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Off-Site Environmental Monitoring Report

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Radiation Monitoring Around United States Nuclear Test Areas, Calendar Year 1988

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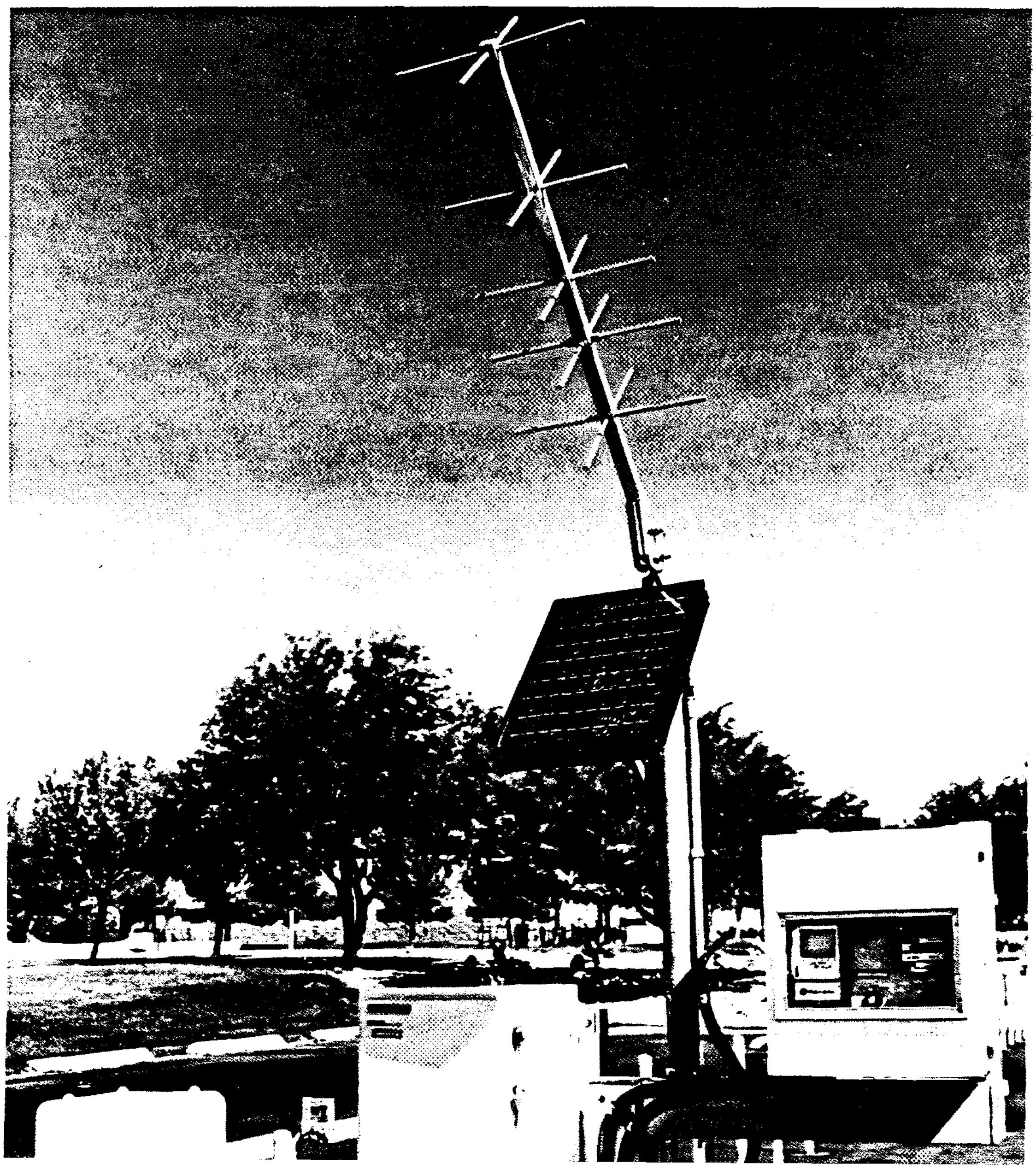

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Off-Site Environmental Monitoring Report

Radiation Monitoring Around United States Nuclear Test Areas, Calendar Year 1988

contributors

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NOTICE

ERRATA

On pages 48, 49, and 50 the "æ" character in the columns should be replaced by the "±" symbol.

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LIST OF ABBREVIATIONS, ACRONYMS, AND CONVERSIONS

ABBREVIATIONS

ALARA	--	As Low as Reasonably Achievable
ALI	--	Annual Limits of Intake
ASN	--	Air Surveillance Network
AVG	--	Average
Bq	--	Becquerel, one disintegration per second
CFR	--	Code of Federal Regulations
CG	--	Concentration Guide
Ci	--	Curie
CMS	--	Community Monitoring Station
CP-1	--	Control Point One
CY	--	Calendar Year
d	--	day
DAC	--	Derived Air Concentration
DOE	--	U.S. Department of Energy
DOE/NV	--	Department of Energy, Nevada Operations Office
DQO	--	Data Quality Objectives
DRI	--	Desert Research Institute
EML	--	Environmental Monitoring Laboratory
EMSL-LV	--	Environmental Monitoring Systems Laboratory, Las Vegas
EPA	--	U.S. Environmental Protection Agency
eV	--	electron volt
g	--	gram
Gy	--	Gray, equivalent to 100 rad (1 J/kg)
GZ	--	Ground Zero
hr	--	hour
HTO	--	tritiated water
L	--	liter
LTHMP	--	Long-Term Hydrological Monitoring Program
m	--	meter
mL	--	milliliter
MDC	--	Minimum Detectable Concentration
MSL	--	Mean Sea Level
MSN	--	Milk Surveillance Network
NIST	--	National Institute of Standards and Technology
NGTSN	--	Noble Gas and Tritium Surveillance Network
NNE	--	North-Northeast
NNW	--	North-Northwest
NRD	--	Nuclear Radiation Assessment Division
NTS	--	Nevada Test Site
Pa	--	Pascal - unit of pressure
PIC	--	Pressurized ion chamber
QA	--	Quality Assurance
QC	--	Quality Control
R	--	Roentgen

continued

ABBREVIATIONS (Continued)

rad	--	unit of absorbed dose, 100 ergs/g
rem	--	dose equivalent, the rad adjusted for biological effect
SD	--	Standard deviation
SI	--	International System of Units
SOP	--	Standard Operating Procedure
Sv	--	Sievert, equivalent to 100 rem
TLD	--	thermoluminescent dosimeter
WHO	--	World Health Organization

PREFIXES

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

CONVERSIONS

Multiply	by	To Obtain
Concentration Guides		
Ci/mL	10^{9}	pCi/L
Ci/mL	10^{12}	pCi/m3
SI Units		
rad	10^{-2}	Gray (Gy = 1 Joule/kg)
rem	10^{-2}	Sievert (Sv)
pCi	0.037	Becquerel (Bq)

1.0 Abstract

This report describes the Off-Site Radiation Safety Program conducted during 1988 by the Environmental Protection Agency's (EPA's) Environmental Monitoring Systems Laboratory-Las Vegas (EMSL-LV). This laboratory operates an environmental radiation monitoring program in the region surrounding the Nevada Test Site (NTS) and at former test sites in Alaska, Colorado, New Mexico, and Mississippi. The surveillance program is designed to detect and document any changes in radiation levels in the environs of nuclear test areas and to take the actions needed to protect the health and well-being of the public in the event of any accidental release of radioactive contaminants. Information presented in this report includes the following results and interpretation of data for 1988: the measurement of external exposure using thermoluminescent dosimeters (TLDs) and pressurized ion chambers (PICs); air surveillance including radioactive particulates, noble and reactive gases, and tritium; long-term hydrological monitoring; milk surveillance; and the biological monitoring of both animals and humans. Comparison of the measurements and sample analysis results with background levels and with appropriate standards and regulations indicated that no significant radioactivity, of recent NTS origin, was detected off site by the various EPA monitoring networks and there was no significant exposure to the population living in the vicinity of the NTS. The major contribution to population exposure came from naturally occurring background radiation which yielded approximately 85 mrem/yr and worldwide fallout which accounted for about 0.14 mrem/yr.

2.0 Introduction

The U.S. Atomic Energy Commission used the Nevada Test Site, between January 1951 and January 1975, for conducting nuclear weapons tests, nuclear rocket engine development, nuclear medicine studies, and for other nuclear and non-nuclear 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 Nevada Test Site 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 for the above ground and shallow underground tests of Operation Sunbeam and in cratering experiments conducted under the Plowshare program between 1962 and 1968.

Prior to 1954, an off-site 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. Since 1970, the EPA has provided an off-site Radiological Safety Program, both in Nevada and at other nuclear test sites, under interagency agreements with the DOE or its predecessor agencies.

Since 1954, the objectives of the off-site radiation surveillance program have included: the measurement and documentation of the levels and trends of any radiation or radioactive contaminants in the environment in the vicinity of atomic testing areas; and the determination as to whether the testing is in compliance with radiation protection standards, guidelines, and regulations. Off-site levels of radiation and radioactivity are assessed by sampling air and water; by measurements using pressurized ion chambers and thermoluminescent dosimeters; by sampling milk, food crops and other vegetation, soil, and animals; and by biological assay procedures.

Personnel with mobile monitoring equipment are placed in areas downwind from the test site before each test to provide immediate radiation measurements; to obtain environmental samples; and to initiate any action needed to protect the public if radioactive contamination of the off-site area should occur. Aircraft are also available to rapidly monitor and sample any releases from a test. Monitoring data obtained by the aircraft crew immediately after a test can be used to position radiation monitors on the ground. Data from the aircraft may also be used to estimate the amount of activity released and the diffusion, dispersion, and distribution of any airborne radioactive contaminants.

Beginning with operation Upshot-Knothole in 1953, a report, summarizing the monitoring data obtained from each test series, was published by the U.S. Public Health Service. 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 off-site area. Publication of summary data for each six-month period was initiated in 1964. In 1971, the Atomic Energy Commission implemented a requirement, 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. Sixteen annual reports were published by the Environmental Protection Agency between 1971 and 1987. During 1988, Order 5481.1 was superseded by the General Environmental Protection Program Requirements (Order 5400.1) (DOE88) of the Department of Energy. This is the first annual report prepared in accordance with the new order. It summarizes the radiation monitoring activities of the U.S. Environmental Protection Agency in the vicinity of the Nevada Test Site and at former nuclear testing areas in the United States. Included in this report are descriptions of the pertinent features of the Nevada Test Site and its environs; summaries of the dosimetry and sampling methods; a delineation of analytical and quality control procedures; and the results of environmental measurements. Where applicable, dosimetry and analytical data are compared with appropriate standards and guidelines for the external and internal exposure of humans to ionizing radiation.

Although written to meet the terms of the interagency agreement between the Environmental Protection Agency and the Department of Energy as well as the requirements of Order 5400.1, the data and information contained in this report also should be of interest and use to the citizens of Nevada, Utah and California who live in the downwind areas of the Nevada Test Site; to state, federal, and local agencies involved in protecting the environment and the health and well-being of the public; to individuals and organizations concerned with environmental quality and the possible release of radioactive contaminants into the biosphere; and to scientists and students interested in the natural radiation environment, population dosimetry, or environmental monitoring.

3.0 Summary

Purpose

"EPA is charged by Congress to protect the nation's land, air and water systems." (EPA89). This policy applies to radioactive contamination of the biosphere and accompanying radiation exposure of the population. To accomplish this and in agreement with the DOE policy of keeping radiation exposure of the general public as low as reasonably achievable (ALARA), the EPA's Environmental Monitoring Systems Laboratory in Las Vegas conducts an Off-Site Radiological Safety Program around the DOE's Nevada Test Site. This program is conducted under an Interagency Agreement between EPA and DOE. The main activity at the NTS is testing of nuclear devices, however, other related projects are conducted as well.

The principle activities of the Off-Site Radiological Safety Program are: routine environmental monitoring for radioactive materials in various media and for radiation in areas which may be affected by nuclear tests, and protective actions in support of the nuclear testing program. These activities are conducted to document compliance with standards, to identify trends, and to provide information to the public. This report summarizes these activities for the calendar year of 1988.

In 1988 the Air Surveillance Network (ASN) consisted of 31 continuously operating sampling stations surrounding the NTS and 78 standby stations (operated one or two weeks each quarter) in all states west of the Mississippi River. During 1988, no airborne radioactivity related to current nuclear testing at the NTS was detected on any sample from the ASN. Other than naturally occurring ^{7}Be the only activity detected by this network was ^{238}Pu and ^{239}Pu from worldwide fallout.

The Noble Gas and Tritium Surveillance Network (NGTSN) consisted of 18 stations off site (off the NTS and exclusion areas) in 1988. No NTS-related radioactivity was detected at any off-site station by this network. As in previous years, radioxenon and tritium levels in samples from the off-NTS stations were generally below the minimum detectable concentration (MDC).

The Long Term Hydrological Monitoring Program (LTHMP) involves the analysis of ground and surface water samples from sites of nuclear tests. These wells and surface water showed only background radionuclide concentrations except for those wells that had detectable activity in previous years or those that had been spiked with radionuclides for hydrological tests.

The Milk Surveillance Network (MSN) consisted of 29 locations within 300 kilometers of the NTS and 102 standby locations throughout the western United States. Strontium-89 above the minimum detectable activity was found in one MSN sample. One of the standby samples collected in Minnesota had detectable ^{137}Cs. Tritium concentrations in milk were at background levels. Strontium-90 from worldwide fallout from atmospheric testing continued the slow downward trend documented over the past several years.

Other foods are analyzed regularly, most of which are meat from domestic or game animals. The radionuclide most frequently found in the edible portion of the sampled animals is ^{137}Cs. However, its concentration has been near the MDC since 1968. Strontium-90 in samples of animal bone remain at very low levels as does ^{239}Pu in both bone and liver samples.

External Exposure

External exposure is monitored by a network of TLDs at 154 fixed locations surrounding the NTS and by TLDs worn by 61 off-site residents. With one exception, there were no exposures above natural background when tests for statistical significance of variation were applied. This net exposure above natural background was at Warm Springs, NV, and was determined to be due to higher levels of naturally occurring radioactivity in the ground water at that location (see Section 5.2.6). The range of background exposures measured, varied with altitude and soil constituents, is similar to the range of such exposures found in other areas of the U.S.

Dose Assessment

The maximum dose calculated for an adult living in Nevada using the radionuclides measured in samples collected by the monitoring networks would have been about 0.1 μrem (10^{-3} mSv) for 1988. No radioactivity originating on the NTS was detectable by the monitoring networks; therefore, no dose assessment can be made. However, based on the NTS releases reported in Table 2, atmospheric dispersion calculations (AIRDOS/EPA) indicate that the highest individual dose would have been 0.01 μrem (10^{-4} μSv), and the dose to the population within 80 km of Control Point One (CP-1) would have been 4.7×10^{-5} person-rem (4.7×10^{-7} person-Sv). The person receiving the highest dose was also exposed to 138 mrem from natural background radiation.

In the unlikely event that a certain mule deer had been collected by a hunter rather than by EPA personnel, that hunter could have received a dose equivalent of 100 mrem (1.0 mSv) if he ate all the liver and meat from the deer.

Internal Exposure

Internal exposure is assessed by whole body counting, using a single germanium detector, lung counting using semi-planar detectors and bioassay using radiochemical procedures. In 1988, counts were made on 188 individuals from the following: 100 off-site areas around the Nevada Test Site, EMSL-LV Laboratory, EG&G facilities throughout the United States, five DOE contractors and members of the general public concerned about possible radiation exposure. No nuclear test related radioactivity was detected. In addition, physical examinations of the off-site residents revealed a normally healthy population consistent with the age and sex distribution of that population.

Community Monitoring Stations (CMS)

The Community Monitoring Stations are operated for the Environmental Protection Agency, Department of Energy and the Desert Research Institute by local residents. Fifteen of the eighteen CMS became operational in 1982, the sixteenth, seventeenth and eighteenth in 1988. Each station is an integral part of the Air Surveillance Network (ASN), Noble Gas and Tritium Surveillance Network (NGTSN), and Thermoluminescent Dosimetry (TLD) network, in addition they are equipped with a Pressurized Ion Chamber (PIC) connected to a gamma rate recorder, and a microbarograph. Samples and data from these stations are analyzed and reported by the EPA at EMSL-LV. Data is also interpreted and reported by Desert Research Institute, University of Nevada. Data from these stations are reported herein as a part of the networks in which they participate. All measurements for 1988 were within the normal background range for the United States.

4.0 Description of the Nevada Test Site

A. N. Jarvis

The principle activity at the Nevada Test Site (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. Thus, the major activity of the EPA's Off-Site Radiological Safety Program is radiation monitoring around the NTS. This section is included to provide readers with an overview of the climate, geology and hydrology, as well as with land uses, in this generally arid and sparsely populated area of the southwest. The information included should provide a better 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 subject, and the distances traveled by field monitors in collecting samples and maintaining equipment.

Location

The NTS is located in Nye County, Nevada, with its southeast corner about 90 km northwest of Las Vegas (Figure 1). It has an area of about 3,500 square km and varies from 40 to 56 km in width (east-west) and from 64 to 88 km in length (north-south). This area consists of large basins or flats about 900 to 1,200 m above mean sea level (MSL) surrounded by mountain ranges rising 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 provide a buffer zone between the test areas and public lands. This buffer zone varies from 24 to 104 km between the test area and land that is open to the public. Depending upon wind speed and direction, from 2 to more than 6 hours will elapse before any release of airborne radioactivity could pass over public lands.

Climate

The climate of the NTS and surrounding area is variable, due to its wide range in altitude and its rugged terrain. Generally, the climate is referred to as continental arid. Throughout the year, there is insufficient water to support the growth of common food crops without irrigation.

Climate may be classified by the types of vegetation indigenous to an area. According to Houghton et al. (HO75), this method of classification of dry condition, developed by Doppen, is further subdivided on the basis of temperature and severity of drought. Table 1 (HO75) summarizes the characteristics of climatic types for Nevada.

According to Quiring (QU68), the NTS average annual precipitation ranges from about 10 cm at the lower elevations to around 25 cm on 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 high (low) temperatures at the lower altitudes are around 50°F (25°F) in January and 95°F (55°F) in July, with extremes of 120°F and -15°F. Corresponding temperatures on the plateaus are 35°F (25°F) in January and 80°F (65°F) in July with extremes of 115°F and -30°F.

The wind direction, as measured on a 30 m tower at an observation station about 9 km NNW of Yucca Lake, is predominantly northerly except during the months of May through August when winds from the south-southwest predominate (QU68). 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 have only a slight edge 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.

Geology and Hydrology

Two major hydrologic systems shown in Figure 2 exist on the NTS (ERDA77). Ground water in the northwestern part of the NTS or in the Pahute Mesa area flows at a rate of 2 m 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 moves from north to south at a rate of not less than 2 m nor greater than 220 m per year. Carbon-14 analyses of this eastern ground water indicate that the lower velocity is

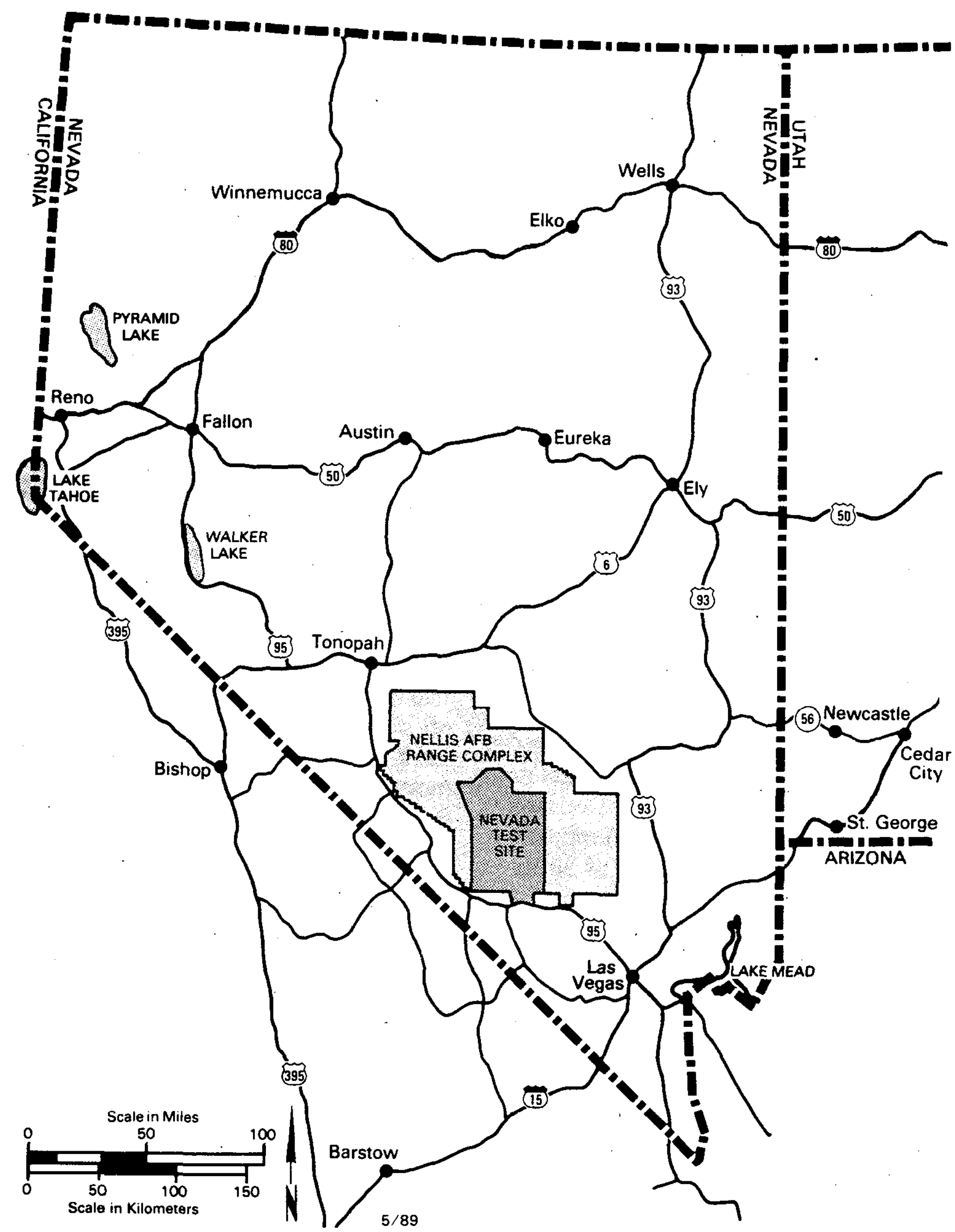

Figure 1. Location of the Nevada Test Site (NTS).

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

Climate Type	Mean Temperature °C (°F) Winter	Summer	Annual Precipitation cm (inches) Total*	Snowfall	Dominant Vegetation	% of Area
Alpine tundra	-18° to -9° *(0° to 15°)*	4° to 10° *(40° to 50°)*	38 to 114 *(15 to 45)*	Medium to heavy	Alpine meadows	--
Humid continental	-12° to -1° *(10° to 30°)*	10° to 21° *(50° to 70°)*	64 to 114 *(25 to 45)*	Heavy	Pine-fir forest	1
Subhumid continental	-12° to -1° *(10° to 30°)*	10° to 21° *(50° to 70°)*	30 to 64 *(12 to 25)*	Moder-ate	Pine or scrub woodland	15
Mid-latitude steppe	-7° to 4° *(20° to 40°)*	18° to 27° *(65° to 80°)*	15 to 38 *(6 to 15)*	Light to moderate	Sagebrush, grass, scrub	57
Mid-latitude desert	-7° to 4° *(20° to 40°)*	18° to 27° *(65° to 80°)*	8 to 20 *(3 to 8)*	Light	Grease-wood, shadscale	20
Low-latitude desert	-4° to 10° *(40° to 50°)*	27° to 32° *(80° to 90°)*	5 to 25 *(2 to 10)*	Neglig-ible	Creosote bush	7

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

nearer the true value. At Mercury Valley in the extreme southern part of the NTS, the eastern ground water flow shifts south-westward toward the Ash Meadows Discharge Area.

Land Use of NTS Environs

Figure 3 is a map of the off-NTS area showing a wide variety of land uses, such as farming, mining, grazing, camping, fishing, and hunting within a 300-km radius of the NTS. For example, west of the NTS, elevations range from 85 m below MSL in Death Valley to 4,420 m above MSL in the Sierra Nevada Range. Parts 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 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 the State within 300 km of the NTS Control Point-1 (CP-1). Many of the residents grow or have access to locally grown fruits and vegetables.

Many recreational areas, in all directions around the NTS (Figure 3) are used for such activities as hunting, fishing, and camping. In general, the camping and fishing sites to the northwest, north, and northeast of the NTS are utilized throughout the

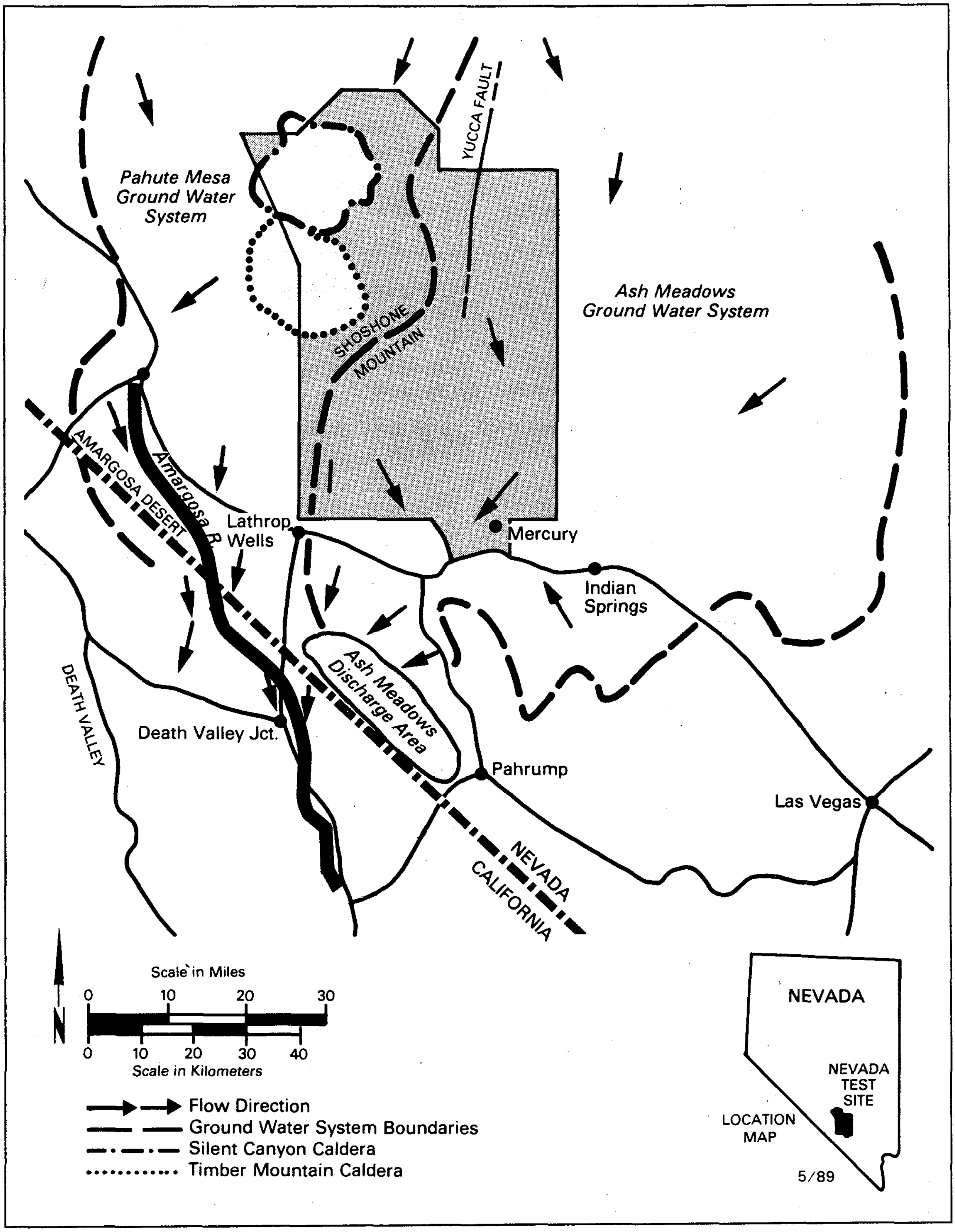

Figure 2. Ground Water Flow Systems Around the Nevada Test Site

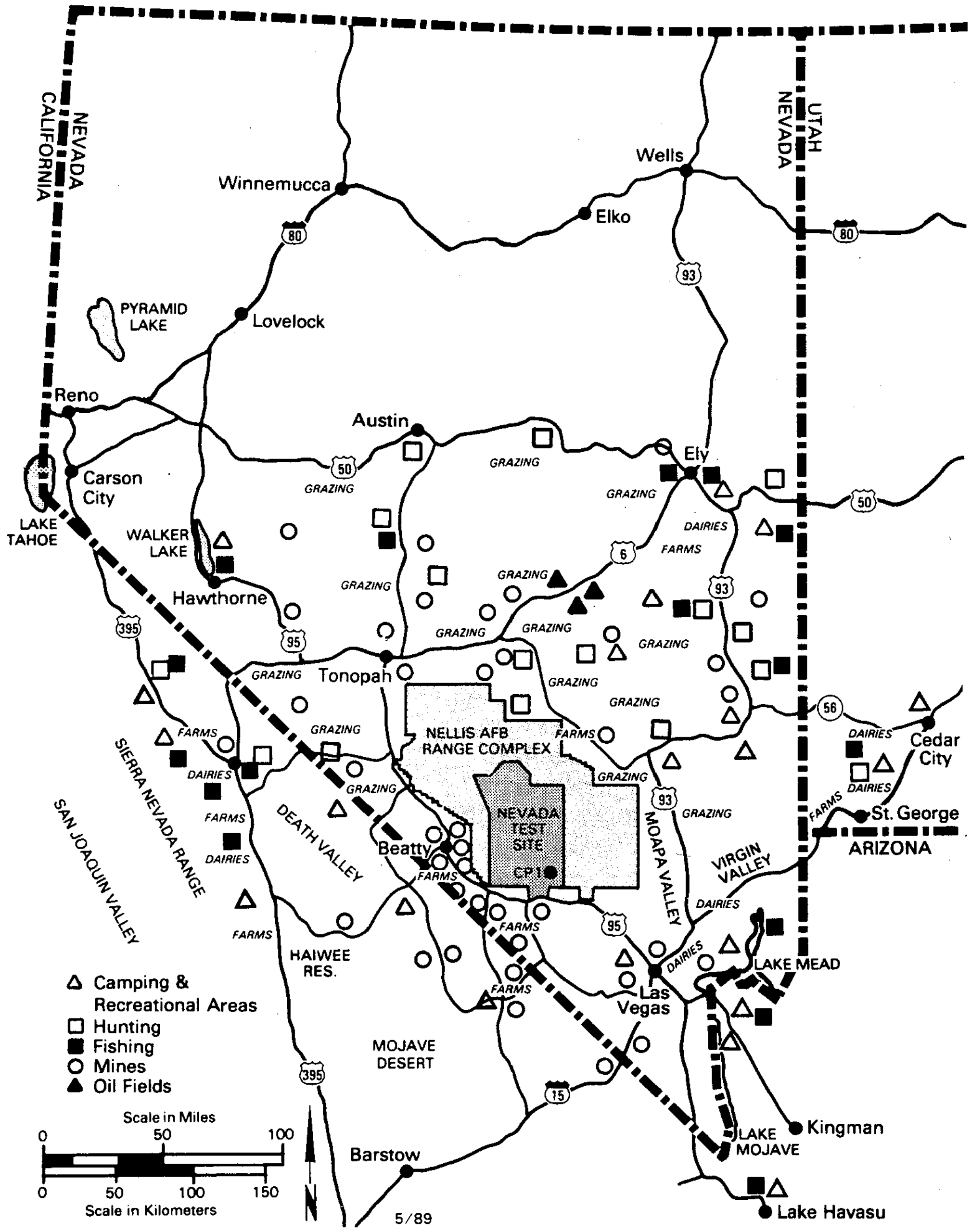

Figure 3. General Land Use Within 300 km of the Nevada Test Site.

year except for the winter months. Camping and fishing locations to the southeast, south, and southwest are utilized throughout the year. The hunting season is from September through January.

Population Distribution

Figure 4 shows the current population of counties surrounding the NTS based on 1986 Bureau of Census estimates (DOC86). Excluding Clark County, the major population center (approximately 569,500 in 1986), the population density within a 150 km radius of the NTS is about 0.5 persons per square kilometer. For comparison, the 48 contiguous states (1980 census) had a population density of approximately 29 persons per square kilometer. The estimated average population density for Nevada in 1980 was 2.8 persons per square kilometer.

The off-site area within 80 km of CP-1 (the 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 the Pahrump Valley. This growing rural community, with an estimated population of about 6,000 is located about 72 km south of the NTS CP-1. The Amargosa Farm Area, which has a population of about 1,200, is located about 50 km southwest of CP-1. The largest town in the near off-site area is Beatty, which has a population of about 2,000 and is located approximately 65 km to the west of CP-1. A report by Smith and Coogan (EPA84) was published in 1984 which summarized the population distribution within selected rural areas out to 200 kilometers from the Control Point on the NTS.

The Mojave Desert of California, which includes Death Valley National Monument, lies along the southwestern border of Nevada. The National Park Service (NPS80) 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 and 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 the month of November. The largest town and contiguous populated area (about 40 square miles) in the Mojave Desert is Barstow, located 265 km south-southwest of the NTS, with a 1986 population of about 20,250. The next largest populated area is the Ridgecrest-China Lake area, which has a current population of about 25,000 and is located about 190 km southwest of the NTS. The Owens Valley, where numerous small towns are located, lies about 50 km west of Death Valley. The largest town in Owens Valley is Bishop, located 225 km west-north-west of the NTS, with a population of about 3,500.

The extreme southwestern region of Utah is more developed than the adjacent part of Nevada. The largest community is St. George, located 220 km east of the NTS, with a population of 19,800. The next largest town, Cedar City, with a population of 12,380, is located 280 km east northeast of the NTS.

The extreme northwestern region of Arizona is mostly range land except for that portion in the Lake Mead Recreation Area. In addition, several small communities lie along the Colorado River. The largest towns in the area are Bullhead City, 165 km south-southeast of the NTS, with a 1986 population estimate of 18,740 and Kingman, located 280 km southeast of the NTS, with a population of about 10,760. Figures 5 through 8 show the domestic animal populations in the counties near the NTS.

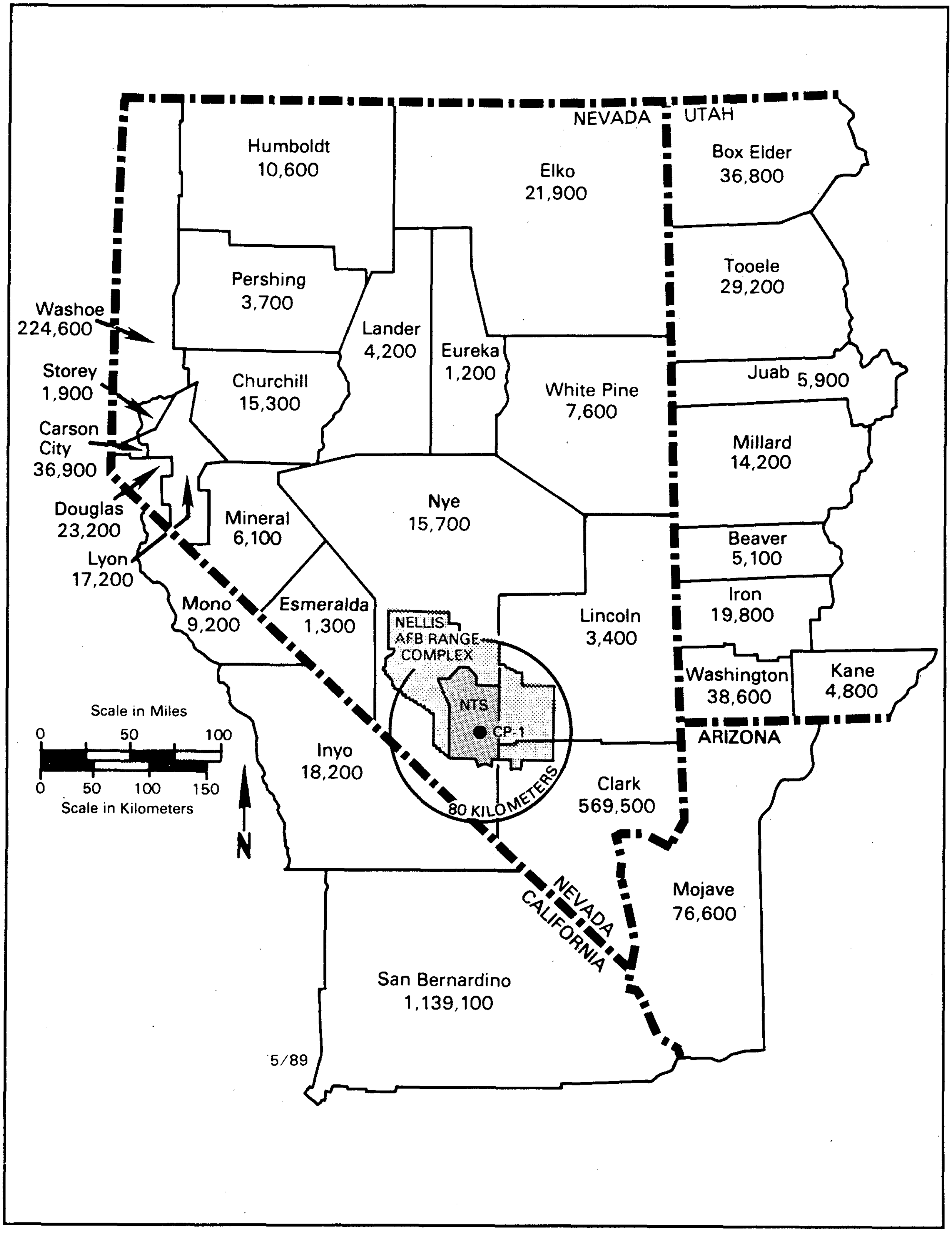

Figure 4. Population of Arizona, California, Nevada and Utah Counties Near the Nevada Test Site (Based on 1986 Census Estimates).

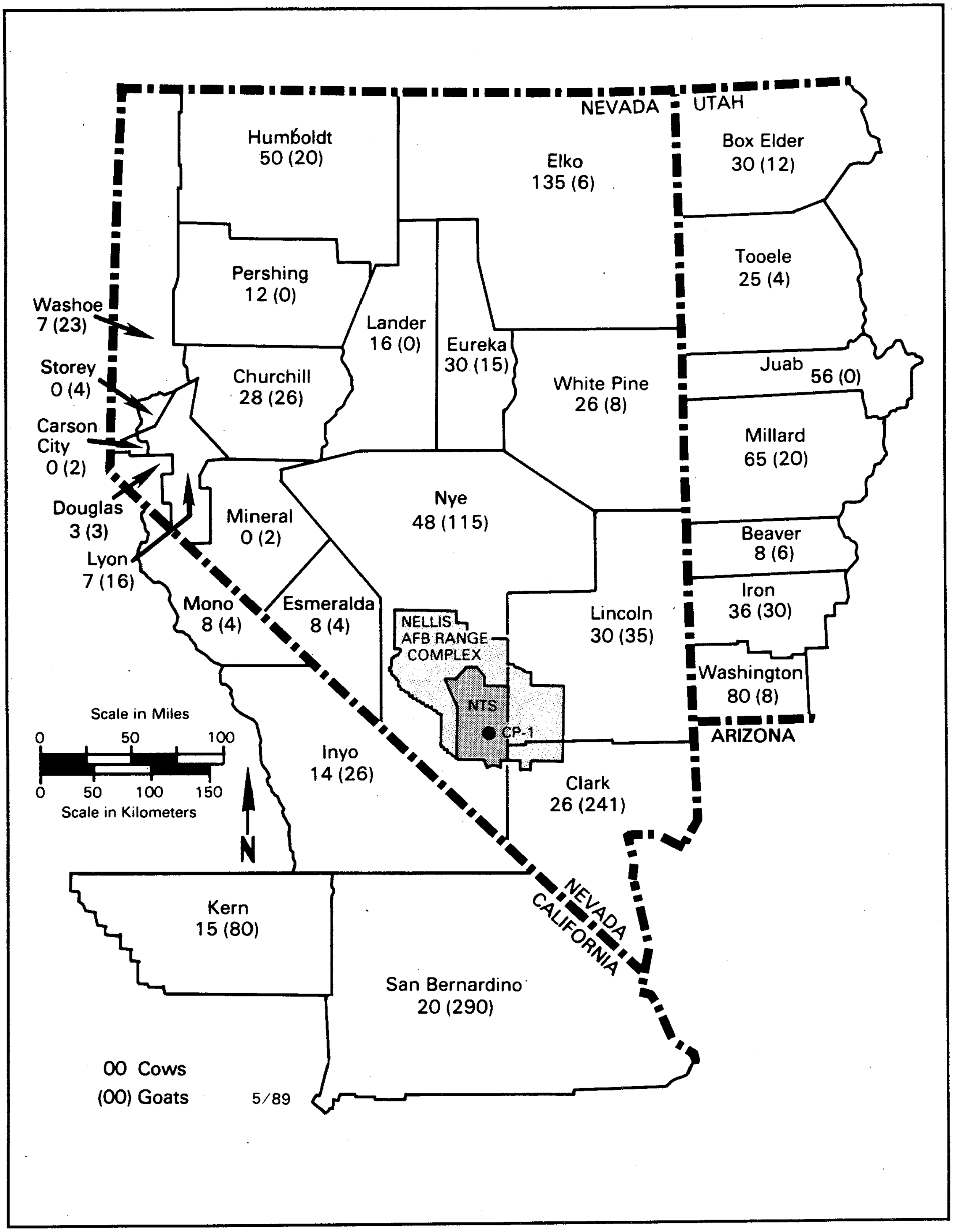

Figure 5. Distribution of Family Milk Cows and Goats, by County (1988).

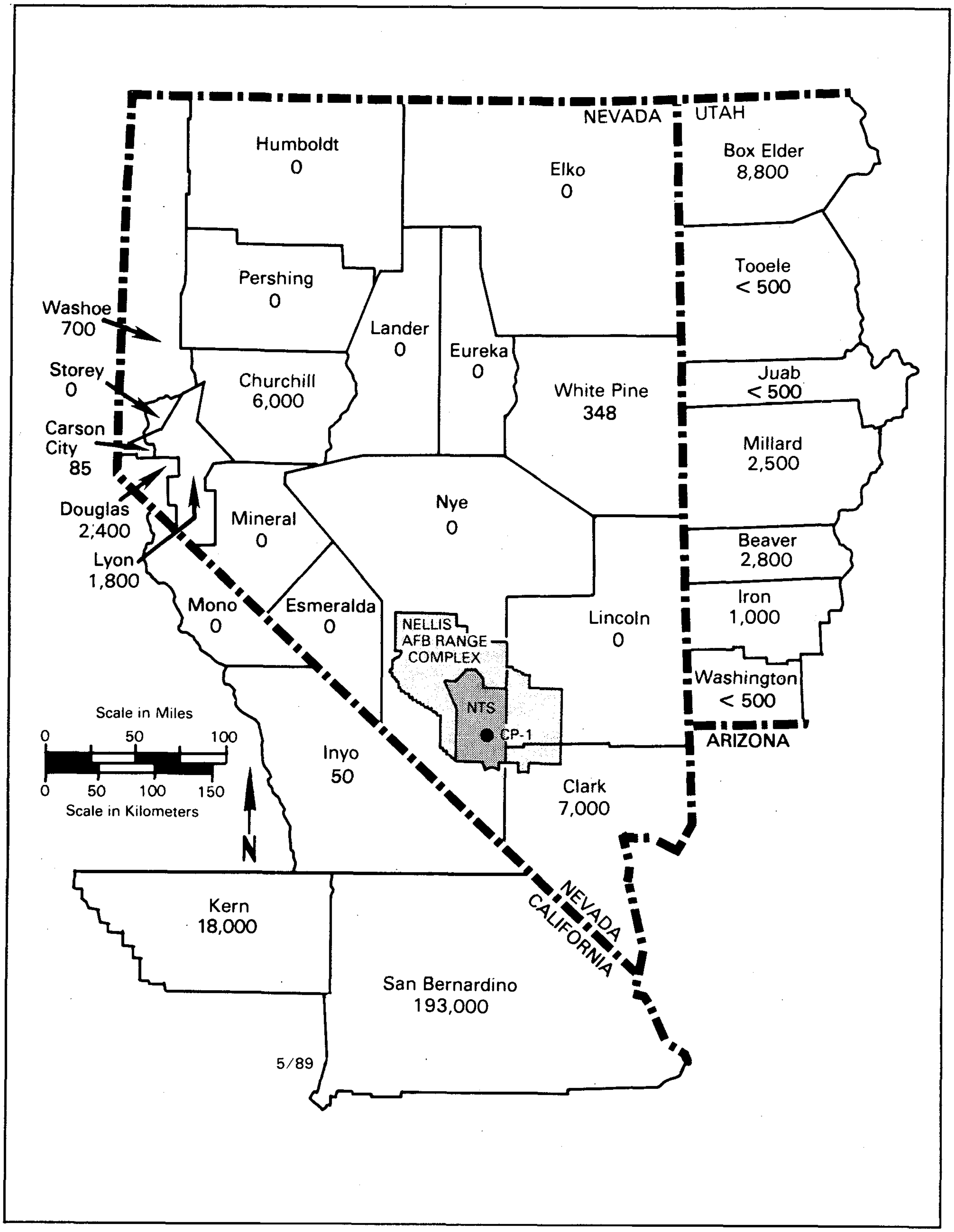

Figure 6. Distribution of Dairy Cows, by County (1988).

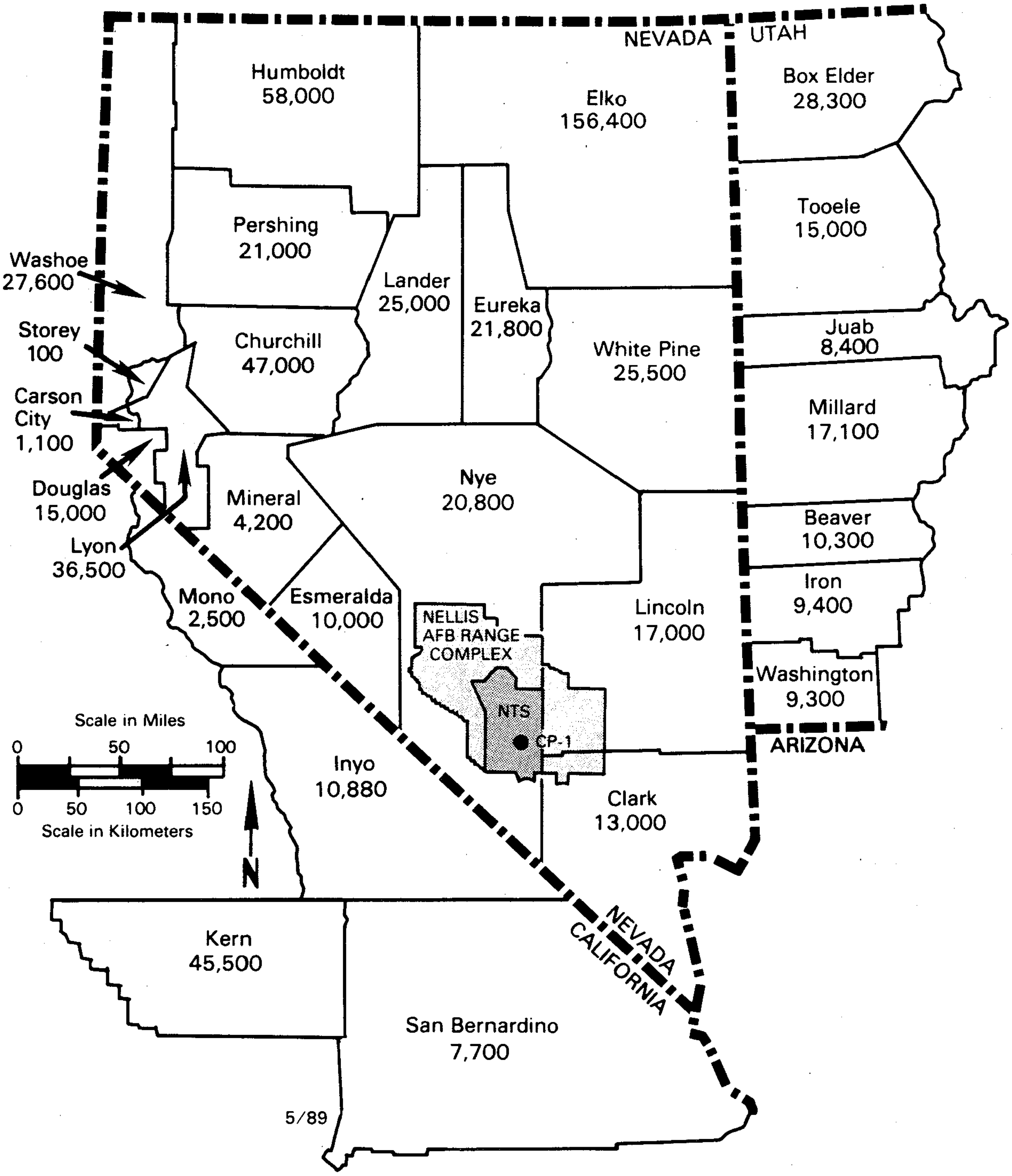

Figure 7. Distribution of Beef Cattle, by County (1988).

