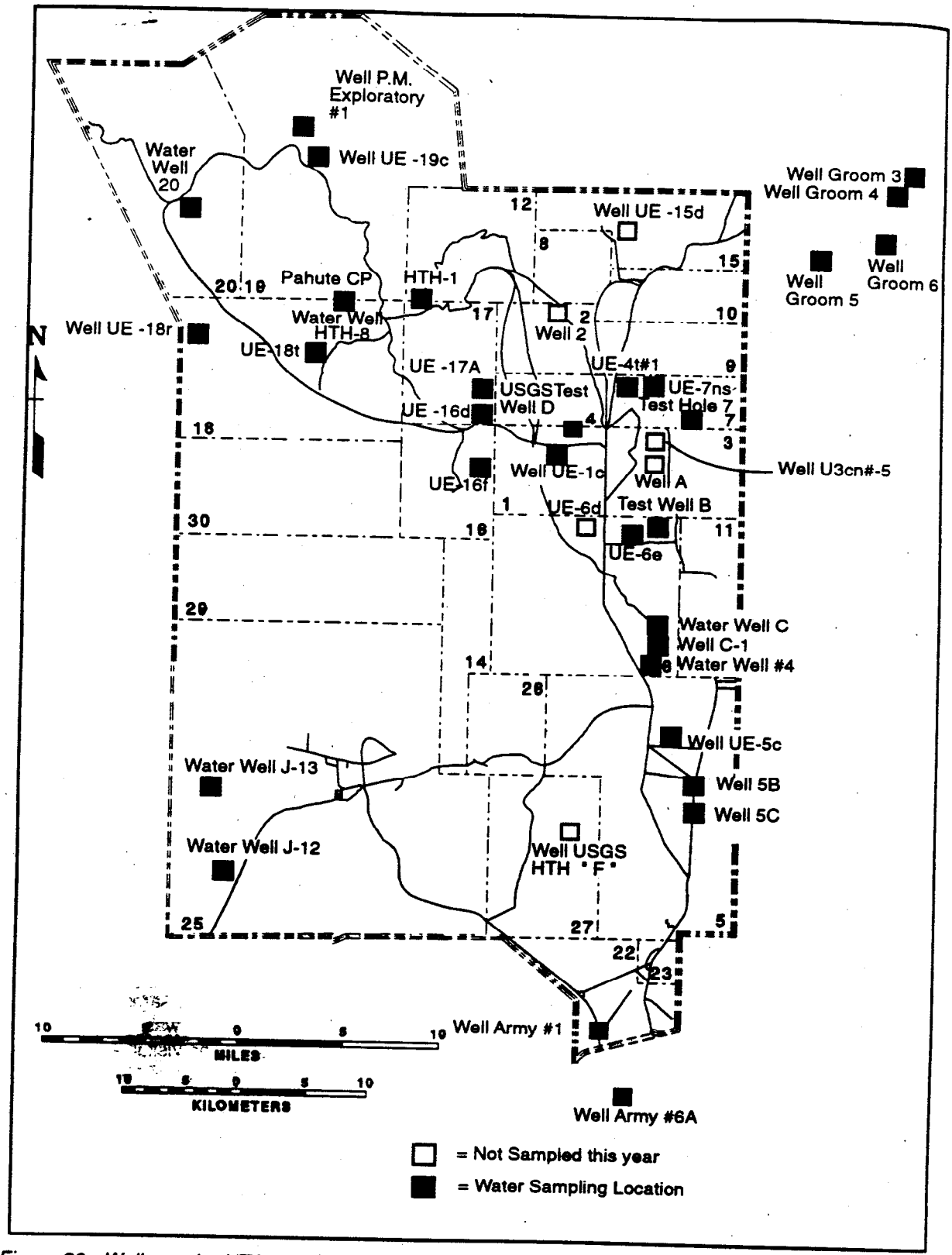

Figure 30. Wells on the NTS included in the LTHMP, 1992.

the August 1992 sample from Well 5B yielded no detectable activity for ^{137}Cs, ^{238}Pu, ^{239}Pu, ^{89}Sr, or ^{90}Sr. The Well 5B sample was also negative for tritium while the sample from Well P.M. Exploratory #1 yielded a tritium activity of 207 ± 3 pCi/L. The March 1992 sample from Well UE-7ns yielded no detectable alpha or gamma emitters; a gross beta activity of 7.87 ± 0.96 (MDC of 2.51) pCi/L was obtained and tritium results were 380 ± 4 pCi/L.

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, Water Well 20 and Well UE-19c were temporarily shut down; *i.e.*, power to the pump was disconnected and the lines were drained. This measure was later reversed, with the result that only the November sampling period was lost. Wells UE-16f, UE-18r, and UE-18t are located in areas with restricted access and/or reduced maintenance (i.e., no snow removal) which precluded collection of any samples after September 1992. It is expected that access restrictions will be removed and power restored in the spring of 1993.

Summary results of tritium analyses are presented in Table 17. Five of the monthly sampled wells and seven of the wells sampled semiannually yielded tritium results greater than the MDC of the enrichment analysis (approximately 5 to 7 pCi/L) in one or more samples. Of these, six involved only a single sample; with tritium activities less than 30 pCi/L (less than 0.03 percent of the DCG). Two of the monthly sampled wells, Test Well B and Water Well C, have consistently shown detectable tritium over their sampling history. The 1992 average for Test Well B was 105 pCi/L (range 94 to 119 pCi/L, 0.10 to 0.13 percent of the DCG) and for Water Well C was 16.1 pCi/L (range 10.9 to 23.7 pCi/L, 0.01 to 0.03 percent of the DCG). A decreasing trend is evident in Test Well B, as shown in Figure 31.

Both of the semiannual samples collected from Wells UE-4t#1, P.M. Exploratory #1, and UE-7ns contained detectable tritium, as did the single sample obtained from Well UE-18t. Average concentrations for these wells were less than 40 pCi/L (0.04 percent of the DCG) in Well UE-4t#1, 207 pCi/L (0.23 percent of the DCG) in Well P.M. Exploratory #1, and 414 pCi/L (0.46 percent of the DCG) in Well UE-7ns. The single sample obtained from Well UE-18t yielded a tritium result of 102 ± 2 pCi/L (0.11 percent of the DCG). Three 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; an increasing trend was evident, with tritium concentrations in excess of 2,500 pCi/L at the time sampling ceased in September 1987.

7.3 Offsite Monitoring In The Vicinity Of The Nevada Test Site

The monitoring sites located in the offsite area around the NTS are shown in Figure 32. Most of the sampling locations represent drinking water sources for rural residents in the offsite area and public drinking water supplies in most of the communities in the area. The sampling sites include 23 wells, seven springs, and two surface water sites. Thirty locations are routinely sampled every month. The remaining two sites, Penoyer Well 13 and Penoyer Wells 7 and 8, are in operation only part of the year; samples are collected whenever the wells are in operation. Water samples are collected each month for gamma spectrometric analysis. Samples for tritium analysis are collected semiannually. One of these semiannual tritium analyses is done by the conventional analysis method; the other analysis is done by the enrichment method.

Over the last decade, only three sites have evidenced detectable tritium activity on a consistent basis. These three sites are in Nevada, namely Lake Mead Intake (Boulder City), Adaven Spring (Adaven), and Specie Springs (Beatty). In all three cases, the tritium activity represents environmental levels that have been generally decreasing over time. The last time tritium concentrations for Specie Springs were greater than the MDC was in 1990.

In 1992, four of the samples, all from sites in Nevada, that were analyzed for tritium by the enrichment method yielded detectable tritium activities. The Adaven Spring January result of 32.4 ± 1.8 pCi/L (0.04 percent of the DCG) was consistent with tritium levels noted in recent years, as shown in Figure 33. The results for the Lake Mead Intake May and September samples were 57.5 ± 2.2 pCi/L (0.06 percent of the DCG) and 62.2 ± 2.3 pCi/L (0.07 percent of the DCG), respectively. These results were similar to results obtained in 1991, as indicated in Figure 34. This

Table 17. Long-Term Hydrological Monitoring Program Summary of Tritium Results for Nevada Test Site Network, 1992

Location	Tritium concentration (pCi/L) Number	Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as %DCG
Well 1 Army	12	3.2	−2.5	0.2	1.8	NA
Well Army #6A	2	3.2	1.7	2.5	1.5	NA
Water Well 2	Well shut down throughout 1992, last sampled December 1990.					
Well Groom 3	12	6.2	−2.0	2.0	2.6	NA
Well Groom 4	12	3.4	−1.9	−0.1	1.6	NA
Water Well #4	12	2.9	−4.8	−0.6	2.1	NA
Well Groom 5	12	3.2	−3.0	−0.0	1.9	NA
Well 5B	1	3.2	3.2	3.2	0.0	NA
Water Well 5C	12	3.7	−2.7	0.1	2.0	NA
Well Groom 6	11	1.2	−1.9	−0.2	1.0	NA
Test Hole 7	2	3.3	2.8	3.0	0.5	NA
Water Well HTH-8	12	10.3*	−5.1	0.3	3.6	NA
Water Well 20	8	4.9	−3.0	1.0	2.7	NA
Well A	Well inactivated by DOE, last sampled October 1988.					
Test Well B	11	119*	94*	105*	7.5	0.12
Water Well C	11	24*	11*	16*	4.4	0.02
Well C-1	2	17*	4.7	10.8*	12.3	0.01
USGS Test Well D	2	5.6	3.1	4.3	2.5	NA
Well USGS HTH "F"	Not sampled in 1992, last sampled February 1980.					
Well HTH-1	1	−2.1	−2.1	−2.1	0	NA
Water Well J-12	8	2.2	−3.9	−0.2	2.2	NA
Water Well J-13	12	3.7	−2.6	0.4	2.0	NA
Well P.M. Expl.#1	2	207*	207*	207*	0	0.23
Well U-3cn#5	Well shut down throughout 1992, last sampled December 1981.					
Well UE-1c	2	2.5	0.0	1.2	2.5	NA
Well UE-4t#1	2	47*	30*	38*	17	0.04
Well UE-5c	2	−1.1	−2.9	−2.0	1.8	NA
Well UE-6d	Inaccessible throughout 1992, has never been successfully sampled.					
Well UE-6e	1	26*	26*	26*	0	0.03
Well UE-7ns	2	448*	380*	414*	68	0.46
Well UE-15d	Pump inoperative, well shut down by DOE.					
Well UE-16d	2	2.3	−4.6	−1.1	6.8	NA
Well UE-16f	1	7.2*	7.2*	7.2*	0	0.01
Well UE-17e	2	2.3	−2.3	0.0	4.6	NA
Well UE-18	1	1.3	1.3	1.3	0	NA
Well UE-18	1	102*	102*	102*	0	0.11
Well UE-19e	11	5.3*	−2.1	0.5	2.5	NA
All	184	448	−5.1	15.5	53.6	0.02

Average MDC ± s is 5.36 ± 1.11 pCi/L.

* = Activity is greater than the minimum detectable concentration (MDC).

NA = Not applicable. Percent of concentration guide is not applicable either because the tritium result is less than the MDC or because the water is known to be nonpotable.

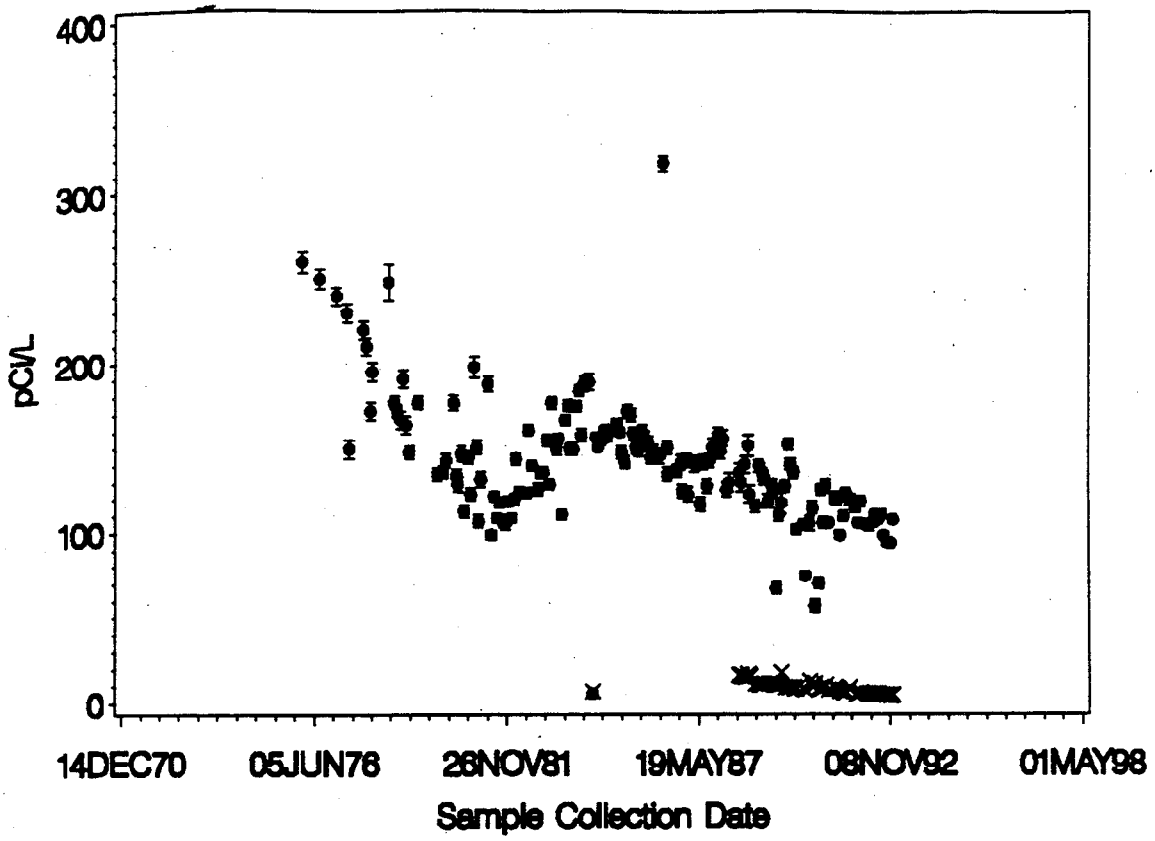

Figure 31. Tritium concentration trend in Test Well B on the NTS.

surface water site may be impacted by rainfall containing scavenged atmospheric tritium to a greater extent than the well and spring sites in the offsite network. The tritium result of 5.98 ± 1.73 pCi/L for the September sample from Johnnie Mine was only slightly higher than the MDC of 5.50 pCi/L and was the first detectable tritium activity obtained for that site since sampling was initiated in 1989. Tritium results for all samples are shown in Table C-1, Appendix C. No gamma-emitting radionuclides were detected in any sample taken in 1992.

7.4 Hydrological Monitoring At Other Locations

In addition to the groundwater monitoring conducted on and in the vicinity of the NTS, monitoring is conducted under the LTHMP at sites of past nuclear device testing in other parts of the U.S. 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. Additionally, sampling is conducted every two years on Amchitka Island, Alaska, site of Projects CANNIKIN, LONG SHOT, and MILROW; sampling was last conducted in 1991. The primary purposes of this portion of the LTHMP are 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. The following subsections summarize results of sampling conducted in 1992; analytical results for all samples are provided in Appendix C.

The sampling procedure is the same as that used for sites on the NTS and offsite areas (described in Section 7.1.2), 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 obtained from the shallow monitoring wells near the Project DRIBBLE ground zero (GZ), the sampling procedure was modified. A second sample is now taken after pumping for a

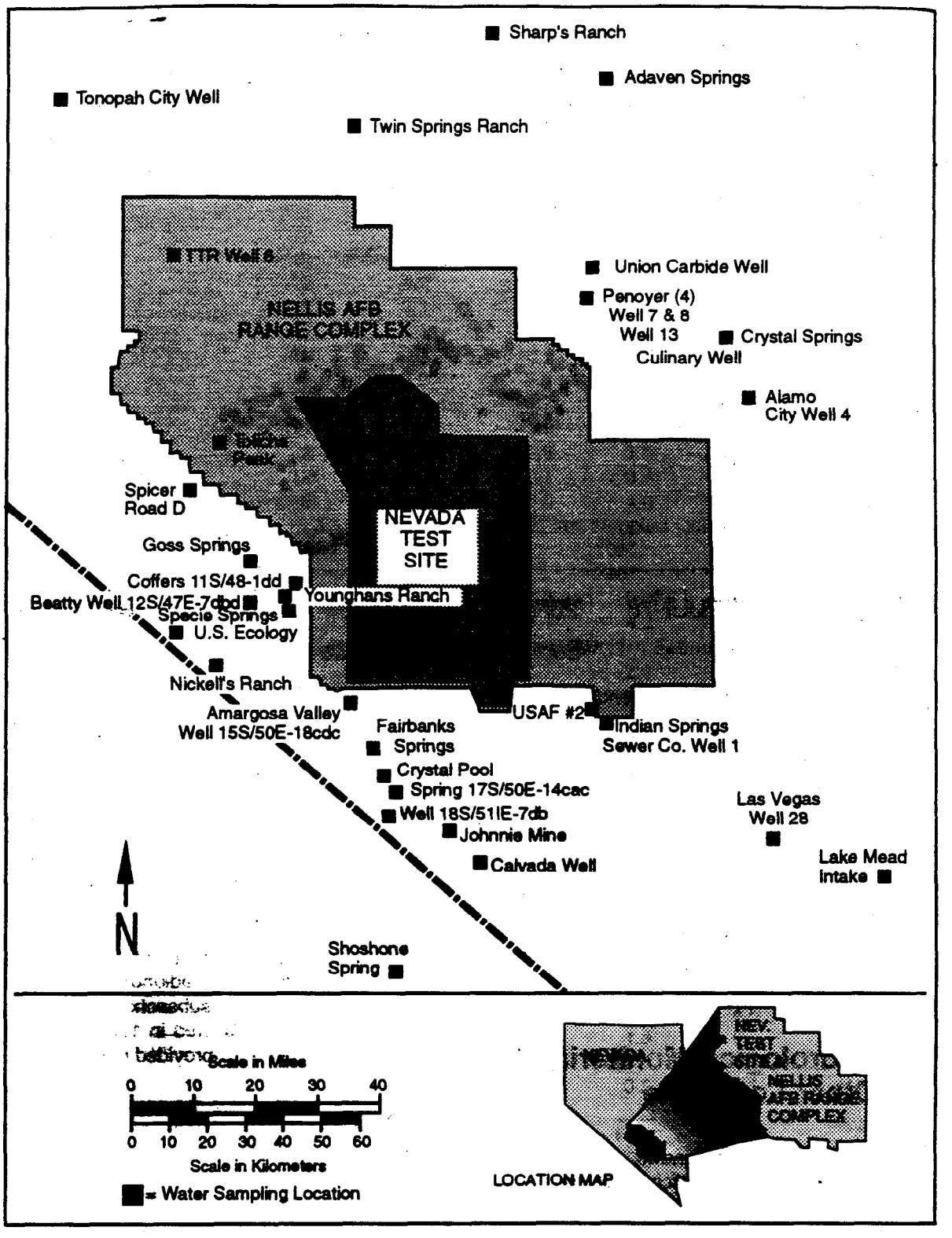

Figure 32. Wells outside the Nevada Test Site included in the LTHMP.

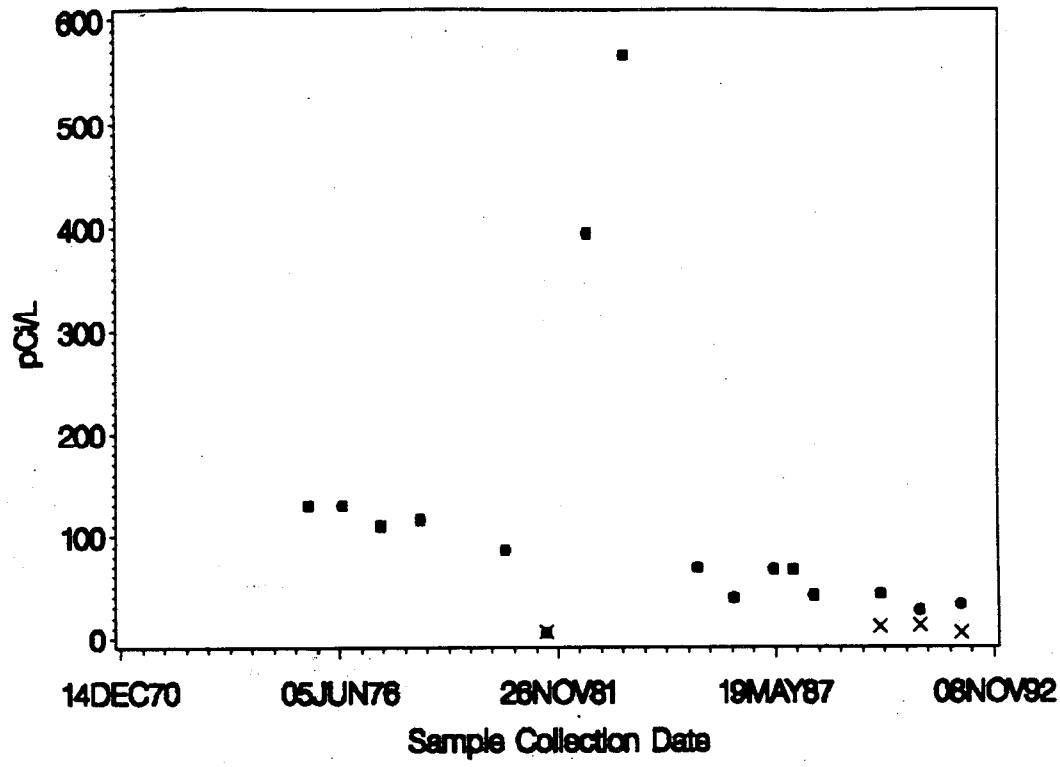

Figure 33. Tritium results in water from Adaven Springs, Nevada.

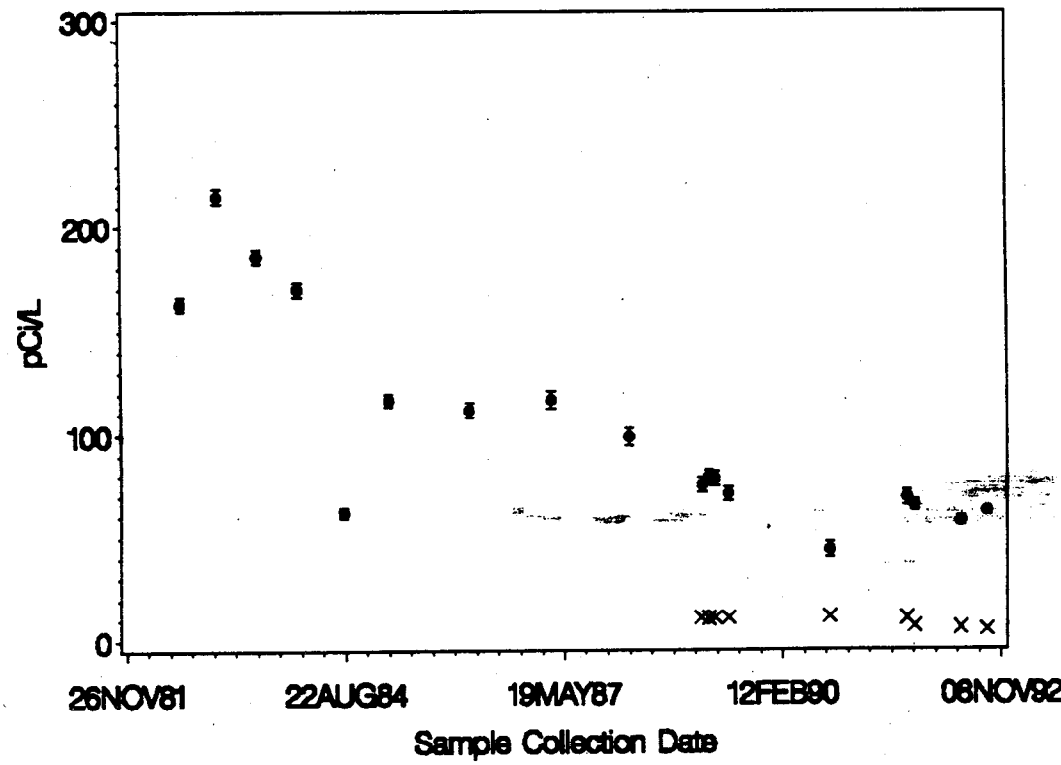

Figure 34. Trend of Tritium results in water from Lake Mead, Nevada.

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.

7.4.1 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 Mt and was designed to test the behavior of seismic waves and to determine the usefulness of the site for high-yield tests. The emplacement depth was 975 m (3,200 ft). A surface crater was created, but as an irregular block along local faults rather than as a saucer-shaped depression. The area is characterized by basin and range topography, with alluvium overlying tuffaceous sediments. The working point of the test was in tuff. The groundwater flow is generally from the highlands to the valley and through the valley to Twin Springs Ranch and Railroad Valley (Chapman and Hokett, 1991).

Sampling was conducted on February 24 and 25, 1992. Sampling locations are shown in Figure 35. Routine sampling locations include one spring and five wells of varying depths. One location, Hot Creek Ranch spring, was not sampled this year because the spring was dry. All of the sampling 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 migration from the test cavity, should it occur (Chapman and Hokett, 1991). All samples yielded negligible gamma activity and tritium activities were less than the MDC and less than 0.01 percent of the DCG (Table C-2, Appendix C). These results are consistent with results obtained in previous years. The consistently below-MDC results for tritium indicate that, to date, migration into the sampled wells has not taken place and no event-related radioactivity has entered area drinking water supplies.

7.4.2 Project SHOAL

Project SHOAL, a 12-kt test emplaced at 365 m (1,200 ft), was conducted on October 26, 1963, in a sparsely populated area near Frenchman Station, Nevada. The test, a 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 11, 1992. Four of the six routine sampling locations shown in Figure 36 were sampled at that time. No sample was collected from Spring Windmill because the well was dry and no sample was collected from Well H-3 because the pump was not operational. The pump was replaced in the fall of 1992 and a sample from Well H-3 was collected on October 21, 1992. The routine sampling locations include one spring, one windmill, and four wells of varying depths. At least one location, Well HS-1, should intercept radioactivity migration from the test cavity, should it occur (Chapman and Hokett, 1991).

No gamma activity was detected in any of the samples. A tritium result of 56 ± 2 pCi/L was detected in the water sample from Smith/James Spring, equivalent to 0.06 percent of the DCG(see Table C-3, Appendix C). 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 37. It is unlikely that the tritium source is the Project SHOAL cavity; the most probable source is considered to be rainwater infiltration.

Because Well H-3 had not been sampled since 1986, analyses of $^{89,90}Sr$ and Pu and U isotopes were completed in addition to tritium analysis. Results were less than the MDC of the analysis for strontium, plutonium, and ^{235}U. Uranium-234 and ^{238}U were detected at low levels (0.14 ± 0.02 pCi/L of ^{234}U and 0.042 ± 0.011 pCi/L of ^{238}U) and are probably of natural origin.

7.4.3 Project RULISON

Co-sponsored by the AEC and Austral Oil Co. 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 43-kt nuclear explosive emplaced at a depth of 2,568 m (8,426 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

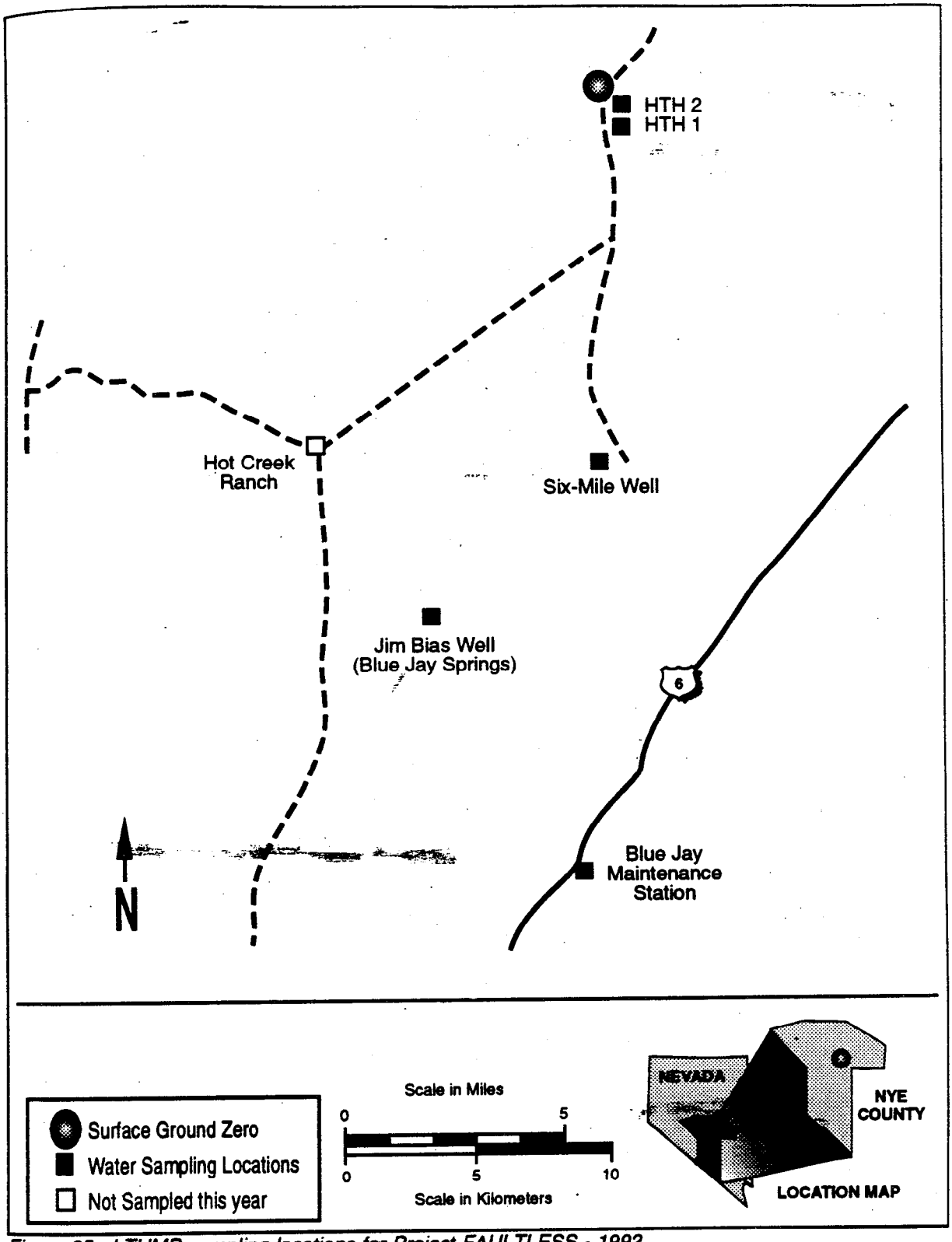

Figure 35. LTHMP sampling locations for Project FAULTLESS - 1992.

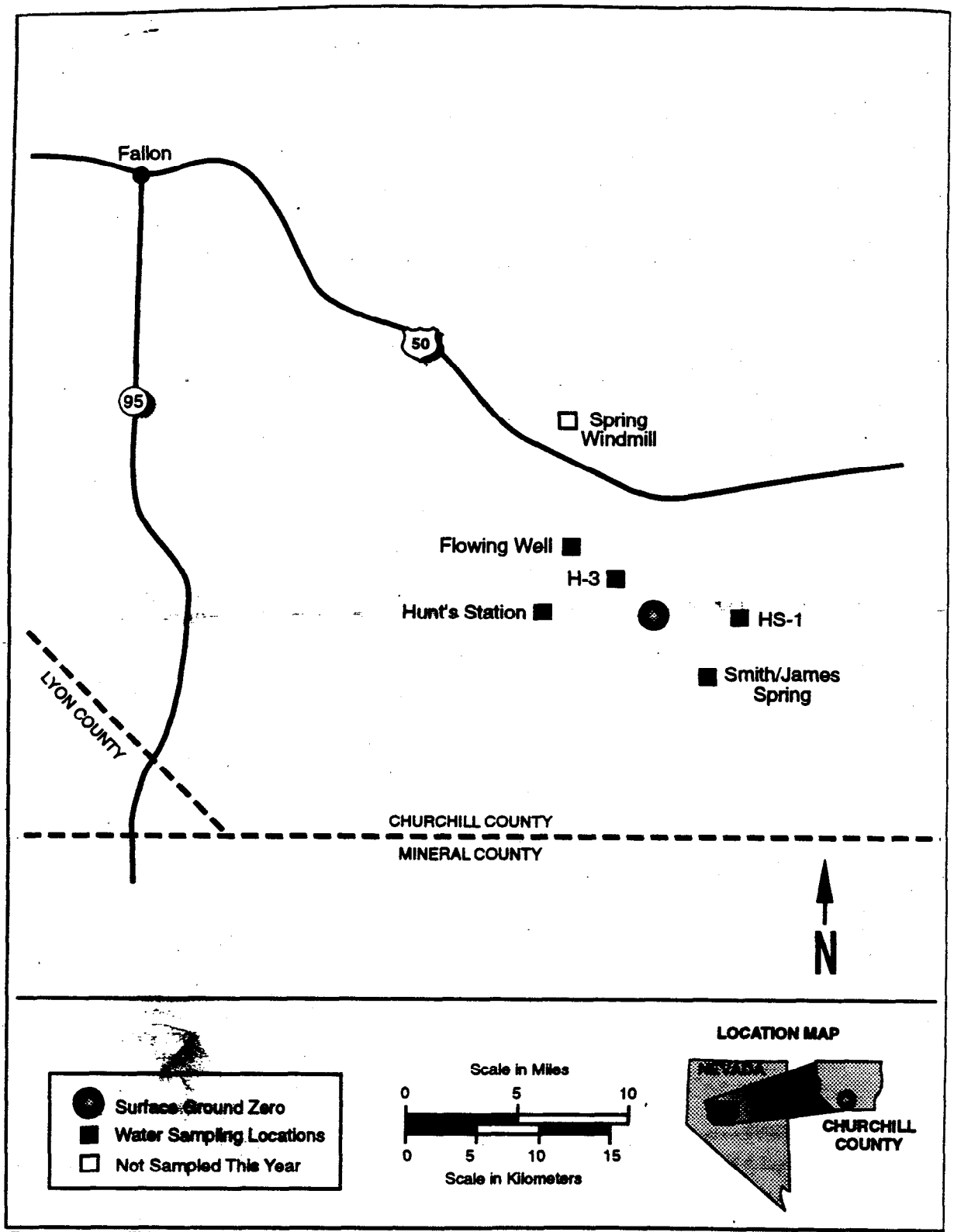

Figure 36. LTHMP sampling locations for Project SHOAL - 1992.

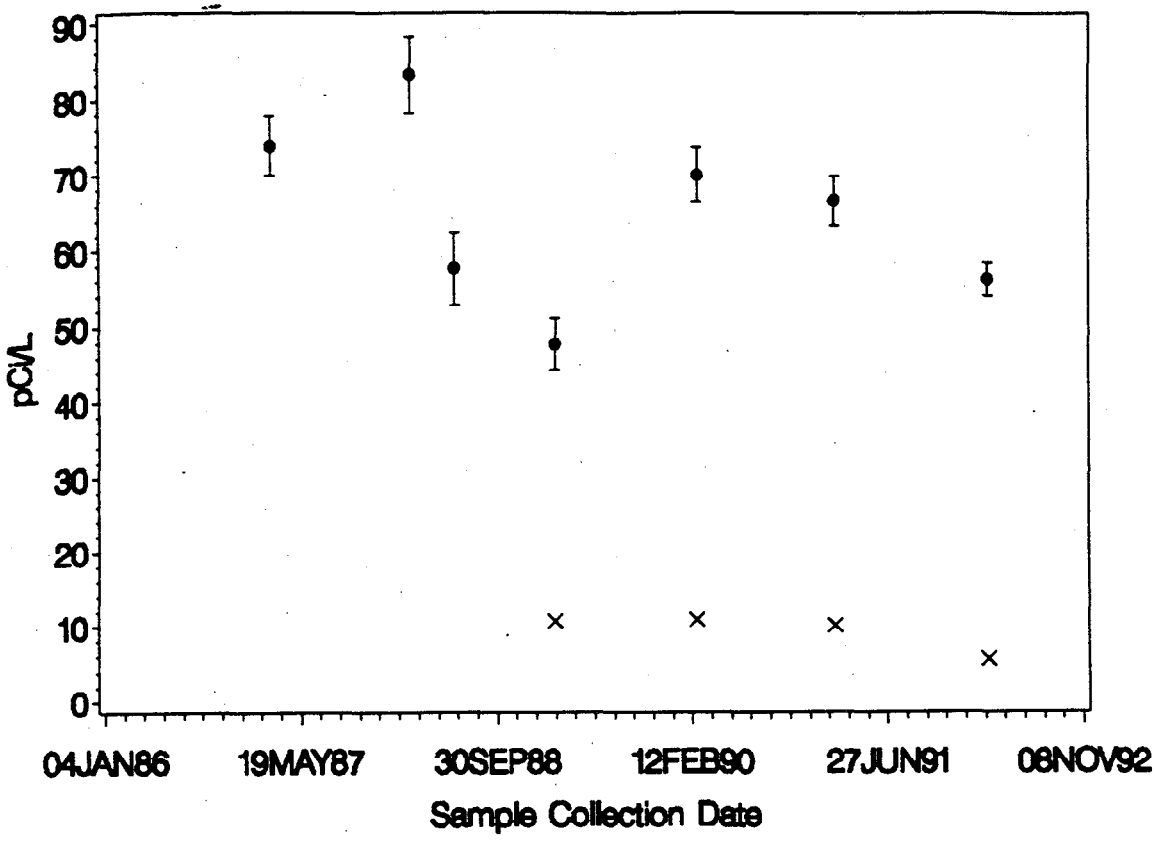

Figure 37. Tritum results for water from Smith/James Spring, Nevada.

and fallout from gas flaring. Soil was removed during the cleanup operations.

