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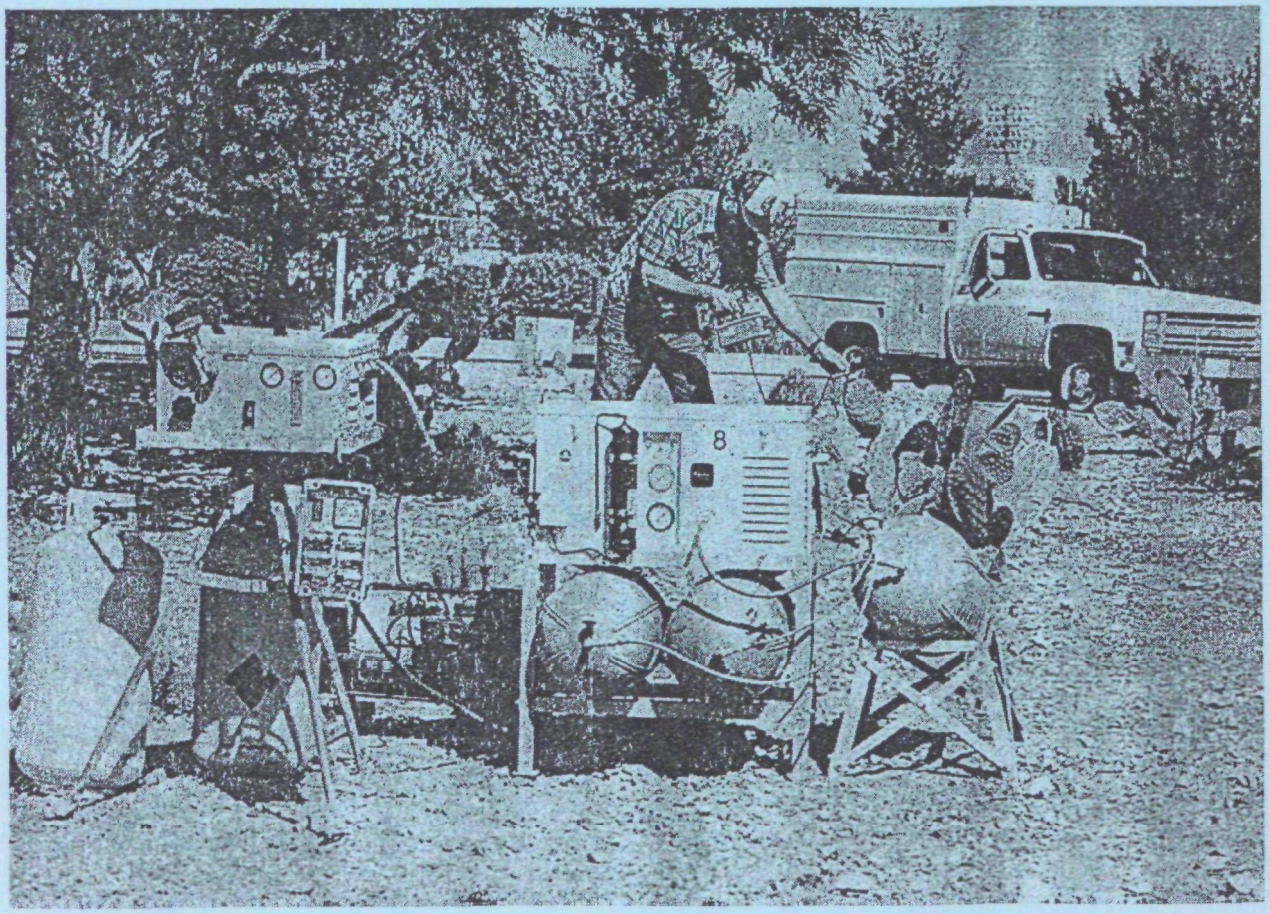
Noble Gas and Tritium-In-Air Offsite Environmental Monitoring Program Summary from 1970 - 1995



Noble Gas and Tritium-In-Air Offsite Environmental Monitoring Program Summary from 1970 - 1995

by

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NOTICE

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Abstract

This report describes the Noble Gas and Tritium-In-Air Offsite Environmental Monitoring Program conducted from 1970 - 1995 by the Environmental Protection Agency's (EPA's), Radiation and Indoor Environments National Laboratory. This laboratory operates an environmental radiation monitoring program in the region surrounding the Nevada Test Site. The surveillance program was designed to measure levels and trends of noble gas and tritium-in-air surrounding the Nevada Test Site and other areas of concern to ascertain whether current radiation levels and associated doses to the general public are in compliance with existing radiation protection standards. The surveillance program additionally has the responsibility to take action to protect the health and well-being of the public in the event of any accidental release of radioactive contaminants. Offsite levels of radiation and radioactivity were assessed in part by this program.

Comparison of the measurements and sample analysis results indicated that no significant amounts of biological radionuclides have been detected in the near offsite areas or on the NTS.

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Abbreviations, Acronyms, Units of Measure, and Conversions

ABBREVIATIONS and ACRONYMS

ALI	-- Annual Limit on Intake
CEDE	-- Committed Effective Dose Equivalent
CFR	-- Code of Federal Regulations
CG	-- Concentration Guide
CP-1	-- Control Point One
CRMP	-- Community Radiation Monitoring Program
DCG	-- Derived Concentration Guide
DOE	-- U.S. Department of Energy
EDE	-- Effective Dose Equivalent
EML	-- Environmental Monitoring Laboratory
EMSL-LV	-- Environmental Monitoring Systems Laboratory-Las Vegas
EPA	-- U.S. Environmental Protection Agency
GZ	-- Ground Zero
HTO	-- tritiated water
HpGe	-- High purity germanium
IAGs	-- Interagency Agreements
ICRP	-- International Commission on Radiological Protection
MDC	-- minimum detectable concentration
NCRP	-- National Council on Radiation Protection and Measurements
NIST	-- National Institute of Standards and Technology
NGSS	-- Noble Gas Sampling System
NGTSN	-- Noble Gas and Tritium Surveillance Network
NTS	-- Nevada Test Site
NRD	-- Nuclear Radiation Assessment Division
PHS	-- U.S. Public Health Service
PIC	-- pressurized ion chamber
QA	-- quality assurance
QC	-- quality control
S.D.	-- standard deviation
SGZ	-- Surface Ground Zero
TLD	-- thermoluminescent dosimetry
USGS	-- U.S. Geological Survey

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Noble Gas and Tritium In Air Offsite Environmental Monitoring Program Summary

Introduction

The noble gas and tritium offsite environmental monitoring program, was designed to detect noble gas and tritium emissions from the Nevada Test Site (NTS). The history of the program; topography of the NTS; population overview; predominant meteorological patterns; and program description follows.

The Nevada Test Site NTS was the primary location for nuclear explosive testing in the continental U.S. from 1951 until the present moratorium began. The U.S. Atomic Energy Commission (AEC) used the NTS from January 1951 through January 19, 1976, for conducting nuclear weapons tests, nuclear rocket-engine development, nuclear medicine studies, and other nuclear and non-nuclear experiments. Beginning January 19, 1976, these activities became the responsibility of the newly formed U.S. Energy Research and Development Administration (ERDA). On October 1, 1977 the ERDA was merged with other energy related agencies to form the U.S. Department of Energy (DOE). Atmospheric nuclear tests were conducted periodically from January 27, 1951, through October 30, 1958, after which a testing moratorium was in effect until September 1, 1961. Since September 1, 1961, all nuclear detonations were conducted underground with the expectation of containment, except for four shallow underground tests of Operation Dominic II in 1962 and five nuclear earth-cratering experiments conducted under the Plowshare program between 1962 and 1968.

Prior to 1954, an offsite surveillance program was performed by the Los Alamos Scientific Laboratory and the U.S. Army. From 1954 through 1970 the U.S. Public Health Service (PHS), and from 1970 to the present the U.S. Environmental Protection Agency (EPA) have provided an Offsite Radiological Safety Program under an Interagency Agreement.

The topography of the NTS is typical of much of the Basin and Range physiographic province of Nevada, Arizona, and Utah. Elevations range from about 910 m (3000 ft) above mean sea level (MSL) in the south and east, rising to 2230 m (7300 ft) in the areas toward the northern and western boundaries. The slopes on the upland surfaces are steep and dissected, whereas the slopes on the lower surfaces are gentle and alluvia with rock debris from adjacent highlands.

Excluding Clark County, the major population center (approximately 741,000 in 1990), the population density within a 150-km (90 mi) radius of the NTS was about 0.5 persons per square kilometer. In comparison, the 48 contiguous states (1990 census) had a population density of approximately 29 persons per square kilometer.

Precipitation levels on the NTS are low, runoff is intermittent, and the former testing areas on the NTS drain into closed basins. Annual precipitation in southern Nevada is very light

and depends largely upon elevation. A characteristic of desert climates is the temporal and spatial variability of precipitation.

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

The movements of large-scale pressure systems control the seasonal changes in the wind direction frequencies. The prevailing wind direction during the winter months is north-northeast and during the summer months is south-southeast.

As part of the program, an air surveillance monitoring program was set up. Air samples were collected and the data were analyzed to quantify the amounts, diffusion, and transport of the radionuclides released. Noble gases and tritium were of particular interest due to their ubiquitous nature and continuance in the environment. Uptakes of tritium into the body through inhalation of tritiated water in the air and through food pathways require dose assessment to establish potential internal exposure. Although noble gases and tritium were emitted from nuclear power plants, propulsion reactors, reprocessing facilities and nuclear explosions -- tritium is also produced naturally. In order to establish which proportion was NTS related and which portion originated from elsewhere, some sampling sites were chosen in close proximity to the NTS, particularly in drainage-wind channels leading from the test areas.

The xenons (124, 125, 126, 129, 130, 131m, 132, 133m, 135m) henceforth referred to as simple xenon, because of their short half-lives, decay before dispersing widely and so environmental levels were normally below the minimum detectable concentration (MDC). Krypton-85 is dispersed more or less uniformly over the entire globe because of its long half-life, 10.7 years and the lack of significant sinks. Considering the amount released, ^{85}Kr results were expected to be detectable.

1970

Beginning in 1970, EPA personnel collected one 20-minute compressed air grab sample weekly at each of the two locations on the NTS and one in Las Vegas, NV. These samples were analyzed for ^{85}Kr and the radio-xenons. During 1970, 39 announced underground nuclear tests were conducted at the Nevada Test Site (NTS) by the Atomic Energy Commission. During this same period, four production test experimental flarings of natural gas were conducted at the Rulison experimental gas well in western Colorado. One test at the NTS, Baneberry, conducted on December 18, released radioactivity into the offsite environment. At the Rulison site, ^{3}H and ^{85}Kr above background levels were detected offsite. From the results of environmental monitoring and sampling conducted by the National Environmental Research Center, Las Vegas (NERC-LV) for these nuclear events, the calculated radiation exposures to offsite populations did not exceed the Radiation Protection Standards of the AEC Manual, Chapter 0524.

The maximum level of ^{3}H in air samples collected offsite by a ground level air sampling station for Project Rulison was 290 pCi/m^3 air, which was less than 0.5% of the Concentration Guide in the AEC Manual 0524 for a suitable population sample in an uncontrolled area. No ^{3}H

levels above background were found offsite in milk, water, food crop, cow feed, human urine, and animal tissue samples collected following the flarings *(EPA, Offsite Surveillance Activities of the National Environmental Research Center, 1970)* NERC-LV-539-17.

PROJECT RULISON

The Project Rulison flaring operations during this six-month period were conducted on the dates summarized in Table 1.

Table 1. Summary of Project Rulison Flaring Operations.

Flaring Period	Start Date	End Date	Volume Gas Flared MSCF†
Preliminary Flow Tests*	8-01-70	8-22-70	1
Calibrated Tests**	10-04-70	10-07-70	12
High-Rate	10-27-70	11-03-70	109
Intermediate Rate	12-01-70	12-20-70	100

* Nine short runs up to 8 hours duration.
** Three short runs up to 14 hours duration.
† MSCF = million standard cubic feet.

Table 2 shows the total number of samples collected during this report period. Tritium and ^{85}Kr were the primary radionuclides released by the flaring operations. All environmental samples, except for the particulate air filters and charcoal cartridges, were analyzed for ^{3}H. The natural gas samples, cryogenic samples, and compressed air samples were also analyzed for ^{85}Kr.

Table 2. Project Rulison Offsite Environmental Sampling

Sample Type	Totals
Air (particulate filters)	1059
Air (charcoal cartridges)	360
Atmospheric Moisture (molecular sieve)	212
Natural Gas	14
Cryogenic (ground)	2
Compressed Air (ground)	8
Compressed Air (aerial)	21
Atmospheric Moisture (freeze-out)	30
Water	251
Precipitation	119
Milk	62
Natural Vegetation	95
Soil	102
Food Crops	95
Cow Feed	55
Urine (residents)	113
Urine (EPA monitors)	94
Animal Tissue and Blood	17

Tritium levels above normal background related to Project Rulison were detected in all types of offsite samples except water, milk, urine, animal tissue, food crops and cow feed. Particulate filters and charcoal cartridges were not analyzed for ^{3}H. The highest concentrations of tritium in offsite atmospheric moisture samples are shown in Table 3.

Krypton-85 was detected in natural gas samples and in compressed air samples. The five highest concentrations of ^{85}Kr detected offsite in compressed air samples on the ground are listed in Table 4. Background levels of ^{85}Kr in the Rulison area ranged from less than 5 pCi/m^3 to 14 pCi/m^3 of air with an average of 12 pCi/m^3.

Table 3. Five Highest ^{3}H Concentrations in Atmospheric Moisture Samples; Rulison (Molecular Sieve Collectors)*

Location - Azimuth and Distance from the Test Well	Date	Time	pCi/L H_2O ^{3}H	pCi/m^3 ^{3}H
Spec. Sta. A-IX (52°, 0.8 mi)	10/5/70	0840-1040	59,000	290
Spec. Sta. A-X (65°, 0.6 mi)	10/5/70	0835-1035	51,000	240
Spec. Sta. A-VII (15°, 0.8 mi)	10/5/70	1452-1553	43,000	220
Spec. Sta. A-X (65°, 0.6 mi)	10/5/70	1450-1550	34,000	180
Spec. Sta. A-IX 52°, 0.8 mi)	10/5/70	1455-1555	27,000	150

* Tritium concentrations in atmospheric moisture samples from the Rulison area had a background range from 500 pCi/L H_2O to 2,600 pCi/L H_2O. The average was 1000 pCi/L H_2O. The Concentration Guides (AEC Manual, Chapter 0524) for continuous exposure of the general population to ^{3}H is 67,000 pCi/m^3 air.

Table 4. Five Highest ^{85}Kr Results for Compressed Air Samples.*

Location - Azimuth and Distance from the Test Well	Sampling Period Date-Time On	Date-Time Off	^{85}K Concentration pCi/m^3 air
Old Control Point Pad (325°, 2.4 mi)	10/28/70-0645	10/28/70-0710	47
Special Station D-1 (286°, 4.6 mi)	12/06/70-0851	12/06/70-0916	27
Special Station D-11 (328°, 4.2 mi)	12/03/70-1955	12/03/70-2025	20
Special Station D-29 (76°, 16.5 mi)	10/27/70-1720	10/27/70-1750	14
3 mi S of Rifle Airport (65°, 13.0 mi)	12/07/70-1535	12/07/70-1600	12

* The Concentration Guide (AEC Manual, Chapter 0524) for the continuous exposure of the general population to ^{85}Kr was 1 x 10^5 pCi/m^3 air.

1971

In 1971 NERC-LV was requested by the Radiation Effluent Subcommittee to the NTS Planning Board, AEC-Nevada Operations Office, to establish a network to continuously monitor radioactive noble gases and atmospheric ^{3}H at ten locations on and off the NTS. The weekly grab sample collection was continued until the ten-station continuous sampling network was put into operation in April 1972.

Results of the weekly grab samples collected at the NTS demonstrated that any exposures off-site would be very low. In order to adequately monitor the impact of the small releases of noble gases on the offsite populated areas, a monitoring system capable of detecting any change in ambient levels was desired. The Technical Services Division at NERC-LV had recently completed development of a new gas analysis system capable of detecting 2 pCi/m^3 of xenon or radiokrypton in a 1-m^3 sample of air. Atmospheric krypton samples analyzed at NERC-LV and at the Eastern Environmental Research Laboratory, Montgomery, Alabama (3, 4) showed that current ambient levels of ^{85}Kr were approximately 16 ± 2 pCi/m^3. Theoretically, the normal background for ^{133}Xe and ^{135}Xe should be zero because of infrequent releases and short half-life.

The design concept, then, was to provide a sampler capable of taking advantage of the high sensitivity capability of the laboratory for xenon and to be able to detect changes in the ^{85}Kr concentration. Since the samples would be compressed air it would be necessary to have them collected at regular intervals by NERC-LV personnel to eliminate shipping problems. Logistics of sample collection from the 10,000 square mile area, plus analytical time required in the laboratory dictated a weekly collection schedule. Final design considerations were that the sample should be unfractioned air, it should be collected at a constant rate over the 1-week period, the system should be as reliable as possible, and the entire operation must be economically feasible.

1972

In 1972, under a Memorandum of Understanding No. AT(26-1)-539 with the U.S. Atomic Energy Commission (AEC), the U.S. Environmental Protection Agency (EPA), National Environmental Research Center-Las Vegas (NERC-LV), continued a program of routine and special radiological surveillance of various media in the environment surrounding the Nevada Test Site (NTS) and other sites designated by the AEC during 1972.

Nevada Test Site

The major programs conducted at the NTS were nuclear weapons development, proof-testing and weapons safety, testing for peaceful uses of nuclear explosives (Project Plowshare), nuclear rocket development (Project Rover), basic high-energy nuclear physics research, and seismic studies (Vela-Uniform).

At the Nuclear Rocket Development Station (NRDS), located in the southwest corner of the NTS, a program of testing reactors of various designs and purposes was conducted over a 13 year period. The major programs were oriented toward design feasibility and subsequent development of a nuclear rocket engine. The last tests of these engines were conducted in 1969.

No reactors were tested in 1970 and 1971. During 1972, a small reactor called the Nuclear Furnace-1 was tested seven times during May, June, and July.

In addition, underground nuclear testing was conducted at the NTS during 1972. No radioactivity was detected at ground level beyond the boundaries of the NTS following any of these nuclear events or the Nuclear Furnace-1 test series.

For each of the underground nuclear detonations and the seven experimental tests of the Nuclear Furnace-1, mobile radiation monitoring personnel equipped with radiation monitoring equipment and supplies were on standby in offsite locations to respond to any inadvertent release of radioactivity which might result in a radiological hazard to offsite populations and property.

The only radioactivity produced by nuclear tests at NTS and detected offsite was ^{133}Xe, which was observed in samples collected at stations of the Noble Gas and Tritium Sampling Network at Beatty, Diablo, and Hiko, Nevada. The levels of ^{133}Xe, which were attributed to gaseous seepage from underground tests, occurred only in a few samples. These levels, averaged over the total period sampled during the year, were less than 0.04% of the Concentration Guide of the AEC Manual, Chapter 0524, for a population sample. All other increases in radioactivity concentrations observed in media collected around the NTS were attributed to seasonal variations in old atmospheric fallout and fallout from nuclear detonations by the People's Republic of China on January 7, 1972, and March 18, 1972. Radioactive noble gases were released during the Nuclear Furnace-1 test series and detected by aircraft sampling; however, no radioactivity was detected on the ground beyond the combined areas of the Nellis Air Force Range and the NTS. Based upon the aircraft results, an estimate of the potential radiation exposure to offsite populations was determined to be less than 1% of the Radiation Protection Standards of the AEC Manual, Chapter 0524.

During the months of March and April 1972, a routine air sampling network for monitoring levels of radiokrypton, xenon, and ^{3}H in the form of HT, HTO, and $CH^{3}T$ was established for the NTS. Due to infrequent releases of radioactive gas during drill-back into the shot zone and occasional gaseous seepage from underground shot locations, the AEC Nevada Operations Office requested the NERC-LV to design, field, and operate this network at four on-NTS and six offsite locations. The locations of the offsite sampling stations were Las Vegas, Beatty, Tonopah, Diablo, and Hiko, Nevada, and Death Valley Junction, California. The offsite stations may be located by referring to Figure 1.