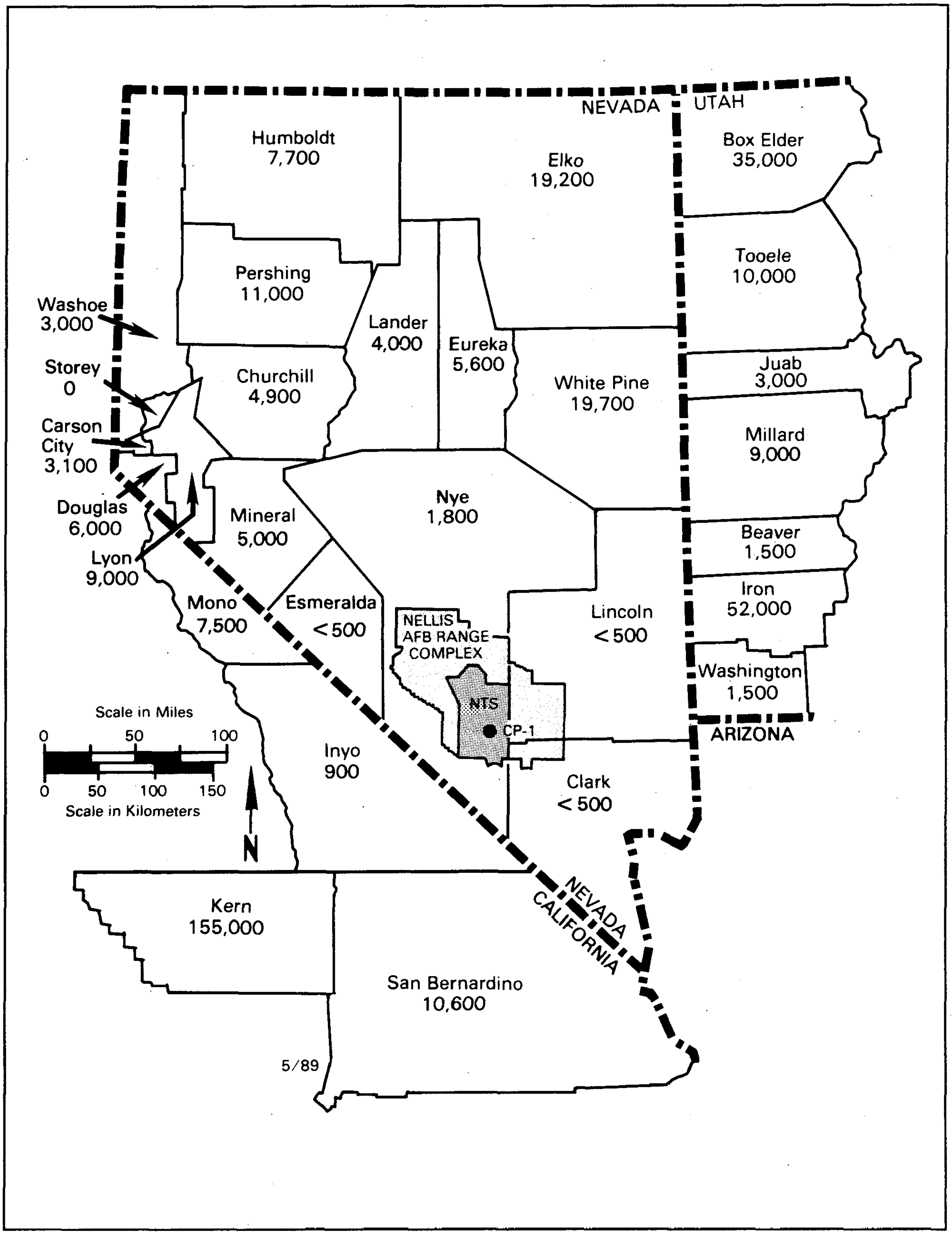

Figure 8. Distribution of Sheep, by County (1988).

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5.0 Radiological Safety Activities

The radiological safety activities of the EMSL-LV are divided into two major areas: special test support and routine environmental surveillance that includes pathways monitoring, internal and external exposure monitoring. Both of these activities are designed to detect any increase in environmental radiation which might cause exposure to individuals or population groups so that protective actions may be taken, to the extent feasible. These activities are described in the following portions of this report.

5.1 Special Test Support

C. A. Fontana

During all nuclear tests mobile monitoring teams are deployed around the NTS. They are prepared to assist in directing protective actions for off-site residents should that become necessary. Prior to the test they ascertain the locations of residents, work crews and domestic animal herds, and obtain information relative to residents in communities and remote areas. Monitors, equipped with radiation survey instruments, gamma exposure-rate recorders, TLDs, portable air samplers, and supplies for collecting environmental samples, are prepared to conduct a monitoring program as directed from the NTS CP-1 via two-way radio communications.

If an underground nuclear test is expected to cause ground motion detectable off site, then EPA monitors 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.

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

An EG&G cloud sampling and tracking aircraft is always flown over the NTS to obtain samples, assess total cloud volume and provide long range tracking in the event of a release of airborne radioactivity. A second aircraft is also flown to gather meteorological data and to perform cloud tracking. Information from these aircraft can be used in positioning the mobile radiation monitors.

During the calendar year of 1988, EMSL personnel were deployed for all underground nuclear tests conducted at the NTS, none of which released radioactivity that could be detected off site.

5.2 Routine Environmental Surveillance

Airborne Releases of Radioactivity at the NTS During 1988

S. C. Black

All nuclear detonations during 1988 were conducted underground and were contained. Releases of low-level radioactivity occurred during re-entry drilling, seepage through fissures in the soil or purging of tunnel areas. Table 2 shows the total quantities of radionuclides released to the atmosphere, as reported by the DOE Nevada Operations Office (DOE89). Because these releases occurred throughout the year and because of the distance from the points of releases to the nearest off-site sampling station, none of the radioactive material listed in this table was detected off site.

To detect any radioactivity that might escape from the NTS, including that listed in Table 2, a routine surveillance program is conducted. This program includes pathways monitoring that consists of air, water, and milk surveillance networks surrounding

Table 2 Total Airborne Radionuclide Emissions at the NTS During 1988

Radionuclide	Half-Life (days)	Quantity Released (Ci)
^{3}H	4511	68.2
^{131}I	8.04	3.2×10^{-5}
^{133}I	0.86	1.1×10^{-4}
^{133}Xe	5.24	18.1
^{133m}Xe	2.19	0.44
^{135}Xe	0.38	8.0

the NTS and a limited animal sampling program. In addition, external and internal exposures of off-site populations are assessed using state-of-the-art dosimetry equipment. The following portions of this report detail the results of these surveillance programs.

5.2.1 Air Surveillance Network (ASN)

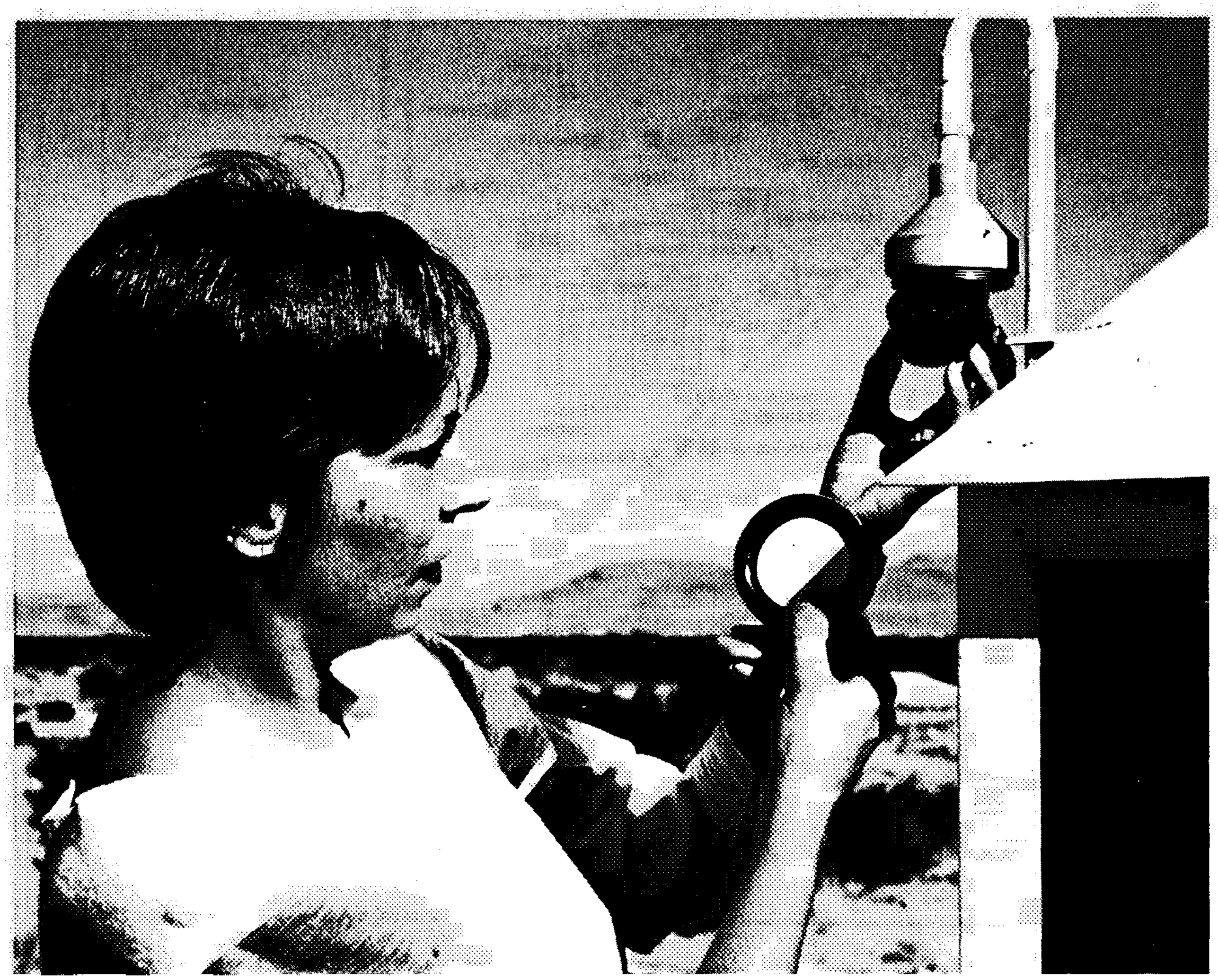
V. E. Niemann

Network Design

The ASN monitors an important route of human exposure to radionuclides, inhalation of airborne materials. The concentration and the source must both be determined if appropriate corrective actions are to be taken. The ASN is designed to monitor the areas within 350 km of the NTS with some concentration of stations in the prevailing downwind direction (Figure 9). Station location is dependent upon the availability of electrical power and, at stations distant from the NTS, of a resident willing to operate the equipment. This continuously operating network is supplemented by a standby network which covers the contiguous states west of the Mississippi river (Figure 10).

Methods

During 1988, the ASN consisted of 31 continuously operating sampling stations and 78 standby stations. The air sampler at each station was equipped to collect both particulate radionuclides on prefilters and reactive gases on charcoal cartridges. The prefilters and charcoal cartridges from all active stations were routinely analyzed. The prefilters from the standby stations were routinely



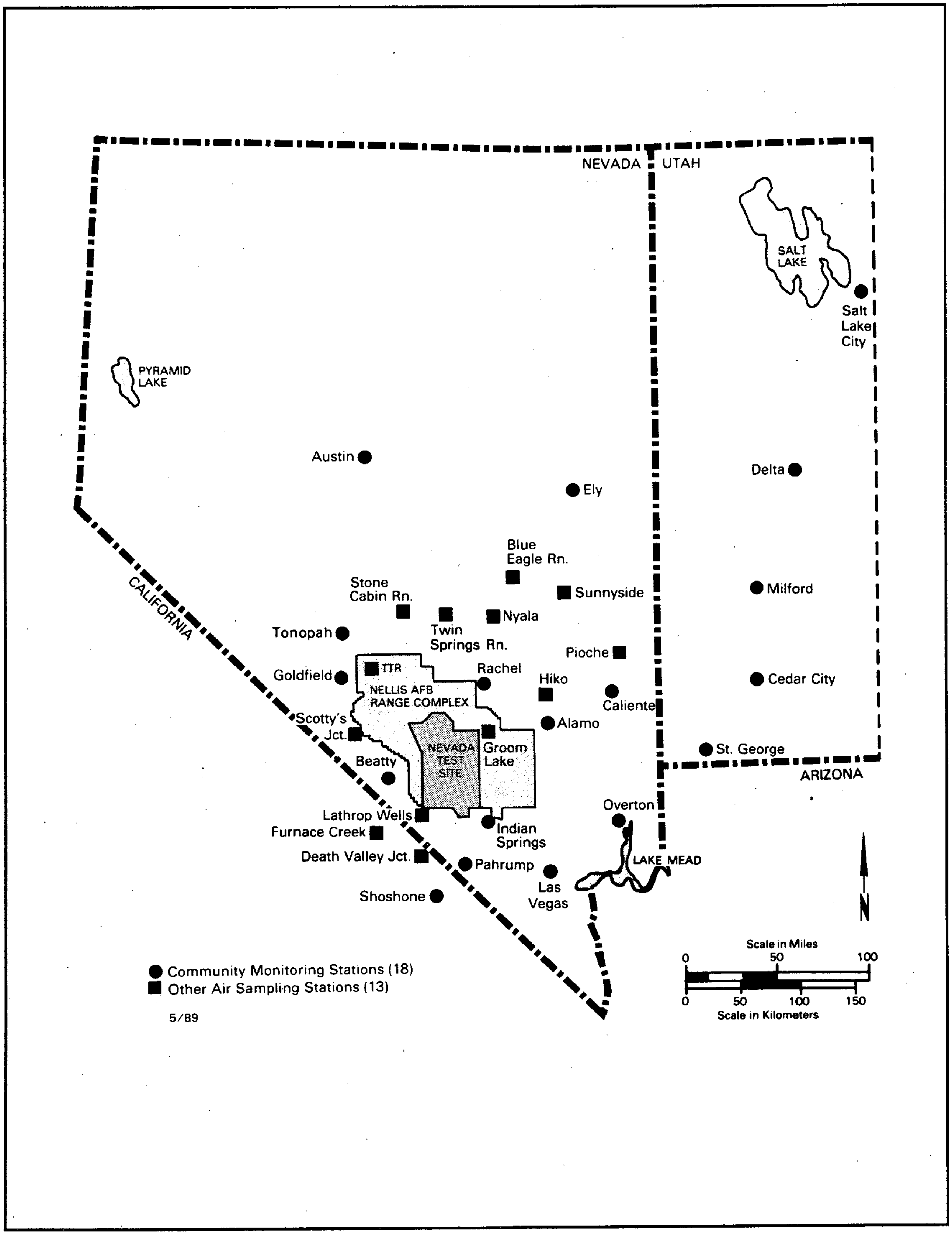


Figure 9. Air Surveillance Network Stations (1988).

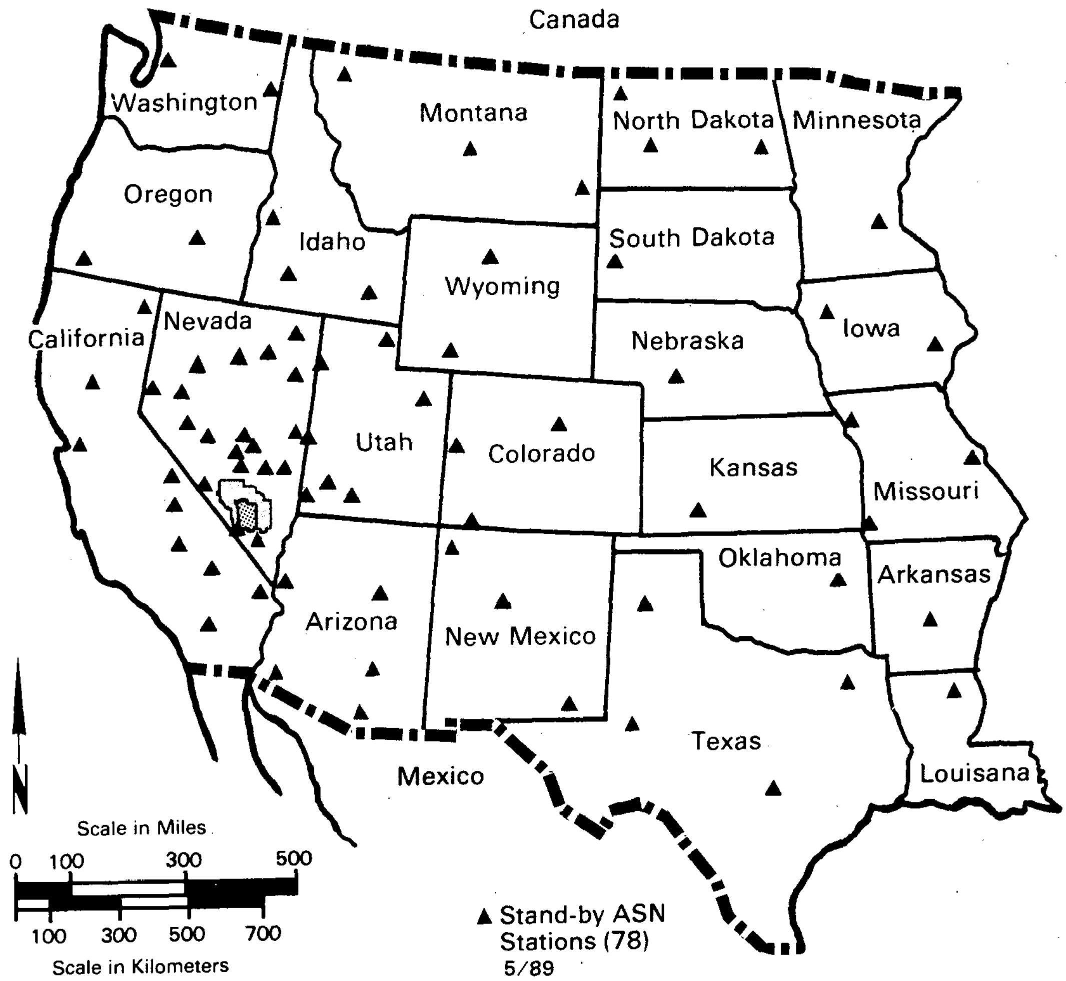


Figure 10. Standby Air Surveillance Network Stations (1988).

analyzed; the charcoal cartridges from the standby stations were not routinely analyzed.

Samples of airborne particulates were collected at each active station on 5-cm diameter glass-fiber filters at a flow rate of 82 m^3 per day. Filters were changed after sampler operation periods of two to three days (160 to 250 m^3). Activated charcoal cartridges placed directly behind the filters to collect gaseous radioiodine were changed at the same time as the filters. The standby network was activated for one week per quarter at most locations. The standby samplers were identical to those used at the active stations and were operated by state and municipal health department personnel or by other local residents. All analytical work was done at the EMSL-LV.

Results

During 1988, no airborne radioactivity related to current nuclear testing at the NTS was detected on any sample from the ASN. Throughout the network, ^7Be was the only nuclide detected by gamma spectroscopy. The principal means of ^7Be production is from spallation of ^{16}O and ^{14}N by cosmic rays in the atmosphere. Tables 3 and 4 summarize the data from the ASN samples. All time-weighted averages ("Wt-Avg" in the tables) are less than one percent of the Concentration Guide (see Section 10) for exposure to the general public. However, these guides do not apply to naturally occurring radionuclides.

Two additional analyses are performed on the samples from the ASN: a gross beta analysis of the filters from five stations, and ^{238}Pu and ^{239}Pu analysis of composited filters from fourteen Western states.

Once each quarter, the prefilters from selected stations are composited and analyzed for ^{238}Pu and ^{239}Pu. Those from the stations at Las Vegas, Lathrop Wells, and Rachel, Nevada, and Salt Lake City, Utah, are composited as monthly samples and submitted quarterly for analysis. The other samples consist of composited filters from two standby stations in each of fourteen states. The results of the ^{238}Pu and ^{239}Pu analyses are shown in Table 5. The January composite from Lathrop Wells, Nevada, yielded a ^{239}Pu result above the MDC (and greater than the 2-sigma error). The June composite from Rachel, Nevada, yielded results above the MDC (and greater than the 2-sigma error) for ^{238}Pu and ^{239}Pu. Because work done on the plutonium analytical procedure during the first quarter of 1988 produced an increased yield, an improved (lower) MDC was achieved. These very small amounts of plutonium may have been present over time but, until improved sensitivity was achieved, it was impossible to quantitate them.

The gross beta analysis is used to detect trends in atmospheric radioactivity since this analysis is more sensitive than gamma spectrometry for this purpose. For this study, five stations around the NTS are used. The three filters per week from each station are analyzed for gross beta activity after a seven day delay to decrease the contribution from naturally-occurring thoron daughter activity. The data suggest little significant difference among stations and indicate a relatively stable concentration compared to previous years. A summary of the data is shown in Table 6.

5.2.2 Noble Gas and Tritium Surveillance Network (NGTSN)

E. A. Thompson

Network Design

There are several sources for the radionuclides monitored by this network. Noble gases are emitted from nuclear power plants, propulsion reactors, reprocessing facilities, and nuclear explosions. Tritium is emitted from the same sources and is also produced naturally. The monitoring network will be affected by all these sources, but must be able to detect NTS emissions. As a part of the monitoring network, samplers are located around the NTS, particularly in drainage-wind channels leading from the test areas. Others are located farther from the test site and outside of drainage-wind channels to provide more complete coverage, especially for populated areas. In 1988 this network consisted of 18 stations as shown in Figure 11. This figure also shows the location of the temporary station operated at Mammoth Lakes, CA, during 1987 and 1988.

Methods

Samples of air are collected by directly compressing air into storage tanks. The equipment continuously samples air over a 7-day period and stores approximately 1 m^3 of air in two tanks. The tanks are exchanged weekly and returned to the

TABLE 3. Summary of analytical results for Air Surveillance Network

CONTINUOUSLY OPERATING STATIONS - 1988

Sampling Location	No. Days Detected /Sampled	Radio-Nuclide	Radioactivity Conc. (pCi/m^3) Max	Min	WT-Avg*
Death Valley Jct CA	37/335	^{7}Be	0.78	0.16	0.047
Furnace Creek CA	47/353	^{7}Be	1.6	0.15	0.079
Shoshone CA	13/348	^{7}Be	1.1	0.18	0.020
Alamo NV	7/346	^{7}Be	0.73	0.26	0.0096
Austin NV	28/349	^{7}Be	0.65	0.17	0.032
Beatty NV	18/352	^{7}Be	1.9	0.29	0.034
Caliente NV	9/303	^{7}Be	0.47	0.17	0.0098
Stone Cabin Ranch NV	8/342	^{7}Be	0.95	0.39	0.013
Blue Eagle Ranch NV	10/345	^{7}Be	0.93	0.33	0.014
Ely NV	8/350	^{7}Be	0.64	0.37	0.010
Goldfield NV	5/349	^{7}Be	0.55	0.26	0.0054
Groom Lake NV	26/357	^{7}Be	0.34	0.058	0.0082
Hiko NV	9/349	^{7}Be	0.57	0.24	0.011
Indian Springs NV	6/351	^{7}Be	0.61	0.23	0.0073
Las Vegas NV	9/352	^{7}Be	1.0	0.14	0.0088
Lathrop Wells NV	26/341	^{7}Be	0.52	0.099	0.018
Overton NV	6/348	^{7}Be	1.4	0.26	0.011
Pahrump NV	20/343	^{7}Be	1.5	0.22	0.036
Pioche NV	11/340	^{7}Be	0.86	0.24	0.015
Scotty's Jct NV	22/329	^{7}Be	0.82	0.20	0.030
Sunnyside NV	12/343	^{7}Be	1.1	0.43	0.022
Rachel NV	10/354	^{7}Be	0.49	0.24	0.010

(continued)

TABLE 3. (Continued)

Sampling Location	No. Days Detected /Sampled	Radio Nuclide	Radioactivity Conc. (pCi/m3) Max	Min	WT-Avg*
Tonopah NV	11/355	^{7}Be	0.68	0.23	0.013
TTR NV	63/238	^{7}Be	1.0	0.14	0.13
Fallini's (Twn Spgs) Ranch NV	11/351	^{7}Be	0.77	0.19	0.015
Cedar City UT	18/348	^{7}Be	0.68	0.29	0.026
Delta UT	26/344	^{7}Be	0.81	0.30	0.037
Milford UT	26/345	^{7}Be	0.67	0.21	0.029
St George UT	29/323	^{7}Be	1.0	0.28	0.062
Salt Lake City UT	27/344	^{7}Be	1.1	0.21	0.042

* Wt-Avg is a Time-Weighted Average over the location's entire sampling period.

The following station had negligible gamma-spectra:
Nyala NV (sampled for 353 days.)

TABLE 4. Summary of analytical results for Air Surveillance Network

STANDBY STATIONS - OPERATED 1 OR 2 WEEKS PER QUARTER - 1988

Sampling Location	No. Days Detected /Sampled	Radio-Nuclide	Radioactivity Conc. (pCi/m^3) Max	Min	WT-Avg*
Kingman AZ	6/28	^{7}Be	0.41	0.23	0.069
Alturas CA	2/28	^{7}Be	0.42	0.42	0.030
Bishop CA	3/28	^{7}Be	0.45	0.45	0.048
Indio CA	2/26	^{7}Be	0.035	0.035	0.0027
Ridgecrest CA	3/14	^{7}Be	0.22	0.22	0.050
Grand Jct CO	5/24	^{7}Be	0.24	0.24	0.025
Great Falls MT	3/28	^{7}Be	0.24	0.24	0.025
Currant NV - Angleworm Ranch	3/35	^{7}Be	0.64	0.64	0.054
Duckwater NV	26/26	^{7}Be	0.74	0.30	0.36
Desert Oasis Resort NV	5/7	^{7}Be	0.21	0.21	0.15
Round Mountain NV	2/24	^{7}Be	1.1	1.1	0.088
Carlsbad NM	2/21	^{7}Be	0.80	0.80	0.076
Shiprock NM	3/21	^{7}Be	0.69	0.69	0.098
Williston ND	4/22	^{7}Be	0.39	0.39	0.068
Burns OR	3/28	^{7}Be	0.59	0.59	0.063
Rock Springs WY	3/28	^{7}Be	0.43	0.43	0.046

* Wt-Avg is a Time-Weighted Average over the location's entire sampling period.

(continued)

TABLE 4. (Continued)

The following stations had negligible gamma-spectra: ( ) is number of days operated.

Globe AZ (27 days)
Tucson AZ (30 days)
Winslow AZ (26 days)
Yuma AZ (27 days)
Little Rock AR (20 days)
Baker CA (20 days)
Chico CA (29 days)
Lone Pine CA (28 days)
Needles CA (22 days)
Santa Rosa CA (28 days)
Cortez CO (21 days)
Denver CO (27 days)
Mountain Home ID (21 days)
Boise ID (28 days)
Pocatello ID (28 days)
Fort Dodge IA (32 days)
Iowa City IA (29 days)
Dodge City KS (28 days)
Monroe LA (28 days)
Minneapolis MN (28 days)
Clayton MO (28 days)
Joplin MO (28 days)
Kalispell MT (29 days)
Miles City MT (28 days)
North Platte NE (20 days)
Battle Mountain NV (20 days)
Blue Jay NV (9 days)
Currie NV - Currie Maintenance Station (19 days)
Elko NV - Phillips 66 Truck Stop (21 days)
Eureka NV (26 days)
Fallon NV (18 days)
Lovelock NV (14 days)
Lund NV (23 days)
Mesquite NV (27 days)
Reno NV (21 days)
Uhalde's Ranch NV (58 days)
Wells NV (19 days)
Winnemucca NV (21 days)
Albuquerque NM (21 days)
Bismarck ND (28 days)
Fargo ND (19 days)
Muskogee OK (20 days)
Medford OR (32 days)
Rapid City SD (21 days)
Amarillo TX (21 days)
Austin TX (21 days)
Midland TX (28 days)
Tyler TX (36 days)
Bryce Canyon UT (20 days)
Enterprise UT (35 days)
Garrison UT (16 days)
Logan UT (21 days)
Parowan UT (16 days)
Vernal UT (29 days)
Wendover UT (21 days)
Seattle WA (19 days)
Spokane WA (21 days)
Worland WY (26 days)

Table 5. Concentrations of ^{238}Pu and ^{239}Pu-Composited Air Samples - 1988

SAMPLING LOCATION	COLLECTION DATE 1988	CONC. ± 2 SIGMA ^{238}Pu (aCi/m^3)	CONC. ± 2 SIGMA ^{239}Pu (aCi/m^3)
AZ COMPOSITE (Winslow & Tucson)			
	03/09	-13 ± 25	-1.4 ± 7
	06/22	-1.6 ± 13	0 ± 7.6
	07/27	-0.5 ± 6.5	-5 ± 3.2
	11/02	-3.6 ± 39	-10 ± 15
CA COMPOSITE (Bishop & Ridgecrest)			
	02/24	5.3 ± 11	9.3 ± 10
	06/17	-4.3 ± 17	2.1 ± 10
	07/29	-7.5 ± 5.8	2.2 ± 19
	10/31	-38 ± 42	-5.5 ± 1.9
CO COMPOSITE (Denver & Cortez)			
	02/29	-4.3 ± 16	-1.0 ± 11
	06/22	-11 ± 29	-3.6 ± 16
	07/29	-1.1 ± 14	-4.3 ± 14
	12/12	-51 ± 36	-5.1 ± 17
ID COMPOSITE (Boise & Mountain Home)			
	03/14	0.5 ± 17	-3.3 ± 12
	06/29	-12 ± 32	0 ± 19
	07/29	-7.5 ± 5.7	-11 ± 7
	10/31	-26 ± 35	-8.7 ± 12
MO COMPOSITE (Clayton & Joplin)			
	02/29	-6.1 ± 11	LOST
	06/29	-19 ± 75	9.3 ± 43
	08/31	-8.9 ± 6.9	-13 ± 8
	11/22	NOT ANALYZED	NOT ANALYZED
MT COMPOSITE (Great Falls & Miles City)			
	02/29	-4.6 ± 8.6	-1.7 ± 6.1
	06/29	-8.7 ± 23	0 ± 13
	08/31	-0.8 ± 11	-8.2 ± 5.3
	12/14	-3.3 ± 2.5	-4.6 ± 3
NV COMPOSITE (Las Vegas)			
	01/29	0.2 ± 8.7	6.9 ± 7.5
	02/29	LOST	LOST
	03/30	-5.7 ± 15	0 ± 8.9

(continued)

Table 5. (Continued)

SAMPLING LOCATION	COLLECTION DATE 1988	CONC. ± 2 SIGMA ^{238}Pu (aCi/m^3)	CONC. ± 2 SIGMA ^{239}Pu (aCi/m^3)
	04/29	-1.5 ± 12	4.4 ± 6.9
	05/03	-1.2 ± 9.9	1.2 ± 5.7
	06/19	-4.3 ± 11	0 ± 6.7
	07/29	-0.6 ± 8.5	1.3 ± 12
	08/31	-0.2 ± 2.9	-2.2 ± 1.4
	09/30	6.2 ± 12	1.1 ± 10
	10/31	-9.1 ± 10	-1.3 ± 4.5
	11/30	-8.5 ± 11	0 ± 5.7
	12/30	-8.6 ± 11	-1.4 ± 5
NV COMPOSITE (LATHROP WELLS)			
	01/30	0 ± 14	27 ± 15**
	02/29	43 ± 72	6.1 ± 51
	03/30	-4.7 ± 18	-1 ± 13
	04/29	-2.5 ± 10	1.3 ± 5.8
	05/24	5.9 ± 12	7.4 ± 7.9
	06/29	3.2 ± 8.6	0 ± 4.9
	07/28	-3.3 ± 2.5	-1.9 ± 6.3
	08/31	0.9 ± 3.0	2.4 ± 4.3
	09/19	1.4 ± 4.9	-2.8 ± 1.8
	10/28	-3.8 ± 6.4	-1.5 ± 2.2
	11/30	-1.9 ± 1.4	-1.1 ± 3.7
	12/30	-2.2 ± 1.7	-3.2 ± 2
NV COMPOSITE (RACHEL)			
	01/31	-21 ± 40	9 ± 28
	02/28	5 ± 8.5	3.1 ± 6
	03/03	-1.6 ± 6.3	1.4 ± 4.4
	04/30	5.6 ± 11	7 ± 7.5
	05/31	-2.9 ± 12	0 ± 6.8
	06/28	12 ± 11**	47 ± 19**
	07/31	5.9 ± 6.1*	4.1 ± 5.6*
	08/30	2.1 ± 4	1.5 ± 4.1
	09/30	-0.1 ± 1.5	2.3 ± 3.2*
	10/30	-2 ± 1.6	2.3 ± 6.3
	11/29	-1.9 ± 1.4	-2.7 ± 1.7
	12/30	-10 ± 14	0 ± 6.9
NM COMPOSITE (Albuquerque & Carlsbad)			
	03/30	-1.6 ± 14	-2.8 ± 9.9
	06/29	-3.1 ± 25	0 ± 14
	12/12	-4.5 ± 3.4	-6.4 ± 4.1

(continued)

Table 5. (Continued)

SAMPLING LOCATION	COLLECTION DATE 1988	CONC. ± 2 SIGMA ^{238}Pu (aCi/m^3)	CONC. ± 2 SIGMA ^{239}Pu (aCi/m^3)
ND COMPOSITE (Bismarck & Fargo)			
	03/28	-8.4 ± 16	-0.9 ± 11
	06/29	-6.8 ± 27	3.4 ± 16
	09/19	-7.2 ± 5.5	2.1 ± 19
	12/12	-4.8 ± 3.6	-6.8 ± 4.4
OR COMPOSITE (Burns & Medford)			
	03/21	5.3 ± 12	-2.3 ± 8.4
	09/21	1.1 ± 5	-1.1 ± 3.8
	12/12	-5.3 ± 4.1	-7.6 ± 4.9
TX COMPOSITE (Austin & Amarillo)			
	03/31	-3.9 ± 9.8	-0.5 ± 6.9
	06/29	-98 ± 264	-33 ±153
	09/18	-13 ± 10	-18 ± 12
	12/23	-8.6 ± 6.6	-12 ± 8
UT COMPOSITE (Logan & Vernal)			
	03/30	-2.2 ± 8.5	4.3 ± 6
	06/29	0.0 ± 32	0.0 ± 18
	12/11	-0.4 ± 5.4	13 ± 14*
UT COMPOSITE (SALT LAKE CITY)			
	01/29	0.2 ± 8.2	5.3 ± 5.8
	02/26	-8.5 ± 23	-2.8 ± 13
	03/30	-2.7 ± 7.3	0.9 ± 4.2
	04/29	0.0 ± 7.2	-0.9 ± 4.2
	05/30	3 ± 8	1.0 ± 4.6
	06/29	0.8 ± 6.3	0.0 ± 3.7
	07/29	-0.2 ± 3.3	-2.5 ± 1.6
	08/31	-0.2 ± 2.7	4.1 ± 5.7*
	09/30	-3.7 ± 2.9	-5.3 ± 3.5
	10/31	-5.1 ± 11	-1.3 ± 4.4
	11/30	-11 ± 18	-4.5 ± 6.3
	12/30	-7.4 ± 16	-1.8 ± 6.4
WA COMPOSITE (Seattle & Spokane)			
	03/30	2.2 ± 13	-0.7 ± 9.3
	06/27	-8.7 ± 35	-4.3 ± 20
	12/12	-0.6 ± 8.6	-6.5 ± 4.2

(continued)

Table 5. (Continued)

SAMPLING LOCATION	COLLECTION DATE 1988	CONC. ± 2 SIGMA ^{238}Pu (aCi/m^3)	CONC. ± 2 SIGMA ^{239}Pu (aCi/m^3)
WY COMPOSITE (Worland & Rock Springs)			
	03/30	-6.1 ± 11	-2.3 ± 8
	06/29	-29 ± 77	-9.5 ± 44
	09/26	-25 ± 19	-35 ± 24
	12/09	-24 ± 20	-5.4 ± 7.7

All concentrations below the minimum detectable concentration (MDC) unless so noted.

* Concentration above the MDC but smaller than the 2-sigma error term.
** Concentration above the MDC and greater than the 2-sigma error term.

TABLE 6. Summary of Gross Beta Analyses for Air Surveillance Network-1988

Sampling Location	No. Days Sampled	Radioactivity Conc. (pCi/m^3) Max	Min	Avg
Shoshone CA	351.0	0.056	0.0010	0.020
Las Vegas NV	356.4	0.055	0.0036	0.021
Delta UT	353.9	0.10	-0.0017	0.022
Milford UT	357.6	0.088	0.0013	0.026
St George UT	328.7 *	0.072	0.0011	0.022

* This station was out of service during May, 1988.

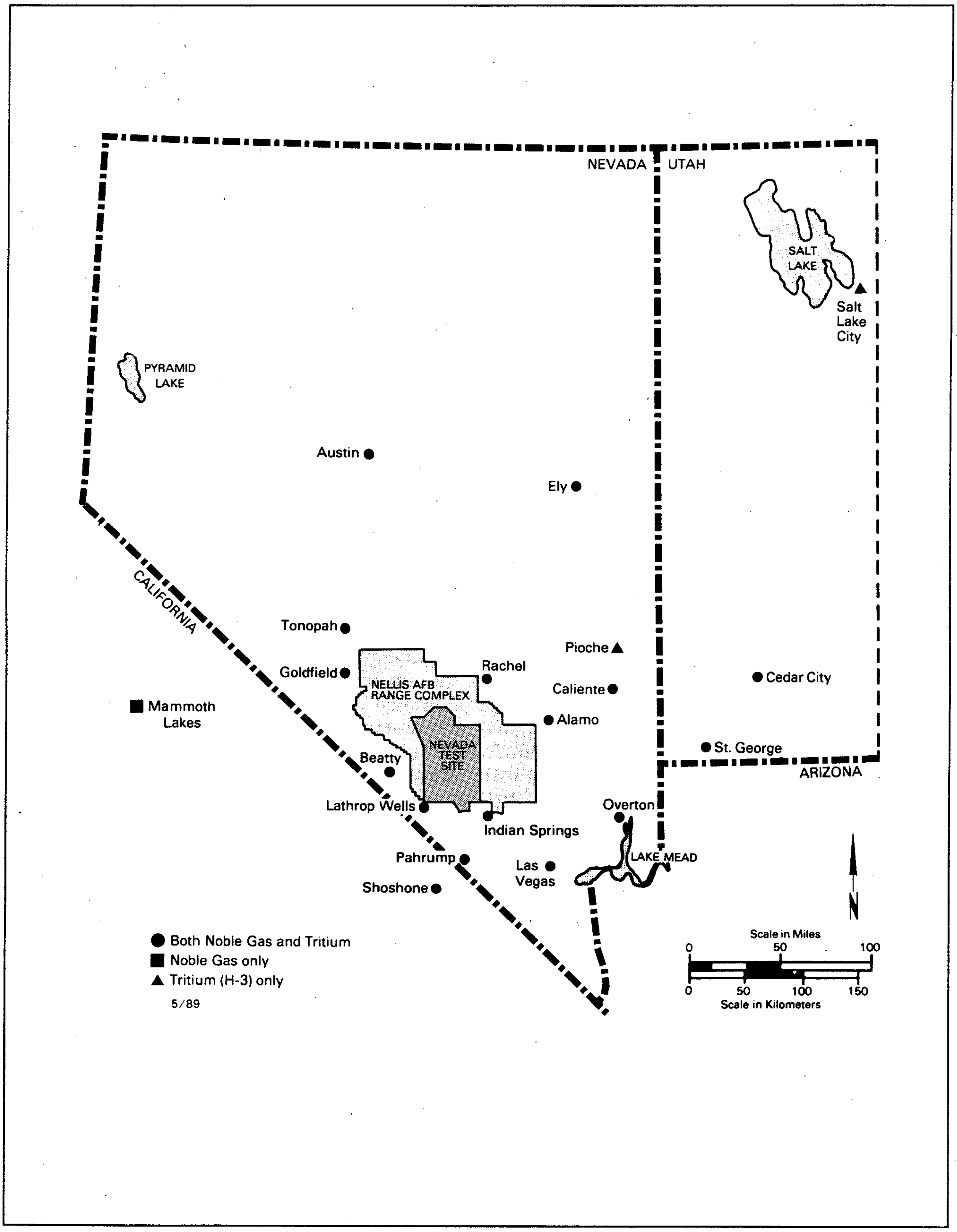


Figure 11. Noble Gas and Tritium Surveillance Network Sampling Locations.

EMSL-LV where their contents are analyzed. Analysis starts by condensing the samples at liquid nitrogen temperature and using gas chromatography to separate the gases. The separate fractions of radioxenon and radiokrypton are dissolved in scintillation cocktail and counted in a liquid scintillation counter (see Section 9.0 Sample Analysis Procedures).

For tritium sampling, a molecular sieve column is used to collect water from air after it passes through a particulate filter. Up to 10 m^3 of air are passed through the column over a 7-day sampling period. Water adsorbed on the molecular sieve is recovered, and the concentration of tritium in the water, as tritiated water (HTO), is determined by liquid scintillation counting (see Section 9.0 Sample Analysis Procedures). This result can then be used to calculate the concentration of tritium in air by knowing the volume of air that passed through the sieve.

Results

Figure 12 contains plots showing the results for all the ^{85}Kr analyses for each station, with the error bars representing the two-sigma counting error. The results all fell within the limits expected from statistical variation.

A summary of the results from the samples collected by the NGTSN is shown in Table 7. This summary consists of the maximum, minimum and average concentration for each station. The number of samples analyzed is typically less than the expected number (fifty-two) since samples are occasionally lost in the analysis procedure, or insufficient volume is collected, or no sample is collected due to equipment problems. Caliente and Mammoth Lakes have particularly low counts for the number of samples analyzed because their noble gas systems were not installed and operational for the entire year. At Caliente, the noble gas sampler was not installed until late April, then it was not functional during the last two months of the year due to equipment problems. The sampler at Mammoth Lakes was removed about half way through the year because the study it was supporting was completed. The low number of samples analyzed for St. George was due to a combination of two factors. The first of these was a series of samples with low volume, and the second was a problem with the equipment which caused it to be out of operation for several weeks. Network weekly averages of ^{85}Kr concentrations (with two-sigma error bars) measured in 1988 are shown in Figure 13. The measured ^{85}Kr concentrations ranged from 18.0 to 34.8 pCi/m^3 (0.67 to 1.3 Bq/m^3).

A paper presented by Bernhardt et al., (BE73) in a 1973 symposium contained a curve predicting ^{85}Kr concentration for the future. In recent years, measured levels have not reached those predicted; but instead seem to have reached a plateau. Two reasons for this may be the decision by the United States to defer fuel reprocessing which is the step in the fuel cycle where the majority of the krypton is

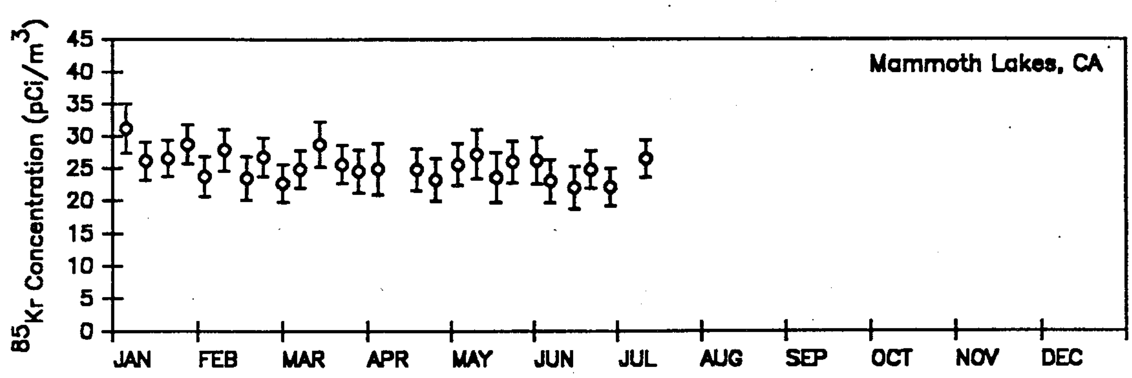


Figure 12. Weekly ^{85}Kr Concentrations in Air by Station, 1988 Data.