Annual sampling was completed on June 9, 1992, with collection of nine samples in the area of Grand Valley and Rulison, Colorado. Routine sampling locations, depicted in Figure 38, 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).

Tritium has never been observed in measurable concentrations in the Grand Valley City Springs. All of the remaining sampling sites show detectable levels of tritium, which have generally exhibited a decreasing to stable trend over the last two decades. The range of tritium activity in the 1992 samples was 48 ± 2 pCi/L at CER Test to 160 ± 3 pCi/L at Lee Hayward Ranch (see Table C-4, Appendix C). These values are less than one percent of the DCG. The detectable tritium activities are probably a result of the natural high 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 39 displays data for the last 20 years for Lee Hayward Ranch. The low value obtained in 1990 may be attributed to analytical bias and was observed consistently for all Project RULISON sampling locations.

7.4.4 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

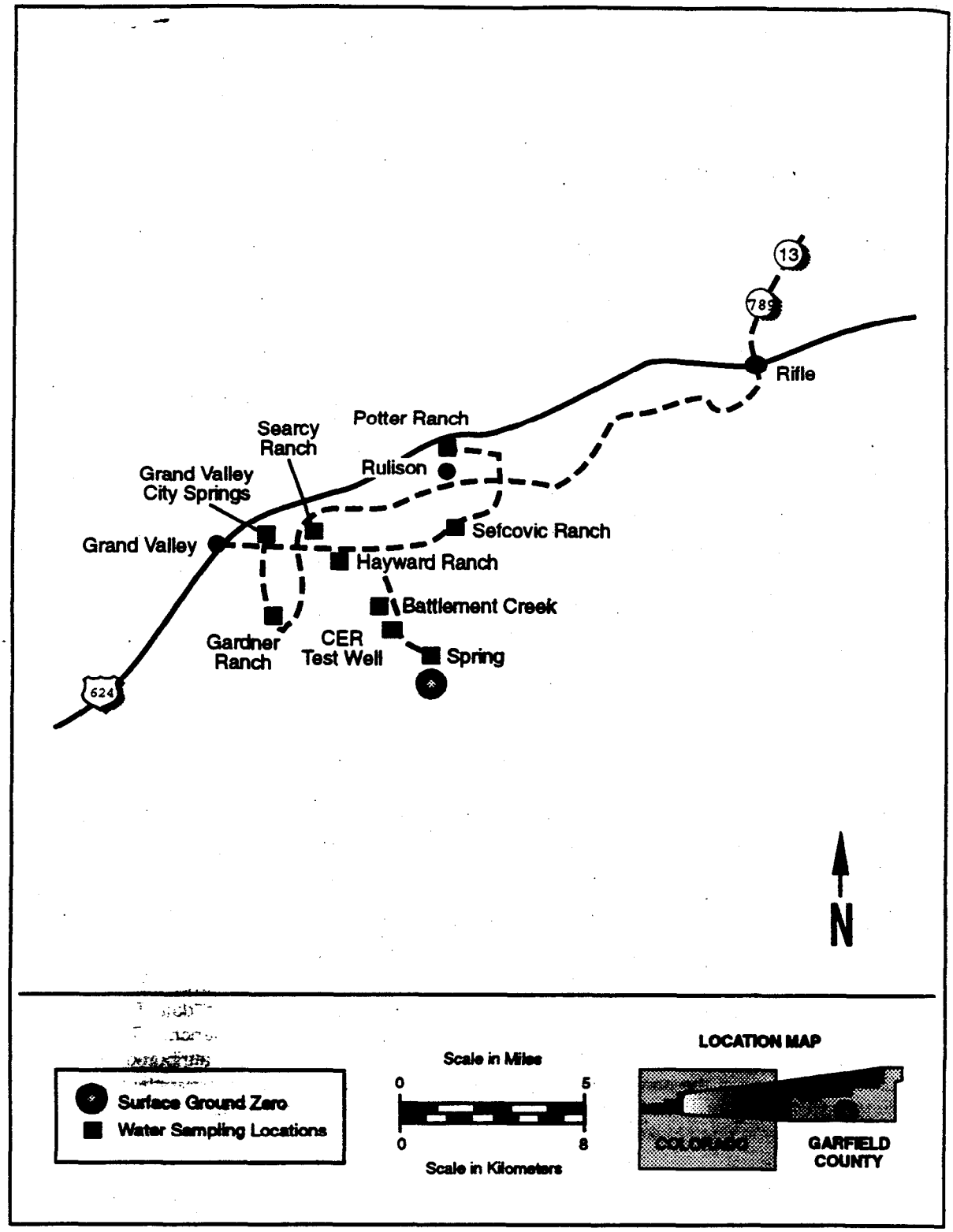

Figure 38. LTHMP sampling locations for Project RULISON - 1992.

Rifle and Meeker, Colorado. Three explosives with a total yield of 90 kt were emplaced at 1,780-, 1,920-, and 2,040-m (5,838-, 6,229-, and 6,689-ft) depths in the Ft. Union and Mesa Verde formations. Production testing continued to 1,976; tritiated water produced during testing was injected to 1,710 m (5,600 ft) in a nearby gas well. Cleanup and restoration activities were completed by November 1976.

Samples were collected on June 10 and 11, 1992. The sampling sites, shown in Figure 40, 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 to 57 pCi/L. These values are <0.1 percent of the DCG (see Table C-5, Appendix C). A generally decreasing trend in tritium activity is evident in the three springs; Figure 41 depicts tritium results from one of the springs. Neither of the two shallow domestic wells located near the RIO BLANCO site yielded detectable tritium activity. All of the sampling sites along Fawn Creek yielded tritium activities of approximately 25 pCi/L (range 21 to 29 pCi/L), less than 0.04 percent of the DCG. There is no statistically significant difference between sites located upstream and downstream of the cavity area. The three monitoring wells all yielded no detectable tritium activity, indicating that migration from the test cavity has not yet been detected. No gamma activity was detected in any sample.

7.4.5 Project GNOME

Project GNOME, conducted on December 10, 1961, near Carlsbad, New Mexico, was a multipurpose test conducted in a salt formation. A slightly-more-than-3-kt nuclear explosive was emplaced at a depth of 1,216 ft in the Salado salt formation. Oil and gas are produced from the geologic units below the working point. The overlying Rustler formation contains three water-bearing zones: brine located at the boundary of the Rustler and Salado formations, the Culebra Dolomite which is used for domestic and stock supplies, and the

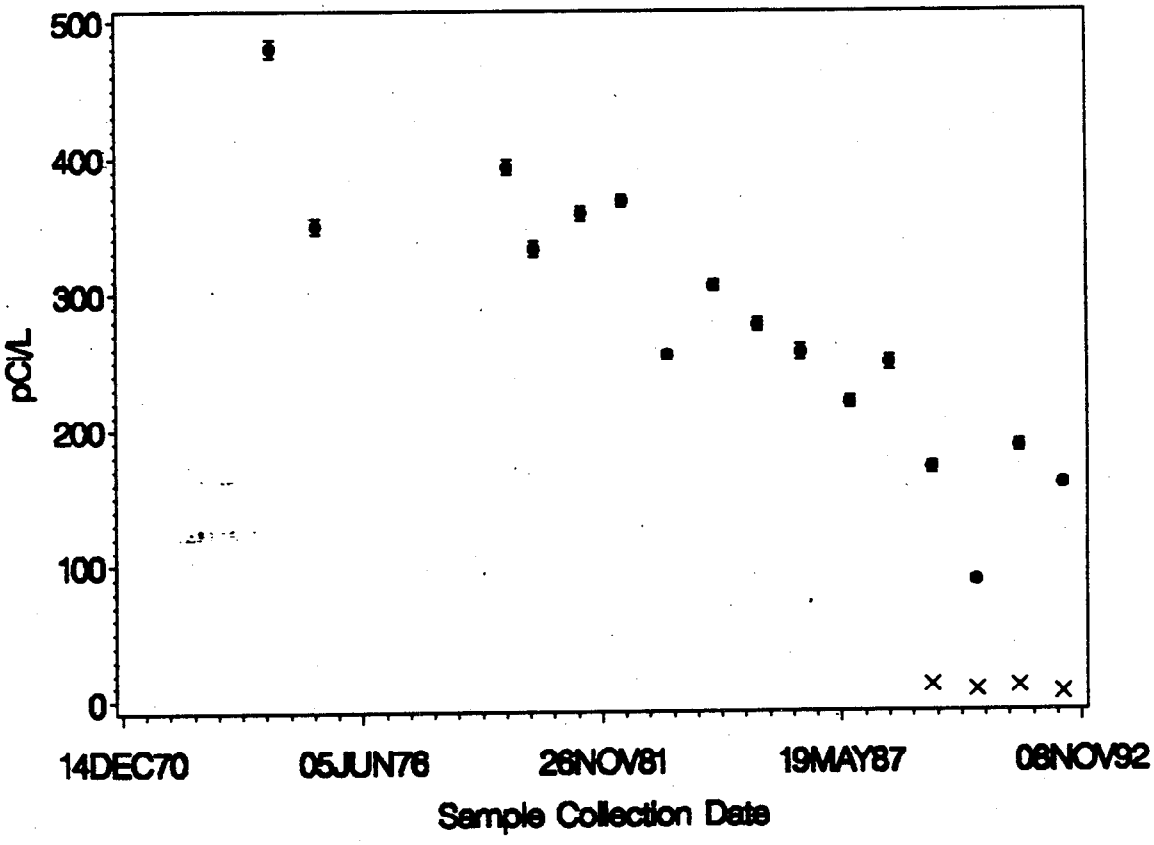

Figure 39. Tritium trends in groundwater, Lee Hayward Ranch, Colorado.

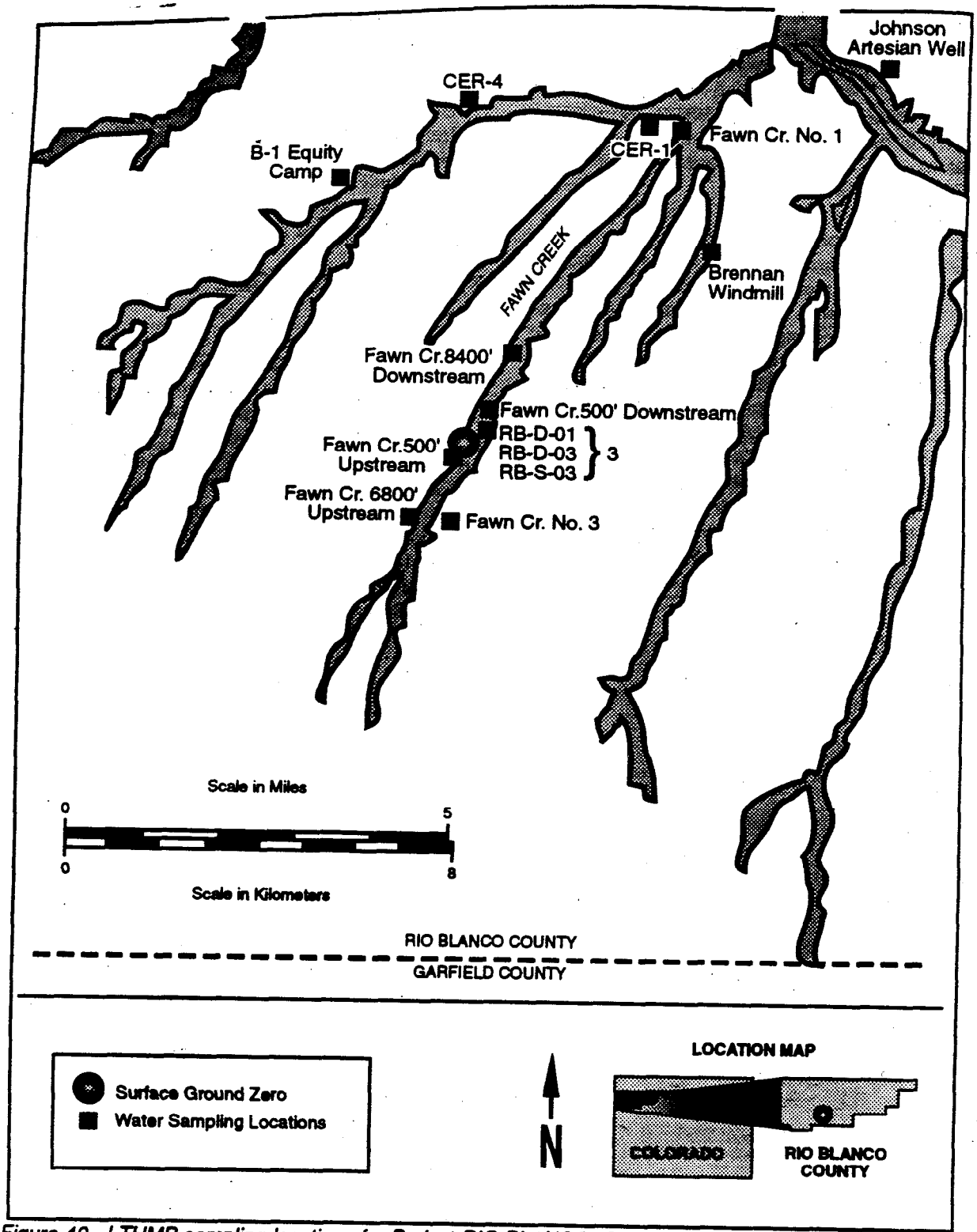

Figure 40. LTHMP sampling locations for Project RIO BLANCO, Colorado.

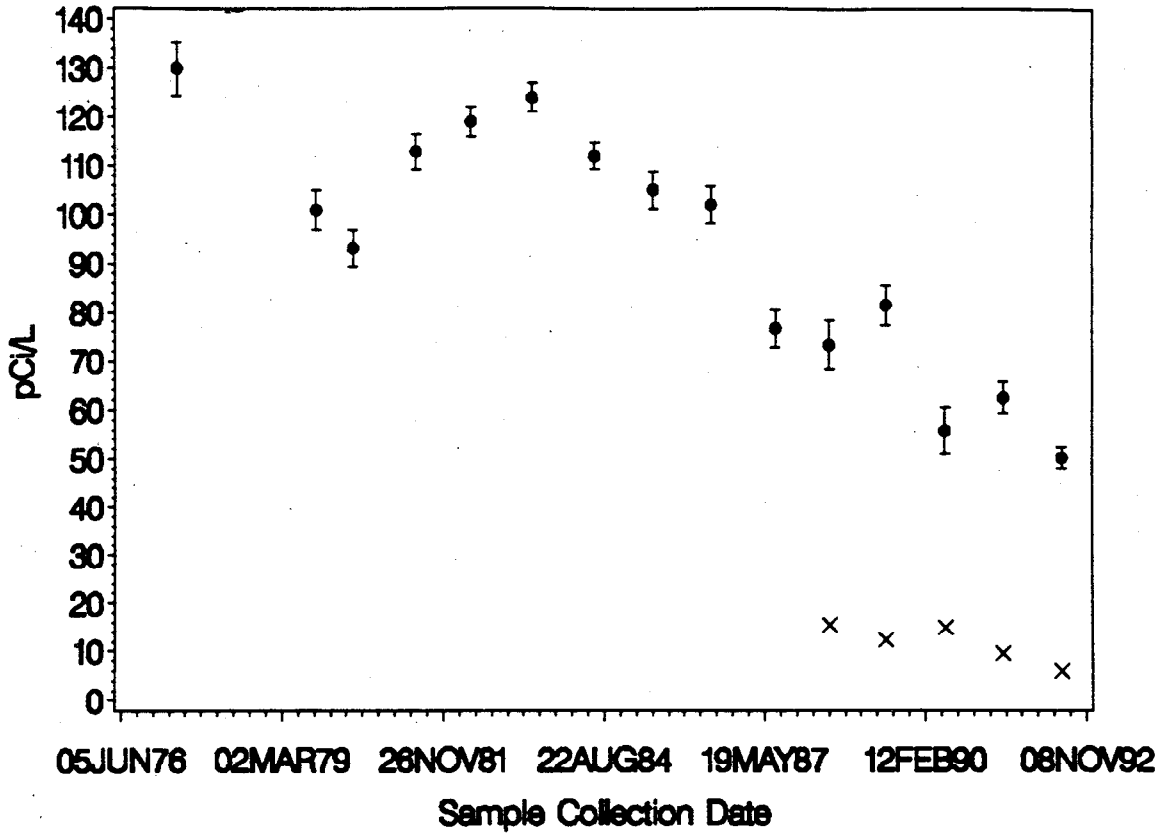

Figure 41. Tritium results in water from CER No. 4, Rio Blanco, Colorado.

Magenta Dolomite which is above the zone of saturation (Chapman and Hokett, 1991). The ground water flow is generally to the west and southwest.

Radioactive gases were unexpectedly vented during the test. In 1963, USGS conducted a tracer study involving injection of 20 Ci tritium, 10 Ci ^{137}Cs, 10 Ci ^{90}Sr, and 4 Ci ^{131}I in the Culebra Dolomite zone; wells USGS 4 and 8 were used for this tracer study. During remediation activities in 1968-69, contaminated material was placed in the test cavity and shaft up to within 7 ft of the surface. More material was slurried into the cavity and drifts in 1979. There is a potential for discharge of this slurry to the Culebra Dolomite and to Rustler-Salado brine. This potential may increase as the salt around the cavity will compress, forcing contamination upward and distorting and cracking the concrete stem and grout.

Annual sampling at Project GNOME was completed between June 15 and 18, 1992. The routine sampling sites, depicted in Figure 42, include nine monitoring wells in the vicinity of surface GZ, the municipal supplies at Loving and Carlsbad, New Mexico, and the Pecos River Pumping Station well. No detectable tritium activity was detected in the Carlsbad municipal supply or the Pecos River Pumping Station well. A tritium activity of 8 ± 2 pCi/L was detected in the Loving municipal supply. An analysis by DRI (Chapman and Hokett, 1991) indicates that this sampling location, located on the opposite side of the Pecos River from the Project GNOME site, is not connected hydrologically to the site and, therefore, cannot become contaminated by Project GNOME radionuclides except 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 11,700 ± 200 pCi/L in Well LRL-7 to $6.48 \times 10^7 \pm 3.2 \times 10^5$ pCi/L in Well DD-1, which are 13 to 720 percent of the DCG. Well DD-1 samples water in the test cavity, Well LRL-7 samples a sidedrift, and wells USGS-4 and -8 were

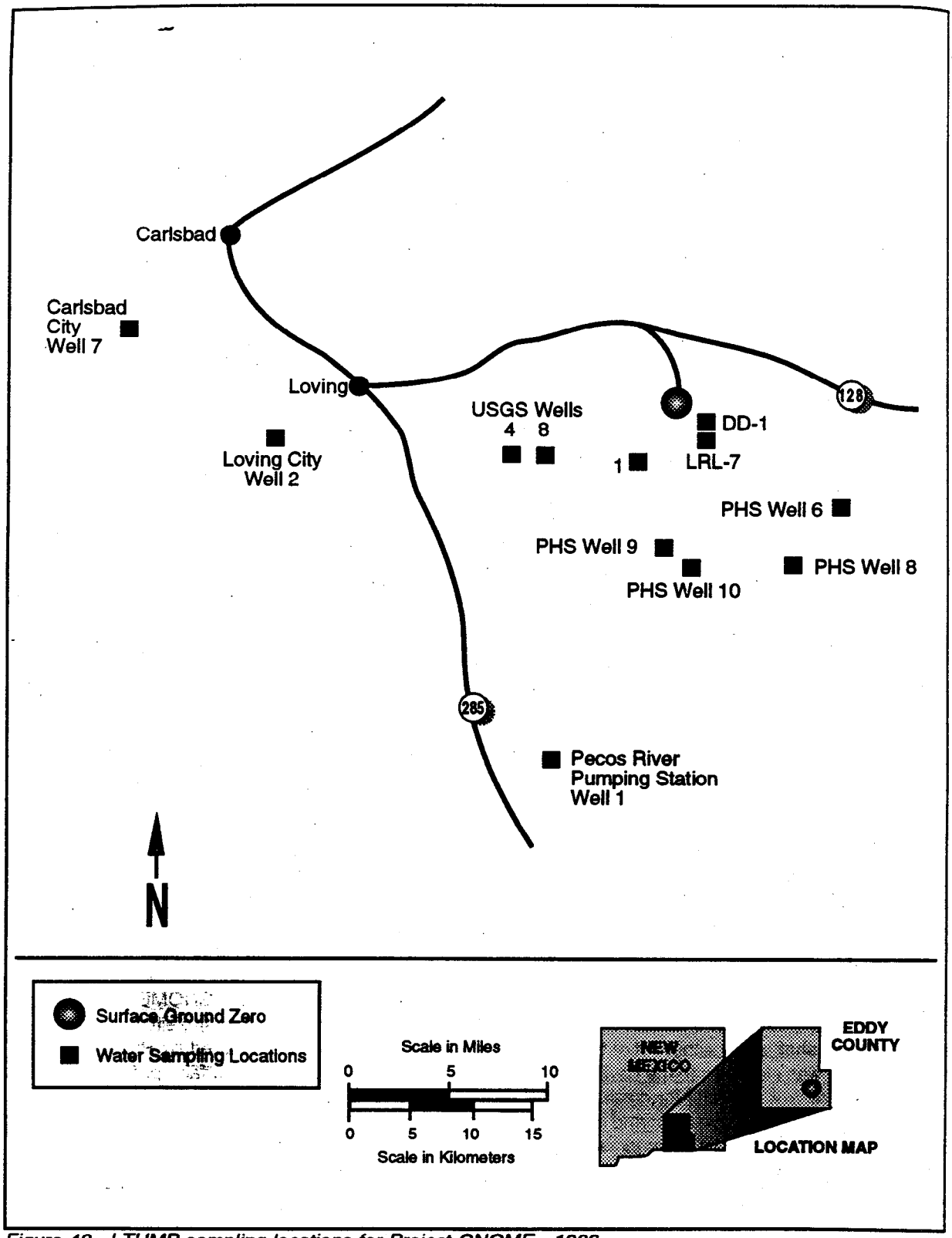

Figure 42. LTHMP sampling locations for Project GNOME - 1992.

used in the radionuclide tracer study conducted by the USGS. In addition to tritium, ^{137}Cs concentrations ranging from 69 ± 1 pCi/L to 551,000 ± 25,600 pCi/L were observed in samples from wells DD-1, LRL-7, and USGS-8, while ^{90}Sr activity ranging from 5,140 ± 16 pCi/L to 13,000 ± 1,200 pCi/L was detected in wells DD-1, USGS-4 and USGS-8. Samples from these four wells were also analyzed for plutonium isotopes; results were less than the MDC in all cases. The samples from wells DD-1, LRL-7, and USGS-4 indicate decreasing trends for all analyzed radionuclides.[4] Although the tritium activity in the 1992 sample from Well LRL-7 was greater than that observed in the 1991 sample, the overall historical trend is decreasing, as shown in Figure 43. An increase was observed in ^{137}Cs and ^{90}Sr concentrations in USGS-8; however, a decrease was observed in the tritium concentration in this well.

The remaining two wells with detectable tritium concentrations were PHS wells 6 and 8, with results of 37 ± 2 pCi/L and 15 ± 2 pCi/L, respectively (see Table C-6, Appendix C). These values are less than 0.05 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 possibly positioned to detect migration of radioactivity from the cavity, should it occur.

7.4.6 Project GASBUGGY

Project GASBUGGY was a Plowshare Program test co-sponsored by the U.S. Government and El Paso Natural Gas Co. 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 1,290 m (4,240 ft). Production testing was completed in 1976 and restoration activities were completed in July 1978.

The principal aquifers are the Ojo Alamo Sandstone, an aquifer containing non-potable water located above the test cavity, the San Jose formation and Nacimiento formation, both surficial aquifers containing potable water. The flow regime of the San Juan Basin is not well known, although it is likely that the Ojo Alamo Sandstone discharges to the San Juan River 50 miles northwest of the GASBUGGY site. Hydrologic gradients in the vicinity are downward, but upward gas migration is possible (Chapman and Hokett, 1991).

The routine sampling locations include six wells, one windmill, three springs, and two surface water sites, all depicted in Figure 44. Sampling was conducted April 14 through 16, 1992. In prior years, samples were collected in June; an earlier trip was scheduled this year because of the tritium increase seen in Well EPNG 10-36 and discussed in last year's Annual Site Environmental Report (Black et al; DOE91). Ten samples were collected. Samples were not collected from Arnold Ranch due to a road washout nor from Well 28.3.33.233 (South) because the windmill was not operational. 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 two surface water sampling sites yielded tritium activities of 34 ± 3 pCi/L and 70 ± 3 pCi/L; a comment by the sampling technician indicated the first-listed sample was primarily rainwater. These values are 0.04 and 0.08 percent of the DCG, respectively. The three springs yielded tritium activities ranging from 42 ± 2 pCi/L to 75 ± 3 pCi/L, which are less than 0.1 percent of the DCG and 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 19 ± 2 pCi/L, which is 0.02 percent of the DCG. Analytical results are presented in Table C-7, Appendix C.

Well EPNG 10-36, a gas well located 132 m (435 ft) northwest of the test cavity with a sampling depth of approximately 1,100 m (3,600 ft), had yielded tritium activities between 100 and 560 pCi/L in each year since 1984, except 1987. The proximity of the well to the test cavity suggests the possibility that the activity increases may indicate migration from the test cavity. The sample collected in April yielded a tritium activity of 33 ± 2 pCi/L. The area had been experiencing heavy rainfall in the weeks prior to and during sampling. The sampling technician had noted that one of the surface sampling sites, a pond, was comprised primarily of rainwater. The tritium concentration in that sample and in Well EPNG 10-36 are identical. Further, the pH and conductivity measured in Well EPNG 10-36 were similar to the values obtained at the surface sampling site and markedly different than measurements of pH and conductivity taken in Well EPNG 10-36 in previous years. Consequently it is suspected that the sample may not be representative of formation water.

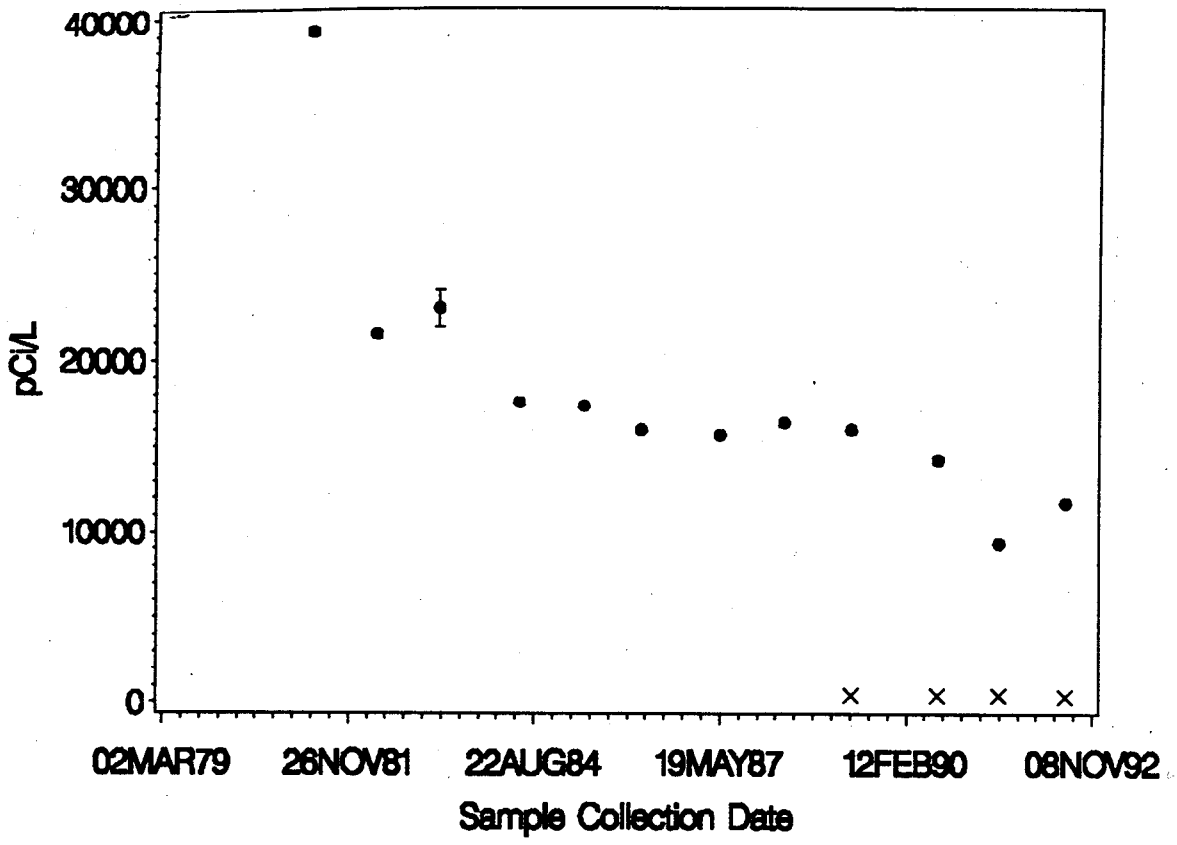

Figure 43. Tritium results in water from Well LRL-7 near Project GNOME, New Mexico.

A second sample was collected from Well EPNG 10-36 on September 16, 1992. Initial results for this sample indicated a concentration of 10.3 ± 2.6 pCi/L (MDC of approximately 7 pCi/L) of ^{137}Cs based on a 100-minute counting time. Presence of ^{137}Cs was confirmed by a 1,000-minute count which yielded results of 5.97 ± 0.85 pCi/L (MDC of 0.83 pCi/L) and a longer 5-day count which confirmed this concentration (with an MDC of 0.1 pCi/L). The tritium activity in this sample was 364 ± 4 pCi/L. No $^{238,239+240}Pu$, or ^{90}Sr was detected at activities greater than the MDC.

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, 1991). In either case, fractures extending from the cavity may be the primary or a contributing mechanism.

7.4.7 Project DRIBBLE

Project DRIBBLE comprised four explosive tests, two nuclear and two gas, conducted in the Tatum Salt Dome 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 (2,710 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 about 380 tons, and the two gas explosions, DIODE TUBE, on February 2, 1969 and HUMID WATER, on April 19, 1970. The ground surface and shallow ground water 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, non-potable aquifers. Shallow wells, labeled HMH wells on Figure 45, have been added to the area near surface GZ to

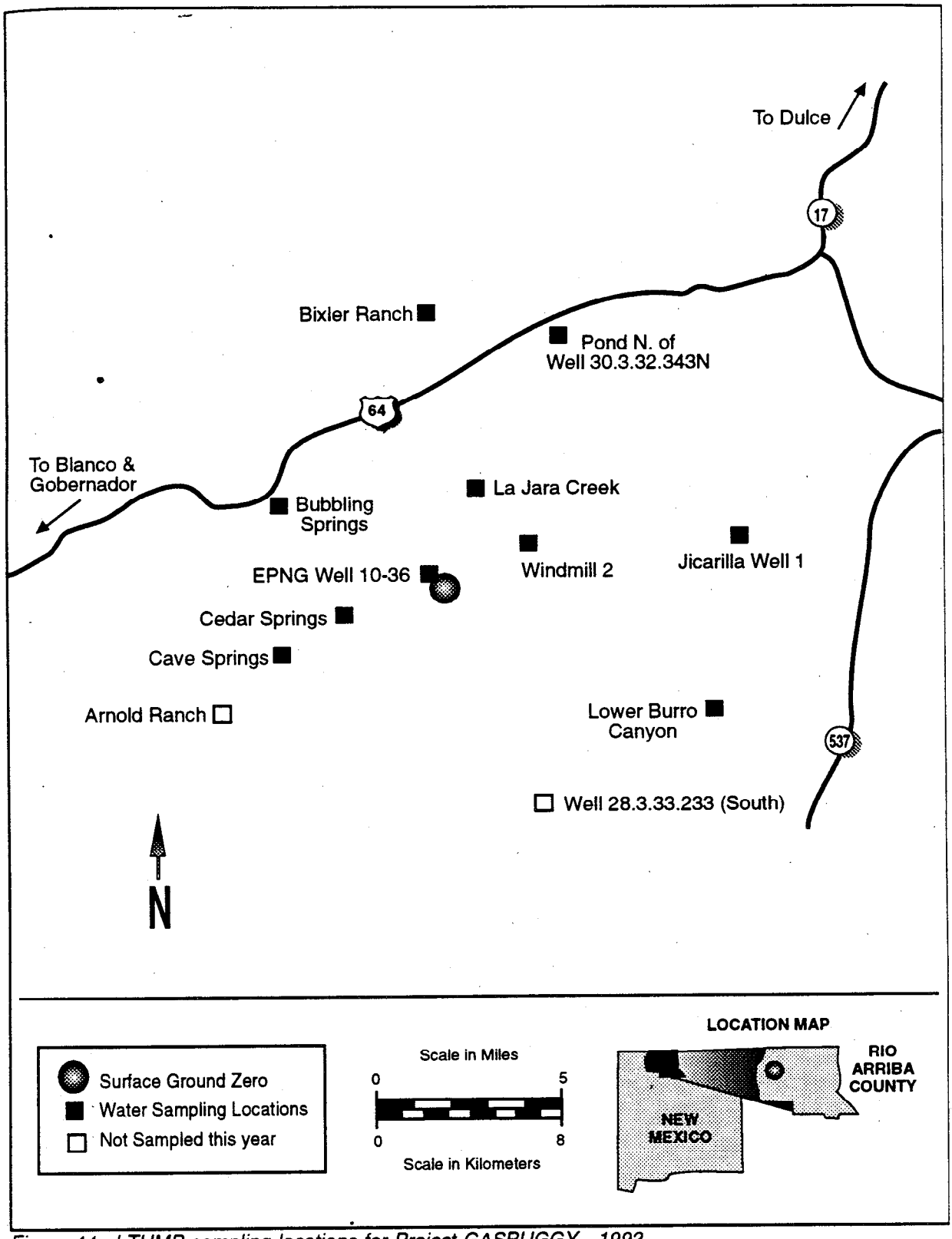

Figure 44. LTHMP sampling locations for Project GASBUGGY - 1992.