The equipment used in this Network was designed as two separate systems: one was a compressed air sampler, and the other was a molecular sieve sampler. The basic design of the compressed air sampler was similar to a sampler in use by Isotopes, Inc. (now Teledyne Isotopes). A schematic of the sampler is shown in Figure 2 and a photograph of a typical station is shown in Figure 3. An aquarium aerator pump draws air at 3 cm^3/sec through a glass fiber filter and pumps it into a 38-1 low pressure tank. A pressure-actuated switch activates a solenoid, starting a high-pressure compressor. The compressor pumps air from the low pressure tank and through a manifold to two 38-1 high pressure tanks, when the pressure drops to 1.5 mm Hg a second pressure-actuated switch de-activates the solenoid, stopping the compressor. Sample pressure in the high-pressure tank is about 2.8 MPA (400 psi).

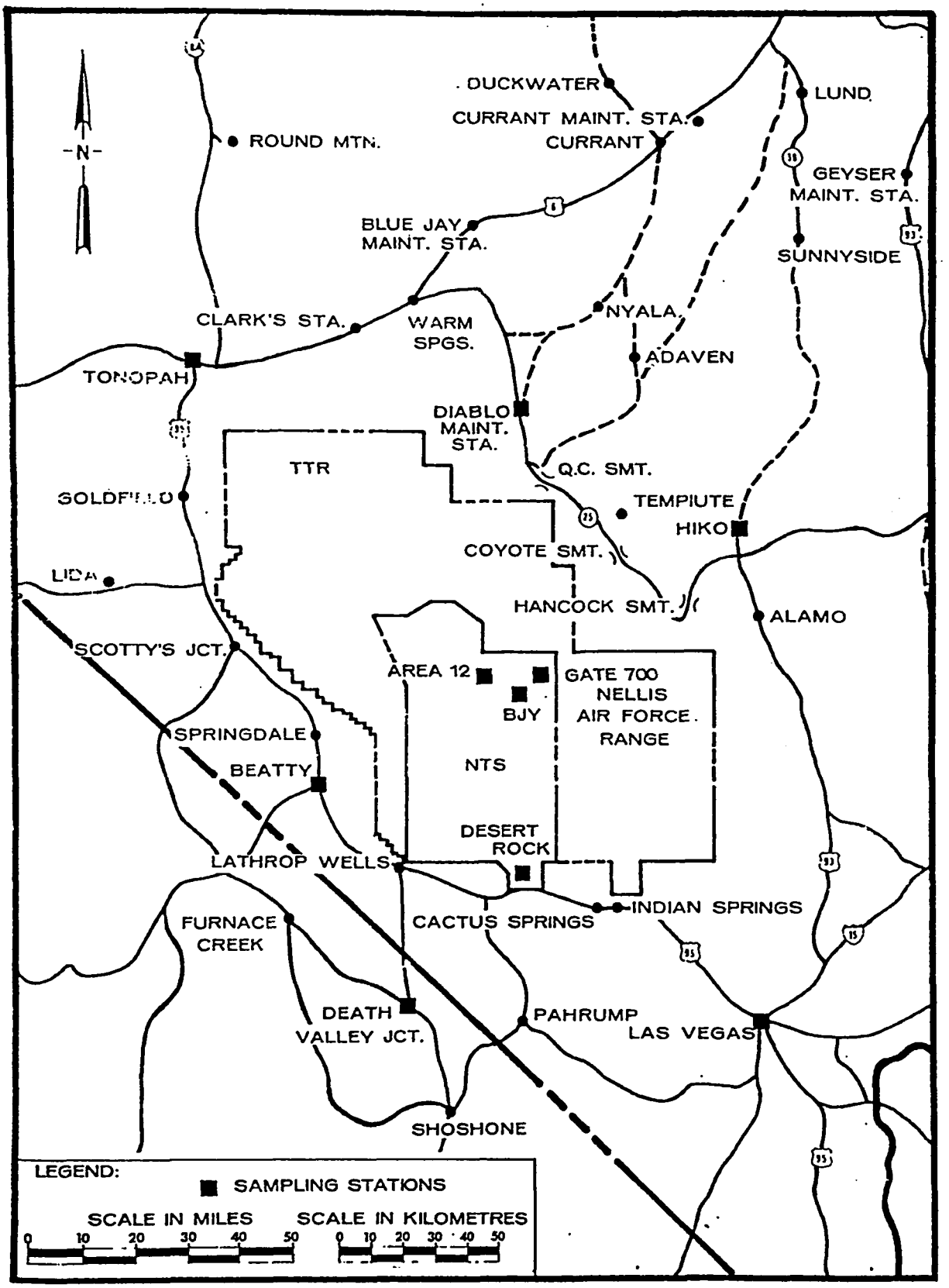

Figure 1. Noble Gas and Tritium Surveillance Network - 1972

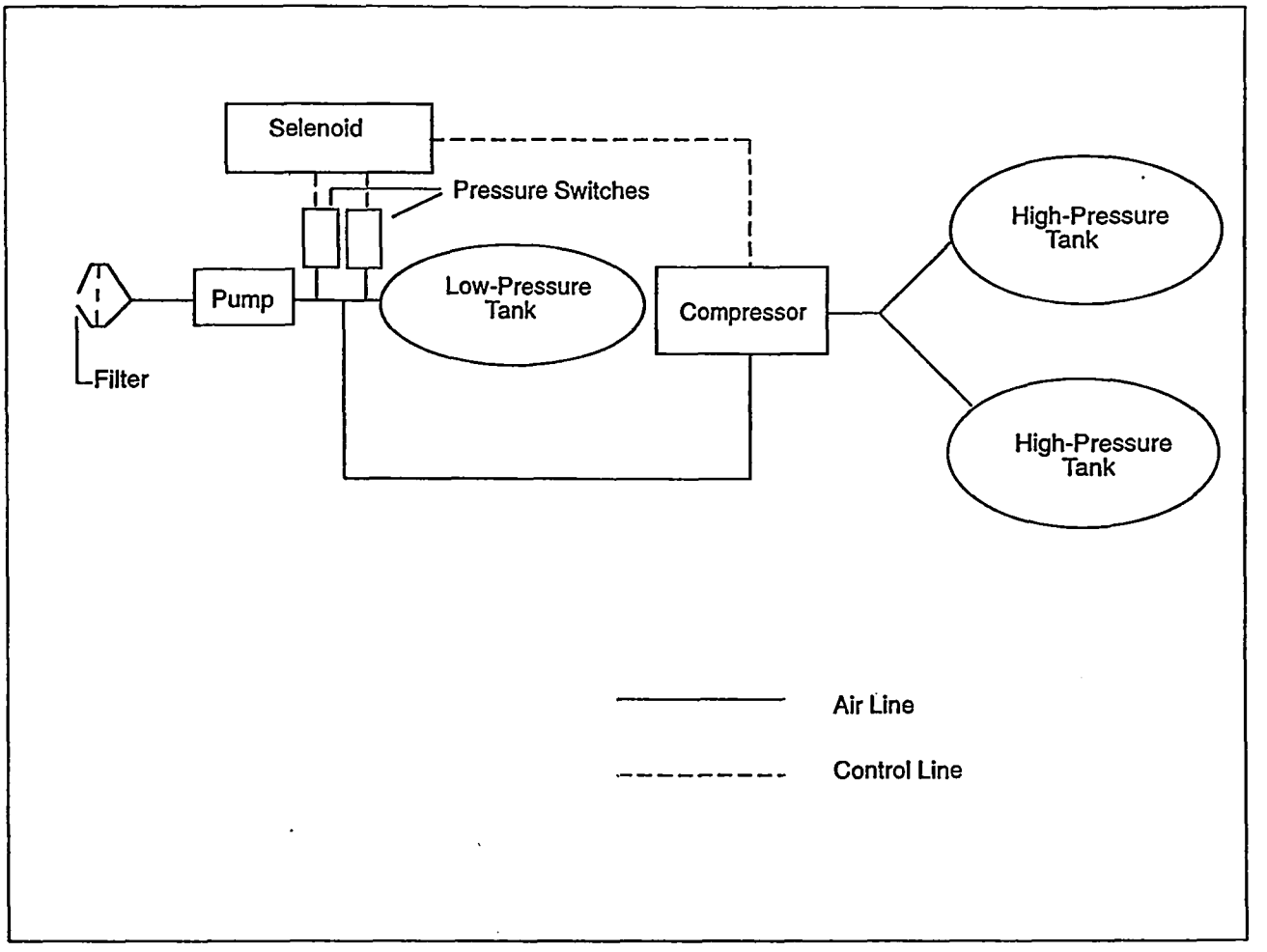

Figure 2. Schematic of Noble Gas Sampler

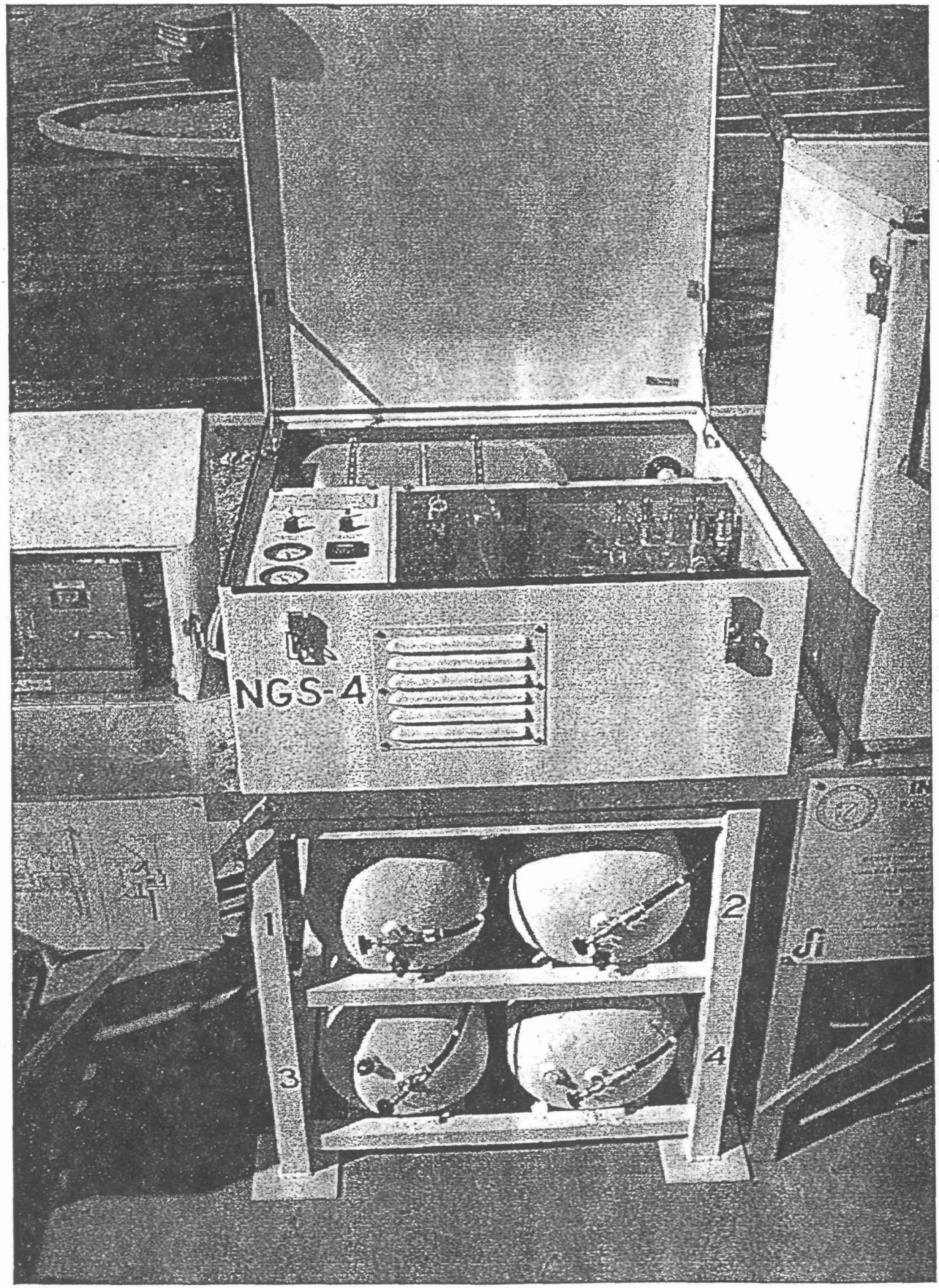

Figure 3. Typical Noble Gas Sampling Station

The high pressure tanks were collected weekly and replaced with evacuated tanks containing one ml of carrier xenon. One tank was analyzed in the laboratory, while the second served as a backup for analysis in case the sample in the first tank was destroyed, lost during analysis, or exhibited unusually high concentrations. The actual standard sample volume in a pressure tank was determined by weighing the full tank as it entered the laboratory and subtracting the tank tare weight. A normal volume was approximately one cubic meter. A separate sampler was designed for collection of atmospheric moisture and H_2 for ^3H analysis to satisfy the requirements of the Effluent Subcommittee. Methane gas collected by the compressed air sampler was also analyzed for ^3H as CH_3T.

After one year of operation the noble gas surveillance network was termed successful. It demonstrated the ability to satisfactorily meet most design requirements, although design changes were being studied to improve sampler operational reliability. The network produced successful sample results 85 percent of the time. Although most of the lost samples were due to sampler failure, some resulted from loss of sample during laboratory analysis. Because of the sample load in the laboratory, duplicate analysis was not performed on the few samples lost in analysis unless results of other stations indicated the possible presence of elevated levels over the network. The improved performance during the final 5 months of the period was due, primarily, to replacement of sub-standard components which were responsible for the high failure rate experienced during the first few months. Based on ^{85}Kr results, the total collection and analytical process was shown to be as accurate as any technique currently available. The network has been shown to be capable of documenting small changes in ^{85}Kr concentrations. As expected, most xenon concentrations were below the 2 pCi/m^3 detectable level; however, several samples have contained measurable ^{133}Xe.

The bottles were replaced weekly and returned to NERC-LV where the samples were analyzed for radioisotopes of Kr and total Xe and for CH_3T by gas chromatography and liquid scintillation techniques summarized in Appendix B and described by *Stevenson and Johns.*

The molecular sieve type equipment samples air through a filter to remove particulate matter and then through a 600-gram column of 13X molecular sieve to remove atmospheric water. Tritium-free hydrogen carrier was added to the air stream by electrolysis of fossil water from deep wells. The air was then passed through another molecular sieve column to remove any water from the electrolysis cell. The dry air with added hydrogen was passed through a palladium catalyst supported on 13X molecular sieve. The hydrogen was converted to water, which was immediately adsorbed on the molecular sieve. The volume of air passed through the sampler was measured by a dry gas meter. Approximately five cubic meters of air are passed through each sampler over a seven-day sampling period. After each sampler was returned to the laboratory, the first molecular sieve column and the catalytic column were degassed; the water was distilled and analyzed for tritium by liquid scintillation techniques. As part of the design of the tritium sampler, a study was done to evaluate the relative accuracy of absolute humidities as determined from various psychrometer measurements and from the molecular sieve sampler consuming 100% removal of moisture from the known volume of air sampled. The findings showed that at the 99% significance levels no differences existed between freeze-out and absorption methods for determining atmosphere concentrations of tritium in the form of water vapor, nor between the technique used to determine absolute humidity.

Appendix A summarizes the results of this Network by listing the maximum, minimum, and average concentrations for ^{85}Kr, total Xe or ^{133}Xe, CH_3T, HTO, and HT. The annual average concentrations for each station were calculated over the time period sampled assuming that all values less than the Minimum Detectable Concentration (MDC) were equal to the MDC. In the table, all concentrations of ^{85}Kr, Xe or ^{133}Xe, CH_3T, HTO and HT were expressed in the same unit, pCi per m^3 of air.

The maximum and average ^{85}Kr levels at all stations were essentially the same, indicating no contribution from NTS operations. The concentrations of ^3H, HTO and HT were generally the same at all locations through the year except for the onsite stations at BJY and Area 12, where concentrations of ^3H, HTO and HT reached a maximum of 130 pCi/m^3, 910 pCi/m^3, and 23 pCi/m^3, respectively.

All average concentrations for the year were less than 0.01% of the Concentration Guides for ^3H in air, which was 6.7×10^{-2} μCi/m^3 for exposure to an offsite population sample and 5.0×10^{-6} for exposure to a radiation worker. No tritium in the form of CH_3T was detected above its MDC of 5×10^{-12} μCi/mL at any of the stations.

The concentrations of ^{133}Xe were below the MDC of 2 pCi/m^3 at all stations throughout the year except for Beatty, Diablo, and Hiko, Nevada, and the onsite locations Desert Rock, BJY, and Area 12. At these stations ^{133}Xe was detected on a few occasions with concentrations as high as 570 pCi/m^3 at Hiko. The average concentrations at all locations was below 0.04% of the Concentration Guide for this nuclide, which was 1×10^{-7} μCi/mL for an offsite population sample and 1×10^{-5} μCi/mL for onsite radiation workers.

Other Test Sites

The purpose of one of the programs in 1972 was to provide additional data on long-term surveillance at all continental test sites, past and present. This was accomplished by sampling for ^3H in natural gas wells adjacent to the Gasbuggy Test Well near Farmington, New Mexico.

Natural Gas Burner Sampling, Gasbuggy Site and Other Test Sites

During 1972, integrated monthly samples of the water condensate from the combustion of natural gas were collected from a trunk line servicing 28 natural gas wells adjacent to the Gasbuggy Test Well near Farmington, New Mexico. This study, which became routine by November 1971 following the development of a gas burner system, was initiated to determine if natural gas from the nuclear-stimulated Gasbuggy Test Well would introduce radioactive contaminants into the surrounding producing wells. Tritium was chosen as a suitable indicator of radioactive contamination.

With the use of the gas burner system described by *Connolly*, an air/gas mixture flowed through a combustion chamber where it was continuously burned. The resultant water vapor was condensed out of the exhaust gases and collected. Each month the condensate was sent to the NERC-LV for liquid scintillation counting for ^3H.

All concentrations of ^3H in the twelve monthly condensate samples collected in CY 1972 were below the minimum detectable concentration of about 220 pCi/L of condensate water.

1973

During 1973, a total of 322 Ci of gaseous radioactivity, primarily xenon, was released into the atmosphere at the NTS. Due to the relatively low quantity, the varying location of release and the discontinuous release rate of the radioactivity, an estimate of the radiation dose to off-NTS populations in accordance with the AEC Manual, Chapter 0513, was not made. However, the concentration of each specific radionuclide detected and attributable to test operations was compared to the appropriate Concentration Guide of the AEC Manual, Chapter 0524.

The only off-NTS indication of radioactivity that was attributable to test operations was found in the Noble Gas and Tritium Surveillance Network (NGTSN).

Results--

The results from the samples collected by the NGTSN are shown in Appendix A. The krypton-85 concentration ranged from 19 to 34.2 pCi/m^3. A paper presented by *Bernhardt et al., (BE73)* in a 1973 symposium contained a curve that predicted krypton-85 concentration for the future. This information was used as the basis for an ongoing study of krypton-85 concentration in air. This actual measurement system began in 1972, so the Bernhardt values for the years 1960, 1965, and 1970 were used to provide a historical reference for the time period preceding the actual measurement of krypton-85 concentrations in air.

Because actual data for the period 1972 - 1987 were collected, it was no longer necessary to include the Bernhardt values. These actual data were used to generate a least squares linear regression line. Comparing this equation to the same equation in prior annual reports showed a difference. This was due to the fact that the new equation was based on sixteen consecutive years of actual data (1972 - 1987) and does not include values given by Bernhardt for 1960, 1965, and 1970.

The concentration over the whole network appeared to have a normal distribution with a mean of 25.5 pCi/m^3 (0.94 Bq/m^3) and a standard deviation of 0.4. This network average concentration, as shown in Appendix A gradually increased since sampling began in 1972. This increase, observed at all stations, reflected the worldwide increase in ambient concentrations resulting from the accelerated use of nuclear technology. The increase in ambient krypton-85 concentration was projected by Bernhardt et al., (Be 73). However, the measured network averages in 1985 was only about 13 percent of the 250 pCi/m^3 (9Bq/m) predicted by Bernhardt. Since nuclear fuel reprocessing is the primary source of krypton-85, the decision of the United States to defer fuel reprocessing may be one reason why krypton-85 levels did not increase as fast as predicted.