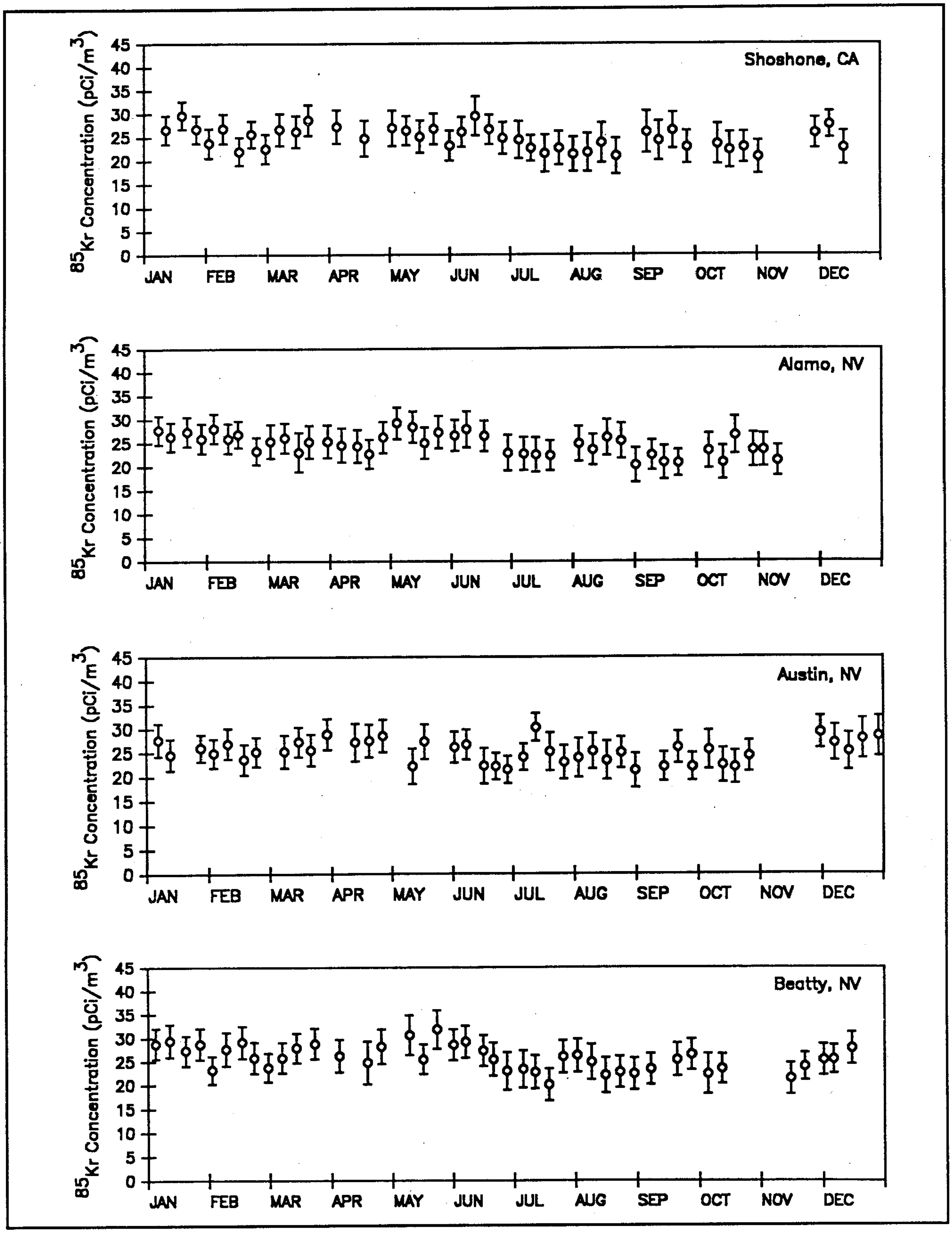


Figure 12. (Continued)

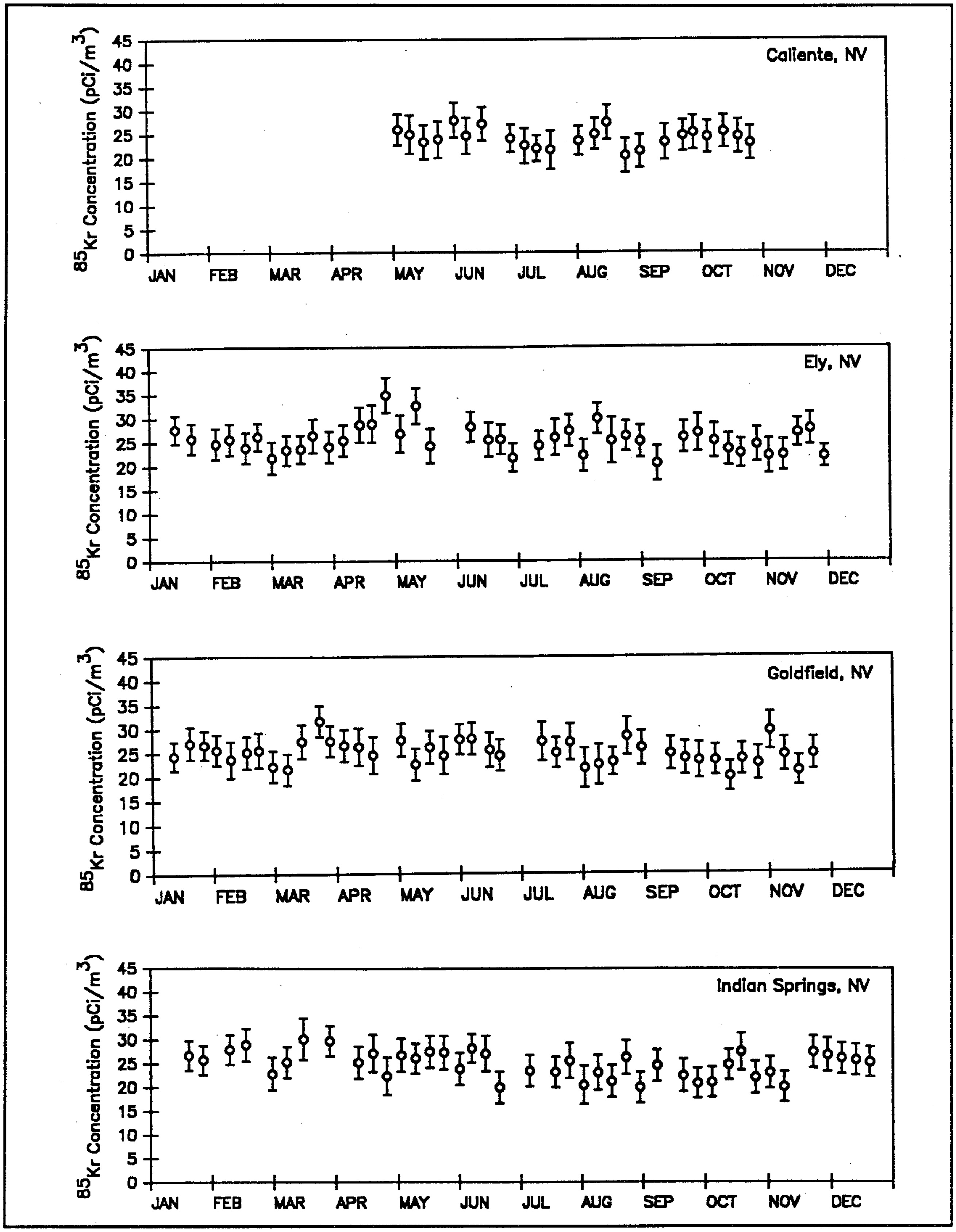


Figure 12. (Continued).

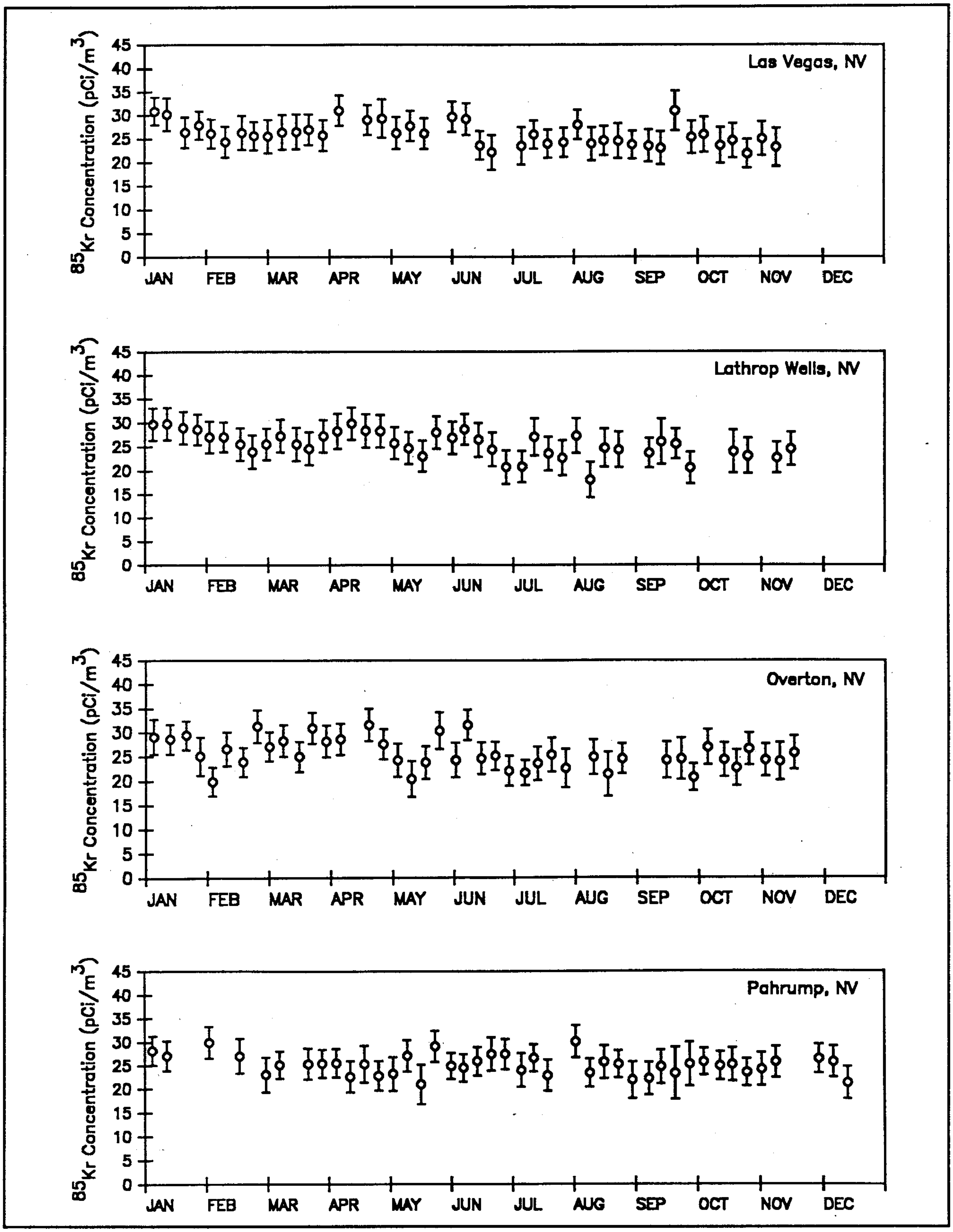


Figure 12. (Continued).

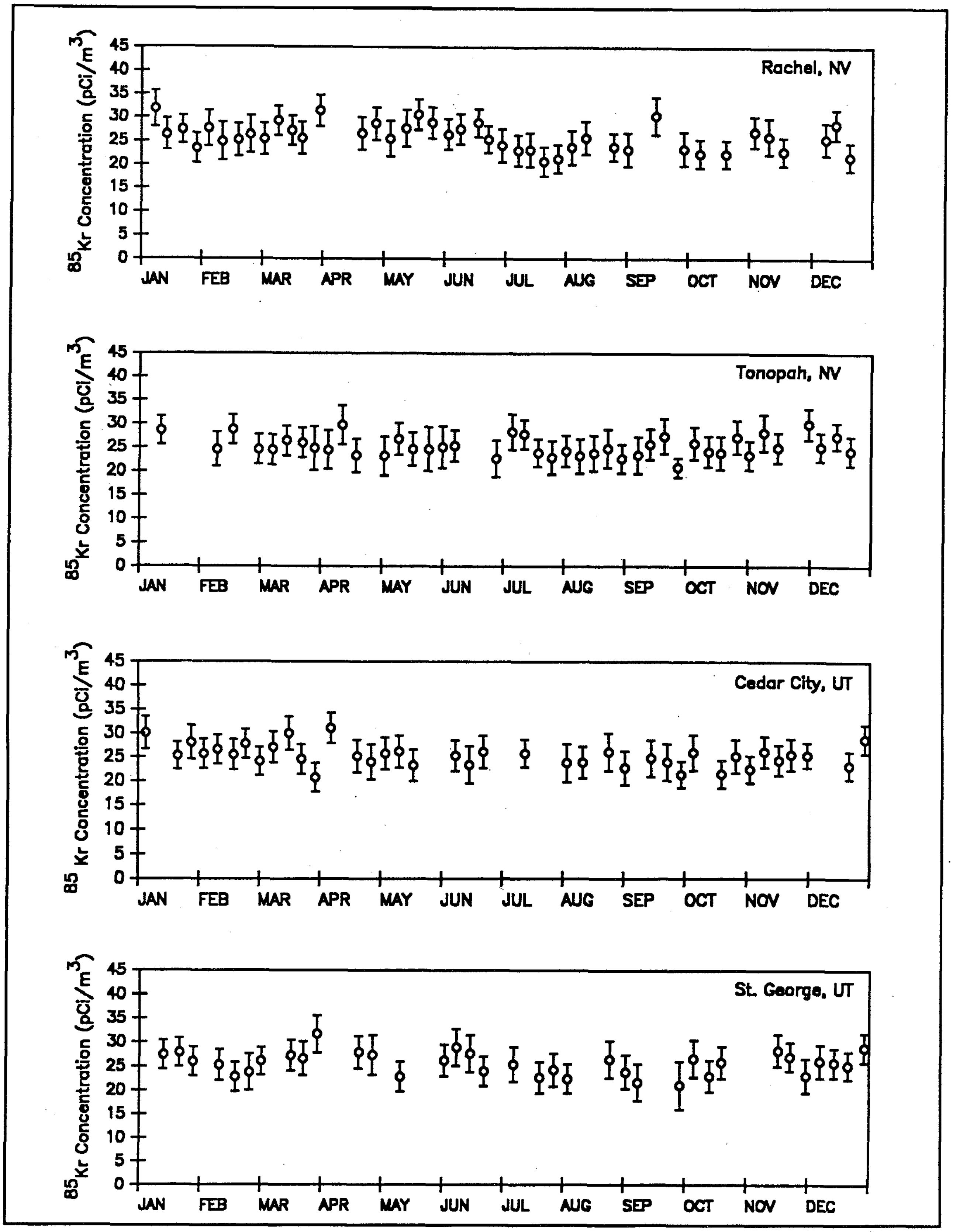


Figure 12. (Continued).

TABLE 7. Summary of analytical results for the Noble Gas and Tritium Surveillance Network - 1988

SAMPLING LOCATION	NUMBER SAMPLES ANALYZED	RADIONUCLIDE	RADIOACTIVITY CONC. (pCi/m^3)* MAX	MIN	AVG	PERCENT CONC. GUIDE**
MAMMOTH LAKES, CA	26	^{85}Kr	31	22	25	< 0.01
	27	^{133}Xe	12	-8.2	2.1	< 0.01
SHOSHONE, CA	43	^{85}Kr	30	21	25	< 0.01
	46	^{133}Xe	8.8	-9.3	0.17	< 0.01
	49	^{3}H in atm. m.*	0.53	-0.73	-0.0027	--
	49	^{3}H as HTO in air	6.9	-8.4	-0.17	< 0.01
ALAMO, NV	49	^{85}Kr	29	20	25	< 0.01
	52	^{133}Xe	20	-9.7	0.58	< 0.01
	50	^{3}H in atm. m.*	0.52	-1.3	0.023	--
	50	^{3}H as HTO in air	5.3	-6.8	0.26	< 0.01
AUSTIN, NV	42	^{85}Kr	30	21	25	< 0.01
	43	^{133}Xe	11	-12	-0.95	< 0.01
	51	^{3}H in atm. m.*	0.74	-0.89	0.019	--
	51	^{3}H as HTO in air	3.0	-5.9	-0.0061	< 0.01
BEATTY, NV	44	^{85}Kr	32	20	26	< 0.01
	45	^{133}Xe	17	-11	1.4	< 0.01
	50	^{3}H in atm. m.*	0.50	-0.64	0.044	--
	50	^{3}H as HTO in air	4.6	-7.5	0.27	< 0.01
CALIENTE, NV	23	^{85}Kr	28	20	24	< 0.01
	23	^{133}Xe	14	-20	-3.8	< 0.01
	48	^{3}H in atm. m.*	0.50	-0.53	0.014	--
	48	^{3}H as HTO in air	6.5	-2.3	0.42	< 0.01
ELY, NV	45	^{85}Kr	35	20	26	< 0.01
	46	^{133}Xe	11	-16	0.51	< 0.01
	50	^{3}H in atm. m.*	1.1	-1.3	0.034	--
	50	^{3}H as HTO in air	7.7	-4.8	0.36	< 0.01
GOLDFIELD, NV	46	^{85}Kr	32	20	25	< 0.01
	46	^{133}Xe	15	-21	0.32	< 0.01
	50	^{3}H in atm. m.*	0.80	-0.64	-0.0019	--
	50	^{3}H as HTO in air	8.3	-6.2	-0.063	< 0.01
INDIAN SPRINGS, NV	41	^{85}Kr	30	20	25	< 0.01
	41	^{133}Xe	7.1	-7.9	-0.54	< 0.01
	48	^{3}H in atm. m.*	0.75	-1.1	0.038	--
	48	^{3}H as HTO in air	3.5	-3.0	0.41	< 0.01
LAS VEGAS, NV	49	^{85}Kr	31	22	26	< 0.01
	50	^{133}Xe	8.8	-11	0.93	< 0.01
	51	^{3}H in atm. m.*	0.60	-0.90	0.033	--
	51	^{3}H as HTO in air	5.2	-8.1	0.39	< 0.01

(Continued)

TABLE 7. (Continued)

SAMPLING LOCATION	NUMBER SAMPLES ANALYZED	RADIONUCLIDE	RADIOACTIVITY CONC. (pCi/m^3)* MAX	MIN	AVG	PERCENT CONC. GUIDE**
LATHROP WELLS, NV	47	^{85}Kr	30	18	26	< 0.01
	47	^{133}Xe	8.6	-14	-0.032	< 0.01
	48	^{3}H in atm. m.*	0.71	-1.0	0.082	--
	48	^{3}H as HTO in air	6.3	-12	0.53	< 0.01
OVERTON, NV	48	^{85}Kr	32	20	26	< 0.01
	51	^{133}Xe	8.2	-10	1.1	< 0.01
	50	^{3}H in atm. m.*	0.74	-0.60	0.070	--
	50	^{3}H as HTO in air	15	-3.8	0.68	< 0.01
PAHRUMP, NV	44	^{85}Kr	30	21	25	< 0.01
	44	^{133}Xe	10	-11	0.67	< 0.01
	50	^{3}H in atm. m.*	0.69	-0.90	0.0051	--
	50	^{3}H as HTO in air	6.7	-8.1	0.18	< 0.01
PIOCHE, NV	51	^{3}H in atm. m.*	0.55	-0.75	0.035	--
	51	^{3}H as HTO in air	4.7	-5.1	0.27	< 0.01
RACHEL, NV	43	^{85}Kr	32	21	26	< 0.01
	48	^{133}Xe	12	-17	0.41	< 0.01
	51	^{3}H in atm. m.*	0.61	-0.76	0.055	--
	50	^{3}H as HTO in air	5.0	-5.0	0.34	< 0.01
TONOPAH, NV	43	^{85}Kr	30	21	25	< 0.01
	43	^{133}Xe	16	-12	1.0	< 0.01
	51	^{3}H in atm. m.*	0.74	-0.67	0.022	--
	51	^{3}H as HTO in air	8.5	-6.0	0.10	< 0.01
FALLINI'S (TWIN SPRINGS) RANCH,NV	1	^{85}Kr	24	24	+	+
	1	^{133}Xe	9.2	9.2	+	+
CEDAR CITY, UT	39	^{85}Kr	31	21	25	< 0.01
	42	^{133}Xe	13	-9.0	2.5	< 0.01
	50	^{3}H in atm. m.*	0.67	-0.73	0.053	--
	49	^{3}H as HTO in air	3.8	-4.2	0.22	< 0.01
ST GEORGE, UT	35	^{85}Kr	32	21	26	< 0.01
	39	^{133}Xe	9.6	-13	-0.047	< 0.01
	45	^{3}H in atm. m.*	0.50	-0.95	0.015	--
	45	^{3}H as HTO in air	4.9	-8.3	0.010	< 0.01
SALT LAKE CITY, UT	50	^{3}H in atm. m.*	0.55	-0.70	0.010	--
	50	^{3}H as HTO in air	4.9	-6.2	0.33	< 0.01

* Concentrations of Tritium in atmospheric moisture (atm. m.) are expressed as Ci per mL of water collected.
** Concentration Guides used are for exposure to a suitable sample of the population in an uncontrolled area.
\+ Insufficient data to calculate an average.

TABLE 8. Annual average ^{85}Kr concentrations in air, 1979-1988

Sampling Locations	^{85}Kr Concentrations (pCi/m^3) 1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Death Valley Jct., CA*	19	--	--	--	--	--	--	--	--	--
Mammoth Lakes, CA*	--	--	--	--	--	--	--	--	26	25
Shoshone, CA	--	--	--	25	25	23	24	25	26	25
Alamo, NV	--	--	27	24	25	24	24	24	26	25
Austin, NV	--	--	--	24	25	23	25	25	25	25
Beatty, NV	19	21	24	25	24	23	25	26	26	26
Caliente, NV	--	--	--	--	--	--	--	--	--	24
Ely, NV	--	--	--	24	25	22	24	26	25	25
Goldfield, NV	--	--	--	25	24	24	24	25	25	25
Hiko, NV*	19	21	24	26	--	--	--	--	--	--
Indian Springs, NV	19	21	24	24	25	22	24	26	26	25
Las Vegas, NV	--	--	24	24	24	23	25	25	25	26
Lathrop Wells, NV	19	22	24	24	26	22	24	25	25	26
NTS, Mercury, NV*	19	21	23	--	--	--	--	--	--	--
NTS, Groom Lake, NV*	19	21	24	--	--	--	--	--	--	--
NTS, BJY, NV*	21	23	26	--	--	--	--	--	--	--
NTS, Area 12, NV*	19	21	24	--	--	--	--	--	--	--
NTS, Area 15, NV*	19	21	25	--	--	--	--	--	--	--
NTS, Area 400, NV*	18	21	23	--	--	--	--	--	--	--
Overton, NV	--	--	26	24	25	23	24	25	25	26
Pahrump, NV	--	--	23	24	24	23	25	25	26	25
Rachel and Diablo, NV**	19	21	24	26	24	22	24	25	25	26
Tonopah, NV	18	21	25	24	25	23	25	25	26	25
Cedar City, UT	--	--	--	25	24	22	24	24	26	25
St. George, UT	--	--	--	24	25	23	24	24	25	26
Salt Lake City, UT*	--	--	--	25	25	25	25	--	--	--
NETWORK AVERAGE	19	21	24	24	25	23	24	25	26	25

* Stations discontinued
** Station at Diablo was moved to Rachel in March 1979.
-- No station was operational at that location during that year.

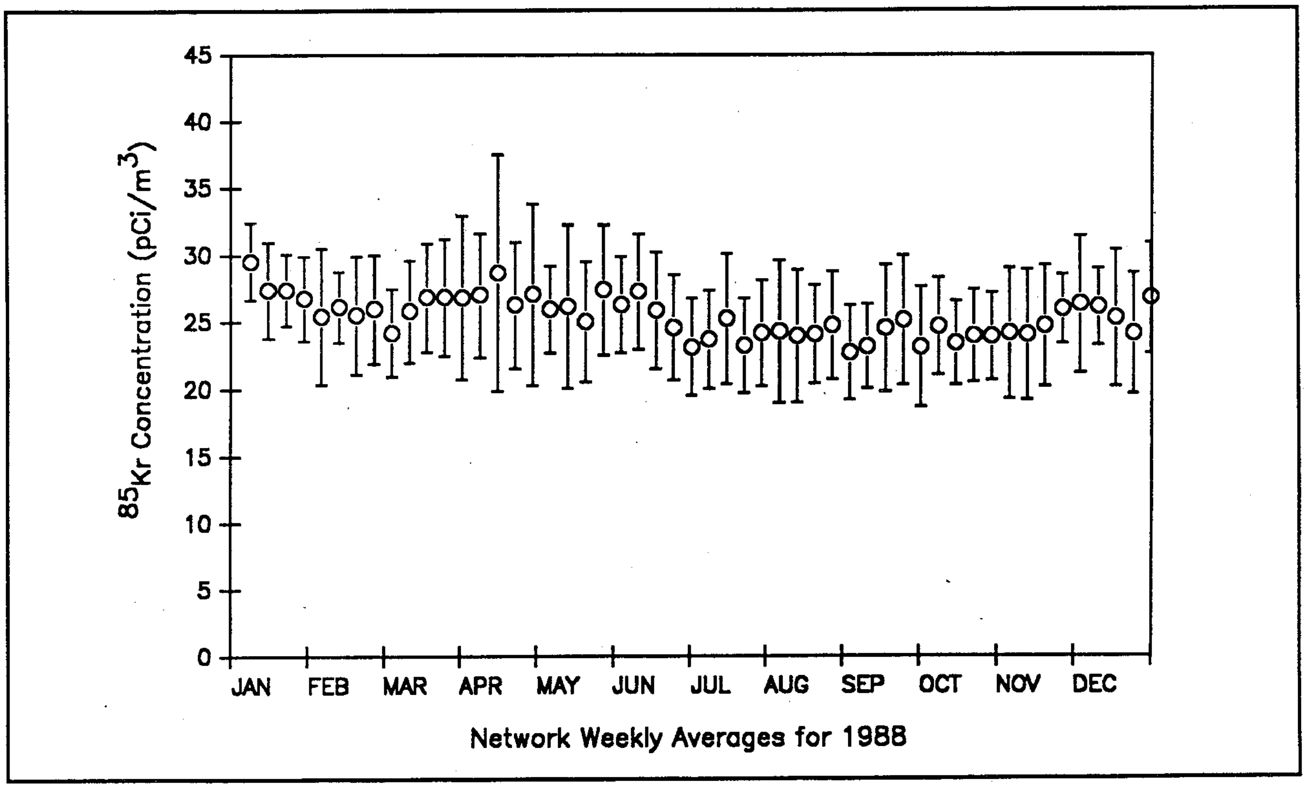


Figure 13. Network Weekly Average ^{85}Kr Concentrations in Air, 1988 Data.

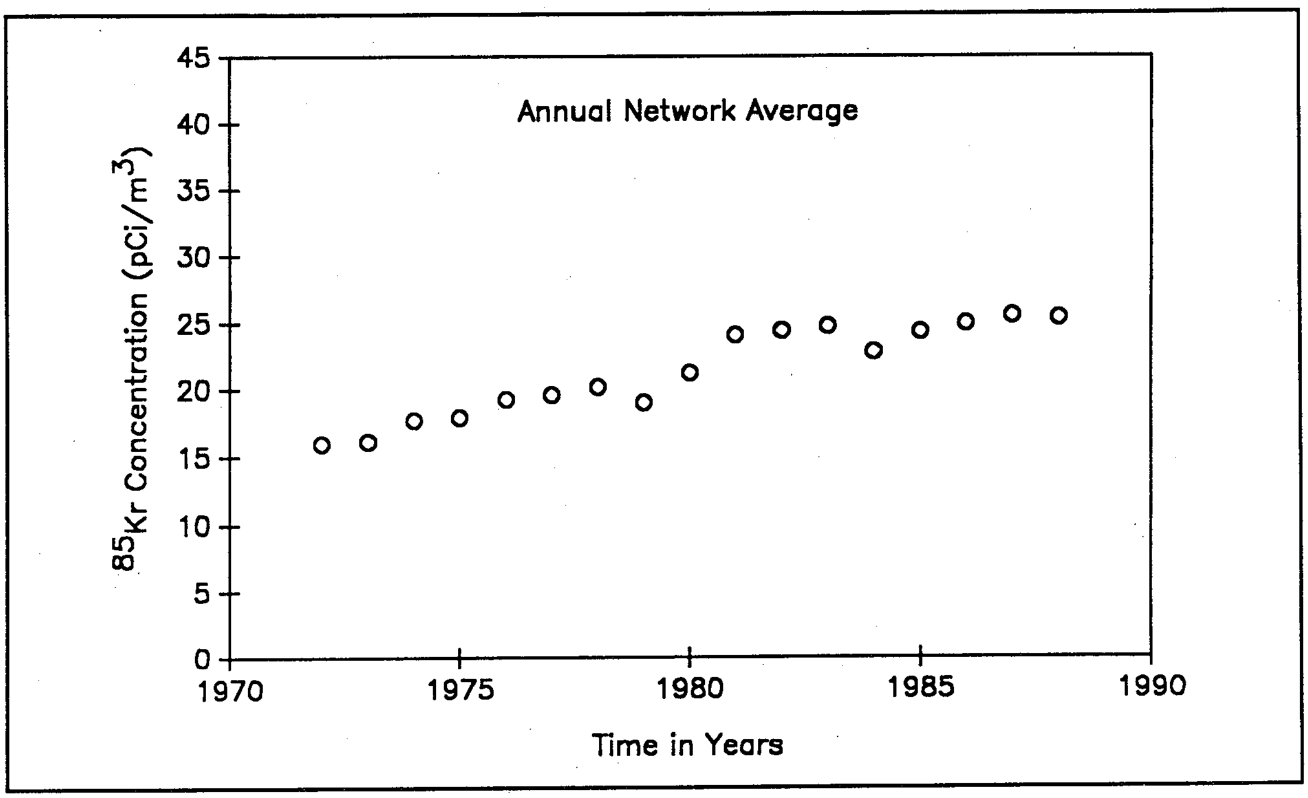


Figure 14. Annual Network Average ^{85}Kr Concentration.

actually released and the failure of the nuclear power industry to grow at predicted rates.

An historical summary of data for this network shows its trends over time. Network average krypton results for the past ten years are shown in Table 8, while results for the period 1972-1988 have been plotted in Figure 14.

The concentration over the whole network showed a mean of 25.4 pCi/m^3 (0.94 Bq/m^3). This network average concentration, as shown in Figure 14 has gradually increased from the time sampling began in 1972 to the present. This increase, observed at all stations, reflects the worldwide increase in ambient concentrations resulting from the increased use of nuclear technology as projected by Bernhardt et al., (BE73). There is no evidence in the ^{85}Kr results to indicate that the radioactive material detected was from tests conducted at the NTS.

The analytical results for the 734 xenon samples counted were all below the MDC which varied, but was generally around 10 pCi/m^3.

As in the past, tritium concentrations in atmospheric moisture samples from the off-NTS stations were generally below the MDC of about 400 pCi/L of water (see Section 9.0 Sample Analysis Procedures). Due to the statistical nature of counting radioactive samples, some samples may yield negative results or results below the MDC. Results below the MDC are not necessarily real but are below the sensitivity of the method. The tritium concentrations observed at off-NTS stations were considered to be representative of environmental background. The mean of the tritium concentrations for all off-site stations was 0.25 pCi/m^3 (9.3 mBq/m^3) of air. Only one of the 891 samples analyzed was above the MDC and the concentration measured for that sample was only slightly above the MDC. That sample was collected in Ely, and although there was a detectable amount of ^{3}H in the atmospheric moisture, the calculated concentration of ^{3}H in air was less than the calculated MDC for that sample.

In conclusion, no NTS releases were detected by this monitoring network during 1988.

5.2.3 Milk Surveillance Network

K. S. Moroney

One important possible means of intake of radionuclides by humans is through airborne deposition of radioactivity on forage crops eaten by dairy cattle, with subsequent transmission to milk. This pathway is monitored by EMSL-LV through an extensive sampling and surveillance system. The system is designed to produce data from areas adjacent to the NTS which could be affected by a release of airborne radioactivity, as well as from areas unlikely to be so affected.

In 1988, the Milk Surveillance Network (MSN) consisted of 29 locations within 300 km. of the NTS (Figure 15) from which samples were collected monthly by EPA monitors. The raw milk is collected in four-liter cubitainers and preserved with formaldehyde.

In addition, all major milksheds west of the Mississippi River, represented by 102 locations in 1988 (Figure 16), are sampled on an annual basis as a part of the Standby Milk Surveillance Network (SMSN). The annual activation of the SMSN helps maintain readiness and highlights any trends of increasing radionuclide concentrations in western states. One exception to the latter portion of the network is Texas; the State Health Department performs the surveillance of the milksheds in that state. SMSN samples are supplied by cooperating State Food and Drug Administration personnel upon the request of the Regional EPA offices. These samples, also preserved with formaldehyde in four liter cubitainers, are mailed to EMSL-LV.

All samples are analyzed by high resolution gamma spectroscopy to detect gamma emitting radionuclides. One sample per quarter for each location in the MSN, and samples from two locations in each western state in the SMSN, are subjected to radiochemical analytical evaluations. These samples are analyzed for tritium (^{3}H) by liquid scintillation counting, and for ^{89}Sr and ^{90}Sr by an ion exchange method, as outlined in Section 9.0 Sample Analysis Procedures.

Although all the samples collected for the MSN were analyzed for gamma-emitting nuclides, only naturally occurring ^{40}K was detected. For those MSN samples analyzed for tritium and radiostrontiums, the results are displayed in Table 9. Two MSN samples with ^{90}Sr slightly above the minimum detectable activity were noted at Mesquite, Nevada, and St. George, Utah. With those exceptions, no ^{89}Sr or ^{90}Sr, or significant levels of tritium, were detected by radiochemical analysis in the laboratory.

Results for SMSN are presented in Table 10. One SMSN sample from Flensberg, Minnesota, contained detectable ^{137}Cs (result = 65 ± 9 picocuries per liter). No other radionuclide aside from naturally occurring 40K was identified for the SMSN. The SMSN had six samples from high rainfall states with detectable ^{90}Sr.

These results are expected, and data from both networks are consistent with data from previous years. These results are also consistent with the results shown in Figure 17 for the Pasteurized Milk Network operated by the EPA's Eastern Environmental Radiation Facility in Montgomery, Alabama. No result was available for Salt Lake City. Results from the New Orleans samples have been consistently higher over the years, and reflect the higher rainfall in that area. Data overall shows a trend of slowly decreasing levels of ^{90}Sr over the past several years (EPA88).

5.2.4 Biomonitoring Program

D. D. Smith

The pathways for transport of radionuclides to humans include air, water, and food. Monitoring of air, water, and milk are discussed elsewhere in this report. Meat from local animals and locally grown fruit and vegetables are food components that may be potential routes of exposure to off-site residents.

Methods

Samples of muscle, lung, liver, kidney, blood, and bone are collected periodically from cattle purchased from commercial herds that graze areas adjacent to the NTS. The soft tissues are analyzed for gamma-emitters. Bone and liver are analyzed for strontium and plutonium and blood/urine or soft tissue is analyzed for tritium. Each November and December, bone and kidney samples which are donated by licensed hunters from desert bighorn sheep killed in southern Nevada (Figure 18) are analyzed for strontium, plutonium and tritium. These kinds of samples have been collected and analyzed for up to 31 years to determine long-term trends. During 1988, four NTS mule deer were collected and sampled in the same manner as the cattle.

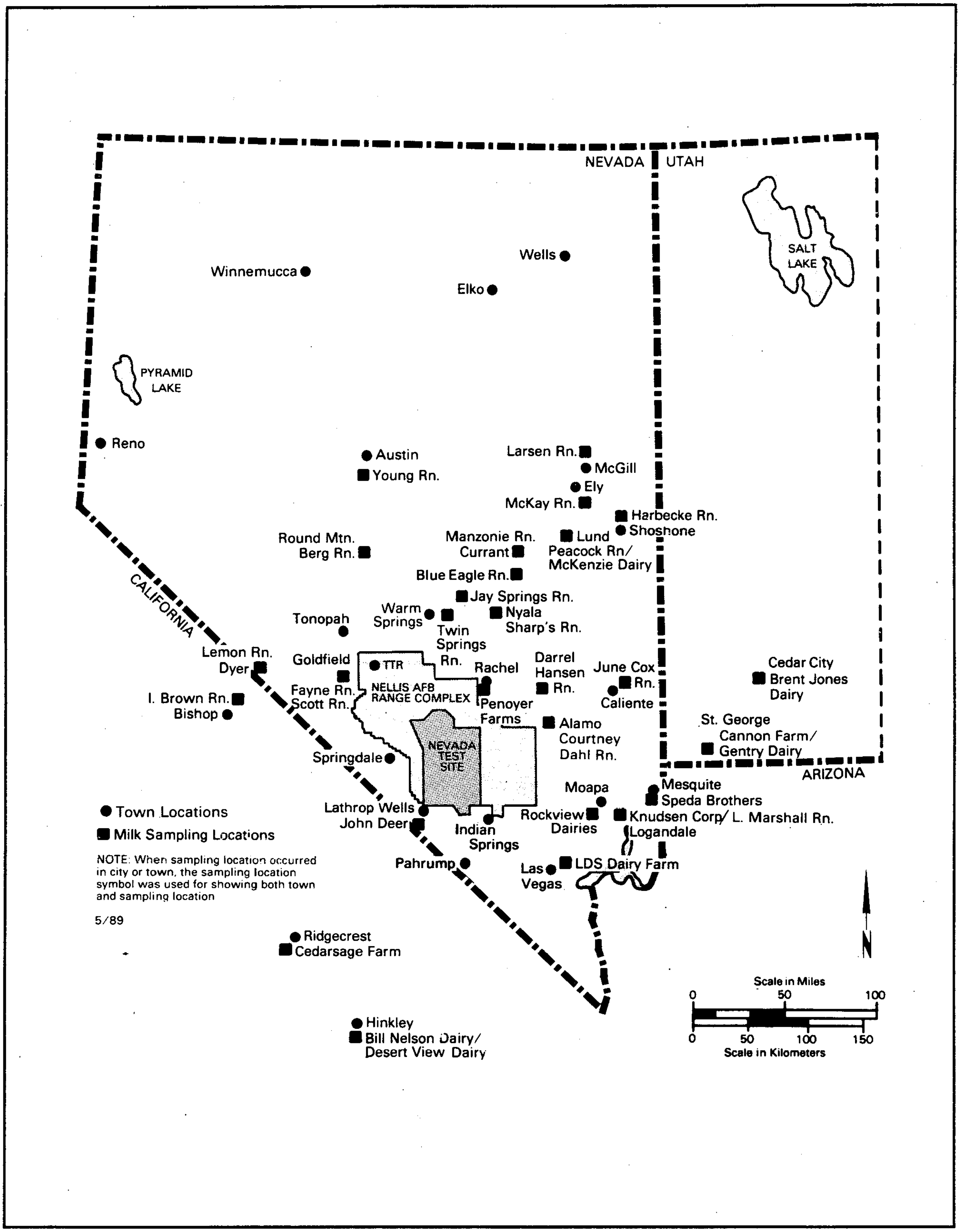


Figure 15. Milk Sampling Locations Within 300 km of the NTS.

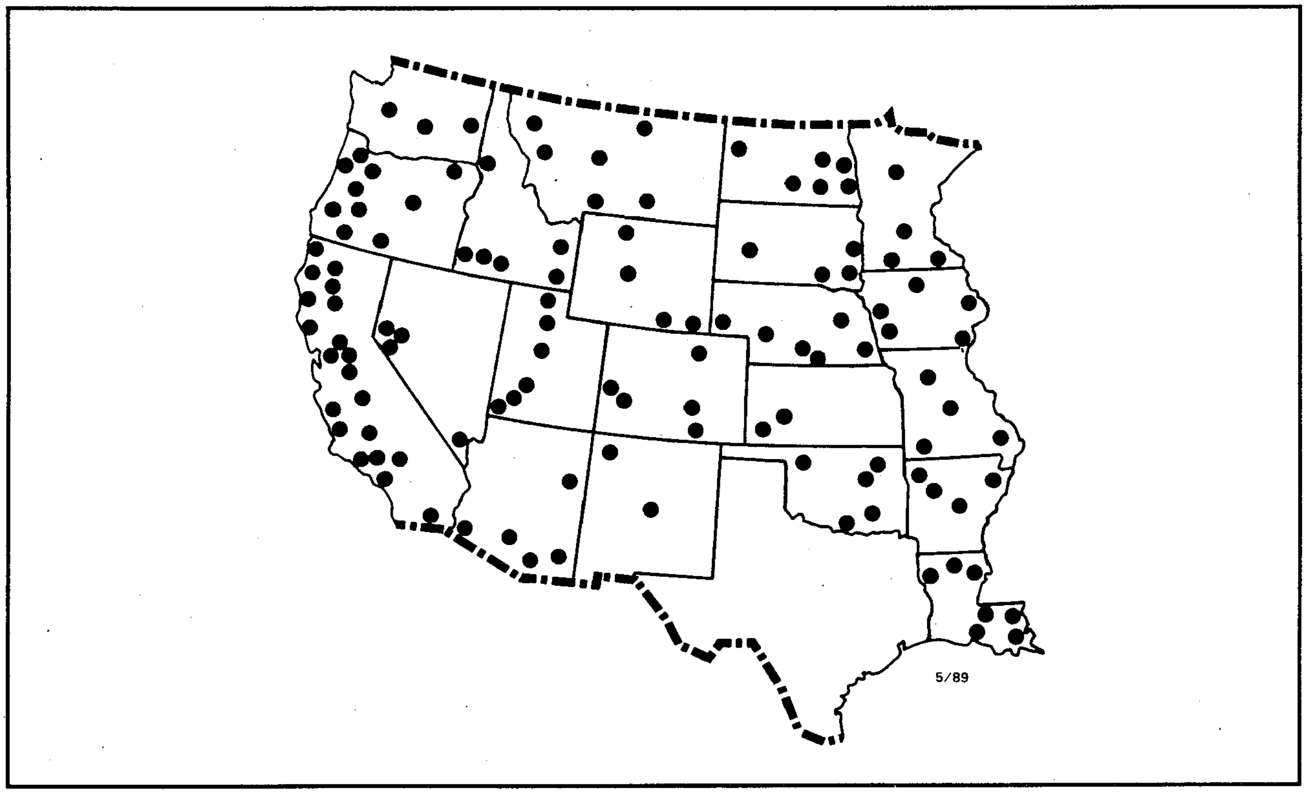


Figure 16. Standby Milk Surveillance Network Stations.

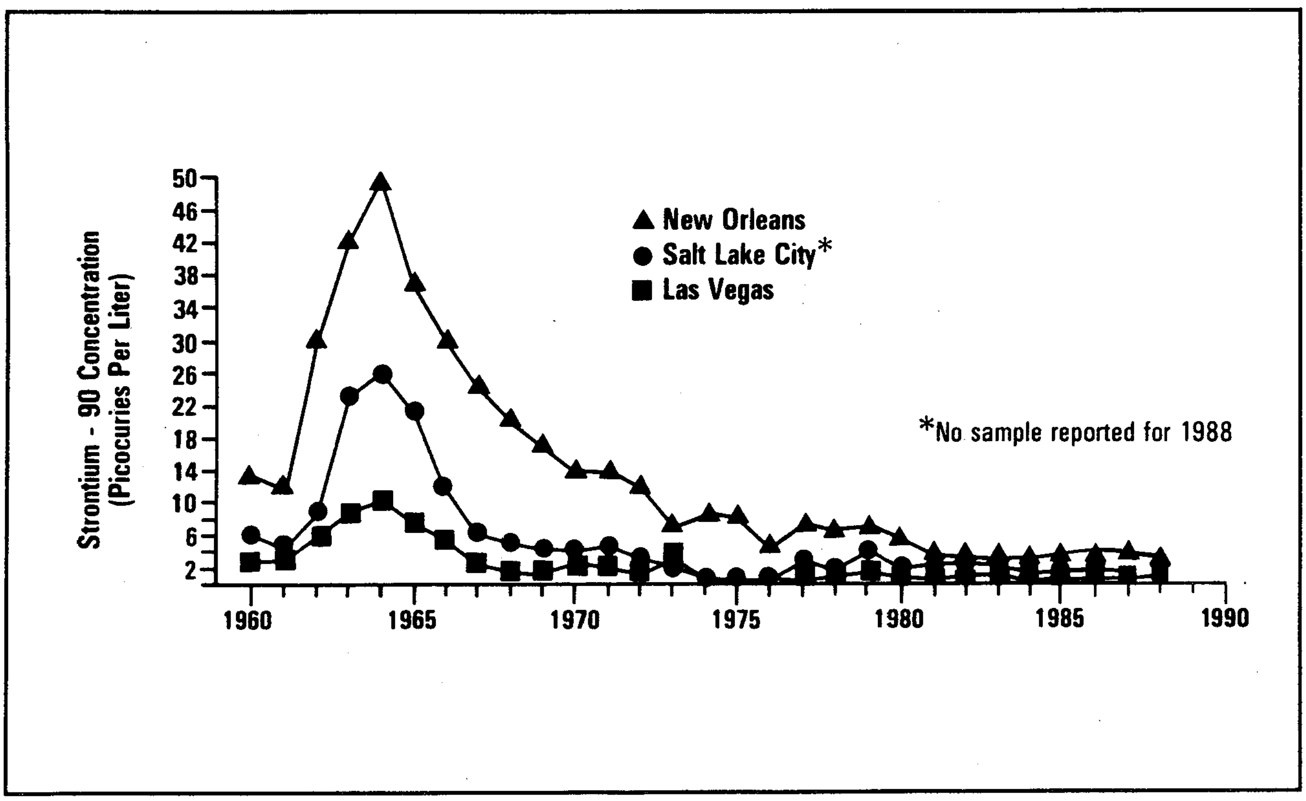


Figure 17. Strontium-90 Concentration in Pasteurized Milk Network Samples.