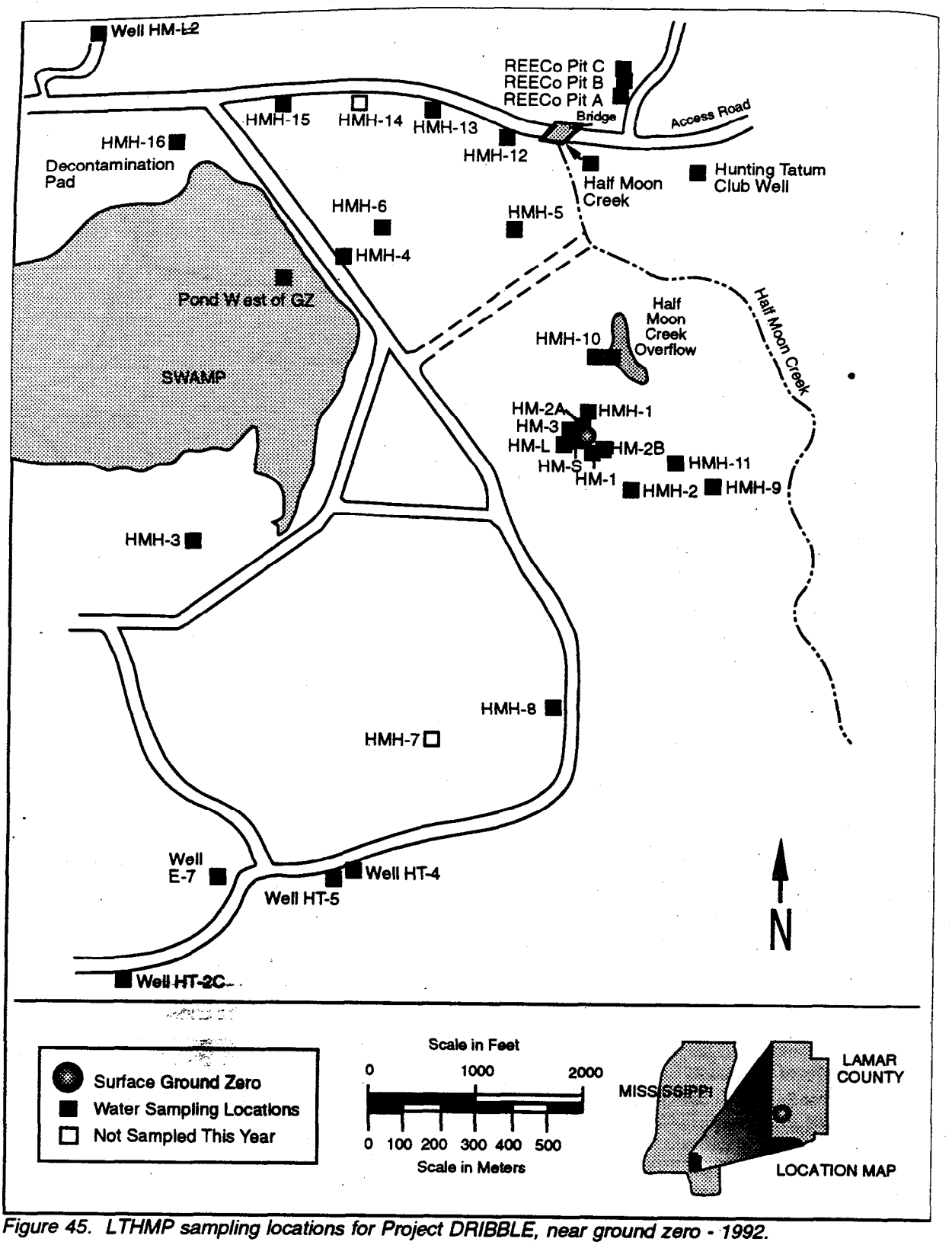

Figure 45. LTHMP sampling locations for Project DRIBBLE, near ground zero - 1992.

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 46.

Sampling on and in the vicinity of the Tatum Salt Dome was conducted between April 26 and 29, 1992. A total of 109 samples were collected; five of these were from new sampling locations in Lumberton, Mississippi. Six routine sampling locations were not sampled. One resident had moved and the well is no longer in operation; another resident was connected to city water and no longer uses the well for drinking water. These sampling locations have been eliminated from the routine sampling directory. The remaining samples not taken this year were unobtainable due to inaccessibility of the sampling location because of local flooding, because the resident was not home, or because the well was dry.

In the 50 samples collected from offsite sampling locations, tritium activities ranged from less than the MDC to 59 ± 5 pCi/L, equivalent to less than 0.07 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 47. Low levels of uranium isotopes were detected in four of the five new sampling locations, ranging from 0.038 to 0.14 pCi of ^{234}U/L and 0.018 to 0.12 pCi of ^{238}U/L. 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. Twenty-four locations in the vicinity of GZ were sampled using this procedure; 19 of these yielded tritium activities greater than the MDC in either the first or second sample. In addition, seven locations were sampled once; five of these samples yielded tritium concentrations greater than the MDC. Overall, tritium activities ranged from less than the MDC to $1.44 \times 10^4 \pm 200$ pCi/L as shown in Table C-8, Appendix C. The locations where the highest tritium activities were measured generally correspond to areas of known contamination. Increases in tritium activity over previous years were noted in REECo pits B and C and Well HMH-10. However, decreasing trends were noted for the wells where high tritium activities have historically been noted, such as Well HM-S depicted in Figure 48. Results of sampling related to Project DRIBBLE are discussed in greater detail in *Onsite and Offsite Environmental Monitoring Report: Radiation Monitoring around Tatum Salt Dome, Lamar County, Mississippi, April 1992* (Thomé and Chaloud).

7.4.8 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 85-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.

Amchitka Island is composed of several hundred feet of permeable tundra overlying tertiary volcanics. The ground water system consists of a freshwater lens floating on seawater; estimates of the depth to the saline-freshwater interface range from 3,900 to 5,250 ft (Chapman and Hokett, 1991). It is likely that any migration from the test cavities would discharge to the nearest salt water body; Project MILROW to the Pacific Ocean and Projects LONG SHOT and CANNIKIN to the Bering Sea (Chapman and Hokett, 1991). The sampling locations on Amchitka Island are shallow wells and surface sampling sites. Therefore, the monitoring network for Amchitka Island is restricted to monitoring of surface contamination and drinking water supplies.

Sampling on Amchitka Island, is conducted every other year. No samples were collected in 1992. The next sampling trip is scheduled for September 1993.

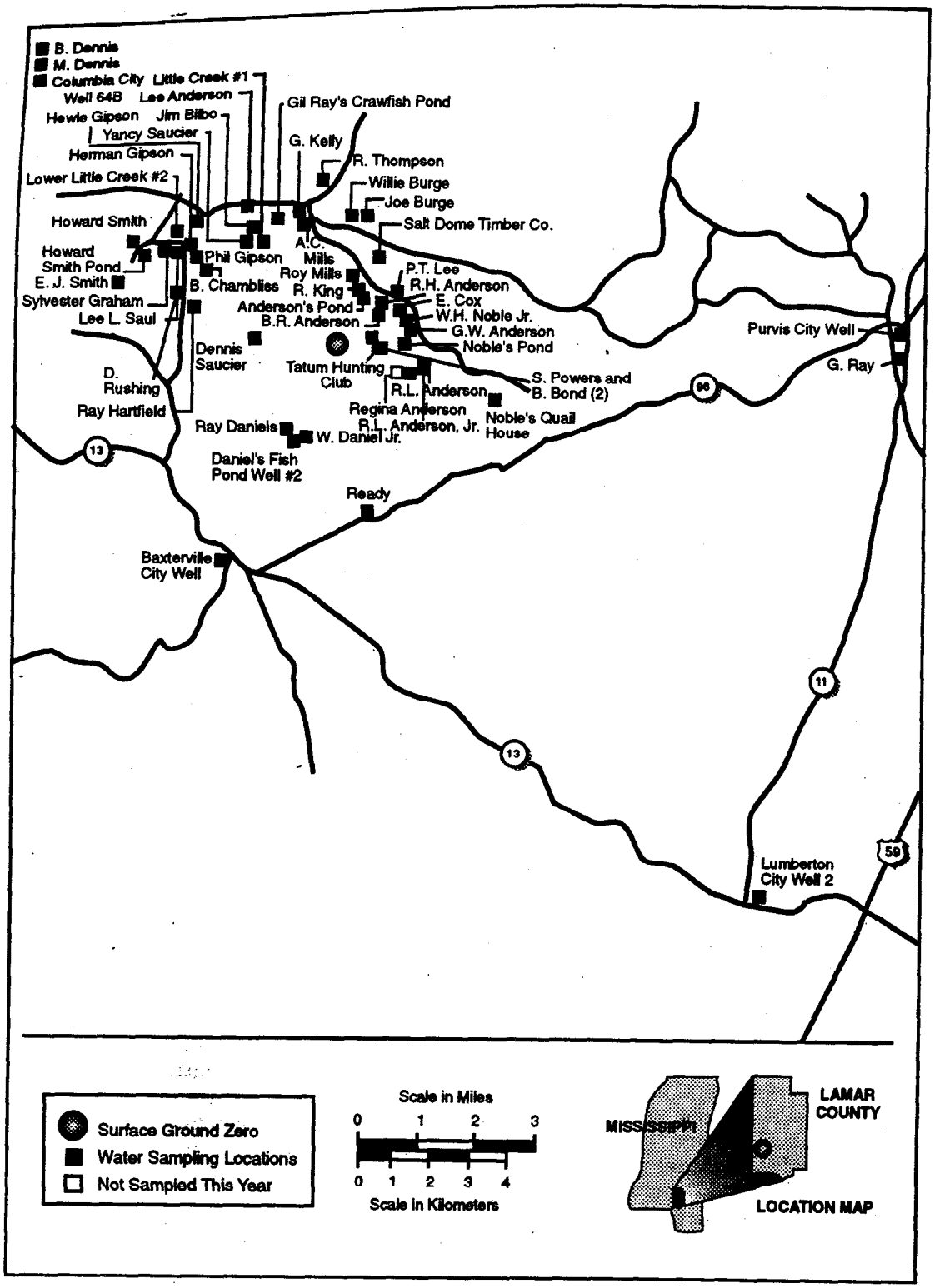

Figure 46. LTHMP sampling locations for Project DRIBBLE, towns and residences - 1992.

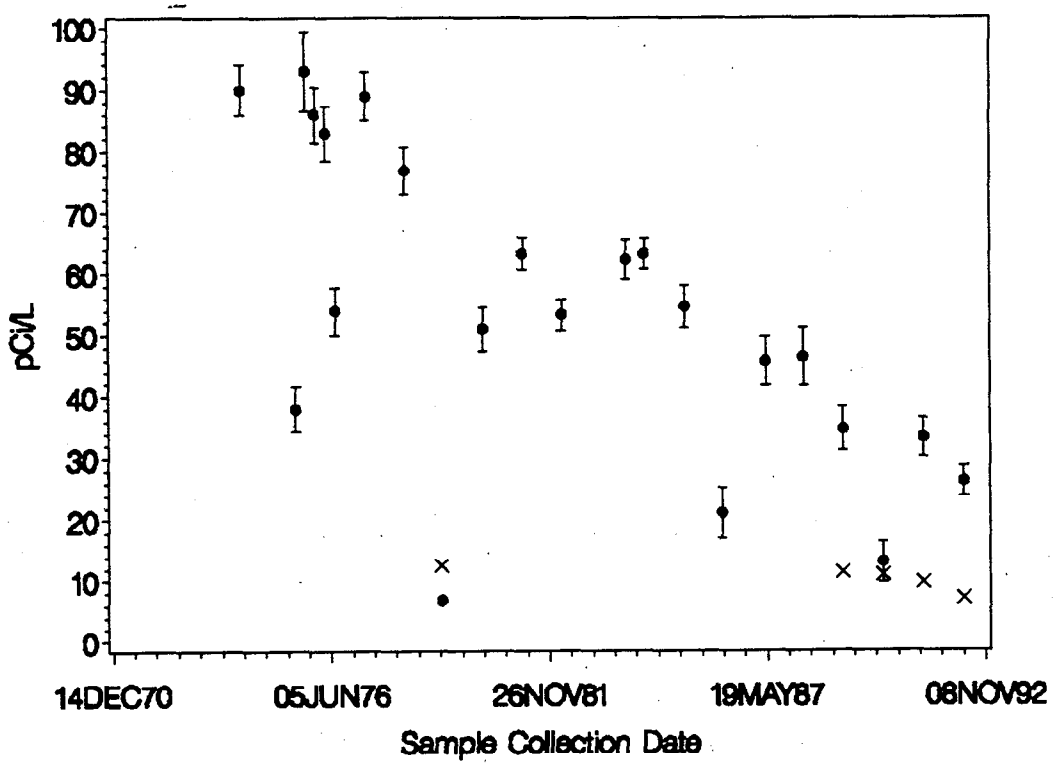

Figure 47. Tritium result trends in Baxterville, MS public drinking water supply - 1992.

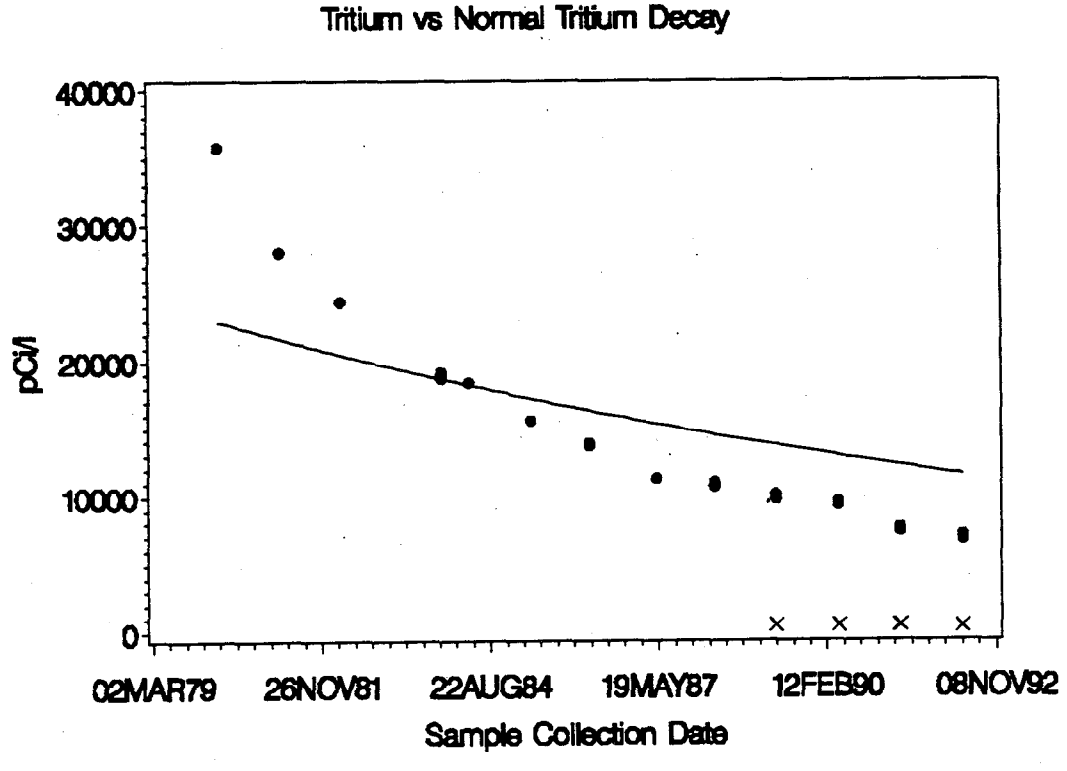

Figure 48. Tritium results in Well HM-S, Tatum Salt Dome, Project DRIBBLE.

7.5 Summary

None of the domestic water supplies monitored in the LTHMP in 1992 yielded tritium activities of any health concern. The greatest tritium activity measured in any water body which has potential to be a drinking water supply was less than one percent of the limit prescribed by the NPDWRs. In general, surface water and spring samples yielded tritium activities greater than those observed in shallow domestic wells in the same area. This is probably due to scavenging of atmospheric tritium by precipitation. Where suitable monitoring wells exist, there were no indications that migration from any test cavity is affecting any domestic water supply.

In most cases, monitoring wells also yielded no radionuclide activity above the MDC. Exceptions include wells into test cavities, wells monitoring known areas of contamination, and one well at Project GASBUGGY. Known areas of contamination exist at Project GNOME where the USGS conducted a tracer study experiment, some areas onsite at Project DRIBBLE, and a few surface areas near Project LONG SHOT. The 1992 results for these monitoring wells are consistent with decreasing trends observed over time. Monitoring well EPNG 10-36 at Project GASBUGGY was a notable exception to wells showing decreasing trends. This well is a former gas well located 435 feet northwest of SGZ. The sampling depth of this well is approximately 3,600 ft in the Ojo Alamo Sandstone, an aquifer containing nonpotable water. The tritium activity in 1992 was 10.3 ± 2.6 pCi/L and in 1991 was 484 ± 4 pCi/L, approximately 10 times the historic background activity. An increase in tritium activity was first observed in 1984, seventeen years after the test was conducted. In every year since then, with the exception of 1987, tritium activities have been between 100 and 560 pCi/L, with wide variability sometimes noted between consecutive years. The proximity of the well to the test cavity suggests the possibility that the increased activity may be indicative of migration from the test cavity.

NOTES

1. The NPDWR states that the sum of all beta/gamma emitter concentrations in drinking water cannot lead to a dose exceeding 4 mrem/year, assuming a person were to drink two L per day for a year (40 CFR 141). Assuming tritium to be the only radioactive contaminant yields a maximum allowable concentration of 20,000 pCi/L.

2. The NPDWR applies only to public systems with at least 15 hookups or 25 users. Although many of the drinking water supplies monitored in the LTHMP serve fewer users and are therefore exempt, the regulations provide a frame of reference for any observed radionuclide activity.

3. The derived concentration guide (DCG) used in this report is 90,000 pCi/L of tritium in water. This DCG is taken from DOE Order 5400.5 (DOE, 1990), which is based on the annual limit on intake given in ICRP-30 (ICRP, 1979) for a maximum dose of 4 mrem/year for ingestion of beta/gamma emitters in water, assuming consumption of two L of water per day and assuming tritium to be the only radioactive contaminant. The current U.S. standard given in the National Primary Drinking Water Regulations (40 CFR 141), although based on the same maximum dose and assumptions, specifically limits tritium to 20,000 pCi/L in drinking water. A revision of the standard has been proposed which will, when enacted, raise the permissible tritium concentration to 63,000 pCi/L in U.S. drinking water.

4. ^{137}Cs was below the MDC in the 1992 sample from Well USGS-4.

8. Dose Assessment

Four pathways of possible radiation exposure to the population of Nevada were monitored by EPA's offsite monitoring networks during 1992. The four pathways were:

- Background radiation due to natural sources such as cosmic radiation, natural radioactivity in soil, and ^{7}Be in air.
- Worldwide distributions of 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 accumulated in migratory game animals during their residence on the NTS.

8.1 Estimated Dose From Nevada Test Site Activity Data

The potential Committed Effective Dose Equivalent (CEDE) to the offsite population due to NTS activities is estimated annually. Two methods are used to calculate the CEDE to a resident of 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. The second method uses data from the ORSP with documented assumptions and conversion factors to calculate the CEDE. Both methods provide an estimate of the CEDE to a hypothetical person who would have to have been continuously present in one outdoor location. In addition, a collective CEDE 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 CEDEs. 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.

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 Committed Effective Dose Equivalent (CEDE) to offsite residents, based on onsite source emission measurements provided by DOE and calculated by EPA's CAP88-PC model, was 0.012 mrem (1.2 x 10^{-4} mSv) to a hypothetical resident of Indian Springs, Nevada 54 km (32 mi) southeast of the NTS CP-I. Pressurized ion chamber data indicated a 1992 dose of 78 mrem from normal background radiation occurring in Indian Springs. The calculated dose to this individual from world-wide distributions of radioactivity as measured from surveillance networks was 0.088 mrem. 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 0.029 person-rem (2.9 x 10^{-4} person-Sv). An additional CEDE of 0.015 mrem would be received if the liver and all of the 45 kg (100 lb) of meat from a deer collected on the NTS were consumed. All of these maximum dose estimates are about one percent of the most restrictive standard.

Onsite source emission measurements, as provided by DOE, are listed in Table 18 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: Desert Rock, Area 12, Area 20, Yucca Flat, and RWMS in Area 5. A calculation of estimated dose from NTS effluents was performed using EPA's CAP88-PC model (EPA 1992). The population living within a radius of 80 km (50 mi) from each of the sources was estimated to be 21,750 individuals, based on 1991 DOC. The collective population dose within 80 km (50 mi) from the airborne emission sources was 0.029 person-rem (2.9 x 10^{-4} person-Sv). Activity concentrations in air that would cause these calculated doses are too small to be detected by the offsite monitoring network. Table 19 summarizes the annual contributions to the CEDEs resulting from 1992 NTS operations as calculated using CAP88-PC.

Table 18. NTS Radionuclide Emissions 1992

Airborne Effluent Releases

Event or Facility Name (Airborne Releases)	Curies[a]									
	^{3}H	^{37}Ar	^{39}Ar	^{85}Kr[b]	^{127}Xe	^{129m}Xe	^{131m}Xe	^{133}Xe	^{131}I	$^{239+240}Pu$
Area 3, DIVIDER								1.1×10^{-1}		
Area 3[c]										2.5×10^{-3}
Area 5, RWMS	6.0×10^{-1}									
Area 6[d]									1.3×10^{-5}	
Area 12,										
N Tunnel	4.9×10^{-2}	7.9×10^{-1}	8.1×10^{-5}	1.3×10^{-2}	5.7×10^{-6}	2.4×10^{-5}	1.5×10^{-2}	3.9×10^{-2}		
P Tunnel	3.6×10^{-1}	2.1×10^{-0}		1.3×10^{-0}				2.4×10^{-1}	6.0×10^{-6}	
Area 19 & 20										
Pahute Mesa[c]				$2.8\times10^{+2}$						
TOTAL	1.0×10^{-0}	2.9×10^{-0}	8.1×10^{-5}	$2.8\times10^{+2}$	5.7×10^{-6}	2.4×10^{-5}	1.5×10^{-2}	3.9×10^{-1}	1.9×10^{-5}	2.5×10^{-3}

Liquid Effluent Releases

Containment Ponds	Curies[a]				
	Gross Beta	^{3}H	^{90}Sr	^{137}Cs	^{238}Pu	$^{239+240}Pu$
Area 6, Decontamination Pad Pond	9.9×10^{-5}	4.8×10^{-3}	3.2×10^{-6}			1.8×10^{-7}
Area 12, E Tunnel	2.1×10^{-3}	6.7×10^{1}	2.4×10^{-4}	1.7×10^{-4}	2.2×10^{-5}	2.1×10^{-4}
Area 12, N Tunnel	4.7×10^{-4}	2.6×10^{1}				1.2×10^{-6}
Area 12, T Tunnel	2.9×10^{-2}	2.2×10^{3}	4.0×10^{-4}	1.1×10^{-2}		6.7×10^{-5}
TOTAL	3.2×10^{-2}	2.2×10^{3}	6.4×10^{-4}	1.1×10^{-2}	2.2×10^{-5}	2.8×10^{-4}

(a) Multiply by 3.7×10^{10} to obtain Bq.

(b) Total includes 4.3×10^{-6} Ci of molecular HT from Hunter's Trophy. Remainder is in the form of tritiated water vapor, primarily HTO.

(c) Calculated from air sampler data.

(d) Assumes all radioactivity on Anti-C clothing is ^{131}I and all becomes airborne during drying.

Table 19. Summary of Effective Dose Equivalents from NTS Operations during 1992

	Maximum EDE at NTS Boundary[a]	Maximum EDE to an Individual[b]	Collective EDE to Population within 80 km of the NTS Sources
Dose	1.7×10^{-2} mrem (1.7×10^{-4} mSv)	$1.2 \pm 0.1 \times 10^{-2}$ mrem (1.2×10^{-4} mSv)	2.9×10^{-2} person-rem (2.9×10^{-4} person-Sv)
Location	Site boundary 60 km SSE of NTS Area 12	Indian Springs, NV, 80 km SSE of NTS Area 12	21,700 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)	not applicable
Percentage of NESHAP	0.17	0.12	not applicable
Background	78 mrem (0.78 mSv)	78 mrem (0.78 mSv)	1660 person-rem (16.6 person-Sv)
Percentage of Background	2.2×10^{-2}	1.5×10^{-2}	1.6×10^{-3}

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

(c) National Emission Standards for Hazardous Air Pollutants.

Input data for the CAP88-PC model include meteorological data from WSNSO and effluent release data reported by DOE. The effluent release data are estimates and the meteorological data are mesoscale; i.e., 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 only estimates of the dose to offsite residents although these results are consistent with the data obtained by offsite monitoring.

8.2 Estimated Dose From ORSP Monitoring Network Data

Potential CEDEs to individuals may be estimated from the concentrations measured by the EPA monitoring networks during 1992. The concentrations of radioactivity detected by the networks and used in the calculation of potential CEDEs are shown in Table 20. Animal and vegetable data are based on maximum concentration in all areas regardless of sampling location. In most cases, the analysis results used in the dose calculations are near the MDC of the analysis. Precision and accuracy data quality objectives (DQOs) are less stringent for values near the MDC; consequently, confidence intervals around the input data are broad.

Table 20. Monitoring Networks Data used in Dose Calculations

Medium	Radionuclide	Concentration	Comment
Animals			
Beef Liver	^{238}Pu	1.01×10^{-4} pCi/g	Concentrations are the maximum concentrations observed for each animal tissue type, corrected to wet weight.
	$^{239+240}Pu$	1.97×10^{-4} pCi/g	
Deer Muscle	$^{239+240}Pu$	8.69×10^{-4} pCi/g	
Deer Liver	$^{239+240}Pu$	6.73×10^{-4} pCi/g	
Milk	^{90}Sr	6.5×10^{-7} µCi/mL	Concentration is the average of all milk surveillance network results.
	^{3}H	1.53×10^{-7} µCi/mL	
Water	^{3}H	3.95×10^{-8} µCi/mL	Average concentration of all results above MDC for sampling locations in the vicinity of the NTS.
Vegetables			
Broccoli	^{90}Sr	9.00×10^{-3} pCi/g	Concentrations are maximum observed for each sample type, corrected to wet weight.
Carrots (with tops)	$^{239+240}Pu$	3.50×10^{-5} pCi/g	
Air	^{85}Kr	3.03×10^{-11} µCi/mL	Maximum concentration for the sampling location in Indian Springs, Nevada.
	^{3}H	9.49×10^{-12} µCi/mL	Maximum concentration for the sampling location in Las Vegas, Nevada.
(Moisture)	^{3}H	1.5×10^{-12} µCi/mL	Maximum concentration for the sampling location in Las Vegas, Nevada.

The concentrations given in Table 20 are expressed in terms of activity per unit volume or mass. These concentrations are converted to a dose by using the assumptions and dose conversion factors described below. The dose conversion factors assume continuous presence at a fixed location and no loss of radioactivity in meat and vegetables through storage and cooking.

- Adult respiration rate = 8,400 m^3/yr (2.3×10^4 L/day [ICRP 1975]).
- Milk intake for a 10-year old child = 450 mL/day (ICRP 1975).
- Consumption of beef liver = 11.5 kg/yr.
- An average deer has 45 kg of meat.
- Water consumption for adult-reference man = 2 L/day (approximately 1,900 mL/day [ICRP 1975]).
- Fresh vegetable consumption for North America = 516 g/day (ICRP 1975), assuming a four-month growing season.

The CEDE conversion factors are derived from EPA-520/1-88-020 (Federal Guidance Report No.

11). Those used here are:

- ^{3}H: 6.4 x 10^{-2} mrem/μCi (ingestion or inhalation).
- ^{90}Sr: 1.4 x 10^{2} mrem/μCi (ingestion).
- ^{85}Kr: 1.5 x 10^{7} mrem/yr/μCi/mL (submersion).
- $^{238,239+240}Pu$:
  3.7 x 10^{-4} mrem/pCi (ingestion).
  3.1 x 10^{-1} mrem/pCi (inhalation).

The algorithm for the dose calculation is:

(concentration) x (assumption in volume/unit time) x (CEDE conversion factors) = CEDE

In calculating the inhalation CEDE from ^{3}H, the value is increased by 50 percent to account for absorption through the skin. Dose calculations from the ORSP data are given in Table 21, except for the dose from consumption of a mule deer collected on the NTS. The individual CEDEs from the various pathways added together give a total of 3.0 mrem/yr. The additional dose from ingestion of deer meat and liver containing the $^{239+240}Pu$ activities given in Table 20 would be:

{[(8.69 x 10^{-4} pCi/g) x (4.5 x 10^{4} g)] + [(6.73 x 10^{-4} pCi/g) x (280 g)]} x (3.7 x 10^{-4} mrem/pCi) = 1.5 x 10^{-2} mrem

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 1992.

Total CEDEs 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.

8.3 Dose 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 2.91 x 10^{-13} μCi/mL. With a dose conversion factor for inhalation of 3.2 x 10^{1} mrem/μCi, this equates to a dose of 7.82 x 10^{-4} mrem. This is a negligible quantity when compared with the PIC Network measurements that vary from 53 to 169 mR/year, depending on location.

8.4 Summary

The extensive offsite environmental surveillance system operated around the NTS by EMSL-LV measured no radiological exposures that could be attributed to recent NTS operations. Calculation with the CAP88-PC model resulted in a maximum inhalation dose of 0.012 mrem (1.2 x 10^{-4} mSv) to a hypothetical resident of Indian Springs, Nevada 54 km (32 mi) southeast of the NTS CP-I. If this individual were to additionally collect and consume an NTS deer such as the one discussed above, the estimated CEDE would increase by another 1.96 x 10^{-4} mrem to a total possible CEDE of slightly over .027 mrem. All of these maximum dose estimates are less than 0.1 percent of the ICRP recommendation that an annual effective dose equivalent for the general public not exceed 100 mrem/yr (ICRP 1985). The calculated population dose (collective committed effective dose equivalent) to the approximately 21,750 residents living within 80 km (50 mi) of each of the NTS airborne emission sources was 0.029 person-rem (2.9 x 10^{-4} person-Sievert).

Data from the PIC Network indicated a 1992 dose of 78 mrem from gamma radiation occurring in Indian Springs. This gamma background value is derived from an average PIC field measurement of 8.7 μR/hr. The 0.067 mrem CEDE calculated from the monitoring networks discussed above is a negligible amount by comparison.

The uncertainty (percent relative standard deviation) for the PIC measurement at the 78 mrem exposure level is approximately 3.1 percent. Extrapolating to the calculated annual exposure at Indian Springs, Nevada yields a total uncertainty of approximately 2.3 mrem. Because the estimated dose from NTS activities is much less than 1 mrem (the lowest level for which DQOs are defined, as given in Section 11), no conclusions can be made regarding the achieved data quality as compared to the DQO for this insignificant dose.

Table 21. Dose Calculations from Monitoring Network Data

Medium	Route of Exposure	Radionuclide	Calculation	Dose (CEDE) (mrem/yr)
Milk				
	Ingestion	^{90}Sr	$(2.29 \times 10^{-9}$ µCi/mL) x (450 mL/day) x (365 days/yr) x (1.4×10^{2} mrem/µCi)	5.27×10^{-2}
		^{3}H	$(4.76 \times 10^{-7}$ µCi/mL) x (450 mL/day) x (365 days/yr) x (6.4×10^{-2} mrem/µCi)	5.00×10^{-3}
TOTAL FROM MILK CONSUMPTION				5.77×10^{-2} mrem/yr
Foodstuffs				
Beef Liver	Ingestion	^{238}Pu	$(1.01 \times 10^{-4}$ pCi/g) x (11.5×10^{3} g/yr) x (3.7×10^{-4} mrem/pCi)	4.3×10^{-4}
		$^{239+240}Pu$	$(1.97 \times 10^{-4}$ pCi/g) x (11.5×10^{3} g/yr) x (3.7×10^{-4} mrem/pCi)	1.13×10^{-4}
Broccoli[a]	Ingestion	^{90}Sr	$(9.00 \times 10^{-3}$ pCi/g) x (516 g/day) x (120 days/yr) x (1.4×10^{-4} mrem/pCi)	7.8×10^{-2}
Carrots[a]	Ingestion	$^{239+240}Pu$	$(3.50 \times 10^{-5}$ pCi/g) x (516 g/day) x (120 days/yr) x (3.7×10^{-4} mrem/pCi)	7.1×10^{-4}
TOTAL FROM FOODSTUFFS				2.372×10^{-1} mrem/yr
Air				
	Submersion	^{85}Kr	$(3.09 \times 10^{-11}$ µCi/mL) x (1.5×10^{7} mrem/yr per µCi/mL)	4.63×10^{-4}
TOTAL FROM AIR				4.63×10^{-4} mrem/yr
TOTAL				2.95×10^{-1} mrem/yr

[a] The assumption for total vegetable consumption (516 g/day) is used in the equations for both broccoli and carrots. Only broccoli is included in the total for foodstuffs. One hundred twenty days was used for consumption based on four 30-day months.

9.0 Weapons Test and Liquefied Gaseous Fuels Spills Facility Support

The EPA participates in the execution of every nuclear test conducted at the NTS. For each test, the EPA performs a pre-test census of the offsite area population and is prepared to take protective actions in the event they are necessary. The EPA also provides offsite safety monitoring in support of chemical spill tests conducted at the Liquified Gaseous Fuels Spill Test Facility (LGFSTF) on the NTS.

9.1 Weapons Tests Support

Two days before each nuclear test, mobile teams of radiation monitoring technicians are dispatched to the counties surrounding the NTS. These technicians perform a census of the offsite areas to determine the locations and numbers of residents, work crews, and domestic animal herds. This information would be essential to providing protective actions in the event of a radiation release from a test. Additionally, the technicians monitor the seasonal population such as hunters, campers, and shepherds to ensure that they too can be notified if necessary. After the census is completed, the information is presented by the EPA to the Test Controller's Science Advisory Panel.

Senior EPA personnel serve as members of the Test Controller's Science Advisory Panel to provide advice on possible public and environmental impact of each test and on feasible protective actions if an accidental release of radioactivity should occur.

At the time of each test, approximately 20 radiation monitoring technicians are positioned in the areas downwind of the test. Each technician is equipped with a variety of radiation survey instruments, dosimeters, portable air samplers, and supplies for collecting environmental samples. The technicians are in constant radio contact with CP-1 which enables them to provide monitoring information and to receive operational instructions from the EPA staff. In the unlikely occurrence of a release of radioactivity, the technicians are prepared to initiate all manner of protective actions to ensure the health and safety of people in the offsite areas. They are also prepared to conduct a radiological monitoring and sampling program to document the radiation levels in the environment. The radiological safety criteria, or protective action guides, used by the EPA are based on those specified in NVO-176 (EPA, 1991a).

If an underground nuclear test is expected to cause detectable ground motion offsite, EPA monitoring technicians are stationed at locations where hazardous situations might occur, such as underground mines. At these locations, occupants are notified of potential hazards so they can take precautionary measures. Miners, for example, are brought above ground before such a test.

Remedial actions that EPA could recommend or implement to reduce exposures include: evacuation, shelter, access control, livestock feeding practices control, milk control, and food and water control. Which action would be appropriate depends largely upon the type of accident and the magnitude of the projected exposures and doses, the response time available for carrying out the action, and local constraints associated with a specific site.

An important factor affecting the effectiveness of the remedial actions is the degree of credibility EPA personnel maintain with offsite residents. Credibility is created and maintained by routine personal contacts made with local officials and law enforcement personnel as well as with the ranchers, miners, and others living in the offsite areas close to the NTS.

To determine the feasible remedial actions for an area, EPA uses its best judgment based on experience gained during atmospheric tests and from those tests conducted in the 1960s that contaminated offsite areas. No remedial actions have been necessary since 1970. However, through routine contact with offsite residents and through continuing population and road surveys, EPA maintains a sense of the degree to which it could implement remedial actions and the kind of cooperation that would be provided by officials and residents of the area.

During 1992, EMSL-LV personnel were deployed for all nuclear tests conducted at the NTS, none of which released radioactivity that could be detected offsite.

9.2 Liquefied Gaseous Fuels Spills Test Facility Support

The EPA provides offsite safety monitoring in support of chemical spill tests conducted at the LGFSTF. This is one of the few non-nuclear related activities conducted at the NTS. A scientist from the EPA is a member of the Spill Test Advisory Panel for each test. For each test, the EPA also conducts monitoring in the downwind direction at the boundary of the NTS.

Prior to the initial test of any given series and during operational trials, an EPA technician inspects the unmaintained jeep-trail routes to the predetermined sampling location to assure ready access. Since each test is contingent on compatible technical and weather conditions, including wind direction and speed, the technician remains at the Test Facility Control Center until the Advisory Panel authorizes initiation of the test. The EPA Advisory Panel representative then dispatches the technician to the sampling location, as close as accessible to the downwind trajectory. When the spill test is in progress, the EPA representative, in coordination with the Advisory Panel meteorologist, determines the travel time of gases from the spill to the sampling location of the monitor. The EPA representative then gives the technician specific clock time(s) to collect gas samples.

Samples are collected using a Model 31 Draeger hand pump into which is inserted a Draeger tube for the types of chemical gases to be detected. The technician remains at the sampling location until the Advisory Panel determines that further offsite monitoring is no longer required for that day's testing.

10. Public Information and Community Assistance Programs

In addition to its many monitoring and data analysis activities, the EMSL-LV conducts a comprehensive program designed to provide information and assistance to individual citizens, organizations, and local government agencies in communities near the NTS. Activities in 1992 included participation in public hearings, "town hall" meetings, continued support of the Community Radiation Monitoring Program (CRMP), and a variety of tours, lectures, and presentations.