As in the past, tritium concentrations in atmospheric moisture samples from the off-NTS stations were generally below the minimum detectable concentration (MDC) of about 400 pCi/L water (see Appendix A). Negative numbers were statistically derived and were only representative of values which was less than the minimum detectable concentration (MDC). 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 0.62 pCi/m^3 (23 mBq/m^3) of air. Only six of the 815 collected samples were above the MDC.

DOSE ASSESSMENT

Estimated Dose from NTS Activities

The estimate of dose equivalent due to NTS activities was based on the total release of radioactivity from the site. Since no significant radioactivity of recent NTS origin was detectable offsite by the various monitoring networks, no significant exposure to the population living around the NTS was 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 7710 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 exposure was 0.2 μrem (2 x 10^{-3} μSv). The population exposure within 80 km would have been 5.9 x 10^{-4} person-rem (5.9 x 10^{-6} person-Sv).

Concentrations of xenon greater than the MDC of 2 pCi/m^3 were detected during the year at all sampling locations except Beatty, and Tonopah, NV. The xenon, identified as ^{133}Xe, was detected on a few occasions with concentrations as high as 240 pCi/m^3 at the on-NTS station at BJY, and 30 pCi/m^3 at Diablo, NV in the off-NTS area. The highest ^{133}Xe concentrations, detected in October, were considered to be anomalies, since there was no known release of radioactivity in the quantity that would have been required to cause the magnitude of ^{133}Xe concentrations which were detected in the off-NTS area.

1974

During 1974 only underground nuclear detonations were conducted. All detonations were contained. However, during re-entry drilling operations, occasional inadvertent releases of airborne radioactivity, primarily xenon, did occur. According to information provided by

the Nevada Operations Office, ERDA, the following quantities of radionuclides were released into the atmosphere during CY 1974:

Radionuclide	Quantity Released (Ci)
^{133}Xe	663
^{133m}Xe	11
^{135}Xe	31
^{3}H	< 2
^{238}U	< 0.0001
$^{131,133,135}I$	< 0.00001

The Noble Gas and Tritium Surveillance Network, was operated to monitor the airborne levels of radiokrypton, xenon, and ^{3}H in the forms HT, HTO, and CH_3T. The Network consisted of four on-NTS and six off-NTS stations (Figure 4).

As shown in the Appendix A, the maximum and average ^{85}Kr levels at all stations were essentially the same. The concentrations of ^{3}H as HTO and as HT for the year were generally the same at all locations except for the on-NTS stations at BJY and Area 12, where the averages and ranges in concentrations were significantly higher than those for all other stations. The higher concentrations were generally associated with seepage from earlier NTS operations, such as the Sedan cratering test and Area 12 tunnel tests. The total of the average tritium concentrations ($HTO+HT+CH_3T$) for either of these on-NTS stations was less than 0.004% of the Concentration Guide for ^{3}H in air, which was 5 pCi/m^3 for an exposure to a radiation worker. Small quantities of ^{3}H in the form CH_3T were occasionally detected off-NTS. However, the concentration averages and ranges for samples collected at all off-NTS locations were generally the same. No definite correlation between CH_3T concentrations and NTS testing could be made.

Concentrations of xenon greater than the MDC were detected during the year at all on-NTS sampling locations and at two off-NTS locations. The xenon, identified as ^{133}Xe, was measured with a maximum concentration of 1100 pCi/m^3 at the on-NTS station at Area 12. The applicable Concentration Guide (CG) for radiation workers was 10 pCi/m^3. In the off-NTS area, the highest concentration was at Beatty with 140 pCi/m^3, and the next highest concentration was at Diablo with 17 pCi/m^3. At either off-NTS location the ^{133}Xe concentrations, when averaged over the total sampling times for the year, were less than 0.008% of the CG for this nuclide which was 1 x10^{-7} μCi/mL for a suitable sample of a population in an uncontrolled area.

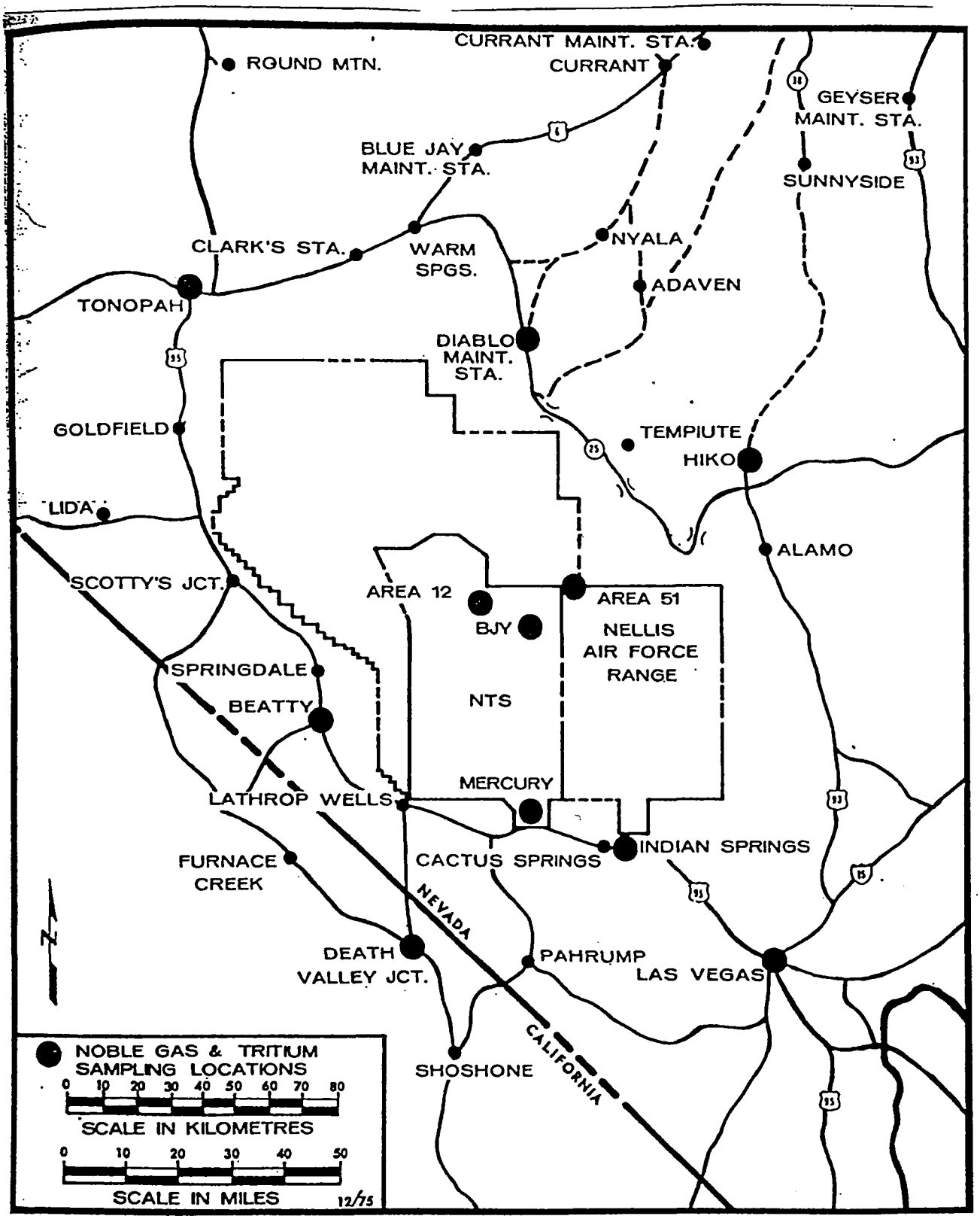

Figure 4. Noble Gas and Tritium Surveillance Network - 1974

1975

During 1975, a total of about 22 curies (Ci) of radioactivity, primarily xenon, was reported by ERDA/NV as being released intermittently throughout the year. The only off-NTS indications of this radioactivity from test operations were low concentrations of xenon-133, krypton-85, and tritium (hydrogen-3) in various combinations, measured in air samples collected at Beatty, Diablo, Hiko, Indian Springs, and Las Vegas, Nevada. The concentrations at these locations when averaged over the year were less than 0.01 percent of the Concentration Guide of 10 μCi/m^3 as listed in the ERDA Manual, Chapter 0524, for exposure to a suitable sample of the population. Based upon time-integrated concentrations of the nuclides at these locations, dose calculations, and population information, the whole-body gamma dose commitment to persons within 80 km of the NTS Control Point for test operations during the year was estimated to be 0.00065 person-rem. The highest dose commitment, [1]0.062 person-rem, occurred beyond 80 km of NTS at Las Vegas, Nevada, a location with a much higher population density than any within 80 km of NTS.

During this report period, only underground nuclear detonations were conducted. All detonations were contained. However, during re-entry drilling operations, occasional low level releases of airborne radioactivity, primarily xenon, did occur. According to information provided by the Nevada Operations Office, ERDA, the following quantities of radionuclides were released into the atmosphere during CY 1975:

Radionuclide	Quantity Released (Ci)
^{133}Xe	19.6
^{133m}Xe	0.3
^{3}H	2.2
Total	22.1

Continuous low-level releases of ^{3}H and ^{85}Kr occurred on the NTS. Tritium was released primarily from the Sedan crater and by evaporation from ponds formed by drainage of water from tunnel test areas in the Rainier Mesa. Krypton-85 slowly seeped to the surface from underground test areas. The quantities of radioactivity from seepage were not quantitated, but were detected at onsite sampling locations.

For "grab" type samples, radionuclide concentrations were extrapolated to the appropriate collection date. Concentrations determined over a period of time were extrapolated to the midpoint of the collection period. Concentration averages were calculated assuming that each concentration less than the minimum detectable concentration (MDC) was equal to the MDC.

[1] The dose commitment (product of estimated average dose and population) at Las Vegas from 1 year's exposure to natural background radiation was about 9700 person-rem.

For the purpose of routinely assessing the total error (sampling replication error plus analytical/counting errors) associated with the collection and analysis of the different types of network samples, plans were made during this report period to initiate a duplicate sampling program for all sample types. Information on the total error associated with the different sample types would allow more complete analysis of variance in sample results and development or greater confidence in identifying results which were higher than normal.

The Noble Gas and Tritium Surveillance Network, consisted of four on-NTS and six off-NTS stations. For the purpose of ensuring that the sampling locations on or near the NTS were situated at population centers, a station was added at Indian Springs, Nevada, on April 1, 1975, and starting at the beginning of the year, the stations at Desert Rock and Gate 700 were moved to Mercury and Area 51, respectively (Figure 4, page 16).

As shown in Appendix A, the average ^{85}Kr concentrations for the year were nearly the same for all stations, ranging from 17 pCi/m^3 to 20 pCi/m^3, with an overall average of 18 pCi/m^3. This compares with overall averages of 16 pCi/m^3 in 1972, the first year of network operation, and 17 pCi/m^3 in 1974. The ambient concentration was increasing world-wide, primarily as a result of nuclear reactor operations. The maximum concentrations for all stations ranged from 23 pCi/m^3 to 38 pCi/m^3. Based upon a review of all past ^{85}Kr data, those concentrations equal to or greater than 25 pCi/m^3 were considered to be above ambient background concentrations and attributable to some outside source or to anomalous variations. The sampling locations and dates for all concentrations above this level during CY 1975 are shown in Table 5, page 19.

As shown by these data, higher than normal ^{85}Kr concentrations for the sampling stations at Beatty, Diablo, Indian Springs, Las Vegas, Mercury, BJY, and Area 12 occurred during the period December 8-24. The highest of the concentrations, occurring at the NTS, were at BJY (38 pCi/m^3) and Mercury (34 pCi/m^3). These concentrations, and the 34 pCi/m^3 sample from March 10-17 at BJY, were attributed to current testing operations or seepage from the ground around the sites of past underground nuclear detonations. The highest concentration averages, either on-NTS or off-NTS, were less than 0.01 percent of the Concentration Guides for on-and offsite exposures (see Appendix A). Since all the other higher than normal ^{85}Kr concentrations in the above table occurred at different times during the year, they do not appear to be associated with NTS operations.

The concentrations of ^3H as HTO were at background levels at all locations except for the off-NTS stations at Beatty and Diablo and at the on-NTS stations at Area 51, BJY, and Area 12. Concentrations of ^3H as HT were above normal background levels only occasionally at the on-NTS station at Area 12. The concentrations of ^3H as CH_3T at all locations were less than the MDC. The higher than normal concentrations of ^3H as HT and HTO were probably the result of seepage from the ground near the sites of past tests, such as the Sedan cratering test and the Area 12 tunnel tests. The total of the average ^3H concentrations (HTO+HT+CH_3T) for either of the off-NTS locations identified with above background concentrations was less than 0.01 percent of the Concentration Guide for ^3H in air.

Table 5. Maximum Concentrations of ^{85}Kr for all Stations

Location	Collection Period Start	Stop	pCi/m^3
Death Valley Jct., California	07/17	06/24	27
Beatty, Nevada	12/09	12/16	25
Diablo, Nevada	12/10	12/17	25
Indian Springs, Nevada	06/02	06/09	27
	12/08	12/15	28
	12/15	12/22	30
Las Vegas, Nevada	04/02	04/09	26
	12/10	12/17	29
	12/17	12/24	30
NTS, Nevada (Mercury)	05/19	05/27	26
	12/08	12/15	34
NTS, Nevada (Area 51)	05/05	05/12	25
	06/02	06/09	25
NTS, Nevada (BJY)	03/03	03/10	25
	03/10	03/17	34
	12/08	12/15	38
NTS, Nevada (Area 12)	12/15	12/22	26
	12/08	12/15	27

Concentrations of xenon greater than the MDC were detected at all Network locations during the year except for Death Valley Junction, Beatty, and Tonopah. Since all off-NTS concentrations occurred in November at the same time that on-NTS concentrations were measured, they were attributable to NTS operations. The maximum concentration of xenon, identified as ^{133}Xe, was 31 pCi/m^3 at the on-NTS stations at BJY. In the off-NTS area, the highest concentration was 25 pCi/m^3 at Diablo. At any of the off-NTS locations, the ^{133}Xe concentrations, when averaged over the total sampling times for the year, were less than 0.01 percent of the Concentration Guide for this nuclide.

Table 6. Radiochemical Detection Limits[a]

Type of Analysis	Analytical Equipment	Counting Period (Min)	Analytical Procedures	Sample Size (mL)	Detection Limit[b]
^{85}Kr	Automatic 200	50	Physical	400-	$^{85}Kr = 2$ pCi/m^3
Xe	liquid scintil-	50	separation	1000	
CH_3T[c]	lation counter	50	by gas chro-		
	With output printer		matography; dissolved in toluene		Xe = 2 pCi/m^3
			"cocktail" for counting		$CH_3T = 2$ pCi/m^3

[a] Lem, P.N. and Snelling, R.N. "Southwestern Radiological Health Laboratory Data Analysis and Procedures Manual," SWRHL-21. Southwestern Radiological Health Laboratory, U.S. Environmental Protection Agency, Las Vegas, NV. March 1971

[b] The detection limit for all samples is defined as that radioactivity which equals the 2-sigma counting error.

[c] Johns, F.B. "Handbook of Radiochemical Analytical Methods," EPA 680/4-75-001. U.S. Environmental Protection Agency, NERC-LV, Las Vegas NV. February 1975.

1976

During 1976, all radioactivity from the underground nuclear tests was contained except for a total of about 91 curies (Ci) of radioactivity which was reported by ERDA/NV as being released intermittently throughout the year from drillback operations and small undetermined amounts of tritium and ^{85}Kr which slowly seeped to the surface from the underground test areas. The only off-NTS indication of this radioactivity was determined from an air sample of the Noble Gas and Tritium Surveillance Network collected at Death Valley Junction during the period August 24-31. This sample had a ^3H in air concentration of 2 pCi/m^3 above background. The estimated whole-body dose resulting from this concentration to a hypothetical receptor at this location was calculated as 1.3 µrem. Based upon this dose and the population of residents between the Nevada Test Site and Death Valley Junction, the estimated dose commitment[2] within a 80-km radius of the NTS Control Point was estimated to be 0.00078 person-rem.

[2] The dose commitment (product of estimated average dose and population) at Las Vegas from 1 year's exposure to natural background radiation is about 10,000 person-rem.

According to information provided by the Nevada Operations Office, ERDA, the following quantities of radionuclides were released into the atmosphere during CY 1976, Table 7:

Table 7. Total Airborne Radionuclide Releases at the Nevada Test Site

Radionuclide	Quantity Released (Ci)
^{3}H	3.11
^{133}Xe	87.7
^{133m}Xe	0.23
^{135}Xe	0.01
	Total 91.05

Continuous low-level releases of ^{3}H and ^{85}Kr occurred on the NTS. Tritium was released primarily from the Sedan crater and by test areas in the Rainier Mesa. Krypton-85 slowly seeped to the surface from underground test areas. The quantities of radioactivity from seepage were not quantitated, but were detected at onsite sampling locations.

For the purpose of routinely assessing the sampling replication error plus analytical/ counting errors associated with the collection and analysis of the different types of network samples, a replicate sampling program for all sample types was initiated at the end of CY 1975. A description of the procedures and results is presented in Appendix C. From the results of the program, the variances that have been observed in all surveillance data were found to be greater than the sampling and analytical/counting errors except for the ^{85}Kr sampling. Apparently the majority of the variation in ^{85}Kr concentrations observed in the past was primarily due to the sampling and analytical/counting errors.

Table 8 summarizes the results of this Network by listing the maximum, minimum, and average concentrations for ^{85}Kr, total Xe or ^{133}Xe, ^{3}H as CH_3T, ^{3}H as HTO, and ^{3}H as HT. The annual average concentrations for each station were calculated over the time period sampled assuming that all values less than MDC were equal to the MDC. All concentrations of ^{85}Kr, total Xe or ^{133}Xe, ^{3}H as CH_3T, ^{3}H as HTO and ^{3}H as HT expressed in the same unit, pCi/m^3 of air.

As shown by Table 8, the average ^{85}Kr concentrations for the year were nearly the same for all stations, ranging from 17 pCi/m^3 to 20 pCi/m^3, with an overall average of 19 pCi/m^3. As shown by the following table, the ^{85}Kr levels for all stations were gradually increasing. Since this happened for all locations, the increase was probably a result of an increase in the ambient concentration of ^{85}Kr world-wide, primarily as a result of nuclear reactor operations. Based upon the Network average concentrations over a 5-year period, this increase amounted to $5x10^{-2}$ to $1.2x10^{-3}$ $pCi/m^3/y$.

Table 8. Annual Average Concentrations of ^{85}Kr 1972-1976

Location	Concentrations, pCi/m3 1972	1973	1974	1975	1976
Death Valley Jct., Calif	16	15	18	17	20
Beatty, NV	16	16	17	19	20
Diablo, NV	16	16	17	18	19
Hiko, NV	16	16	17	17	17
Indian Springs, NV	-	-	-	20	20
Las Vegas, NV	16	16	17	18	18
Mercury, NTS	16	16	18	18	19
Area 51, NTS	16	16	17	18	20
BJY, NTS	17	18	19	19	20
Area 12, NTS	16	16	18	18	20
Tonopah, NV	16	16	18	17	19
Total Network	16.2	16.1	17.6	18.1	19.3

The maximum concentrations for all stations ranged from 24 pCi/m^3 to 29 pCi/m^3. Previously, those concentrations equal to or greater than 25 pCi/m^3 were attributed to some outside source or anomalous variations. However, from the expected geometric standard deviation resulting from the sampling and analytical/counting errors, as determined from the Replicate Sampling Program (Appendix C), the 99% upper confidence limits (UCL's) on the geometric mean concentrations of ^{85}Kr were determined as 3.0 pCi/m^3 or 3.6 pCi/m^3 depending upon whether one was considering the location having the lowest geometric mean concentration (17 pCi/m^3 at Hiko) for the year or the location with the highest geometric mean concentration (20 pCi/m^3 at BJY). Based upon the UCL's, all the Network stations had variations in ^{85}Kr concentrations which were consistent with variations one would expect from the total errors of sample collection and analysis determined from the Replicate Sampling Program.

As in the past, concentrations of ^3H as HTO in atmospheric moisture were generally at background levels at all off-NTS stations and at the on-NTS stations Mercury and Area 51 except for occasional increases in individual samples. The on-NTS stations of BJY and Area 12 continued to have concentrations consistently above background; the concentration averages for these stations for this year were about a factor of 5 greater than the average concentrations for all off-NTS stations.