TABLE 9. Summary of Analytical Results for the Milk Surveillance Network - 1988

SAMPLING LOCATION	COLLECTION DATE 1988	CONC ± 2 SIGMA ^{3}H (pCi/L)	^{89}Sr (pCi/L)	^{90}Sr (pCi/L)
BENTON CA				
Irene Brown Ranch				
	01/21	NO SAMPLE **	GOATS DRY **	**
	04/13	580 ± 240	-2.4 ± 3.7*	1.6 ± 1.6*
	12/01	210 ± 240	-2.0 ± 14*	1.4 ± 2.3*
HINKLEY CA				
Bill Nelson Dairy				
	01/21	430 ± 240	-0.8 ± 10*	0.8 ± 6.5*
	04/13	320 ± 380*	2.1 ± 2.7*	0.3 ± 1.2*
	04/13		OUT OF BUSINESS	
Desert View Dairy (Alt for B. Nelson)				
	10/04	340 ± 250	**	**
RIDGECREST CA				
Cedarsage Farm				
	01/21	521 ± 243	-2.3 ± 4.4*	1.3 ± 2.8*
	04/13	181 ± 369*	-2.7 ± 4.9*	1.4 ± 2.1*
	07/14	93 ± 234*	-2.7 ± 3.2*	1.3 ± 1.7*
	10/04	864 ± 235	-4.3 ± 10.2*	1.0 ± 1.2*
ALAMO NV				
Courtney Dahl Ranch				
	03/02	245 ± 386*	0.6 ± 5.2*	0.0 ± 2.0*
	06/01	243 ± 386*	2.2 ± 2.4*	-0.0 ± 1.4*
	09/01	129 ± 238*	**	-0.3 ± 2.5*
	12/01	70 ± 241*	1.4 ± 5*	-0.2 ± 1.2
AUSTIN NV				
Young's Ranch				
	01/13	**	-0.4 ± 6.2*	1.0 ± 3.6*
	04/12	659 ± 241	-1.4 ± 3.6*	1.5 ± 1.6*
	06/07	NO SAMPLE **	COW DRY **	**
	10/19	183 ± 239*	-2.3 ± 7*	1.8 ± 1.6*
BLUE JAY NV				
Blue Jay Sprgs-Jim Bias				
	08/16	-162 ± 238*	-2.5 ± 20.5*	1.1 ± 1.8*
	11/02	122 ± 234*	-3.2 ± 11*	1.6 ± 1.7*
CURRANT NV				
Blue Eagle Ranch				
	01/05	**	-4.1 ± 1.2*	2.6 ± 6.2*
	04/06	232 ± 366*	1.6 ± 3*	1.1 ± 1.2*
	07/12	72 ± 246*	-3.3 ± 10.7*	2.7 ± 6.9*
	12/07	NO SAMPLE **	COW DRY **	**
Manzonie Ranch				
	01/05	**	1.0 ± 3.7*	0.2 ± 2.0*
	04/06	210 ± 378*	2.3 ± 4.8*	0.2 ± 1.9*
	07/12	118 ± 244*	-0.7 ± 2.6*	0.5 ± 1.4*
	10/12	398 ± 246	-0.1 ± 5.8*	1.1 ± 1.2*

(continued)

TABLE 9. (Continued)

SAMPLING LOCATION	COLLECTION DATE 1988	^{3}H (pCi/L)	CONC ± 2 SIGMA ^{89}Sr (pCi/L)	^{90}Sr (pCi/L)
DYER NV				
Ozel Lemon				
	01/12	**	6.2 æ 6.4*	-0.4 æ 3.7*
	04/15	423 æ 236	3.6 æ 7.3*	0.6 æ 3.2*
	07/12	188 æ 241*	-2.0 æ 4.1*	0.8 æ 2.0*
	10/19	NO SAMPLE **	COW DRY **	**
ELY NV				
McKay, Robert and Carla (Alt. for W. Burdic)				
	12/01	117 æ 236*	-1.2 æ 5.7*	0.8 æ 1.3
GOLDFIELD NV				
Frayne Ranch				
	01/13	NO SAMPLE **	GOAT DRY **	**
	07/28	190 æ 244*	-0.1 æ 2.0*	1.3 æ 1.3*
	10/19	NO SAMPLE **	GOAT DRY **	**
	12/14	NO SAMPLE **	GOATS DRY **	**
Susie Scott Ranch				
	06/17	6.7 æ 370*	1.1 æ 7.0*	-0.1 æ 4.1*
	09/16	-54 æ 240*		**0.7 æ 2.1*
	10/19	NO SAMPLE **	GOATS DRY **	**
	12/15	NO SAMPLE **	GOATS DRY **	**
LAS VEGAS NV				
LDS Dairy Farms				
	02/08	94 æ 368*	1.4 æ 8.0*	0.7 æ 2.2*
	05/06	398 æ 227	1.2 æ 2.3*	0.5 æ 1.8*
	08/01	94 æ 247*	-4.4 æ 27.4*	1.0 æ 2.0*
	11/01	303 æ 236	0.8 æ 4.9*	0.0 æ 1.1*
LATHROP WELLS NV				
John Deer Ranch				
	01/12	NO SAMPLE **	GOATS DRY **	**
	04/15	326 æ 383*	-2.9 æ 7.8*	1.2 æ 2.7*
	08/08	-32 æ 231*	7.3 æ 30.6*	-1.1 æ 2.4*
	12/15	NO SAMPLE **	GOATS DRY **	**
LOGANDALE NV				
Leonard Marshall				
	03/01	**	**	ALTERNATE
	05/02	308 æ 367*	-1.2 æ 7.8*	1.0 æ 2.7*
	07/01	160 æ 240*	-0.4 æ 9.7*	1.5 æ 5.4*
	08/04	170 æ 247*	**	-0.8 æ 1.3*
	10/02	457 æ 245	-3.1 æ 7.0*	1.2 æ 1.3*
	11/01	237 æ 232*	1.0 æ 8.2*	-0.1 æ 1.3*
Knudsen Dairy				
	02/01	509 æ 235	-4.4 æ 10.6*	1.2 æ 2.6*
LUND NV				
Rue Peacock				
	07/12	-68 æ 232*	2.7 æ 4.5*	1.0 æ 3.0*
	08/02	107 æ 235	-4.2 æ 16.8*	0.9 æ 1.3*
	11/02	161 æ 231	0.1 æ 8.4*	0.6 æ 1.7*

(continued)

TABLE 9. (continued)

SAMPLING LOCATION	COLLECTION DATE 1988	CONC ± 2 SIGMA ^{3}H (pCi/L)	^{89}Sr (pCi/L)	^{90}Sr (pCi/L)
LUND NV				
McKenzie Dairy				
	02/01	309 æ 378*	-2.7 æ 6.*	**
	05/04	SOLD OUT **	**	**
MCGILL NV				
Larsen Ranch				
	01/05	NO SAMPLE **	SOLD COW **	**
MESQUITE NV				
Speda Brothers Dairy				
	02/01	333 æ 380*	-0.7 æ 7.2*	0.7 æ 1.8*
	04/04	365 æ 370*	-9.8 æ 6.9*	2.3 æ 2.6*
	05/02	155 æ 371*	-6.9 æ 7.9*	1.6 æ 0.9
	08/09	243 æ 255	**	0.4 æ 3.0
	09/12	**	**	0.5 æ1.4*
	11/01	268 æ 244	2.0 æ 9.9*	0.1 æ 1.6*
MOAPA NV				
Rockview Dairies Inc.				
	02/01	400 æ 230	-1.8 æ 6.6*	1.2 æ 1.7*
	05/02	294 æ 371*	-1.5 æ 5.4*	1.1 æ 1.7*
	07/01	98 æ 236*	-3.1 æ22.6*	1.3 æ13.5*
	07/01	(HIGH Sr ABOVE MDA)		
	08/11	-20 æ 252*	-9.7 æ23.1*	2.1 æ 2.0
	10/03	39 æ 234*	0.1 æ15.9*	0.7 æ 2.8*
	11/01	36 æ 249*	**	0.3 æ 1.4*
NYALA NV				
Sharp's Ranch				
	02/02	378 æ 399*	-4.8 æ10.3*	1.5 æ 2.6*
	05/05	164 æ 376*	1.6 æ 7*	1.0 æ 3.1*
	08/09	71 æ 253*	2.9 æ16.2*	0.4 æ 1.3*
	11/01	159 æ 235*	0.9 æ13.4*	0.6 æ 1.4*
CALIENTE NV				
June Cox Ranch				
	01/06	**	LOST	LOST
	04/04	300 æ 385*	4.2 æ 4.6*	-0.2 æ 1.8*
	07/11	-12 æ 252*	1.1 æ 5.1*	0.3 æ 3.3*
	10/03	200 æ 250*	-0.6 æ 6.4*	0.5 æ 1.2*
ROUND MT NV				
Berg's Ranch				
	03/10	NO SAMPLE **	COW DRY **	**
	09/15	NO SAMPLE **	COW DRY **	**
	12/14	-16 æ 242*	**	1.0 æ 1.6*
SHOSHONE NV				
Harbecke Ranch				
	01/05	**	1.5 æ 4.1*	2.0 æ 2.2*
	03/01	428 æ 238	7.9 æ24.6*	1.3 æ14*
	06/07	583 æ 246	-0.1 æ 2.1*	0.0 æ 1.3*
	09/01	201 æ 239*	**	3.2 æ 3.2*
	12/01	51 æ 226*	3.7 æ 6.2*	0.25 æ 1.4*

(continued)

TABLE 9. (Continued)

SAMPLING LOCATION	COLLECTION DATE 1988	CONC ± 2 SIGMA ^{3}H (pCi/L)	^{89}Sr (pCi/L)	^{90}Sr (pCi/L)
RACHEL NV				
Penoyer Farm				
	02/02	130 æ 372*	6.6 æ 7.2*	0.1 æ 1.8*
C. Castleton				
	05/04	NO SAMPLE **	COW DRY **	**
	08/02	NO SAMPLE **	COW DRY **	**
WARM SPRINGS NV				
Twin Springs Ranch				
	12/06	130 æ 249*	**	0.8 æ 1.9*
CEDAR CITY UT				
Brent Jones Dairy				
	01/04	295 æ 384*	-2.1 æ 5.4*	1.6 æ 2.8*
	03/01	318 æ 353*	-1.9 æ 6.4*	1.7 æ 2.3*
	06/06	315 æ 375*	0.3 æ 2.7*	0.2 æ 1.7*
	07/01	140 æ 234*	-0.5 æ 3.8*	0.9 æ 1.7*
	09/12	40 æ 239*	**	1.1 æ 1.0*
	12/01	148 æ 243*	-0.2 æ 5.1*	0.8 æ 1.2*
ST GEORGE UT				
Gentry Dairy				
	01/04	253 æ 390*	-3.3 æ 1.3*	1.3 æ 4.8*
	03/01	199 æ 374*	6.0 æ 9.1*	0.2 æ 2.1*
	06/06	448 æ 239	-0.4 æ 2.4*	1.3 æ 1.4*
	09/12	155 æ 155*	**	1.3 æ 1.1
Truman Cannon				
	12/01	293 æ 244	2.4 æ 6.4*	-0.4 æ 1.4*

* CONCENTRATION IS LESS THAN THE MINIMUM DETECTABLE CONCENTRATION (MDC).
** SAMPLES NOT ANALYZED.

TABLE 10. **Analytical results for the Standby Milk Surveillance Network 1988**

SAMPLING LOCATION	COLLECTION DATE 1988	CONC. ± 2 SIGMA ^{3}H (pCi/L)	^{89}Sr (pCi/L)	^{90}Sr (pCi/L)
Taylor AZ Sunrise Dairy	07/07	160 ±380*	3.6 ± 5.0*	-1.9 ± 3.7*
Tucson AZ Shamrock Dairy (Pima Co)	07/11	83 ±240*	1.5 ± 4.5*	-1.0 ± 3.5*
Little Rock AR Bordens	07/11	140 ±230*	-1.3 ± 5.3*	2.8 ± 4.1*
Russellville AR Arkansas Tech Univ	07/17	244 ±241*	-2.1 ± 5.2*	2.9 ± 4.4*
Bakersfield CA Carnation Dairy	08/08	142 ±230*	-0.9 ± 2.3*	0.8 ± 1.8*
Weed CA Medo-Bel Creamery	08/16	-11 ±233*	-1.1 ± 1.8*	0.8 ± 1.6*
Willows CA Foremost Foods Company	08/15	107 ±236*	-1.0 ± 1.2*	0.8 ± 1.1
Grand Junction CO Colorado West Dairies	06/29	177 ±233*	0.9 ± 5.6*	-0.05 ±3.7*
Pueblo CO Hyde Park Dairy Co	08/29	243 ±236***	**	1.5 ± 1.9*
Boise ID Meadow Gold Dairies	08/23	117 ±241*	**	1.3 ± 1.6*
Burlington IA MS Valley Milk Pro	06/24	140 ±241*	5.2 ± 9.6*	-1.0 ± 5.0*
Dubuque IA MS Valley Milk Assn	06/16	353 ±240***	1.4 ± 7.2*	1.6 ± 4.0*
Ellis KS Mid-America Dairy	07/18	116 ±234*	-8.9 ± 5.7*	5.5 ± 3.0***
Sabetha KS Mid-America Dairy	07/20	-147 ±230*	1.1 ±35*	-3.0 ± 29*
Manhattan KS Kansas State University	07/20	56 ±241*	-4.8 ± 6.6*	2.5 ± 5.7*
Ellis KS Mid-America Dairy	07/18	116 ±234*	-8.9 ± 5.7*	5.5 ± 3.0***
Sabetha KS Mid-America Dairy	07/20	-147 ±230*	1.1 ±34.9*	-3.0 ±29*
Manhattan MS Kansas City University	07/20	56 ±241*	-4.8 ± 6.6*	2.5 ± 5.7*
Monroe LA Borden's	08/02	248 ±250*	**	1.9 ± 3.0*
Flensburg MN Flensburg Co-op Cmry (Sobieski Dairy)	08/01	66 ±235*	**	1.4 ± 2.4*
Fosston MN Land O'Lakes Inc	08/02	33 ±229*	-1.7 ± 1.8*	2.0 ± 1.0***

(continued)

TABLE 10. (Continued)

SAMPLING LOCATION	COLLECTION DATE 1988	CONC. ± 2 SIGMA ^{3}H (pCi/L)	^{89}Sr (pCi/L)	^{90}Sr (pCi/L)
Rochester MN Rochester Dairy Co-op	08/02	161 ±235*	-5.1 ± 5.9*	3.4 ± 4.1*
Aurora MO Mid-America Dairy Inc	08/29	304 ±241***	**	4.9 ± 2.6***
Jackson MO Mid-America Dairymen Inc	06/27	31 ±230*	-0.1 ± 3.0*	1.7 ± 2.1*
Billings MT Beatrice Foods Co	06/15	43 ±230*	1.4 ±11*	1.5 ± 6.1*
Havre Mt Vita-Rich Dairy	08/18	305 ±250***	**	-0.6 ± 3.0*
Norfolk NE Gillette Dairy	07/21	25 ±232*	-0.38 ± 1.7*	2.4 ± 1.2***
North Platte NE Mid America Dairymen	07/11	131 ±238*	-2.1 ± 2.6*	3.7 ± 1.5***
Superior NE Mid-Amer Dairymn-D Fritz	07/21	135 ±236*	-0.9 ± 3.7*	2.2 ± 3.4*
Albuquerque NM Borden's Valley Gold	06/29	123 ±231*	-3.4 ±15*	0.0 ± 9.9*
La Plata NM Rothlisberger Dairy	07/05	21 ±241*	15 ±17*	-5.0 ± 12*
Bismarck ND Bridgemens Creamery	07/27	245 ±234*	1.0 ± 2.6*	0.9 ± 1.6*
Grand Forks ND Minnesota Dairy	07/07	143 ±239*	-2.3 ± 4.0*	2.3 ± 3.4*
Enid OK AMPI Goldspot Division	09/06	163 ±240*	**	0.0 ± 2.2*
McAlester OK OK State Penitentiary	09/26	142 ±244*	**	1.5 ± 2.0*
Corvallis OR Sunny Brook Dairy	07/25	61 ±234*	-4.4 ± 6.1*	1.6 ± 5.7*
Medford OR Dairygold Farms	07/26	88 ±239*	-1.4 ± 3.3*	1.1 ± 2.1*
Tillamook OR Tillamook Co Crmy	07/28	138 ±239*	-0.5 ± 3.4*	1.5 ± 2.3*
Sioux Falls SD Land O'Lakes Inc	06/17	97 ±233*	3.0 ± 5.2*	0.6 ± 3.0*
Volga SD Land O'Lakes Inc	06/20	129 ±234*	1.9 ±15*	0.5 ± 8.7*
Provo UT BYU Dairy Products Lab	07/15	20 ±232*	-0.2 ± 2.0*	0.7 ± 1.8*
Moses Lake WA Safeway Stores Inc	09/01	311 ±253***	**	**
Seattle WA Consolidated Dairy Prod	08/11	319 ±265***	-3.7 ±17.2*	1.9 ± 13.1*

(continued)

TABLE 10. (Continued)

SAMPLING LOCATION	COLLECTION DATE 1988	CONC. ± 2 SIGMA ^{3}H (pCi/L)	^{89}Sr (pCi/L)	^{90}Sr (pCi/L)
Spokane WA Consolidated Dairy	09/01	324 ±250***	**	-6.3 ± 4.4*
Powell WY Cream of the Valley Dairy	07/23	384 ±235***	**	2.4 ± 2.2***

* Concentration is less than the minimum detectable concentration (MDC).
** Samples not analyzed.
*** Concentration is greater than the minimum detectable concentration (MDC).

SAMPLES FROM THE FOLLOWING LOCATIONS WERE ANALYZED BY GAMMA SPECTROSCOPY ONLY:

In all cases gamma spectroscopy results were negligible.

SAMPLING LOCATION	COLLECTION DATE 1988	SAMPLING LOCATION	COLLECTION DATE 1988
Joseph City AZ		**Smith River CA**	
Midway Dairy	07/11	Country Maid Dairy	08/01
Tempe AZ		**Soledad CA**	
United Dairyman of AZ	07/11	CTF Dairy	08/04
Yuma AZ		**Tracy CA**	
Golden West Dairy	07/12	Deuel Voc Inst	08/15
Batesville AR		**Colorado Springs CO**	
Hills Valley Foods	09/19	Sinton Dairy Co	07/05
Fayetteville AR		**Delta CO**	
University of AR	07/20	Arden Meadow Gold Dairy	08/18
Helendale CA		**Lewiston ID**	
Osterkamp Dairy No 2	08/08	Golden Grain Dairy Prod	06/16
Chino CA		**Pocatello ID**	
CA Inst for Men	08/09	Rowland's Dairy	08/17
Holtville CA		**Twin Falls ID**	
Schaffner & Son Dairy	08/08	Associated Dairy Inc	08/17
Manteca CA		**Kimballton IA**	
Dejager Dairy #2 North	08/10	AMPI Receiving Sta	06/21
Oxnard CA		**Lake Mills IA**	
Chase Bros Dairy	08/09	Lake Mills Coop Crmy	07/11
Redding CA		**Lemars IA**	
McColl's Dairy Prod	08/15	Wells Dairy	07/12
San Jose CA		**Hammond LA**	
Marques Bros Mexican Impo	08/02	Southeastern LA College	08/03
San Luis Obispo CA		**Dalton MN**	
Cal State Poly	08/08	Dalton Co-op Creamery	07/28

(continued)

TABLE 10. (continued)

SAMPLING LOCATION	COLLECTION DATE 1988	SAMPLING LOCATION	COLLECTION DATE 1988
Saugus CA		**Nicollet MN**	
Wayside Honor Ranch	08/08	Nicollet County Dairy	08/01
Sebastopol CA		**Chillicothe MO**	
WM Miller Dairy	08/16	Mid-America Dairymen	06/15
Jefferson City MO		**Eugene OR**	
Central Dairy Co	07/19	Echo Springs Dairy	07/25
Boseman MT		**Grants Pass OR**	
Darigold Farms	06/15	Valley of Rogue Dairy	07/25
Great Fall MT		**Klamath Falls OR**	
Meadow Gold Dairy	06/17	Medo Bel Creamery	08/17
Missoula MT		**Union OR**	
Community Creamery	08/22	Gram-Bell Dairy	07/25
Caldwell ID		**Omaha NE**	
DCA Receiving Sta	06/15	Roberts Dairy-Marshall Gro	07/11
Chappell NE		**Redmond OR**	
Leprino Foods	07/25	Eberhard's Creamery Inc	07/25
Fallon NV		**Mitchell SD**	
Creamland Dairy	07/25	Culhanes Dairy	08/17
Logandale NV		**Rapid City SD**	
Knudsen Dairy	07/24	Brown Swiss Dairy	06/21
Reno NV		**Beaver UT**	
Model Dairy	07/26	Cache Valley Dairy	08/24
Yerington NV		**North Ogden UT**	
Valley Dairy	07/25	Western General Dairy	07/08
Devils Lake ND		**Richfield UT**	
Lake View Dairy	07/05	Ideal Dairy	07/05
Fargo ND		**Smithfield UT**	
Cassclay Creamery	07/29	Cache Valley Dairy	07/13
Atoka OK		**Cheyenne WY**	
Mungle Dairy	09/07	Dairy Gold Foods	06/10
Claremore OK		**Laramie WY**	
Swan Bros Dairy	09/08	Univ of WY (Dairy Farm)	09/14
Myrtle Point OR		**Riverton WY**	
Safeway Stores Inc	07/26	Albertson's Plant	06/10

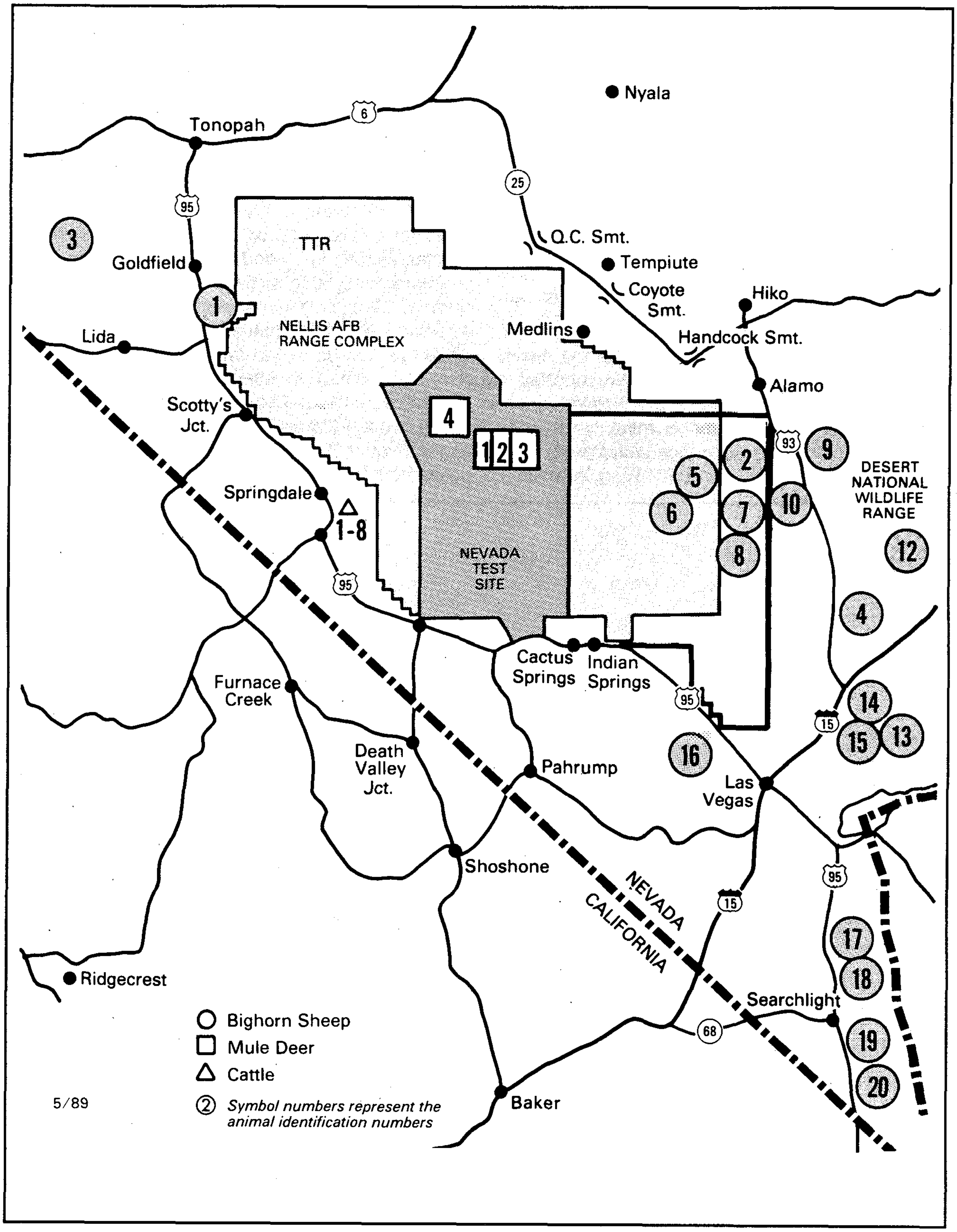


Figure 18. Collection Sites for Animals Sampled, 1988.

Results

Analytical data from bones and kidneys collected from desert bighorn sheep during the late fall of 1987 are presented in Table 11. Tritium concentrations reported from the kidneys ranged from 100 pCi/L to 970 pCi/L with a median value of 510 pCi/L. Kidney tissue concentration in eight animals exceeded the minimum detectable activity of 560 pCi/L. The naturally occurring ^{40}K was the only gamma-emitting radionuclide detected in the kidneys of the sheep. Strontium-90 levels in the bones (average 2.3 pCi/g ash) are consistent with those reported in recent years (Figure 19).

Plutonium concentration in tissues from the desert bighorn sheep were also similar to those reported in previous years. Counting errors exceeded the reported concentrations in the majority of bone samples. Plutonium-238 concentrations in bone ash ranged from 0.02 fCi/g to 8.2 fCi/g ash with a median of 2.95 fCi/g ash. The ^{239}Pu concentrations ranged from -0.07 fCi/g ash to 17 fCi/g ash with a median value of 2.6 fCi/g ash.

Eight beef cattle were sampled during 1988, four in May and four in October. All eight animals were purchased from G. L. Coffer of Beatty, Nevada, and grazed the Beatty Wash adjacent to Yucca Mountain and Area 30 of NTS (Figure 18). Tritium concentrations in blood did not exceed the minimum detectable activity in any of the eight animals. The only gamma-emitting radionuclides detected other than naturally occurring ^{40}K, was ^{137}Cs (15 ± 7 pCi/kg) in the muscle from an aged cow. Strontium-90 concentration in bone ash samples from the 1988 cattle ranged from 0.2 pCi/g of ash to 0.8 pCi/g ash with an average of 0.6 pCi/g of ash (Figure 19). Strontium-90 concentrations in bones from four cattle from the Steve Medlin Ranch

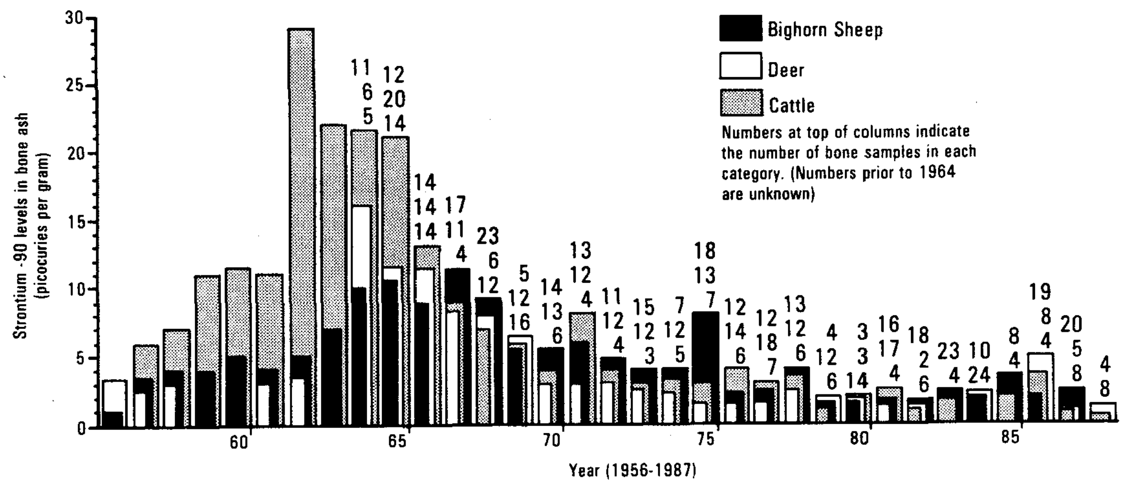


Figure 19. Average ^{90}Sr Concentrations in Animal Bone.

Table 11. Radionuclide concentrations in desert bighorn sheep samples - 1987

Bighorn Sheep (collected Winter 1987)	Bone ^{90}Sr (pCi/g Ash)	Bone ^{238}Pu (fCi/g Ash)	Bone ^{239}Pu (fCi/g Ash)	Kidney ^{3}H(pCi/L)*
1	1.9 ± 0.1	4.8 ± 4.5	17 ± 4.7	460 ± 350
2	2.2 ± 0.1	1.2 ± 4.0**	4.7 ± 2.7	570 ± 350
3	2.9 ± 0.1	1.8 ± 3.1**	1.5 ± 1.9**	760 ± 350
4	2.1 ± 0.1	2.4 ± 3.6**	2.2 ± 2.3**	100 ± 320**
5	6.4 ± 1.0	5.6 ± 3.5	0.1 ± 1.4**	470 ± 350
6	1.6 ± 0.1	2.8 ± 3.6**	3.2 ± 2.5	120 ± 340**
7	2.4 ± 0.1	5.1 ± 3.2	6.6 ± 2.8	480 ± 350
8	2.3 ± 0.1	2.2 ± 3.1	2.7 ± 1.6	180 ± 340**
9	1.2 ± 0.1	1.2 ± 4.2**	2.9 ± 2.4	370 ± 340
10	1.7 ± 0.1	1.1 ± 3.9**	-0.07 ± 1.4**	380 ± 340
11	1.0 ± 0.1	2.2 ± 4.3**	2.9 ± 2.2	810 ± 350
12	3.6 ± 0.2	0.02 ± 0.03**	-0.2 ± 0.8**	710 ± 350
13	6.7 ± 0.7	3.1 ± 3.1	0.5 ± 1.1**	970 ± 550
14	1.3 ± 0.2	3.1 ± 3.1	1.0 ± 1.7**	760 ± 350
15	2.3 ± 0.2	8.2 ± 4.0	6.1 ± 2.9	680 ± 350
16	1.0 ± 0.1	5.4 ± 3.6	4.2 ± 5.3**	340 ± 350**
17	0.9 ± 0.07	4.9 ± 3.2	0.8 ± 1.5**	540 ± 350
18	0.5 ± 0.06	3.2 ± 3.6**	1.0 ± 1.9**	580 ± 350
19	1.0 ± 0.07	1.1 ± 3.5	2.4 ± 2.1	260 ± 340**
20	1.0 ± 0.08	4.2 ± 3.4	7.0 ± 3.0	510 ± 350
Median	1.8	2.95	2.55	510
Range	0.5 - 6.7	0.02 - 8.2	−0.2 - 17.0	100 - 970

* Aqueous portion of kidney tissue, MDA is 560 pCi/L
** Counting error exceeds reported activity

sampled in October 1987 averaged 1.2 pCi/g of ash (analyses were not completed in time for data to be included in the 1987 annual report).

Concentrations of ^{238}Pu did not exceed the counting errors in any of the bone and liver samples collected from cattle during October 1987, or 1988. Liver concentrations of ^{239}Pu exceeded the counting error in all samples. Concentrations ranged from 6.3 to 28 fCi/g ash (median of 11 fCi/g ash) for the Medlin cattle and from 6 to 31 fCi/g ash (median 12 fCi/g ash) for liver samples from the Coffer cattle. Plutonium-239 concentrations in cattle bone samples exceeded the counting error in only one of the Medlin animals (20 ± 13 fCi/g ash) and one of the 1988 cows (4.8 ± 2.5 fCi/g ash). Whole body concentrations of plutonium in two feti from the 1988 October cattle were similar to those found in their dams, i.e., ^{238}Pu concentration did not exceed its counting error and ^{239}Pu concentrations were 1.1 ± 1.7 and 6.1 ± 3 fCi/g of ash.

During 1988, four NTS mule deer were sampled. Analytical data from these animals plus those from the last two mule deer sampled in 1987 (data from these animals was not available for 1987 annual report) are presented in Table 12.

Other than the naturally occurring ^{40}K, the only gamma-emitting radionuclides detected were ^{137}Cs in the soft tissues of deer #4 (1987) and deer #3 (1988) and ^{106}Ru and ^{125}Sb in the rumen contents of the same animals. The ^{106}Ru values in rumen contents were 50 and 54 pCi/kg, respectively, and the ^{125}Sb values were 1500 and 110 pCi/kg, respectively: the kidneys of deer #3 (1988) also contained 220 pCi/kg of ^{106}Ru.

Strontium-90 values in the 1988 deer ranged from 0.5 to 2.2 pCi/g of bone ash with an average value of 1.2 pCi/g of ash (Figure 19). The ^{90}Sr values in the two 1987 deer were 1.3 and 1.7 pCi/g of bone ash (average for all 1987 deer were 1.0 pCi/g of bone ash). Bone levels of ^{238}Pu and ^{239}Pu did not exceed the counting error in any of the deer. Soft tissue concentrations of ^{239}Pu, which exceeded the counting errors, ranged from 1.3 fCi/g of ash (lung 1988 No. 3) to 52 fCi/g of ash (muscle 1988 No. 1). Soft tissue concentration of ^{238}Pu, which exceeded the counting errors, occurred in muscle samples from three of the 1988 deer and ranged from 0.1 fCi/g of ash to 6.9 fCi/g of ash.

Detectable tritium concentrations found in the kidneys of two 1988 deer were quite elevated in the kidneys of two deer (No. 1, 1.5 μCi/L of tissue water and No. 3, 39 μCi/L of tissue water). Both of these animals and No. 4 from 1987 were collected in close proximity to the tunnel area of Area 12 and probably were drinking from the drainage waters in this area. These unfenced drainage waters continue to be a potential source of exposure to the off-site population which may consume meat from mule deer or migratory fowl which travel off the NTS. Dose estimates from consumption of NTS deer are presented in the dose assessment section.

Two migratory ducks from the Overton Wildlife Refuge were collected through the cooperation of the Nevada Department of Wildlife. Other than ^{40}K, no gamma-emitting radionuclides were detected. Strontium-90 concentrations in bones were 0.2 pCi/g of ash in both ducks. Plutonium-238 concentrations exceeded the counting errors in the muscle of duck No. 1 (21 ± 4.4 fCi/g ash). Plutonium-239 levels exceeded the counting error in the muscle of duck No. 1 (53 ± 14 fCi/g ash) and internal organs of duck No. 2 (12 ± 5 fCi/g ash).

Certain radionuclide analyses of composited tissue from two NTS chukars collected during 1987 were not completed prior to publishing the 1987 annual report. Therefore, that data is summarized as follows: the ^{90}Sr value of the bones was 0.04 ± 0.03 pCi/g of bone ash. Plutonium-238 values that exceeded the counting error were 100 ± 17 fCi/g bone ash and 18 ± 6 fCi/g of ash from internal organs. Plutonium-239 values that exceeded the counting error were 930 ± 130 fCi/g of bone ash, 40 ± 15 fCi/g of ash from muscle and 170 ± 20 fCi/g ash from the internal organs.

During the summer of 1988, samples of produce were collected from the Fallis and Penoyer Farm gardens in Rachel, Nevada. All of these samples (turnips, turnip greens, potatoes, squash, and cucumbers) were submitted for gamma analysis, the spectra were negligible for all samples collected.

Table 12. Radionuclide Concentration in Tissues From Mule Deer Collected on the Nevada Test Site - 1988

Tissue	^{137}Cs (pCi/Kg)	^{3}H (uCi/L)	^{238}Pu fCi/g/ash	^{239}Pu fCi/g/ash	^{90}Sr fCi/g/ash
		Mule Deer No. 4 Collected 07/28/87			
Thyroid	ND	NA	NA	NA	NA
Kidney	270 ± 40	NA	NA	NA	NA
Muscle	90 ± 20	NA	ND*	ND*	NA
Liver	90 ± 20	NA	NA	NA	NA
Lung	120 ± 30	NA	ND*	ND*	NA
Rumen Contents	830 ± 40	NA	53 ± 11	205 ± 27	NA
Blood	NA	41.4 ± 0.08	NA	NA	NA
Bone	NA	NA	ND*	ND*	1.7 ± 0.1
		Mule Deer No. 5 Collected 11/02/87			
Liver	ND	NA	ND*	11 ± 9	NA
Lung	ND	NA	ND*	8.9 ± 3.6	NA
Rumen Contents	ND	NA	ND*	39 ± 17	NA
Blood	NA	0.23 ± 0.02	NA	NA	NA
Bone	NA	NA	ND*	ND*	1.3 ± 0.1
		Mule Deer No. 1 Collected 03/11/88			
Kidney	ND	1.5 ± 0.004	ND*	ND*	NA
Lung	ND	NA	ND*	4.6 ± 3.9	NA
Muscle	ND	NA	0.1 ± 0.07	52 ± 14	NA
Rumen Contents	ND	NA	9.5 ± 68	24 ± 7.8	NA
Bone	NA	ND	ND*	ND*	2.2 ± 1.3
		Mule Deer No. 2 Collected 05/23/88			
Liver	ND	NA	ND	6.7 ± 4.6	NA
Muscle	ND	NA	ND*	6.3 ± 3.1	NA
Rumen Contents	ND	NA	ND*	3.1 ± 7.3	NA
Bone	NA	NA	ND*	ND*	1.1 ± 0.1

(continued)

Table 12. Continued

Tissue	^{137}Cs (pCi/Kg)	^{3}H (uCi/L)	^{238}Pu fCi/g/ash	^{239}Pu fCi/g/ash	^{90}Sr fCi/g/ash
			Mule Deer No. 3 Collected 09/13/88		
Kidney	60 ± 14	39 ± 0.002	NA	NA	NA
Liver	35 ± 2	NA	ND*	5.8 ± 3.3	NA
Lung	ND	NA	ND*	1.3 ± 0.6	NA
Muscle	50 ± 17	NA	6.9 ± 54	7.6 ± 3.8	NA
Rumen Contents	--	ND	NA	ND	30 ± 13
Bone	NA	NA	ND*	ND*	1 ± 0.1
			Mule Deer No. 4 Collected 10/24/88		
Muscle	ND	NA	ND*	4.2 ± 2.0	NA
Liver	ND	NA	ND*	ND*	NA
Lung	ND	NA	6.3 ± 5.9	8.6 ± 4.4	NA
Rumen Contents	ND	NA	9.9 ± 8.5	11 ± 8	NA
Bone	NA	NA	ND*	ND*	0.5 ± 0.05

ND = Not Detected
ND* = Counting error exceeds reported activity
NA = Not Analyzed

5.2.5 Thermoluminescent Dosimetry Network

B. B. Dicey

EPA's primary method of measuring external radiation exposures is the thermoluminescent dosimeter (TLD). Calendar year 1988 represented the first full year of operations using the Panasonic TLD system. This system, installed in 1987, provides greater sensitivity and precision than was possible using film or the previous TLD system. There is an added advantage in that the dosimeters used are more nearly tissue-equivalent. This facilitates correlating individual measured exposures with the absorbed biological dose equivalent.

Network Design

The TLD network is designed to measure total ambient gamma exposures at specified locations rather than exposures to specific individuals. This method is generally preferred because of multiple uncontrollable variables associated with personnel monitoring. Measuring environmental ambient gamma exposures in fixed locations provides a reproducible index which can then be easily correlated to the maximum exposure an individual would have received were he continuously present at that location. In addition to the fixed locations, several individuals residing within and outside estimated fallout zones from past nuclear tests at the NTS have been monitored. These individuals are monitored both to determine individual exposures and to confirm the validity of correlating fixed-site ambient gamma measurements to projected individual exposures.

A network of environmental stations and monitored personnel has been established in locations encircling the NTS. Monitoring locations are as shown on Figure 20. This arrangement permits both an estimate of average background exposures and prompt detection of any increase due to NTS activities.

Net exposure to an individual is determined by comparing the results of each dosimeter issued to that individual with the results obtained from the previous four dosimeters located at the associated reference background location established for that individual. The reference background dosimeters measure ambient gamma radiation exposure. An associated reference background dosimeter reading that varies by greater than a statistically determined amount from the historical mean is not used in calculating net exposures to individuals because this variation could represent an anomaly or a contribution from NTS activities.

Monitoring of off-site personnel is accomplished with the Panasonic UD-802 dosimeter. This dosimeter contains two elements of $Li_2B_4O_7$:Cu and two of $CaSO_4$:Tm phosphors. The four elements are behind 14, 300, 300, and 1000 mg/cm^2 filtration, respectively. Monitoring of off-site environmental stations is accomplished with the Panasonic UD-814 dosimeter. This dosimeter contains a single element of $Li_2B_4O_7$:Cu and three replicate $CaSO_4$:Tm elements. The first element is filtered by 14 mg/cm^2 of plastic and the remaining three are filtered by 1000 mg/cm^2 of plastic and lead. The three replicate phosphors are used to provide improved statistics and extended response range.

5.2.6 Results of TLD Monitoring

5.2.6.1 Off-Site Personnel

During 1988 a total of 61 individuals living in areas surrounding the Nevada Test Site were provided with personnel TLD dosimeters. All measured exposures are presumed to be due to gamma radiation and hence are numerically equivalent to absorbed dose.

Of the 61 individuals monitored, 57 showed zero detectable exposure above that measured at the associated reference background location. One individual did not return the dosimeter for processing. Three apparent individual exposures were slightly greater than the associated reference background. These ranged from 3.6 to 10.0 mrem for the year. Each of these represented total exposures obtained from several dosimeters worn during the year. Apparent exposures to an individual dosimeter of less than three times the associated reference background are considered to be within the range of normal variation for the Panasonic TLD system. Therefore, none of the three apparent net individual exposures are considered to represent an abnormal occurrence. Figure 21 illustrates that the TLD monitoring results for off-site personnel were all well within the range of the associated reference background values. Table 13 lists the results of off-site personnel TLD monitoring for 1988.

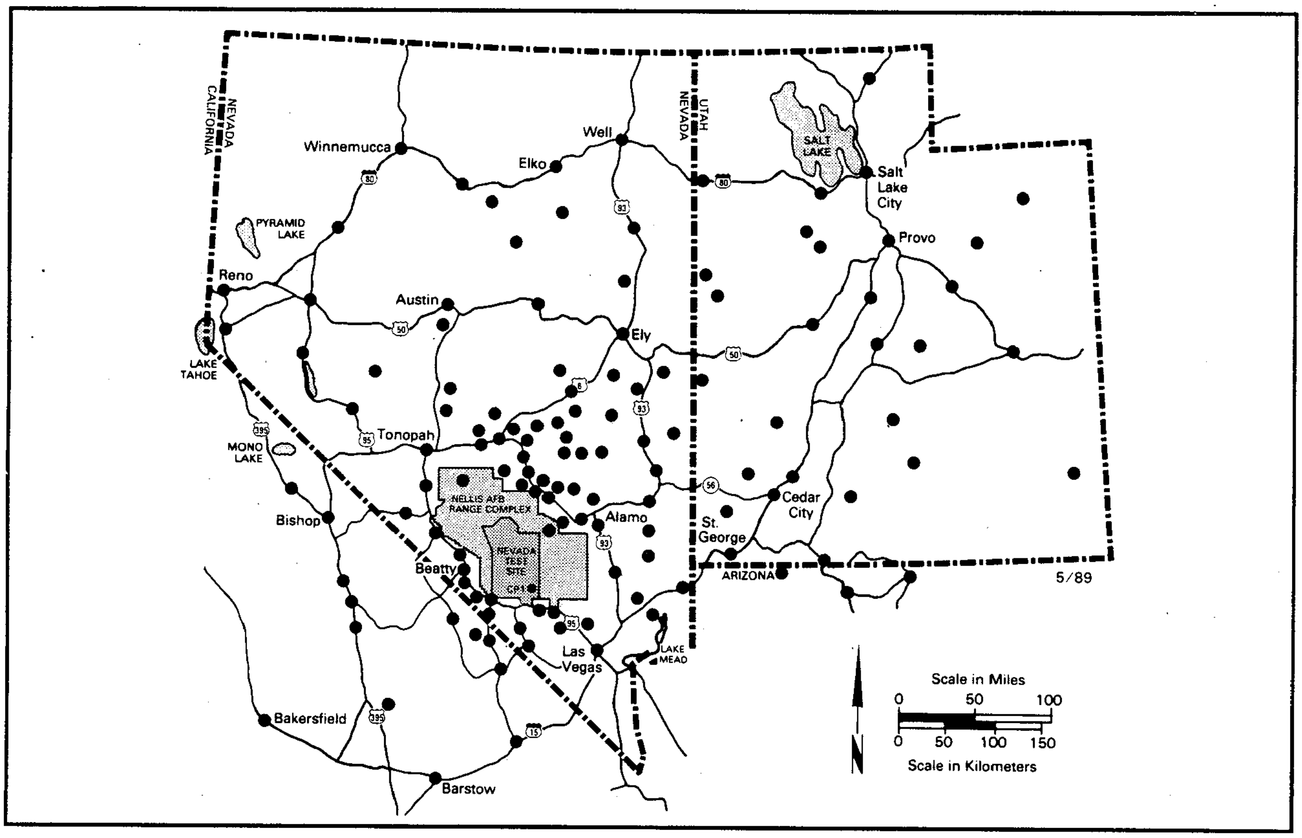


Figure 20. Locations Monitored with TLDs.

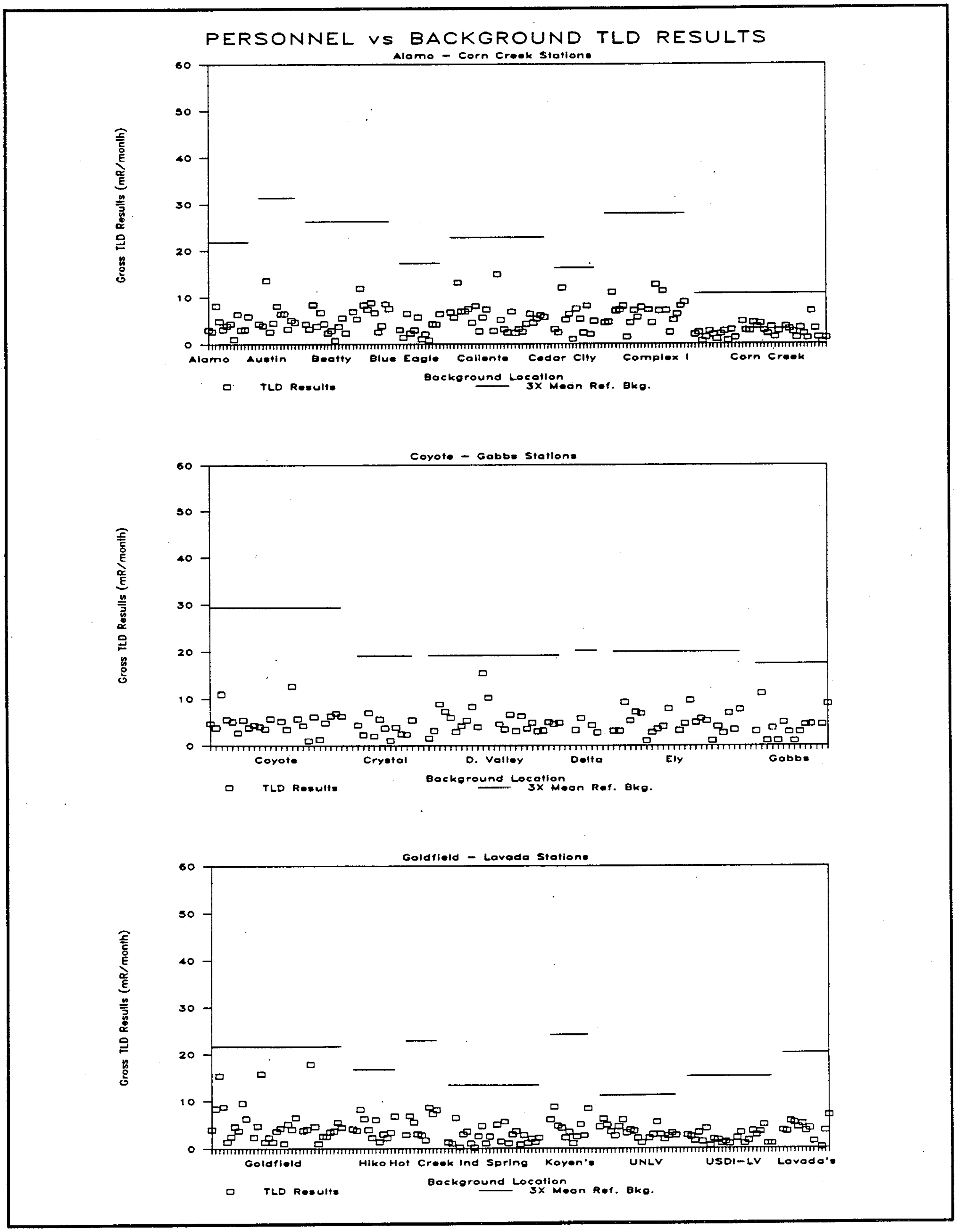
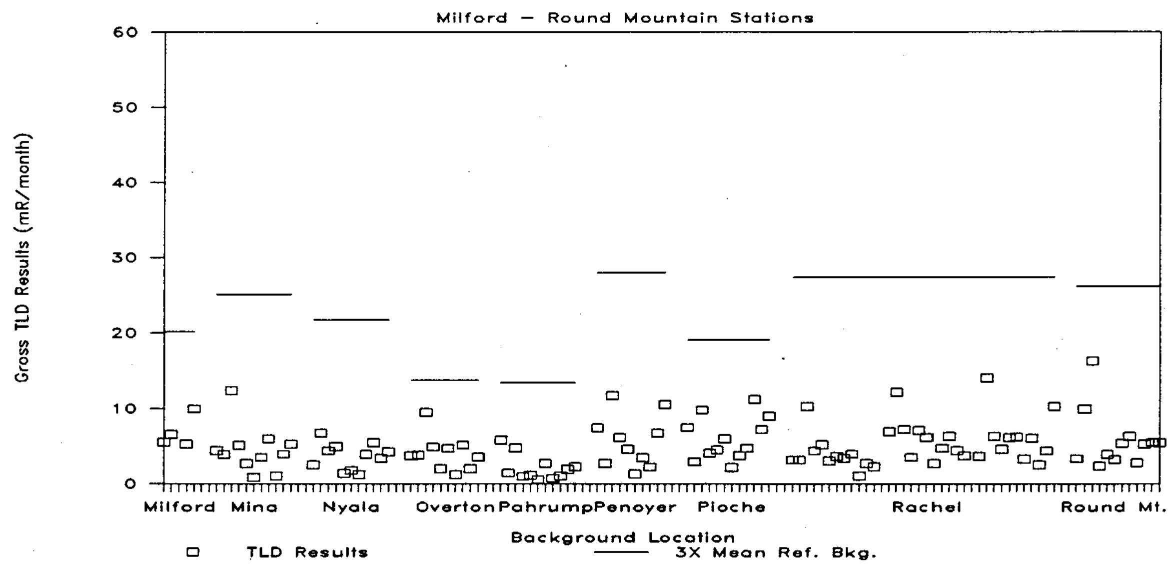


Figure 21. Personnel vs. Background TLD Results.