10.1 Community Radiation Monitoring Program

Beginning in 1981, DOE and EPA established a network of CRMP stations in the offsite areas to perform radiological sampling and monitoring, to increase public awareness, and to disseminate the results of radiation monitoring activities to the public. These stations continued operation in 1992. The DOE, through an interagency agreement with EPA, 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 and utility meters, and by providing QA checks of the data. The University of Utah provides in-depth training for station managers and alternates twice a year on issues related to nuclear science, radiological health, and radiation monitoring. In each community, EPA and DRI work with civic leaders to select and hire a local manager and an alternate. Whenever possible, they choose residents with some scientific training, such as a high school or university science teacher.

All of the 19 CRMP stations contain one each of the samplers for the air, noble gas, and tritium networks discussed in the previous chapters. Each station also contains a TLD and a PIC with a recorder for immediate readout of external gamma exposure, and a recording barograph. The standby samplers are routinely activated for one week each quarter to assure proper operation. Sample collection can be initiated at any time by notifying the station manager or alternate or by EMSL-LV personnel.

All 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 have ready access to the PIC and barometric data. The locations of the CRMP stations are shown in Figure 12, Section 3. The data from these stations were discussed in Sections 3 and 4.

Computer-generated reports for each station are issued weekly. These reports indicate the current weekly average gamma exposure rate as measured by the PICs, the average for the previous week, and the average for the previous year. For comparison these reports also show the maximum and minimum background concentrations in the U.S. These reports are distributed to each CRMP station for public display.

10.2 Town Hall Meetings

These meetings provide an opportunity for the public to meet directly with EPA, DOE, and DRI personnel, ask questions, and express their concerns regarding nuclear testing. During a typical meeting, the procedures used and the safeguards in place during every nuclear test are described. The EPA's radiological monitoring and surveillance networks are explained and the proposed High Level Waste Repository at Yucca Mountain is discussed.

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 22 lists the outreach presentations conducted in 1992. A list of presentation subjects is provided in Table 23.

The CRMP outreach program is managed by Mr. Nate Cooper of DRI. All inquiries regarding the outreach program and presentations should be directed to Mr. Cooper at (702) 895-0461. 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 22. Community Radiation Monitoring Program Outreach Presentations - 1992

Date	Location	Audience	Subject	Attendance
02/12	Adaven, NV	Uhalde Ranch County School	NTS Deer Migration Study	21
02/24	Tonopah, NV	Alpha Sigma Phi (women's college sorority)	Consumer Electronic Product Radiation	16
02/25	Tonopah, NV	Tonopah Junior High School	Downwind Radiation and Sheep Kill	104
04/07	Panaca, NV	Lincoln County Middle and High Schools	NTS Deer Migration Study	75
04/20	Tonopah, NV	Tonopah Rotary Club	NTS Archaeology	20
04/24	Tonopah, NV	Tonopah Elementary and High Schools	ABC's of Radiation	87
05/02	Beatty, NV	Beatty High School	NTS Archaeology; Archaeology in Egypt; Career Opportunities in Archaeology, Geology, and Hydrology; NASA's astronaut program	125
06/01	Coal Valley, NV	Complex I Residents	NTS Deer Migration Study	6
06/09	Tonopah, NV	Tonopah Rotary Club	Joint Verification Experiment	19
07/14	Tonopah, NV	Tonopah Rotary Club	NTS Deer Migration Study	16
09/16	Indian Springs, NV	Indian Springs High School Government Class	Current Events and the NTS	35
10/12	Cedar City, UT	American Legion and Auxiliary	Consumer Electronic Product Radiation	19
10/13	Cedar City, UT	Cedar City High School	Consumer Electronic Product Radiation	122
10/13	Cedar City, UT	Women in Business	Consumer Electronic Product Radiation	30
11/16	Tonopah, NV	Tonopah Rotary Club	NTS Hydrology	19
12/15	Parowan, UT	Parowan High School	NTS Deer Migration Study	96
12/16	Cedar City, UT	Cedar City High School	NTS Deer Migration Study	78
12/16	Cedar City, UT	Cedar City Exchange Club	NTS Deer Migration Study	16
			Attendance Total	904

Table 23. Community Radiation Monitoring Program Presentation Topics

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

2. **Testing Nuclear Weapons.** How nuclear weapons are tested (safely) on the NTS.

3. **Joint Verification Experiments.** Interaction with the USSR during exchange of weapons tests at the NTS and the USSR.

4. **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.

5. **Offsite Radiation Monitoring and the Community Monitoring Program.** The offsite monitoring program which is performed by the EPA 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.

6. **Hiroshima-Nagasaki Experience.** Predicted radiation affects based on the Hiroshima-Nagasaki data.

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

8. **Onsite Environmental Monitoring.** The NTS onsite environmental monitoring program.

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

10. **NTS Archaeology.** Prehistory and cultural resources of the southern Great Basin and NTS.

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

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

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

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

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

11 Quality Assurance

11.1 Policy

One of the major goals of the EPA is to ensure that all agency 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 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 EMSL-LV are summarized in the *Quality Assurance Program Plan* (EPA, 1987). Policies and requirements specific to the ORSP are documented in the *Quality Assurance Program Plan for the Nuclear Radiation Assessment Division Offsite Radiation Safety Program* (EPA, 1992). The requirements of these documents establish a framework for consistency in the continuing application of quality assurance standards and procedures in support of the ORSP. Administrative and technical procedures based on these QA requirements are maintained in appropriate manuals or are described in SOPs. It is NRD policy that personnel adhere to the requirements of the QA Plan and all SOPs applicable to their duties to ensure that all environmental radiation monitoring data collected by the EMSL-LV in support of the ORSP are of adequate quality and properly documented for use by the 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 QC procedures, NRD participates in external intercomparison programs. One such intercomparison program is managed and operated by a group within 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, 1981). 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. External systems and performance audits are conducted for the TLD Network as part of the certification requirements for DOE's Laboratory Accreditation Program (DOE-LAP) (DOE, 1986, 1986b). These external intercomparison and audit programs are used to monitor analysis accuracy.

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 representative of all 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, another aspect of comparability is examined through long-term comparison and trend analysis of various radionuclide activity concentrations, and TLD, and PIC data. Use of SOPs, maintained under a document control system, is an important component of comparability, ensuring that all personnel conform to a unified, consistent 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%. The completeness objective for the LTHMP is 80%; a lower objective has been established because dry wells or access restrictions occasionally preclude sample collection.

11.2.2 Precision and Accuracy Objectives of Radioanalytical Analyses

Measurements of sample volumes should be accurate to ± 5% for aqueous samples (water and milk) and to ± 10% for air and soil samples. The sensitivity of radiochemical and gamma spectrometric analyses must allow no more than a 5% risk of either a false negative or false positive value. Precision to a 95% confidence interval, monitored through analysis of duplicate and blind samples, must be within ± 10% for activities greater than 10 times the minimum detectable concentration (MDC) and ± 30% for activities greater than the MDC but less than 10 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% confidence level. Control limits for accuracy, monitored with matrix spike samples, are required to be no greater than ± 20% for all gross alpha, gross beta, and gamma spectrometric analyses, depending upon the media type.

At concentrations greater than 10 times the MDC, precision is required to be within ± 10% for:

- Conventional Tritium Analyses
- Uranium
- Thorium (all media)
- Strontium

and within ± 20% for:

- Enriched Tritium Analyses
- Strontium (in milk)
- Noble Gases
- Plutonium.

At concentrations less than 10 times the MDC, both precision and accuracy are expressed in absolute units, not to exceed 30% of the MDC for all analyses and all media types.

11.2.3 Quality of Dose Estimates

The allowable uncertainty of the effective dose equivalent to any human receptor is ± 0.1 mrem annually. This uncertainty 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, effective dose equivalents must have an accuracy (bias) of no greater than 50% for annual doses greater than or equal to 1 mrem but less than 5 mrem and no greater than 10% for annual doses greater than or equal to 5 mrem.

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 noncollection 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 nonanalysis 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 Field Operations 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:

1. Completeness - all samples scheduled to be collected have, in fact, been collected and analyzed or the data base contains documentation explaining the reasons for noncollection or nonanalysis.

2. Transcription errors - checks are made of all manually entered information to ensure that the information contained in the data base is accurate.

3. Quality control data - field and analytical duplicate, audit sample, and matrix blank data are checked to ensure that the collection and analytical processes are within specified QC tolerances.

4. Analysis schedules - lists of samples awaiting analysis are generated and checked against normal analysis schedules to identify backlogs in analysis or data entry.

5. Unidentified malfunctions - 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 base has been validated, the data are compared to the DQOs. Completeness, accuracy, and precision statistics are calculated. The achieved quality of the data is reported at least annually. If data fail to meet one or more of the established DQOs, the data may still be used in data analysis; however, the data and any interpretive results are to be qualified.

All sample results exceeding the 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. 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. 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, EPA's CAP88-PC model (EPA, 1992) 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 and reported with the estimate.

11.4 Quality Assessment Of 1992 Data

Data quality assessment is associated with the regular QA and QC practices within the radio-

analytical laboratory. The analytical QC 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 QC samples prepared by other organizations in which data are compared between several laboratories and assessed for accuracy.

Achieved data quality statistics are compiled on a quarterly and annual basis. 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 1992.

11.4.1 Completeness

Completeness is calculated as:

$$\%C = \left(\frac{V}{n}\right) \times 100$$

where:
$\%C$ = *percent completeness*
V = *number of measurements judged valid*
n = *total number of measurements*

The percent completeness of the 1992 data is given in Table 24. 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 one, resulting in a completeness of 100 percent by definition.

The achieved completeness of over 96 percent for the LTHMP exceeds the DQO of 80 percent. If the wells which have been shut down by DOE are included in the completeness calculation, the achieved completeness is 86 percent for the LTHMP overall, but only 78 percent for sites sampled on the NTS.

Overall completeness for the routine Air Surveillance Network was greater than 98 percent, exceeding the DQO of 90 percent. Individually, all stations exceeded 95 percent data recovery and four stations achieved completeness of 100 percent. Plutonium analyses, conducted on composited filters from selected routine and standby air stations, were over 93 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 seven routine sampling locations, and greater than 80 percent for another five routine sampling locations. Completeness was less than 70 percent for one routine sampling location (Amargosa Center) and for all of the standby station locations. Generally, recovery of less than 75 percent of the sampling period indicate the data cannot be considered to be representative of that period; consequently, an annual average for Amargosa Center cannot be considered representative of the year.

The achieved completeness for the atmospheric moisture network was greater than 95 percent, exceeding the DQO of 90 percent. On an individual station basis, all of the routine sampling locations achieved data recoveries greater than 80 percent; all but one were greater than 90 percent. Data recoveries were lower for the standby stations; however, the issue of annual representation does not apply to the standby locations, which are operated only one week per quarter to retain operational reliability.

Overall data recovery for the MSN was less than the DQO of 90 percent. Many of the milk sampling locations consist of family-owned cows or goats that can provide milk only when the animal is lactating. Less than 75 percent of the total possible number of samples were collected from seven ranches: Dahl (Alamo, Nevada), Lemon (Dyer, Nevada), John Deer (Amargosa Valley, Nevada), Frayne (Goldfield, Nevada), Brown (Benton, California), Blue Eagle (Currant, Nevada), and Scott (Goldfield, Nevada). Annual means for these locations individually cannot be considered to be representative of the year. However, the milkshed may be adequately represented if an alternate location in the area was sampled when the primary station could not supply milk.

Table 24. Data Completeness of Offsite Radiological Safety Program Networks

Network	No. of Sampling Locations	Total Samples Possible	Valid Samples Collected	Percent Completeness
LTHMP	243	423[a]	408	96.5[a]
Air Surveillance	30 18 ($^{238, 239+240}$Pu)	10,950 days[b] 196[c]	10,824 184	98.8 93.9
Noble Gas	21[d]	4,969 days[b]	4,519 (^{85}Kr) 4,545 (^{133}Xe)	90.9 (^{85}Kr) 91.5 (^{133}Xe)
Atmospheric Moisture	21[e]	5,306 days[b]	5,054	95.3
Milk Surveillance	25	288	225	78.1
Animal Investigation	3	12[f]	11	91.7
PIC	27	1,404 weeks[g]	1,379	98.2

(a) 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).

(b) Continuous samplers with samples collected at intervals of approximately one week. Days used as units to account for differences in sample interval length.

(c) Includes five quarters (July 1991 through September 1992) of data for 13 standby network locations and five routine sampling locations. Analyses of plutonium isotopes for one routine sampling location (Salt Lake City, Utah) were discontinued at the beginning of 1992.

(d) Thirteen stations are operated on a routine basis and another eight are operated one week per quarter.

(e) Fourteen stations are operated on a routine basis and another seven are operated one week per quarter.

(f) Includes four mule deer from the Nevada Test Site and four cows from each of two locations. Does not include bighorn sheep, fruits and vegetables, and other animals which are "samples of opportunity."

(g) Continuous samplers with data summarized on a weekly basis.

All of the animals scheduled for collection in the AIP were collected, with the exception that no mule deer was collected from the NTS in the first quarter of 1992. There were no road kills in that quarter and no deer were found on two hunting trips conducted during the quarter. Overall completeness exceeded the DQO of 90 percent.

The achieved completeness of over 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. If necessary, strip charts would be digitized to fill gaps if data were not available from either of the other two sources; however, no digitized data were needed in 1992.

11.4.2 Precision

Precision is monitored through analysis of duplicate samples. Field duplicates (i.e., 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 MSN. 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. 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; i.e., 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), also known as coefficient of variation, and is calculated by:

$$\%RSD = \left(\frac{std.\ dev.}{mean}\right) \times 100$$

The precision or %RSD 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.

Figure 49 displays %RSDs for LTHMP field and spiked sample duplicate pairs analyzed by the conventional tritium method. This figure includes 48 pairs of matrix spike samples and one field duplicate pair with means equal to or greater than the MDC but less than ten times the MDC. All pairs yielded %RSDs of less than 12 percent; the DQO for precision of samples in this activity range is 30 percent. Two field duplicate pairs with means equal to or greater than 10 times the MDC are not included in the figure; these two pairs had means of 118,000 and 91,800 pCi/L and %RSDs of 0.02 and 1.1 percent, respectively. These results are well within the DQO of ten percent for values equal to or greater than ten times the MDC.

Figure 50 displays %RSDs for duplicate pairs analyzed by the enriched tritium method. Of 26 field and two matrix spike sample duplicate pairs with means equal to or greater than the MDC but less than ten times the MDC, only one pair exceeded the DQO of 30 %RSD. The mean for this pair was approximately two times the MDC and the %RSD was 31.4 percent. The %RSD for all matrix spike and field duplicate sample pairs with means equal to or greater than 10 times the MDC was within the DQO of 20 percent. Six of the field duplicate pairs are not included on the figure because the means were much higher than the remaining values. These means of these six pairs range from 373 to 721 pCi/L and the %RSDs range from 1.3 to 12.6 percent. The single matrix spike duplicate pairs analyzed for gross alpha and for gross beta in water had means equal to or greater than ten times the MDC and yielded %RSDs of less than 10 percent. Duplicate analyses were performed for ^{137}Cs, however, all results were less than the MDC.

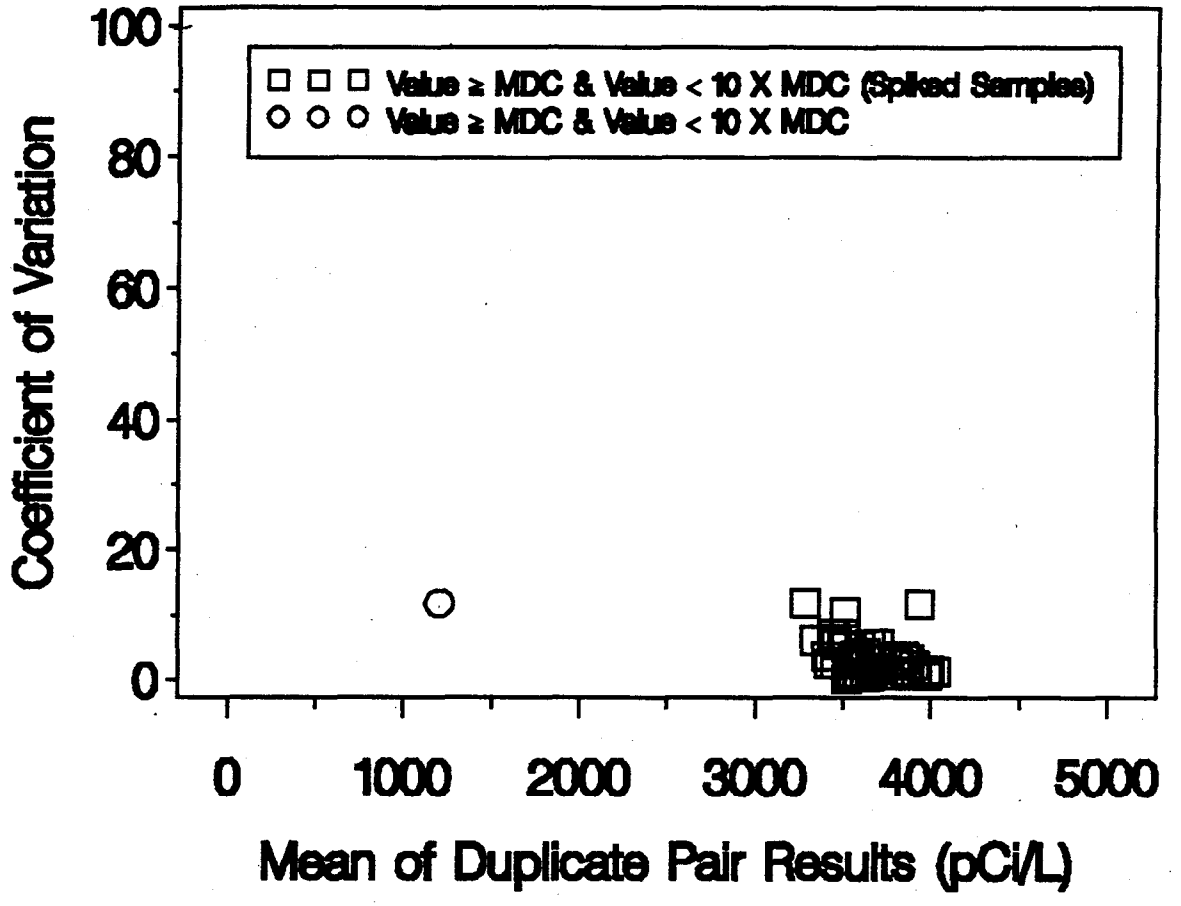

Figure 49. Field and spiked sample pair precision for LTHMP conventional tritium analyses.

In the ASN, field duplicate pairs are analyzed for gross alpha, gross beta, and gamma-emitting radionuclides. Figure 51 shows the %RSD distribution for gross alpha field duplicate analyses. Of 55 field duplicate pairs with means greater than or equal to the MDC but less than ten times the MDC, 36 pairs were within the DQO of 30 %RSD. Another seven pairs yielded %RSDs between 30 and 40 percent. As shown in Figure 52, gross beta field duplicate analyses yielded %RSDs ranging from less than one percent to greater than 100 percent for the 117 field duplicate pairs greater than or equal to the MDC but less than 10 times the MDC. Of the 117 pairs, 94 yielded %RSDs within the DQO of 30 %RSD and another eight pairs yielded %RSDs less than 40 %RSD. There were only three duplicate pairs with means equal to or greater than ten times the MDC; the %RSDs for these pairs were all within the DQO of 20 percent.

These results indicate that the true achieved precision for these gross spectrometric analyses, at concentrations less than 10 times the MDC, is closer to 40 percent. The data users are currently reevaluating the data quality required to achieve program objectives; the DQO may be modified if it is determined that the achieved data quality is adequate for program needs. Of the five field duplicate pairs with ^{7}Be activities equal to or greater than ten times the 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 74 duplicate analyses for gross alpha with results equal to or greater than the MDC but less than 10 times the MDC, 63 yielded %RSDs within the DQO of 30 percent and another three yielded %RSDs of less than 40 percent. Of

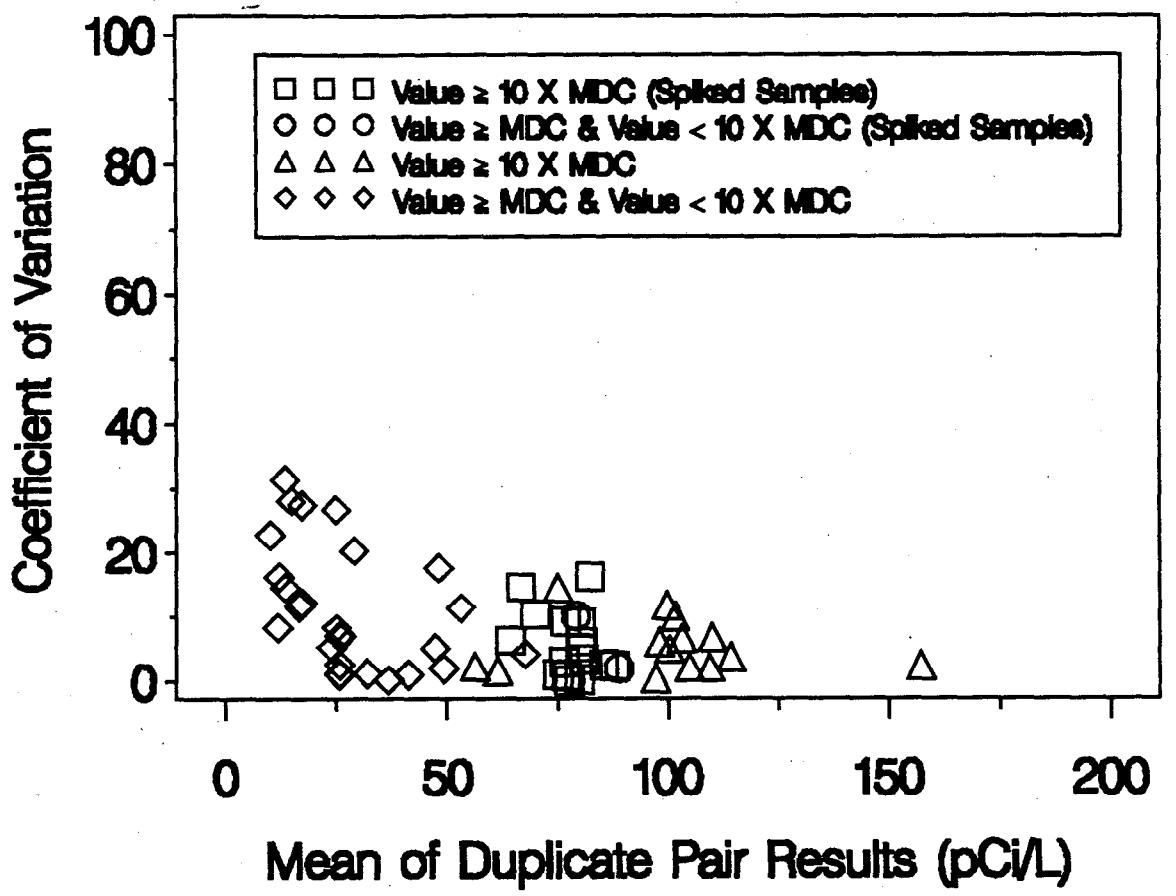

Figure 50. Field and spiked sample duplicate pair precision for LTHMP enriched tritium analyses.

174 duplicate analyses for gross beta with means equal to or greater than the MDC but less than ten times the MDC, all but one yielded %RSDs of less than 20 percent. In addition, 13 duplicate analyses for gross beta yielded means equal to or greater than ten times the MDC; the %RSDs for these pairs were all less than ten percent. Four duplicate gamma spectrometry analyses yielded ^{7}Be results with means equal to or greater than ten times the MDC and %RSDs for the pairs were all less than four percent.

All of the 48 noble gas sample splits analyzed for ^{85}Kr had activities greater than or equal to the MDC but less than ten times the MDC. All but two %RSDs were less than 20 percent, better than the DQO of 30 percent for sample pairs in this activity range. The %RSDs for ^{85}Kr are shown in Figure 53. Of 104 analyses of split sample pairs analyzed in the atmospheric moisture network, only nine pairs yielded results equal to or greater than the MDC but less than ten times the MDC. With one exception, the %RSDs for these were all less than 22 percent.

Only one of the 31 field duplicate pairs from the MSN analyzed for tritium yielded results equal to or greater than the MDC but less than ten times the MDC. The %RSD for this sample pair was 5.8 percent. Total potassium was measured at concentrations equal to or greater than ten times the MDC in 74 field duplicate pairs and in 36 duplicate analyses. In all but two cases, the %RSDs for the pairs was less than 20 percent and the remaining two pairs were within 25 percent. The %RSD results for the field duplicate pairs are shown in Figure 54. Four spiked sample duplicate pairs yielded means of ^{90}Sr equal to or greater than the MDC but less than ten times the MDC; the %RSDs for these pairs were all less than 12 percent.

In the AIP, matrix (bone ash) spike sample duplicates were analyzed for ^{90}Sr and $^{239+240}$Pu. The single pair analyzed for ^{90}Sr yielded a mean equal

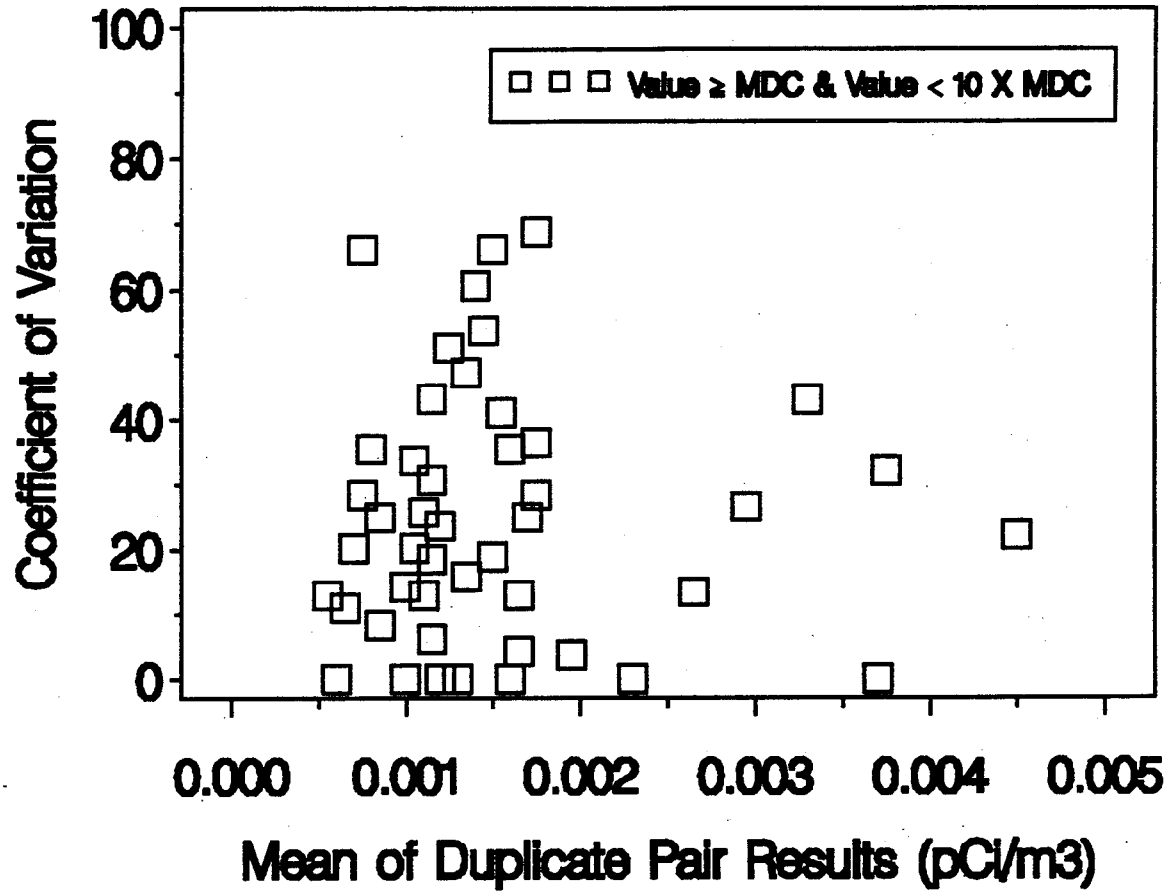

Figure 51. Field duplicate pair precision for Air Surveillance Network gross alpha analyses.

to or greater than the MDC but less than ten times the MDC and a %RSD of 12.9 percent. The single pair analyzed for $^{239+240}$Pu yielded a mean equal to or greater than ten times the MDC and a %RSD of 2.2 percent. Vegetable sample splits were analyzed for ^{90}Sr, but all results were less than the MDC. Similarly, all 14 split bioassay sample pairs yielded results less than the MDC.

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 25 presents the pooled data and estimates of overall precision. The pooled standard deviations and %RSD indicate that, with the exception of gross alpha analyses, the achieved precision is better than the DQO for the analysis and activity range. The pooled %RSD for tritium in air is based on a limited number of sample pairs, with the result influenced by one outlier with a %RSD of over 40 percent.

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 EMSL-LV Radioanalysis Laboratory participates in two such intercomparison studies. An independent verification of the accuracy of the TLDs is performed

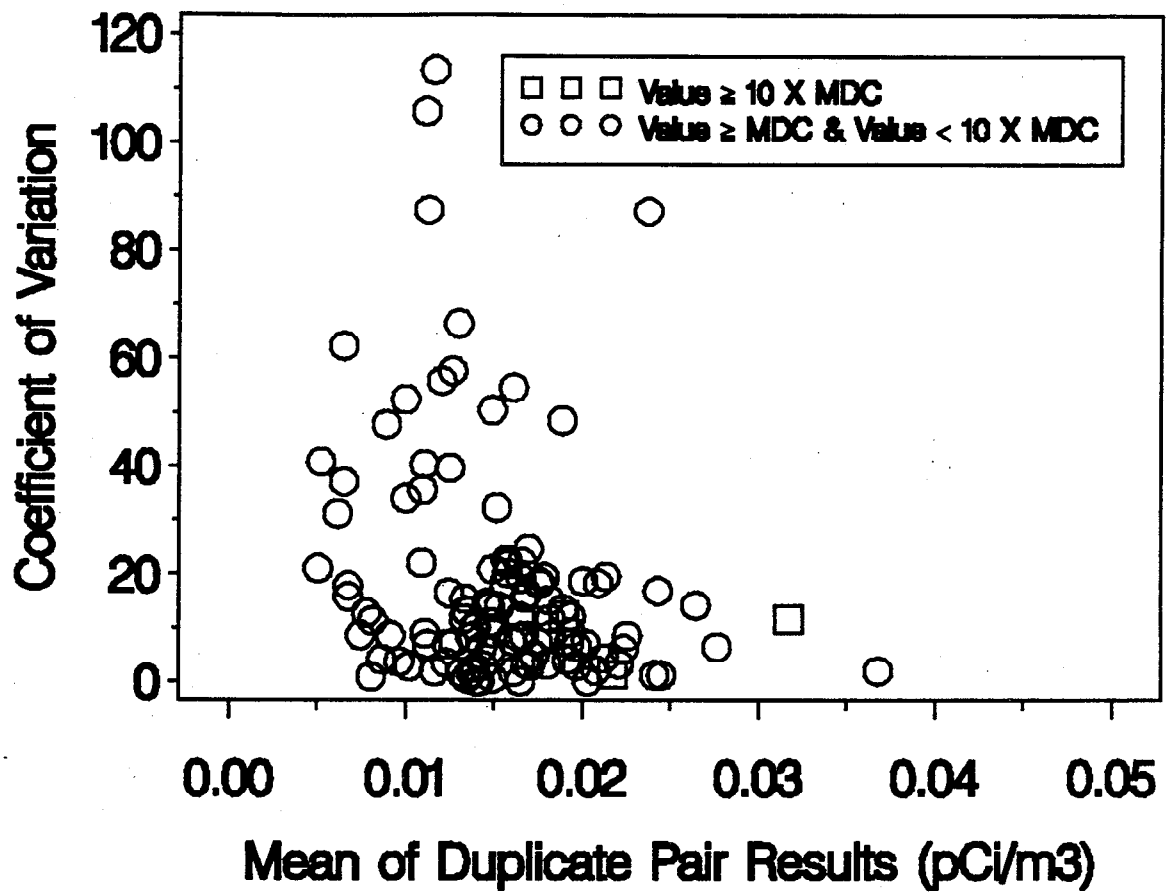

Figure 52. Field duplicate pair precision for Air Surveillance Network gross beta analyses.

every two or three years by DOELAP, with a "pass/fail" report given.

In the 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 are 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 26 presents accuracy 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 250 laboratories participate in any given intercomparison study.

Accuracy, as percent difference or percent bias, is calculated by: With the exception of gross alpha in

$$\%BIAS = \left(\frac{C_m - C_a}{C_a}\right) \times 100$$

where:
%BIAS = percent bias
C_m = *measured concentration*
C_a = *known/ theoretical concentration*

water and ^{106}Ru in the October gamma in water intercomparison study sample, the achieved accuracy was better than ± 20 percent. For most analyses, the DQOs are ± 20 percent for values greater than 10 times the MDC and ± 30 percent for results greater than the MDC but less than ten times the MDC. The achieved %Bias for the alpha activity in water samples was approximately 25 to 35 percent. The other intercomparison study in which the EMSL-LV Radioanalysis Laboratory participates is the semiannual DOE QA Program conducted by EML in New York, NY. Approximately 20 laboratories participate in this intercomparison

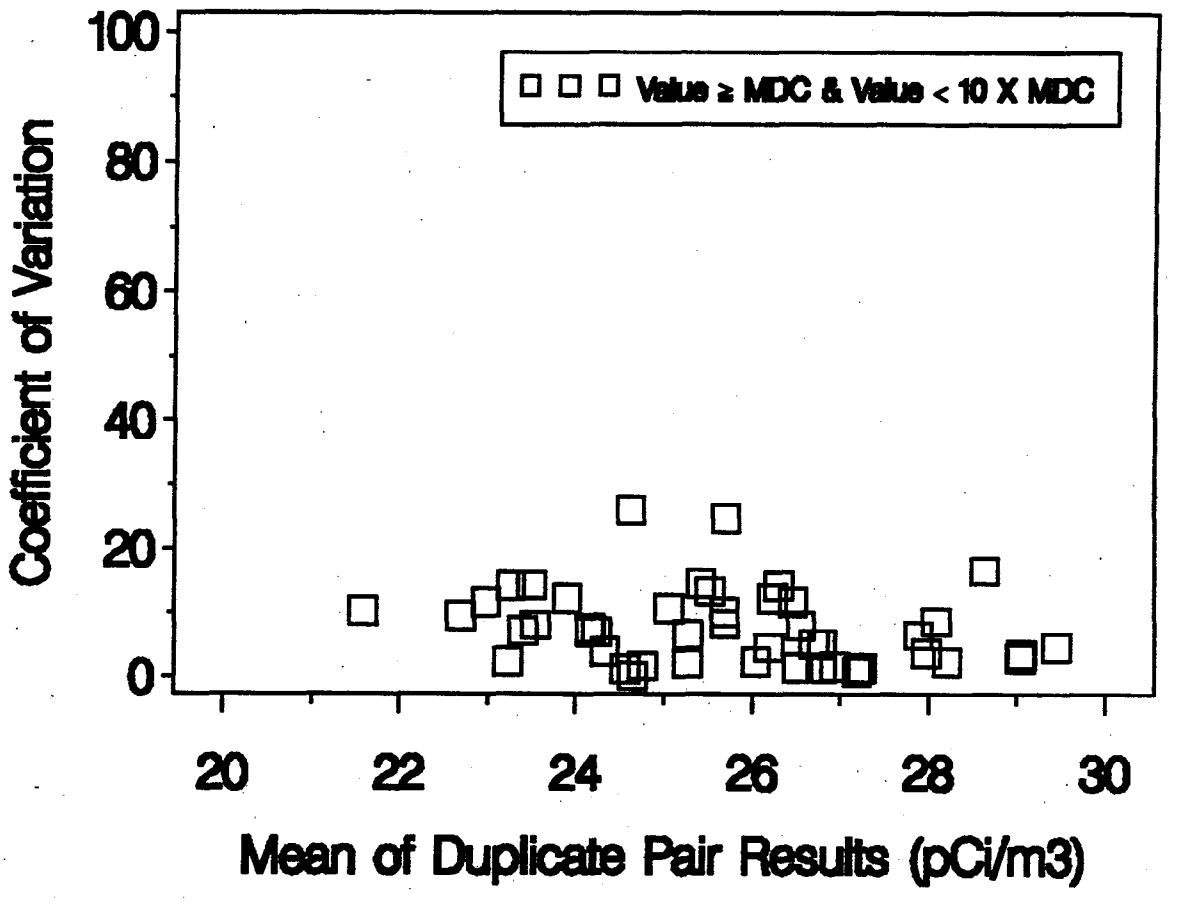

Figure 53. Split sample precision for Noble Gas Network ^{85}Kr analyses.

study program. Sample matrices include water, air filters, vegetation, and soil. The EML result is assumed to represent the known or true activity for calculation of %Bias. Results for these performance audit samples are given in Table 27. The DQOs for accuracy were exceeded for a number of analyses, primarily for gamma-emitter results in the September air and water samples. The cause of the evident bias is under investigation. Routine sample data were not affected and internal QC checks indicated the systems were in control. Gamma spectroscopy results for the March water and air filter samples were all well within the DQO of ± 20 percent. The DQO was also exceeded for ^{239}Pu in the March soil and vegetation samples and for ^{90}Sr in the September vegetation sample. Routine and internal QC check samples processed in the same time frame on the same systems are being checked to determine if results may be affected, requiring flagging or invalidation.