All of the off-NTS stations had concentrations of ^3H as HTO in atmospheric moisture which were above the expected upper limit of background (approximately 1.0×10^{-6} µCi/mL H_2O) used in the past. From the estimate of sampling and analytical counting errors for this type of sample (Appendix C), this upper limit appeared to be reasonable; however, an evaluation of the

cumulative frequency distributions of the annual data for each station indicated that occasional concentrations above this limit were all within the cumulative frequency distribution of environmental background except for Death Valley Junction, which had a ^3H concentration of $4.2x10^{-6}$ μCi/mL of atmospheric moisture during the period of August 24-31. This indicated that the variances in concentration for the other off-NTS stations were normal variations in environmental background. The total of the average ^3H concentrations ($HTO+HT+CH_3T$) at this location was 70 pCi/m^3, or ,<0.01 percent of the Concentration Guide (CG) for continuous exposure to a suitable sample of the exposed population.

The average concentrations of ^3H as HT at all off-NTS stations and at the on-NTS stations Mercury and Area 51 were generally less than the averages for these locations in 1975, whereas the average concentrations for Area 12 and BJY were slightly higher than the last 1975 averages. From a review of the cumulative frequency distributions of the data for each station, all concentrations seemed to be part of the environmental background.

Concentrations of ^3H as CH_3T were below the MDC at all locations as normally observed except for a few detectable concentrations at all locations except Diablo during the months of September through November. The maximum concentrations for all locations ranged between 4.0 pCi/m^3 to 18 pCi/m^3. The total of the average ^3H concentrations ($HTO+HT+CH_3T$) for the location having the highest CH_3T concentration (18 pCi/m^3 at Indian Springs) was <0.03 percent of the CG for exposure to a suitable sample of the exposed population. Since the detectable concentration occurred generally throughout the Network during the same period, the concentrations were not attributed to NTS operations.

DOSE ASSESSMENT

The only radionuclide ascribed to NTS operations detected off-NTS was ^3H at Death Valley Junction. The above background concentration of ^3H concentration in this sample was $4.2x10^{-6}$ μCi/mL H_2O or 29 pCi/m^3 air. Based upon an ambient ^3H concentration of 2 pCi/m^3 air, the net ^3H concentration at Death Valley Junction was 27 pCi/m^3. The whole-body dose from this concentration was estimated as

$$\frac{(2.7x10^{-11}\ \mu Ci/m^3)\ (7\ days)\ (500\ mrem/year)}{(2.0x10^{-7}\ \mu Ci/m^3)\ (365\ days/year)} = 1.3\ \mu rem.$$

The 80-km dose commitment for the area between the NTS and Death Valley Junction (population of 600) was estimated to be 0.00078 person-rem.

1977

In 1977 all radioactivity from the underground nuclear tests was contained except for a total of about 36 curies (Ci) of radioactivity which was reported by DOE/NV as having been released intermittently throughout the year during drillback operations and small undetermined amounts of xenon, tritium, and ^{85}Kr which slowly seeped to the surface from the

underground test areas. The only off-NTS indication of this radioactivity was ^{133}Xe in several air samples of the Noble Gas and Tritium Surveillance Network collected at Beatty, Diablo, Hiko, Las Vegas, and Tonopah during the period August 2 to September 28. The highest concentration of ^{133}Xe detected (14 pCi/m^3) was in a sample collected at Beatty. The estimated whole-body dose to a hypothetical receptor at this location was calculated as 2.5 microrem (μrem), which is 0.001 percent of the Radiation Protection Standard of 170 millirem (mrem) to a suitable sample of the exposed population. Based upon this dose and the population of Beatty, the estimated dose commitment[3] within a 80-km radius of the NTS Control Point was estimated to be 0.0013 person-rem. Due to the greater population density within the Las Vegas area, the highest dose commitment, 0.36 person-rem, was for this area, which was small compared to the 26,000 person-rem which residents of Las Vegas and nearby communities received from natural background radiation.

During this report period, only underground nuclear detonations were conducted. All detonations were contained. However, during re-entry drilling operations, occasional low level releases of airborne radioactivity, primarily xenon, did occur. According to information provided by the Nevada Operations Office, DOE, the following quantities of radionuclides were released into the atmosphere during CY 1977 (Table 9):

Table 9. Total Airborne Radionuclide Releases at the Nevada Test Site

Radionuclide	Quantity Released (Ci)
^{3}H	6.880
^{133}Xe	28.286
^{133m}Xe	0.621
^{135}Xe	0.849
^{131}I	2.6 (pCi)
Total	36.636

The average ^{85}Kr concentrations for the year were nearly the same for all stations, ranging from 19 pCi/m^3 to 21 pCi/m^3, with an overall average of 20 pCi/m^3. The ^{85}Kr levels for all stations had been gradually increasing. Since this happened for all locations, the increase was probably a result of an increase in the ambient concentration worldwide, primarily as a result of nuclear reactor operations. Based upon the Network average concentrations over a 5-year period, this increase amounted to between 3.0 to 1.5 pCi/m^3/y.

The maximum concentration of ^{85}Kr for all stations ranged from 23 pCi/m^3 to 35 pCi/m^3 (Appendix A). From the expected geometric standard deviation resulting from the sampling and analytical/counting errors, as determined from the Replicate Sampling Program (EMSL-LV, 1977), the 99 percent upper confidence limits (UCL's) on the geometric mean concentrations of ^{85}Kr would have been 34 pCi/m^3 to 38 pCi/m^3 depending upon whether one was considering the

[3] Product of estimated average dose equivalent and population.

location having the lowest geometric mean concentration (19 pCi/m^3 at Diablo and Hiko) for the year or the location with the highest geometric mean concentration (21 pCi/m^3 at BJY). Based upon the UCL's, all the Network stations had variations one would expect from the total errors of sample collection and analysis determined from the Replicate Sampling Program.

Xenon-133 was detected above its MDC of about 2 pCi/m^3 at the locations, periods, and concentrations shown in the following Table 10.

As shown by the table, detectable concentrations occurred only in one or two samples at each location. The highest of these concentrations at an off-NTS location was 15 pCi/m^3 at Tonopah, NV. If this level had persisted throughout the year, the result would have been 0.02 percent of the Concentration Guide.

Table 10. Concentrations of Airborne ^{133}Xe Detected On and Off the NTS

Location	Sampling Period	133Xe Concentration +2-Sigma Counting Error pCi/m3
Beatty, NV	08/02-09	12 ± 4.0
	09/20-27	14 ± 5.2
Diablo, NV	09/21-28	12 ± 4.3
Hiko, NV	09/21-28	11 ± 4.6
Las Vegas, NV	09/21-28	10 ± 8.2
Mercury, NTS, NV	08/08-15	7.1 ± 4.0
BJY, NTS, NV	10/25-31	100 ± 4.0
	11/14-21	30 ± 4.0
Area 12, NTS, NV	08/22-29	18 ± 7.5
Tonopah, NV	09/20-27	15 ± 7.8

As in the past, concentrations of ^{3}H as HTO in atmospheric moisture were generally at background levels at all off-NTS stations and at the on-NTS stations Mercury and Area 51 except for occasional increases in individual samples. The on-NTS stations of BJY and Area 12 continued to have concentrations consistently above background; the concentration averages for these stations for 1977 were greater than the average concentrations for all off-NTS stations. All of the off-NTS stations had concentrations of ^{3}H as HTO in atmospheric moisture which were below the expected upper limit of background (approximately 1.0×10^{-6} µCi/mL H_2O) used in the past.

The average concentrations of ^{3}H as HT at off-NTS Network stations were comparable to the averages for these locations in 1976. This year the averages ranged from <6 pCi/m^3 to <2 pCi/m^3 whereas last year the averages ranged from <0.6 pCi/m^3 to <3 pCi/m^3. From a review of the cumulative frequency distributions of the data for each station and for the whole Network, all concentrations appeared to be part of the environmental background.

Concentrations of ^{3}H as CH_3T were generally below the MDC at all locations as normally observed. Detectable concentrations did occur at Diablo, Hiko, Las Vegas, and Tonopah during the months of January, March, August, and December. The maximum concentrations for all locations ranged between 5.0 pCi/m^3 to 14 pCi/m^3. The total of the average ^{3}H concentrations (HTO+HT+CH_3T) for the locations having the highest CH_3T concentration (14 pCi/m^3 at Indian Springs) was <0.009 percent of the CG for exposure to a suitable sample of the exposed population. Since the detectable concentrations occurred generally throughout the Network both on NTS and off NTS at the same level, the concentrations were not attributed to NTS operations.

DOSE ASSESSMENT

The only radionuclide ascribed to NTS operations detected off-NTS was ^{133}Xe at Beatty, Diablo, Hiko, Las Vegas, and Tonopah, Nevada, ^{133}Xe concentrations in air occurred during the months of August and September. The highest whole-body dose calculated for these locations was at Beatty, Nevada, where the dose equivalent was estimated to be

$$\frac{(7 \text{ days})\,(1.2\times10^{-11}\ \mu\text{Ci/mL} \pm 1.4\times10^{-11}\ \mu\text{Ci/mL})\,(500 \text{ mrem/year})}{(10^{-7}\ \mu\text{Ci/mL})\,(365 \text{ days/year})} = 2.5\ \mu\text{rem}$$

which was 0.001 percent of the Radiation Protection Standard of 170 mrem (Appendix B). The estimated doses for all locations are shown in Table 11 with the estimated dose commitment (product of estimated average dose equivalent and population).

Table 11. Estimated Dose Commitment from ^{133}Xe Concentrations

Location	Population	Estimated Dose Equivalent (μrem)	Dose Commitment (pers-rem)	Dose Commitment Within 80 km (pers-rem)
Beatty, NV	500	2.5	0.0013	0.0013
Diablo, NV	6	1.2	0.0000072	0.0
Hiko, NV	60	1.1	0.000066	0.0
Las Vegas, NV	370,500*	0.96	0.36	0.0
Tonopah, NV	2,000	1.4	0.0028	0.0
Total			0.36	0.0013

*Population was for Las Vegas and nearby communities within Clark County.

Due to the greater population density within the Las Vegas area, the highest dose commitment (0.36 person-rem) was for this area, which is approximately 100 km from the NTS. This dose commitment was small compared to the 26,000 person-rem, which residents of Las Vegas and nearby communities received from natural background radiation during this reporting period.

1978

During this report period, only underground nuclear detonations were conducted. All detonations were contained. However, during re-entry drilling operations, occasional low level releases of airborne radioactivity, primarily xenon, did occur. According to information provided by the Nevada Operations Office, DOE, the following quantities of radionuclides were released into the atmosphere during CY 1978 (see Table 12):

Table 12. Total Airborne Radionuclide Releases at the Nevada Test Site

Radionuclide	Quantity Released (Ci)
^{3}H	90.470
^{85}Kr	15.000
^{131}I	0.0001
^{133}Xe	8.213
^{133m}Xe	1.44
^{135}Xe	0.369
Total	115.4921

There was a continuous low-level release of tritium and krypton-85 on the NTS. Tritium was released primarily from the Sedan crater and by evaporation from ponds formed by drainage of water from tunnel test areas in the Rainier Mesa. Krypton-85 slowly seeps to the surface from underground test areas. The quantity of radioactive seepage was not quantified, but had been detected at onsite sampling locations and occasionally at off-NTS locations.

All radioactivity from the underground nuclear tests was contained except for a total of about 115 curies (Ci) of radioactivity which was reported by DOE/NV as being released intermittently throughout the year by post-shot drilling operations, and small undetermined amounts of xenon, tritium, and krypton-85 which slowly seeped to the surface from the underground test areas.

The only off-NTS indication of this radioactivity was xenon-133 (concentration, 65 pCi/m^3 in an air sample collected at Diablo, Nevada, during the period April 19 to 26 and tritiated hydrogen (HT) in two air samples collected at Indian Springs, Nevada, during the periods November 13 to December 4 (18 pCi/m^3). The estimated whole-body dose equivalents estimated to a hypothetical receptor at these locations were estimated to be 6.2 microrem (μrem) at Diablo and 5.8 microrem (μrem) at Indian Springs. Based upon the respective populations at these locations, six persons and 1500 persons, the dose commitment was estimated to be 0.000037 person-rem at Diablo and 0.0087 person-rem at Indian Springs. As Diablo is beyond the 80 km-radius of the NTS Control Point, the 80-km dose commitment was estimated to be 0.0087 person-rem.

Beginning in 1978, the definition of the minimum detectable concentration for all analyses was redefined as the total counting error resulting from the sum of a 5 percent Type II error (failure to recognize the presence of radioactivity when it is present). This essentially increased the MDC's about a factor of two compared with the MDC values used in prior years, defined as the two-sigma counting error for determinations that were equal to or less than the two-sigma error.

QUALITY ASSURANCE

The quality assurance program for laboratory analyses consisted of a combination of instrumental quality control procedures, the analysis of replicate samples to measure precision, and the analysis of cross-check samples from an independent laboratory to measure the accuracy of analyses.

The instrumental quality control procedures consisted of calibration, background quality control, and reference standard quality control.

Background quality control for all laboratory systems was maintained by the periodic background measurements for each system. The backgrounds were plotted on control charts to check trends and to determine whether individual measurements were within required limits. Background quality control was especially important on instruments such as alpha spectrometers and germanium diodes where the backgrounds were extremely low.

Quality control for reference standards was basically the same for all laboratory instruments although the details of application were different. A reference standard was one which produced a consistent response for the instrument with which it was used. The reproducibility (within limits) of instrument response versus time was plotted on a quality control chart.

The precision of the laboratory analyses as influenced by sampling, analytical errors, and counting errors, was estimated through a program of replicate analysis and sampling. About 10 percent of the routine samples were split, and the pairs were both analyzed individually to obtain an estimate of the analytical and counting errors combined. The total error, the above errors plus any sampling error, was estimated from replicate sampling. About 10 percent of the sampling workload was collected in duplicate. The results of the replicate sampling program were then used to identify those results that were significantly different than those obtained in the past.

Accuracy checks were made by the analyzing laboratory intercomparison samples provided by the Quality Assurance Branch, EMSL-LV (EPA 1979). These intercomparison samples were simulated environmental samples containing known amounts of one or more radionuclides. The intercomparison samples were analyzed by the laboratory and the results were sent to the Quality Assurance Branch for statistical analysis and comparison with the known value and analytical values obtained by other participating laboratories. The intercomparisons were performed bimonthly, quarterly, and semiannually, depending upon the type of sample. A report and a control chart for each type of analysis were returned to each participant. The identities of the participants were coded with each participant knowing his/her own code, but not those of the other participants. The report sent to each participant listed the individual results (analyses were done in triplicate), the mean and the experimental standard deviation of the three

results, the mean range plus the standard deviation of the range, the known value, and the number of standard deviations of each participant's mean value from the grand average of all results and from the known value.

In general, the 1978 analyses were within acceptable limits. In 1978 the Noble Gas and Tritium Surveillance Network, monitored the airborne levels of radiokrypton, xenon, and three forms of tritium (^3H)--tritiated hydrogen (HT), tritiated water (HTO), and tritiated methane (CH_3T). The network consisted of four stations on and seven off-NTS shown in Figure 5. Area 51, which appears to be off NTS, was considered to be on NTS as it was an access-controlled area with radiological safety support provided by NTS personnel.

As shown in Table 13, the average concentration of krypton-85 for the year at all stations was the same (20 pCi/m^3), except for BJY (22 pCi/m^3), which was significantly different than the Network average at the 95% and 99% confidence levels. The average concentration at this station had been the highest in the Network more often than at any other station. The results from its central location on the NTS where seepage of the noble gases from past underground nuclear detonation had occurred. The average concentration of krypton-85 for the whole Network gradually increased since sampling was initiated in 1972. This increase observed at all stations probably reflected the worldwide increase in ambient concentrations resulting from the proliferation of nuclear technology. (See Figure 7)

The maximum concentration of krypton-85 for all stations ranged from 24 pCi/m^3 to 29 pCi/m^3 (Appendix A). As shown by Figure 7, these higher concentrations and all the other concentrations for the Network stations combined followed a log-normal distribution with a geometric mean of 20.1 pCi/m^3 and a geometric standard deviation of 1.1. As the expected geometric standard deviation of the krypton-85 measurements attributed to sampling/analytical/ counting errors was determined to be 1.2 from the duplicate sampling program (Appendix C), the variation in the krypton-85 concentrations throughout the Network appears to be caused primarily by the errors in its measurement.

Table 13. Average Krypton-85 Concentrations in Air -1978, On and Off the NTS

	Concentration, pCi/m^3
Locations	1978
Death Valley Jct., Calif.	20
Beatty, NV	20
Diablo, NV	20
Hiko, NV	20
Indian Springs, NV	20
Las Vegas, NV	20
Mercury, NTS, NV	20
Area 51, NTS, NV	20
BJY, NTS, NV	22
Area 12, NTS, NV	20
Tonopah, NV	20
Network Average	20