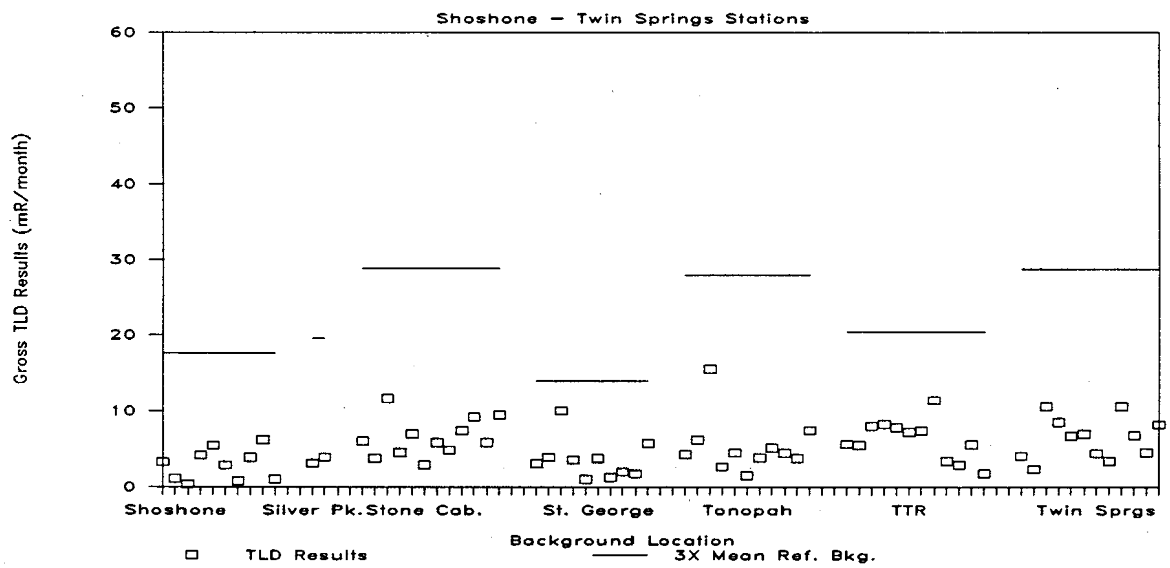


Figure 21. (Continued).

5.2.6.2 Off-Site Stations

During 1988 a total of 154 off-site stations were monitored to determine background ambient gamma radiation levels. The annual adjusted dose equivalent (mrem/year) was calculated by multiplying the average daily rate for each station by 365.

During 1988 the maximum apparent net annual exposure to an off-site station was measured to be 225 mrem. This exposure, at Warm Springs, NV, was felt to be due to high levels of naturally occurring radioactive material in a stream. During the first two quarters of 1988 the TLD was located adjacent to the stream. Average ambient gamma radiation readings measured by TLDs were 0.85 mR/day. The TLD was moved away from the stream for the second half of 1988. Average readings with the TLD located away from the stream were 0.38 mR/day. If the TLD had been located away from the stream for the entire year, the adjusted dose

Table 13. Annual Summary TLD Results - Offsite Personnel - 1988

ASSOCIATED REFERENCE BACKGROUND STATION LOCATION (See Table 14)	RESIDENT No.	MEASUREMENT PERIOD START DATE	END DATE	DOSE EQUIV. RATE (mrem/day) MAX.	MIN.	AVG.	NET ANNUAL DOSE (mrem)*	COMMENTS
*** CALIFORNIA ***								
DEATH VALLEY JCT, CA	304	01/07/88	01/06/89	0.57	0.05	0.22	10.00	
DEATH VALLEY JCT, CA	331	01/07/88	01/05/89	0.18	0.07	0.15	0.00	
SHOSHONE, CA	60	01/04/88	01/04/89	0.21	0.02	0.10	0.00	
*** NEVADA ***								
ALAMO, NV	22	01/05/88	01/04/89	0.22	0.04	0.13	0.00	
AUSTIN, NV	329	01/13/88	01/12/89	0.41	0.08	0.20	0.00	
BEATTY, NV	38	01/05/88	01/06/89	0.43	0.09	0.23	0.00	
BEATTY, NV	21	01/06/88	01/06/89	0.20	0.03	0.13	0.00	
BLUE EAGLE RANCH, NV	9	01/05/88	01/04/89	0.18	0.02	0.11	0.00	
CALIENTE, NV	2	01/05/88	01/04/89	0.39	0.09	0.22	0.00	
CALIENTE, NV	336	02/03/88	01/04/89	0.44	0.08	0.16	0.00	
COMPLEX 1, NV	10	01/06/88	01/05/89	0.32	0.05	0.19	0.00	
COMPLEX 1, NV	11	01/06/88	01/05/89	0.37	0.08	0.22	0.00	
CORN CREEK, NV	25	01/04/88	01/03/89	0.10	0.02	0.06	0.00	
CORN CREEK, NV	56	01/04/88	01/03/89	0.17	0.05	0.11	0.00	
CORN CREEK, NV	223	01/04/88	01/03/89	0.23	0.01	0.08	0.00	
COYOTE SUMMIT, NV	15	01/05/88	01/04/89	0.32	0.03	0.17	0.00	
COYOTE SUMMIT, NV	14	01/05/88	01/04/89	0.27	0.09	0.16	0.00	
CRYSTAL, NV	301	01/04/88	01/04/89	0.17	-1.16	0.01	0.00	
ELY, NV	47	01/05/88	01/11/89	0.27	0.04	0.15	0.00	
ELY, NV	233	01/04/88	01/11/89	0.28	0.05	0.15	0.00	
GABBS, NV	302	01/14/88	01/10/89	0.32	0.03	0.12	0.00	
GABBS, NV	305	01/14/88	03/11/88	0.28	0.17	0.23	0.00	
OLDFIELD, NV	7	01/14/88	01/11/89	0.49	0.04	0.20	0.00	

(continued)

Table 13. (Continued)

ASSOCIATED REFERENCE BACKGROUND STATION LOCATION (See Table 14)	RESIDENT No.	MEASUREMENT PERIOD START DATE	END DATE	DOSE EQUIV. RATE (mrem/day) MAX.	MIN.	AVG.	NET ANNUAL DOSE (mrem)*	COMMENTS
OLDFIELD, NV	19	01/05/88	01/11/89	0.56	0.03	0.16	0.00	
GOLDFIELD, NV	40	01/06/88	01/11/89	0.48	0.04	0.15	0.00	
HIKO, NV	232	01/04/88	01/04/89	0.24	0.05	0.14	0.00	
HOT CK RNCH, NV	3	01/06/88	01/05/89	0.28	0.07	0.17	0.00	
INDIAN SPRINGS, NV	37	01/04/88	01/03/89	0.14	0.04	0.08	0.00	
INDIAN SPRINGS, NV	6	01/04/88	01/03/89	0.16	0.00	0.07	0.00	
IONE, NV	333	02/09/88	10/18/88	0.55	0.08	0.25	0.00	
IONE, NV	343	10/18/88	01/10/89	0.19	0.15	0.17	0.00	
KOYEN'S RANCH, NV	300	01/11/88	01/12/89	0.26	0.03	0.14	0.00	
LAS VEGAS (UNLV), NV	49	01/04/88	01/03/89	0.22	0.03	0.13	0.00	
LAS VEGAS (UNLV), NV	335	01/15/88	10/04/88	0.24	0.03	0.11	0.00	
LAS VEGAS (USDI), NV	326	01/04/88	01/03/89	0.18	0.03	0.08	0.00	
LAS VEGAS (USDI), NV	297	01/04/88	01/03/89	0.13	0.02	0.06	0.00	
LAVADA'S MARKET, NV	332	01/05/88	10/04/88	0.25	0.08	0.14	0.00	
LAVADA'S MARKET, NV	342	10/04/88	01/04/89	0.19	0.01	0.11	0.00	
MINA, NV	307	01/14/88	01/10/89	0.36	0.03	0.14	0.00	
MON SYS LAB ROOM 22	339	09/15/88	01/11/89	0.27	0.13	0.19	0.00	
NYALA, NV	18	01/05/88	01/04/89	0.19	0.04	0.12	0.00	
OVERTON, NV	348	12/01/88	01/03/89					TLD NOT RETURNED
OVERTON, NV	57	01/05/88	11/28/88	0.28	0.04	0.14	3.60	
PAHRUMP, NV	36	01/04/88	01/04/89	0.17	0.02	0.07	0.00	
PENOYER FARMS, NV	248	01/05/88	01/05/89	0.30	0.04	0.18	0.00	
PIOCHE, NV	293	01/05/88	01/04/89	0.39	0.10	0.20	0.00	
RACHEL, NV	264	01/11/88	01/05/89	0.35	0.09	0.18	0.00	
RACHEL, NV	54	01/06/88	01/03/89	0.25	0.04	0.12	0.00	
RACHEL, NV	334	01/11/88	01/05/89	0.33	0.08	0.19	0.00	
ROUND MT, NV	299	01/13/88	01/12/89	0.47	0.07	0.19	0.00	
SILVER PEAK, NV	341	10/08/88	01/11/89	0.11	0.10	0.10	0.00	

(continued)

Table 13. (Continued)

ASSOCIATED REFERENCE BACKGROUND STATION LOCATION (See Table 14)	RESIDENT No.	MEASUREMENT PERIOD START DATE	END DATE	DOSE EQUIV. RATE (mrem/day) MAX.	MIN.	AVG.	NET ANNUAL DOSE (mrem)*	COMMENTS
STONE CABIN RNCH, NV	29	01/05/88	01/04/89	0.33	0.08	0.21	0.00	
TONOPAH, NV	42	01/06/88	01/13/89	0.60	0.05	0.18	0.00	
TTR, NV	52	01/04/88	01/04/89	0.36	0.05	0.21	4.60	
TWIN SPRGS RNCH, NV	8	01/05/88	01/04/89	0.31	0.08	0.21	0.00	
*** UTAH ***								
CEDAR CITY, UT	44	01/05/88	01/04/89	0.29	0.04	0.16	0.00	
DELTA, UT	345	11/03/88	01/06/89	0.15	0.08	0.12	0.00	
DELTA, UT	344	11/03/88	01/06/89	0.16	0.12	0.14	0.00	
MILFORD, UT	347	11/03/88	01/06/89	0.28	0.19	0.23	0.00	
MILFORD, UT	346	11/03/88	01/06/89	0.20	0.18	0.19	0.00	
ST. GEORGE, UT	45	01/08/88	01/06/89	0.26	0.04	0.11	0.00	

* Net annual dose = (Average Gross mR/day * 365.25) - (Adjusted Annual Dose Equivalent for Ref. Bkg. Station)
Apparent net annual dose values < = 2 mrem are reported as zero.

# of People Monitored	61		
Ave. Max mrem/day	0.29	Min. Net Annual Dose (mrem)	0
Ave. Min mrem/day	0.04	Max. Net Annual Dose (mrem)	10
Ave. Mean mrem/day	0.15	Mean Net Annual Dose (mrem)	0.30

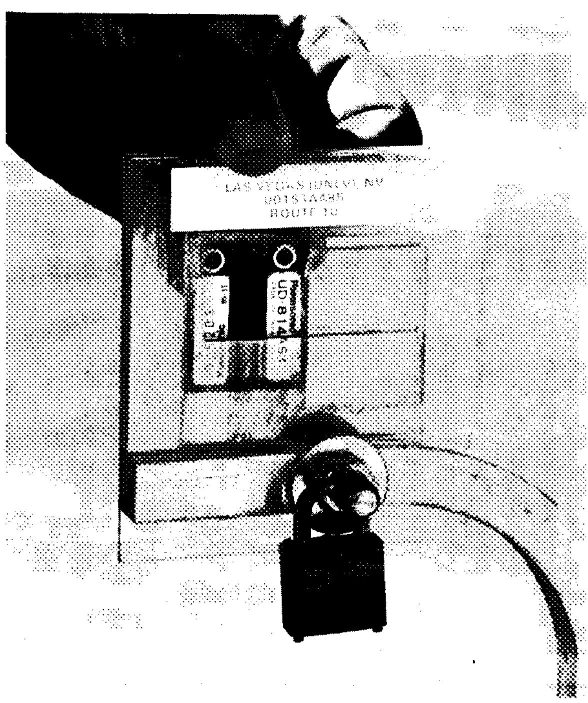
equivalent for that station would have been approximately 139 mrem.

The minimum net annual exposure to an off-site station was measured to be 23 mrem, noted at several sites. The mean net annual exposure for all off-site stations of 72 mrem represented a slight decrease from that reported in previous years. A major factor contributing to this decrease was that, for most of 1988, associated reference background readings no longer required adjustment to account for differing sensitivities of the Panasonic and the former Harshaw TLD systems.

Table 14 summarizes the results of off-site station TLD monitoring for 1988.

Preliminary information gathered during 1988 indicates the possibility that some TLD readings may be slightly lowered due to self-annealing of the phosphors during the hottest portion of the year. This phenomenon will be studied in greater detail during the coming year.

Because of the great range in the results, an average for all off-site station TLDs is not an appropriate tool for estimating individual exposures. Environmental ambient radiation levels vary markedly with natural radioactivity in the soil, with altitude, and other factors. If environmental TLD data is to be used in estimating the background radiation exposure of an individual, the dose equivalent for the station location closest to that individual would be the most appropriate reference point.



Figures 22 - 26 provide a general summary of mean annual background radiation levels at established off-site locations in Arizona, California, Nevada, and Utah, as well as a mean of all monitored locations.

5.2.6.3 Comparison with Direct Exposure Measurements

When TLD results are compared with results of co-located Pressurized Ionization Chambers (PICs), an average difference of approximately 38% is noted. The range of differences was 24 to 55%. A uniform overresponse of PIC vs TLD continues to be observed. This difference is attributed to several factors: (1) The PIC measures ionization in air (the Roentgen) while the TLD measures energy deposited in matter (the rad). Results of the two methods are not adjusted to account for this difference; (2) The PIC is an exposure rate measuring device, sampling every five seconds, while the TLD as an integrating dosimeter is analyzed approximately once each quarter. Some reduction in TLD results may be due to a small amount of loss due to normal fading (studies by Panasonic have shown this loss to be minimal over the sampling period used); (3) PICs are more sensitive to lower energy gamma radiation than are the TLDs. A review of manufacturer's specifications for the PIC and TLD systems shows their responses to be close to linear above approximately 80 and above approximately 150 keV, respectively; and (4) The PIC units are calibrated by the manufacturer against ^{60}Co, while the TLDs are calibrated using ^{137}Cs. No adjustment is made to account for the differing energies at which the two systems are calibrated. Figure 27 correlates PIC and TLD results for 1988.

Table 14. Annual Summary TLD Results - Offsite Stations - 1988

REFERENCE BACKGROUND STATION LOCATIONS	YEAR STATION ESTAB-LISHED	MEASUREMENT PERIOD START DATE	MEASUREMENT PERIOD END DATE	DOSE EQUIVALENT RATE (mR/day) MAX.	DOSE EQUIVALENT RATE (mR/day) MIN.	DOSE EQUIVALENT RATE (mR/day) AVG.	ADJUSTED DOSE EQUIVALENT (mR/year)	COMMENTS
*** ARIZONA ***								
COLORADO CITY, AZ	1985	10/27/87	11/01/88	0.19	0.11	0.15	56	
JACOB'S LAKE, AZ	1985	10/27/87	11/01/88	0.29	0.14	0.23	85	
PAGE, AZ	1985	10/28/87	11/01/88	0.19	0.10	0.14	51	
*** CALIFORNIA ***								
BAKER, CA	1971	11/03/87	11/02/88	0.23	0.19	0.22	80	
BARSTOW, CA	1971	11/03/87	11/02/88	0.27	0.24	0.25	92	
BISHOP, CA	1971	11/04/87	11/02/88	0.38	0.23	0.28	101	
DEATH VALLEY JCT, CA	1971	01/07/88	01/06/89	0.29	0.18	0.23	85	
FURNACE CREEK, CA	1971	01/07/88	01/06/89	0.21	0.15	0.18	65	
INDEPENDENCE, CA	1971	11/04/87	11/02/88	0.23	0.20	0.22	81	
LONE PINE, CA	1971	11/04/87	11/02/88	0.25	0.22	0.24	87	
MAMMOTH GEOTHERMAL	1972	11/04/87	11/02/88	0.29	0.25	0.27	100	No data 1973 - 1975
MAMMOTH LAKES, CA	1972	11/05/87	11/02/88	0.34	0.20	0.27	97	No data 1973 - 1975
OLANCHA, CA	1971	11/04/87	11/02/88	0.23	0.19	0.21	76	
RIDGECREST, CA	1971	11/03/87	11/02/88	0.22	0.14	0.18	67	
SHOSHONE, CA	1971	11/03/87	11/01/88	0.18	0.15	0.17	62	
VALLEY CREST, CA	1980	01/07/88	01/06/89	0.15	0.08	0.12	43	
*** NEVADA ***								
ALAMO, NV	1971	10/30/87	11/03/88	0.24	0.13	0.19	69	
AMERICAN BORATE, NV	1977	01/07/88	01/04/89	0.34	0.24	0.28	104	No data 1974 - 1980
ATLANTA MINE, NV	1985	12/07/87	12/01/88	0.20	0.13	0.18	65	
AUSTIN, NV	1971	02/03/88	11/22/88	0.42	0.27	0.34	124	No data 1973 - 1976

(continued)

Table 14. (Continued)

REFERENCE BACKGROUND STATION LOCATIONS	YEAR STATION ESTAB-LISHED	MEASUREMENT PERIOD START DATE	MEASUREMENT PERIOD END DATE	DOSE EQUIVALENT RATE (mR/day) MAX.	DOSE EQUIVALENT RATE (mR/day) MIN.	DOSE EQUIVALENT RATE (mR/day) AVG.	ADJUSTED DOSE EQUIVALENT (mR/year)	COMMENTS
BATTLE MOUNTAIN, NV	1985	12/15/87	11/29/88	0.21	0.11	0.16	60	No data 1972 - 1984
BEATTY, NV	1971	01/05/88	01/04/89	0.40	0.25	0.31	113	
BLUE EAGLE RANCH, NV	1971	01/05/88	01/04/89	0.19	0.12	0.16	57	
BLUE JAY, NV	1971	01/06/88	01/05/89	0.42	0.27	0.34	125	
CACTUS SPRINGS, NV	1971	11/02/87	11/01/88	0.16	0.09	0.13	47	
CALIENTE, NV	1971	10/27/87	11/01/88	0.25	0.15	0.20	73	
CARP, NV	1977	10/27/87	11/03/88	0.22	0.11	0.17	61	
CHERRY CREEK, NV	1985	12/10/87	12/01/88	0.25	0.17	0.22	81	
CLARK STATION, NV	1971	01/04/88	01/04/89	0.36	0.24	0.30	109	No data 1973
COALDALE, NV	1983	02/09/88	11/08/88	0.26	0.22	0.24	89	
COMPLEX 1, NV	1977	10/28/87	11/02/88	0.29	0.16	0.23	84	
CORN CREEK, NV	1971	11/02/87	11/01/88	0.13	0.07	0.09	34	Formerly Desert Game
CORTEZ RD/HWY 278,NV	1985	12/15/87	11/29/88	0.26	0.16	0.21	78	
COYOTE SUMMIT, NV	1971	10/28/87	11/03/88	0.31	0.17	0.27	98	
CRESCENT VALLEY, NV	1985	12/16/87	11/29/88	0.25	0.11	0.18	65	
CRYSTAL, NV	1983	11/05/87	11/01/88	0.19	0.15	0.17	61	
CURRANT, NV	1971	01/06/88	01/05/89	0.34	0.21	0.26	97	
CURRIE, NV	1971	12/10/87	12/01/88	0.27	0.17	0.23	86	No data 1972 - 1984
DIABLO MAINT STA, NV	1971	01/04/88	01/06/89	0.41	0.28	0.33	120	
DUCKWATER, NV	1971	01/06/88	01/05/89	0.31	0.21	0.25	91	
ELGIN, NV	1971	10/27/87	11/03/88	0.32	0.19	0.27	97	
ELKO, NV	1971	12/15/87	11/29/88	0.20	0.10	0.16	57	No data 1972 - 1984
ELY, NV	1971	12/09/87	12/01/88	0.20	0.12	0.17	63	No data 1987
EUREKA, NV	1971	01/06/88	01/06/89	0.33	0.22	0.27	98	No data 1973 - 1976
FALLON, NV	1985	12/14/87	12/01/88	0.19	0.09	0.15	54	
FLYING DIAMND CP, NV	1985	10/30/87	11/02/88	0.20	0.10	0.15	56	
GABBS, NV	1983	02/09/88	11/16/88	0.17	0.13	0.15	56	
GEYSER RANCH, NV	1971	12/07/87	12/01/88	0.26	0.17	0.22	82	

(continued)

Table 14. (Continued)

REFERENCE BACKGROUND STATION LOCATIONS	YEAR STATION ESTAB-LISHED	MEASUREMENT PERIOD START DATE	END DATE	DOSE EQUIVALENT RATE (mR/day) MAX.	MIN.	AVG.	ADJUSTED DOSE EQUIVALENT (mR/year)	COMMENTS
GOLDFIELD, NV	1971	02/08/88	11/07/88	0.21	0.20	0.21	75	
GROOM LAKE, NV	1971	11/05/87	11/08/88	0.22	0.18	0.20	72	
HALLOWAY RANCH, NV	1971	01/06/88	01/05/89	0.38	0.24	0.30	108	
HANCOCK SUMMIT,NV	1971	10/29/87	11/03/88	0.37	0.24	0.32	116	
HIKO, NV	1971	10/29/87	11/03/88	0.18	0.10	0.14	49	
HOT CREEK RANCH, NV	1971	01/06/88	01/05/89	0.28	0.18	0.22	82	
INDIAN SPRINGS, NV	1971	11/02/87	11/01/88	0.15	0.08	0.11	41	
IONE, NV	1971	02/09/88	11/16/88	0.24	0.22	0.23	85	
KIRKEBY RANCH, NV	1973	12/07/87	12/01/88	0.19	0.11	0.16	57	
KOYEN'S RANCH, NV	1971	10/28/87	11/03/88	0.23	0.14	0.18	67	
LAS VEGAS (UNLV), NV	1981	01/04/88	01/03/89	0.13	0.05	0.08	29	
LAS VEGAS (USDI), NV	1971	01/04/88	01/03/89	0.19	0.11	0.14	49	BLM Office
LAS VEGAS(AIRPRT), NV	1972	01/04/88	01/03/89	0.16	0.08	0.11	39	
LATHROP WELLS, NV	1971	01/05/88	01/04/89	0.27	0.03	0.18	66	
LAVADA'S MARKET, NV	1981	01/05/88	01/04/89	0.29	0.19	0.23	85	
LIDA, NV	1971	02/11/88	11/08/88	0.22	0.21	0.22	79	
LOVELOCK, NV	1985	12/15/87	11/30/88	0.20	0.09	0.15	56	
LUND, NV	1971	12/09/87	12/01/88	0.21	0.14	0.19	69	
MANHATTAN, NV	1971	02/03/88	11/17/88	0.32	0.28	0.30	111	
MEDLIN'S RANCH, NV	1982	10/28/87	11/01/88	0.30	0.18	0.24	87	Formerly Tikaboo
MESQUITE, NV	1971	10/30/87	11/01/88	0.17	0.09	0.13	48	
MINA, NV	1983	02/09/88	11/16/88	0.22	0.21	0.21	78	
MOAPA, NV	1983	10/27/87	11/01/88	0.21	0.10	0.15	56	
MTN MEADOWS RNCH, NV	1971	10/06/87	01/04/89	0.21	0.12	0.16	60	Formerly Casey's
NASH RANCH, NV	1985	10/30/87	11/03/88	0.21	0.10	0.16	59	
NYALA, NV	1971	01/05/88	01/04/89	0.25	0.15	0.21	75	
OVERTON, NV	1982	10/27/87	11/01/88	0.17	0.06	0.11	40	
PAHRUMP, NV	1971	11/03/87	11/01/88	0.22	0.08	0.13	46	

(continued)

Table 14. (Continued)

REFERENCE BACKGROUND STATION LOCATIONS	YEAR STATION ESTAB-LISHED	MEASUREMENT PERIOD		DOSE EQUIVALENT RATE (mR/day)			ADJUSTED DOSE EQUIVALENT (mR/year)	COMMENTS
		START DATE	END DATE	MAX.	MIN.	AVG.		
PENOYER FARMS, NV	1971	10/28/87	11/02/88	0.31	0.19	0.25	90	
PINE CREEK RANCH, NV	1971	10/28/87	11/03/88	0.31	0.20	0.26	95	
PIOCHE, NV	1971	10/27/87	11/01/88	0.20	0.12	0.16	60	
QUEEN CITY SMT, NV	1971	01/04/88	01/06/89	0.45	0.28	0.35	127	
RACHEL, NV	1977	10/28/87	11/03/88	0.29	0.17	0.24	86	
REED RANCH, NV	1971	01/04/88	01/06/89	0.39	0.24	0.30	108	
RENO, NV	1987	12/14/87	11/30/88	0.20	0.09	0.15	56	
ROUND MT, NV	1971	02/03/88	11/17/88	0.28	0.26	0.27	98	
RUBY VALLEY, NV	1971	12/17/87	11/29/88	0.27	0.16	0.23	84	No data 1972 - 1984
S DESERT COR CTR, NV	1983	11/02/87	11/01/88	0.13	0.08	0.11	39	
SCHURZ, NV	1985	12/14/87	12/01/88	0.26	0.15	0.22	80	
SHERI'S RANCH, NV	1971	10/30/87	05/03/88	0.26	0.26	0.26	95	
SILVER PEAK, NV	1987	02/09/88	11/16/88	0.18	0.15	0.17	60	
SPRINGDALE, NV	1971	01/06/88	01/05/89	0.40	0.24	0.31	112	
STEWARD RANCH, NV	1987	12/08/87	12/01/88	0.28	0.21	0.25	93	
STONE CABIN RNCH, NV	1977	01/05/88	01/04/89	0.40	0.22	0.30	110	
SUNNYSIDE, NV	1971	12/07/87	12/01/88	0.24	0.08	0.16	57	
TEMPIUTE, NV	1971	10/29/87	11/02/88	0.29	0.19	0.23	86	
TONOPAH, NV	1971	02/09/88	11/08/88	0.27	0.26	0.26	96	
TONOPAH TEST RNG, NV	1972	02/10/88	11/15/88	0.26	0.25	0.25	92	
TWIN SPRGS RNCH, NV	1971	01/05/88	01/04/89	0.36	0.22	0.29	106	
UHALDE'S RNCH, NV	1971	10/28/87	11/02/88	0.29	0.18	0.24	86	
US ECOLOGY, NV #2	1971	01/06/88	01/04/89	0.40	0.24	0.31	113	
WARM SPRINGS, NV	1971	01/04/88	01/04/89	0.88	0.35	0.62	225 **	
WELLS, NV	1971	12/16/87	11/29/88	0.21	0.13	0.17	62	No data 1972 - 1984
WINNEMUCCA, NV	1985	12/15/87	11/29/88	0.23	0.12	0.18	65	
YOUNG'S RANCH, NV	1973	02/03/88	11/17/88	0.20	0.19	0.20	73	
YUCCA - AMARGOSA CMS	1988	10/20/88	01/18/89	0.15	0.15	0.15	53	

(continued)

Table 14. (Continued)

REFERENCE BACKGROUND STATION LOCATIONS	YEAR STATION ESTAB-LISHED	MEASUREMENT PERIOD START DATE	MEASUREMENT PERIOD END DATE	DOSE EQUIVALENT RATE (mR/day) MAX.	DOSE EQUIVALENT RATE (mR/day) MIN.	DOSE EQUIVALENT RATE (mR/day) AVG.	ADJUSTED DOSE EQUIVALENT (mR/year)	COMMENTS
YUCCA - BRIGHT RES.	1988	10/12/88	01/18/89	0.22	0.22	0.22	79	
YUCCA - CL103	1988	08/29/88	01/19/89	0.08	0.05	0.06	23	
YUCCA - CL108	1988	08/29/88	01/19/89	0.09	0.04	0.07	25	
YUCCA - CL113	1988	08/29/88	01/19/89	0.08	0.04	0.06	23	
YUCCA - CL117	1988	08/29/88	01/19/89	0.08	0.05	0.06	23	
YUCCA - CL128	1988	08/29/88	01/18/89	0.12	0.08	0.10	36	
YUCCA - CL98	1988	08/29/88	01/19/89	0.08	0.07	0.08	28	
YUCCA - HALE RANCH	1988	10/12/88	01/19/89	0.13	0.13	0.13	46	
YUCCA - MILE 47	1988	10/11/88	01/18/89	0.25	0.25	0.25	90	
YUCCA - NY1	1988	08/29/88	01/18/89	0.12	0.08	0.10	37	
YUCCA - NY11	1988	08/29/88	01/18/89	0.13	0.12	0.13	47	
YUCCA - NY16	1988	08/29/88	01/18/89	0.09	0.06	0.08	28	
YUCCA - NY21	1988	09/01/88	01/18/89	0.13	0.11	0.12	43	
YUCCA - NY26	1988	09/01/88	01/18/89	0.19	0.19	0.19	69	
YUCCA - NY36	1988	09/01/88	01/18/89	0.28	0.27	0.28	101	
YUCCA - NY41	1988	09/02/88	01/18/89	0.30	0.28	0.29	106	
YUCCA - NY46	1988	09/02/88	01/18/89	0.20	0.20	0.20	72	
YUCCA - NY51	1988	09/02/88	01/18/89	0.28	0.25	0.26	96	
YUCCA - NY56	1988	09/02/88	01/18/89	0.18	0.17	0.17	64	
YUCCA - NY6	1988	08/31/88	01/18/89	0.15	0.15	0.15	55	
YUCCA-NICKELL QUIK-S	1988	10/12/88	01/18/89	0.20	0.20	0.20	74	
*** UTAH ***								
BOULDER, UT	1985	12/08/87	09/13/88	0.21	0.11	0.17	63	
BRYCE CANYON, UT	1985	12/08/87	09/13/88	0.18	0.08	0.15	54	
CEDAR CITY, UT	1971	12/07/87	09/12/88	0.17	0.06	0.13	46	
DELTA, UT	1985	01/05/88	01/06/89	0.24	0.14	0.20	73	

(continued)

Table 14. (Continued)

REFERENCE BACKGROUND STATION LOCATIONS	YEAR STATION ESTAB-LISHED	MEASUREMENT PERIOD START DATE	MEASUREMENT PERIOD END DATE	DOSE EQUIVALENT RATE (mR/day) MAX.	DOSE EQUIVALENT RATE (mR/day) MIN.	DOSE EQUIVALENT RATE (mR/day) AVG.	ADJUSTED DOSE EQUIVALENT (mR/year)	COMMENTS
DUCHESNE, UT	1985	01/07/88	01/04/89	0.21	0.12	0.17	61	
ENTERPRISE, UT	1973	12/07/87	09/15/88	0.28	0.15	0.23	84	
FERRON, UT	1985	10/29/87	01/04/89	0.19	0.10	0.14	52	
GARRISON, UT	1971	12/08/87	12/01/88	0.18	0.10	0.15	54	No data 1973 - 1976
GRANTSVILLE, UT	1985	01/06/88	01/05/89	0.23	0.14	0.18	67	
GREEN RIVER, UT	1985	10/28/87	11/02/88	0.22	0.11	0.17	63	
GUNNISON, UT	1985	12/08/87	09/14/88	0.17	0.06	0.13	46	
IBAPAH, UT	1985	12/07/87	12/01/88	0.25	0.18	0.23	83	
KANAB, UT	1985	10/27/87	11/01/88	0.16	0.10	0.12	45	
LOA, UT	1985	12/08/87	09/13/88	0.31	0.16	0.25	91	
LOGAN, UT	1985	01/05/88	01/03/89	0.19	0.14	0.16	60	
LUND, UT	1985	12/07/87	09/12/88	0.24	0.20	0.22	81	
MILFORD, UT	1972	12/09/87	09/14/88	0.22	0.15	0.19	70	No data 1973 - 1984
MONTICELLO, UT	1985	10/28/87	11/02/88	0.24	0.16	0.20	74	
NEPHI, UT	1985	01/05/88	01/06/89	0.18	0.11	0.15	54	
PAROWAN, UT	1985	12/07/87	09/14/88	0.19	0.12	0.16	57	
PRICE, UT	1985	10/29/87	01/04/89	0.19	0.11	0.15	54	
PROVO, UT	1985	01/05/88	01/05/89	0.21	0.12	0.15	56	
SALT LAKE CITY, UT	1982	01/04/88	01/04/89	0.23	0.16	0.19	68	
ST. GEORGE, UT	1971	12/09/87	09/12/88	0.15	0.07	0.12	42	
TROUT CREEK, UT	1985	12/09/87	12/01/88	0.19	0.12	0.16	57	
VERNAL, UT	1985	01/07/88	01/04/89	0.22	0.12	0.18	65	
VERNON, UT	1985	01/06/88	01/05/89	0.22	0.15	0.18	66	
WENDOVER, UT	1971	12/16/87	11/28/88	0.21	0.09	0.16	59	No data 1972 - 1984
WILLOW SPRGS LDGE, UT	1985	01/06/88	01/05/89	0.19	0.12	0.16	58	

(continued)

Table 14. (Continued)

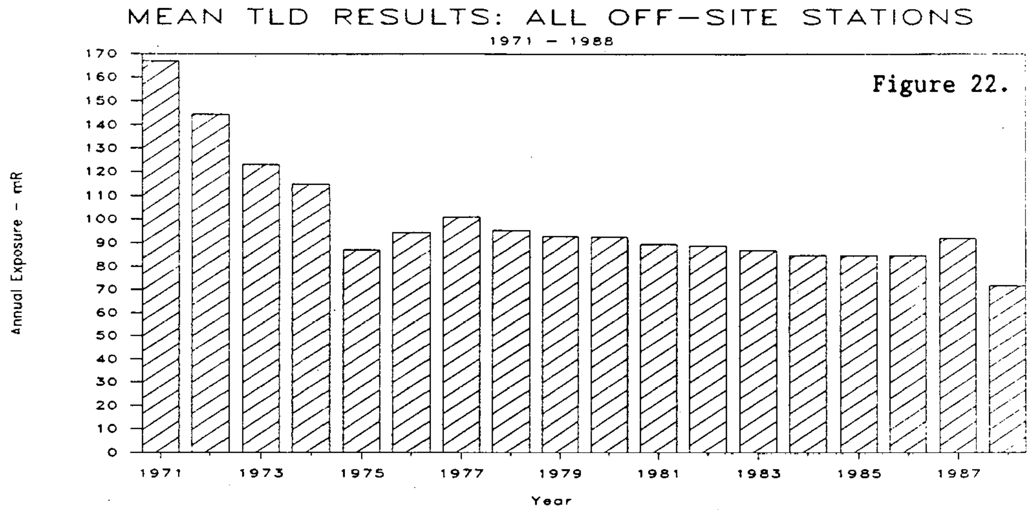
No. of Stations Monitored	157
Avg. Max mR/day	0.24
Avg. Min mR/day	0.16
Avg. Mean mR/day	0.20
Max. Net Annual Exposure	225
Min. Net Annual Exposure	23
Mean Net Annual Exposure	72.3

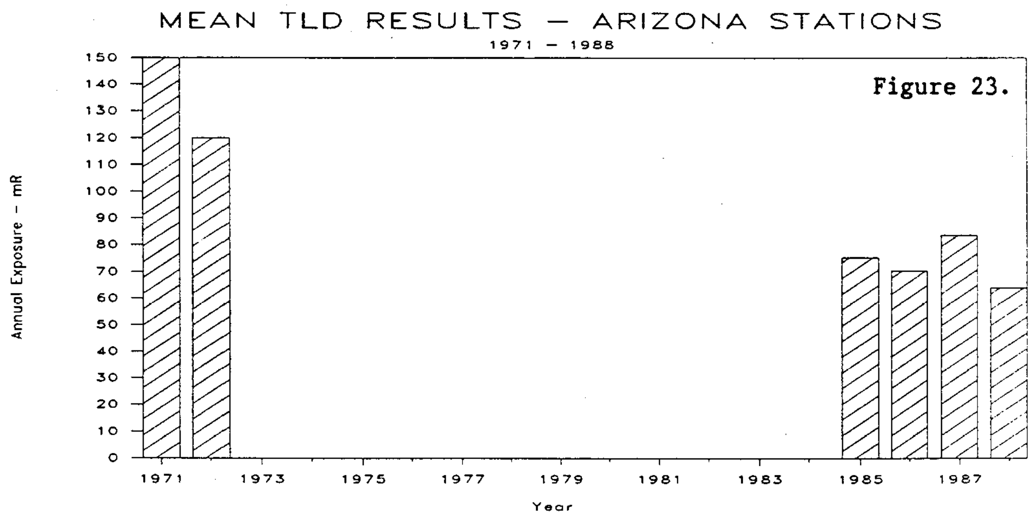
Statistics of 1988 Offsite Station TLD Results:

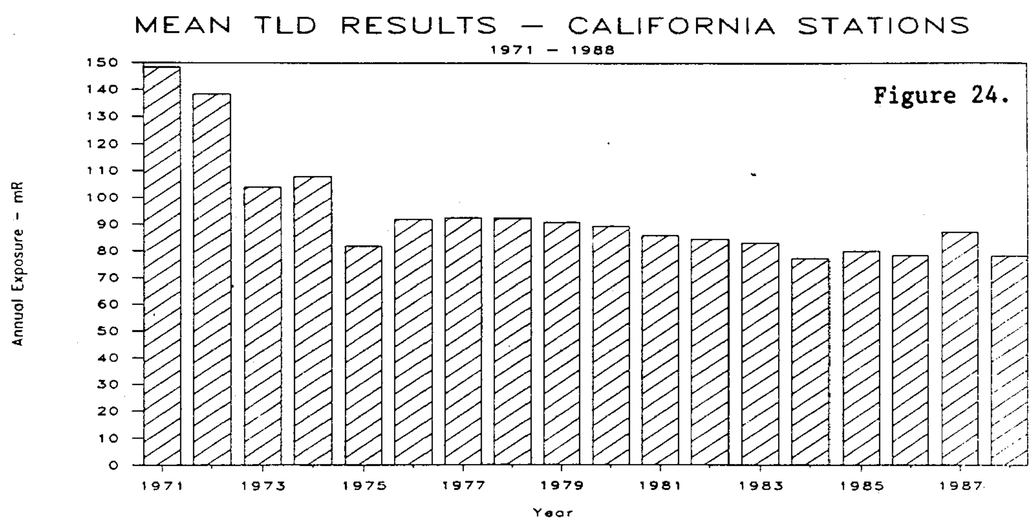
	# C.V.	Best Std. Dev.	# REPS	# RECORDS	# STATS
1st Qtr.	0.043	0.010	699	118	117
2nd Qtr.	0.085	0.016	786	131	131
3rd Qtr:	0.074	0.014	876	148	147
4th Qtr:	0.062	0.012	870	145	143
YEAR	0.066	0.013	3231	542	147

** NOTE TO WARM SPRINGS, NV, TLD RESULTS:

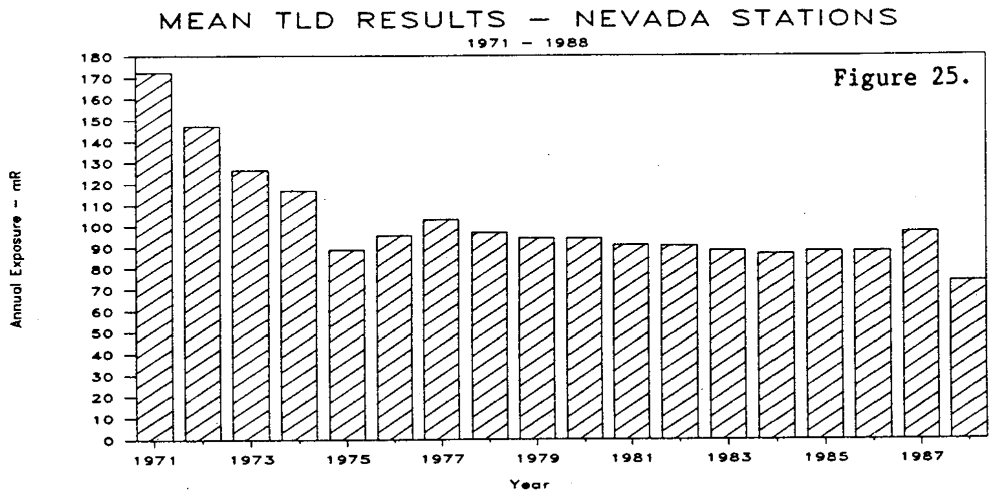
Anomalous high reading due to TLD located adjacent to stream containing high amount of Radium/Radon. TLD relocated away from stream 3rd and 4th quarters.
Average results with TLD near stream = 0.85 mR/day.
Average results with TLD located away from stream = 0.38 mR/day.
If TLD had been located away from stream for entire year, adjusted dose equivalent would be approximately 139 mrem.

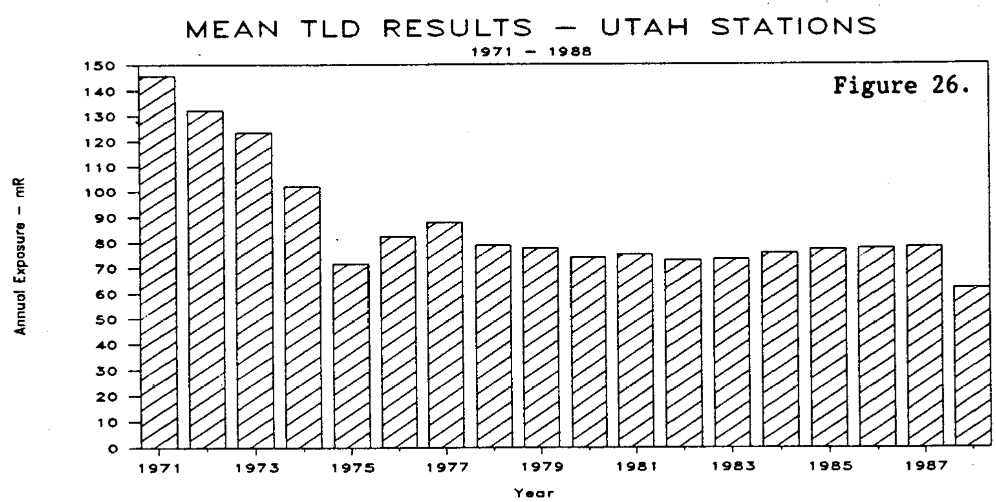


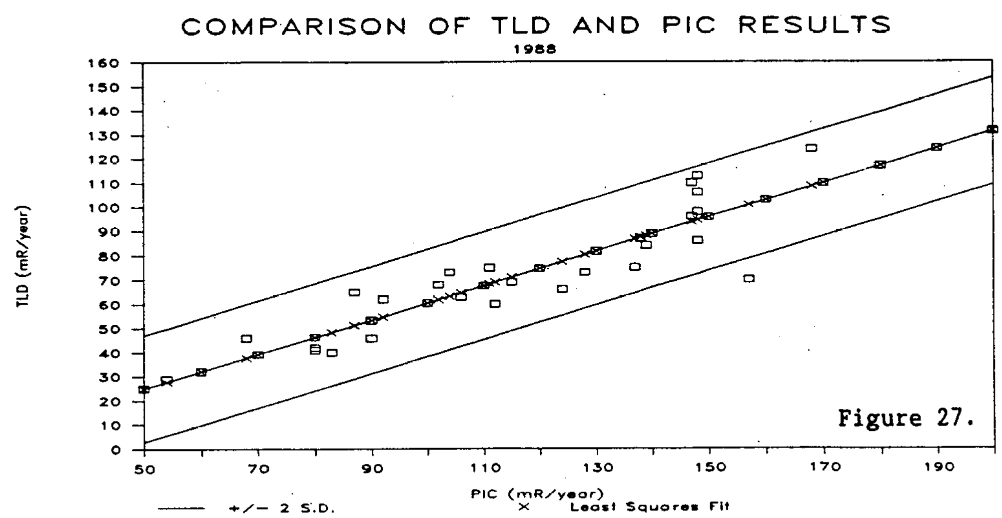




Figures 22 - 24. Mean TLD Results - 1988.







Figures 25 - 27. Mean TLD Results and Comparison of TLD and PIC Results - 1988.

5.2.7 Pressurized Ion Chamber (PIC) Network

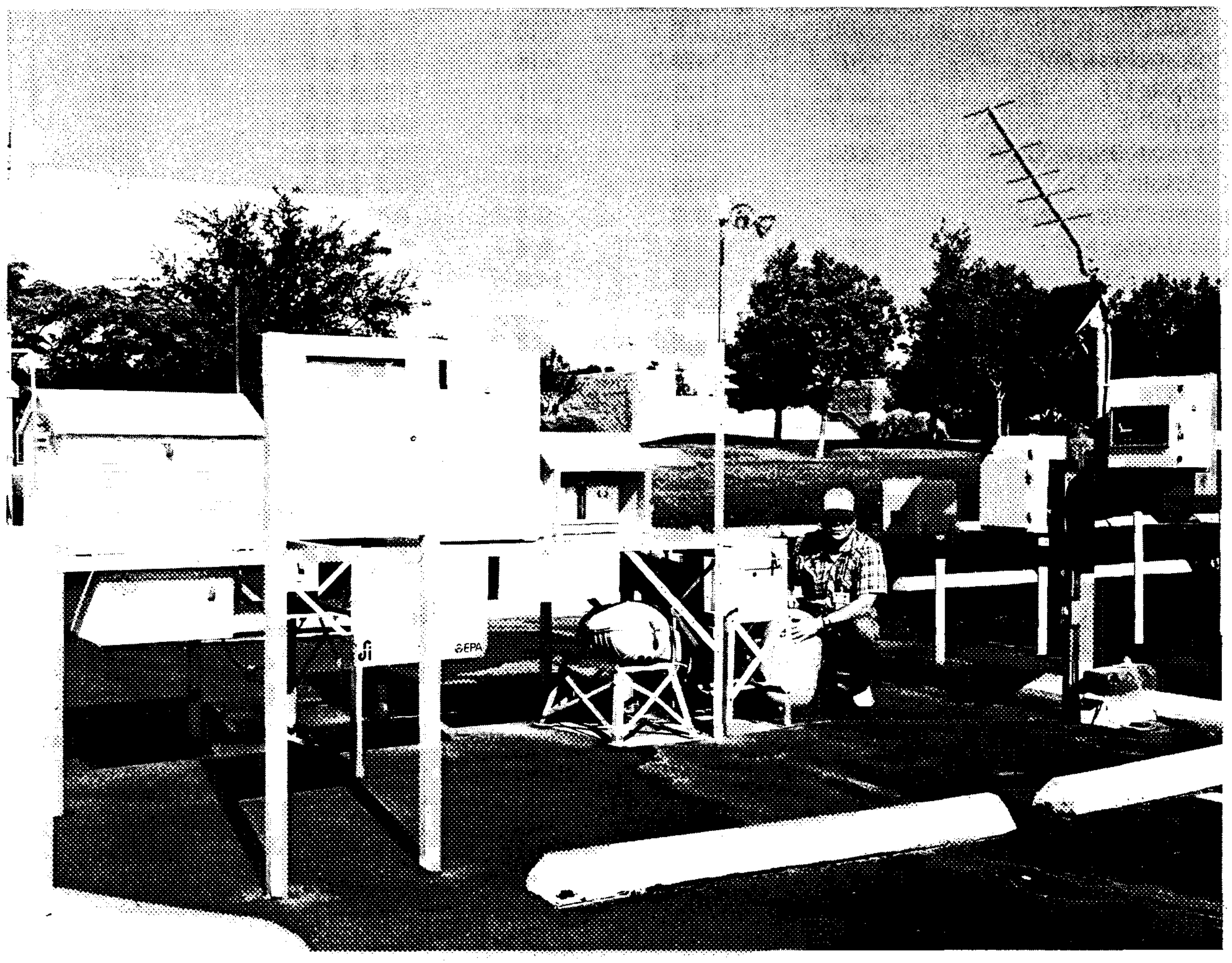
C. A. Fontana

The Pressurized Ion Chamber is a spherical shell filled with argon gas to 25 times atmospheric pressure. Inside 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 electrode, the current is measured and the intensity of the radiation field is determined.

There are 28 PICs deployed around the Nevada Test Site, of these, 18 are at Community Monitoring Stations described in Section 6.1. In addition, there are ten other PIC locations. Data are collected weekly in the form of magnetic tapes, paper tapes, and via a satellite telemetry system. Data are displayed in μR/hr on a digital readout display at each location for easy access by the public. Computer analysis of the data is accomplished on a weekly basis at EMSL-LV. Trends are noted and compared to previous years. During 1988, as in previous years background levels dropped in the higher elevation locations during the winter. This drop is attributed to snow cover shielding the PIC from low energy gamma radiation coming from the ground.