In addition to use of irradiated control samples in the processing of TLDs, DOELAP monitors accuracy, precision, and bias as part of the accreditation program. As with the intercomparison studies, dosimeters receiving a known type and level exposure 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 radiation type or level to which the dosimeter has been exposed except that dosimeters are identified as having been exposed in either the "protection range" or the "accident range." Individual results are not provided to the participant laboratories by DOELAP until the conclusion of the third round of performance testing in each test cycle. Issuance of the accreditation certificate indicates acceptable accuracy, precision, and bias and successful completion of a comprehensive onsite review by independent DOELAP site assessors.

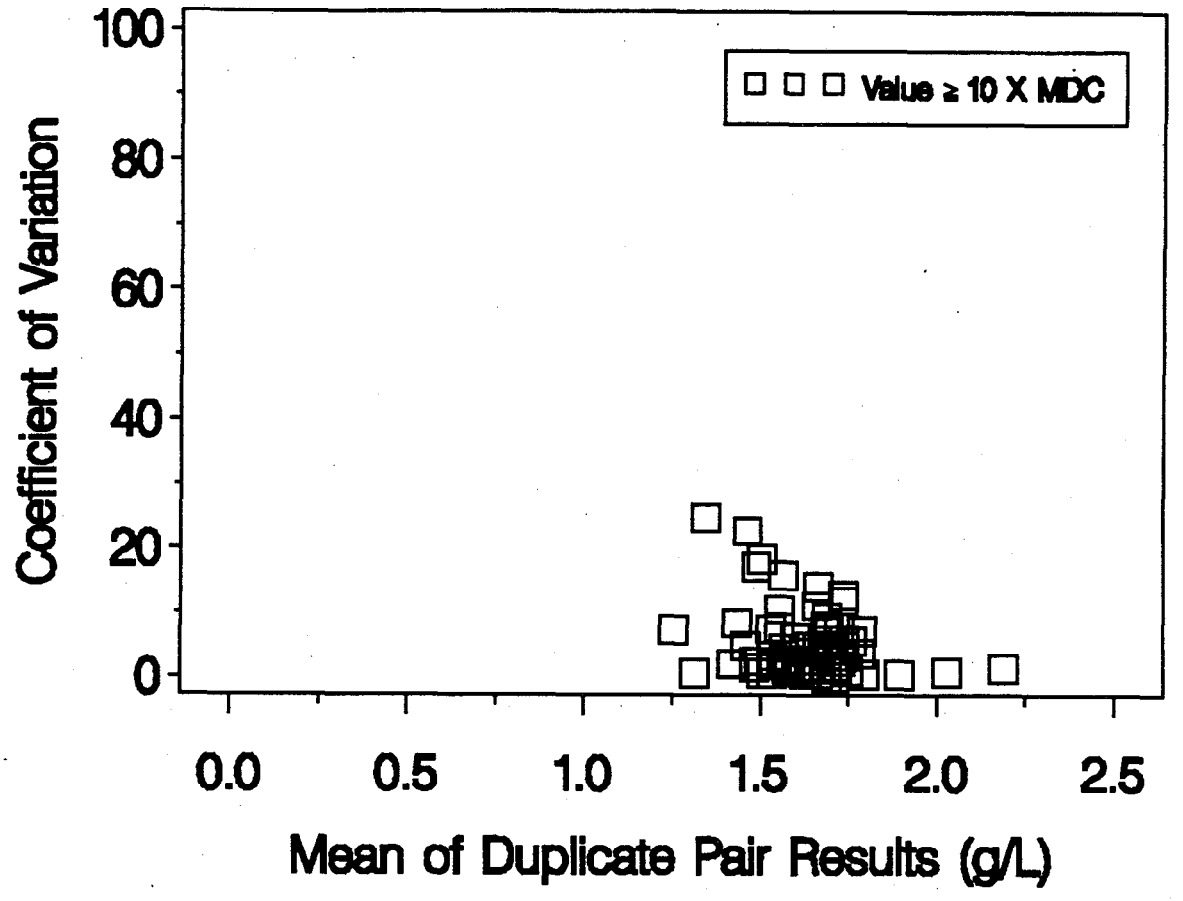

Figure 54. Field Duplicate Pair Precision for Milk Surveillance Network Total Potassium Analyses.

11.4.4 Comparability

The EPA Intercomparison Study reports (EPA, 1991) provide results for all laboratories participating in each intercomparison study. A grand average is computed for all values, excluding outliers. A normalized deviation statistic compares each laboratory's result (mean of three replicates) to the known value and to the grand average. If the value of this statistic (in multiples of standard normal deviate, unitless) lies between control limits of -3 and +3, the accuracy (deviation from known value) or comparability (deviation from grand average) is within normal statistical variation. Table 28 displays data from the 1992 intercomparison studies for the variables most commonly measured in the ORSP. Of the commonly measured variables, there were three instances in which the Radioanalysis Laboratory results deviated from the grand average by more than three standard normal deviate units. These were the April intercomparison sample for total potassium in milk, the August sample for beta emitters on an air filter, and the September water intercomparison sample containing ^{89}Sr.. The first two of these also exceeded the DQO for accuracy (see Section 11.4.3, above). The third sample, ^{89}Sr in water, was within the DQO for accuracy. Apart from these three, all of the normalized deviations from the grand average were within the statistical control limit range of -3 to +3. This indicates acceptable comparability of the Radioanalysis Laboratory with the 69 to 207 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

Table 25. Overall Precision of Analysis

Network	Analysis	Sample Type	Range	n	Pooled Standard Deviation	%RSD
LTHMP	Gross Alpha	Spiked	≥10x MDC	1	1.42	5.8
	Gross Beta	Spiked	≥10x MDC	1	2.75	8.7
	Conv. Tritium	Spiked	≥MDC,<10x MDC	48	157.65	4.3
	Conv. Tritium	Field	≥MDC,<10x MDC	1	141.77	11.8
	Conv. Tritium	Field	≥10x MDC	2	725.16	0.7
	Enrich. Tritium	Spiked	≥MDC,<10x MDC	2	5.75	6.8
	Enrich. Tritium	Field	≥MDC,<10x MDC	26	3.37	11.9
	Enrich. Tritium	Spiked	≥10x MDC	16	5.62	7.2
	Enrich. Tritium	Field	≥10x MDC	20	19.79	8.6
Air Surveillance	Gross Alpha	Field	≥MDC,<10x MDC	55	0.000	33.8
	Gross Alpha	Lab Dup	≥MDC,<10x MDC	74	0.000	23.6
	Gross Beta	Field	≥MDC,<10x MDC	117	0.004	27.6
	Gross Beta	Lab Dup	≥MDC,<10x MDC	174	0.001	8.3
	Gross Beta	Field	≥10x MDC	3	0.003	10.4
	Gross Beta	Lab Dup	≥10x MDC	13	0.001	3.8
	^{7}Be	Field	≥10x MDC	5	0.025	8.8
	^{7}Be	Lab Dup	≥10x MDC	4	0.006	2.4
Noble Gas	^{85}Kr	Split	≥MDC,<10x MDC	46	2.43	9.5
Tritium in Air	HTO	Split	≥MDC,<10x MDC	9	1.46	20.9
Milk	Conv. Tritium	Field	≥MDC,<10x MDC	1	25.21	5.8
	Potassium (total)	Field	≥10x MDC	74	0.111	6.8
	Potassium (total)	Lab Dup	≥10x MDC	36	0.076	4.7
	^{90}Sr	Spiked	≥MDC,<10x MDC	4	1.56	7.5
Animal Investigation Program	^{90}Sr (ash)	Spiked	≥MDC,<10x MDC	1	2.69	12.9
	$^{239+240}$Pu (ash)	Spiked	≥10x MDC	1	0.09	2.2

radiation exposure of the resident population. Monitoring stations are located in 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 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, in most cases, meet the siting requirements. 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 primary "targets of opportunity", i.e., the sam-

Table 26. Accuracy of Analysis from EPA Intercomparison Studies

Nuclide	Month	Known Value (pCi/L)[a]	EPA Average (pCi/L)[a]	Percent Bias
		Water Intercomparison Studies		
Alpha	Jan	30.0	22.67	-24.43
Alpha	Apr (PE)	40.0	49.67	24.18
Alpha	May	15.0	18.33	22.20
Alpha	Sep	45.0	56.67	25.93
Alpha	Oct (PE)	29.0	40.00	37.93
Beta	Jan	30.0	31.33	4.43
Beta	Apr (PE)	140.0	130.67	-6.66
Beta	May	44.0	47.00	6.82
Beta	Sep	50.0	59.00	18.00
Beta	Oct (PE)	53.0	48.33	-8.81
^{3}H	Feb	7,904.0	7,965.0	0.77
^{3}H	June	2,125.0	2,070.33	-2.57
^{3}H	Oct	5,962.0	5,896.67	-1.10
^{60}Co	Feb	40.0	42.00	5.00
^{60}Co	Apr (PE)	56.0	55.3	-1.20
^{60}Co	May	20.0	19.33	-3.35
^{60}Co	Oct	10.0	10.00	0.00
^{60}Co	Oct (PE)	15.0	14.67	-2.20
^{65}Zn	Feb	148.0	165.00	11.49
^{65}Zn	May	99.0	102.67	3.71
^{65}Zn	Oct	148.0	153.00	3.38
^{89}Sr	Jan	51.0	44.33	-13.08
^{89}Sr	Apr (PE)	15.0	12.67	-15.53
^{89}Sr	May	29.0	26.33	-9.21
^{89}Sr	Sep	20.0	18.67	-6.65
^{89}Sr	Oct (PE)	8.0	8.33	4.13
^{90}Sr	Jan	20.0	20.33	1.65
^{90}Sr	Apr (PE)	17.0	16.33	-3.94
^{90}Sr	May	8.0	8.00	0.00
^{90}Sr	Sep	15.0	14.00	-6.67
^{90}Sr	Oct (PE)	10.0	11.00	10.00
^{106}Ru	Feb	203.0	182.00	-10.34
^{106}Ru	May	141.0	128.67	-8.74
^{106}Ru	Oct	175.0	135.33	-22.67
^{131}I	Feb	59.0	60.33	2.25
^{131}I	Aug	45.0	45.00	0.00
^{133}Ba	Feb	76.0	67.00	-11.84
^{133}Ba	May	98.0	91.67	-6.46
^{133}Ba	Oct	74.0	73.67	-0.45
^{134}Cs	Feb	31.0	29.67	-4.29
^{134}Cs	Apr (PE)	24.0	23.00	-4.17
^{134}Cs	May	15.0	13.33	-11.13

[a] Values were obtained from the individual intercomparison study reports and are reported with the units and significant figures included in those reports.

pling locations are primarily wells developed for purposes other than radioactivity monitoring. Guidance or requirements developed for Comprehensive Environmental Response, Compensation, and Liability Act and Resource Conservation Recovery Act regarding the number and location of monitoring wells have 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, on and around the NTS, all potentially impacted drinking water

Table 27 Accuracy of Analysis from DOE Intercomparison Study

Nuclide	Month	EML Value[a]	EPA Value[a]	Percent Bias
		Air Intercomparison Studies		
^{7}Be	Mar	28.6	29.4	2.80
^{7}Be	Sept	308	389	26.30
^{54}Mn	Mar	5.97	6.39	7.04
^{54}Mn	Sept	25.9	35.9	38.61
^{57}Co	Mar	7.93	7.33	-7.57
^{57}Co	Sept	6.4	8.1	26.56
^{60}Co	Mar	5.81	6.09	4.82
^{60}Co	Sept	3.06	4.3	40.52
^{90}Sr	Mar	0.207	0.172	-16.91
^{134}Cs	Mar	4.44	5.20	17.12
^{134}Cs	Sept	3.72	4.8	29.03
^{137}Cs	Mar	5.76	6.43	11.63
^{137}Cs	Sept	5.82	8.3	42.61
^{144}Ce	Mar	63.9	69.8	9.23
^{144}Ce	Sept	43.3	51.4	18.71
^{238}Pu	Mar	0.270	0.261	-3.33
^{238}Pu	Sept	0.042	0.0346	-17.62
^{239}Pu	Mar	0.285	0.254	-10.88
^{239}Pu	Sept	0.045	0.0392	-12.89
		Soil Intercomparison Studies		
^{238}Pu	Sept	21.9	20	-8.68
^{239}Pu	Mar	25.5	31.6	23.92
^{239}Pu	Sept	7.76	6.98	-10.05
		Vegetation Intercomparison Studies		
^{90}Sr	Mar	376	350	-6.91
^{90}Sr	Sept	489	618	26.38
^{238}Pu	Mar	1.08	1.13	4.63
^{238}Pu	Sept	1.25	1.34	7.20
^{239}Pu	Mar	0.311	0.374	20.26
^{239}Pu	Sept	0.379	0.342	-9.76

[a] Values were obtained from the Environmental Measurements Laboratory (EML) and reported with the significant figures provided by EML. Units are Bq/filter for air, Bq/L for water, and Bq/Kg for the remaining matrices.

supplies are monitored, as are many supply sources with virtually no potential to be impacted by radioactivity resulting from past or present 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 7.

Table 28. Comparability of Analysis from EPA Intercomparison Studies[a]

Nuclide	Month	EPA Lab Average (pCi/L)	Grand Value (pCi/L)	Known Average (pCi/L)	Normalized Deviation from Grand Average	Normalized Deviation from Known Value
			Water Intercomparison Studies			
Alpha	January	23	24	30	-0.30	-1.6
Alpha	April (PE)	50	40	40	1.7	1.7
Alpha	May	18	14	15	1.4	1.2
Alpha	September	57	36	45	3.2	1.8
Alpha	October (PE)	40	28	29	2.9	2.7
Beta	January	31	30	30	0.50	0.46
Beta	April (PE)	130	118	140	1.0	-0.77
Beta	May	47	43	44	1.5	1.0
Beta	September	59	49	53	0.31	3.1
Beta	October (PE)	48	46	53	0.31	-0.81
^{3}H	February	8,000	7,900	7,900	0.05	0.13
^{3}H	June	2,100	2,100	2,120	-0.16	-0.21
^{3}H	October	5,900	6,000	5,960	-0.29	-0.19
^{60}Co	February	42	40	40	0.67	0.69
^{60}Co	April (PE)	55	56	56	-0.38	-0.23
^{60}Co	June	19	21	20	-0.44	-0.23
^{60}Co	October	10	11	10	-0.33	0
^{60}Co	October (PE)	15	15	15	-0.22	-0.12
^{65}Zn	February	160	150	148	1.9	2.0
^{65}Zn	June	100	100	98	-0.34	0.64
^{65}Zn	October	160	160	148	0.33	1.4
^{89}Sr	January	44	47	51	-0.97	-2.3
^{89}Sr	April (PE)	13	16	15	-0.99	-0.81
^{89}Sr	May	26	28	29	-0.59	-0.29
^{89}Sr	September	19	20	20	-0.47	-0.46
^{89}Sr	October (PE)	8.3	8.6	8	-0.09	0.12
^{90}Sr	January	20	19	20	0.36	0.12
^{90}Sr	April (PE)	16	16	17	0.17	-0.23
^{90}Sr	May	8	7.7	8	0.09	0
^{90}Sr	September	14	14	15	-0.17	-0.35
^{90}Sr	October (PE)	11	10	10	0.17	0.35
^{106}Ru	February	180	190	203	-1.1	-1.8
^{106}Ru	June	130	140	141	-1.2	-1.5
^{106}Ru	October	140	160	175	-2.4	-3.8
^{131}I	February	60	60	59	0.05	0.38
^{131}I	August	45	46	45	-0.26	0
^{133}Ba	February	67	75	76	-1.8	-2.0
^{133}Ba	June	92	96	98	-0.78	-1.1
^{133}Ba	October	74	73	74	0.15	-0.08
^{134}Cs	February	30	29	31	0.08	0.46
^{134}Cs	April (PE)	23	23	24	-0.15	-0.35
^{134}Cs	June	15	15	15	-0.49	-0.58
^{134}Cs	October	7	8.1	8	-0.39	-0.35
^{134}Cs	October (PE)	5	5.3	5	-0.11	0

(a) Values were obtained from the individual, intercomparison study reports and are reported with all values rounded to two significant figures.

Continued

Table 28. (Comparability of Analysis from EPA Intercomparison Studies[a], cont.)

Nuclide	Month	EPA Lab Average (pCi/L)	Grand Value (pCi/L)	Known Average (pCi/L)	Normalized Deviation from Grand Average	Normalized Deviation from Known Value
			Water Intercomparison Studies (cont.)			
^{134}Cs	October (PE)	5	5.3	5	-0.11	0
^{137}Cs	February	51	51	49	0.11	0.69
^{137}Cs	April (PE)	23	23	22	-0.07	0.35
^{137}Cs	June	15	16	15	-0.5	-0.12
^{137}Cs	October (PE)	8.3	8.9	8	-0.18	0.12
^{137}Cs	October	8.7	8.7	8	-0.02	0.23
			Air Filter Intercomparison Studies			
Alpha	March	8	8.3	7	-0.12	0.35
Alpha	August	30	31	30	-0.19	0
Beta	March	39	42	41	-1.0	-0.58
Beta	August	71	72	69	-0.17	0.35
^{90}Sr	March	15	15	15	0.02	-0.12
^{90}Sr	August	22	24	25	-0.8	-1.0
^{137}Cs	March	11	11	10	-0.12	0.23
^{137}Cs	August	20	20	18	0.11	0.69
U (Nat)	March	26	24	25	1.1	0.21
U (Nat)	April (PE)	4.2	4.3	4.2	1.7	1.7
U (Nat)	July	4	4	4	0.03	0.02
U (Nat)	October (PE)	10	10	10	2.9	2.7
U (Nat)	November	15	14	15	0.17	-0.27
^{239}Pu	January	16	16	17	0.35	-0.85
^{239}Pu	August	8.7	8.6	9	0.23	-0.58
			Milk Intercomparison Studies			
^{89}Sr	April	32	31	38	0.22	-2.2
^{89}Sr	September	12	14	15	-0.48	-0.92
^{90}Sr	April	26	25	29	0.35	-1.2
^{90}Sr	September	14	13	15	0.41	-0.35
^{131}I	April	78	78	78	-0.1	0
^{131}I	September	96	101	100	-0.92	-0.75
^{137}Cs	April	40	40	39	-0.23	0.23
^{137}Cs	September	15	16	15	-0.27	0.12
K (Total)	April	1,760	1,700	1,710	1.1	0.94
K (Total)	September	1,820	1,710	1,750	2.2	1.4

(a) Values were obtained from the individual intercomparison study reports and are reported with the significant figures included in those reports.

12. Sample Analysis Procedures

The procedures for analyzing samples collected for this report are described in *Radiochemical and Analytical Procedures for Analysis of Environmental Samples* (Johns, 1979) and are summarized in Table 29. These include gamma analysis, gross beta on air filters, strontium, tritium, plutonium, and noble gas analyses. These procedures outline standard methods used to perform given analytical procedures.

Table 29. Summary of Analytical Procedures

Type of Analysis	Analytical Equipment	Counting Period (min)	Analytical Procedures	Sample Size	Approximate Detection Limit[a]
HpGe Gamma[b]	HpGe detector-calibrated at 0.5 keV/channel (0.04 to 2 meV range) individual detector efficiencies ranging from 15 to 35%.	Air charcoal cartridges and individual air filters, 30; 100 for milk, water, suspended solids.	Radionuclide concentration quantified from gamma spectral data by online computer program.	1.0 and 3.5 L for routine liquids; 560 m^3 for low-volume air filters, and approximately 10,000 m^3 for high-volume air filters.	For Cs-137, routine liquids; 5×10^{-9} µCi/mL (1.8×10^{-1} Bq/L) low-volume airfilters; 5×10^{-14} µCi/mL (1.8×10^{-3} Bq/m^3), high-volume airfilters; 5×10^{-16} µCi/mL (1.8×10^{-5} Bq/m^3).
Gross alpha and beta on air filters	Low-level end windows, gas flow proportional counter with a 5-cm diameter window.	30	Samples are counted after decay of naturally occurring radionuclides.	560 m^3	alpha: 8.0×10^{-16} µCi/mL (3.0×10^{-6} Bq/m^3) beta: 2.5×10^{-15} µCi/mL (9.25×10^{-5} Bq/m^3)
$^{89,90}Sr$	Low background thin-window, gas-flow, proportional counter.	50	Chemical separation by ion exchange. Separated sample counted successively; activity calculated by simultaneous solution of equations.	1.0 L for milk or water. 0.1 to 1 kg for tissue.	^{89}Sr=5×10^{-9} µCi/mL (1.85×10^{-1} Bq/L) ^{90}Sr=2×10^{-9} µCi/mL (7.4×10^{-2} Bq/L)
^{3}H	Automatic liquid scintillation counter with output printer.	300	Sample prepared by distillation.	5 to 10 mL for water.	300 to 700 x 10^{-9} µCi/mL (11-26 Bq/L)[c]

Continued

Table 29. (Summary of Analytical Procedures, cont.)

Type of Analysis	Analytical Equipment	Counting Period (min)	Analytical Procedures	Sample Size	Approximate Detection Limit[a]
^{3}H Enrichment (LTHMP samples)	Automatic liquid scintillation counter with output printer.	300	Sample concentrated by electrolysis followed by distillation.	250 mL for water.	10 x10^{-9} µCi/mL (3.7 x 10^{-1} Bq/L)
$^{238,239+240}Pu$	Alpha spectrometer with silicon surface barrier detectors operated in vacuum chambers.	1,000	Water sample, acid-digested filter or tissue samples separated by ion exchange and electroplated on stainless steel planchet.	1.0 L for water; 0.1 to 1 kg for tissue; 5,000 to 10,000 m^3 for air.	^{238}Pu=0.08 x 10^{-9} µCi/mL (2.9 x 10^{-3} Bq/L), $^{239+240}$ Pu=0.04 x 10^{-9} µCi/mL (1.5 x 10^{-3} Bq/L) for water. For tissue samples, 0.04 pCi (1.5 x 10^{-3} Bq) per sample for all isotopes; 5 x 10^{-17} to 10 x 10^{-17} µCi/mL (1.9 x 10^{-6} to 3.7 x 10^{-6} Bq/m^3) for plutonium on air filters.
^{85}Kr, ^{133}Xe	Automatic liquid scintillation counter with output printer.	200	Separation by gas chromatography; dissolved in toluene "cocktail" for counting.	0.4 to 1.0m^3 for air.	^{85}Kr, ^{133}Xe = 4x 10^{-12} µCi/mL (1.5 x 10^{-1} Bq/m^3)

[a] The detection limit is defined as the smallest amount of radioactivity that can be reliably detected, i.e., probability of Type I and Type II error at 5 percent each (DOE81).
[b] Gamma spectrometry using a high purity intrinsic germanium (HpGe) detector.
[c] Depending on sample type.

13 Training Program

Proper and efficient performance of radiological health functions by qualified personnel is required to ensure protection from radiological hazards. The purpose of the training program is to provide well-trained, qualified personnel to safely and efficiently perform their assigned duties at a predetermined level of expertise.

The training program includes; tracking training requirements, maintaining training records, developing in-house training, and documenting personnel qualifications and accomplishments. Systematic determination of job requirements promotes consistent training activities and develops or improves knowledge, skills, and abilities that can be utilized in the work environment.

A Plutonium Valley Exercise was conducted at Area 11 of the NTS from November 2 through November 6, 1992 (see Figures 55, 56, and 57). This was a combined effort of the EPA, REECo, EG&G and the DOE Albuquerque Field Office Accident Response Group. The exercise included full face respirator dress out, monitoring for alpha contamination using Field Instruments for the Detection of Low Energy Radiation Sources, sample handling, health and safety, hot line, radio communications, data control, and decontamination procedures.

Evaluation and assessment of both laboratory and field data were performed. Some federal emergency response classroom training was provided, and there was an opportunity to practice a shift change. This provided a unique opportunity

Figure 55. The Control Room in the Plutonium Valley Exercise on the NTS.

for hands-on practice of monitoring/sampling operations in an aged fallout area contaminated with $^{239+240}Pu$. A weapons accident scenario was used.

A Federal Radiological Monitoring and Assessment Center (FRMAC) and a Joint Hazard Evaluation Center was operational during the exercise; each exercised technical interfaces. The FRMAC exercised its data center, which included the database for field monitoring and laboratory results, Geographical Information System, and Global Positioning System. FRMAC field teams from the EMSL-LV, EPA/Office of Radiation and Indoor Air, and state teams participated.

Each year the Nuclear Radiation Assessment Division hosts a two-day Environmental Radiation Monitoring-Monitor's Refresher course. This year the course was conducted October 22 through October 23, 1992.

In addition NRD hosted two Radiation Safety Training Courses. The first course was held on January 19. It covered risks from occupational exposure, health effects from ionizing radiation, regulations regarding reporting to the Radiation Safety Officer a suspected or confirmed pregnancy, and "Radiation Safety: Introduction, Lab Techniques and Emergency Procedures" (video). The second course was held on June 5; it covered basic radiological health, including biological effects, radiation detectors, exposure control, and regulations.

The final course was a Quality Assurance indoctrination course held on June 26, 1992. It covered the "Quality Assurance Program Plan for the Nuclear Radiation Assessment Division, Offsite Radiation Safety Program", Standard Operating Procedures, each person's role in quality assurance, rights, responsibilities and authorities, stop work mechanisms to effect change, surveillance, and audits.

Figure 56. Personnel suiting up for the exercise.

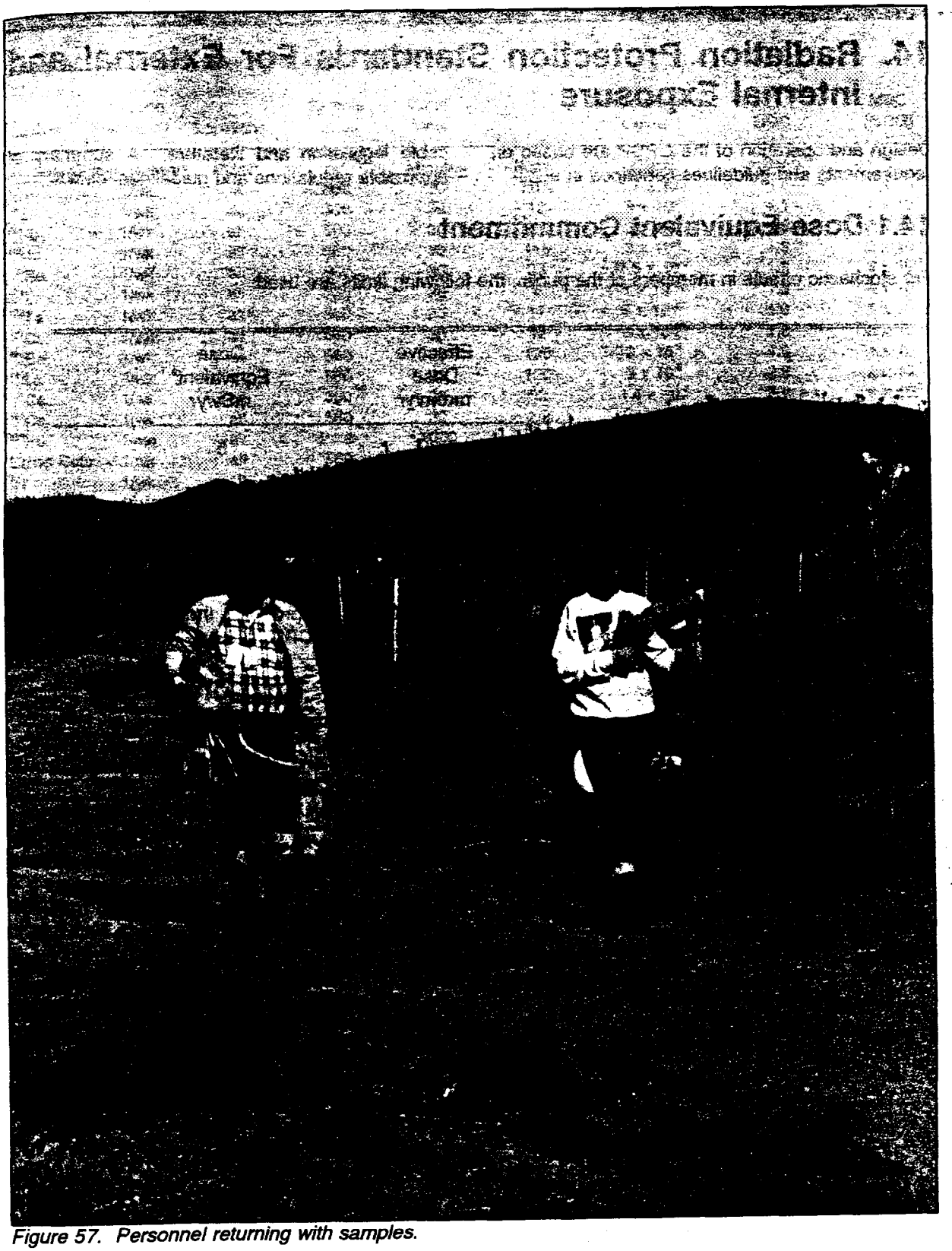

Figure 57. Personnel returning with samples.

14. Radiation Protection Standards For External and Internal Exposure

Design and operation of the ORSP are based on requirements and guidelines contained in applicable legislation and literature. A summary of applicable regulations and guidelines follows.

14.1 Dose Equivalent Commitment

For stochastic effects in members of the public, the following limits are used:

	Effective Dose mrem/yr	Dose Equivalent[a] mSv/yr
Occasional annual exposures[b]	500	5
Prolonged period of exposure	100	1

[a] Includes both effective dose equivalent from external radiation and committed effective dose equivalent from ingested and inhaled radionuclides.

[b] Occasional exposure implies exposure over a few years with the provision that over a lifetime the average exposure does not exceed 100 mrem (1 mSv) per year (ICRP, 1983).

14.2 Concentration Guides

ICRP-30 (ICRP, 1979) lists Derived Air Concentrations (DAC) and Annual Limits on Intake (ALI). The ALI is the secondary limit and can be used with assumed breathing rates and ingested volumes to calculate concentration guides. The concentration guides (CGs) in Table 30 were derived in this manner and yield the committed effective dose equivalent (50 year) of 100 mrem/yr for members of the public.

14.3 U.S. Environmental Protection Agency Drinking Water Guide

In 40 CFR 141 (CFR, 1988), the EPA set allowable concentrations for radionuclides in drinking water sources. Any combination of beta and gamma emitters may not lead to exposures exceeding 4 mrem/yr. For tritium, this is 2.0×10^{-5} µCi/mL (740 Bq/L) and for ^{90}Sr it is 8×10^{-9} µCi/mL (0.3 Bq/L).

Table 30. Routine Monitoring Guides

Nuclide	Sampling Frequency	Locations	Sample Size	Count Time	Concentrations Guide[a]		MDC	MDC (%CG)
Air Surveillance Network		(ASN)	m^3	Minutes	Bq/m^3	µCi/mL	mBq/m^3	
^{7}Be	1/wk	all	560	30	1700	4.7×10^{-8}	17	1×10^{-3}
^{95}Zr	1/wk	all	560	30	12	3×10^{-10}	4.1	4×10^{-2}
^{95}Nb	1/wk	all	560	30	110	3×10^{-9}	1.8	2×10^{-3}
^{99}Mo	1/wk	all	560	30	110	3×10^{-9}	1.5	2×10^{-3}
^{103}Ru	1/wk	all	560	30	58	1.5×10^{-9}	1.8	3×10^{-3}
^{131}I	1/wk	all	560	30	4	1×10^{-10}	1.8	4×10^{-2}
^{132}Te	1/wk	all	560	30	17	5×10^{-10}	1.8	1×10^{-2}
^{137}Cs	1/wk	all	560	30	12	3×10^{-10}	1.8	2×10^{-2}
^{140}Ba	1/wk	all	560	30	120	3×10^{-9}	4.8	4×10^{-3}
^{140}La	1/wk	all	560	30	120	3×10^{-9}	2.6	2×10^{-3}
^{141}Ce	1/wk	all	560	30	52	1.4×10^{-9}	3.0	6×10^{-3}
^{144}Ce	1/wk	all	560	30	1.2	3×10^{-11}	12	1.0
^{238}Pu	1/mo	all	2400	1000	5×10^{-4}	1×10^{-14}	1.5×10^{-3}	0.32
Gross Beta	1/wk	all	560	30	2×10^{-2}	5×10^{-13}	0.11	6×10^{-1}
^{3}H	1/wk	19	5	150	4.6×10^{3}	1.2×10^{-7}	148	3×10^{-3}
^{85}Kr	1/wk	16	0.4	200	2.2×10^{4}	6.2×10^{-7}	148	6×10^{-4}
^{133}Xe	1/wk	16	0.4	200	1.8×10^{4}	4.9×10^{-7}	370	2×10^{-3}
^{135}Xe	1/wk	16	0.4	200	2.3×10^{3}	6.2×10^{-8}	370	2×10^{2}
Water Surveillance Network (LTHMP)[b]			Liters	Minutes	Bq/L	µCi/mL	Bq/L	
^{3}H	1/mo	all	1	300	740	2×10^{-5}	12	1.6
^{3}H+ (enriched tritium)	1/mo	all	0.25	300	740	2×10^{-5}	0.37	5×10^{-2}
^{89}Sr	1st time	all	1	50	16	4.4×10^{-7}	0.18	1.1
^{90}Sr	1st time	all	1	50	0.8	2.2×10^{-8}	0.074	9.2
^{137}Cs	1/mo	all	1	100	3.3	8.8×10^{-8}	0.33	10
^{226}Ra	1st time	all	1	1000	1.4	3.9×10^{-8}	0.037	2.6
^{234}U	1st time	all	1	1000	8.2	2.2×10^{-7}	0.0035	0.04
^{235}U	1st time	all	1	1000	10	2.8×10^{-8}	0.0035	0.035
^{238}U	1st time	all	1	1000	10	2.8×10^{-8}	0.0035	0.035
^{238}Pu	1st time	all	1	1000	6.2	1.7×10^{-8}	0.003	0.05
$^{239+240}Pu$	1st time	all	1	1000	4.1	1.1×10^{-8}	0.002	0.05
Gamma	1/mo	all	3.5	30	--	--	0.18	<0.2
Milk Surveillance Network		(MSN)	Liters	Minutes	Bq/L	µCi/mL	Bq/L	
^{3}H	1/mo	all	3.5	300	12×10^{4}	3×10^{-3}	12	0.01
^{131}I	1/mo	all	3.5	100	41	1×10^{-6}	0.18	0.44
^{137}Cs	1/mo	all	3.5	100	160	4×10^{-6}	0.33	0.2
^{89}Sr	1/mo	all	3.5	50	820	2×10^{-5}	0.18	0.02
^{90}Sr	1/mo	all	3.5	50	40	1×10^{-6}	0.074	0.18

Dosimetry Networks		Locations	Number	Exposure Guide	MDC	MDC(%CG)
TLD (Personnel)	1/mo	72	1	100mR	3.01mrem	2
TLD (Station)	1/quarter	130	3 to 6	--	5.10mrem	--
PIC	weekly	29	Continuous	--	2µR/hr	--

[a] ALI and DAC values from ICRP-30 modified to 1 mSv annual effective dose equivalent for continuous exposure. Te and I data corrected to 2 g thyroid, greater milk intake, and smaller volume of air breathed annually (1 year-old infant).