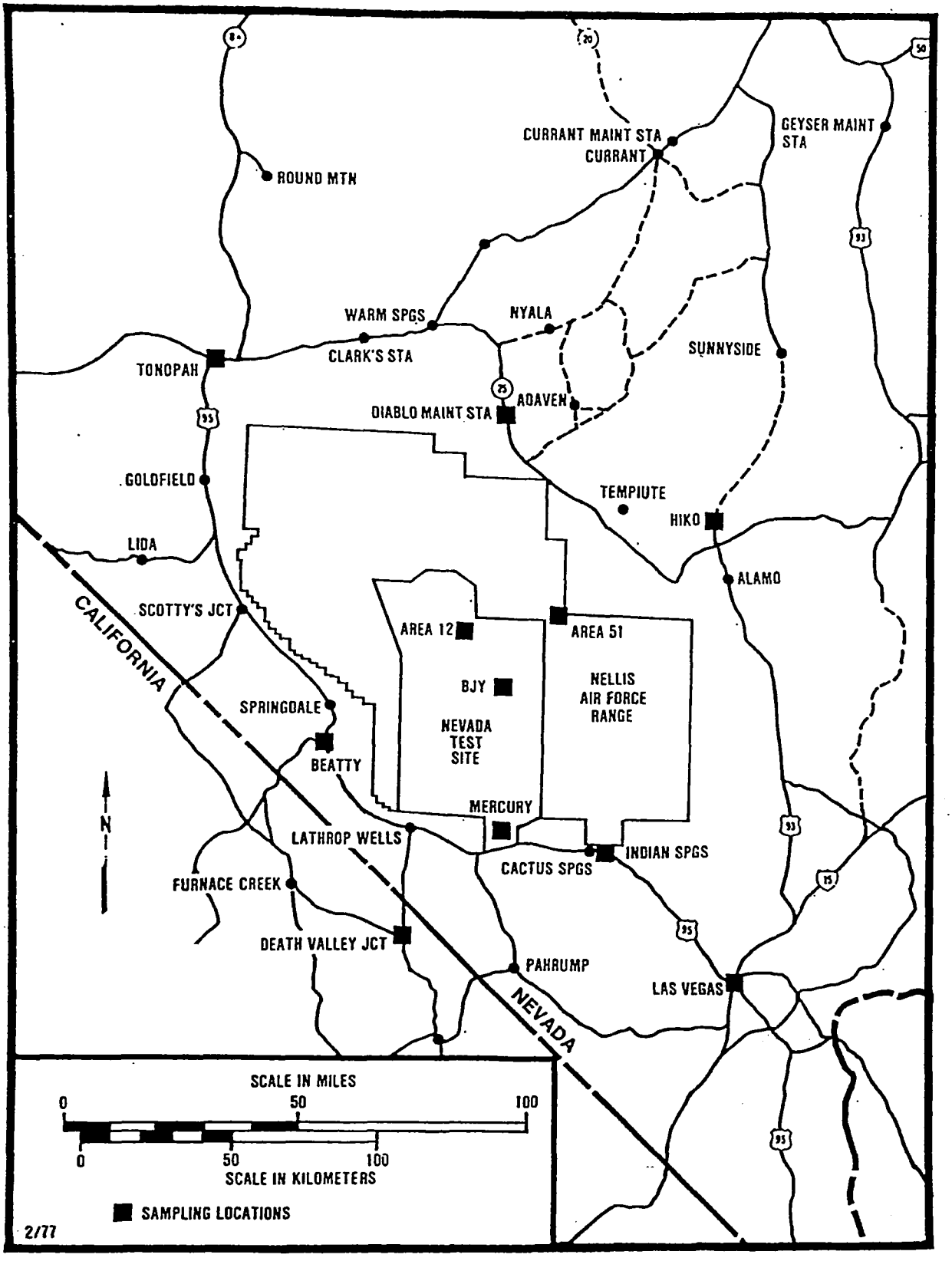

Figure 5. Noble Gas and Tritium Surveillance Network - 1978

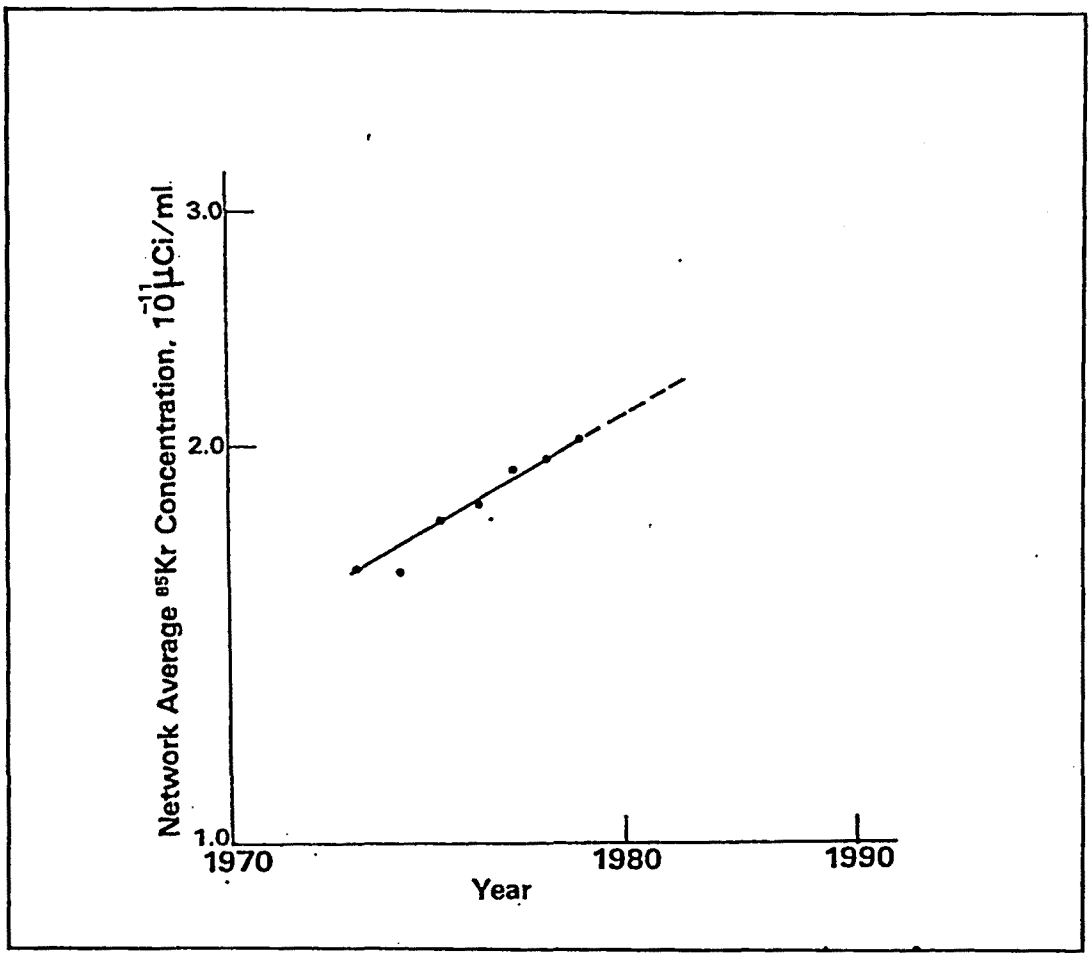

Figure 6. Trend in Annual Network Concentrations of Krypton-85 1972 - 1978.

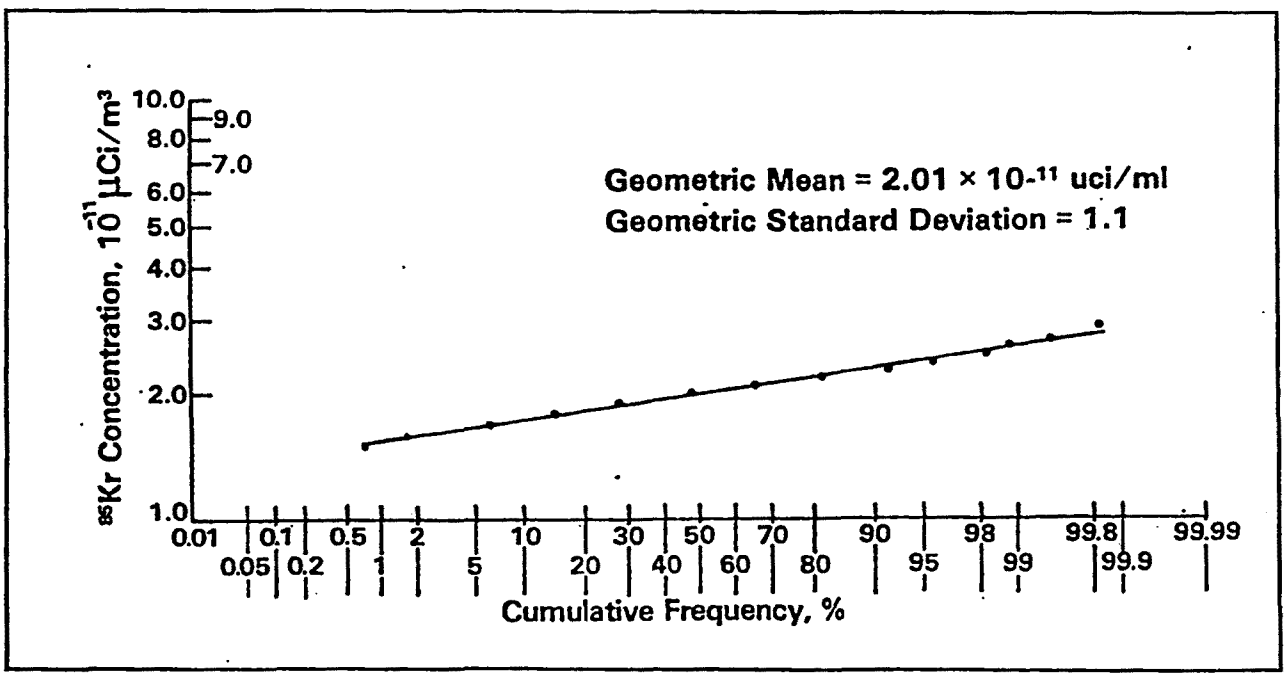

Figure 7. Distribution of Network Concentrations of Krypton-85.

Xenon-133 was detected above its MDC of about 4 pCi/m^3 at the locations, during the periods, and at the concentrations shown in Table 14.

Table 14. Concentrations of Airborne Xenon-133 Detected On and Off the NTS - 1978

Location	Sampling Period	Xenon-133 Concentration ± 2 Sigma Counting Error (pCi/m^3)
Diablo, NV	4/19-26	65 ± 4.0
Mercury, NTS, NV	2/27-3/6	29 ± 5.4
	5/8-15	170 ± 3.0
Area 51, NTS, NV	2/21-27	45 ± 5.2
	2/27-3/6	16 ± 4.4
BJY, NTS, NV 2/21-27		14,000 ± 30*
	2/27-3/6	100 ± 5.2
	4/3-10	26 ± 4.2
	5/1-8	10 ± 3.8

* This high value resulted from post-shot drilling operations.

As shown in Table 14, xenon-133 was detected on the NTS and at only one location off the NTS, namely Diablo, NV. This concentration measured at Diablo, if it had persisted throughout the year, would have been only 0.065 percent of the Concentration Guide.

As in the past, tritium as HTO in atmospheric moisture samples was generally at background concentrations, below the MDC of 3 to 4 X 10^{-6} µCi/mL at all off-NTS stations and at the on-NTS stations at Mercury and Area 51. Occasional increases in concentrations appeared to be a part of the normal fluctuations in background. The on-NTS stations were comparable to those observed in 1977. During 1978 the averages ranged from <0.6 pCi/m^3 to 1.8 pCi/m^3, whereas in 1977 the averages ranged from <60 pCi/m^3 to <2 pCi/m^3. From a review of the cumulative frequency distributions of the data for each station, two samples collected at Indian Springs had concentrations of 24 pCi/m^3 and 18 pCi/m^3 during the respective periods November 13 to 20 November 27 to December 4, which did not appear to be a part of the background. If the highest of these concentrations had persisted for the year, the exposure of off-NTS residents would have been 0.036 percent of the Concentration Guide.

The concentrations of tritium as tritiated methane were generally below the MDC of 4 pCi/m^3 at all locations as normally observed. Detectable concentrations were observed in two samples collected at Beatty, Nevada; however, based upon the cumulative frequency distribution for the tritiated methane concentrations for the total Network, the concentrations appeared to be part of the background.

RADIATION PROTECTION STANDARDS
FOR EXTERNAL AND INTERNAL EXPOSURE

DOE ANNUAL DOSE COMMITMENT

Type of Exposure	Dose Limit to Critical Individual in Uncontrolled Area at Points of Maximum Probable Exposure (rem)	Dose Limit to Suitable Sample of the Exposed Population in an Uncontrolled Area (rem)
Whole Body, gonads or bone marrow	0.5	0.17
Other organs	1.5	0.5

"Radiation Protection Standards," DOE Manual, Chapter 0524.

DOE CONCENTRATION GUIDES (CG'S)

Network or Program	Sampling Medium	Radio-nuclide	CG (μCi/mL)	Basis of Exposure
Noble Gas and Tritium Surveillance Network On-NTS	air	^{85}Kr	1.0×10^{-5}	Individual in controlled area.
		^{3}H	5.0×10^{-6}	
		^{133}Xe	1.0×10^{-5}	
Noble Gas and Tritium Surveillance Network Off-NTS	air	^{85}Kr	1.0×10^{-7}	Suitable sample of the exposed population in uncontrolled area.
		^{3}H	6.7×10^{-8}	
		^{133}Xe	1.0×10^{-7}	

1979

In May 1979, the sampling stations in Death Valley Junction and Las Vegas were removed from the Network, and new stations were added at Area 15 and Area 400 on the NTS and at Lathrop Wells in the offsite area to enhance the monitoring for effluents from experimental high-level waste study areas. This network consisted of six stations on and six stations off the NTS as shown in Figure 8 (the Area 51 station is considered an NTS station).

Two sampling systems were used in this Network: a compressor-type air sampler and a molecular sieve sampler. The compressor-type equipment continuously sampled air over a 7-day period and stored it in two pressure tanks, which together held approximately 1 cubic meter of air at about 220 psi (1.6 Mpa). The tanks were exchanged weekly and returned to the laboratory where their contents were analyzed for krypton-85 and .

A molecular sieve column was used to collect tritiated water from air. A prefilter was used to remove particles before air passed through the molecular sieve column. Approximately 5 cubic meters of air were passed through each sampler over a 7-day sampling period. Tritiated water (HTO) absorbed on the molecular sieve column was recovered, and the concentration of tritium in water, expressed in μCi/mL of sampled air, was determined by liquid scintillation counting techniques. Analyses for tritium hydride and tritiated methane were discontinued in 1979.

Maximum concentrations of krypton-85 for the stations in the Noble Gas and Tritium Surveillance Network ranged from 11 pCi/m^3 to 33 pCi/m^3 (Appendix A). The maximum concentrations for the Network stations combined followed a log normal distribution with a geometric mean of 18.8 pCi/m^3 and a geometric deviation of 1.16. As the expected geometric standard deviation of krypton-85 measurements attributed to sampling, analytical, and counting errors was determined to be 1.1 from the duplicate sampling program (Appendix A), the variation in the krypton-85 concentrations throughout the Network appeared to be caused primarily by the measurement errors. The annual average concentrations at each station were calculated over the time period sampled using all values, including those less than the MDC.

The average concentration of krypton-85 for the year at all stations was the same (19 pCi/m^3), except for the concentration at BJY (22 pCi/m^3), which was significantly different from the Network average at the 95 percent confidence level.

Xenon-133 was detected only on the NTS. If the highest concentration measured had persisted throughout the year, the occupational exposure would have been less than 0.01 percent of the CG (Appendix A).

As in the past, tritium as HTO in atmospheric moisture samples was generally at background concentrations; i.e., below the MDC of approximately 3×10^{-7} μCi/mL at all off-NTS stations and at the on-NTS stations at Mercury, Area 400, and Area 51. Occasional increased concentrations were observed at Area 400 and Area 51. The on-NTS stations at Area

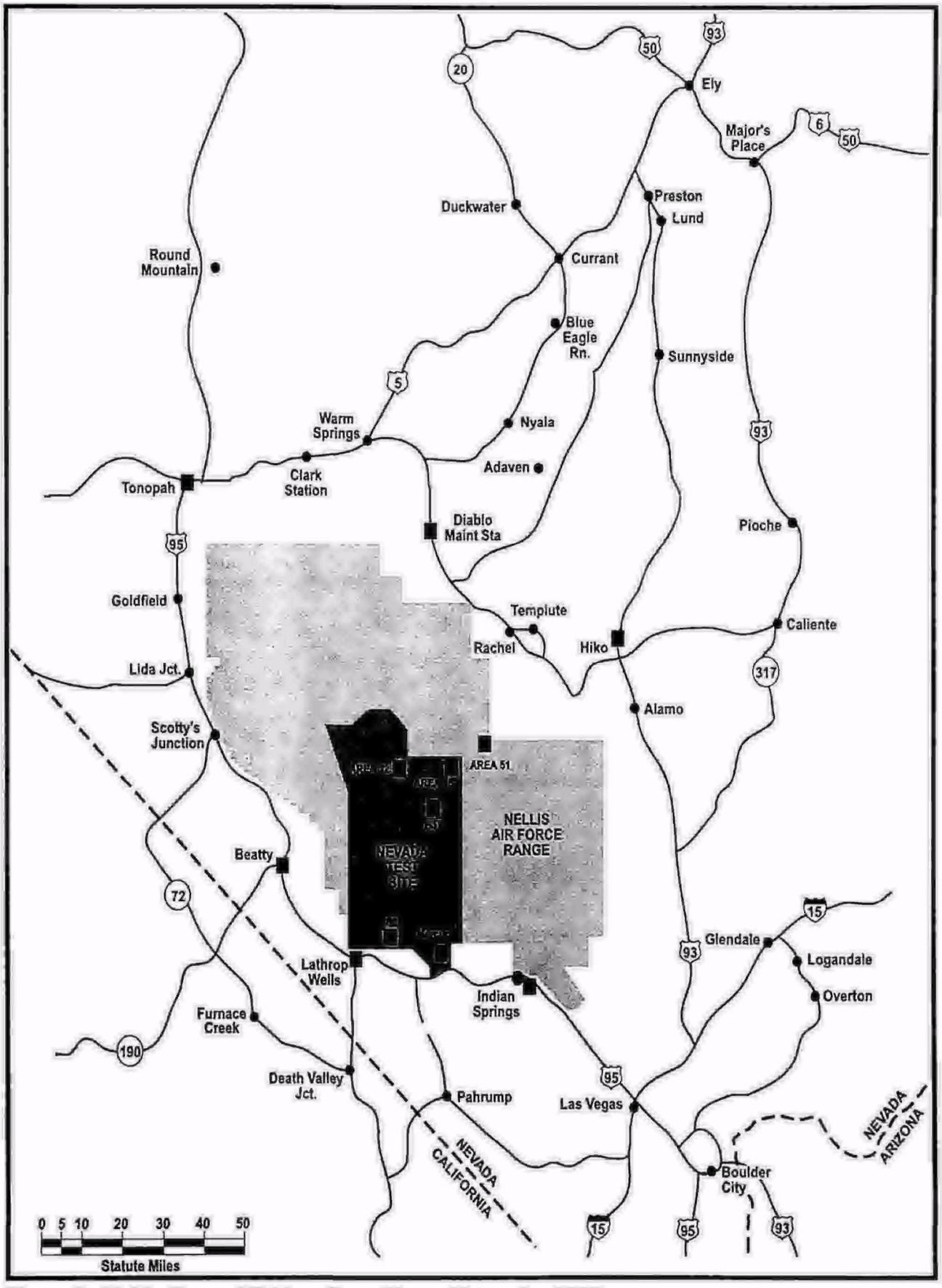

Figure 8. Noble Gas and Tritium Surveillance Network - 1979

15, BJY, and Area 12 had concentrations consistently above background; the concentration averages for these stations were factors of 5 to 65 times the average for all off-NTS stations.

Table 15. Annual Average Krypton-85 Concentrations in Air, 1972-1980

Sampling Locations	^{85}Kr Concentrations (x 10^{-11} µCi/mL)								
	1972	1973	1974	1975	1976	1977	1978	1979	1980
Beatty, Nev	16	16	17	19	20	20	20	19	21
Diablo & Rachel, NV‡	16	16	17	18	19	19	20	19	21
Hiko, NV	16	16	17	17	17	19	20	19	21
Indian Springs, NV				20	20	20	20	19	21
NTS, Mercury, NV	16	16	18	18	19	20	20	19	21
NTS, Area 51, NV	16	16	17	18	20	19	20	19	21
NTS, BJY, NV	17	18	19	19	20	21	22	21	23
NTS, Area 12, NV	16	16	18	18	20	19	20	19	21
Tonopah, NV	16	16	17	18	18	20	20	18	21
Las Vegas, NV*	16	16	17	18	18	20	20	-	
Death Valley Jct., Calif.*	16	15	18	17	20	20	20	19	
NTS, Area 15, NV†	-			-	-	-	-	19	21
NTS, Area 400, NV†	-		-		-	-	-	18	21
Lathrop Wells, NV†	-	-	-		-	-	-	19	22
Network Average	16	16	18	18	19	20	20	19	21

* Removed 1979
†New stations 1979
‡Station at Diablo was moved to Rachel in March 1979.

1980

In 1980, test-related radioactivity from the NTS was detected offsite following the Riola Test conducted on September 25, 1980. This consisted of xenon-133 (34 pCi/m^3) and xenon-135 (360 pCi/m^3) in a compressed air sample collected at Lathrop Wells, Nevada. The estimated dose equivalent to the whole body of a hypothetical receptor at Lathrop Wells from exposure to the was 0.011 mrem, which was 0.006 percent of the radiation protection guide for a suitable sample of the general population.

AIRBORNE RELEASES OF RADIOACTIVITY AT THE NTS DURING 1980

All nuclear detonations during 1980 were conducted underground. Occasional releases of low-level radioactivity occurred during reentry drilling and radioactive noble gases leaked to the atmosphere during the evening hours after the Riola test was conducted on September 25.

Table 16 shows the total quantities of radionuclides released to the atmosphere, as reported by the DOE Nevada Operations Office.

Table 16. Total Airborne Radionuclide Releases at the NTS - 1980

Radionuclide	Half-Life (Days)	Quantity Released (Ci)
Tritium	4,500	450
Krypton-85	3,916	87
Iodine-131	8.04	1.0
Xenon-133	5.29	1,262
Xenon-133m	2.33	1.69
Xenon-135	0.38	2,228.46
Xenon-135m	0.01	476
Total		4,506.15

There was also a continuous low-level release of tritium and krypton-85 on the NTS. Tritium was released primarily from the Sedan Crater and by the evaporation of water from ponds formed by drainage of water from, or ventilation of, the tunnel test areas in the Rainier Mesa. The seepage of krypton-85 and tritium to the surface from underground tests areas was suspected. The short-lived iodines and xenons were released only during a venting or during a drillback operation.

RIOLA TEST

Immediately following this event, no radioactivity was detected onsite or offsite by ground and aerial monitoring teams; therefore, the teams were released two hours after the test. During the evening, airborne radioactivity began seeping from the test and continued into the next day. EPA personnel were notified about the release by the Department of Energy at about 7:30 a.m. the following day (September 26, 1980),and an estimate of where the effluent traveled was obtained from the National Oceanic and Atmospheric Administration, Las Vegas. Radiation monitors were then deployed to monitor the highways surrounding the NTS and to activate standby air samplers at Tempiute north of NTS, at Dansby's store southwest of NTS, and at the Fleur de Lis Ranch west of NTS. Gamma-rate recorders were also placed at Lathrop Wells, Area 51, and Dansby's store. No radiation was detected by survey instruments used by the monitors or by the gamma-rate recorders.