For an 11 hour period during the week of August 22-29, 1988, the PIC located at Lathrop Wells showed elevated readings which were approximately twice the level normally expected. Upon further investigation these elevated readings were determined to be due to the presence of a shipment of low-level radioactive waste which was en route to the U.S. Ecology low level radioactive waste disposal site in nearby Beatty, Nevada.

This finding contributed to a decision to expand the scope of monitoring adjacent to the disposal site. Through a cooperative agreement with the Nevada State Health Division, additional equipment is being installed. It is anticipated that the expanded monitoring adjacent to the disposal site will be fully operational in 1989.



Data for 1988 is displayed in Table 15 as the average μR/hr and annual mR/yr from each station. Figure 28 shows annual averages for each location in mR/yr as compared to the maximum and minimum United States background (BEIR80). The U.S. background maximum and minimum values shown represent the highest and lowest values respectfully, of the combined terrestrial and cosmic components of environmental gamma radiation nationwide. When these data are compared to TLD results for the same 28 stations, it is found that the PIC exposure is approximately 38% higher than the TLD exposure. This has been attributed primarily to the differences in energy response of the two systems. Since PICs have a greater sensitivity to lower energy gamma radiation, they normally record higher apparent exposure rates than do the TLDs.

The 1988 PIC data is consistent with previous year trends. No prolonged unexplained deviations from background levels occurred during 1988.

Table 15. Pressurized Ion Chamber Readings -1988

Station	No. of Weekly Values	Exposure Rate (μR/hr)*			mR/yr
		Minimum	Maximum	Average ± S.D.	
Alamo, NV	50	12.9	13.5	13.1 ± 0.2	115
Austin, NV	49	13.7	20.6	19.2 ± 1.6	168
Beatty, NV	50	16.4	17.5	16.9 ± 0.3	148
Caliente, NV	49	13.1	15.2	14.6 ± 0.4	128
Cedar City, UT	52	9.7	10.8	10.3 ± 0.2	90
Complex I, NV	49	14.0	16.5	15.8 ± 0.5	138
Delta, UT	9	11.6	12.1	11.9 ± 0.1	104
Ely, NV	51	11.4	12.7	12.2 ± 0.2	107
Furnace Creek, CA	50	9.5	10.5	10.0 ± 0.3	88
Goldfield, NV	47	14.6	16.2	15.7 ± 0.3	137
Indian Springs, NV	49	8.5	9.4	9.1 ± 0.1	80
Las Vegas, NV	50	6.0	6.4	6.2 ± 0.9	54
Lathrop Wells, NV	49	13.9	14.6	14.2 ± 0.2	124
Mammoth Lakes, CA	24	14.6	17.8	16.9 ± 0.9	148
Medlins' Ranch, NV	52	14.2	16.2	15.8 ± 0.3	138
Milford, UT	10	16.9	18.4	17.9 ± 0.4	157
Nyala, NV	45	11.6	13.1	12.6 ± 0.3	110
Overton, NV	52	9.0	10.5	9.5 ± 0.3	83
Pahrump, NV	51	7.6	8.0	7.7 ± 0.1	67
Pioche, NV	52	11.2	13.4	12.7 ± 0.4	111
Rachel, NV	46	13.5	17.0	15.9 ± 0.8	139
St. George, UT	51	8.8	9.6	9.1 ± 0.2	80
Shoshone, CA	45	9.7	11.3	10.5 ± 0.5	92
Salt Lake City, UT	45	11.0	12.4	11.6 ± 0.3	102
Stone Cabin Ranch, NV	41	14.2	18.4	16.7 ± 0.9	146
Tonopah, NV	46	16.3	17.8	16.8 ± 0.3	147
Twin Springs Ranch, NV	45	15.7	18.7	16.9 ± 0.5	148
Uhaldes Ranch, NV	51	14.1	18.5	17.0 ± 0.9	149

* Weekly Averages

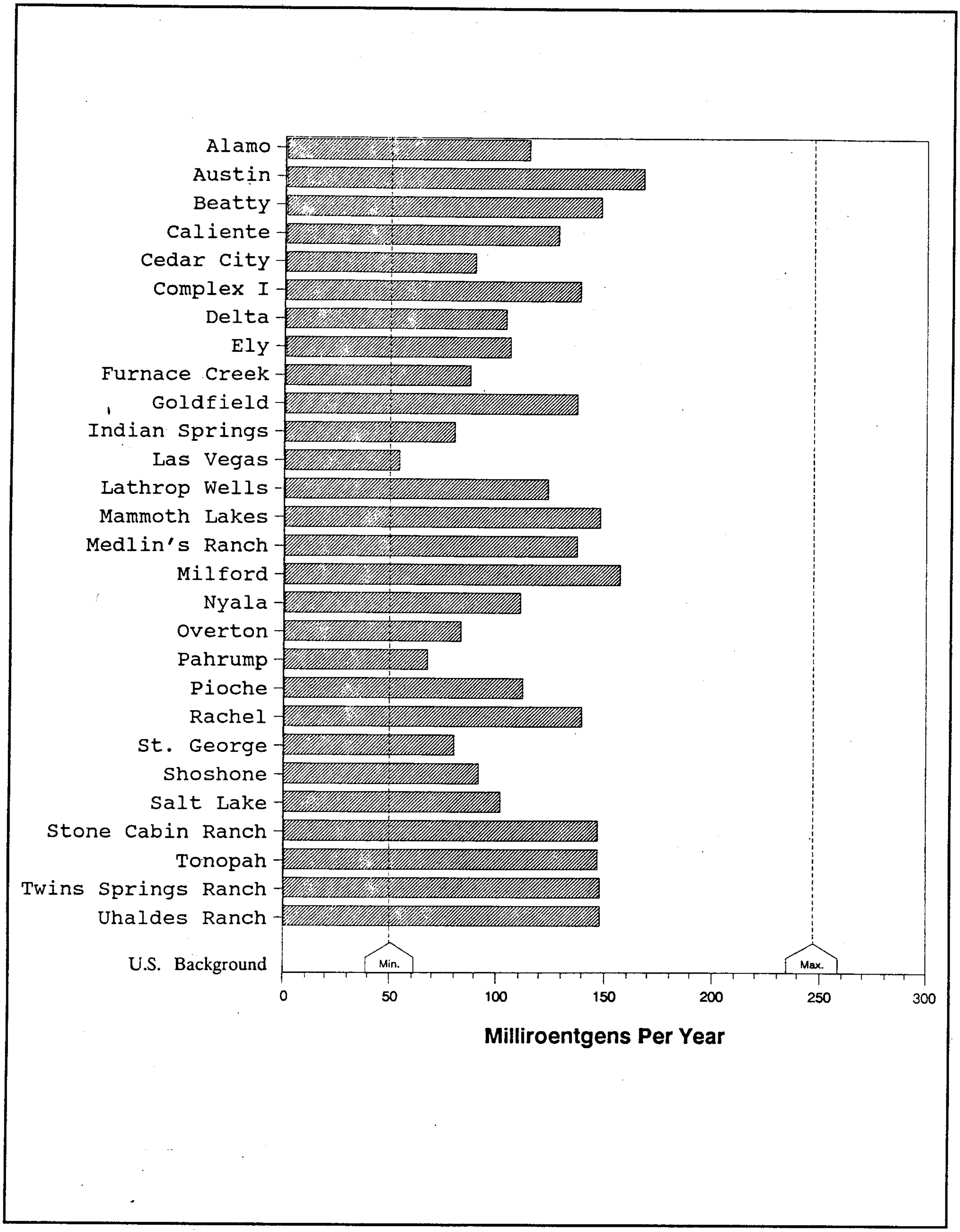


Figure 28. Annual Exposure Rates as Measured by PICs - 1988.

5.2.8 Internal Exposure Monitoring

A. A. Mullen

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

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 which may have been inhaled or ingested. Routine examination consists of a 2000 second count in each of 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 2.5 MeV in the whole body. The other vault contains an adjustable chair with two germanium detectors mounted above the chest area; two intrinsic germanium semi-planar detectors were used until the latter part of the year when four additional semi-planar detectors were added. The semi-planar array is designed for detection of gamma emitting radionuclides with energy ranges from ten to 300 KeV. Specially designed software was obtained to allow individual detector spectra to be analyzed to obtain a summation of left-or right-lung arrays and the total lung area. This provides much greater sensitivity for the transuranic radionuclides but maintains the ability to pinpoint "hot spots." Specially designed detector mounts were also installed to allow maximum flexibility for the placement of detectors in various configurations for skull, knee, ankle, or other geometries.

Network Design

This activity consists of two portions, an Off-Site Human Surveillance Program and a Radiological Safety Program. The Off-Site Human Surveillance Program is designed (1) to 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) to act as a biological monitoring system for present nuclear testing activities. A few families who reside in areas not affected by such fallout were also selected for comparative study.

Methods

The Off-Site Human Surveillance Program was initiated in December 1970, to determine levels of radionuclides in some of the families residing in communities and ranches surrounding the NTS. Biannual counting is performed in the spring and fall. This program started with 34 families (142 individuals). In 1986, 16 of these families (37 individuals) were still active in the program together with 7 families added in recent years. When the Community Monitoring Station Network was started in 1982, the families of the station managers were added to the program. These families are counted in the winter and summer of each year. The geographical locations of the families which participated in 1988 are shown in Figure 29.

These persons travel to the EMSL-LV where a whole-body count and a lung count of each person is made to determine the body burden of gamma-emitting radionuclides. A urine sample is collected for tritium analysis. Results of the whole-body count are available before the families leave the facility and are discussed with the subjects. At 18-month intervals a physical exam, health history and the following are performed: a urinalysis, complete blood count, serology, chest x-ray (3-year intervals), sight screening, audiogram, vital capacity, EKG (over 40 years old), and thyroid panel. The individual is then examined by a physician. The results of the examination can be requested for use by their family physician.

Analysis for internally deposited radionuclides is also performed for EPA employees, the DOE contractor employees, and for other workers who may be occupationally exposed as well as for concerned members of the general public. Results of counts on individuals from Las Vegas and other cities are used for comparison.

The QC Program utilizes daily equipment checks and calibrations with NBS traceable radionuclides. Calibration phantoms are exchanged among this facility and other whole-body counting facilities across the nation for intercomparison studies.

Results

During 1988, a total of 600 gamma spectra were obtained from 188 individuals, of whom 100 were participants in the Off-Site Human Surveillance Program. Also, 1825 spectra for calibrations and background were generated. Cesium-137 is

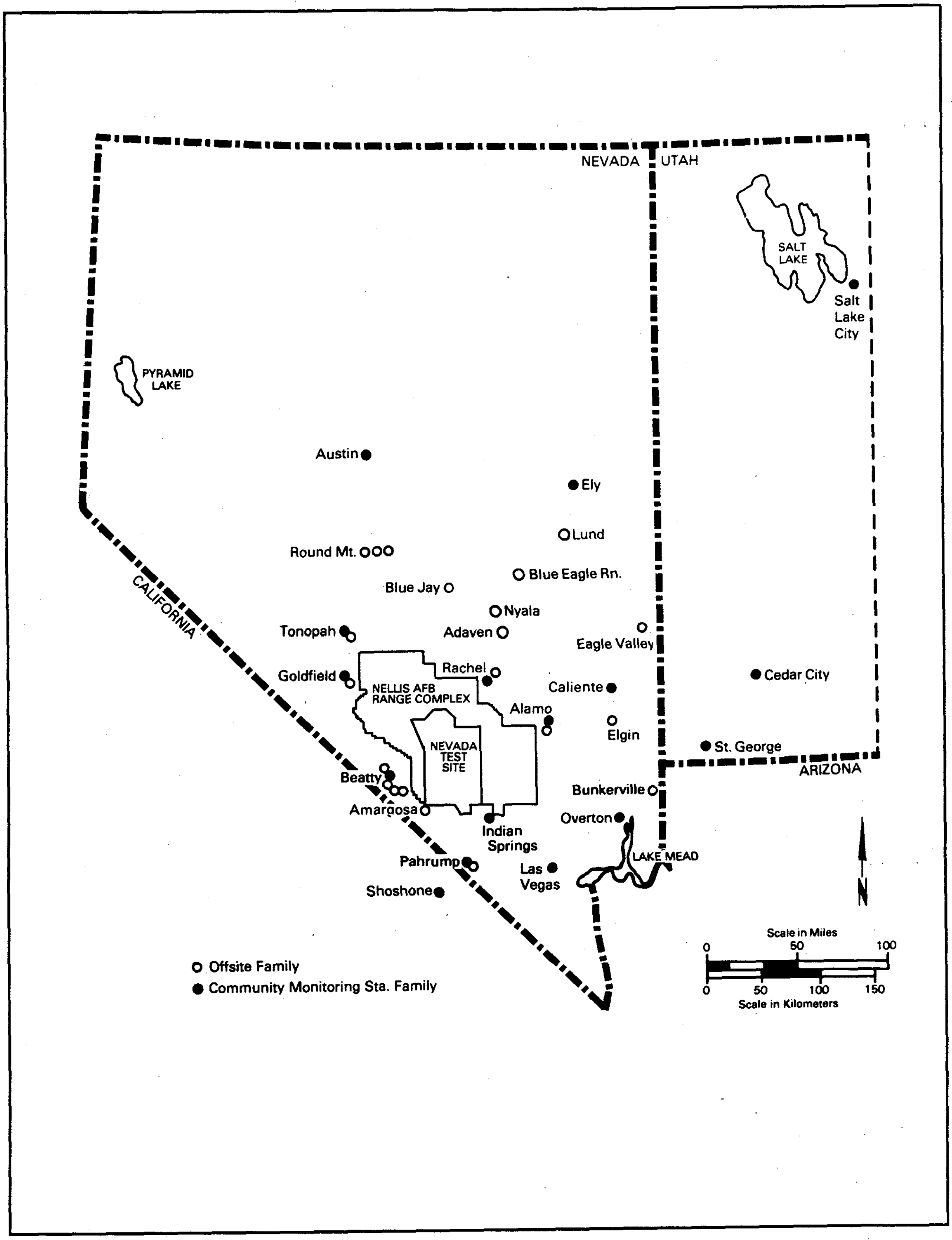


Figure 29. Location of Families in the Off-Site Human Surveillance Program.

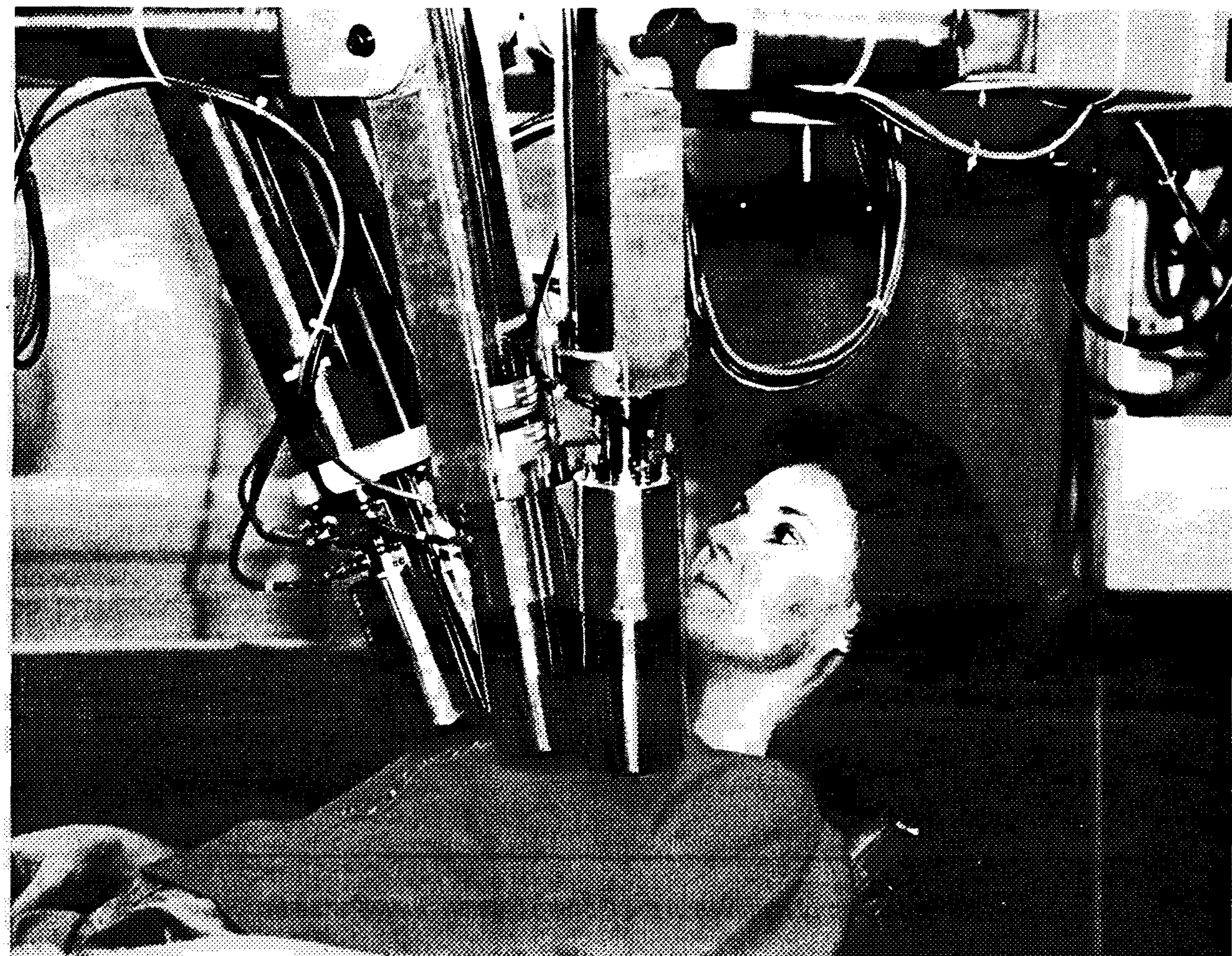
generally the only fission product detected. As a result of worldwide fallout following the Chernobyl accident, trace amounts of ^{137}Cs and ^{134}Cs were detected in a limited number of individuals, mainly those contractor personnel flown in from California, and people stationed in or visiting Europe. In general, the spectra were representative of normal background for people and showed only naturally occurring ^{40}K. No transuranic radionuclides were detected in any lung counting data.

Bioassay results for the Off-Site Human Surveillance Program showed that the concentration of tritium in urine samples from the off-site residents varied from 0 to 1300 pCi/L (0 to 48 Bq/L) with an average value of 140 pCi/L (5.19 Bq/L). Nearly all the concentrations measured were in the range of background levels measured in water and reflect only natural exposure. The ^{3}H concentrations in urine samples from EPA employees had a range of 0 to 1200 pCi/L (44 Bq/L) with an average value of 210 pCi/L (7.7 Bq/L).

As reported in previous years, medical examinations of the off-site families revealed a generally healthy population. The blood examinations and thyroid profiles showed no abnormal results which could be attributed to past or present NTS testing operations. Two deaths occurred in the Off-Site Human Surveillance Program participants of causes unrelated to NTS testing.

EG&G personnel participating in the Joint Verification Experiment, Shagan Event, in the USSR were counted upon their return. Those people who visited Germany, Scandinavia, England and Ireland were found to have very small amounts of ^{137}Cs; while those persons who travelled directly to and from the Russian Test Site did not pick up this radionuclide.

One EG&G employee from California was also found to have a very small body burden of ^{134}Cs and ^{137}Cs. This individual had been eating large quantities of imported cheeses. A limited survey of imported cheese available in local stores was



conducted and only one, a goat cheese from Norway, was found to have ^{134}Cs and ^{137}Cs.

Four members of the general public were counted. Two of these were: a man who had travelled in Italy and was concerned about possible uptake of fission products from the Chernobyl-4 accident; and a woman travelling around the U.S. Nothing over natural background was detected in either person. Additionally, a photographer from the National Geographic Magazine requested a count as she had been in Sweden for a week and had eaten a small amount of reindeer meat, mushrooms, vegetables and cheese while photographing the Laplanders. Cesium-134 and ^{137}Cs were detected. A visiting scientist from Poland also requested a count. Her ^{134}Cs and ^{137}Cs values were about twice those found in the photographer.

5.2.9 Long-Term Hydrological Monitoring Program

S.C. Black

Tritium and gamma-spectral analysis were done on samples taken from 193 wells, springs, and other sources of water at locations where underground nuclear explosives tests have been conducted. Gamma radioactivity was found in only one sampled location where ^{137}Cs had been used in a hydrologic study. The tritium concentrations found during this sampling year were consistent with the levels found in previous years, except for a slight upward trend in one NTS well. In only three samples were the tritium concentrations greater than the Drinking Water Standards, and those samples were from wells not accessible to the general public.

Background

Surface- and ground-water sampling and analysis from water sources around the NTS have been performed for many years. When underground nuclear tests occurred in other states, water sampling programs were instituted. Finally, in 1972, all of the water sampling programs were combined to constitute the Long-Term Hydrological Monitoring Program (LTHMP). At each of the sites of underground nuclear tests, water sampling points were established by the U.S. Geological Survey so that any migration of radioactivity from the test

cavities to potable water sources could be detected by radioanalysis.

The 23 wells on the NTS and the 32 wells in areas around the NTS which are part of this program are shown in Figures 30 and 31, respectively. The locations of the sampling points at other than NTS locations in Nevada, and at locations in Alaska, Colorado, Mississippi, and New Mexico are shown in Figures 32 through 43.

Methods

At nearly all locations, the standard operating procedure is to collect four samples. Two samples are collected in 500-mL glass bottles to be analyzed for tritium. The results from analysis of one of these is reported while the other sample serves as a backup in case of loss, or if the tritium is at detectable concentration, as a duplicate sample. The remaining two samples are collected in 4 L plastic containers (cubitainers). One of these is analyzed by gamma spectrometry and the other is stored as a backup or for duplicate analysis. For wells with operating pumps, the 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-liter samples from wells as deep as 1800 meters. The pH, conductivity, and temperature of the water are measured when the sample is collected.

The tritium and gamma spectrometric analyses are described in Section 9.0 Sample Analysis Procedures. For those samples in which the tritium concentration is less than 700 pCi/L (26 Bq/L), an enrichment procedure is performed which reduces the MDC from about 600 to about 10 pCi/L (from 22 to 0.4 Bq/L). Also, the first time a water source is sampled the sample is analyzed for ^{89}Sr and ^{90}Sr, ^{226}Ra, uranium isotopes, ^{238}Pu and ^{239}Pu.

For those operations conducted in other states, samples for the LTHMP are collected annually. For the locations on the NTS listed in Table 16, the samples are collected monthly, when possible, and analyzed by gamma spectrometry as well as for tritium. For a few NTS wells and for all the water sources around the NTS a sample for tritium analysis is collected twice per year at about a 6-month interval. One of the semi-annual samples is analyzed for tritium by the conventional method, the other by the enrichment method. During the other 10 months, only a cubitainer of water is collected for analysis by gamma spectrometry. Since all gamma spectra were negligible only the tritium results are shown in Table 16.

Table 16. LTHMP Tritium Results for the Monthly NTS Network for 1988

Sampling Location	No. Samples	Tritium Concentration (pCi/L) Max	Min	Avg	Percent Conc. Guide
Well 1 Army	12	14	-19	1.6	< 0.01
Well 2	12	11	-16	0.63	< 0.01
Well 3	11	16	-16	0.33	< 0.01
Well 4	11	18	-16	-0.17	< 0.01
Well 4 CP-1	12	3.7	-19	-2.4	< 0.01
Well 5C	12	9.0	-18	-1.8	< 0.01
Well 8	11	4.4	-23	-2.1	< 0.01
Well 20	12	4.4	-21	-2.3	< 0.01
Well A	10	52	14	37	0.19
Well B Test	9	156	120	140	0.70
Well C	12	76	5.9	29	0.14
Well J-13	12	5.9	-26	-0.27	< 0.01
Well U19C	12	8.9	-18	-0.47	< 0.01
Well UE18R	7	110	-4.2	17	0.10

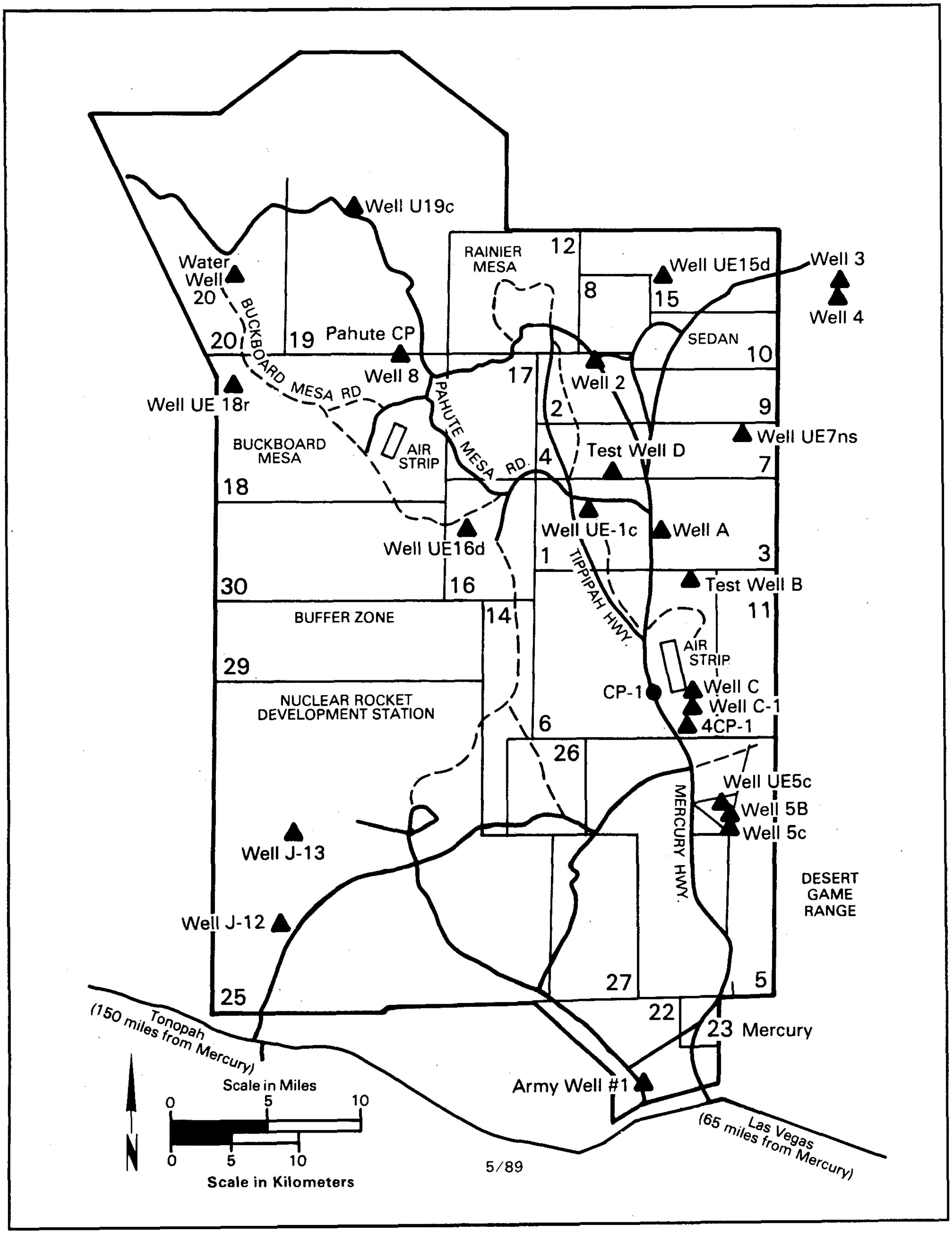


Figure 30. LTHMP Sampling Locations on the NTS.

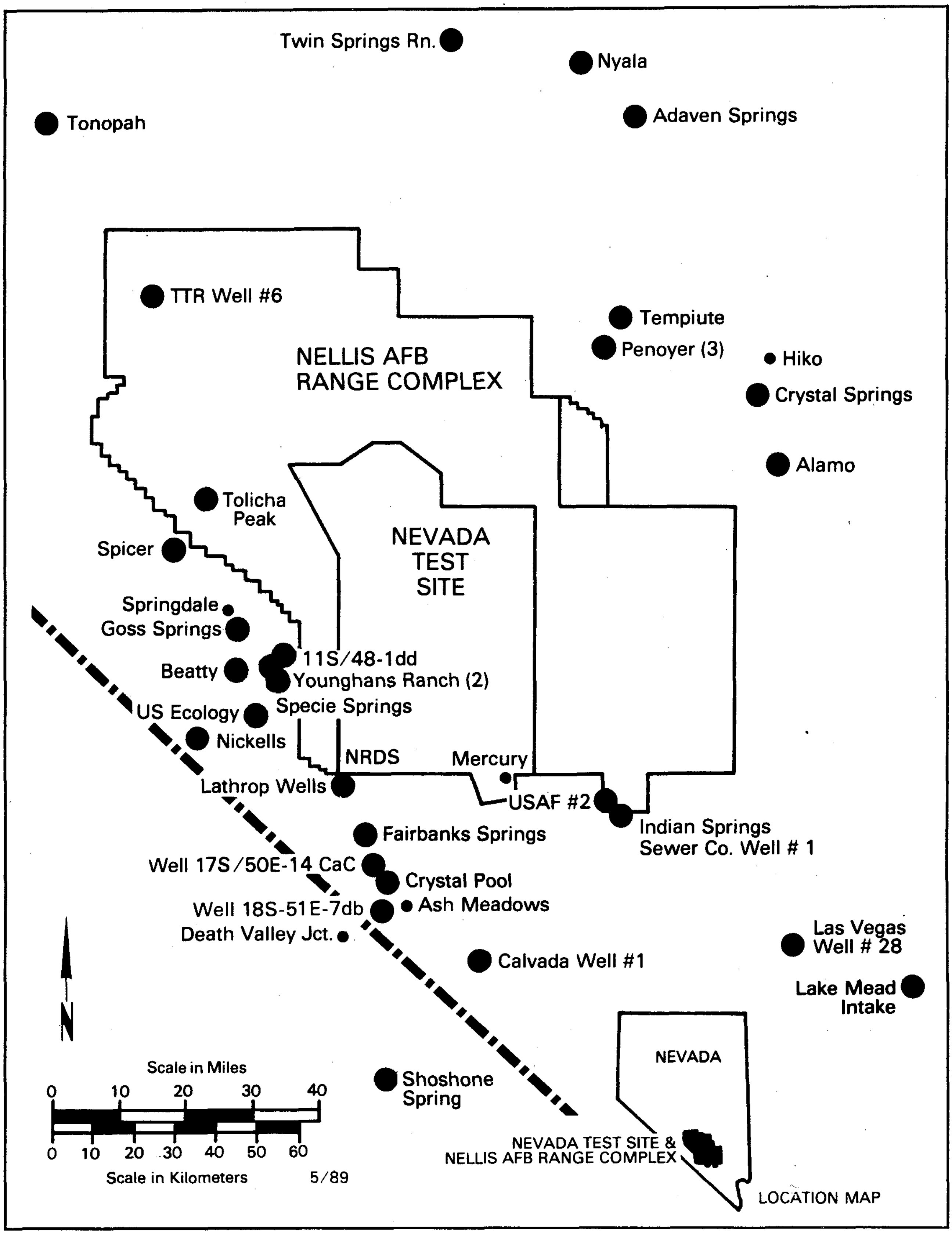


Figure 31. LTHMP Sampling Locations Near the NTS.

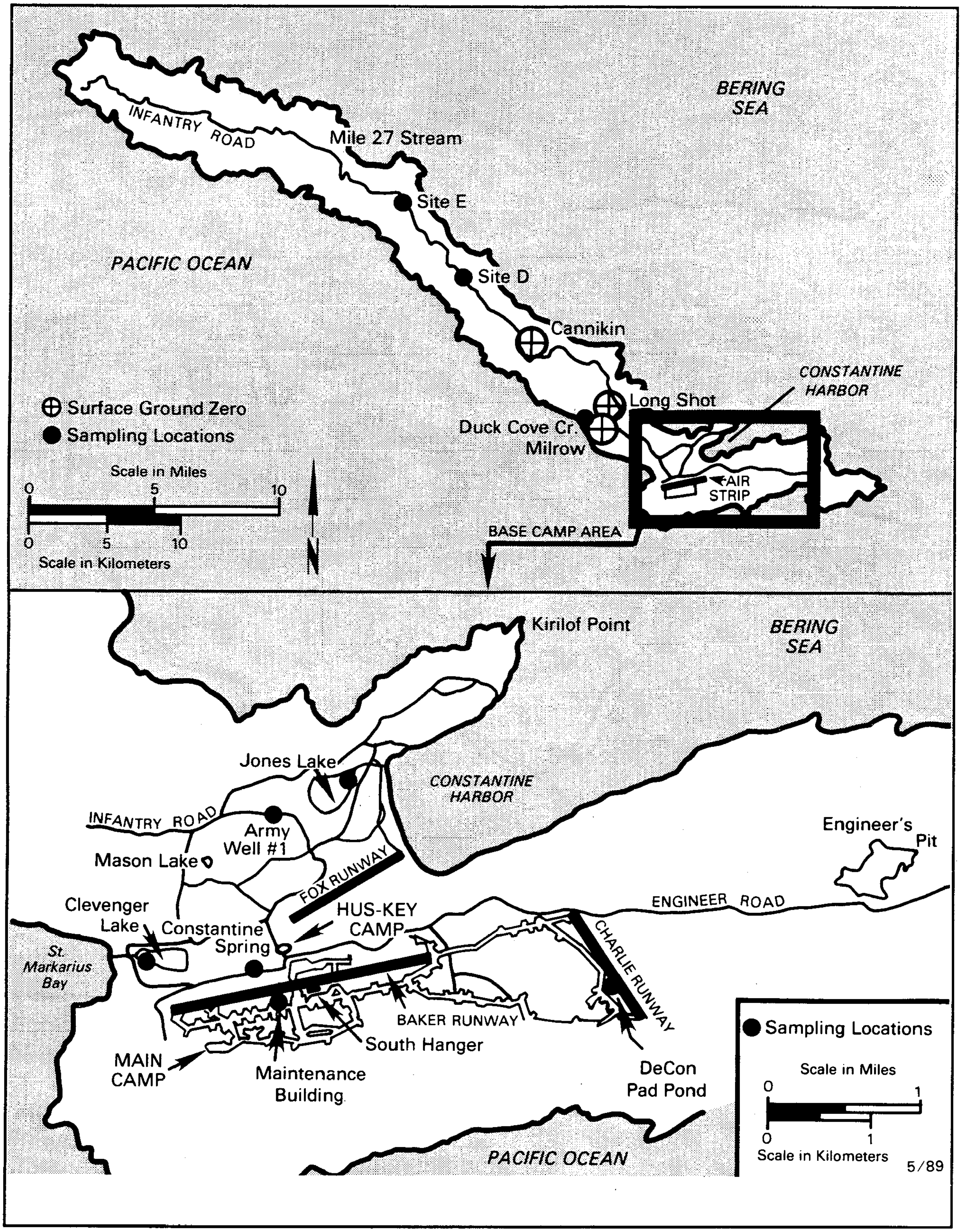


Figure 32. Amchitka Island and Background Sampling Locations for the LTHMP

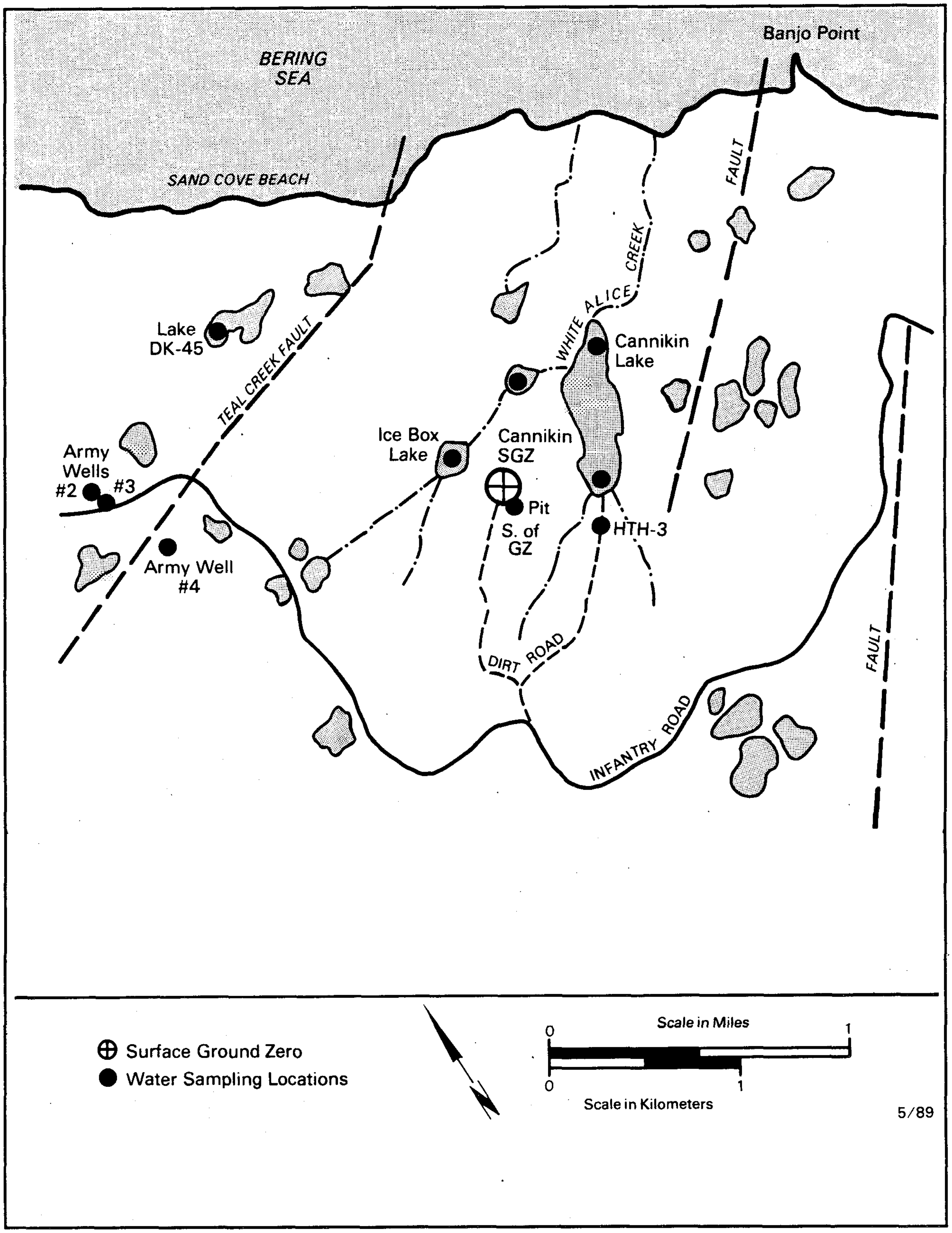


Figure 33. LTHMP Sampling Locations for Project Cannikin.

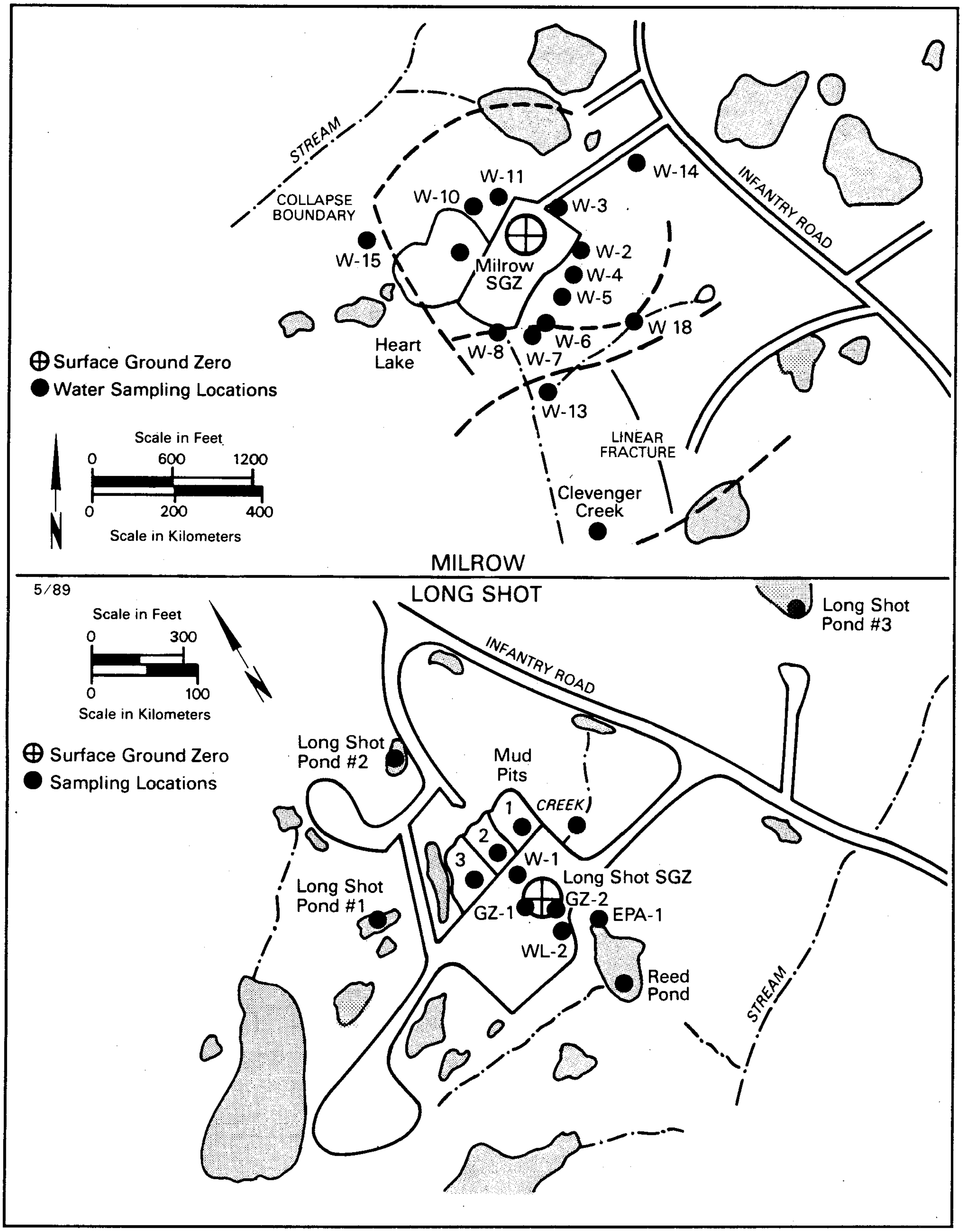


Figure 34. LTHMP Sampling Locations for Projects Milrow and Long Shot.

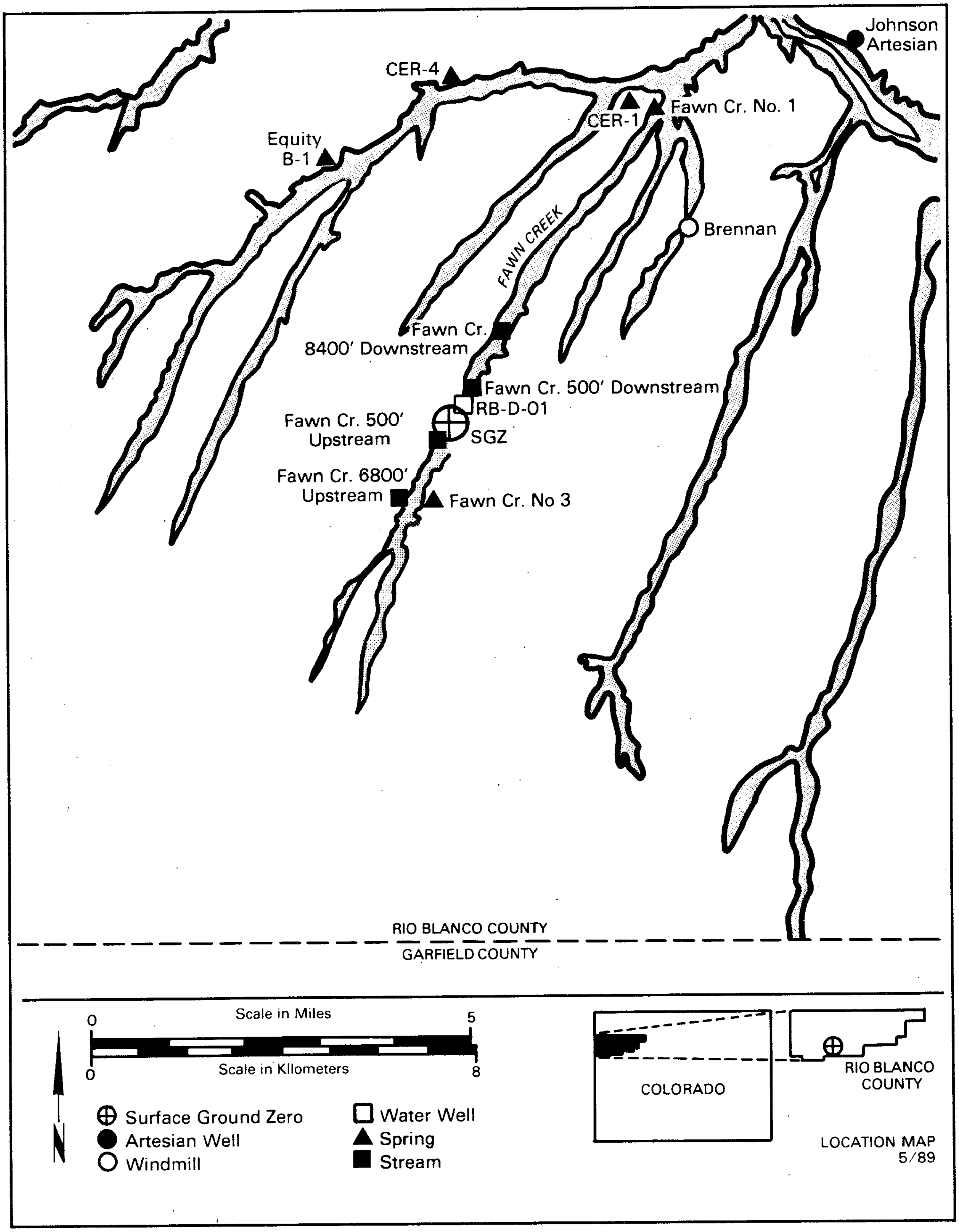


Figure 35. LTHMP Sampling Locations for Project Rio Blanco.