[b] For tritium, Sr, and Cs the concentration guide is based on Drinking Water Regs, (4 mrem/yr) (CFR, 1988).

15 Summary and Conclusions

The primary functions of the ORSP are to conduct routine environmental monitoring for radioactive materials in areas potentially impacted by nuclear tests and, when necessary, to implement actions to protect the public from radiation exposure. Components of the ORSP include surveillance networks for air, noble gases, atmospheric tritium, and milk; biomonitoring of meat, game animals, and vegetables; exposure monitoring by thermoluminescent dosimetry, pressurized ion chambers, and whole body counting; and long-term hydrological monitoring of wells and surface waters. In 1992, data from all networks and monitoring activities indicated no radiation directly attributable to current activities conducted at the NTS. Therefore, protective actions were not required. The following sections summarize the ORSP activities for 1992.

15.1 Thermoluminescent Dosimetry Program

In 1992, external exposure was monitored by a network of thermoluminescent dosimeters (TLDs) at 131 fixed locations surrounding the NTS and by TLDs worn by 67 offsite residents. No apparent net exposures were related to NTS activities. As discussed in Section 3, regulatory or as low as reasonably achievable investigation limits were not exceeded for any individual or cumulative exposure. The range of exposures was similar to those observed in other areas of the U.S.

15.2 Pressurized Ion Chamber Network

The Pressurized Ion Chamber (PIC) network measures ambient gamma radiation exposure rates. The 27 PICs deployed around the NTS in 1992 showed no unexplained deviations from background levels. The data from Goldfield, Nevada, show the greatest range. From October 1990 until the sensor unit was exchanged in February 1992, the PIC unit at this location had been under-estimating the gamma exposure rate. The gamma exposure rates measured from February to December 1992 closely resemble those seen prior to October 1990. As discussed in Section 3.2 all PIC values are within the U.S. background range and are consistent with previous years' trends.

15.3 Air Surveillance Network

In 1992, the Air Surveillance Network (ASN) consisted of 30 continuously operating sampling locations surrounding the NTS. These stations were complemented by 77 standby stations which were operated at least one week each quarter. At least one standby sampler is located in each state west of the Mississippi River.

In the majority of cases, no gamma-emitting radionuclides were detected by gamma spectrometry (i.e., the results were gamma-spectrum negligible). Naturally occurring ^{7}Be was the only radionuclide occasionally detected. As in previous years, the majority of the gross beta results exceeded the MDC. The plutonium result greater than the analysis MDC was for the fourth quarter New Mexico sample, a single sample collected in Carlsbad. The plutonium results are consistent with data from previous years. Operation of the ASN and the data results were discussed in Section 4.1.

15.4 Tritium In Atmospheric Moisture

At the beginning of 1992, the tritium network consisted of 14 continuously operating and two standby stations. Of the 716 routine and 15 standby samples collected in 1992, 15 samples were not analyzed: five because of broken sieves, three were lost, and seven contained insufficient sample (moisture). Two samples exceeded the analysis MDC. Both samples were collected June 16 - 24, one from Las Vegas and the other from Overton, Nevada. The operation of the tritium samplers and the data results are discussed in Section 4.2.

15.5 Noble Gas Sampling Network

At the beginning of 1992, the Noble Gas Sampling Network consisted of 13 routinely operated and

three standby stations. Of the 699 samples collected in 1992, analyses were not performed on 74 samples (10.6 percent) due to insufficient volume collected or sampler malfunctions. Twelve quarterly samples were collected from standby samplers; none were collected from Milford and Salt Lake City, Utah. As expected, all ^{85}Kr results were above the MDC and were within the range anticipated from sampling background levels and all ^{133}Xe results were below the MDC.

15.6 Foodstuffs

Milk samples were collected from 24 Milk Surveillance Network (MSN) and 115 Standby Milk Surveillance Network (SMSN) stations in 1992. 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 or decreasing trends are evident. Although there was a slight increase in the number of samples whose results exceeded the MDC for ^{3}H, ^{89}Sr, and ^{90}Sr in 1992, as listed in Table 10, the average annual concentrations have, in general, decreased slightly. A summary of the MSN results are in Tables 11 for ^{3}H, 12 for ^{89}Sr, and 13 for ^{90}Sr. The results for the annual SMSN samples analyzed for ^{3}H, ^{89}Sr, and ^{90}Sr are given in Table B-6, Appendix B. Samples analyzed by gamma spectrometry for the SMSN are listed in Table B-7, Appendix B. The MSN and SMSN data are consistent with previous years and are not indicative of increasing or decreasing trends. No radioactivity directly related to current NTS activities was evident.

Sampling under the Animal Investigation Program in 1992 showed similar results to those reported for mule deer collected in 1991 for bone tissue analyses and ^{238}Pu analyses in all tissues (DOE, 1992). The average ^{90}Sr levels found in mule deer bone ash since 1955 are shown in Figure 27. Marked differences between years are observed in the medians of tritium activity in blood and $^{239+240}Pu$ in ashed soft tissues. These differences are due to the fact that two contaminated animals were collected in 1991. The analysis of bighorn sheep showed only one sample with a $^{239+240}Pu$ result greater than the MDC. The four cattle purchased in May 1992 from the G.L. Coffer Fleur de Lis Ranch of Beatty, Nevada, had detectable concentrations of ^{90}Sr in bone ash samples ranging from 0.27 ± 0.08 to 0.75 ± 0.13 pCi/g ash. One bone sample contained 0.001 ± 0.001 pCi/g ash of ^{238}Pu and 0.003 ± 0.001 pCi/g ash of $^{239+240}Pu$. One of the cows was pregnant. The fetal bone contained no ^{90}Sr above the detectable concentration of 0.70 pCi/g ash. The average ^{90}Sr levels found in cattle bone ash since 1955 are shown in Figure 28. All liver samples from the adult cattle contained $^{239+240}Pu$, ranging from 0.004 ± 0.001 pCi/g ash to 0.015 ± 0.004 pCi/g ash. No ^{3}H was detected above the MDC. These animals had ranged from Beatty into the NTS in the Beatty Wash area. As the objective of the Animal Investigation Program is to detect worst-case conditions, the results indicate that the component of possible radionuclide ingestion from meat is small (see Chapter 8, Dose Assessment).

In the fall of 1992, eight samples of locally grown fruits and vegetables were donated by offsite residents in Utah and Nevada. Fruits and vegetables sampled included apples, broccoli, cabbage, carrots, and summer squash. All samples were analyzed for gamma-emitting radionuclides and only naturally occurring ^{40}K was detected. All samples were analyzed for tritium; no results greater than the MDC of the analysis were obtained. Samples were then ashed and analyzed for ^{90}Sr, ^{238}Pu, and $^{239+240}Pu$. Results which were greater than the MDC of the analysis are listed in Table 15. Four vegetable samples from Nevada (cabbage, broccoli, and two samples of carrots with tops) contained ^{90}Sr greater than the MDC of the analysis. The source of the ^{90}Sr may have been soil particles adhered to the vegetable. No ^{238}Pu was found in any of the samples. Concentrations of $^{239+240}Pu$ greater than the analysis MDC were found in all carrots with tops samples. None of the smooth-skinned surface crops contained these radionuclides.

15.7 Internal Exposure Monitoring

Internal exposure is assessed by whole body counting using a single intrinsic coaxial germanium detector, lung counting using six intrinsic germanium semiplanar detectors, and bioassay using radiochemical procedures. During 1992, a total of 2,800 gamma spectra was obtained from whole-body counting of 281 persons (including those individuals who were counted twice). One hundred and seven of the counts were on participants of the Offsite Internal Dosimetry Program. All spectra were representative of normal background and showed only naturally occurring ^{40}K. No transu-

ranic radionuclides were detected in any lung-counting data. No internal exposure above applicable regulatory limits was detected in either occupationally exposed individuals or members of the general public who participated in the Internal Dosimetry Program at EMSL-LV.

Bioassay results for single urine samples collected at random periods of time from participants in the Offsite Dosimetry Network showed only five samples, from random locations and times, with tritium concentrations greater than the MDC. The greatest tritium concentration detected in a sample was $3.43 \times 10^{-7} \pm 2.99 \times 10^{-7}$ μCi/mL, which is only 0.4 percent of the annual limit of intake for the general public. Table 16 provides a summary of bioassay results. Two participants from McGill, Nevada, did not participate in the bioassay portion of the program this year. As reported in previous years, medical examinations of the offsite families revealed a generally healthy population. The blood examinations and thyroid profiles showed no symptoms which could be attributed to past or present NTS testing operations.

15.8 Long-Term Hydrological Monitoring Program

The Long-Term Hydrological Monitoring Program is discussed in detail in Section 7. None of the domestic water supplies monitored in the LTHMP in 1992 yielded tritium activities of any health concern. The greatest tritium activity measured in any water body which has potential to be a drinking water supply was less than one percent of the NPDWRs. In general, surface water and spring samples yielded tritium activities greater than those observed in shallow domestic wells in the same area. This is probably due to scavenging of atmospheric tritium by precipitation. Where suitable monitoring wells exist, there were no indications that migration from any test cavity is affecting any domestic water supply.

In most cases, monitoring wells also yielded no radionuclide activity above the MDC. Exceptions include wells into test cavities, wells monitoring known areas of contamination, and one well at GASBUGGY. Known areas of contamination exist at Project GNOME where the USGS conducted a tracer study experiment, some areas onsite at Project DRIBBLE. The 1992 results for these monitoring wells are consistent with decreasing trends observed over time. Monitoring well EPNG 10-36 at Project GASBUGGY was a notable exception to wells evidencing decreasing trends. This well is a former gas well located 435 feet northwest of SGZ. The sampling depth of this well is approximately 3600 ft in the Ojo Alamo Sandstone, an aquifer containing nonpotable water. The tritium activity in 1992 was 10.3 ± 2.6 pCi/L and in 1991 was 484 ± 4 pCi/L, approximately 10 times the historic background activity. An increase in tritium activity was first observed in 1984, seventeen years after the test was conducted. In every year since then, with the exception of 1987 and 1992, tritium activities have been between 100 and 560 pCi/L, with wide variability sometimes noted between consecutive years. The proximity of the well to the test cavity suggests the possibility that the increased activity may be indicative of migration from the test cavity.

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Glossary of Terms

Definitions of terms given here are modified from the U.S. Nuclear Regulatory Commission Glossary of terms (NRC81).

background radiation — The radiation in man's natural environment, including cosmic rays and radiation from the naturally radioactive elements, both outside and inside the bodies of humans and animals. It is also called natural radiation. The usually quoted average individual exposure from background radiation is 125 millirem per year in midlatitudes at sea level.

becquerel (Bq) — A unit, in the International System of Units, of measurement of radioactivity equal to one nuclear transformation per second.

beta particle (*B*) — A charged particle emitted from a nucleus during radioactive decay, with a mass equal to 1/837 that of a proton. A positively charged beta particle is called a positron. Large amounts of beta radiation may cause skin burns, and beta emitters are harmful if they enter the body. Beta particles are easily stopped by a thin sheet of metal or plastic.

blind samples — A spiked sample, the composition of which is unknown to the technician, which has been introduced into the laboratory as a separate sample. These samples are used for the verification of analytical accuracy. Approximately one percent of the sample load shall be blind samples.

Committed Effective Dose Equivalent — The summation of Dose Equivalents to specific organs or tissues that would be received from an intake of radioactive material by an individual during a 50-year period following the intake, multiplied by the appropriate weighting factor.

cosmic radiation — Penetrating ionizing radiation, both particulate and electromagnetic, originating in space. Secondary cosmic rays, formed by interactions in the earth's atmosphere, account for about 45 to 50 millirem of the 125 millirem background radiation that an average individual receives in a year.

curie (Ci) — The basic unit used to describe the rate of radioactive disintegration. The curie is equal to 37 billion disintegrations per second, which is approximately the rate of decay of 1 gram of radium; named for Marie and Pierre Curie, who discovered radium in 1898.

dosimeter — A portable instrument for measuring and registering the total accumulated dose of ionizing radiation.

duplicate — A second aliquot of a sample which is approximately equal in mass or volume to the first aliquot and is analyzed for the sample parameters. The laboratory performs duplicate analyses to evaluate the precision of an analysis.

half-life — The time in which half the atoms of a particular radioactive substance disintegrate to another nuclear form. Measured half-lives vary from millionths of a second to billions of years. Also called physical half-life.

ionization — The process of creating ions (charged particles) by adding one or more electrons to, or removing one or more electrons from, atoms or molecules. High temperatures, electrical discharges, nuclear radiation, and X-rays can cause ionization.

ionization chamber — An instrument that detects and measures ionizing radiation by measuring the electrical current that flows when radiation ionizes gas in a chamber.

isotope — One of two or more atoms with the same number of protons, but different numbers of neutrons in their nuclei. Thus, ^{12}C, ^{13}C, and ^{14}C are isotopes of the element carbon, the numbers denoting the approximate atomic weights. Isotopes have very nearly the same chemical properties, but often different physical properties (for example, ^{13}C and ^{14}C are radioactive).

matrix spike — An aliquot of a sample which is spiked with a known concentration of the analyte of interest. The purpose of analyzing this type of sample is to evaluate to the effect of the sample matrix upon the analytical methodology.

method blank — A method blank is a volume of demineralized water for liquid samples, or an appropriate solid matrix for soil/sediment samples, carried through the entire analytical procedure. The volume or weight of the blank must be approximately equal to the volume or weight of the sample processed. Analysis of the blank verifies that method interferences caused by contaminants in solvents, reagents, glassware, and other sample processing hardware are known and minimized.

minimum detectable (MDC) — The smallest amount of radioactivity that can be reliably detected with a probability of Type I and Type II error at five percent each (DOE81).

millirem (mrem) — A one-thousandth part of a rem. (See rem.)

milliroentgen (mR) — A one-thousandth part of a roentgen. (See roentgen.)

noble gas — A gaseous element that does not readily enter into chemical combination with other elements. An inert gas.

personnel monitoring — The determination of the degree of radioactive contamination on individuals using survey meters, or the determination of radiation dosage received by means of internal or external dosimetry methods.

picocurie (pCi) — One trillionth part of a curie.

quality factor — The factor by which the absorbed dose is to be multiplied to obtain a quantity that expresses, on a common scale for all ionizing radiations, the biological damage to exposed persons. It is used because some types of radiation, such as alpha particles, are more biologically damaging than other types.

rad — Acronym for radiation absorbed dose. The basic unit of absorbed dose of radiation. A dose of one rad means the absorption of 100 ergs (a small but measurable amount of energy) per gram of absorbing material.

radioisotope — An unstable isotope of an element that decays or disintegrates spontaneously, emitting radiation.

radionuclide — A radioisotope.

rem — Acronym for roentgen equivalent man. The unit of dose of any ionizing radiation that produces the same biological effect as a unit of absorbed dose of ordinary X-rays. (See quality factor.)

roentgen (R) — A unit of exposure to ionizing radiation. It is that amount of gamma or X-rays required to produce ions carrying one electrostatic unit of electrical charge in one cubic centimeter of dry air under standard conditions. Named after Wilhelm Roentgen, German scientist who discovered X-rays in 1895.

scintillation (dectector or counter) — The combination of phosphor, photomultiplier tube, and associated counter electronic circuits for counting light emissions produced in the phosphor by ionizing radiation.

Sievert (Sv)	A unit, in the International System of Units (SI), of dose equivalent which is equal to one joule per kilogram (1 Sv equals 100 rem).
terrestrial	The portion of natural radiation (background) that is emitted by naturally occurring radiation radioactive materials in the earth.
tritium	A radioactive isotope of hydrogen that decays by beta emission. It's half-life is about 12.5 years.
verification/ reference standard	A prepared sample of known concentration of a purchased standard reference material. These samples are analyzed in triplicate and the results are used to verify accuracy and precision of the procedure.
X-rays	Penetrating electromagnetic radiation (photon) having a wavelength that is much shorter than that of visible light. These rays are usually produced by excitation of the electron field around certain nuclei. In nuclear reactions, it is customary to refer to photons originating in the nucleus as gamma rays, and to those originating in the electron field of the atom as X-rays. These rays are sometimes called roentgen rays after their discoverer, Wilhelm K. Roentgen.

Appendix A

Thermoluminescent Dosimetry Tables and Figures

Table A-1 Personnel Thermoluminescent Dosimetry Results, 1992

Station Name		# of Days	Daily Deep Dose Exposure (mrem) Min	Max	Mean	Total Annual[a] Exposure (mrem)	Percent Completeness
002	Caliente, NV	341	0.49	0.82	0.59	216	93
003	Hot Creek Ranch, NV	237	0.24	1.78	0.85	293	65
006	Indian Springs, NV	336	0.28	0.54	0.39	145	92
007	Goldfield, NV	376	0.29	0.71	0.49	184	103
009	Blue Eagle Ranch, NV	305	0.21	2.23	0.63	219	84
010	Complex I, NV	341	0.36	0.78	0.57	204	93
011	Complex I, NV	335	0.40	0.68	0.54	197	92
014	Coyote Summit, NV	343	0.33	0.64	0.46	167	94
015	Coyote Summit, NV	342	0.32	0.60	0.46	167	94
018	Nyala, NV	320	0.25	1.14	0.73	271	88
019	Goldfield, NV	307	0.33	0.97	0.55	215	84
021	Beatty, NV	275	0.38	0.78	0.54	201	75
022	Alamo, NV	338	0.33	0.53	0.41	150	93
025	American Borate, NV	262	0.25	0.40	0.33	125	72
029	Stone Cabin Ranch, NV	349	0.33	1.46	0.74	264	96
037	Indian Springs, NV	302	0.23	0.57	0.39	145	83
038	Beatty, NV	360	0.13	0.69	0.51	188	99
040	Goldfield, NV	337	0.32	0.78	0.53	194	92
042	Tonopah, NV	336	0.35	0.77	0.53	203	92
044	Cedar City, UT	309	0.31	0.71	0.50	180	85
045	ST. George, UT	341	0.18	0.56	0.37	136	93
052	Salt Lake City, UT	339	0.31	0.81	0.48	166	93
056	American Borate, NV	280	0.22	1.39	0.40	154	77
060	Shoshone, CA	297	0.24	0.60	0.45	150	81
232	Hiko, NV	336	0.29	0.61	0.45	165	92
248	Penoyer Farms, NV	239	0.33	0.68	0.50	178	65
264	Rachel, NV	344	0.34	0.62	0.48	174	94
293	Pioche, NV	342	0.19	0.75	0.48	177	94
300	Koyne Ranch, NV	336	0.32	0.52	0.42	157	92
302	Gabbs, NV	337	0.27	0.69	0.49	184	92
304	Death Valley Jct, CA	311	0.13	0.80	0.54	198	85
307	Mina, NV	354	0.35	1.19	0.59	231	97
329	Austin, NV	316	0.42	0.82	0.63	239	87
334	Rachel, NV	335	0.32	0.64	0.50	183	92
336	Caliente, NV	331	0.30	0.75	0.46	168	91
339	Tonopah, NV	337	0.38	0.76	0.60	218	92
341	Silver Peak, NV	310	0.38	0.71	0.56	206	85
344	Delta, UT	340	0.29	0.82	0.47	168	93
345	Delta, UT	340	0.32	0.75	0.46	166	93
346	Milford, UT	339	0.30	0.76	0.48	192	93
347	Milford, UT	339	0.31	0.84	0.47	186	93
348	Overton, NV	303	0.26	0.68	0.43	157	83
358	Beatty, NV	245	0.33	0.71	0.48	184	67
359	Death Valley, CA	285	0.35	0.75	0.56	198	78

Table A-1 (Personnel Thermoluminescent Dosimetry Results - 1992, con't)

Station Name		# of Days	Daily Deep Dose Exposure (mrem) Min	Max	Mean	Total Annual[a] Exposure (mrem)	Percent Completeness
370	Twin Springs Ranch, NV	342	0.33	0.99	0.61	227	94
372	Pahrump, NV	327	0.12	0.63	0.40	148	90
377	Las Vegas USDI, NV	196	0.23	1.06	0.44	166	54
379	Manhattan, NV	337	0.40	0.83	0.61	231	92
380	Amargosa Valley, NV	325	0.40	1.60	1.03	370	89
404	Shoshone, CA	327	0.32	0.68	0.46	172	90
405	Indian Springs, NV	296	0.31	0.58	0.43	166	81
411	Pahrump, NV	354	0.18	0.57	0.37	130	97
426	Amargosa Center, NV	352	0.25	0.64	0.50	177	96
427	Alamo, NV	279	0.25	0.71	0.44	160	76
429	Beatty, NV	365	0.15	0.63	0.46	173	100
443	Rachel, NV	345	0.34	0.70	0.48	175	95
444	Ely, NV	343	0.32	0.62	0.46	167	94
445	Terrell's Ranch, NV	364	0.16	0.71	0.52	194	100
448	Ione, NV	309	0.37	0.84	0.54	206	85
449	Round Mountain, NV	314	0.45	0.86	0.64	230	86
450	Pahrump, NV	333	0.19	0.59	0.42	154	91
453	Las Vegas USDI, NV	258	0.24	1.15	0.39	145	71
454	Cedar City, UT	305	0.33	0.70	0.45	163	84
455	Ely, NV	336	0.41	0.82	0.53	191	92
467	Las Vegas USDI, NV	251	0.19	1.29	0.43	165	69
468	Las Vegas USDI, NV	251	0.25	1.39	0.47	180	69
470	Las Vegas USDI, NV	175	0.17	0.40	0.31	121	48

Total data completeness: 86.8%

(a) Total annual exposure is calculated by multiplying the mean daily exposure rate by 365.25.

Table A-2 Environmental Thermoluminescent Dosimetry Results - 1992

Station Name	# of Days	Daily Exposure (mR) Min	Max	Mean	Total Exposure[a] (mR)	Percent Completeness
Alamo, NV	366	0.28	0.31	0.30	110	100
Amargosa Center, NV	268	0.34	0.40	0.37	135	73
Amargosa Valley, NV	269	0.31	0.40	0.35	128	74
American Borate, NV	268	0.31	0.40	0.36	131	73
Atlanta Mine, NV	275	0.20	0.29	0.24	88	75
Austin, NV	275	0.38	0.46	0.40	146	75
Baker, CA	366	0.25	0.30	0.28	102	100
Barstow, CA	366	0.30	0.36	0.33	121	100

Table A-2 (Environmental Thermoluminescent Dosimetry Results - 1992, con't)

Station Name	# of Days	Daily Exposure (mR) Min	Max	Mean	Total Exposure[a] (mR)	Percent Completeness
Battle Mountain, NV	274	0.19	0.36	0.28	102	75
Beatty, NV	267	0.34	0.40	0.37	135	73
Bishop, NV	364	0.31	0.36	0.34	124	100
Blue Eagle Ranch, NV	359	0.21	0.26	0.24	88	98
Blue Jay, NV	360	0.37	0.46	0.41	150	99
Boulder, UT	296	0.21	0.30	0.25	91	81
Bryce Canyon, UT	296	0.20	0.29	0.24	88	81
Cactus Springs, NV	366	0.19	0.23	0.21	77	100
Caliente, NV	366	0.29	0.35	0.32	117	100
Carp, NV	366	0.28	0.34	0.30	110	100
Cedar City, UT	303	0.17	0.26	0.22	80	83
Cherry Creek, NV	272	0.25	0.35	0.30	110	75
Clark Station, NV	358	0.32	0.39	0.37	135	98
Coaldale, NV	276	0.31	0.38	0.34	124	76
Colorado City, AZ	232	0.20	0.32	0.26	95	64
Complex I, NV	365	0.09	0.38	0.30	110	100
Corn Creek, NV	366	0.15	0.18	0.17	62	100
Cortez Hwy 278, NV	206	0.26	0.47	0.33	121	56
Coyote Summit, NV	364	0.36	0.48	0.42	153	100
Crescent Valley, NV	303	0.21	0.37	0.28	102	83
Currant , NV	358	0.33	0.36	0.35	128	98
Currie, NV	179	0.28	0.47	0.38	139	49
Death Valley Jct, CA	181	0.32	0.33	0.33	121	50
Delta, UT	357	0.23	0.28	0.25	91	98
Desert Co. Fty, NV	366	0.17	0.20	0.19	69	100
Diablo Well, NV	360	0.37	0.43	0.41	150	99
Duchesne, UT	359	0.20	0.26	0.23	84	98
Duckwater, NV	359	0.31	0.37	0.33	121	98
Elgin, NV	365	0.40	0.50	0.43	157	100
Elko, NV	303	0.19	0.37	0.26	95	83
Ely, NV	275	0.19	0.29	0.24	88	75
Enterprise, UT	296	0.31	0.47	0.38	139	81
Eureka, CA	359	0.07	0.41	0.29	106	98
Fallon, NV	302	0.21	0.48	0.30	110	83
Ferron, UT	359	0.20	0.26	0.23	84	98
Flying Diamond, NV	366	0.06	0.29	0.23	84	100
Furnace Creek, CA	268	0.23	0.30	0.26	95	73
Gabbs, NV	274	0.25	0.30	0.27	99	75
Garrison, UT	272	0.19	0.24	0.22	80	75
Geyser Ranch, NV	275	0.18	0.28	0.23	84	75
Goldfield, NV	276	0.30	0.35	0.32	117	76
Grantsville, UT	358	0.22	0.27	0.24	88	98
Green River, UT	366	0.23	0.38	0.28	102	100
Groom Lake, NV	236	0.29	0.37	0.32	117	65

Table A-2 (Environmental Thermoluminescent Dosimetry Results - 1992, con't)

Station Name	# of Days	Daily Exposure (mR) Min	Max	Mean	Total Exposure[a] (mR)	Percent Completeness
Gunnison, UT	302	0.16	0.26	0.20	73	83
Hancock Summit, NV	366	0.46	0.57	0.50	183	100
Hiko, NV	366	0.25	0.31	0.27	99	100
Hot Creek Ranch, NV	353	0.28	0.44	0.36	131	97
Ibapah, UT	272	0.25	0.36	0.30	110	75
Independence, CA	211	0.10	0.33	0.24	88	58
Indian Springs, NV	364	0.19	0.22	0.21	77	100
Ione, NV	231	0.31	0.43	0.36	131	63
Jacob's Lake, AZ	364	0.27	0.42	0.33	121	100
Kanab, UT	366	0.19	0.31	0.24	88	100
Kirkeby Ranch, NV	280	0.17	0.26	0.22	80	77
Koyen's Ranch, NV	366	0.31	0.38	0.33	121	100
Las Vegas, Apt., NV	267	0.13	0.25	0.18	66	73
Las Vegas, UNLV, NV	267	0.11	0.25	0.17	62	73
Las Vegas, USDI, NV	267	0.15	0.33	0.22	80	73
Lida, NV	275	0.30	0.38	0.33	121	75
Loa, NV	296	0.32	0.42	0.35	128	81
Lone Pine, CA	315	0.30	0.35	0.32	117	86
Lovelock, NV	302	0.20	0.37	0.27	99	83
Lund, NV	274	0.20	0.32	0.26	95	75
Lund, UT	296	0.27	0.43	0.33	121	81
Mammoth Geother, CA	365	0.33	0.41	0.36	131	100
Mammoth Lakes, CA	134	0.30	0.34	0.32	117	37
Manhattan, NV	231	0.38	0.45	0.41	150	63
Medlin's Ranch, NV	366	0.36	0.44	0.39	142	100
Mesquite, NV	365	0.19	0.36	0.25	91	100
Milford, UT	210	0.34	0.41	0.36	131	58
Mina, NV	275	0.31	0.36	0.33	121	75
Moapa, NV	365	0.07	0.29	0.23	84	100
Monticello, UT	365	0.26	0.44	0.33	121	100
Mtn Meadows Ranch, NV	272	0.22	0.26	0.24	88	75
Nash Ranch, NV	366	0.06	0.29	0.23	84	100
Nephi, UT	302	0.17	0.25	0.20	73	83
Nyala, NV	359	0.27	0.31	0.29	106	98
Olancha, CA	365	0.28	0.31	0.30	110	100
Overton, NV	366	0.19	0.43	0.26	95	100
Page, AZ	366	0.07	0.27	0.21	77	100
Parowan, UT	294	0.19	0.28	0.24	88	81
Penoyer Farms, NV	365	0.38	0.47	0.41	150	100
Pine Creek Ranch, NV	265	0.40	0.42	0.41	150	73
Pioche, NV	366	0.26	0.30	0.28	102	100
Price, UT	359	0.22	0.28	0.25	91	98
Provo, UT	358	0.21	0.26	0.23	84	98
Pahrump, NV	366	0.17	0.22	0.19	69	100

Table A-2 (Environmental Thermoluminescent Dosimetry Results - 1992, con't)

Station Name	# of Days	Daily Exposure (mR) Min	Max	Mean	Total Exposure[a] (mR)	Percent Completeness
Queen City Summit, NV	360	0.40	0.46	0.43	157	99
Rachel, NV	366	0.35	0.45	0.39	142	100
Reed Ranch, NV	360	0.35	0.43	0.39	142	99
Reno, NV	290	0.30	0.32	0.31	113	79
Ridgecrest, CA	366	0.29	0.36	0.32	117	100
Round Mountain, NV	276	0.36	0.40	0.38	139	76
Ruby Valley, NV	302	0.23	0.49	0.35	128	83
Salt Lake City, UT	358	0.23	0.28	0.25	91	98
Shoshone, CA	366	0.24	0.28	0.26	95	100
Shurz, NV	301	0.26	0.40	0.33	121	82
Silver Peak, NV	274	0.25	0.30	0.28	102	75
Springdale, NV	267	0.35	0.47	0.41	150	73
St. George, UT	356	0.15	0.22	0.18	66	98
Steward Ranch, NV	275	0.27	0.42	0.34	124	75
Stone Cabin Ranch, NV	356	0.36	0.43	0.39	142	98
Sunnyside, NV	273	0.14	0.22	0.18	66	75
Tempiute, NV	366	0.35	0.45	0.38	139	100
Terrel's Ranch, NV	267	0.36	0.41	0.39	142	73
Tonopah Test Range, NV	358	0.38	0.47	0.41	150	98
Tonopah, NV	275	0.36	0.42	0.38	139	75
Trout Creek, UT	271	0.21	0.28	0.24	88	74
Twin Springs Ranch, NV	360	0.33	0.41	0.37	135	99
U.S. Ecology, NV	267	0.37	0.47	0.41	150	73
US Ecology, NV	268	0.36	0.43	0.40	146	73
Uhaldes Ranch, NV	366	0.33	0.43	0.38	139	100
Valley Crest, CA	268	0.19	0.23	0.21	77	73
Vernal, UT	359	0.21	0.26	0.24	88	98
Vernon, UT	358	0.22	0.27	0.24	88	98
Warm Springs #2, NV	176	0.93	1.08	1.00	365	48
Wells, NV	301	0.21	0.41	0.29	106	82
Wendover, UT	238	0.18	0.28	0.22	80	65
Willow Springs Lodge, UT	358	0.18	0.28	0.22	80	98
Winnemucca, NV	302	0.22	0.40	0.30	110	83
Young's Ranch, NV	274	0.31	0.36	0.32	117	75

Minimum total exposure is 56.5 at Las Vegas, UNLV, Nv.
Maximum total exposure is 365.6 at Warm Springs #2, Nv
Mean of total exposure is 113.4

TOTAL DATA COMPLETENESS: 85.7%

(a) Total exposure is calculated by multiplying the mean daily exposure rate 365.25.