One of two aircraft used for aerial monitoring left Las Vegas at 9:45 a.m. on September 26 and flew 500 feet over the terrain at the NTS and along Highway 16 leading to Pahrump, Nevada. The aircraft detected no radiation above background levels, and returned to Las Vegas

at 12:15 a.m. the same date. The second aircraft departed Las Vegas at 10:15 a.m. for the NTS, where a survey was made for airborne radioactivity at an elevation of 500 feet over the terrain. No radioactivity was detected with sensitive gamma-radiation instrumentation except directly over the shot area. A compressed air sample, a sample of particulates collected by electrostatic precipitation, a sample of airborne particulates collected by filtration, and a sample of gases absorbed on activated charcoal were collected between 11:23 a.m. and 12:10 p.m. directly over the Riola test location. This aircraft returned to Las Vegas to be refitted with clean sampling media and then traveled over Highway 95 between the Mercury turn-off and eight miles east of the turn-off to the Nuclear Engineering Company where a second set of samples was collected between 2:21 p.m. and 2:50 p.m.

Only gaseous radioactivity, krypton-85, xenon-133, and xenon-135 was measured in the compressed air sample collected over the Riola test area; no particulate radioactivity or any other radioactivity was detected in the aerial samples collected offsite.

The concentrations of krypton-85 for the stations in the Network ranged from 14 pCi/m^3 to 33 pCi/m^3 (Appendix A). As shown in Figure 9, a plot of the logarithm of the concentrations for the Network stations against probits (the number of standard deviations from the mean) was a straight line suggesting that the data was lognormally distributed. To aid the reader, the geometric mean of 21 pCi/m^3 and the geometric standard deviation of 1.15 was evaluated and shown on the figure. As the expected geometric standard deviation of the krypton-85 measurements attributed to sampling, analytical, and counting errors was determined to be 1.08 from the duplicate sampling program (Appendix A), the variation in the krypton-85 concentrations throughout the Network appeared to be caused primarily by the errors in its measurement and collection.

The average concentrations of krypton-85 for the year at all stations was the same (21 pCi/m^3), except for the concentrations at BJY (23 pCi/m^3) and Lathrop Wells (22 pCi/m^3). However, only the concentration average at BJY was significantly greater than the Network average at the 95 percent significance level.

As shown in Table 15 (see page 36) and Figure 10, the average concentrations of krypton-85 for the Network had gradually increased since sampling began in 1972. This increase, observed at all stations, probably reflected the worldwide increase in ambient concentrations resulting from the proliferation of nuclear technology.

As in the past, tritium concentrations in atmospheric moisture samples collected at all off-NTS stations and at the NTS stations at Mercury and Area 51 were generally below the minimum detectable concentration (MDC) of about 4×10^{-7} $\mu Ci/mL$ water, except for occasional detectable concentrations. All detectable concentrations observed at off-NTS stations were considered to be representative of the environmental background. A few of the values above the MDC at Area 51

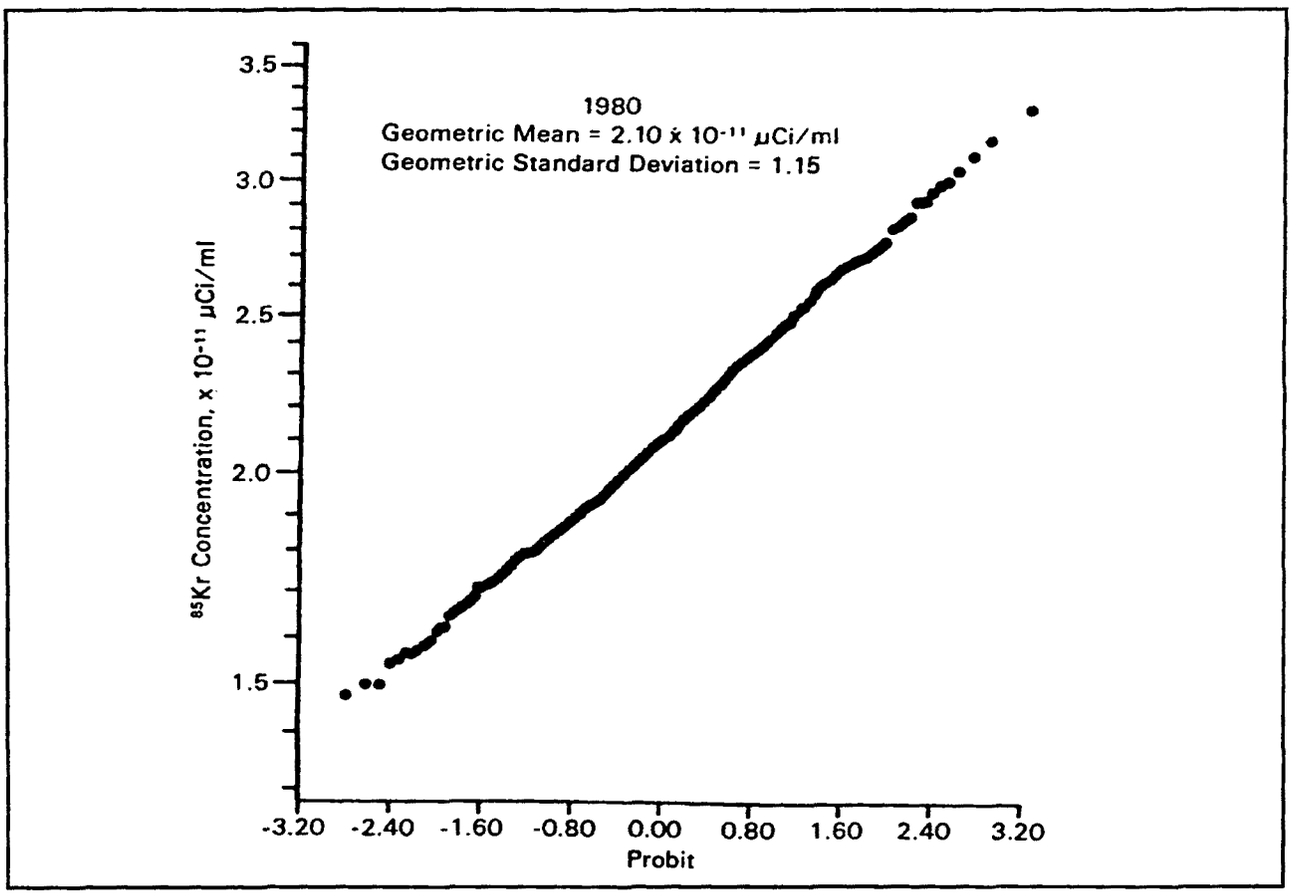

Figure 9. Distribution of Network Concentration of Krypton-85.

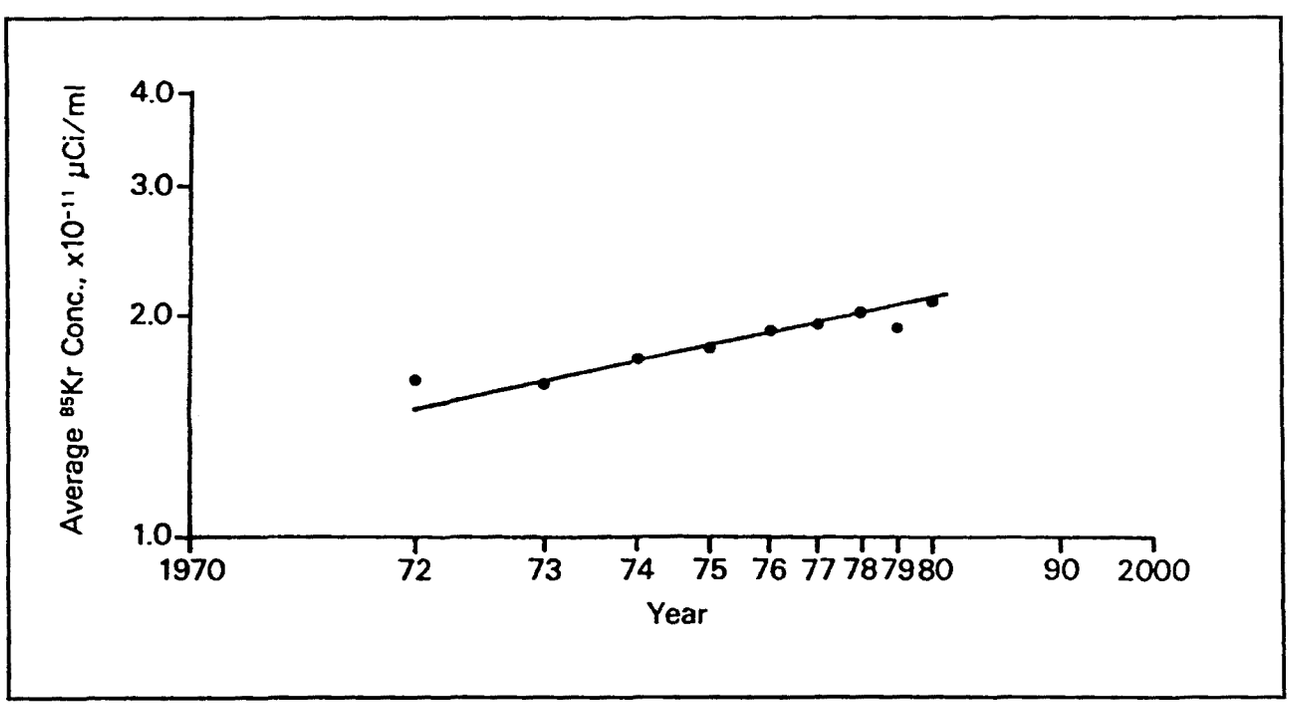

Figure 10. Trend in Annual Network Concentrations of Krypton-85.

and Mercury appeared to be slightly above the environmental background which fluctuated up to 3×10^{-6} μCi/mL. The NTS stations at Area 51, BJY, and Area 12 had tritium concentrations consistently above background; the concentration average for these stations were factors of 1.7 to 17 times the average for all off-NTS stations.

DOSE ASSESSMENT

The only radioactivity detected in an offsite populated area was xenon-133 (1.7×10^{-9} μCi·h/mL) and xenon -135 (1.8×10^{-8} μCi·h/mL) in a compressed air sample collected at Lathrop Wells, Nevada, during the period September 24 to 26 following the Riola test.

The estimated dose equivalent to the whole body of a hypothetical receptor at Lathrop Wells from the exposure to the would have been

$$\frac{1.97 \times 10^{-8} \text{ μCi·h/mL) (500 mrem/year)}}{10^{-7} \text{ μCi/mL) (8,760 hours/year) (1 mrem/1,000 μrem)}} = 11 \text{ μrem}$$

This dose equivalent was 0.006 percent of the radiation protection standard (170 mrem per year) for a suitable sample of the general population.

Based upon a population of 65 at Lathrop Wells, the estimated population dose for the area was 0.00072 person-rem. As this area was within 80 km of the center of the NTS, the 80 km population dose would be the same. This dose was small compared to the 6.2 person-rem that residents of Lathrop Wells received from natural background radiation during this report period.

1981

AIRBORNE RELEASES OF RADIOACTIVITY AT THE NTS DURING 1981

All nuclear detonations during 1981 were conducted underground and were contained, although occasional releases of low-level radioactivity occurred during re-entry drilling. Table 16 shows the total quantities of radionuclides released to the atmosphere, as reported by the DOE Nevada Operations Office (1982).

Table 17. Total Airborne Radionuclide Emissions at the NTS - 1981

Radionuclide	Half-Life (days)	Quantity Released (Ci)
Tritium	4,500	534
Iodine	8.04	0.05
Xenon-133	5.29	2,700
Xenon-133m	2.33	29
Xenon-135	0.38	142
Total		3,405.05

Network Design--

There were several sources of the radionuclides monitored by this network. Noble gases were emitted from nuclear power plants, propulsion reactors, reprocessing facilities and nuclear explosions. Tritium was emitted from the same sources and is also produced naturally. The monitoring network was affected by all these sources, but had to be able to detect NTS emissions. For this purpose the samplers were located close to the NTS and particularly in drainage-wind channels leading from the test areas. In 1981 this network included ten stations around the NTS as well as six stations onsite as shown in Figure 11.

Results--

All results are shown in Appendix A as the maximum, minimum, and average concentration for each station. These data indicate that no radioactivity from NTS tests was detected offsite by the Noble Gas and Tritium Surveillance Network during 1981. However, radioactive xenon-133 was detected four times onsite at the BJY station. Those samples containing xenon-133 are listed in Table 17 with their associated krypton-85 results. All of these concentrations were less than 0.02 percent of the concentration guide for occupational exposures from xenon-133.

As shown in Figure 12, the concentrations of krypton-85 within the whole network appeared to have a bimodal distribution with three values not fitting the distribution. The samples from which these three values were measured were the first three samples listed in Table 18.

As these three values did not fit the distribution for the whole network and two of them also contained xenon-133, they were attributed to nuclear testing operations at the NTS. The bimodal distribution suggested that two sources of krypton-85 with different averages were sampled. The distribution with the lower modal concentration near 22 pCi/m^3 was possibly from worldwide ambient concentrations resulting from nuclear power generation and nuclear fuel processing. The source of the other distribution was not known, but was not attributed to nuclear testing at NTS due to the fact that the same bimodal distribution was observed at all network stations both onsite and offsite. The weighted average concentration of krypton-85 at all offsite stations that

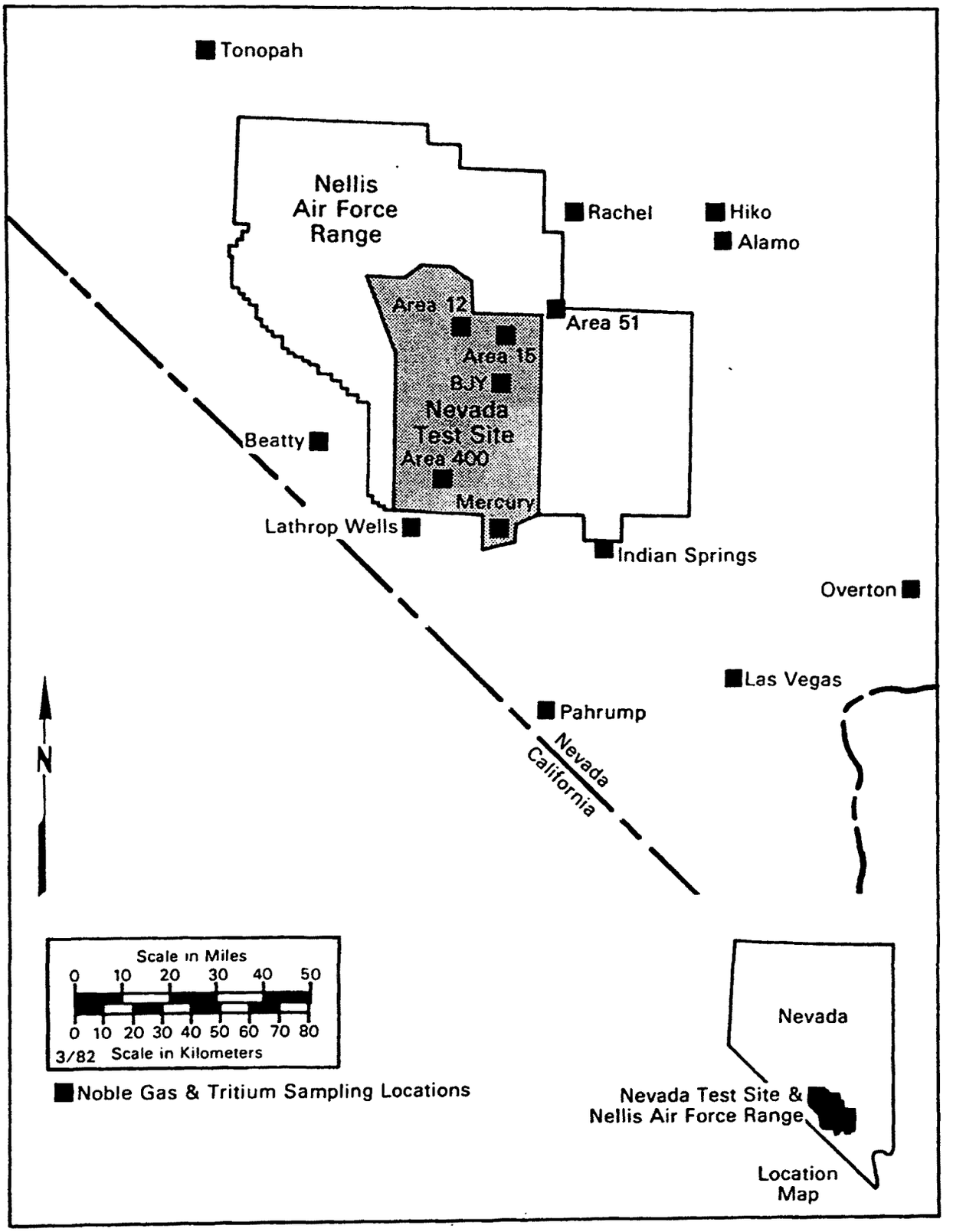

Figure 11. Noble Gas and Tritium Surveillance Network Sampling Locations - 1981

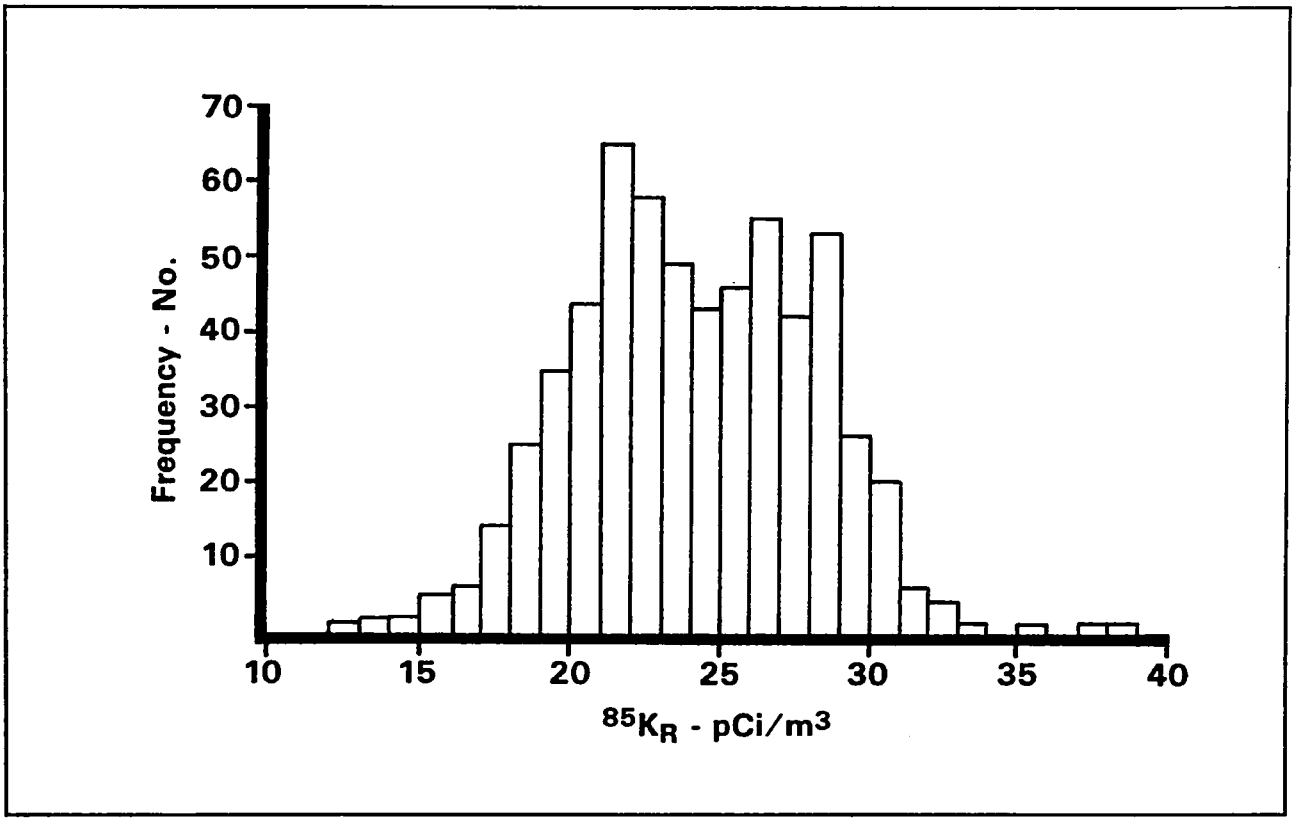

Figure 12. Frequency Distribution of Krypton-85 Concentration in Air - 1981

Table 18. BJY Compressed Air Samples Containing High Concentrations

Collection Period				Concentration - pCi/m^3		
Date and Time ON		Date and Time OFF		Xe-133		Kr-85
02/18	1200	02/24	1025		<20	37 ± 3
03/241	1500	08/31	1500	1,500	± 22	35 ± 3
09/08	1342	09/12	0815	26	± 9	39 ± 6
09/12	0815	09/14	1500	310	± 25	(Lost)
11/17	1335	11/23	1505	340	± 10	25 ± 4

operated throughout the year was 24 pCi/m^3. During 1980 the concentrations of krypton-85 were lognormally distributed with an average concentration of 21 pCi/m^3.