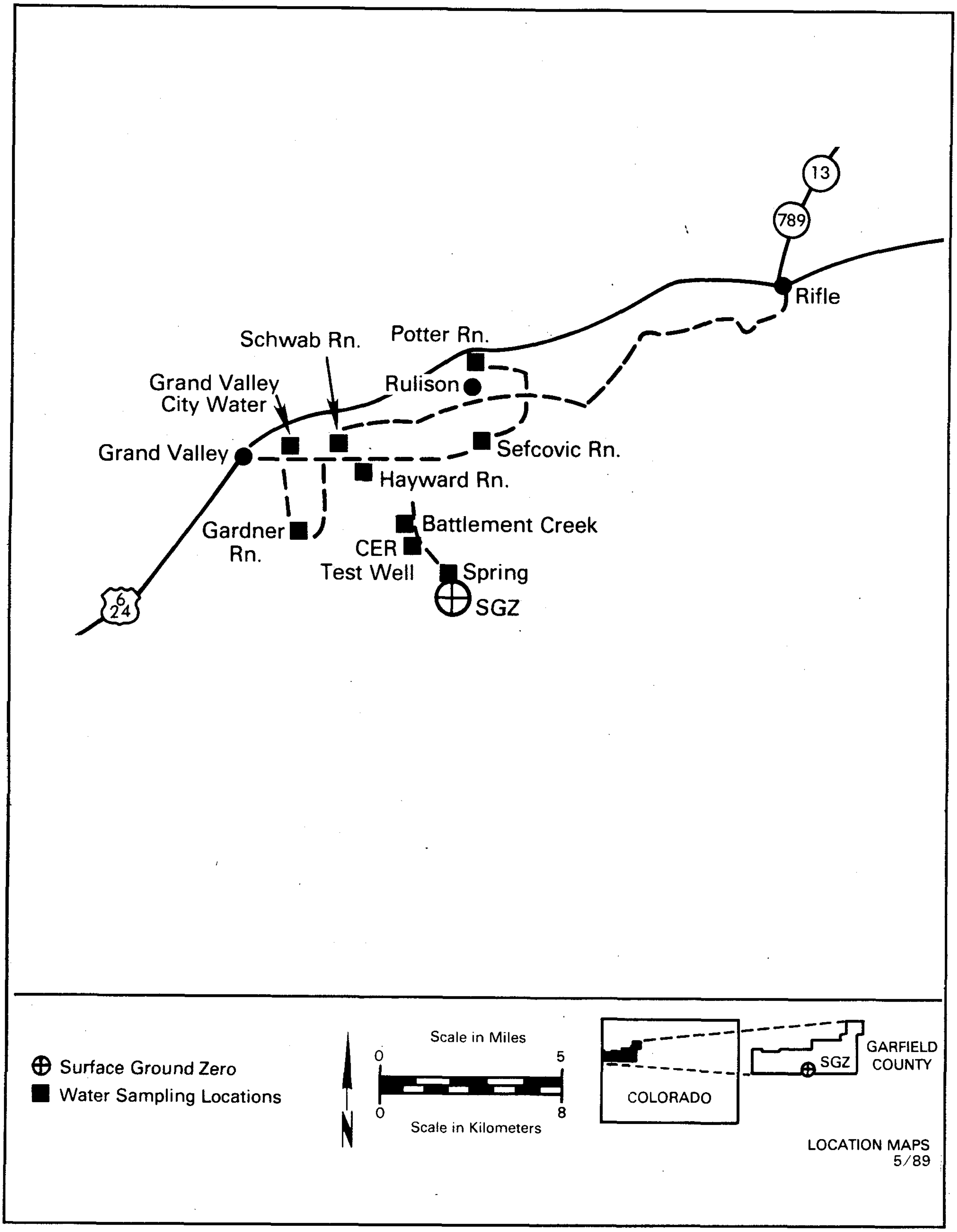


Figure 36. LTHMP Sampling Locations for Project Rulison.

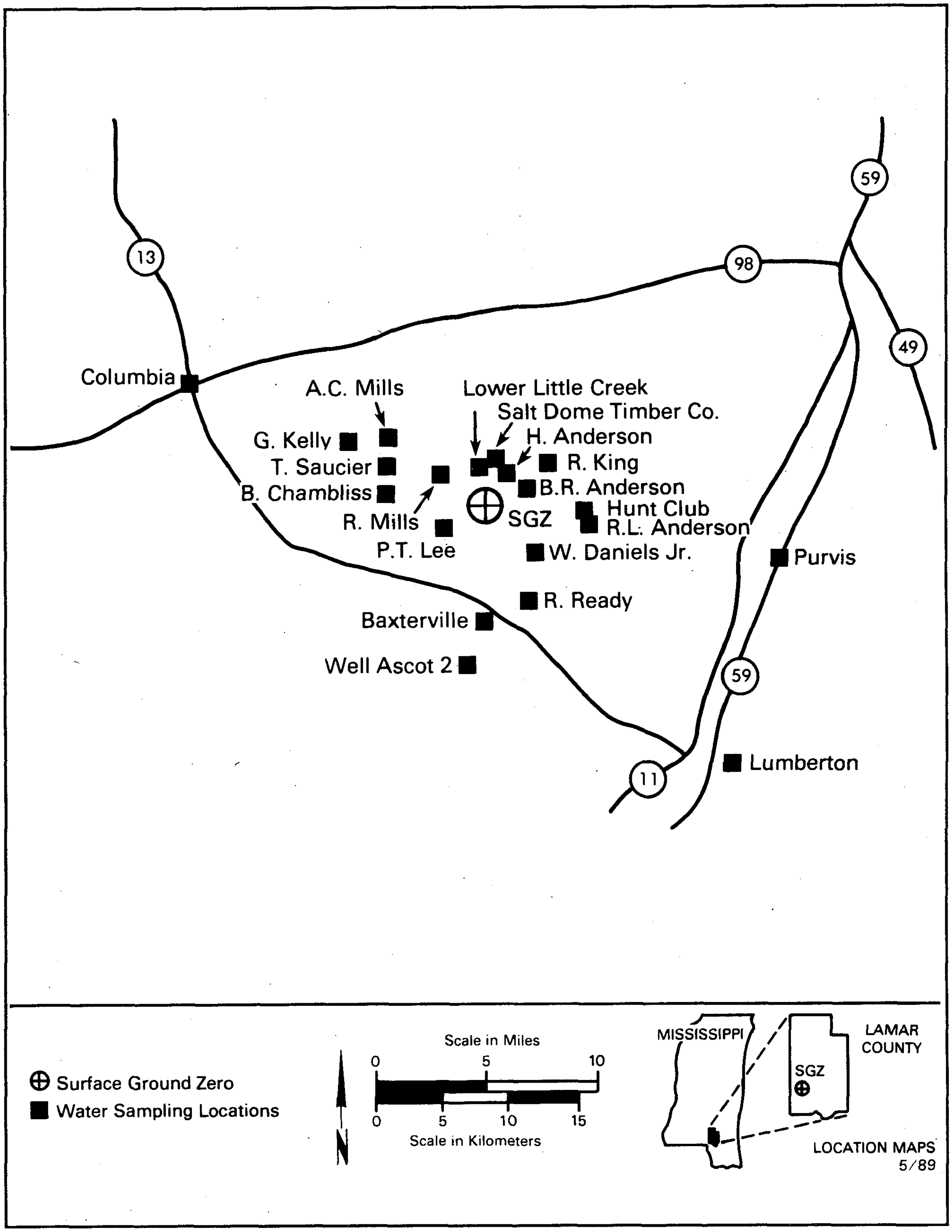


Figure 37. LTHMP Sampling Locations for Project Dribble - Towns and Residences.

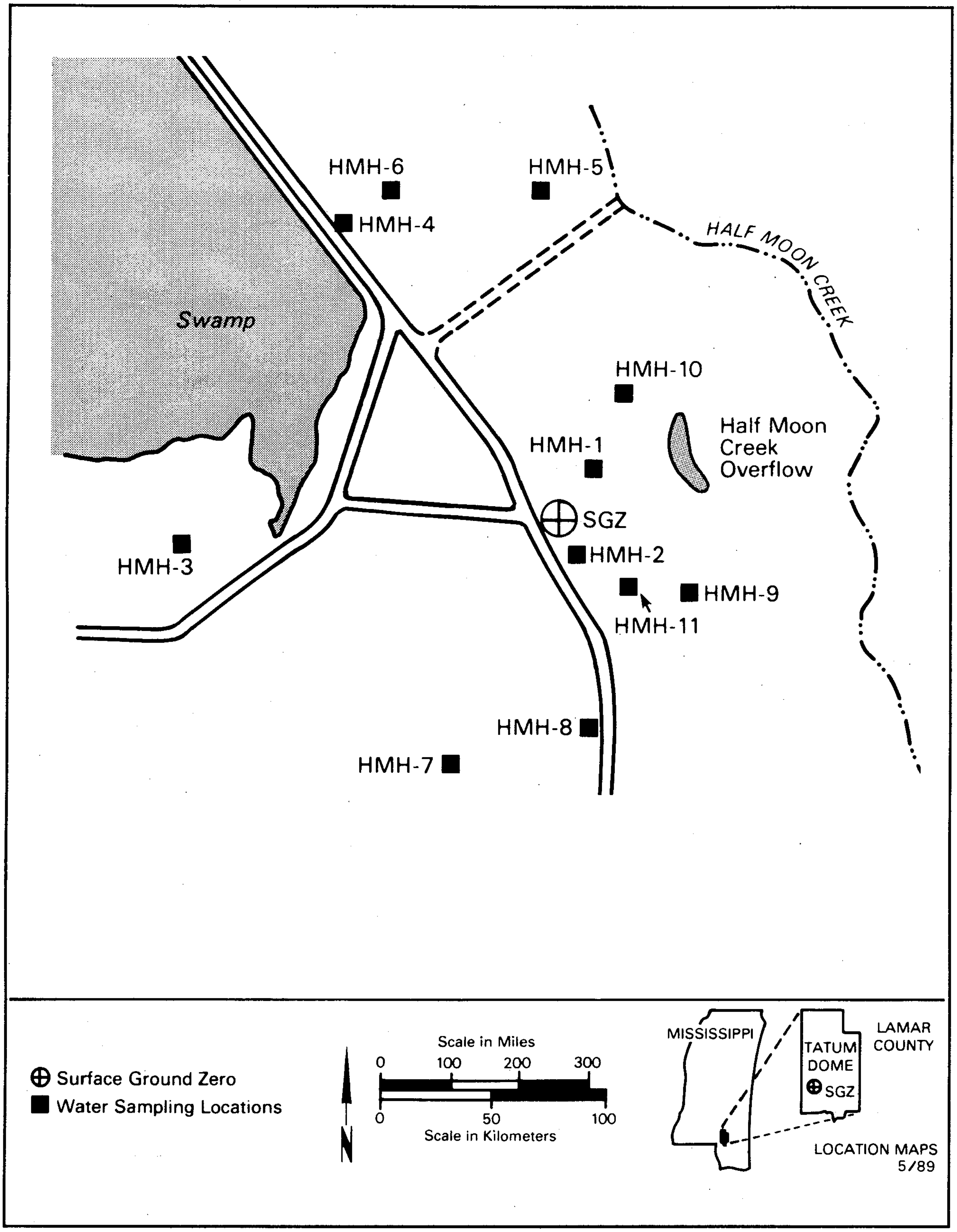


Figure 38. LTHMP Sampling Locations for Project Dribble - Near GZ.

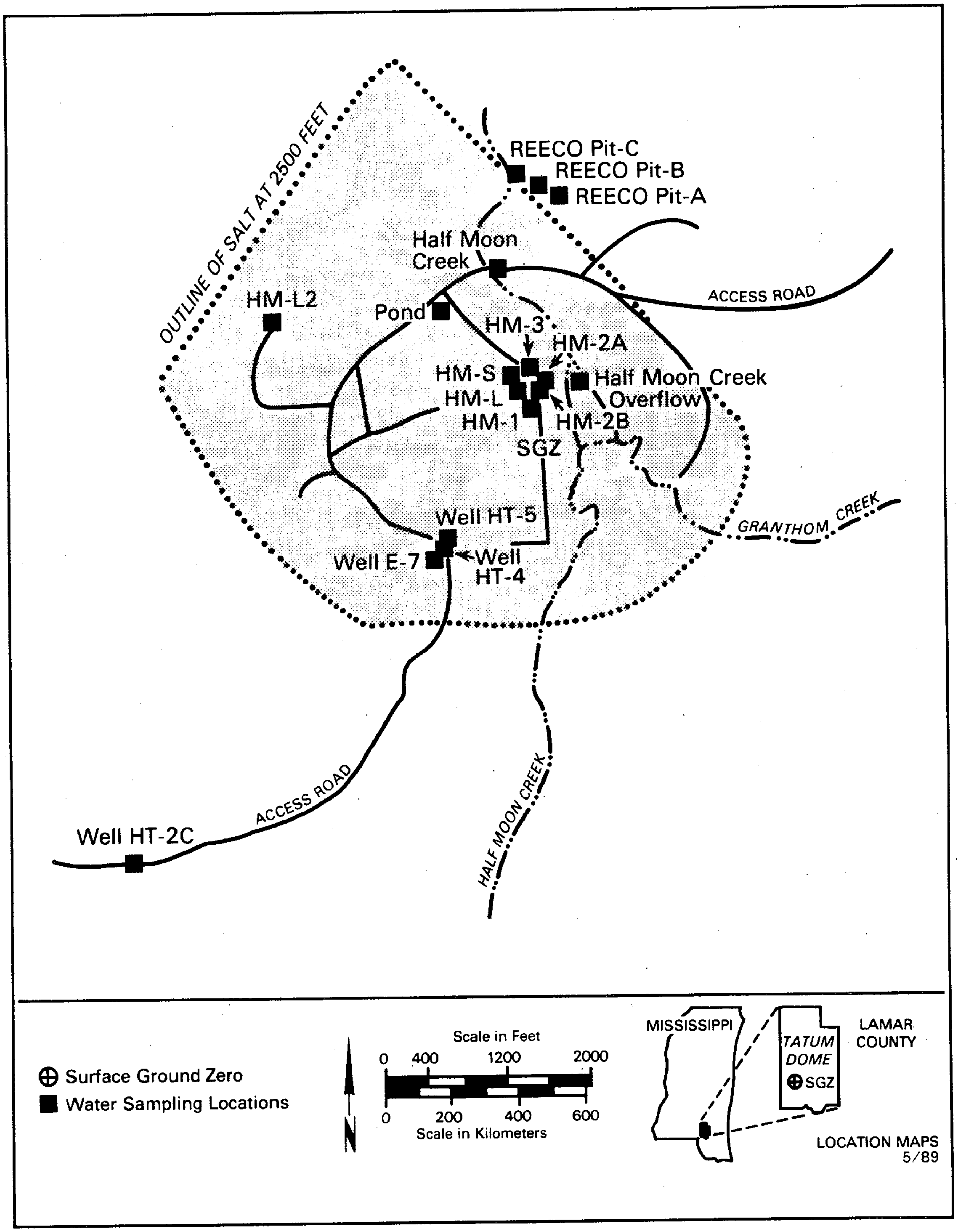


Figure 39. LTHMP Sampling Locations for Project Dribble - Near Salt Dome.

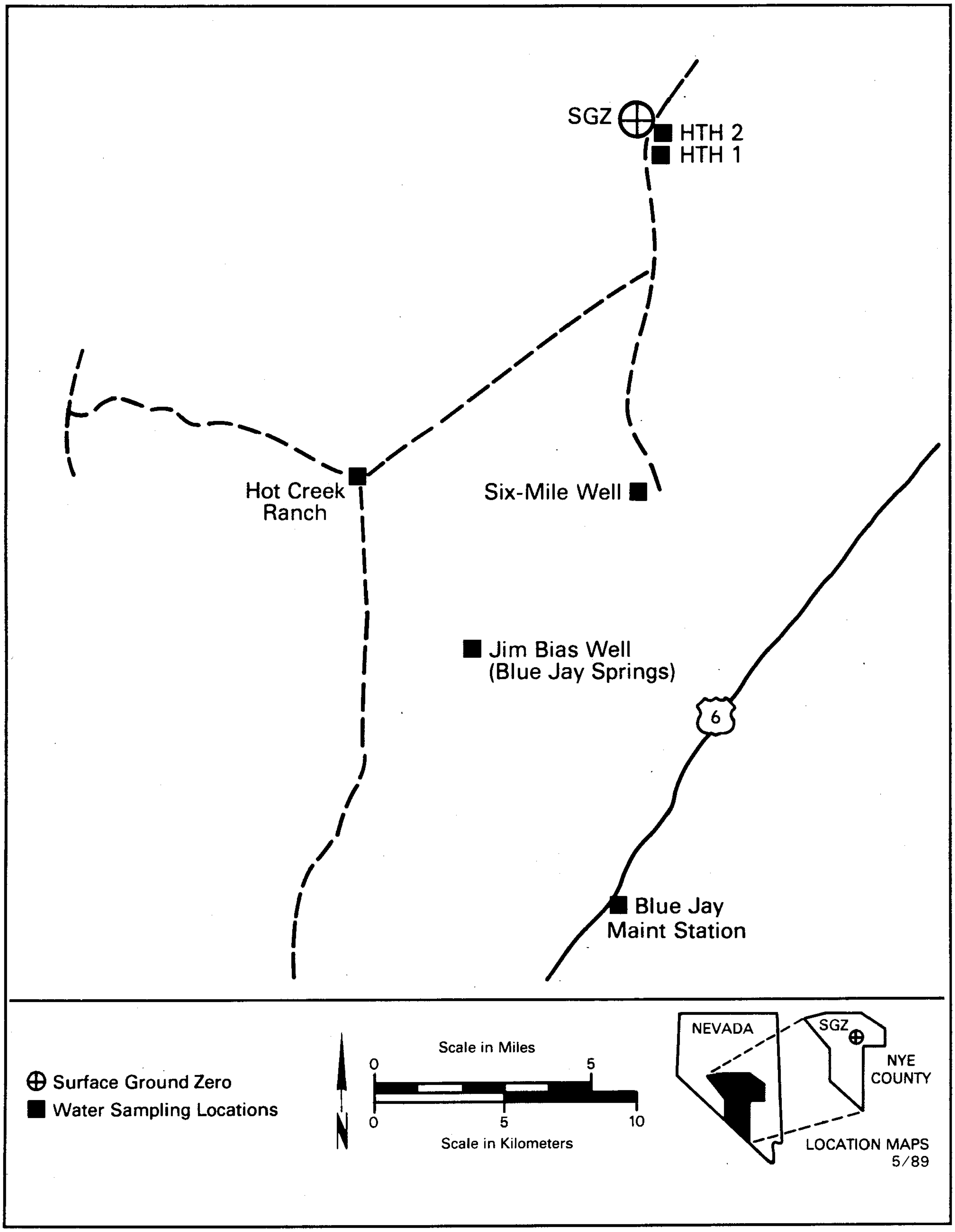


Figure 40. LTHMP Sampling Locations for Project Faultless.

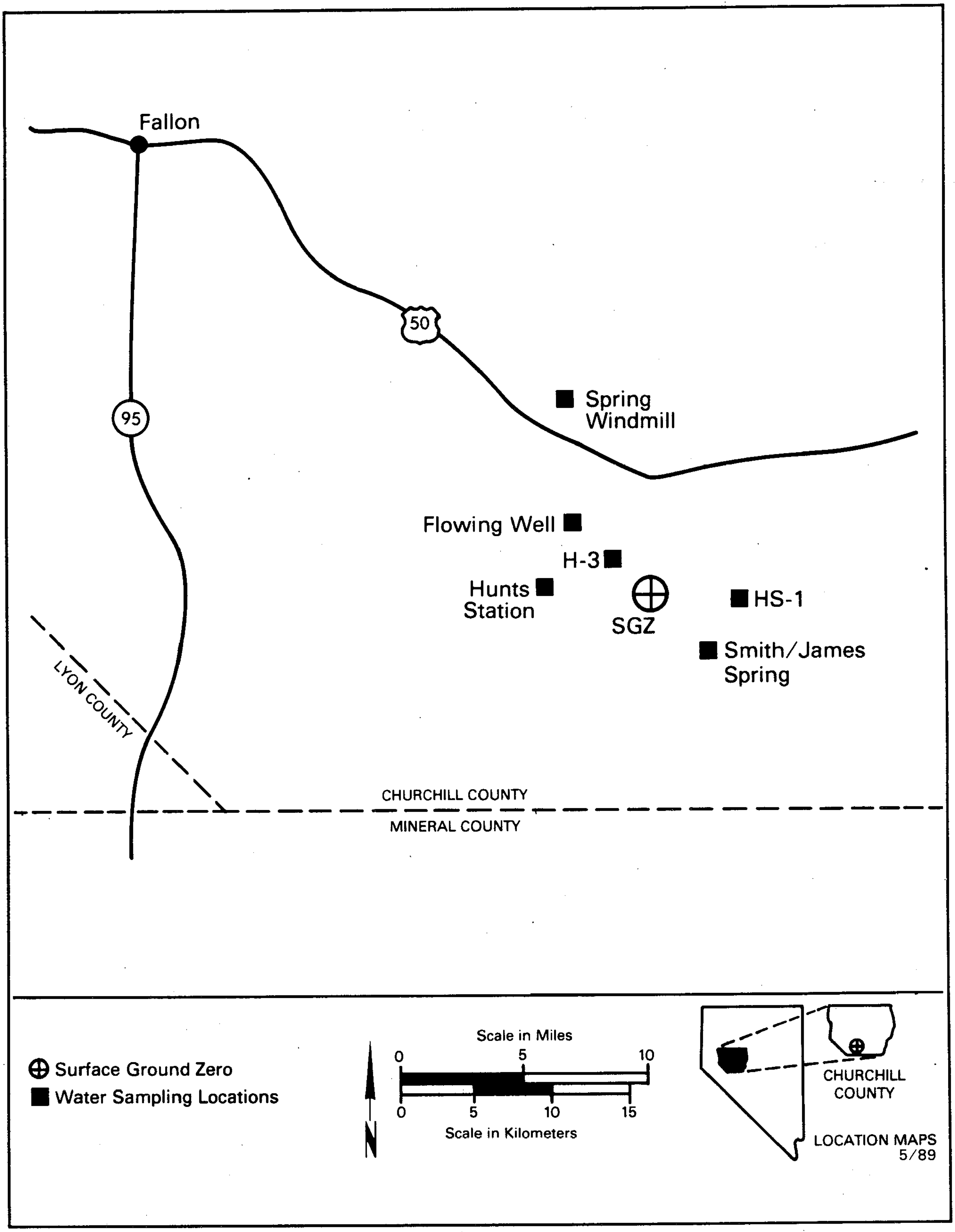


Figure 41. LTHMP Sampling Locations for Project Shoal.

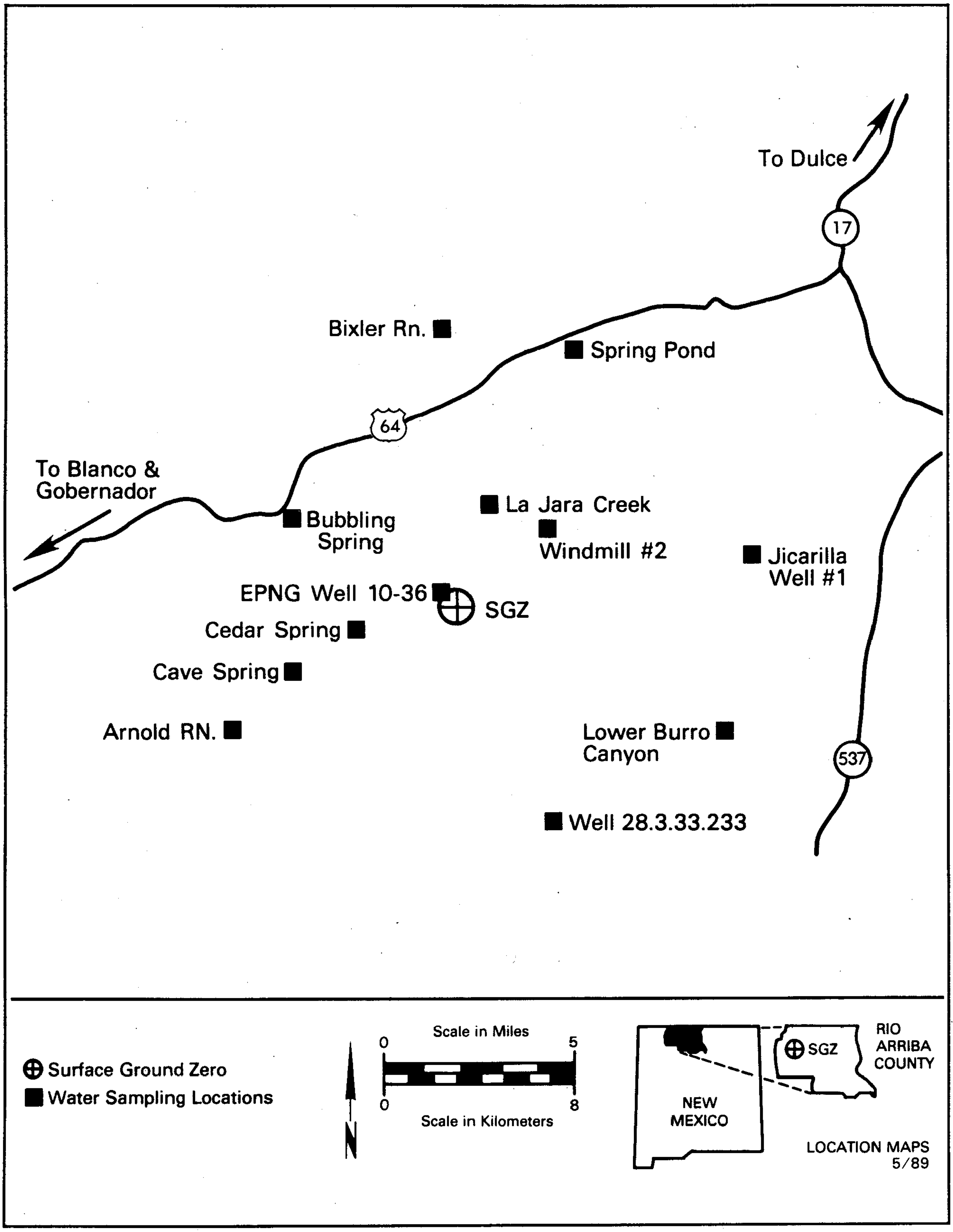


Figure 42. LTHMP Sampling Locations for Project Gasbuggy.

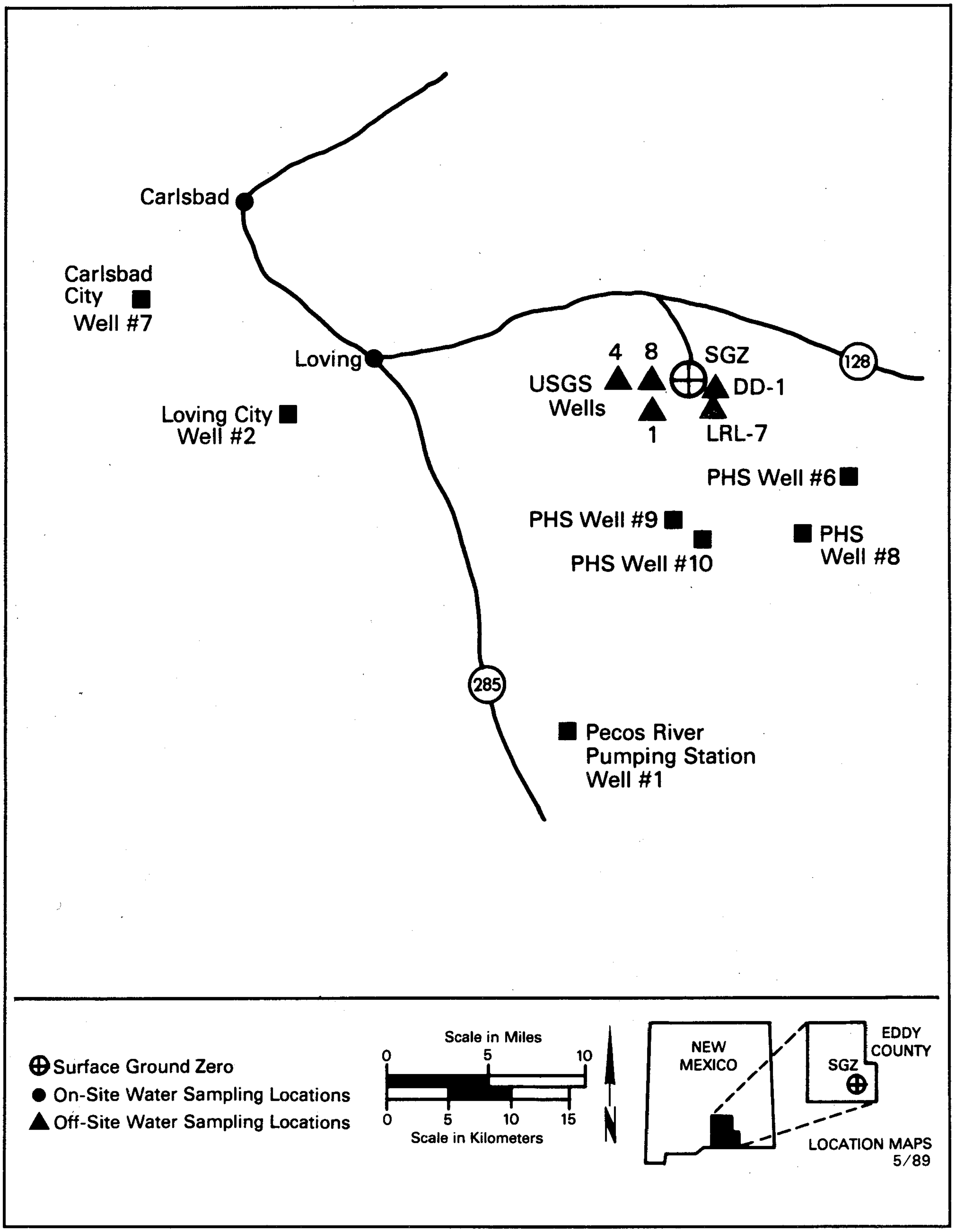


Figure 43. LTHMP Sampling Locations for Project Gnome.

The tritium concentration in samples from Well A were plotted as a running average to minimize the variability in the data. The plot indicated an increase in concentration was occurring that had started in early 1988. Although the maximum (50 pCi/L) was only 0.25 percent of the Drinking Water Regulation, the DOE removed the well from industrial and culinary water production. There were no other trends noted for these wells.

Because of the variability noted in samples obtained at the shallow monitoring wells at the Project Dribble site, these wells were pumped extensively during the 1988 sample collection trip. Some of the shallow wells were pumped and sampled up to eight times and others less frequently. Only the highest tritium concentration obtained on multiple sampling is reported in Table 18 on the assumption it is representative of formation water.

Results

The locations at which the water samples were found to contain man-made radioactivity are shown in Table 17 along with the analytical results. For tritium concentrations, only those samples in which the concentration exceeded 0.01 of the Drinking Water Standard (i.e., 200 pCi/L) are shown. The radioactivity in the samples collected from those locations has been reported in earlier reports. Several samples were analyzed for plutonium and

TABLE 17. Water sampling locations where samples contained man-made radioactivity - 1988

Sampling Location	Type of Radioactivity	Conc. (pCi/L)
PROJECT GNOME, NM		
USGS Well 4	^{3}H	190,000
	^{90}Sr	3,600
USGS Well 8	^{3}H	150,000
	^{90}Sr	2,300
Well LRL-7	^{3}H	16,000
	^{137}Cs	200
PROJECT RULISON, CO		
Hayward Ranch	^{3}H	250
PROJECT DRIBBLE, MS		
Half Moon Creek Overflow	^{3}H	1,400
Well HMH-1 through 11	^{3}H	24-35,000
Well HM-S	^{3}H	11,000
Well HM-L	^{3}H	1,300
REECo Pit Drainage-A	^{3}H	230
PROJECT LONGSHOT, AK		
Stream E of GZ	^{3}H	530
Well GZ, No. 1	^{3}H	2,100
Mud Pit No. 1	^{3}H	250
Mud Pit No. 2	^{3}H	280
Mud Pit No. 3	^{3}H	420

two from the Gnome site in New Mexico were analyzed for ^{90}Sr to confirm results obtained previously.

The results of analysis for all collected samples are shown in Table 18 together with the percent of the relevant concentration guide that is listed in Table 25.

Discussion

The NTS network presently consists of 24 wells that are sampled periodically. However, there are another 31 wells that have never been monitored. These are being added to the NTS network as time permits. They will be sampled and analyzed semiannually.

Although some positive results, that is detectable amounts of man-made radionuclides, are shown for some of the water samples, none of them are expected to give measurable radiation exposures to residents in the areas where the samples were collected. Specifically, these were:

Project Gnome -- Wells USGS 4 and 8 were used for a hydrological tracer study many years ago so the radionuclides detected were consistent with previous results. These wells are capped and locked to prevent use. Well LRL-7 is expected to show elevated levels of radionuclides as it was used for disposal of contaminated soil and salt. It is also guarded to prevent access.

Project Dribble -- Wells at this location are on private land, about one mile from the nearest resident and are not sources for drinking water.

Project Alaska -- The shallow wells at Project Longshot on Amchitka Island are in an isolated location and are not sources of drinking water.

Table 18. Tritium Results for the LTHMP - 1988

SAMPLING LOCATION	COLLECTION DATE 1988	CONC. ± 2 SIGMA TRITIUM (pCi/L)	PCT OF CONC. GUIDE	
CARLSBAD NM				
WELL 7 CITY	04/25	9 ± 15*	0.05	(1)
LOVING NM				
WELL 2 CITY	04/25	17 ± 10	0.08	(2)
MALAGA NM				
WELL 1 PECOS PUMPING STAT	04/25	10 ± 15*	0.05	(3)
WELL LRL-7	04/26	16000 ± 460	82.0	(4)
WELL PHS 6	04/24	57 ± 10	0.29	(5)
WELL PHS 8	04/26	21 ± 10	0.10	(6)
WELL PHS 9	04/24	-9 ± 15*	< 0.01	(7)
WELL PHS 10	04/24	-5 ± 16*	< 0.01	(8)
WELL USGS 1	04/24	0.4 ± 15*	< 0.01	(9)
WELL USGS 4	04/26	190,000 ± 1100	955.	(10)
WELL USGS 8	04/26	150,000 ± 1000	735.	(11)
FRENCHMAN STATION NV				
FRENCHMAN STATION	02/22	**		
		PUMP REMOVED SITE CLOSED		
HUNT'S STATION	02/23	1 ± 15*	< 0.01	
SMITH/JAMES SPRGS	02/24	83 ± 10	0.42	
	06/15	58 ± 10	0.29	
SPRING WINDMILL	02/23	**		
		NO SAMPLE WINDMILL OUT		
WELL FLOWING	02/23	-4 ± 16*	< 0.01	
WELL H-3	02/24	**		
		NOT SAMPLED		
WELL HS-1	02/24	-6 ± 18*	< 0.01	
BAXTERVILLE MS				
HALF MOON CREEK	04/18	31 ± 10	0.15	
	04/18	36 ± 9	0.18	
HALF MOON CREEK OVRFLW	04/18	1400 ± 390	6.80	
	04/18	1200 ± 380	6.20	
LOWER LITTLE CREEK	04/18	49 ± 10	0.24	
POND WEST OF GZ	04/18	28 ± 10	0.14	
	04/18	15 ± 16*	0.08	
ANDERSON POND	04/20	13 ± 15*	0.07	(12)
REECO PIT DRAINAGE-A	04/19	230 ± 11	1.14	
REECO PIT DRAINAGE-B	04/19	120 ± 10	0.59	
REECO PIT DRAINAGE-C	04/19	200 ± 11	0.98	

(continued)

Table 18. (continued)

SAMPLING LOCATION	COLLECTION DATE 1988	CONC. ± 2 SIGMA TRITIUM (pCi/L)	PCT OF CONC. GUIDE
BAXTERVILLE MS (Cont)			
SALT DOME HUNTING CLUB	04/19	42 ± 10	0.21
SALT DOME TIMBER CO.	04/18	46 ± 10	0.23
ANDERSON, B. R.	04/19	23 ± 11	0.11
ANDERSON, H.	04/19	27 ± 11	0.13
ANDERSON, R. L.	04/18	36 ± 11	0.18
CHAMBLISS, B.	04/18	-3 ± 17*	< 0.01
DANIELS, W. JR.	04/18	40 ± 10	0.20
KELLY, G.	04/18	-8 ± 16*	< 0.01
KING, RHONDA	04/19	36 ± 10	0.18
LEE, P. T.	04/19	51 ± 9	0.25
LOWE, M.	04/18	** NOT SAMPLED	
MILLS, A. C.	04/18	4 ± 16*	0.02
MILLS, R.	04/18	35 ± 10	0.17
READY, R.	04/18	80 ± 11	0.40
SAUCIER, T. S.	04/18	46 ± 9	0.23
SPEIGHTS, T.	04/18	** NOT SAMPLED	
WELL ASCOT 2	04/19	46 ± 10	0.23
WELL CITY	04/18	46 ± 9	0.23
WELL E-7	04/19	15 ± 9	0.08
WELL HM-1	04/18	11 ± 15*	0.06
WELL HM-2A	04/18	11 ± 16*	0.06
WELL HM-2B	04/18	15 ± 15*	0.08
WELL HM-3	04/18	5 ± 15*	0.02
WELL HM-L	04/18	1300 ± 390	6.65
WELL HM-L2	04/18	6 ± 16*	0.03
WELL HM-S	04/18	11000 ± 470	55.0
WELL HMH-1	04/19	35000 ± 620	173.
WELL HMH-2	04/19	17000 ± 510	85.5
WELL HMH-3	04/17	51 ± 10	0.25
WELL HMH-4	04/17	24 ± 9	0.12
WELL HMH-5	04/17	5400 ± 420	27.1
WELL HMH-6	04/17	100 ± 10	0.52
WELL HMH-7	04/17	180 ± 11	0.91
WELL HMH-8	04/17	43 ± 9	0.22
WELL HMH-9	04/17	73 ± 11	0.36
WELL HMH-10	04/17	24 ± 11	0.12
WELL HMH-11	04/17	78 ± 11	0.39
WELL HT-2C	04/19	** NOT SAMPLED	

(continued)

Table 18. (continued)

SAMPLING LOCATION	COLLECTION DATE 1988	CONC. ± 2 SIGMA TRITIUM (pCi/L)	PCT OF CONC. GUIDE
BAXTERVILLE MS (Cont)			
WELL HT-4	04/19	16 ± 9	0.08
WELL HT-5	04/19	3 ± 15*	0.02
COLUMBIA MS			
WELL 64B CITY	04/18	26 ± 9	0.13
LUMBERTON MS			
WELL 2 CITY	04/18	7 ± 15*	0.04
PURVIS MS			
CITY SUPPLY	04/18	2 ± 15*	0.01
GOBERNADOR NM			
ARNOLD RANCH	06/22	7.5 ± 9.2	0.04
BIXLER RANCH	06/21	15 ± 9	0.08
BUBBLING SPRINGS	06/21	69 ± 10	0.35
CAVE SPRINGS	06/22	25 ± 9	0.13
CEDAR SPRINGS	06/21	83 ± 10	0.42
LA JARA CREEK	06/21	73 ± 10	0.36
LOWER BURRO CANYON	06/22	12 ± 9	0.06
RESAMPLE OF WINDMILL			
POND N WELL 30.3.32.343	06/21	580 ± 13	2.91
WELL EPNG 10-36	06/23	750 ± 15	3.77
RESAMPLE OF WELL			
WELL JICARILLA 1	06/22	5 ± 9.3	0.03
WELL 28.3.33.233 (SOUTH)	06/21	** NO SAMPLE-WELL OUT	
WELL 30.3.32.343 (NORTH)	06/21	** NO SAMPLE-WELL OUT	
WINDMILL 2	06/22	5.1 ± 9.5	0.03
GRAND VALLEY CO			
BATTLEMENT CREEK	06/25	140 ± 11	0.70
CITY SPRINGS	06/25	-2 ± 16*	< 0.01
ALBERT GARDNER RANCH	06/25	170 ± 12	0.86
SPRING 300 YRD N OF GZ	06/25	84 ± 11	0.42
WELL CER TEST	06/25	160 ± 12	0.79
RULISON CO			
LEE HAYWARD RANCH	06/25	250 ± 12	1.24
POTTER RANCH	06/27	140 ± 11	0.71
ROBERT SEARCY RN (SCHWAB)	06/25	150 ± 11	0.76

(continued)

Table 18. (continued)

SAMPLING LOCATION	COLLECTION DATE 1988	CONC. ± 2 SIGMA TRITIUM (pCi/L)	PCT OF CONC. GUIDE
RULISON CO (continued)			
FELIX SEFCOVIC RANCH	06/25	160 ± 11	0.82
RIO BLANCO CO			
B-1 EQUITY CAMP	06/26	92 ± 10	0.46
BRENNAN WINDMILL	06/27	46 ± 11	0.23
CER NO.1 BLACK SULPHUR	06/26	87 ± 10	0.43
CER NO.4 BLACK SULPHUR	06/26	73 ± 10	0.36
FAWN CREEK 1	06/27	46 ± 11	0.23
FAWN CREEK 3	06/27	60 ± 10	0.30
FAWN CREEK 6800FT UPSTRM	06/27	62 ± 10	0.31
FAWN CREEK 500FT UPSTRM	06/27	57 ± 9	0.29
FAWN CREEK 500FT DWNSTRM	06/27	53 ± 10	0.26
FAWN CREEK 8400FT DWNSTR	06/27	45 ± 11	0.22
WELL JOHNSON ARTESIAN	06/27	-7 ± 10*	< 0.01
WELL RB-D-01	06/27	7.9 ± 9.2*	0.04
WELL RB-D-03	06/27	4.8 ± 9.2*	0.02
WELL RB-S-03	06/27	1.2 ± 9.1*	< 0.01
BLUE JAY NV			
HOT CREEK RANCH SPRING	07/20	** NOT SAMPLED	
MAINTENANCE STATION	07/21	7 ± 10*	0.03
WELL BIAS	07/20	0.8 ± 9.2*	< 0.01
WELL HTH-1	07/21	-8.4 ± 9.1*	< 0.01
WELL HTH-2	07/21	-5.5 ± 9.2*	< 0.01
WELL SIX MILE	07/20	** NOT SAMPLED	
AMCHITKA AK			
CLEVENGER LAKE	09/07	47 ± 10	0.24
CONSTANTINE SPRING	09/07	53 ± 10	0.26
DUCK COVE CREEK	09/07	36 ± 10	0.18
JONES LAKE	09/07	34 ± 10	0.17
RAIN SAMPLE	09/08	27 ± 10	0.13
SITE D HYDRO EXPLORE HOLE	09/08	72 ± 10	0.36
WELL ARMY 1	09/08	48 ± 10	0.24
WELL ARMY 2	09/08	34 ± 10	0.17
WELL 4 ARMY	09/08	43 ± 11	0.22
CANNIKIN LAKE (NORTH END)	09/08	34 ± 10	0.17
CANNIKIN LAKE (SOUTH END)	09/08	44 ± 11	0.22
DK-45 LAKE	09/08	36 ± 9	0.18
ICE BOX LAKE	09/08	46 ± 10	0.23
PIT SOUTH OF CANNIKIN GZ	09/08	38 ± 10	0.19

(continued)

Table 18. (continued)

SAMPLING LOCATION	COLLECTION DATE 1988	CONC. ± 2 SIGMA TRITIUM (pCi/L)	PCT OF CONC. GUIDE
AMCHITKA AK (continued)			
WELL HTH-3	09/08	40 ± 10	0.20
WHITE ALICE CREEK	09/08	19 ± 9	0.09
LONG SHOT POND 1	09/07	38 ± 10	0.19
LONG SHOT POND 2	09/07	38 ± 11	0.19
LONG SHOT POND 3	09/07	56 ± 11	0.28
MUD PIT NO.1	09/07	250 ± 12	1.23
MUD PIT NO.2	09/07	280 ± 12	1.38
MUD PIT NO.3	09/07	420 ± 13	2.13
REED POND	09/07	28 ± 10	0.14
STREAM EAST OF LONGSHOT	09/07	530 ± 14	2.64
WELL EPA-1	09/08	54 ± 10	0.27
WELL GZ NO.1	09/08	2100 ± 379	10.3
WELL GZ NO.2	09/08	81 ± 10	0.40
WELL WL-1	09/08	28 ± 10	0.14
WELL WL-2	09/08	180 ± 11	0.92
CLEVENGER CREEK	09/08	46 ± 10	0.23 (13)
HEART LAKE	09/08	31 ± 9	0.15
WELL W-2	09/08	29 ± 9	0.15
WELL W-3	09/08	23 ± 9	0.11
WELL W-4	09/08	** NOT SAMPLED	
WELL W-5	09/08	** NOT SAMPLED	
WELL W-6	09/08	** NOT SAMPLED	
WELL W-7	09/08	40 ± 11	0.20
WELL W-8	09/08	32 ± 10	0.16
WELL W-9	09/08	** NOT SAMPLED	
WELL W-10	09/08	34 ± 12	0.17
WELL W-11	09/08	69 ± 12	0.35
WELL W-12	09/08	** NOT SAMPLED	
WELL W-13	09/08	51 ± 11	0.25
WELL W-14	09/08	** NOT SAMPLED	
WELL W-15	09/08	36 ± 10	0.18
WELL W-16	09/08	** NOT SAMPLED	
WELL W-17	09/08	28 ± 11	0.14
WELL W-18	09/08	50 ± 12	0.25
WELL W-19	09/08	** NOT SAMPLED - WELL DRY	

(continued)

Table 18. (continued)

SAMPLING LOCATION	COLLECTION DATE 1988	CONC. ± 2 SIGMA TRITIUM (pCi/L)	PCT OF CONC. GUIDE
SHOSHONE CA			
SHOSHONE SPRING	01/04	170 ± 330*	0.87
	06/07	0.4 ± 16*	< 0.01
ADAVEN NV			
ADAVEN SPRING	05/05	41 ± 10	0.21
	09/01	150 ± 610*	0.74
	10/04	95 ± 360*	0.47
ALAMO NV			
WELL 4 CITY	04/14	-11 ± 16*	< 0.01
	09/21	60 ± 610*	0.30
ASH MEADOWS NV			
CRYSTAL POOL	02/11	10 ± 13*	0.05
	07/12	-53 ± 600*	< 0.01
FAIRBANKS SPRINGS	03/03	7 ± 13*	0.03
	08/01	-33 ± 610*	< 0.01
WELL 17S-50E-14CAC	02/11	13 ± 13*	0.07
	07/12	69 ± 600*	0.35
WELL 18S-51E-7DB	02/11	2.4 ± 14*	0.01
	07/12	-90 ± 600*	< 0.01
BEATTY NV			
SPECIE SPRINGS	03/03	250 ± 550*	1.23
	08/04	48 ± 11	0.24
TOLICHA PEAK	02/04	5 ± 14*	0.02
	07/07	0 ± 600*	
		NOT SAMPLED	
US ECOLOGY WELL (NECO)	01/06	6 ± 14*	0.03
	06/08	-26 ± 500*	< 0.01
WELL 11S-48-1DD COFFERS	02/04	4 ± 13*	0.02
	07/07	16 ± 600*	0.08
WELL 12S-47E-7DBD CITY	03/04	5 ± 13*	0.03
	08/04	38 ± 610*	0.19
	07/07	250 ± 600*	1.24
WELL ROAD D SPICERS	02/04	-3 ± 14*	< 0.01
YOUNGHANS RCH WELL	11 Samples:	Max. 20 ± 8*	
		Min. -7 ± 17*	
		Avg. 3 ± 12*	

(continued)

Table 18. (continued)

SAMPLING LOCATION	COLLECTION DATE 1988	CONC. ± 2 SIGMA TRITIUM (pCi/L)	PCT OF CONC. GUIDE
BOULDER CITY NV			
LAKE MEAD INTAKE	03/11	99 ± 9	0.50
	08/11	110 ± 610*	0.57
CLARK STATION NV			
WELL 6 TTR	06/01	-2 ± 15*	< 0.01
NOT SAMPLED	10/06	180 ± 360*	0.92
HIKO NV			
CRYSTAL SPRINGS	04/14	-16 ± 15*	< 0.01
	09/02	170 ± 610*	0.84
INDIAN SPRINGS NV			
WELL 1 SEWER COMPANY	01/04	11 ± 14*	0.06
	06/07	-70 ± 500*	< 0.01
WELL 2 US AIR FORCE	01/04	24 ± 9	0.12
	06/07	-52 ± 500*	< 0.01
LAS VEGAS NV			
WELL 28 WATER DISTRICT	01/08	-3 ± 330*	< 0.01
	06/09	0 ± 16*	
LATHROP WELLS NV			
CITY 15S-50E-18CDC	01/05	6 ± 14*	0.03
	06/08	-180 ± 500*	< 0.01
NYALA NV			
SHARP'S RANCH	04/05	-14 ± 16*	< 0.01
	09/01	38 ± 610*	0.19
OASIS VALLEY NV			
GOSS SPRINGS	03/02	13 ± 14*	0.07
	08/04	-210 ± 610*	< 0.01
PAHRUMP NV			
WELL 3 CALVADA	05/03	-2 ± 15*	< 0.01
	10/04	-100 ± 360*	< 0.01
RACHEL NV			
WELLS 7 AND 8 PENOYER	04/13	-1 ± 15*	< 0.01
	09/01	60 ± 610*	0.30
WELL 13 PENOYER	05/10	6 ± 15*	0.03
	09/01	5 ± 610*	0.03

(continued)

Table 18. (continued)

SAMPLING LOCATION	COLLECTION DATE 1988	CONC. ± 2 SIGMA TRITIUM (pCi/L)	PCT OF CONC. GUIDE
RACHEL NV (continued)			
WELL PENOYER CULINARY	02/02	51 ± 330*	0.25
	07/12	53 ± 600*	0.26
TEMPIUTE NV			
UNION CARBIDE WELL	01/06	59 ± 330*	0.29
	06/02	5 ± 16*	0.03
TONOPAH NV			
CITY WELL	06/01	-6 ± 16*	< 0.01
	10/06	42 ± 360	0.21
WARM SPRINGS NV			
TWIN SPRINGS RANCH	04/05	-18 ± 16*	< 0.01
	09/01	-120 ± 610*	< 0.01
NTS NV			
WELL 5B	02/04	140 ± 330*	0.70
	07/19	-4 ± 10*	< 0.01
WELL C-1	02/03	5 ± 330*	0.03
	07/19	9 ± 10*	0.04
WELL D TEST	04/04	-230 ± 560*	< 0.01
	08/09	9 ± 9.4	0.05
WELL UE1C	03/03	-120 ± 550*	< 0.01
	08/08	-0.2 ± 9.4*	< 0.01
WELL UE5C	02/04	140 ± 330*	0.70
	07/19	-2 ± 10*	< 0.01
WELL UE15D	01/06	140 ± 330*	0.70
	06/07	103 ± 10	0.51
WELL UE16D	02/03	13 ± 330*	0.07
	07/19	-6.3 ± 9.9*	< 0.01

* CONCENTRATION IS LESS THAN THE MINIMUM DETECTABLE CONCENTRATION (MDC).
** SAMPLES NOT ANALYZED.