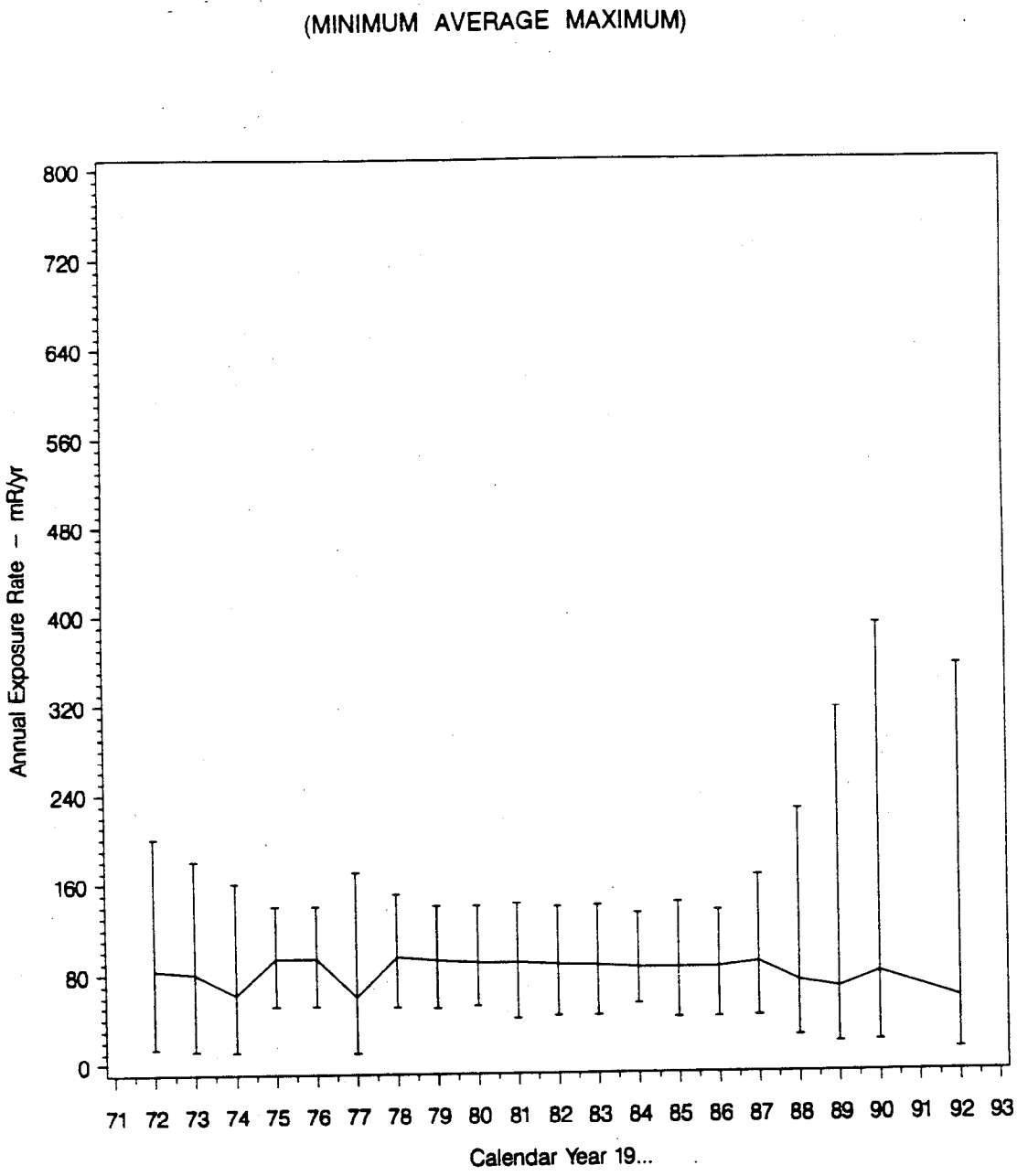

Figure A-1. Summary of Annual TLD Data

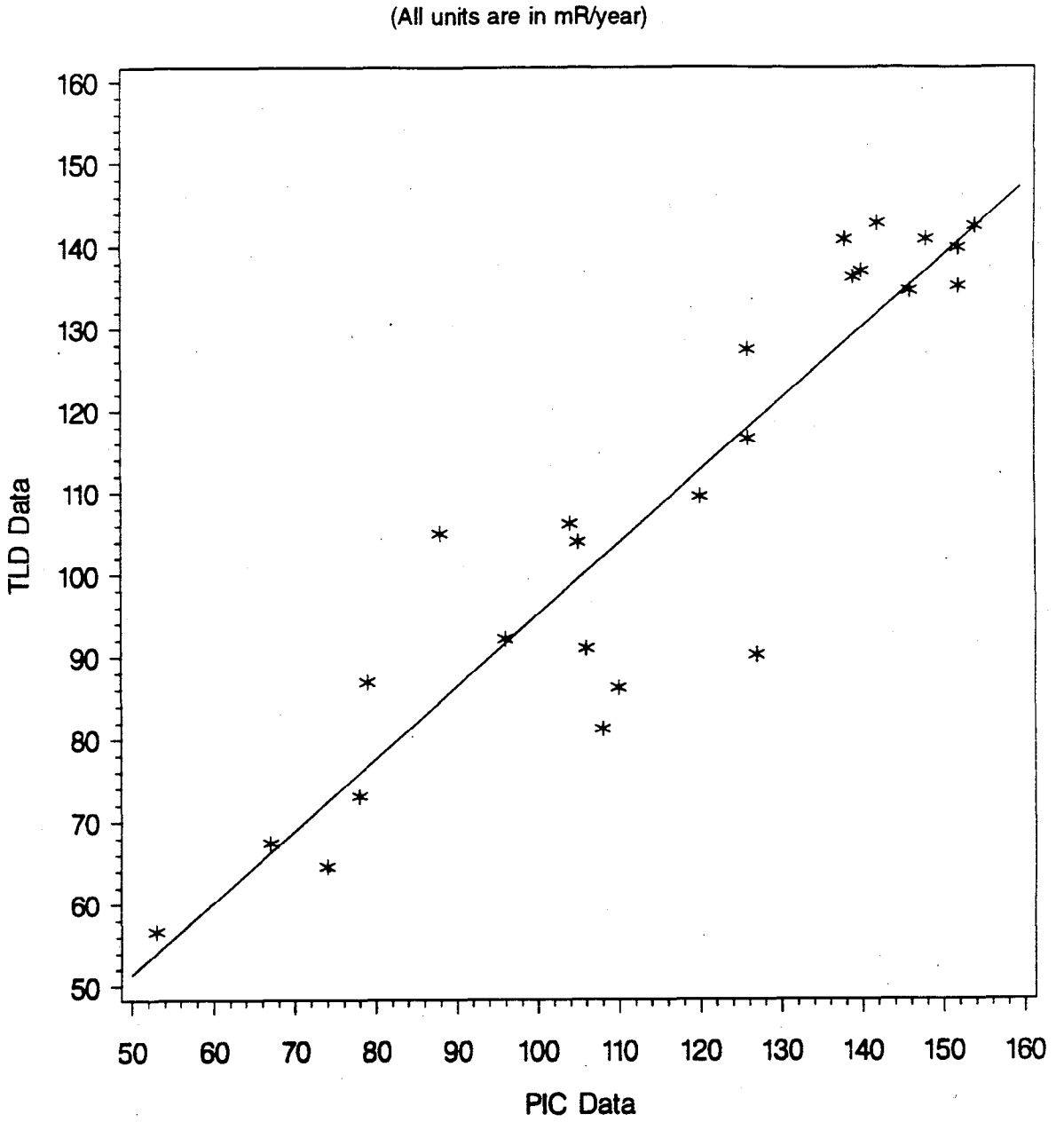

Figure A-2. TLD vs. PIC Data - 1992

Appendix B

Atmospheric Monitoring Tables And Figures

Table B-1. Gross Beta Results for the Offsite Standby Air Surveillance Network - 1992

Sampling Location	Number	Gross Beta Concentration (10^{-14} µCi/mL) Maximum	Minimum	Arithmetic Mean	Standard Deviation
Little Rock, AR	4	2.75*	1.40*	2.04	0.63
Globe, AZ	4	2.77*	1.06*	1.75	0.76
Kingman, AZ	3	2.44*	0.59*	1.45	0.93
Tuscon, AZ	4	2.26*	0.84*	1.79	0.65
Winslow, AZ	4	5.51*	1.45*	3.14	1.79
Yuma, AZ	3	2.49*	1.37*	1.97	0.56
Alturas, CA	4	1.76*	0.06*	0.91	0.81
Baker, CA	3	2.34*	1.74*	1.99	0.31
Bishop, CA	5	3.00*	1.21*	1.89	0.69
Chico, CA	3	3.12*	1.44*	2.07	0.91
Indio, CA	4	4.08*	1.81*	2.73	0.96
Lone Pine, CA	3	2.59*	1.24*	1.75	0.73
Needles, CA	2	2.37*	1.18*	1.77	0.84
Ridgecrest, CA	2	0.15	0.08	0.11	0.05
Santa Rosa, CA	3	2.52*	0.20	1.40	1.16
Cortez, CO	3	2.95*	2.50*	2.72	0.22
Denver, CO	3	2.12*	1.67*	1.93	0.23
Grand Junction, CO	3	2.52*	1.63*	2.00	0.46
Mountain Home, ID	3	3.35*	0.51*	1.66	1.50
Nampa, ID	4	2.35*	0.76*	1.66	0.75
Pocatello, ID	2	1.58*	1.08*	1.33	0.35
Fort Dodge, IA	3	2.22*	1.30*	1.71	0.47
Iowa City, IA	2	2.37*	1.96*	2.16	0.29
Dodge City, KS	4	2.21*	1.67*	1.98	0.26
Monroe, LA	3	2.59*	1.29*	1.87	0.66
Minneapolis, MN	4	2.38*	0.91*	1.58	0.73
Clayton, MO	4	3.11*	1.52*	2.06	0.74
Joplin, MO	4	3.17*	0.90*	2.01	1.04
St. Joseph, MO	3	2.11*	-0.06	0.71	1.21
Great Falls, MT	4	1.59*	0.98*	1.22	0.26
Kalispell, MT	2	1.90*	1.40*	1.65	0.35
Miles City, MT	4	2.30*	1.26*	1.77	0.52
North Platte, NE	3	2.69*	1.51*	2.09	0.59
Adaven-Uhalde Ranch, NV	8	2.83*	0.52*	1.64	0.80
Battle Mountain, NV	5	2.19*	1.53*	1.89	0.24
Blue Jay, NV	4	2.49*	1.05*	1.46	0.69
Clark Station, NV	4	2.70*	1.18*	1.73	0.69

Mean MDC: 2.50×10^{-15} µCi/mL Standard Deviation of Mean MDC: 3.07×10^{-16} µCi/mL

MDC = minimum detectable concentration.
* = result is greater than the MDC of analysis.

Table B-1. (Gross Beta Results for the Offsite Standby Air Surveillance Network - 1992, cont.)

Sampling Location	Number	Gross Beta Concentration (10^{-14} µCi/mL) Maximum	Minimum	Arithmetic Mean	Standard Deviation
Currant-Angle					
Worm Ranch, NV	4	2.10*	1.39*	1.60	0.34
Currie Maint. Station, NV	4	1.78*	0.76*	1.16	0.44
Duckwater, NV	4	1.42*	1.07*	1.26	0.15
Elko, NV	3	1.28*	0.04	0.67	0.62
Eureka, NV	4	1.56*	0.83*	1.18	0.31
Fallon, NV	3	3.56*	1.65*	2.73	0.98
Geyser Ranch, NV	4	3.23*	1.28*	2.19	0.81
Lida, NV	2	1.77*	1.37*	1.57	0.28
Lovelock, NV	4	2.11*	1.28*	1.64	0.39
Lund, NV	4	1.43*	0.33*	1.03	0.50
Mesquite, NV	2	4.27*	3.40*	3.83	0.62
Reno, NV	4	1.73*	1.04*	1.34	0.30
Round Mountain, NV	3	1.64*	1.06*	1.30	0.30
Wells, NV	5	1.78*	0.86*	1.34	0.38
Winnemucca, NV	4	1.55*	0.89*	1.21	0.37
Albuquerque, NM	4	2.52*	1.08*	1.69	0.67
Carlsbad, NM	4	2.59*	0.93*	1.52	0.79
Shiprock, NM	3	1.84*	1.35*	1.59	0.24
Bismarck, ND	4	2.18*	0.94*	1.57	0.56
Fargo, ND	4	3.35*	1.32*	2.00	0.92
Williston, ND	4	5.93*	1.19*	2.53	2.27
Muskogee, OK	-	Quarterly sampling not performed			
Burns, OR	1	1.07*	1.07*	1.07	--
Medford, OR	4	2.36*	0.39*	1.26	1.00
Rapid City, SD	-	Quarterly sampling not performed			
Amarillo, TX	4	3.18*	1.59*	2.08	0.74
Austin, TX	3	1.54*	1.06*	1.28	0.24
Midland, TX	2	1.59*	0.66*	1.12	0.66
Tyler, TX	2	1.60*	1.25*	1.43	0.25
Bryce Canyon, UT	4	1.96*	1.59*	1.79	0.17
Enterprise, UT	6	2.25*	1.61*	1.94	0.25
Garrison, UT	2	1.41*	1.02*	1.21	0.28
Logan, UT	4	3.13*	1.93*	2.33	0.55
Parowan, UT	4	1.59*	0.99*	1.39	0.27
Vernal, UT	4	2.39*	0.57*	1.52	0.86
Wendover, UT	4	1.94*	1.23*	1.58	0.37
Seattle, WA	4	1.37*	0.57*	0.91	0.34
Spokane, WA	4	3.01*	1.29*	2.25	0.73
Rock Springs, WY	4	3.40*	1.56*	2.09	0.88
Worland, WY	4	1.97*	1.40*	1.63	0.27

Mean MDC: 2.50 x 10^{-15} µCi/mL Standard Deviation of Mean MDC: 3.07 x 10^{-16} µCi/mL

MDC = minimum detectable concentration.
* = result is greater than the MDC of analysis.

Table B-2. Gross Alpha Results for the Offsite Standby Air Surveillance Network - 1992

Sampling Location	Number	Gross Alpha Concentration (10^{-15} µCi/mL) Maximum	Minimum	Arithmetic Mean	Standard Deviation
Little Rock, AR	4	2.1*	0.6	1.3	0.72
Globe, AZ	4	2.1*	1.4*	1.8	0.40
Kingman, AZ	3	2.2*	0.2	1.2	1.0
Tuscon, AZ	4	1.4*	0.4	0.97	0.43
Winslow, AZ	4	2.8*	0.8*	1.5	0.92
Yuma, AZ	3	1.7*	0.5	1.2	0.62
Alturas, CA	4	1.6*	0.0	0.62	0.69
Baker, CA	3	2.7*	2.0*	2.4	0.35
Bishop, CA	5	2.3*	1.4*	2.0	0.37
Chico, CA	3	1.7*	0.2	0.83	0.78
Indio, CA	4	1.5*	1.1*	1.3	0.17
Lone Pine, CA	3	1.1*	1.0	1.0	0.06
Needles, CA	2	1.5*	1.0*	1.2	0.35
Ridgecrest, CA	2	0.6	0.0	0.30	0.42
Santa Rosa, CA	3	2.1*	0.6	1.2	0.78
Cortez, CO	3	2.1*	0.6*	1.5	0.81
Denver, CO	3	0.8*	0.5	0.63	0.15
Grand Junction, CO	3	1.9*	1.1*	1.6	0.44
Mountain Home, ID	3	2.6*	0.2	1.2	1.2
Nampa, ID	4	1.5*	0.4	0.90	0.53
Pocatello, ID	2	1.2*	0.7*	0.95	0.35
Fort Dodge, IA	3	2.0*	1.3*	1.6	0.36
Iowa City, IA	2	0.7	0.6	0.65	0.07
Dodge City, KS	4	0.9	0.3	0.70	0.27
Monroe, LA	3	1.4*	0.4	0.77	0.55
Minneapolis, MN	4	1.7*	-0.1	0.80	0.77
Clayton, MO	4	1.0*	0.5	0.82	0.24
Joplin, MO	4	2.3*	0.5	1.1	0.82
St. Joseph, MO	3	1.8*	-0.1	0.70	0.98
Great Falls, MT	4	2.7*	0.4	1.6	1.2
Kalispell, MT	2	0.9	0.5	0.70	0.28
Miles City, MT	4	3.1*	2.2*	2.8	0.39
North Platte, NE	3	1.3*	0.7*	0.93	0.32
Adaven-Uhalde Ranch, NV	8	2.2*	0.1	1.0	0.83
Battle Mountain, NV	5	1.7*	0.0	0.88	0.71
Blue Jay, NV	4	2.2*	0.6	1.2	0.71
Clark Station, NV	4	1.3*	0.1	0.60	0.50
Currant-Angle Worm Ranch, NV	4	1.1*	0.5	0.82	0.25
Currie Maint. Station, NV	4	1.8*	0.0	0.95	0.84
Duckwater, NV	4	1.2*	0.9*	1.0	0.14

Mean MDC: 7.70×10^{-16} µCi/mL Standard Deviation of Mean MDC: 2.49×10^{-16} µCi/mL

MDC = minimum detectable concentration.
* = result is greater than the MDC of analysis.

Table B-2. (Gross Alpha Results for the Offsite Standby Air Surveillance Network - 1992, cont.)

Sampling Location	Number	Gross Alpha Concentration (10^{-15} µCi/mL) Maximum	Minimum	Arithmetic Mean	Standard Deviation
Elko, NV	3	1.6*	0.1	0.87	0.75
Eureka, NV	4	1.2*	0.2	0.72	0.43
Fallon, NV	3	3.0*	1.1*	1.7	1.1
Geyser Ranch, NV	4	2.3*	0.4	1.6	0.90
Lida, NV	2	0.7	0.4	0.55	0.21
Lovelock, NV	4	1.1*	0.3	0.75	0.34
Lund, NV	4	3.1*	0.2	1.3	1.3
Mesquite, NV	2	3.9*	1.7*	2.8	1.6
Reno, NV	4	1.3*	0.1	0.60	0.56
Round Mountain, NV	3	1.6*	0.4	0.87	0.64
Wells, NV	5	1.6*	0.2	1.0	0.54
Winnemucca, NV	4	0.6	0.1	0.32	0.26
Albuquerque, NM	4	1.6*	0.4	1.1	0.51
Carlsbad, NM	4	1.6*	0.1	0.70	0.67
Shiprock, NM	3	1.5*	0.0	0.87	0.78
Bismarck, ND	4	1.3*	0.0	0.75	0.54
Fargo, ND	4	3.8*	0.4	1.3	1.6
Williston, ND	4	7.4*	0.8*	2.6	3.2
Muskogee, OK	-	Quarterly sampling not performed			
Burns, OR	1	1.1*	1.1*	1.1	--
Medford, OR	4	2.1*	0.1	0.82	0.88
Rapid City, SD	-	Quarterly sampling not performed			
Amarillo, TX	4	3.6*	0.7	2.0	1.3
Austin, TX	3	0.8	0.4	0.67	0.23
Midland, TX	2	0.5	0.5	0.50	0.00
Tyler, TX	2	1.0*	0.4	0.70	0.42
Bryce Canyon, UT	4	1.4*	0.9*	1.0	0.24
Enterprise, UT	6	2.3*	0.6*	1.2	0.63
Garrison, UT	2	1.3*	0.5*	0.90	0.57
Logan, UT	4	1.2*	0.5	0.80	0.32
Parowan, UT	4	1.8*	0.9*	1.3	0.39
Vernal, UT	4	2.6*	0.0	1.2	1.2
Wendover, UT	4	1.5*	0.4	1.0	0.46
Seattle, WA	4	1.8*	-0.3	0.65	0.89
Spokane, WA	4	1.0*	0.3	0.65	0.31
Rock Springs, WY	4	1.5*	0.2	0.85	0.53
Worland, WY	4	2.1*	-0.1	1.1	0.91

Mean MDC: 7.70×10^{-16} µCi/mL Standard Deviation of Mean MDC: 2.49×10^{-16} µCi/mL

MDC = minimum detectable concentration.
* = result is greater than the MDC of analysis.

Table B-3. Offsite Atmospheric Plutonium Results for Standby Samplers - 1992

Sampling Location	Number	Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as %DCG
			^{238}Pu Concentration (10^{-18} µCi/mL)			
AZ (Winslow & Tucson)	4	24.90	-7.30	4.400	14.093	70.15
CA (Bishop & Ridgecrest)	2	6.01	-8.48	-1.235	10.246	N/A
CO (Denver & Cortez)	4	22.50	-11.90	1.512	15.744	0.05
ID (Nampa & Mountain Home)	4	0.00	-18.50	-7.250	8.986	N/A
MO (Clayton & Joplin)	4	16.50	-11.90	0.295	11.905	0.01
MT (Great Falls & Miles City)	4	12.10	-6.60	1.820	9.515	0.06
NM (Albuquerque & Carlsbad)	4	85.70*	-6.69	19.682	44.219	0.66
ND (Bismarck & Fargo)	4	0.00	-18.50	-4.625	9.250	N/A
OR (Hines & Medford)	4	6.77	-49.90	-23.132	23.668	N/A
TX (Austin & Amarillo)	4	<0.01	-38.90	-21.400	18.168	N/A
UT (Logan & Vernal)	4	<0.01	-14.50	-4.180	6.959	N/A
WA (Seattle & Spokane)	4	0.00	-4.44	-2.218	2.561	N/A
WY (Worland & Rock Springs)	4	22.20*	-8.97	5.807	14.334	0.19

Mean MDC: 4.19×10^{-17} µCi/mL Standard Deviation of Mean MDC: 2.62×10^{-17} µCi/mL
DCG = derived concentration guide. Established by DOE Order as 3×10^{-15} µCi/mL.

			$^{239+240}$Pu Concentration (10^{-18} µCi/mL)			
AZ (Winslow & Tucson)	4	14.60	-6.52	2.610	9.692	0.13
CA (Bishop & Ridgecrest)	2	0.00	-8.48	-4.240	5.997	N/A
CO (Denver & Cortez)	4	9.16	-7.49	0.418	6.814	0.02
ID (Nampa & Mountain Home)	4	0.00	-10.50	-5.902	4.409	N/A
MO (Clayton & Joplin)	4	0.00	-16.50	-6.045	7.854	N/A
MT (Great Falls & Miles City)	4	13.20	1.93	6.025	5.074	0.30
NM (Albuquerque & Carlsbad)	4	120.00*	-3.76	29.862	60.288	1.49
ND (Bismarck & Fargo)	4	<0.01	-9.26	- 5.798	4.111	N/A
OR (Hines & Medford)	4	<0.01	-24.90	- 8.750	11.772	N/A
TX (Austin & Amarillo)	4	16.90	-7.79	2.795	10.317	0.14
UT (Logan & Vernal)	4	4.82	-2.22	0.650	2.971	0.03
WA (Seattle & Spokane)	4	12.10	-5.94	3.760	8.246	0.19
WY (Worland & Rock Springs)	4	3.70	-8.97	-3.480	6.338	N/A

Mean MDC: 3.39×10^{-17} µCi/mL Standard Deviation of Mean MDC: 2.02×10^{-17} µCi/mL
DCG = derived concentration guide. Established by DOE Order as 2×10^{-15} µCi/mL.
MDC = minimum detectable concentration.
* = result is greater than the MDC of analysis.
N/A = not applicable.

Table B-4. Offsite Atmospheric Tritium Results for Standby Samplers - 1992

		HTO Concentration (10^{-7} pCi/mL)				
Sampling Location	Number	Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as %DCG
Shoshone, CA	4	25.8	4.47	14.2	9.03	0.01
Austin, NV	2	4.90	-5.22	-0.157	7.15	N/A
Caliente, NV	1	-11.6	-11.6	-11.6	--	N/A
Ely, NV	1	-5.53	-5.53	-5.53	--	N/A
Cedar City, UT	3	8.78	-13.8	-3.18	11.3	N/A
Delta, UT	1	-3.99	-3.99	-3.99	--	N/A
Milford, UT	1	15.9	15.9	15.9	--	0.02

Mean MDC: 4.89×10^{-6} pCi/mL Standard Deviation of Mean MDC: 2.40×10^{-6} pCi/mL

DCG = derived concentration guide. Established by DOE Order as 1×10^{-2} pCi/mL.
MDC = minimum detectable concentration.
N/A = not applicable.

Table B-5. Offsite Noble Gas Results for Standby Samplers - 1992

		^{85}Kr Concentration (10^{-11} µCi/mL)				
Sampling Location	Number	Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as %DCG
Shoshone, CA	2	2.86*	2.65*	2.75	0.14	0.01
Austin, NV	2	2.55*	2.44*	2.50	0.08	0.01
Caliente, NV	2	2.76*	2.34*	2.55	0.30	0.01
Ely, NV	1	2.35*	2.35*	2.35	--	0.01
Cedar City, UT	4	2.82*	2.11*	2.55	0.33	0.01
Delta, UT	1	2.80*	2.80*	2.80	--	0.01
Milford, UT	-	Quarterly sampling was not performed				
Salt Lake City, UT	-	Quarterly sampling was not performed				

Mean MDC: 5.82×10^{-12} µCi/mL Standard Deviation of Mean MDC: 1.40×10^{-12} µCi/mL

DCG = derived concentration guide. Established by DOE Order as 3×10^{-7} µCi/mL.
MDC = minimum detectable concentration.
* = result is greater than the MDC of analysis.

Table B-5. (Offsite Noble Gas Results for Standby Samplers - 1992, cont.)

Sampling Location	Number	^{133}Xe Concentration (10^{-12} µCi/mL) Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as %DCG
Shoshone, CA	2	0.880	0.285	0.582	0.421	0.01
Austin, NV	2	0.000	-12.1	-6.07	8.59	N/A
Caliente, NV	2	0.328	-0.438	-0.055	0.542	N/A
Ely, NV	1	-3.21	-3.21	-3.21	--	N/A
Cedar City, UT	4	1.73	-16.8	-4.63	8.34	N/A
Delta, UT	1	0.000	0.000	0.000	--	0.00
Milford, UT	-	Quarterly sampling was not performed				
Salt Lake City, UT	-	Quarterly sampling was not performed				

Mean MDC: 1.68×10^{-11} µCi/mL Standard Deviation of Mean MDC: 6.96×10^{-12} µCi/mL

DCG = derived concentration guide. Established by DOE Order as 5×10^{-8} µCi/mL.
MDC = minimum detectable concentration.
N/A = not applicable.

Table B-6. Standby Milk Surveillance Network Radiochemical Analyses Results - 1992

Sampling Location	Collection Date in 1992	Concentration ± 1s (MDC)[a] ^{3}H x 10^{-9} µCi/mL[b]	^{89}Sr x 10^{-9} µCi/mL[b]	^{90}Sr x 10^{-9} µCi/mL[b]
Little Rock, AR Borden's	06/18	206 ± 84 (270)	0.59 ± 1.1 (1.1)	2.6 ± 0.48 (1.4)*
Russellville, AR Arkansas Tech Univ.	06/18	153 ± 83 (271)	0.087 ± 0.85 (1.1)	0.86 ± 0.37 (1.4)
Taylor, AZ Sunrise Dairy	10/18	385 ± 124 (400)	N/A	-0.29 ± 0.40 (1.5)
Tucson, AZ University of Arizona	10/20	296 ± 130 (421)	N/A	-0.40 ± 0.32 (1.4)
Bakersfield, CA Favorite Foods, Inc.	10/05	368 ± 128 (413)	-0.47 ± 1.1 (1.5)	0.63 ± 0.40 (1.5)

(a) = minimum detectable concentration (MDC).
(b) = multiply the results by 3.7×10^{-7} to obtain Bq/L.
* = result is greater than the MDC of analysis.
N/A = not analyzed.

Table B-6. (Standby Milk Surveillance Network Radiochemical Analyses Results - 1992, cont.)

Sampling Location	Collection Date in 1992	Concentration ± 1s (MDC)[a] ^{3}H x 10^{-9} µCi/mL[b]	^{89}Sr x 10^{-9} µCi/mL[b]	^{90}Sr x 10^{-9} µCi/mL[b]
Orland, CA Meadow Glen/Jerseyland	10/21	213 ± 119 (386)	N/A	-0.20 ± 0.35 (1.4)
Redding, CA McColl's Dairy Prod	11/04	47 ± 123 (403)	0.021 ± 1.8 (2.8)	0.65 ± 0.40 (1.6)
Willows, CA Glenn Milk Producers Assn.	10/19	468 ± 121 (387)*	N/A	-0.075 ± 0.41 (1.5)
Delta, CO Meadow Gold Dairy	05/20	209 ± 75 (242)	0.96 ± 0.68 (0.99)	-0.025 ± 0.32 (1.3)
Denver, CO Safeway Dairy Plant	05/11	90 ± 75 (244)	1.8 ± 0.85 (1.2)*	0.052 ± 0.35 (1.3)
Quincy, IL Prairie Farms Dairy	06/19	257 ± 86 (275)	-0.34 ± 0.90 (1.1)	1.7 ± 0.41 (1.4)*
Boise, ID Meadow Gold Dairies	08/31	69 ± 120 (395)	N/A	0.41 ± 0.34 (1.4)
Idaho Falls, ID Reed's Dairy	08/07	55 ± 77 (253)	N/A	1.1 ± 0.41 (1.5)
Dubuque, IA Swiss Valley Farms, Inc.	08/03	-6.9 ± 75 (248)	N/A	1.31 ± 0.36 (1.3)*
Ellis, KS Mid-America Dairymen	06/03	54 ± 71 (231)	0.30 ± 0.87 (1.2)	0.65 ± 0.37 (1.4)
Sabetha, KS Mid-America Dairymen	06/15	181 ± 73 (237)	-0.26 ± 0.99 (1.3)	1.6 ± 0.42 (1.5)*
Baton Rouge, LA Borden's	04/14	96 ± 69 (226)	0.46 ± 0.94 (1.1)	1.8 ± 0.42 (1.4)*
Monroe, LA Borden's Dairy	04/30	86 ± 72 (234)	0.96 ± 1 (1.3)	1.5 ± 0.39 (1.3)*
New Orleans, LA Brown's Velvet Dairy	04/09	79 ± 70 (228)	0.54 ± 0.85 (0.99)	1.42 ± 0.44 (1.4)*

(a) = minimum detectable concentration (MDC).
(b) = multiply the results by 3.7×10^{-7} to obtain Bq/L.
* = result is greater than the MDC of analysis.
N/A = not analyzed.

Table B-6. (Standby Milk Surveillance Network Radiochemical Analyses Results - 1992, cont.)

Sampling Location	Collection Date in 1992	Concentration ± 1s (MDC)[a] ^{3}H x 10^{-9} µCi/mL[b]	^{89}Sr x 10^{-9} µCi/mL[b]	^{90}Sr x 10^{-9} µCi/mL[b]
Fosston, MN Land O' Lakes, Inc.	04/28	94 ± 72 (234)	1.6 ± 1.1 (1.3)*	1.7 ± 0.41 (1.3)*
Rochester, MN Assoc Milk Prod, Inc.	05/26	53 ± 71 (234)	0.22 ± 1.1 (1.4)	1.4 ± 0.42 (1.4)
Monett, MO Mid-America Dairy, Inc.	07/27	-68 ± 76 (252)	N/A	1.8 ± 0.42 (1.4)*
Chillicothe, MO Mid-America Dairymen	09/03	413 ± 126 (407)*	N/A	1.6 ± 0.34 (1.3)*
Billings, MT Meadow Gold Dairy	07/17	322 ± 86 (273)*	0.82 ± 0.77 (0.86)	1.7 ± 0.42 (1.3)*
Great Falls, MT Meadow Gold Dairy	07/16	298 ± 85 (273)*	N/A	1.4 ± 0.43 (1.5)
Norfolk, NE Gillette Dairy	07/14	171 ± 83 (268)	2.0 ± 0.80 (0.93)*	1.0 ± 0.42 (1.3)
North Platte, NE Mid-America Dairymen	07/27	46 ± 78 (257)	N/A	1.5 ± 0.40 (1.4)*
Albuquerque, NM Borden's Valley Gold	09/08	293 ± 122 (394)	N/A	0.53 ± 0.42 (1.5)
La Plata, NM River Edge Dairy	07/11	298 ± 90 (287)*	-0.60 ± 0.65 (0.93)	1.34 ± 0.34 (1.3)*
Bismarck, ND Bridgeman Creamery, Inc	04/14	-70 ± 68 (227)	0.063 ± 0.82 (1)	2.0 ± 0.38 (1.3)*
Grand Forks, ND Minnesota Dairy	04/22	82 ± 71 (232)	-0.74 ± 0.77 (1)	1.6 ± 0.38 (1.4)*
Enid, OK AMPI Goldspot Division	06/08	127 ± 71 (231)	0.94 ± 1.1 (1.3)	1.0 ± 0.43 (1.5)
McAlester, OK Jackie Brannon Corr Ctr	07/16	241 ± 87 (281)	0.21 ± 0.70 (0.91)	1.0 ± 0.37 (1.3)

(a) = minimum detectable concentration (MDC).
(b) = multiply the results by 3.7×10^{-7} to obtain Bq/L.
* = result is greater than the MDC of analysis.
N/A = not analyzed.

Table B-6. (Standby Milk Surveillance Network Radiochemical Analyses Results - 1992, cont.)

Sampling Location	Collection Date in 1992	Concentration ± 1s (MDC)[a] ^{3}H x 10^{-9} µCi/mL[b]	^{89}Sr x 10^{-9} µCi/mL[b]	^{90}Sr x 10^{-9} µCi/mL[b]
Medford, OR Dairygold Farms	07/13	171 ± 83 (268)	-0.22 ± 0.59 (0.89)	0.86 ± 0.32 (1.3)
Salem, OR Curly's Dairy	07/06	101 ± 84 (275)	0.047 ± 0.68 (0.99)	1.2 ± 0.34 (1.3)
Tillamook, OR Tillamook Creamery	08/17	-6.4 ± 78 (257)	N/A	0.81 ± 0.36 (1.4)
Rapid City, SD Gillette Dairy - Black Hills	04/06	67 ± 69 (226)	1.0 ± 0.82 (1.1)	-0.065 ± 0.39 (1.5)
Sioux Falls, SD Lakeside Dairy	04/02	25 ± 70 (229)	0.66 ± 0.93 (1.2)	0.84 ± 0.43 (1.5)
Sulphur Springs, TX Tommy Rue Potts Dairy	11/13	108 ± 91 (296)	0.24 ± 1 (1.2)	1.7 ± 0.45 (1.4)*
Windthorst, TX Lloyd Wolf Dairy	11/13	153 ± 118 (387)	-3.3 ± 0.90 (1.2)	1.2 ± 0.39 (1.4)
Beaver, UT Cache Valley Dairy	05/26	128 ± 74 (241)	0.80 ± 0.65 (0.91)	0.22 ± 0.33 (1.3)
Provo, UT BYU Dairy Products Lab	06/15	92 ± 73 (238)	0.39 ± 0.80 (1.2)	0.38 ± 0.35 (1.4)
Seattle, WA Darigold, Inc.	10/12	114 ± 125 (410)	1.3 ± 2.1 (3.4)	0.37 ± 0.35 (1.4)
Spokane, WA Darigold, Inc.	10/06	437 ± 128 (412)*	N/A	1.1 ± 0.39 (1.4)
Cheyenne, WY Dairy Gold Foods	07/15	214 ± 87 (280)	0.62 ± 0.70 (0.86)	1.33 ± 0.38 (1.3)*
Sheridan, WY Mydland Dairy	05/19	41 ± 76 (250)	1.3 ± 0.85 (1)*	0.99 ± 0.40 (1.3)

(a) = minimum detectable concentration (MDC).
(b) = multiply the results by 3.7×10^{-7} to obtain Bq/L.
* = result is greater than the MDC of analysis.
N/A = not analyzed.

Table B-7. Standby Milk Surveillance Network Gamma Spectrometry Results - 1992

Samples from the following locations were analyzed by gamma spectrometry only: in all cases only naturally occuring radionuclides were detected.

Sampling Location	Collection Date
Duncan, AZ	
Lunt Dairy	09/23
Tempe, AZ	
United Dairymen of Arizona	10/07
Batesville, AR	
Hills Valley Foods	06/24
Fayetteville, AR	
University Of Arkansas	06/10
Chino, CA	
CA Institute for Men	10/27
Cresent City, CA	
Rumiano Cheese Company	10/16
Fernbridge, CA	
Humboldt Creamery Assn.	10/16
Fresno, CA	
CA State University Creamery	10/19
Helendale, CA	
Osterkamp Dairy No. 2	10/07
Holtville, CA	
Schaffner & Son Dairy	10/05
Lompoc, CA	
Federal Penitentiary Camp	10/27
Long Beach, CA	
Paul's Dairy	10/26
Manchester, CA	
Point Arena Dairies	10/14
Manteca, CA	
Supremo Foods	11/20
Modesto, CA	
Foster Farms - Jersey Dairy	12/03
Petaluma, CA	
Point Reyes Seashore Dairy	10/14
San Jose, CA	
Marquez Bros Mexican Cheese	10/07
San Luis Obispo, CA	
Cal Poly University Dairy	10/27
Soledad, CA	
Correction Training Industry	10/20
Tracy, CA	
Deuel Vocational Institute	10/20
Colorado Springs, CO	
Sinton Dairy	07/10
Greeley, CO	
Meadow Gold Dairy	07/08
Ft Collins, CO	
Poudre Valley Creamery	06/08
Caldwell, ID	
Darigold, Inc.	08/31
Pocatello, ID	
Rowland's Meadowgold Dairy	08/06
Twin Falls, ID	
Triangle Young's Dairy	08/03
Kimballton, IA	
Assoc. Milk Pro., Inc.(AMPI)	06/10
Lake Mills, IA	
Lake Mills Coop Creamery	06/01
Lemars, IA	
Wells Dairy	06/10
Manhattan, KS	
Kansas State University	06/11
Lafayette, LA	
Borden's	04/28
New Orleans, LA	
Walker Roemer Dairy	04/09
Shreveport, LA	
Foremost Dairy	05/11
Fergus Falls, MN	
Mid-America Dairymen	04/08
Browerville, MN	
Land O' Lakes, Inc.	04/28
Nicollet, MN	
Doug Schultz Farm	05/09
Jackson, MO	
Mid-America Dairymen, Inc.	06/23
Jefferson City, MO	
Central Dairy Company	07/23
Bozeman, MT	
Country Classic-DBA-Darigold	07/28
Kalispell, MT	
Equity Supply Co	07/20
Omaha, NE	
Roberts Dairy, Marshall Green	07/28
Chappell, NE	
Leprino Foods	07/06
Superior, NE	
Mid-America Dairymen	09/08
Fargo, ND	
Cass Clay Creamery	04/24
Minot, ND	
Bridgemen Creamery	04/13
Las Vegas, NV	
Anderson Dairy	10/07
Reno, NV	
Model Dairy	10/19
Yerington, NV	
Valley Dairy	10/26
Coalgate, OK	
Larry Krebs Dairy	06/15

Table B-7. (Standby Milk Surveillance Network gamma Spectrometry Results - 1992, cont.)

Samples from the following locations were analyzed by gamma spectrometry only: in all cases only naturally occuring radionuclides were detected.

Sampling Location	Collection Date	Sampling Location	Collection Date
Claremore, OK		Volga, SD	
Swan Brothers Dairy	06/17	Land O'Lakes Inc	07/09
Stillwater, OK		Canyon, TX	
OK State University Dairy	06/17	West Texas State Dairy	11/06
Grants Pass, OR		Corpus Christi, TX	
Valley Of Rouge Dairy	07/07	Hygeia Milk Plant	11/16
Junction City, OR		Fabens, TX	
Lockmead Farms Inc	07/20	Island Dairy - El Paso County	12/01
Klamath Falls, OR		Glen Rose TX	
Klamath Dairy Products	07/22	Dewayne Hankins Dairy	11/09
Myrtle Point, OR		Richfield, UT	
Safeway Stores, Inc.	08/03	Ideal Dairy	05/18
Ontario, OR		Smithfield, UT	
Eastway Dairy	09/01	Cache Valley Dairy	05/27
Portland, OR		Moses Lake, WA	
Darigold Farms	07/27	Safeway Stores, Inc	10/05
Redmond, OR		Riverton, WY	
Eberhard's Creamery, Inc.	07/14	Western Dairymen's Co-op	07/07
Ethan, SD		Thayne, WY	
Ethan Dairy Products	04/07	Western Dairymen's Co-op	06/08

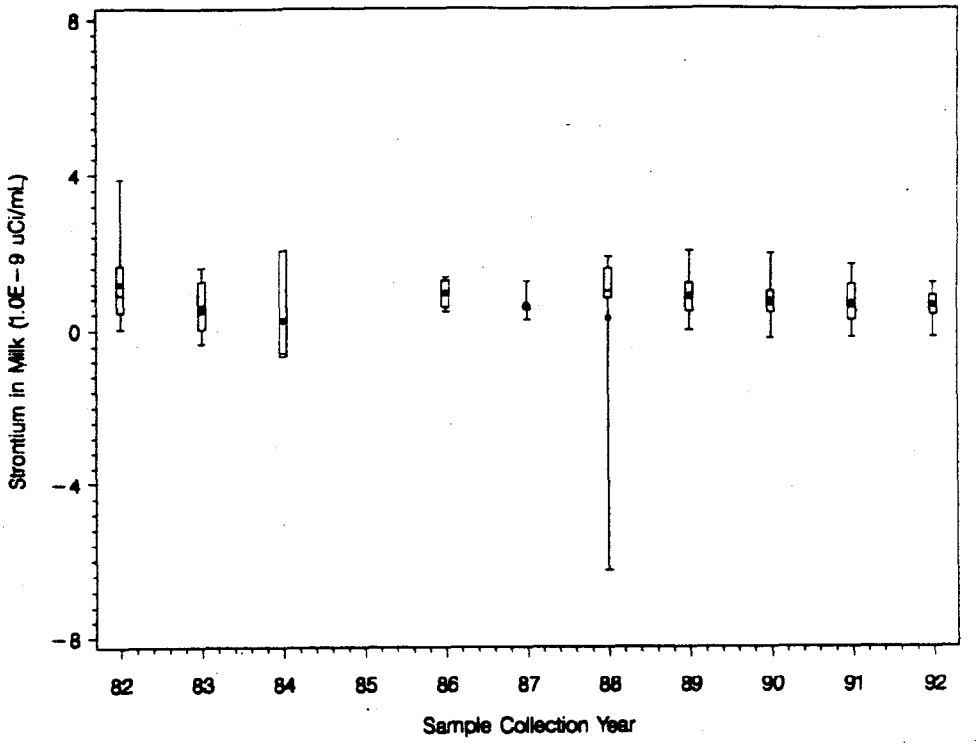

Figure B-1. Distribution for strontium results for the standby milk stations, Western Region 1982 - 1992.