The rate of increase of ambient krypton-85 concentrations seemed to have accelerated in 1981. This was consistent with projections (Bernhardt, et al., 1973) of rapidly increasing concentrations. However, the measured network average in 1981 was only about 25 percent of the projected value of 99 pCi/m3. Since nuclear fuel reprocessing was the primary source of

krypton-85, the decision of the United States to defer fuel reprocessing may be one reason why krypton-85 levels have not increased as fast as predicted.

Using published data for krypton-85 concentration in air (NCRP 1975) and the data from our network (Table 19), the change over time was plotted as shown in Figure 13. Linear correlation analysis indicated that the krypton concentration/time relation was $pCi/m^3 = 5.8 + 0.8\ t$, where t was number of years after 1960.

As in the past, tritium concentration in atmospheric moisture samples from the off-NTS stations were generally below the minimum detectable concentration (MDC) of about 400 pCi/L water (Appendix A). The tritium concentrations observed at off-NTS stations were considered to be representative of environmental background. Several stations on the test site had tritium concentrations consistently above background; the concentration averages for Area 15, BJY, and Area 12 were approximately 10 times the average for the offsite stations but were still less than 0.01 percent of the appropriate CG.

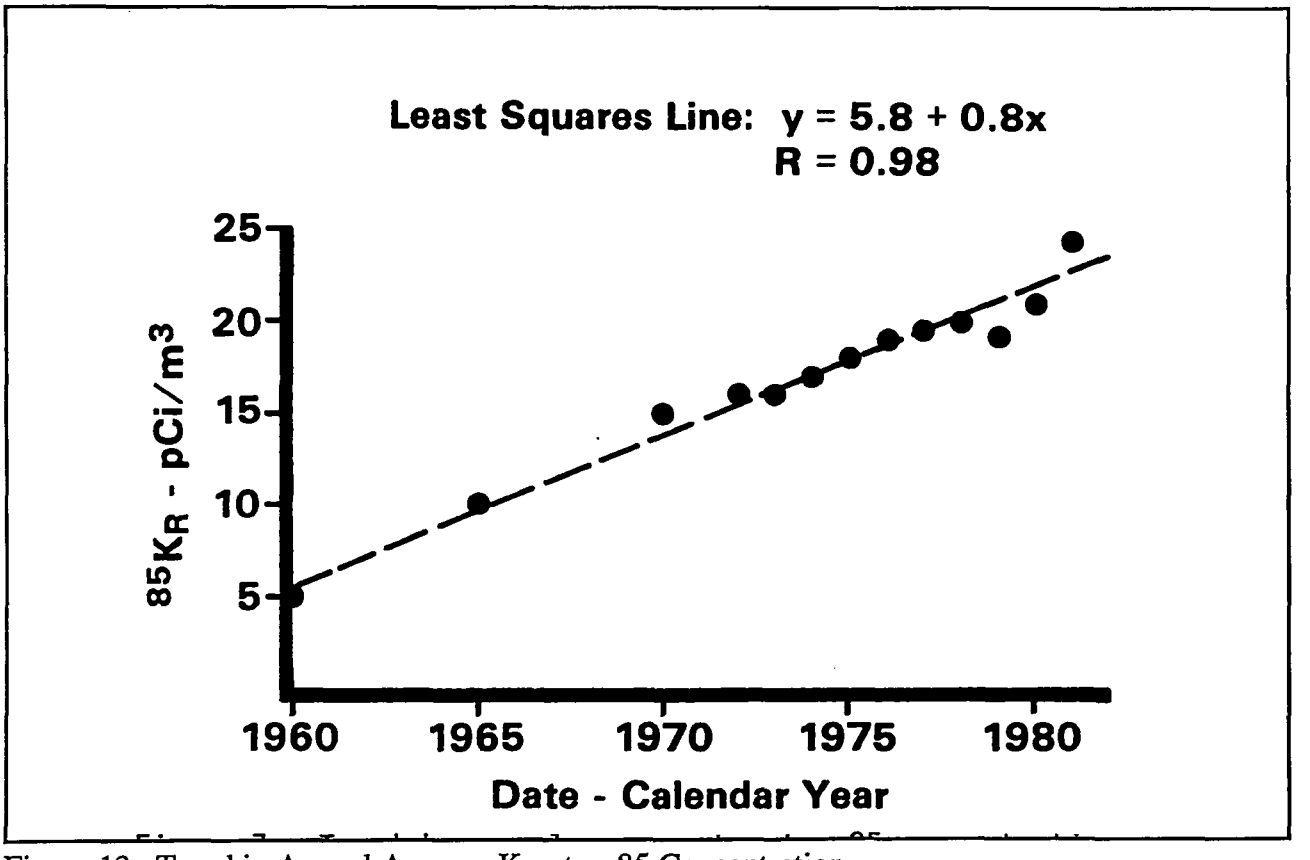

Figure 13. Trend in Annual Average Krypton-85 Concentration.

The distribution of all the measurements of tritium in atmospheric moisture for the whole network consisted of possibly two lognormal distributions with different means and standard deviations. All the tritium concentrations above background were measured in samples collected at the onsite stations. The geometric mean of the tritium concentration for all offsite stations was evaluated as 170 pCi/L of moisture, which was below the minimum detectable concentration of about 400 pCi/L. The geometric standard deviation for the mean was determined to be 1.72.

Table 19. Annual Average Krypton-85 Concentration in Air 1972-1981

Sampling Locations	^{85}Kr Concentrations (pCi/m^3)									
	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Alamo, NV†	--	--	--	--	--	--	--	--	--	27
Beatty, NV	16	16	17	19	20	20	20	19	21	24
Diablo and Rachel, NV‡	16	16	17	18	19	19	20	19	21	24
Hiko, NV	16	26	27	27	27	29	20	19	21	24
Indian Springs, NV	--	--	--	20	20	20	20	19	21	24
NTS, Mercury, NV	16	16	18	18	19	20	20	19	21	23
NTS, Area 51, NV	16	16	17	18	20	19	20	19	21	24
NTS, BJY, NV	17	18	19	19	20	21	22	21	23	26
NTS, Area 12, NV	16	16	18	18	20	19	20	19	21	24
Tonopah, NV	16	16	18	17	19	19	20	18	21	25
Las Vegas NV	16	16	17	18	18	20	20	--	--	24
Death Valley Jct., Calif.*	16	15	18	17	20	20	20	19	--	--
NTS, Area 15, NV	--	--	--	--	--	--	--	19	21	25
NTS, Area 400, NV	--	--	--	--	--	--	--	18	21	23
Lathrop Wells, NV	--	--	--	--	--	--	--	19	21	24
Pahrump, NV†	--	--	--	--	--	--	--	--	--	23
Overton, NV†	--	--	--	--	--	--	--	--	--	26
Network Average	16	16	18	18	19	20	20	19	21	24

*Removed 1979
†New stations
‡Station at Diablo was moved to Rachel in March 1979.

Table 20. Radiochemical Detection Limits

Type of Analysis	Analytical Equipment	Counting Period (min)	Analytical Procedures	Sample Size	Approximate Detection Limit*
^{85}Kr, ^{133}Xe, ^{135}Xe	Automatic liquid scintillation counter with output printer	200	Physical separation by gas chromatography; dissolved in toluene "cocktail" for counting.	0.4-1.0 m^3 for air	^{85}Kr, ^{133}Xe, ^{135}Xe = 4 pCi/m^3

* The detection limit for all samples received after January 1, 1978 was defined as 3.29 sigma equals the counting error of the sample and Type I error - Type II error = 5 percent. (Corley, J. P., D. H. Denham, D. E. Micheles, A. R. Olsen and D. A. Waite, "*A Guide for Environmental Radiological Surveillance at ERDA Installations,*" ERDA 77024 pp. 3.19-3.22, March, 1977, Energy Research and Development Administration, Division of Safety, Standards and Compliance, Washington, D. C.)

DOSE ASSESSMENT

Doses were calculated for an average adult living in Nevada based on the Kr-85, Sr-90, Cs-137 and Pu-239 detected by the monitoring networks. Using conservative assumptions, the estimated dose would have been less than 0.5 mrem per year, a small fraction of the variation of 10 mrem per year due to the natural radionuclide content of the body. Since no radioactivity originating on the NTS was detectable offsite, no dose assessment related to NTS activities could be made.

1982

All nuclear detonations during 1982 were conducted underground and were contained, although occasional releases of low-level radioactivity occurred during re-entry drilling. Table 21 shows the total quantities of radionuclides released to the atmosphere, as reported by the DOE Nevada Operations Office (1983). Because these releases occurred throughout the year, and because of the distance from the points of releases to the nearest sampling station no tritium or noble gases above background were detected offsite.

Table 21. Total Airborne Radionuclide Emissions at the NTS - 1982

Radionuclide	Half-Life (days)	Quantity Released (Ci)
Tritium	4,500	165
Iodine	8.04	0.0001
Xenon-133	5.29	74
Xenon-133m	2.33	25
Xenon-135	0.38	42
Total		306.0001

Network Design--

There were several sources of the radionuclides monitored by this network, Noble gases were emitted from nuclear power plants, propulsion reactors, reprocessing facilities and nuclear explosions. Tritium was emitted from the same sources and was also produced naturally. The monitoring network was affected by all these sources, but was able to detect NTS emissions. In 1982 this network consisted of 16 stations as shown in Figure 14.

Results--

All results are shown in Appendix A as the maximum, minimum, and average concentration for each station. These data indicate that no radioactivity from NTS tests was detected offsite by the Noble Gas and Tritium Surveillance Network during 1982. The average concentrations at all network stations ranged from 24 to 26 pCi/m^3. Additional samples were collected at Canfield's Ranch (Adaven), Reveille Project (near Warm Springs), Twin Springs Ranch, and Hiko to monitor a deliberate release of gaseous radioactivity from a tunnel experiment on the NTS on September 24, 1982. However, no radioactivity was detected.

As shown in Figure 15, the concentrations of krypton-85 within the whole network appeared to have a skewed distribution. The lognormal distribution had a geometric mean of 24 pCi/m^3 and a geometric standard deviation of 1.15.

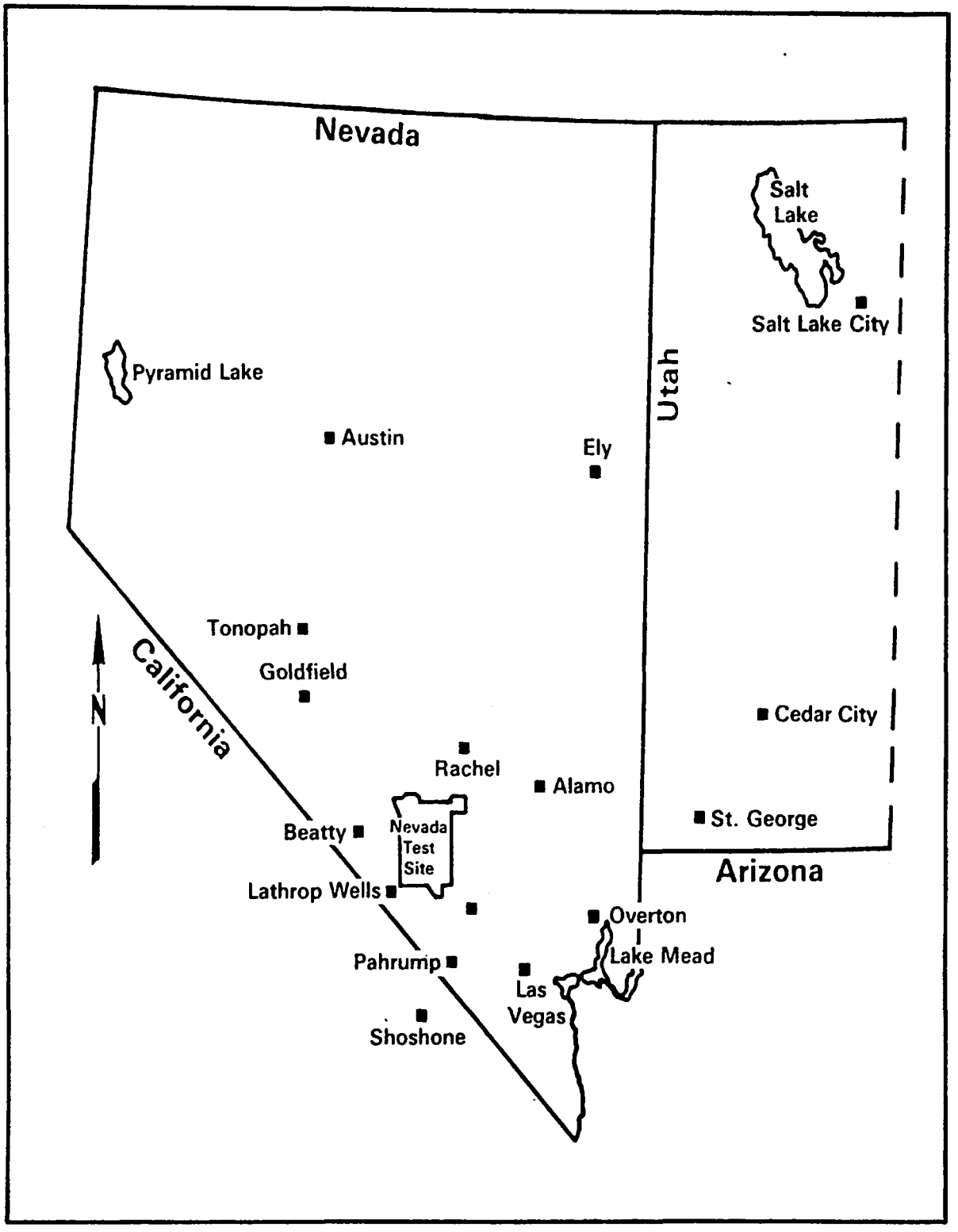

Figure 14. Noble Gas and Tritium Surveillance Network Sampling Locations - 1982

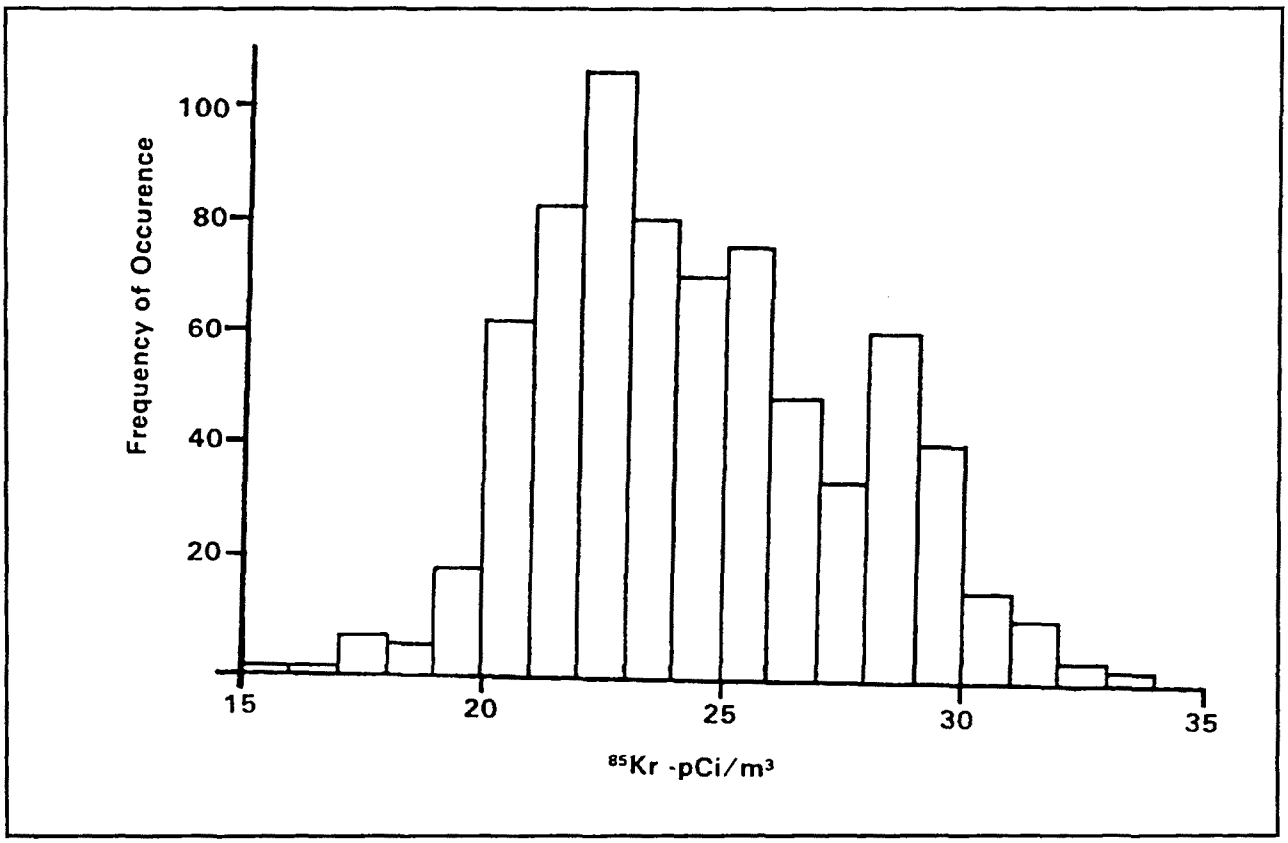

Figure 15. Frequency Distribution of Krypton-85 Concentration in Air - 1982

As shown in Table 22, and Figure 16, the average concentration of krypton-85 for the whole network had gradually increased since sampling began in 1972. This increase, observed at all stations, reflects the worldwide increase in ambient concentrations resulting from the increased use of the nuclear technology. The increase in ambient krypton-85 concentration was projected by Bernhardt, et al., (1973). However, the measured network average in 1982 was only about 25 percent of the 99 pCi/m^3 predicted by Bernhardt.

Table 22. Annual Average Krypton-85 Concentration in Air 1973 - 1982

Sampling Locations	^{85}Kr Concentrations (pCi/m^3)									
	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Alamo, NV†	--	--	--	--	--	--	--	--	27	24
Austin, NV†	--	--	--	--	--	--	--	--	--	24
Beatty, NV	16	17	19	20	20	20	19	21	24	25
Diablo and† Rachel, NV	16	17	18	19	19	20	19	21	24	26
Ely, NV†	--	--	--	--	--	--	--	--	--	24
Goldfield, NV†	--	--	--	--	--	--	--	--	--	25
Hiko, NV	26	27	27	27	29	20	19	21	24	26
Indian Springs, NV	--	--	20	20	20	20	19	21	24	24
NTS, Mercury, NV	16	18	18	19	20	20	19	21	23	--
NTS, Area 51, NV	16	17	18	20	19	20	19	21	24	--
NTS, BJY, NV	18	19	19	20	21	22	21	23	26	--
NTS, Area 12, NV	16	18	18	20	19	20	19	21	24	--
Tonopah, NV	16	18	17	19	19	20	18	21	25	24
Las Vegas NV	16	17	18	18	20	20	--	--	24	24
Death Valley Jct., Calif.*	15	18	17	20	20	20	19	--	--	--
NTS, Area 15, NV	--	--	--	--	--	--	19	21	25	--
NTS, Area 400, NV	--	--	--	--	--	--	18	21	23	--
Lathrop Wells, NV	--	--	--	--	--	--	19	21	24	24
Pahrump, NV†	--	--	--	--	--	--	--	--	23	24
Overton, NV†	--	--	--	--	--	--	--	--	26	24
Cedar City, Ut.†	--	--	--	--	--	--	--	--	--	25
St. George, Ut.†	--	--	--	--	--	--	--	--	--	24
Salt Lake City, Ut.†	--	--	--	--	--	--	--	--	--	25
Network Average	16	18	18	19	20	20	19	21	24	24

*Stations discontinued

†New stations

‡Station at Diablo was moved to Rachel in March 1979.