FOOTNOTES

ANALYSIS	RESULT	2 SIGMA	UNITS
(1) ^{239}Pu	2.2E - 03	1.8E - 02*	pCi/L

(continued)

Table 18. FOOTNOTES (continued)

ANALYSIS		RESULT	2 SIGMA	UNITS
(2)	^{238}Pu	9.5E - 03	2.1E - 02*	pCi/L
	^{239}Pu	-1.2E - 03	1.5E - 02*	pCi/L
	^{90}Sr	1.0E - 01	1.2E+00*	pCi/L
(3)	^{238}Pu	-3.4E - 03	1.4E - 02*	pCi/L
	^{239}Pu	-2.7E - 03	9.6E - 03*	pCi/L
	^{90}Sr	3.0E - 01	1.5E+00*	pCi/L
(4)	^{137}Cs	2.0E+02	1.7E+01	pCi/L
	^{239}Pu	2.9E - 03	1.0E - 02*	pCi/L
	^{90}Sr	-1.2E+00	1.9E+00*	pCi/L
(5)	^{238}Pu	9.2E - 04	3.2E - 02*	pCi/L
	^{239}Pu	-6.4E - 03	2.3E - 02*	pCi/L
	^{90}Sr	4.7E - 01	1.6E+00*	pCi/L
(6)	^{238}Pu	4.6E - 04	1.6E - 02*	pCi/L
	^{239}Pu	3.6E - 03	1.1E - 02*	pCi/L
	^{90}Sr	-2.5E+00	4.6E+00*	pCi/L
(7)	^{238}Pu	5.3E - 03	1.7E - 02*	pCi/L
	^{239}Pu	1.4E - 03	1.2E - 02*	pCi/L
(8)	^{238}Pu	1.4E - 02	1.9E - 02*	pCi/L
	^{239}Pu	1.6E - 03	1.3E - 02*	pCi/L
	^{90}Sr	3.2E+00	4.5E+00 *	pCi/L
(9)	^{238}Pu	9.0E - 03	2.0E - 02*	pCi/L
	^{239}Pu	-4.0E - 03	1.4E - 02*	pCi/L
(10)	^{238}Pu	-2.2E - 03	2.0E - 02*	pCi/L
	^{239}Pu	-3.9E - 03	1.4E - 02*	pCi/L
	^{90}Sr	3.6E+03	3.6E+01	pCi/L
(11)	^{239}Pu	-3.7E - 03	1.3E - 02*	pCi/L
	^{90}Sr	2.3E+03	5.6E+01	pCi/L
(12)	^{238}Pu	-1.2E - 02	5.7E - 02*	pCi/L
	^{239}Pu	-1.1E - 02	4.1E - 02*	pCi/L
	^{90}Sr	4.9E+00	2.3E+00	pCi/L
	^{234}U	2.8E - 02	2.3E - 02	pCi/L
	^{235}U	7.5E - 03	9.0E - 03*	pCi/L
	^{238}U	1.3E - 02	1.5E - 02*	pCi/L
(13)	^{7}Be	7.2E - 01		cpm

* Concentrations of Tritium in atmospheric moisture (atm. m.) are expressed as pCi/mL of water collected.
\+ Concentration Guides used are for 25 mrem annual exposure.

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6.0 Public Information and Community Assistance Programs

A. N. Jarvis

In addition to its many monitoring and data analysis activities, the Nuclear Radiation Division (NRD) provides a comprehensive program designed to provide information and assistance to individual citizens, organizations, and local government agencies in communities in the environs of the NTS. During 1988 activities included: participation in public hearings; "town hall" meetings; a school radiation science program; continued support of Community Monitoring Stations; and a variety of tours, lectures, and presentations.

Public Hearings

A workshop on monitoring radioactivity in the environment was held by the Congressional Office of Technology Assessment in Las Vegas, Nevada, on September 25 and 26, 1988. Presentations were given by two NRD staff members. They described the criteria that must be met prior to testing a nuclear device as well as the extensive monitoring, surveillance, and analytical activities carried out by the EMSL-LV to ensure that any accidental releases of radioactivity from the NTS will be detected and reported.

Town Hall Meetings

The "town hall" meetings, which have been conducted since 1982, were continued in 1988. These meetings provide an opportunity for attendees 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 taken during any test are described, the monitoring and surveillance networks are explained, and for meetings in Nevada the proposed High Level Waste Repository at Yucca Mountain discussed. During 1988, meetings were held in the communities listed below. Attendance varied from 4 to 35 with an average of 15 participants per meeting.

Town Hall Meetings

February 16	Enterprise, UT
February 17	Milford, UT
March 22	Lee Vining CA
March 23	Furnace Creek CA
May 18	Delta UT
May 19	Beaver Dam AZ
June 22	Tropic UT
June 23	Escalante UT
September 21	Gabbs NV
September 22	Fish Lake / Dyer NV
November 15	Laughlin NV
November 16	Needles CA

Animal Investigations

One of the public service functions of the EMSL-LV is to investigate claims of injury allegedly due to radiation originating from NTS activities. A veterinarian, qualified by education and experience in the field of radiobiology, investigates problems with domestic animals and wildlife to determine whether or not radiation exposure may be involved.

No animal investigations were requested during 1988.

NTS Tours

To complement the "town-hall" meetings and to familiarize Nevada citizens with both the DOE testing program at the NTS and the Environmental Monitoring Program conducted by the EPA, tours are arranged for business and community leaders from towns in the environs of the NTS, as well as for government employees and the news media. Between January and December 1988, the following tours were sponsored by the EPA:

Employees of Gold Bar Mine, Scotty's Castle and Beatty Residents	February 24
Teachers, Round Mountain, NV	April 4-5
Public Officials and Residents of Kingman, AZ	May 9-10
Attendees, 34th Annual Conference on Bioassay, Analytical and Environmental Radiochemistry	October 21

School Science Program

The Introduction to Radiation Science Program was conceived by the NRD staff in 1986, to provide a service to schools in communities in the environs of the NTS. The aim of this program being to supplement school program with an activity involving the interaction between students, teachers and NRD personnel. Following the reactor accident at Chernobyl, USSR, in April 1986, the need for such a program became obvious as indicated by recurring indications of misunderstanding of ionizing radiation by both the media and the public. In response, the NRD staff developed a program designed to help students better understand radiation and radioactivity and to provide them with some of the basic knowledge required to make sound decisions concerning the many societal issues arising from the use and disposal of radioactive materials.

Beginning in October 1986, and continuing through 1988, an NRD staff member has been teaching radiation concepts to students. The instructor spends from one to five days in each school. During this time he presents lecture-demonstrations and conducts laboratory exercises. During 1988, the program was presented in the schools listed below:

Virgin Valley High School, Mesquite, NV

Moapa Valley High School, Overton, NV

Amargosa School, Amargosa, NV

C.V.T. Gilbert School, Las Vegas, NV

Emergency Response

As a result of continued population growth in the off-site communities, there is an increasing need for assistance from and coordination with both state and local agencies in order to implement the protective actions that may be needed if an underground nuclear test accidentally released radioactive contaminants into the environment. Therefore, during 1988, there has been a continuing dialogue between the EMSL-LV staff and the State of Nevada's Division of Emergency Management as well as with the local and county officials responsible for emergency planning.

In a continuing effort to provide and improve personal dosimetry to citizens living in communities in the environs of the Nevada Test Site, plans were developed in 1988 to replace film badge caches with thermoluminescent dosimeters. Three thousand TLDs were received and calibrated during 1988 and are awaiting distribution to communities in California, Nevada, and Utah. The dosimeters will be issued by county or state personnel in the unlikely event of a significant release of radioactive materials from the NTS.

Community Monitoring Stations

Beginning in 1981 DOE and EPA established a network of Community Monitoring Stations in the off-site areas in order to increase public awareness of radiation monitoring activities. The DOE, through an interagency agreement with EPA, sponsors the program and contracts with the Desert Research Institute (DRI) to manage the stations, and the University of Utah to train station managers. Each station is operated by a local resident, in most cases a science teacher, who is trained in radiation monitoring methods by the University of Utah. These stations continued to be maintained by the NRD personnel during 1988. Samples were collected and analyzed at the EMSL-LV. The DRI provides data interpretation to the communities involved and pays the station operators for their services.

During 1988, new stations were installed at Caliente, NV, and at Milford and Delta, Utah. Each of the 18 stations contains one of the samplers for the ASN, NGTSN and Dosimetry networks discussed earlier, plus a pressurized ion chamber (PIC) and recorder for immediate readout of external gamma exposure, and a recording barograph. The new stations at Milford and Delta are complete except for noble gas samplers, which will be added when the equipment becomes available. All of the equipment is mounted on a stand at a prominent location in each community so the residents are aware of the surveillance and, if interested, can have ready access to the data. The data from these stations are included in the tables in Section 5 with the other data from the appropriate networks. Table 15 contains a summary of the PIC data.

New computer generated reports for each station were developed. These reports, issued weekly, indicate the current weekly PIC average, the previous week and previous year averages, and show the maximum and minimum backgrounds in the U.S. In addition to being posted at each station, copies are sent to newspapers in Nevada and Utah and provided to appropriate federal and state personnel in California, Nevada and Utah.

Installation of the satellite telemetry equipment, initiated on an experimental basis at three stations during 1987, was completed in 1988. All of the community monitoring stations are equipped with transmitting equipment and the telemetry system is fully operational. With this equipment, gamma exposure measurements acquired by the pressurized ion chambers can be transmitted via satellite directly to the NTS and from there to the EMSL-LV by telephone line.

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7.0 Quality Assurance and Procedures

K. S. Moroney and C. A. Fontana

Policy

One of the major goals of the Agency is to ensure that all EPA decisions which are dependent on environmental data are supported by data of known quality. Consequently, agency policy requires that all EPA laboratories participate in a centrally managed and locally implemented Quality Assurance (QA) Program.

EMSL-LV's QA policies and requirements are summarized in EPA/600/X-87/241, Quality Assurance Program Plan (EPA87), and are fully adhered to by the Nuclear Radiation Assessment Division (NRD).

Standard Operating Procedures

Elements of the QA program include local Standard Operating Procedures (SOPs) which define methods of sample collection, handling, sample control, analysis, data validation, trending and reporting. These SOPs support the goal of the QA program in maintaining the quality of results within established limits of acceptance.

Data Quality Objectives

In addition, the EPA as an Agency requires all projects involving environmentally related measurements to develop data quality objectives (DQOs). DQOs must clearly define the level of uncertainty that a decision maker is willing to accept in results derived from environmental data. DQOs contain quantitative statements relating to the decision to be made, how environmental measurements will be used, time and resource constraints on data collection, descriptions of the data or measurements to be made, specifications of which portions of the physical systems from which samples will be collected, and the calculations that will be performed on the data in order to arrive at a result.

Data Validation

An essential element of QA is the validation of data. Four categories of data validation methods are employed by NRD: procedures which are applied routinely to ensure adherence of acceptable analytical methods, those that ensure that completeness of data is attained, those which are used to test the internal comparability within a given data set, and procedures for comparing data sets with historical data and other data sets.

Completeness is the amount of data successfully collected with respect to that amount intended in the design, and comparability refers to the degree of similarity of data from different sources included in a single data set. All data is reviewed by supervisory personnel to ensure that sufficient data have been collected and the conclusions are based upon valid data. Completeness is an important part of quality, since missing data may reduce the precision of estimates, introduce bias, and thus lower the level of confidence in the conclusions.

Quality Control

The quality control (QC) portion of the NRD QA program consists of routine use of methods and procedures designed to achieve and maintain the specified level of quality for the given measurement system. Accuracy of analysis is achieved through the regular determination of bias and precision of the results.

Bias is defined as the difference between the data set mean value (or sample average for statistical purposes) and the true or reference value (EPA87). The NRD laboratory participates in EPA, DOE/Environmental Measurements Laboratory (EML), and World Health Organization (WHO) laboratory intercomparison crosscheck studies. The results of the EPA intercomparison study are discussed later in this section. Blank samples and samples "spiked" with known quantities of radionuclides are also routinely run. Internal "blind spiked" samples, (that is, samples spiked with known amounts of radionuclides but unknown to the analyst) are also entered into the normal chain of analysis.

Precision is the degree of mutual agreement among individual measurements made under prescribed conditions (EPA87). As a minimum, 10 percent of all samples are collected and analyzed in duplicate, and results compared.

In addition, instruments are calibrated with standards directly or indirectly traceable to National Institute for Standards and Technology (NIST; formerly National Bureau of Standards) or NIST-approved EPA generated sources, performance checks are routinely accomplished, control charts of background and check source data are maintained, and preventive maintenance on equipment is scheduled and performed.

Health Physics Oversight

All analytical results receive a final review by the health physics staff of the Dose Assessment Branch for completeness and comparability. Trends of increasing or decreasing amounts of radionuclides in the environment are identified, and potential risks to humans and the environment are determined based on the data.

Precision of Analysis

The duplicate sampling program was initiated for the purpose of routinely assessing the errors due to sampling, analysis, and counting of samples obtained from the surveillance networks maintained by the EMSL-LV.

The program consists of the analysis of duplicate or replicate samples from the ASN, the NGTSN, the MSN, and LTHMP, and the Dosimetry Network. As the radioactivity concentration in samples collected from the LTHMP and the MSN are usually below detection levels, most duplicate samples for these networks are prepared from spiked solutions. The noble gas samples are generally split for analysis, and duplicate samples are collected in the ASN. Since two TLD cards consisting of three TLD phosphors each are used at each station of the Dosimetry Network, no additional samples were necessary.

At least 30 duplicate samples from each network are normally collected and analyzed over the report period. Since duplicate samples were collected for all other sample types, the variances, s^2, for these types were calculated from $s^2 = (0.886R)^2$ where R is the range of the results. For small sample sizes, this estimate of the variance is statistically efficient (SNE67) and certainly more convenient to calculate than the standard expression. The standard deviation is obtained by taking the square root of the variance. Table 19 summarizes the sampling information for each surveillance network.

TABLE 19. Samples and analyses for Duplicate Sampling Program - 1988

Surveillance Network	Number of Sampling Locations	Samples Collected This Year	Sets of Duplicate Samples Collected	Number Per Set	Sample Analysis
ASN	109	9,807	745	2	Gross beta, γ Spectrometry
NGTSN	18	710(^{85}Kr) 734(^{133}Xe)	54	2	^{85}Kr, ^{3}H, H_20, HTO, ^{133}Xe
Dosimetry	156	542	542	4-6	Effective dose from gamma
MSN	29	380	150	2	^{40}K, ^{89}Sr, ^{90}Sr, ^{3}H
LTHMP	193	746	416	2	^{3}H

The variance, s^2, of each set of replicate results was estimated by the standard expression,

$$s^2 = \sum_{i=1}^{n} (x_i - \bar{x})^2 / (n-1)$$

where n = number of sets of replicates.

The principle that the variances of random samples collected from a normal population follow a chi-square distribution (χ^2) was then used to estimate the expected population standard deviation for each type of sample analysis. The expression used is a follows: (FRE62)

$$s = \sqrt{\sum_{i=1}^{k} (n_i - 1) s_i^2 / \sum_{i=1}^{k} (n_i - 1)}$$

where n_i-1 = the degrees of freedom for n_i samples collected for the ith replicate sample

s_i^2 = the expected variance of the ith replicate sample

s = the pooled estimate of sample standard deviation derived from the variance estimates of all replicate samples (the expected value of s^2 is σ^2).

For expressing the precision of measurement in common units, the coefficient of variation ($s/\bar{x}$) was calculated for each sample type. These are displayed in Table 20 for those analyses for which there were adequate data.

To estimate the precision of counting, approximately ten percent of all samples are counted a second time. These are unknown to the analyst. Since all such replicate counting gave results within the counting error, the precision data in Table 20 represents errors principally in analysis.

Accuracy of Analysis

Data from the analysis of intercomparison samples are statistically analyzed and compared to known values and values obtained from other participating laboratories. A summary of the statistical analysis is given in Table 21, which compares the mean of three replicate analyses with the known value. The normalized deviation is a measure of the accuracy of the analysis when compared to the known concentration. The determination of this parameter is explained in detail in the reference (JA81). If the value of this parameter (in multiples of standard normal deviate, unitless) lies between control limits

TABLE 20. Sampling and Analytical Precision - 1988

Surveillance Network	Analysis	Sets of Replicate Samples Evaluated	Coefficient of Variation (%)
ASN	^{7}Be	6	59
NGTSN	^{85}Kr	53	7.4
	H_2O *	90	3.8
Dosimetry	TLD	542	6.6
MSN	^{40}K	70	10
	^{90}Sr	12	11
LTHMP	^{3}H	65	18
	^{3}H+	67	24

* Measurement of Atmospheric Moisture

TABLE 21. EPA Quality Assurance Intercomparison Results - 1988

Analysis	Month	Mean of Replicate Analyses (pCi/L)	Known Value	Normalized Deviation from Known Concentration
Water Studies:				
^{3}H	June	6042	5565	1.5
	October	2575	2316	1.3
^{51}Cr	June	298.7	302.0	-0.2
	October	259.7	251.0	0.6
^{60}Co	February	69.0	69.0	0.0
	June	16.0	15.0	0.3
	October	26.3	25.0	0.5
^{65}Zn	February	97.3	94.0	0.6
	June	104.0	101.0	0.5
	October	160.0	151.0	1.0
^{89}Sr	April	4.0	5.0	-0.3
^{90}Sr	April	4.7	5.0	-0.4
^{106}Ru	February	98.0	105.0	-1.2
	June	186.3	202.0	-1.4
	October	140.0	152.0	-1.4
^{131}I	August	24.7	26.0	-0.3
	December	117.0	115.0	0.3
^{134}Cs	February	57.0	64.0	-2.4
	June	19.7	20.0	-0.1
	October	24.0	25.0	-0.3
^{137}Cs	February	92.3	94.0	-0.6
	June	25.0	25.0	0.0
	October	15.0	15.0	0.0

(continued)

TABLE 21. EPA Quality Assurance Intercomparison Results - 1988

Analysis	Month	Mean of Replicate Analyses (pCi/L)	Known Value	Normalized Deviation from Known Concentration
Milk Studies:				
^{89}Sr	June	123.7*	40.0	29.0
^{90}Sr	June	6.7*	60	-30.8
	October	50.3	60	-5.0
^{131}I	June	103.0	94.0	1.7
	October	90.7	91.0	-0.1
K	June	1189 mg/L**	1600 mg/L	-8.9
	October	1600 mg/L	1600 mg/L	1.3
Urine Studies:				
^{3}H	April	6028	6202	-0.5
	November	2861	3025	-0.8
Air Filter Studies:				
Gross Alpha	March	13.3 pCi (total)	20.0 (total)	-2.3
Gross Beta	March	25.7* pCi (total)	50.0 (total)	8.0

* Normalized deviation from the known value exceeds three sigma due to computational errors.

** Normalized deviation from the known value exceeds three sigma due to inadequate counting time.

of -3 and +3, the precision or accuracy of the analysis is within normal statistical variation. However, if the parameters exceed these limits, one must suspect that there is some other than normal statistical variation that contributed to the difference between the measured values and the known value. As shown by Table 21, all but three analyses were within the control limit, the three analyses which exceed three sigma are footnoted.

The analytical methods were further checked on by Laboratory participation in the semiannual Department of Energy Quality Assurance Program conducted by the Environmental Measurements Laboratory, New York, New York. The results from these tests (Table 22) indicate that this Laboratory's results were of acceptable quality.

TABLE 22. Quality Assurance results from DOE Program - 1988

Analysis	Month	EPA EMSL-LV Results	EML Results	Ratio EPA/EML
^{7}Be in air	March	5.09E03	4.73E03	1.08
	Sept.	2.33E03	2.16E03	1.08
^{54}Mn in air	March	3.98E02	3.63E02	1.10
	Sept.	2.08E02	1.85E02	1.12
^{57}Co in air	March	1.65E02	1.62E02	1.02
	Sept.	4.16E02	3.94E02	1.06
^{60}Co in air	March	2.96E02	2.82E02	1.05
	Sept.	3.74E02	3.74E02	1.00
^{134}Cs in air	March	3.68E02	3.81E02	0.97
	Sept.	1.96E02	1.91E02	1.03
^{137}Cs in air	March	2.38E02	2.11E02	1.13
	Sept.	7.47E02	2.45E02	3.05
^{137}Cs in soil	March	0.413E00	0.400E00	1.03
	Sept.	1.16E00	9.10E-01	1.27
^{239}Pu in soil	March	5.99E-02	0.410E-02	1.46
	Sept.	3.55E-01	3.80E-01	0.93
^{40}K in soil	Sept.	8.90E00	7.48E00	1.19
^{40}K in vegetation	March	4.05E01	3.60E01	1.13
	Sept.	1.10E01	1.05E01	1.05
^{137}Cs in air	March	2.38E02	2.11E02	1.13
	Sept.	7.47E02	2.45E02	3.05
^{137}Cs in soil	March	0.413E00	0.400E00	1.03
	Sept.	1.16E00	9.10E-01	1.27
^{239}Pu in soil	March	5.99E-02	0.410E-02	1.46
	Sept.	3.55E-01	3.80E-01	0.93
^{40}K in soil	Sept.	8.90E00	7.48E00	1.19
^{40}K in vegetation	March	4.05E01	3.60E01	1.13
	Sept.	1.10E01	1.05E01	1.05

(continued)

TABLE 22. Continued

Analysis	Month	EPA EMSL-LV Results	EML Results	Ratio EPA/EML
^{137}Cs in vegetation	March	5.18E00	4.62E00	1.12
	Sept.	1.63E00	1.52E00	1.07
^{239}Pu in vegetation	March	6.10E-02	4.50E-02	1.36
	Sept.	2.46E-02	2.10E-02	1.17
^{3}H in water	March	2.18E01	2.07E01	1.05
	Sept.	1.13E01	1.06E01	1.07
Mn in water	March	6.97E00	6.80E00	1.02
	Sept.	1.59E00	1.52E00	1.05
^{57}Co in water	March	1.85E00	2.06E00	0.90
	Sept.	3.65E00	3.36E00	1.09
^{60}Co in water	March	1.82E00	2.03E00	0.90
	Sept.	3.86E00	3.68E00	1.05
^{90}Sr in water	March	1.15E-01	5.30E-01	0.22*
	Sept.	8.79E-01	9.30E-01	0.95
^{134}Cs in water	March	3.03E00	3.56E00	0.85
	Sept.	1.08E00	9.70E-01	1.11
^{137}Cs in water	March	1.68E00	1.84E00	0.91
	Sept.	2.05E00	1.95E00	1.05
^{239}Pu in water	Sept.	5.39E-03	5.40E-03	1.00

* Low result was caused by an arithmetic error.Our corrected result is 0.607 pCi/mL and the ratio of reported to EML is 1.15.

To measure the performance of the contractor laboratory that analyzed the animal tissues, a known amount of activity was added to several sets of bone ash samples. The reported activity is compared to the known amount in Table 23 together with the calculated bias and precision. The average bias for ^{239}Pu was -16 percent and the average bias for ^{90}Sr was -22. The average precision determined from three sets of duplicate ash samples was 79 percent for ^{239}Pu and 17 percent for ^{90}Sr at background levels but was 5.4 percent and 0.4 percent, respectively, for a duplicate spiked sample.

TABLE 23. Quality Assurance results for the Bioenvironmental Program - 1988

Sample ID and Shipment Number	Nuclide	Activity Added pCi/g Bone Ash	Activity Reported pCi/g Bone Ash	%Bias* or Precision**
Bone Ash				
Ash A 75	^{239}Pu	0.0822	0.065 ± 0.013	-23*
	^{90}Sr	11.08	11.3 ± 0.3	-22*
Ash B 75	^{239}Pu	0.0765	0.095 ± 0.021	+20*
	^{90}Sr	10.31	11.7 ± 0.3	-13*
Ash C 75	^{239}Pu	0	-0.002 ± 0.003	
	^{90}Sr	0	2.9 ± 0.13	
Ash D 75	^{239}Pu	0	-0.002 ± 0.004	0.0**
	^{90}Sr	0	2.9 ± 0.12	0.0**
Ash-1 76	^{239}Pu	0	0.009 ± 0.003	
	^{90}Sr	0	2.7 ± 0.11	
Ash-2 76	^{239}Pu	0	0.001 ± 0.0015	141**
	^{90}Sr	0	2.9 ± 0.11	0.06**
Ash-3 76	^{239}Pu	0.03245	0.014 ± 0.007	-61.0*
	^{90}Sr	8.60	9.5 ± 0.2	-21.0*
Ash-4 76	^{239}Pu	0.0325	0.035 ± 0.007	-3.4*
	^{90}Sr	8.63	9.6 ± 0.2	-20.0*
Ash A 77	^{239}Pu	0.0778	0.063 ± 0.009	-21.0*
	^{90}Sr	10.3	9.9 ± 0.3	-30.0*
Ash B 77	^{239}Pu	0.0778	0.067 ± 0.001	-16.0*
	^{90}Sr	11.9	11.5 ± 0.3	-26.0*

(continued)

TABLE 23. Continued

Sample ID and Shipment Number	Nuclide	Activity Added pCi/g Bone Ash	Activity Reported pCi/g Bone Ash	%Bias* or Precision**
Ash C	^{239}Pu	0	0.002 ± 0.0015	
77	^{90}Sr	0	2.4 ± 0.14	
Ash D	^{239}Pu	0	0.0006 ± 0.0015	0.95**
77	^{90}Sr	0	2.4 ± 0.15	0.0**

* Bias (B) = Recovery -1; where recovery is x_1/u
and x_1 = net activity reported
u = activity added

$$\text{** Precision } (C_v) = 2\left(\frac{x_1 - x_2}{x_1 + x_2}\right) \times \left(\frac{1}{1.128}\right)$$

where x_1 = first value
x_2 = second value

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8.0 Dose Assessment

S. C. Black

Estimated Dose from NTS Activities

The estimate of dose equivalent due to NTS activities is based on the total release of radioactivity from the site as listed in Table 2. Since no significant radioactivity of recent NTS origin was detectable off site by the various monitoring networks, no significant exposure to the population living around the NTS would be expected. To confirm this expectation, a calculation of estimated dose was performed using EPA's AIRDOS/RADRISK program. The individuals exposed were considered to be all of those living within a radius of 80 km of CP-1 on the NTS, a total of 8,000 individuals. The individual with the maximum exposure from airborne NTS radioactivity would have been living at Medlin's Ranch which is NNE from the NTS. That maximum dose was 0.01 μrem (1 x 10^{-4} μSv). The population dose within 80 km would have been 47 pers-μrem (4.7 x 10^{-7} person-Sv).

During calendar year 1988 there were four sources for possible radiation exposure to the population of Nevada, all of which produced negligible exposures. The four sources were:

- **Operational releases of radioactivity from the NTS, including that from drillback and purging activities;**
- **Radioactivity in migratory animals that was accumulated during residence on the NTS;**
- **World-wide distributions such as ^{90}Sr in milk, ^{85}Kr in air, etc.; and**
- **Background radiation due to natural sources such as cosmic radiation, natural radioactivity in soil, and ^{7}Be in air.**

The estimated dose equivalent exposures from these sources to people living near the NTS are calculated separately in the following subsections.

Estimated Dose from Worldwide Fallout

From the monitoring networks described in previous sections of this report, the following concentrations of radioactivity were found:

Tritium (0.25 pCi/m^3 of air [9 mBq/m^3])
^{85}Kr (26 pCi/m^3 of air [0.9 Bq/m^3])
^{90}Sr (1.5 pCi/L in milk [55 mBq/L])
^{137}Cs (15 pCi/kg beef muscle [0.6 Bq/kg])
^{239}Pu (140 fCi/kg beef liver [5.2 fBq/kg])

The dose is estimated from these findings by using the assumptions and dose conversion factors as follows:

Adult breathing rate is 8400 m^3/yr,
Milk intake (10-yr old) is 160 L/yr,
Liver consumption is 0.5 lb/week = 11.8 kg/yr,
Meat consumption 248 g/day, when liver consumption is subtracted this is 78.7 kg/yr.

The dose conversion factors are based on the ALI divided by 5000 to convert to becquerels/mrem, then converted to mrem/pCi:

^{3}H (6.2 x 10^{-8} mrem/pCi)
^{90}Sr (1.8 x 10^{-4} mrem/pCi)
^{137}Cs (4.5 x 10^{-5} mrem/pCi)
^{239}Pu (9 x 10^{-4} mrem/pCi)
^{85}Kr (1.6 x 10^{-4} mrem/yr per pCi/m^3)
^{133}Xe (2 x 10^{-4} mrem/yr per pCi/m^3)

As an example calculation, the following is the result for tritium:

0.25 pCi/m^3 x 8400 m^3/yr x 6.2 x 10^{-8} mrem/pCi x 10^3 μrem/mrem = 0.13 μrem

Also:

^{90}Sr (1.5 x 160 x 1.8 x 10^{-4} x 10^3 = 43 μrem)
^{137}Cs (15 x 78.7 x 4.5 x 10^{-5} x 10^3 = 53 μrem)
^{239}Pu (0.14 pCi/kg x 11.8 kg x 9 x 10^{-4}mrem/pCi x 10^3 = 1.5 μrem)
^{85}Kr (26 x 1.6 x 10^{-3} = 4.2 μrem)

Therefore, exposure to worldwide fallout causes dose equivalent equal to the sum of the above or 266 μrem or 0.266 mrem.

Estimated Dose from Radioactivity in NTS Deer

The highest measured concentrations of radionuclides in mule deer tissues occurred in deer collected on the NTS. The average values were:

Tissue	^{3}H	^{137}Cs	^{239}Pu
Liver (pCi/kg)	2×10^{7}	47	0.094
Muscle (pCi/kg)	2×10^{7}	70	0.21

In the unlikely event that one such deer was collected by a hunter in off-site areas, his intake could be calculated. Assuming 3 pounds of liver and 100 pounds of meat and the radionuclide concentrations listed above, the dose equivalents could be:

Liver: $1.36 \text{ kg} \times [(2 \times 10^{7} \times 6.2 \times 10^{-8}) + (47 \times 4.5 \times 10^{-5}) + (0.094 \times 9 \times 10^{-4})]$
= 1.7 mrem

Muscle: $78.7 \text{ kg} \times [(2 \times 10^{7} \times 6.2 \times 10^{-8}) + (70 \times 4.5 \times 10^{-5}) + (0.21 \times 9 \times 10^{-4})]$
= 97.8 mrem

Thus, approximately 100 mrem would be delivered to one individual consuming the stated quantity of meat and assuming no radioactivity was lost in food preparation. About 99.85 percent of this dose equivalent is caused by the tritium content of the meat.

Dose from Background Radiation

In addition to external radiation exposure due to cosmic rays and that due to the gamma radiation from naturally occurring radionuclides in soil (^{40}K, uranium and thorium daughters, etc.), 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 our air surveillance network was 0.5 pCi/m^{3}. With a dose conversion factor for inhalation of 2.6×10^{-7} mrem/pCi, this equates to 1.1 μrem, a negligible quantity when compared with the PIC measurements that vary from 56 to 172 mrem, depending on location.

Summary

For an individual with the highest exposure to NTS effluent, that is someone living at the Medlin's Ranch, the NTS exposure, plus that due to world-wide fallout plus background would add to: $(1 \times 10^{-5} + 0.1 + 138)$mrem = 138 mrem (1.4 mSv). Both the NTS and worldwide distributions contribute a negligible amount of exposure compared to natural background. If that same individual used the NTS deer meat without sharing it with someone else, the exposure would increase to 138 + 100 = 238 mrem (2.38 mSv).

9.0 Sample Analysis Procedures

Analytical procedures

The procedures for analyzing samples collected for offsite surveillance are described by Johns et al. (EMSL79) and are summarized in Table 24.

Table 24. Summary of Analytical Procedures

Type of Analysis	Analytical Equipment	Counting Period (min)	Analytical Procedures	Sample Size	Approximate Detection Limit*
IG Ge(Li) Gamma Spectrometry**	IG or GE(Li) 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 min; air filter composites, 1200 min. 100 min for milk, water, suspended solids.	Radionuclide concentration quantified from gamma spectral data by on-line computer program. Radionuclides in air filter composite samples are identified only.	120-370 m^3 for air filters; and charcoal cartridges; 3-1/2 liters for milk and water:	For routine milk and water generally, 5 pCi/L for most common fallout radionuclides in a simple spectrum. Filters for LTHMP suspended solids, 6 pCi/L. Air filters and char- coal cartridges, 0.04 pCi/m^3.
Gross beta on air filters	Low-level end window, gas flow proportional counter with a 12.7 cm diameter window (80 μg/cm^2).	30	Samples are counted after decay of naturally occurring radionuclides and, if necessary, extrapolated to midpoint of collection in accordance with $t^{-1.2}$ decay or an experimentally derived decay.	120-370 m^3	0.5 pCi/sample.
^{89}Sr, ^{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 liter for milk or water. 0.1 to 1 kg for tissue.	^{89}Sr = 5 pCi/L ^{90}Sr = 2 pCi/L

(continued)

Table 24. (Continued)					
Type of Analysis	**Analytical Equipment**	**Counting Period (min)**	**Analytical Procedures**	**Sample Size**	**Approximate Detection Limit***
^{3}H	Automatic liquid scintillation counter with output printer.	300	Sample prepared by distillation.	4 ml for water.	400 pCi/L
^{3}H Enrichment (Long Term Hydrological Samples)	Automatic scintillation counter with output printer.	300	Sample concentrated by electrolysis followed by distillation.	250 ml for water.	10 pCi/L
^{238}Pu, ^{239}Pu	Alpha spectrometer with silicon surface barrier detectors operated in vacuum chambers.	1000 - 4000	Water sample or acid-digested filter or tissue samples separated by ion exchange, electroplated on stainless steel planchet.	1.0 liter for water; 0.1 to 1 kg for tissue; 5000 to 10,000 m^3 for air.	^{238}Pu = 0.08 pCi/L ^{239}Pu = 0.04 pCi/L for water. For tissue samples, 0.04 pCi per total sample for all isotopes; 5 to 10 aCi/m^3 for plutonium on air filters.
^{85}Kr, ^{133}Xe, ^{135}Xe	Automatic liquid scintillation counter with output printer	200	Separation by gas chromatography; dissolved in toluene "cock-tail" for counting.	0.4 to 1.0 m^3 for air.	^{85}Kr, ^{133}Xe, ^{135}Xe = 4 pCi/m^3

* The detection limit is defined as 3.29 sigma, where sigma equals the counting error of the sample and Type I error = Type II error = 5 percent (DOE81).

** Gamma Spectrometry using either an intrinsic germanium (IG), or lithium-drifted germanium diode (Ge(Li)) detector.

10.0 Radiation Protection Standards for External and Internal Exposure

Dose Equivalent Commitment

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

	Effective Dose Equivalent*	
	mrem/yr	mSv/yr
Occasional annual exposures**	500	5
Prolonged period of exposure	100	1

***Includes both effective dose equivalent from external radiation and committed effective dose equivalent from ingested and inhaled radionuclides.**

****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 (ICRP83).**

Concentration Guides

ICRP-30 (ICRP79) lists Derived Air Concentrations (DAC) and Annual Limits of 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 25 were derived in this manner and yield the committed effective dose equivalent (50 year) of 100 mrem/yr for members of the public.

EPA Drinking Water Guide

In 40 CFR 141 (CFR88) the EPA set allowable concentrations for continuous controlled releases of radionuclides to drinking water sources. Any single or combination of beta and gamma emitters should not lead to exposures exceeding 4 mrem/yr. For tritium this is 20,000 pCi/L (740 Bq/L) and for ^{90}Sr is 8 pCi/L (0.3 Bq/L).

TABLE 25. Routine Monitoring Frequency, sample size, MDC and concentration guides

Nuclide	Sampling Frequency	Locations	Sample Size	Count Time	Concentrations Guide*		MDC	MDC % CG
Air Surveillance Network			m^3	Minutes	Bq/m^3	nCi/m^3	mBq/m^3	
^{7}Be	3/wk	all	160-240	30	1700	47	17	1E-3
^{95}Zr	3/wk	all	160-240	30	12	0.3	4.1	4E-2
^{95}Nb	3/wk	all	160-240	30	110	3	1.8	2E-3
^{99}Mo	3/wk	all	160-240	30	110	3	1.5	2E-3
^{103}Ru	3/wk	all	160-240	30	58	1.5	1.8	3E-3
^{131}I	3/wk	all	160-240	30	4	0.1	1.8	4E-2
^{132}Te	3/wk	all	160-240	30	17	0.5	1.8	1E-2
^{137}Cs	3/wk	all	160-240	30	12	0.3	1.8	2E-2
^{140}Ba	3/wk	all	160-240	30	120	3	4.8	4E-3
^{140}La	3/wk	all	160-240	30	120	3	2.6	2E-3
^{141}Ce	3/wk	all	160-240	30	52	1.4	3.0	6E-3
^{144}Ce	3/wk	all	160-240	30	1.2	0.03	12	1.0
^{239}Pu	3/wk	all	1120	1000	5E-4	1E-5	1.48E-3	0.32

(continued)

TABLE 25. (Continued)

Nuclide	Sampling Frequency	Locations	Sample Size	Count Time	Concentrations Guide*		MDC	MDC % CG
Noble Gas & Tritium in Air			m^3	Minutes	Bq/m^3	nCi/m^3	mBq/m^3	
Gross Beta	3/wk	all	160-240	30	2E-2	5E-4	0.11	6E-1
^{3}H	1/wk	17	5	150	46E2	125	148	3E-3
^{85}Kr	1/wk	17	0.4	200	22E3	620	148	6E-4
^{133}Xe	1/wk	17	0.4	200	18E3	490	370	2E-3
^{135}Xe	1/wk	17	0.4	200	2300	62	370	2E-2
Water Surveillance Network (LTHMP)**			Liters	Minutes	Bq/L	pCi/L	Bq/L	
^{3}H	1/mo	all	1	200	740	2E4	12	1.6
$^{3}H+$	1/mo	all	0.1	200	740	2E4	0.37	5E-2
^{89}Sr	1st time	all	1	50	16	440	0.18	1.1
^{90}Sr	1st time	all	1	50	0.8	22	0.074	9.2
^{137}Cs	1/mo	all	1	100	3.3	88	0.33	10
^{226}Ra	1st time	all	1	1000	1.4	39	NA	
^{234}Ru	1st time	all	1	1000	8.2	220	NA	

(continued)

TABLE 25. ROUTINE MONITORING FREQUENCY, SAMPLE SIZE, MDC AND CONCENTRATION GUIDES

Nuclide	Sampling Frequency	Locations	Sample Size	Count Time	Concentrations Guide*		MDC	MDC % CG
Water Surveillance Network (LTHMP)			Liters	Minutes	Bq/L	pCi/L	Bq/L	
^{235}U	1st time	all	1	1000	10	280	NA	
^{238}U	1st time	all	1	1000	10	280	NA	
^{238}Pu	1st time	all	1	1000	6.2	170	0.003	0.05
^{239}Pu	1st time	all	1	1000	4.1	110	0.002	0.05
Gamma	1/mo	all	3.5	30	--	--	0.18	< 0.2
Milk Surveillance Network								
^{3}H	1/mo	all	3.5	200	12E4	3E6	12	0.01
^{131}I	1/mo	all	3.5	100	41	1E3	0.18	0.44
^{137}Cs	1/mo	all	3.5	100	160	4E3	0.33	0.2
^{89}Sr	1/mo	all	3.5	50	820	2E4	0.18	0.02
^{90}Sr	1/mo	all	3.5	50	40	1E3	0.074	0.18
Gamma	1/mo	all	3.5	50	--	--	0.18	< 0.2

(continued)

TABLE 25. ROUTINE MONITORING FREQUENCY, SAMPLE SIZE, MDC AND CONCENTRATION GUIDES

Nuclide	Sampling Frequency	Locations	Sample Size	Count Time	Concentrations Guide*	MDC	MDC % CG
Dosimetry Network			Number		Exposure Guide	MDA	
TLD (Personnel)	1/mo	61	1	--	100mR	2mR	2
TLD (Station)	1/qtr	154	6	--	--	2mR	--
PIC	weekly	28	2016	--	--	2μR/hr	--

NA - Not Available

* 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).

** For tritium, Sr and Cs the concentration guide is based on Drinking Water Regs. (4 mrem/yr).

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11.0 References

BEIR80 The Effects on Populations of Exposure to Low Levels of Ionizing Radiation: 1980, Committee on the Biological Effects of Ionizing Radiations. (Available from National Academy Press, 2101 Constitution Ave, N.W., Washington, DC 20418.)

BE73 Bernhardt, D. E., A. A. Moghissi and J. A. Cochran, 1973, Atmospheric Concentrations of Fission Product Noble Gases, pp. 4-19, in Noble Gases, CONF-730915.

CA85 California, 1985, personal communication from California county agents.

CFR88 Title 40 Code of Federal Regulations Section - 141, Drinking Water Regulations, Federal Register, Volume 41, 1988.

DOC86 1986 Population and 1985 Per Capita Income Estimates for Counties and Incorporated Places, U.S. Department of Commerce, Bureau of the Census, Publication P-26.

DOE81 J. P. Corley, D. H. Denham, R. E. Jaquish, D. E. Michels, A. R. Olsen, D. A. Waite, A Guide for Environmental Radiological Surveillance at U.S. Dept of Energy Installations, July 1981, Office of Operational Safety Report, DOE/EP-0023, U.S. DOE, Washington, D.C.

DOE85 U.S. Department of Energy, 1985, Environmental Protection, Safety, and Health Protection Information Reporting Requirements. Order DOE 5484.1, November 6, 1987.

DOE89 U.S. Department of Energy, 1989, personal communication from Health Physics Division, DOE/NV, Las Vegas, NV.

DOE88 U.S. Department of Energy, 1988, General Environmental Protection Program, DOE Order 5400.1, November 9, 1988.

EMSL79 "Radiochemical and Analytical Procedures for Analysis of Environmental Samples" (EMSL-LV-0539-17-1979).

EPA80 U.S. Environmental Protection Agency, 1980, Upgrading Environmental Radiation Data, Health Physics Society Committee Report HPSR-1, EPA 520/1-80-012, U.S. Environmental Protection Agency, Washington, DC.

EPA84 U.S. Environmental Protection Agency, 1984, Donald D. Smith and J. S. Coogan, Population Distribution Around the Nevada Test Site, EPA-600/4-84-067, DOE/DP/00539-053, U.S. Environmental Protection Agency, Washington, D.C.

EPA87 U.S. Environmental Protection Agency, 1987, Quality Assurance Program Plan, EPA/600/X-87/241, EMSL-LV, P.O. Box 93478, Las Vegas, NV 89193-3478.

EPA88 Environmental Radiation Data, Draft Report 55, U.S. EPA, Office of Radiation Programs Eastern Environmental Radiation Facility, Montgomery Alabama, 1988.

EPA89 EPA Journal, United States Environmental Protection Agency, Office of Public Affairs (A-107), Washington, D.C. 20460.

ERDA77 U.S. Energy Research and Development Administration, 1977, "Final Environmental Impact Statement, Nye County, Nevada." Nevada Operations Office, Las Vegas, NV, Report ERDA-1551. (Available from U.S. Department of Commerce, NTIS, Springfield, VA 22161.)

FRE62 Freund, J. E. Mathematical Statistics. Prentice Hall, Englewood, New Jersey, 1962, pp. 189-235.

HO75 Houghton, J. G., C. M. Sakamoto, and R. O. Gifford, 1975, "Nevada Weather and Climate." Special Publication 2. Nevada Bureau of Mines and Geology, Mackay School of Mines, University of Nevada, Reno, Nevada. pp. 69-74.

ICRP79 International Commission in Radiological Protection, Limits for Intake of Radionuclides by Workers, ICRP-30, 3 parts, 1979.

ICRP83 Annual Limits on Intakes (ALI) and Derived Air Concentrations (DAC) for Members of the Public, ICRP-39, 1983.

JA81 Jarvis, A. N. and L. Siu, 1981, Environmental Radioactivity Laboratory Intercomparison Studies Program - FY 1981-82, EPA-600/4-81-004, U.S. EPA, Environmental Monitoring Systems Laboratory, Las Vegas, Nevada.

NEL75 Nelson, Loyd S. J. Qual. Tech. 7 (1), January (1975).

NPS80 National Park Service, 1980, personal communication with Chief Ranger R. Rainer, Death Valley National Monument, Death Valley, California.

NV86 Nevada Department of Agriculture, 1986, "Nevada Agricultural Statistics 1985." Nevada Crop and Livestock Reporting Service, Reno, Nevada.

QU68 Quiring, R. E., 1968, "Climatological Data, Nevada Test Site, Nuclear Rocket Development Station (NRDS)." ERLTM-ARL-7. ESSA Research Laboratories, Las Vegas, Nevada.

SNE67 Snedecor, G. W., and W. G. Cochran. Statistical Methods. The Iowa State University Press, Ames, Iowa, 6th Ed. 1967, pp. 39-47.

UT87 Utah Department of Agriculture, 1987, "Utah Agricultural Statistics, 1987." State of Utah Department of Agriculture, Salt Lake City, Utah.

WI75 Winograd, I. J. and W. Thordarson, 1975, Hydrogeologic and hydrochemical framework, south-central Great Basin, Nevada-California, with special reference to the Nevada Test Site, USGS Professional Paper 712-C, Denver, Colorado.

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16. ABSTRACT

This report covers the routine radiation monitoring activities conducted by the Environmental Monitoring Systems Laboratory-Las Vegas in areas which may be affected by nuclear testing programs of the Department of Energy. This monitoring is conducted to document compliance with standards, to identify trends in environmental radiation, and to provide such information to the public. It summarizes these activities for calendar year 1988.

No radioactivity attributable to NTS activities was detectable offsite by the monitoring networks. Using recorded wind data and Pasquill stability categories, atmospheric dispersion calculations based on reported radionuclides releases yield an estimated dose of 4.7×10^{-5} person-rem to the population within 80 km of the Nevada Test Site during 1988. World-wide levels of ^{85}Kr, ^{90}Sr, ^{137}Cs, and ^{239}Pu detected by the monitoring networks would cause maximum exposure to an individual of less than 0.27mrem per year. The increase in ^{85}Kr air concentration continued at a lower rate. Cesium and strontium in milk were near their detection limits. An occasional net exposure to offsite residents has been detected by the TLD network. On investigation, the cause of such net exposures has been due to personal habits or occupational activities, not to NTS activities.

17. KEY WORDS AND DOCUMENT ANALYSIS

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