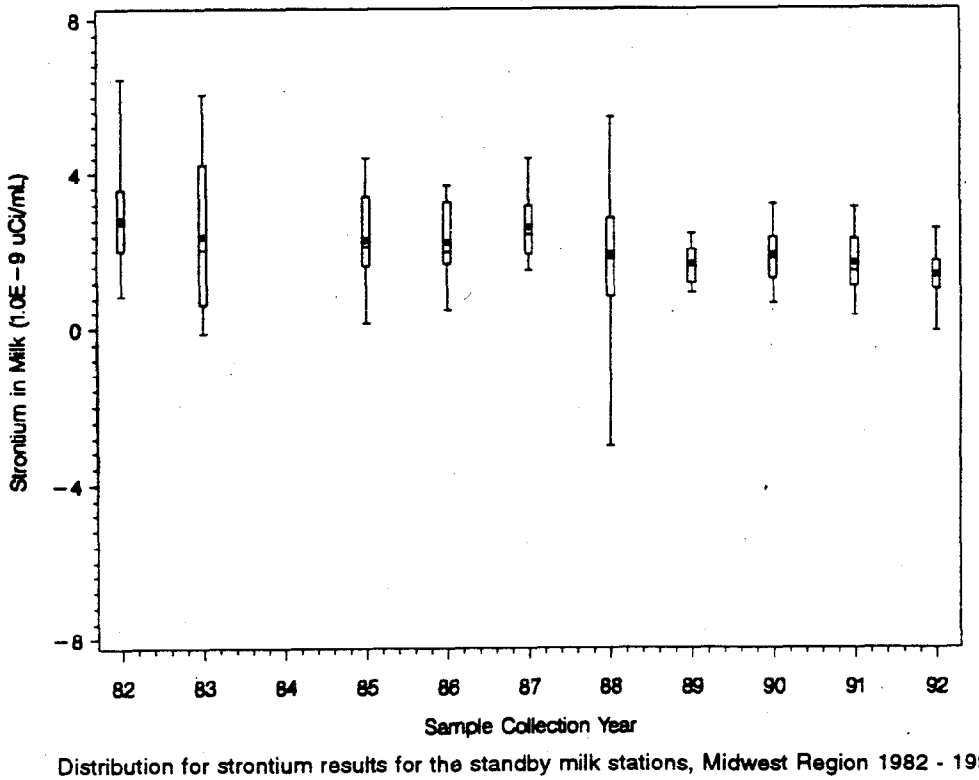

Figure B-2. Distribution for strontium results for the standby milk stations, Midwest Region 1982 - 1992.

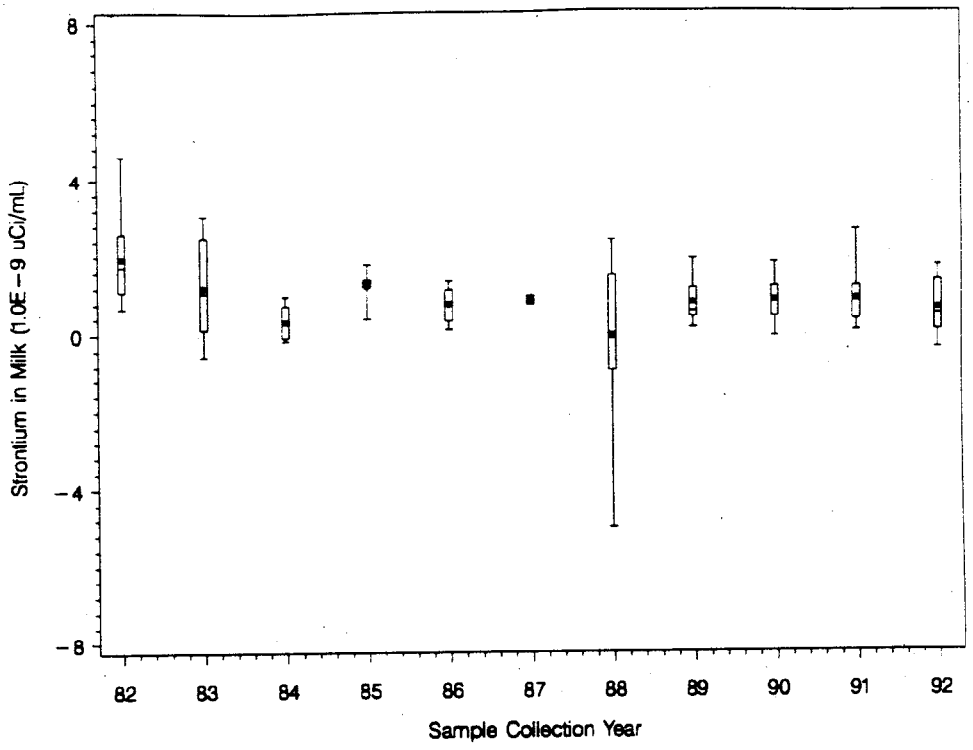

Figure B-3. Distribution for strontium results for standby milk stations, Mountain Region 1982 - 1992.

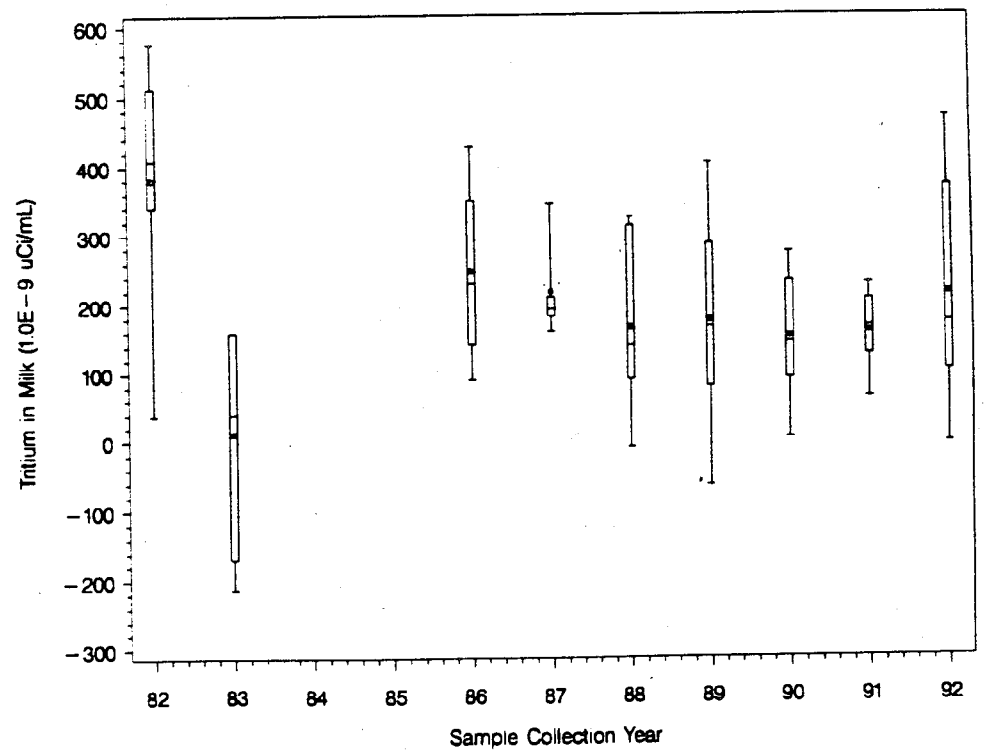

Figure B-4. Distribution for tritium results for standby milk stations, Western Region 1982 - 1992.

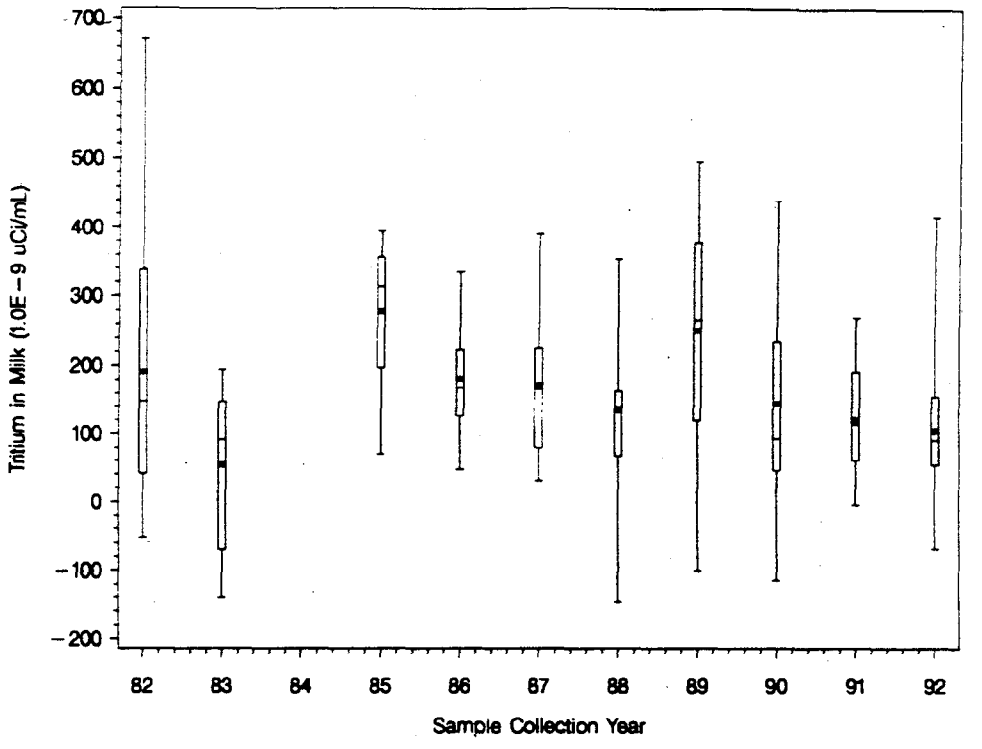

Figure B-5. Distribution for tritium results for standy milk stations, Midwest Region 1982 - 1992.

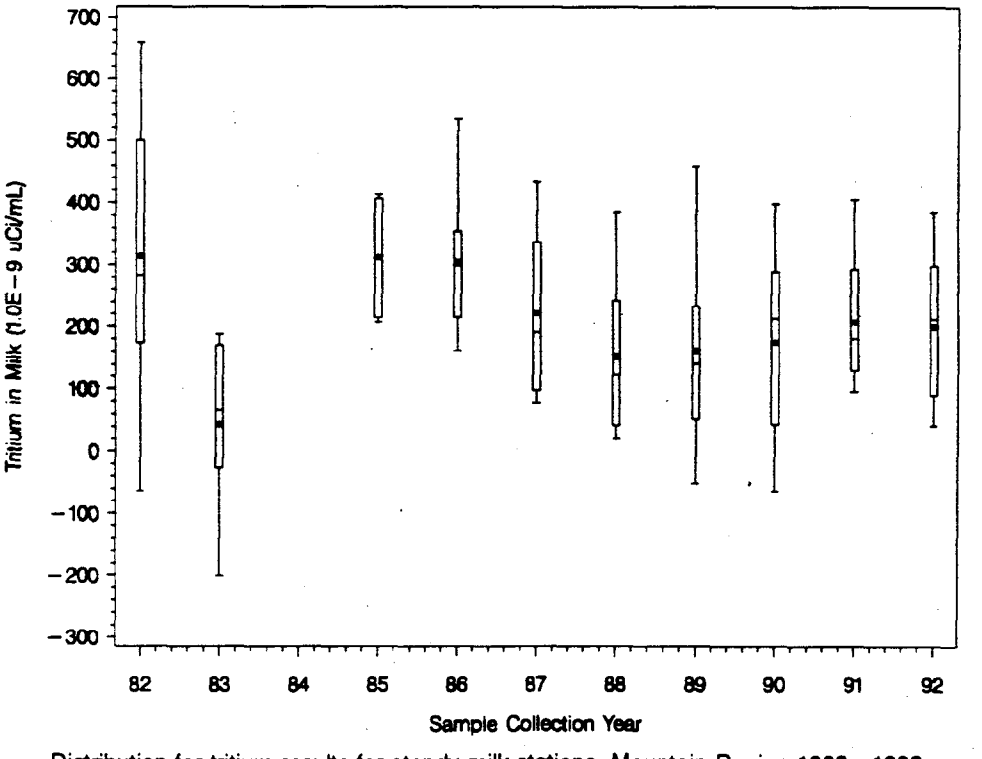

Figure B-6. Distribution for tritium results for standy milk stations, Mountain Region 1982 - 1992.

Appendix C

Long-Term Hydrological Monitoring Tables

Table C-1. Long-Term Hydrological Monitoring Program Analytical Results for Locations in the NTS Vicinity - 1992

Sampling Location	Collection Date in 1992	Concentration ± 1s of Tritium (pCi/L)(b)	Percent of Concentration Guide[a]
Amargosa Valley, NV			
Well Mary Nickell's	02/06	1.3 ± 2.2	N/A
	08/04	46 ± 140	N/A
Shoshone, CA			
Shoshone Spring	02/04	0.0 ± 1.8	N/A
	08/05	82 ± 140	N/A
Adaven, NV			
Adaven Spring	01/14	32 ± 2	0.04
	07/01	−114 ± 113	N/A
Alamo, NV			
Well 4 City	01/16	0.0 ± 1.7	N/A
	07/02	−45 ± 114	N/A
Ash Meadows, NV			
Crystal Pool	05/07	4.6 ± 3.7	N/A
	11/02	138 ± 145	N/A
Fairbanks Springs	05/07	−2.3 ± 4.6	N/A
	11/02	−411 ± 143	N/A
Spring-17S-50E-14cac	06/08	−4.1 ± 1.7	N/A
	12/14	374 ± 142	N/A
Well 18S-51E-7db	05/07	1.9 ± 3.8	N/A
	11/02	52 ± 145	N/A
Beatty, NV			
U.S. Ecology	06/08	1.9 ± 2.0	N/A
	12/08	315 ± 142	N/A
Specie Springs	03/04	−82 ± 127	N/A
	07/09	4.6 ± 1.6	N/A
Tolicha Peak	02/05	−32 ± 127	N/A
	08/05	0.21 ± 1.74	N/A
Well 11S-48-1dd Coffers	01/08	111 ± 126	N/A
	07/09	2.7 ± 1.5	N/A
Well 12S-47E-7dbd City	01/07	243 ± 127	N/A
	07/09	3.0 ± 1.5	N/A

(a) Established by DOE Order as 90,000 pCi/L tritium
(b) Multiply the results by 3.7×10^7 to obtain Bq/L
N/A Not applicable. Percent of concentration guide is not applicable either because the tritium result is less than the MDC or because the water is known to be nonpotable

Table C-1. (Long-Term Hydrological Monitoring Program Analytical Results for Locations in the NTS Vicinity - 1992, cont.)

Sampling Location	Collection Date in 1992	Concentration ± 1s of Tritium (pCi/L)	Percent of Concentration Guide[a]
Well Road D Spicers	02/05	85 ± 127	N/A
	08/05	−1.9 ± 1.7	N/A
Younghans Ranch	06/11	−1.3 ± 1.9	N/A
(House Well)	12/09	−81 ± 140	N/A
Boulder City, NV			
Lake Mead Intake	03/06	−32 ± 127	N/A
	05/07	58 ± 2	0.06
	09/03	62 ± 2	0.07
Clark Station, NV			
Well 6 TTR	02/04	−21 ± 127	N/A
	08/05	1.8 ± 1.6	N/A
Hiko, NV			
Crystal Springs	01/16	−2.9 ± 1.6	N/A
	07/02	33 ± 115	N/A
Indian Springs, NV			
Well 1 Sewer Company	03/03	25 ± 127	N/A
	09/10	1.1 ± 2.6	N/A
Well 2 US Air Force	03/03	−118 ± 126	N/A
	09/03	1.5 ± 1.3	N/A
Johnnie, NV			
Well Johnnie Mine	03/03	96 ± 128	N/A
	09/10	6.0 ± 1.7[b]	0.01
Las Vegas, NV			
Well 28 Water District	09/03	−0.50 ± 1.32	N/A
	10/08	−1.3 ± 1.7	N/A
Lathrop Wells, NV			
City 15S-50E-18cdc	04/06	1.5 ± 2.2	N/A
	10/16	−14 ± 140	N/A
Nyala, NV			
Sharp's Ranch	02/04	−92 ± 127	N/A
	08/03	0.81 ± 1.56	N/A

(a) Established by DOE Order as 90,000 pCi/L tritium
(b) Multiply the results by 3.7×10^7 to obtain Bq/L
N/A Not applicable. Percent of concentration guide is not applicable either because the tritium result is less than the MDC or because the water is known to be nonpotable

Table C-1. (Long-Term Hydrological Monitoring Program Analytical Results for Locations in the NTS Vicinity - 1992, cont.)

Sampling Location	Collection Date in 1992	Concentration ± 1s of Tritium (pCi/L)	Percent of Concentration Guide[a]
Oasis Valley, NV			
Goss Springs	02/05	−11 ± 127	N/A
	08/05	0.0 ± 1.9	N/A
Pahrump, NV			
Calvada Well	02/04	0.0 ± 1.5	N/A
	08/05	107 ± 140	N/A
Rachel, NV			
Wells 7 & 8 Penoyer	06/03	44 ± 112	N/A
	09/21	0.63 ± 1.45	N/A
Well 13 Penoyer	06/03	−165 ± 110	N/A
	09/09	−0.89 ± 1.76	N/A
Well Penoyer Culinary	04/01	39 ± 133	N/A
	10/06	−0.21 ± 1.65	N/A
Tempiute, NV			
Union Carbide Well	02/12	−153 ± 126	N/A
	08/06	−2.0 ± 1.9	N/A
Tonopah, NV			
City Well	03/03	121 ± 128	N/A
	09/08	4.2 ± 1.4	N/A
Warm Springs, NV			
Twin Springs Ranch	04/01	−291 ± 132	N/A
	10/01	-0.47 ± 1.25	N/A

(a) Established by DOE Order as 90,000 pCi/L tritium
(b) Activity is greater than the minimum detectable concentration (MDC)
N/A Not applicable; Percent of concentration guide is not applicable either because the tritium result is less than the MDC or because the water is known to be nonpotable

Table C-2. Long-Term Hydrological Monitoring Program Analytical Results for Project FAULTLESS - 1992.

Sampling Location	Collection Date in 1992	Concentration ± 1s of Tritium (pCi/L)	Percent of Concentration Guide[a]
Blue Jay, NV			
Hot Creek Ranch Spring	02/24	Not Sampled - Spring and well dry	
Maintenance Station	02/24	0.0 ± 1.4	N/A
Well Bias	02/25	4.2 ± 1.8	N/A
Well HTH-1	02/25	0.73 ± 1.22	N/A
Well HTH-2	02/25	1.4 ± 1.2	N/A
Well Six Mile	02/25	0.9 ± 1.5	N/A

(a) Established by DOE Order as 90,000 pCi/L tritium
N/A Not analyzed

Table C-3. Long-Term Hydrological Monitoring Program Analytical Results for Project SHOAL - 1992

Sampling Location	Collection Date in 1992	Concentration ± 1s of Tritium (pCi/L)	Percent of Concentration Guide[a]
Frenchmen Station, NV			
Hunt's Station	03/11	0.88 ± 1.50	N/A
Smith/James Springs	03/11	56 ± 2[c]	0.06
Spring Windmill	03/11	Not Sampled - Well dry	
Well Flowing	03/11	−1.1 ± 1.8	N/A
Well H-3	10/21	−0.38 ± 1.62	N/A [b]
Well HS-1	03/11	0.86 ± 1.47	N/A

(a) Established by DOE Order as 90,000 pCi/L tritium
(b) Additional analyses performed on this sample and results are greater than MDC
(c) Activity is greater than the minimum detectable concentration (MDC)
N/A Not applicable; Percent of concentration guide is not applicable either because the tritium result is less than the MDC or because the water is known to be nonpotable

Additional analyses on Well H-3

Analysis	Result	1 sigma	MDC	Units
U-234	0.14	0.02	0.03	pCi/L
U-238	0.042	0.011	0.020	pCi/L

Table C-4. Long-Term Hydrological Monitoring Program Analytical Results for Project RULISON - 1992

Sampling Location	Collection Date in 1992	Concentration ± 1s of Tritium (pCi/L)	Percent of Concentration Guide[a]
Rulison, CO			
Lee Hayward Ranch	06/09	160 ± 3[b]	0.18
Potter Ranch	06/09	67 ± 2[b]	0.07
Robert Searcy Ranch	06/09	78 ± 2[b]	0.09
Felix Sefcovic Ranch	06/09	57 ± 2[b]	0.06
Grand Valley, CO			
Battlement Creek	06/09	63 ± 2[b]	0.07
City Springs	06/09	0.43 ± 1.49	[b]
Albert Gardner Ranch	06/09	98 ± 3[b]	0.11
Spring 300 Yd. N of GZ	06/09	63 ± 2[b]	0.07
Well CER Test	06/09	48 ± 2[b]	50.05

(a) Established by DOE Order as 90,000 pCi/L tritium
(b) Activity is greater than the minimum detectable concentration (MDC)
N/A Not applicable. Percent of concentration guide is not applicable either because the tritium result is less than the MDC or because the water is known to be nonpotable

Table C-5. Long-Term Hydrological Monitoring Program Analytical Results for Project RIO BLANCO - 1992

Collection Sampling Location	Concentration ± 1s Date in 1992	Percent of of Tritium (pCi/L)	Concentration Guide[a]
Rio Blanco, CO			
B-1 Equity Camp (spring)	06/10	49 ± 2[b]	0.05
CER No.1 Black Sulfur (spring)	06/10	57 ± 3[b]	0.06
CER No.4 Black Sulfur (spring)	06/10	50 ± 2[b]	0.06
Fawn Creek 1	06/10	21 ± 2[b]	0.02
Fawn Creek 3	06/10	26 ± 2[b]	0.03
Fawn Creek 500 Ft Upstream	06/10	26 ± 2[b]	0.03
Fawn Creek 500 Ft Downstream	06/10	26 ± 2[b]	0.03
Fawn Creek 6800 Ft Upstream	06/10	26 ± 2[b]	0.03
Fawn Creek 8400 Ft Downstream	06/10	29 ± 2[b]	0.03
Johnson Artesian Well	06/10	-1.8 ± 2.3	N/A
Brennan Windmill (well)	06/10	3.7 ± 1.6	N/A
Well RB-D-01	06/11	-2.1 ± 1.3	N/A
Well RB-D-03	06/11	0.75 ± 1.44	N/A
Well RB-S-03	06/11	1.7 ± 1.5	N/A

(a) Established by DOE Order as 90,000 pCi/L tritium
(b) Activity is greater than the minimum detectable concentration (MDC)
N/A Not applicable; Percent of concentration guide is not applicable either because the tritium result is less than the MDC or because the water is known to be nonpotable

Table C-6. Long-Term Hydrological Monitoring Program Analytical Results for Project GNOME - 1992

Sampling Location	Collection Date in 1992	Concentration ± 1s of Tritium (pCi/L)	Percent of Concentration Guide[a]
Malaga, NM			
Well 1 Pecos Pumping Station	06/17	−2.6 ± 1.5	N/A
Well DD-1	06/16	$6.5 \times 10^7 \pm 3.2 \times 10^5$[b]	N/A[c]
Well LRL-7	06/16	11,700 ± 170[b]	N/A[d]
Well PHS 6	06/15	37 ± 2[b]	0.04
Well PHS 8	06/15	15 ± 2[b]	0.02
Well PHS 9	06/15	0.14 ± 2.35	N/A
Well PHS 10	06/15	−2.0 ± 1.9	N/A
Well USGS 1	06/15	−0.40 ± 1.12	N/A
Well USGS 4	06/16	118,000 ± 416[b]	N/A[e]
Well USGS 8	06/16	91,100 ± 370[b]	N/A[f]
Carlsbad, NM			
Well 7 City	06/18	−0.98 ± 1.01	N/A
Loving, NM			
Well 2 City	06/17	8.2 ± 1.6[b]	<0.01

(a) Established by DOE Order as 90,000 pCi/L tritium
(b) Activity is greater than the minimum detectable concentration (MDC)
(c,d,e,f) Additional analyses greater than MDC
N/A Not applicable; Percent of concentration guide is not applicable either because the tritium result is less than the MDC or because the water is known to be nonpotable

Additional analyses greater than MDC

	Analysis	Result	1 sigma	MDC	Units
(c)	Cs-137	551,000	25,600	N/A	pCi/L
	Sr-90	13,000	1,180	2,920	pCi/L
(d)	Cs-137	200	11	N/A	pCi/L
(e)	Sr-90	6,200	18	59	pCi/L
(f)	Cs-137	69	1	N/A	pCi/L
	Sr-90	5,140	16	53	pCi/L

Table C-7. Long-Term Hydrological Monitoring Program Analytical Results for Project GASBUGGY - 1992

Sampling Location	Collection Date in 1992	Concentration ± 1s of Tritium (pCi/L)	Percent of Concentration Guide[a]
Gobernador, NM			
Arnold Ranch	04/14	Not Sampled - Road washed out	
Bixler Ranch	04/16	13 ± 2[c]	0.01
Bubbling Springs	04/14	42 ± 2[c]	0.05
Cave Springs	04/14	75 ± 3[c]	0.08
Cedar Springs	04/14	55 ± 3[c]	0.06
La Jara Creek	04/15	70 ± 3[c]	0.08
Lower Burro Canyon	04/15	0.0 ± 1.8	N/A
Pond N of Well 30.3.32.343	04/15	34 ± 3[c]	0.04[b]
Well EPNG 10-36	04/16	33 ± 2[c]	0.04[f]
	09/16	364 ± 4[c]	0.40[d]
Well Jicarilla 1	04/15	19 ± 2[c]	0.02[e]
Well 28.3.33.233 (South)	04/16	Windmill inoperative	
Windmill 2	04/15	−1.3 ± 2.2	N/A

(a) Established by DOE Order as 90,000 pCi/L tritium
(b) Sample estimated to be 90 percent rainwater
(c) Activity is greater than the minimum detectable concentration (MDC)
(d) Resampling, Additional analyses greater than MDC
(e) Sample from stock tank
(f) pH and conductivity indicate sample predominantly rainwater
N/A Not applicable. Percent of concentration guide is not applicable either because the tritium result is less than the MDC or because the water is known to be nonpotable

Additional analyses on Well EPNG 10-36

Analysis	Result	1 sigma	MDC	Units
Cs-137	5.97	0.85	0.83	pCi/L

Table C-8. Long-Term Hydrological Monitoring Program Analytical Results for Project DRIBBLE - 1992

Sampling Location	Collection Date in 1992	Concentration ± 1s of Tritium (pCi/L)	Percent of Concentration Guide[a]
	Onsite Sampling Locations		
Baxterville, MS			
Half Moon Creek	04/26	15 ± 1[c]	0.02
	04/27	27 ± 2[c]	0.03
Half Moon Creek Overflow	04/26	690 ± 5[c]	0.8
	04/27	587 ± 4[c]	0.7
Pond West Of GZ	04/26	16 ± 2[c]	0.02
	04/27	14 ± 2[c]	0.02
REECO Pit Drainage-A	04/26	31 ± 2[c]	0.03
REECO Pit Drainage-B	04/26	1,317 ±114[c]	1.5
REECO Pit Drainage-C	04/26	556 ± 4[c]	0.6
Well E-7	04/28	6.0 ± 1.8[c]	0.01
Well HM-1	04/27	1.8 ± 1.6	N/A
	04/27	0.0 ± 1.6	N/A
Well HM-2A	04/27	−2.3 ± 2.0	N/A
	04/27	−1.6 ± 1.5	N/A
Well HM-2B	04/27	2.1 ± 1.9	N/A
	04/27	−4.5 ± 1.3	N/A
Well HM-3	04/27	3.3 ± 2.0	N/A
	04/27	−0.88 ± 1.6	N/A
Well HM-L	04/27	1,305 ±114[c]	1.5
	04/27	611 ± 4[c]	0.7
Well HM-L2	04/27	2.4 ± 2.1	N/A
	04/27	−3.0 ± 1.8	N/A
Well HM-S	04/26	7,073 ±143[c]	7.9
	04/27	6,724 ±142[c]	7.5
Well HMH-1	04/26	5,835 ±137[c]	6.5
	04/27	14,395 ±174[c]	16.0
Well HMH-2	04/26	5,115 ±134[c]	5.7
	04/27	12,841 ±168[c]	14.2
Well HMH-3	04/26	11 ± 1[c]	0.01
	04/27	27 ± 2[c]	0.03
Well HMH-4	04/26	13 ± 2[c]	0.01
	04/27	15 ± 1[c]	0.02
Well HMH-5	04/26	1856 ±117[c]	2.1
	04/27	2064 ±118[c]	2.3
Well HMH-6	04/26	72 ± 2[c]	0.08
	04/27	57 ± 3[c]	0.06
Well HMH-7	04/26	Not Sampled - Well under water	
	04/27	Not Sampled - Well under water	
Well HMH-8	04/26	13 ± 2[c]	0.01
	04/27	20 ± 2[c]	0.02
Well HMH-9	04/26	87 ± 2[c]	0.1
	04/27	91 ± 3[c]	0.1
Well HMH-10	04/26	298 ± 3[c]	0.3
	04/27	256 ± 4[c]	0.3
Well HMH-11	04/26	23 ± 2[c]	0.03
	04/27	28 ± 2[c]	0.03

Table C-8. (Long-Term Hydorlogical Monitoring Program Analytical Results for Project GNOME - 1992, cont.)

Sampling Location	Date in 1992	Concentration ± 1s of Tritium (pCi/L)	Percent of Concentration Guide[a]
Onsite Sampling Locations			
Well HMH-12	04/26	12 ± 2[c]	0.01
	04/27	12 ± 3[c]	0.01
Well HMH-13	04/26	11 ± 2[c]	0.01
	04/27	7.6 ± 1.9[c]	0.01
Well HMH-14	04/26	Not Sampled - Well dry	
	04/27	Not Sampled - Well dry	
Well HMH-15	04/26	12 ± 2[c]	0.01
	04/27	9.1 ± 2.3[c]	0.01
Well HMH-16	04/26	75 ± 2[c]	0.08
	04/27	117 ± 3[c]	0.1
Well HT-2C	04/28	9.0 ± 1.5[c]	0.01
Well HT-4	04/28	6.1 ± 2.5	N/A
Well HT-5	04/28	0.99 ± 1.69	N/A
Offsite Sampling Locations			
Baxterville, MS			
Little Creek #1	04/28	20 ± 2[c]	0.02
Lower Little Creek #2	04/28	18 ± 1[c]	0.02
Salt Dome Hunting Club	04/29	24 ± 2[c]	0.03
Salt Dome Timber Co.	04/27	27 ± 2[c]	0.03
Anderson Pond	04/27	8.5 ± 1.3[c]	0.01
Anderson, Billy Ray	04/27	16 ± 2[c]	0.02
Anderson, Regina	04/27	Not Sampled - No one home	
Anderson, Robert Harvey	04/27	17 ± 2[c]	0.02
Anderson, Robert Lowell, Sr.	04/27	20 ± 2[c]	0.02
Anderson, Robert Lowell, Jr.	04/27	17 ± 1[c]	0.02
Bilbo, Timothy	04/28	24 ± 2[c]	0.03[d]
Burge, Joe	04/27	18 ± 2[c]	0.02
Chambliss, B.	04/28	−0.85 ± 1.43	N/A
Daniels, Ray	04/29	15 ± 2[c]	0.02
Daniels, Webster Jr.	04/29	18 ± 2[c]	0.02
Daniels Fish Pond Well #2	04/29	19 ± 2[c]	0.02
Kelly Gertrude	04/27	−0.87 ± 1.54	[b]
King, Rhonda	04/27	20 ± 2[c]	0.02
Lee, P. T.	04/27	45 ± 2[c]	0.05
Mills, A. C.	04/27	−0.90 ± 1.59	[b]
Mills, Roy	04/29	18 ± 2[c]	0.02
Nobles Pond	04/27	18 ± 2[c]	0.02
Noble's Quail House	04/27	59 ± 5[c]	0.07
Noble, W. H., Jr.	04/27	37 ± 2[c]	0.04
Ready, R. C.	04/29	Not Sampled - Now on city water	
Saucier, Dennis	04/28	41 ± 3[c]	0.05
Saucier, Wilma/Yancy	04/28	3.1 ± 1.7	N/A
Smith, Rita	04/27	Not Sampled - Moved, Well Down	
Well Ascot 2	04/28	Not Sampled - Well In Water	
City Well	04/29	26 ± 2[c]	0.03

Table C-8. (Long-Term Hydorlogical Monitoring Program Analytical Results for Project GNOME - 1992, cont.)

Sampling Location	Date in 1992	Concentration ± 1s Percent of Tritium (pCi/L)	Concentration Guide[a]
	Offsite Sampling Locations (continued)		
Columbia, MS			
Dennis, Buddy	04/28	21 ± 3[c]	0.02
Dennis, Marvin	04/28	14 ± 3[c]	0.02
City Well 64B	04/28	6.8 ± 2.1[c]	0.01
Lumberton, MS			
Anderson, G. W.	04/27	19 ± 3[c]	0.02
Anderson, Lee L.	04/29	20 ± 1[c]	0.02
Bond, Bradley K.	04/29	16 ± 3[c]	0.02
Cox, Eddie	04/27	28 ± 2[c]	0.03
Gil Ray's Crawfish Pond	04/27	7.0 ± 1.6[c]	0.01
Gipson, Herman	04/28	−1.8 ± 1.5	N/A
Gipson, Hewie	04/27	23 ± 3[c]	0.03[b][e]
Gipson, Phillip	04/27	21 ± 4[c]	0.02[b][f]
Graham, Sylvester	04/28	−2.0 ± 1.8	N/A
Hartfield, Ray	04/28	−2.8 ± 3.8	N/A[b][g]
Moree, Rita-House Well	04/28	Not Sampled - Moved, Well Down	
Beach, Donald	04/27	Not Sampled - Moved, Well Down	
Powers, Sharon	04/29	13 ± 2[c]	0.01
Rushing, Debra	04/28	27 ± 2[c]	0.03
Saul, Lee L.	04/28	0.0 ± 1.7	N/A
Smith, E. J.	04/28	18 ± 4[c]	0.02[b]
Smith, Howard	04/28	1.5 ± 2.2	N/A
Smith, Howard-Pond	04/29	12 ± 3[c]	0.01
Thompson, Roswell	04/28	28 ± 5[c]	0.03[b][h]
Well 2 City	04/29	2.2 ± 2.0	N/A
Purvis, MS			
Burge Willie Ray and Grace	04/27	15 ± 3[c]	0.02
City Supply	04/27	2.9 ± 1.8	N/A
Gil, Ray-House Well	04/27	−2.9 ± 1.6	N/A

* = Activity is greater than the minimum detectable concentration (MDC)
N/A = Not applicable; Percent of concentration guide is not applicable either because the tritium result is less than the MDC or because the water is know to be nonpotable
(a) = Established by DOE Order as 90,000 pCi/L tritium
(b) = Formerly the residence of Talmadge S. Saucier
(c) = New sampling location
(d,e,f,g) = Additional analyses greater than MDC:

	Analysis	Result	1 sigma	MDC	Units
(d)	U-234	0.038	0.012	0.026	pCi/L
	U-238	0.021	0.007	0.010	pCi/L
(e)	U-238	0.018	0.009	0.014	pCi/L
(f)	U-234	0.099	0.018	0.036	pCi/L
	U-238	0.057	0.011	0.009	pCi/L
(g)	U-234	0.14	0.02	0.01	pCi/L
	U-238	0.12	0.02	0.01	pCi/L