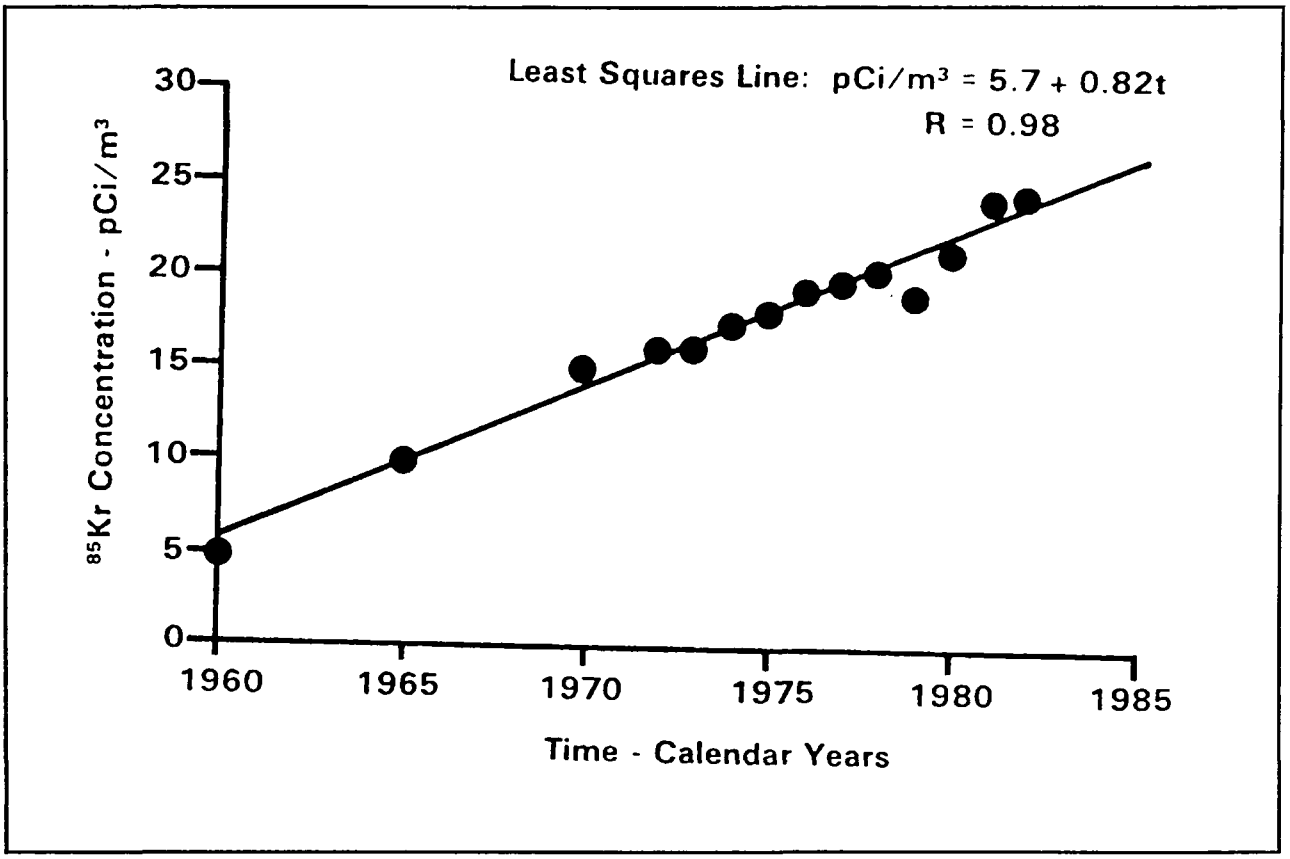

Figure 16. Trend in annual average krypton-85 concentration.

1983

AIRBORNE RELEASES OF RADIOACTIVITY AT THE NTS DURING 1983

All nuclear detonations during 1983 were conducted underground and were contained, although occasional releases of low-level radioactivity occurred during re-entry drilling. Table 23 shows the total quantities of radionuclides released to the atmosphere, as reported by the DOE Nevada Operations Office (1984). Because these releases occurred throughout the year, and because of the distance from the points of releases to the nearest sampling station, none of the radioactive nuclides listed in this table were detected offsite.

Table 23. Total Airborne Radionuclide Emissions at the NTS - 1983

Radionuclide	Half-Life (days)	Quantity Released (Ci)
Tritium	4,500	98.2
Iodine-131	8.04	1×10^{-5}
Iodine-135	0.27	3×10^{-5}
Xenon-133	5.29	26.6
Xenon-133m	2.33	1.5
Xenon-135	0.38	28.9
Total		155.20004

During 1983 the Noble Gas and Tritium Surveillance Network consisted of 16 stations as shown in Figure 17.

Results --

All results are shown in Appendix A . These data indicate that no radioactivity from NTS tests was detected offsite by the Noble Gas and Tritium Surveillance Network during 1983. The average concentrations of krypton-85 at all network stations ranged from 23 to 27 pCi/m^3. The lognormal distribution has a geometric mean of 24 pCi/m^3 and a geometric standard deviation of 1.15.

As in the past, tritium concentrations in atmospheric moisture samples from the off-NTS stations were generally below the minimum detectable concentration (MDC) of about 400 pCi/L water (Appendix A). The tritium concentrations observed at off-NTS stations were considered to be representative of environmental background. The geometric mean of the tritium concentrations for all offsite stations was evaluated as 0.08 pCi/mL of moisture, which was below the minimum detectable concentration of about 0.4 pCi/mL. The geometric standard deviation for the mean was determined to be 1.5.

QUALITY ASSURANCE PROCEDURES
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 consisted of the analysis of duplicate or replicate samples from the NGTSN. The NGTSN samples were generally split for analysis.

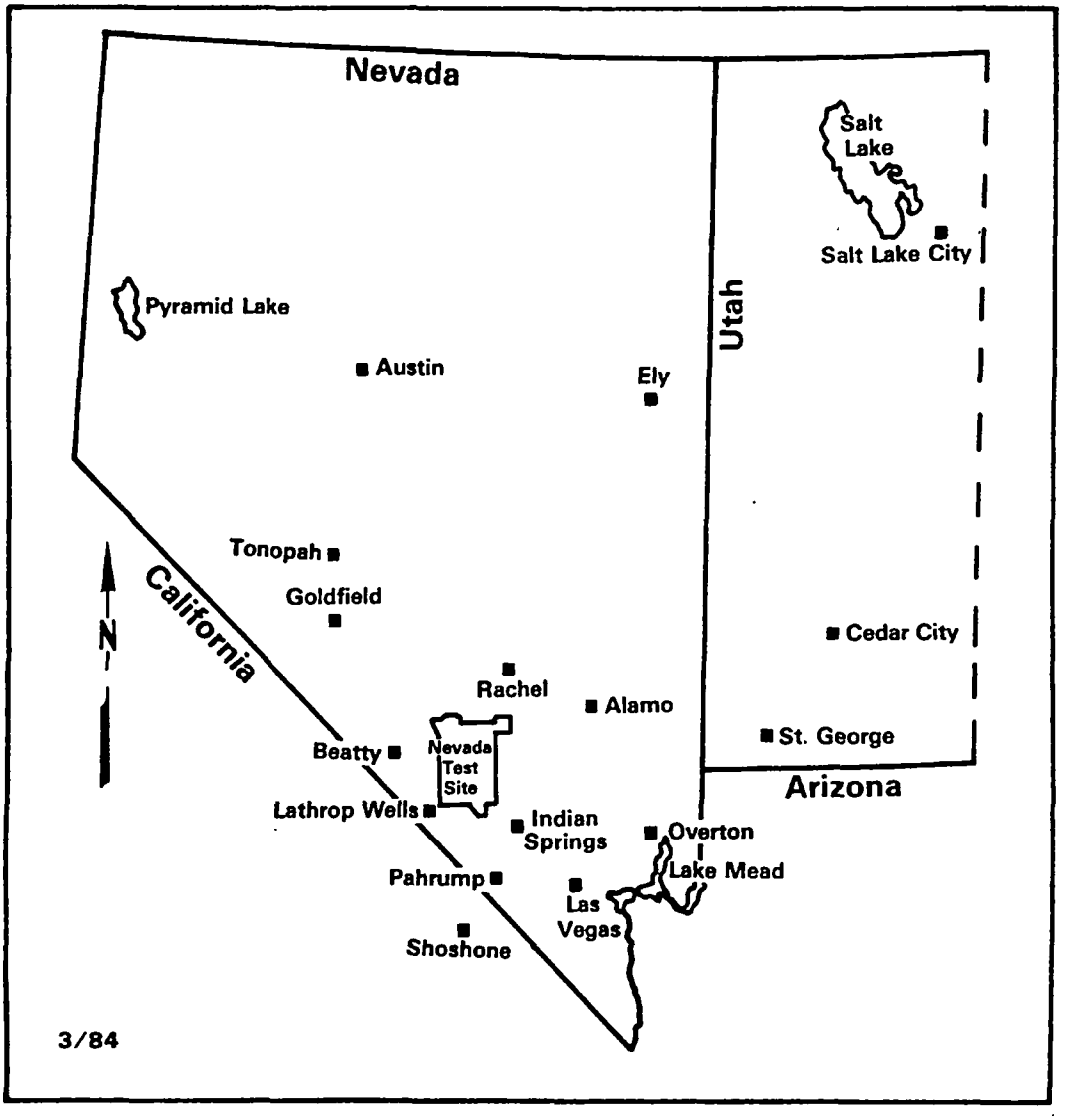

Figure 17. Noble Gas and Tritium Surveillance Network Sampling Locations - 1983

Table 24. Samples and Analyses for Duplicate Sampling Program - 1983

Surveillance Network	Number of Sampling Locations	Sets of Samples Collected Per Year	Duplicate Samples Collected	Number Per Set	Sample Analysis
NGTSN	16	824 (NG) 829 (H^3)	47 57	2	Kr-85, H-3 H_2O, HTO

Table 25. Sampling and Analytical Precision - 1983

Surveillance Network	Analysis	Sets of Replicate Samples Evaluated	Coefficient of Variation (%)
NGTSN	Kr-85	18	14
	HTO	*	24
	H_2O	48	23

*Estimate of precision was calculated from the errors in the H-3 conventional analysis and the measurement of atmospheric moisture (H_2O).

ACCURACY OF ANALYSIS

Data from the analysis of intercomparison samples were statistically analyzed and compared to known values and values obtained from other participating laboratories. A summary of the statistical analysis is given in Table 25, which compares the mean of three replicate analyses with the known value. The normalized deviation was a measure of the accuracy of the analysis when compared to the known concentration. If the value of this parameter (in multiples of standard normal deviate, unitless) was between control limits of -3 and +3, the precision or accuracy of the analysis was within normal statistical variation. However, if the parameters exceed these limits, one must suspect that there was some cause other than normal statistical variation that contributed to the difference between the measured values and the known value. As shown by Table 26, all analyses were within the control limit.

Table 26. DOE Concentration Guides

Network or Program	Sampling Medium	Radio-nuclide	CG (pCi/m^3)	MDC as % of CG
Noble Gas and Tritium Surveillance Network	air	Kr-85	1.0×10^5	4.0×10^{-3}
		H-3	6.7×10^4	6.0×10^{-1}
		Xe-133	1.0×10^5	4.0×10^{-0}
		Xe-135	3.3×10^4	1.2×10^{-2}

DOSE ASSESSMENT

Since no radioactivity originating on the NTS was detectable offsite, no dose assessment related to NTS activities could be made. However, atmospheric dispersion calculations, based on known emissions from the NTS, indicate that the population dose within 80 km of CP-1 was about 5×10^{-5} person-rem for 1983.

1984

All nuclear detonations during 1984 were conducted underground and were contained, although occasional releases of low-level radioactivity occurred during re-entry drilling or seepage, through fissures in the soil. Table 27, shows the total quantities of radionuclides released to the atmosphere, as reported by the DOE Nevada Operations Office (1985). Because these releases occurred throughout the year, and because of the distance from the points of releases to the nearest sampling station, none of the radioactive nuclides listed in this table were detected offsite. In 1984 this network consisted of the same 16 stations as shown for 1983 in Figure 17 (see page 53).

Table 27. Total Airborne Radionuclide Emissions at the NTS 1984

Radionuclide	Half-Life (days)	Quantity Released (Ci)
Tritium	4,500	197
Argon-37	35.1	9.6
Krypton-83m	0.08	21.3
Krypton-85m	0.19	34
Krypton-87	0.05	0.8
Xenon-133	5.24	160
Xenon-133m	2.2	8.5
Xenon-135	0.38	1297
Xenon-135m	0.00018	156
Total		1884.2

Results--

All results are shown in Appendix A. These data indicate that no radioactivity from NTS tests was detected offsite by the Noble Gas and Tritium Surveillance Network during 1984. The average concentrations of krypton-85 at all network stations ranged from 25 to 29 pCi/m^3.

As in the past, tritium concentrations in atmospheric moisture samples from the off-NTS stations were generally below the minimum detectable concentration (MDC) of about 400 pCi/L water (Appendix A). The tritium concentrations observed at off-NTS stations were considered to be representative of environmental background. The geometric mean of the tritium

concentrations for all offsite stations was evaluated as 0.018 pCi/mL of moisture, which is below the minimum detectable concentration of about 0.4 pCi/mL. The geometric standard deviation for the mean was determined to be 1.5.

Table 28. Sampling and Analytical Precision - 1984

Surveillance Network	Analysis	Sets of Replicate Samples Evaluated	Coefficient of Variation (%)
NGTSN	Kr-85	26	15
	HTO	*	26
	H_2O	29	24

*Estimate of precision was calculated from the errors in the H-3 conventional analysis and the measurement of atmospheric moisture (H_2O).

DOSE ASSESSMENT

Doses were calculated for an average adult living in Nevada based on the Kr-85, Sr-90, Cs-137, and Pu-239 detected by the monitoring networks. Using conservative assumptions, the estimated dose would have been less than 0.6 mrem per year, a small fraction of the variation of 10 mrem per year due to the natural radionuclide content of the body. Since no radioactivity originating on the NTS was detectable offsite, no dose assessment related to NTS activities could be made. However, atmospheric dispersion calculations, based on known emissions from the NTS, indicated that the population dose within 80 km of CP-1 was about 1 x 10^{-3} person-rem for 1984.

1985

Table 29. Total Airborne Radionuclide Emissions at the NTS - 1985

Radionuclide	Half-Life (days)	Quantity Released (Ci)
Tritium	4500	116
Argon-37	35.1	9.0
Krypton-85	3920	17
Xenon-133	5.24	734.9
Xenon-133 m	2.2	8.3
Xenon-135	0.38	28.9
Iodine-131	8.07	0.007
Iodine-133	0.87	0.042
Iodine-135	0.28	0.042
Total		914.191

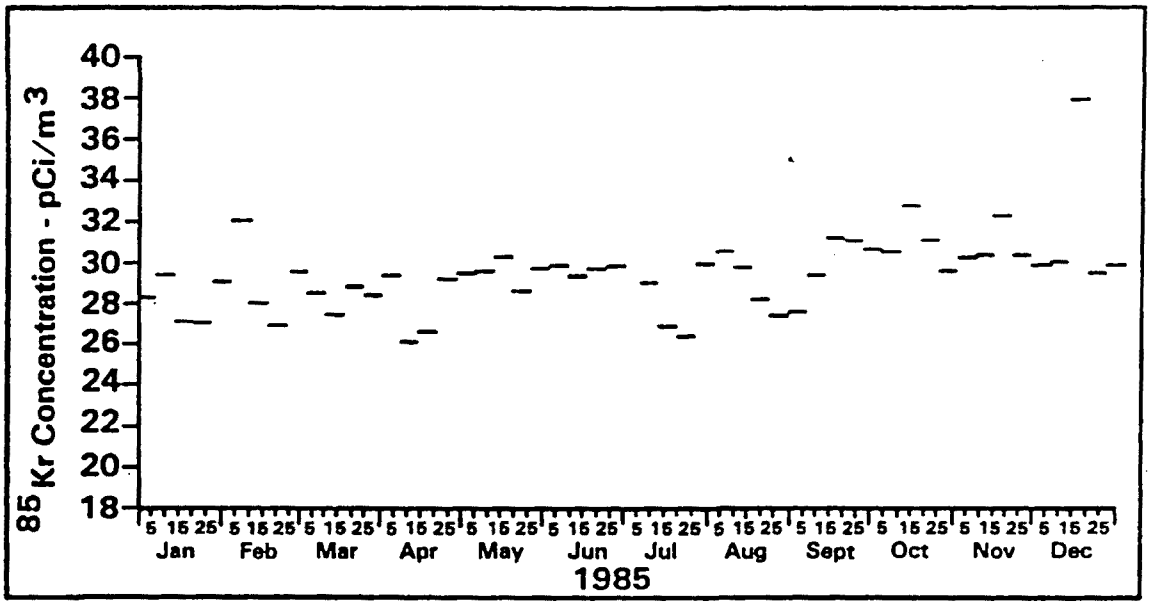

Figure 18. Weekly Average Krypton-85 Concentration in Air - 1985

Results--

The results from the samples collected by the NGTSN are shown in Appendix A. The average krypton-85 concentration per station ranged from 29 to 31 pCi/m^3. The concentration over the whole network appeared to have a normal distribution with a mean of 29.4 pCi/m^3 (1.1 Bq/m^3) and a standard deviation of 3.2. The weekly averages for the network are shown in Figure 18.

As in the past, tritium concentrations in atmospheric moisture samples from the off-NTS stations were generally below the minimum detectable concentration (MDC) of about 400 pCi/L water (Appendix A). The tritium concentrations observed at off-NTS stations were considered to be representative of environmental background. The mean of the tritium concentrations for all offsite stations was 0.43 pCi/m^3 (16 mBq/m^3) of air. Only six of the 857 collected samples were above the MDC.

DOSE ASSESSMENT

Doses were calculated for an average adult living in Nevada based on the Kr-85, Sr-90, HTO, and Pu-239 detected by the monitoring networks. Using conservative assumptions, the estimated dose was about 0. 14 mrem/yr (1.4 μSv/yr), a small fraction of the variation of 10 mrem/yr due to the natural radionuclide content of the body. The only NTS-related radioactivity detected during 1985 was xenon-133 collected in a noble gas sampler placed at Rachel during the tunnel ventilat-ion following the Misty Rain test. The concentration of 11 pCi/m^3 for the 24-hour sample was not detectable on the normal noble gas sampler. This concentration would have caused a dose of 0.06 μrem to a person outdoors for the 24 hours. Otherwise, no radioactivity

originating on the NTS was detectable by the monitoring networks so no dose assessment could be made on the reported emissions. However, atmospheric dispersion calculations, based on those emissions, indicated that the highest individual dose would have been 40 nanorem (4×10^{-7} mSv) and the dose to the population within 80 km of CP-1 would have been 2×10^{-4} person-rem (2×10^{-6} person-Sv).

Other than the Xe-133 detected during the planned ventilation of the tunnel following the Misty Rain event, none of the radionuclides released at the NTS as listed in Table 29 were detected offsite. The normal one week noble gas sample at Rachel had no detectable xenon so that the 11 pCi/m^3 detected on the one day sample at Rachel (as stated in the section on Special Test Support) probably was valid only for that day. The skin dose from that concentration would have been about 0.06 μrem or about 0.002% of the background exposure measured by the PIC at Rachel.

Only tritium (116 Ci) and Xe-133 (735 Ci) were released in airborne emissions in significant quantities. Since human exposure to these nuclides was straight-forward, a simple atmospheric dispersion calculation sufficed. AIRDOSE-RADRISK, which calculates exposure resulting from multiple transport pathways, was inappropriate for those cases, where a single pathway predominated. The atmospheric dispersion calculation yielded a maximum individual dose of 4×10^{-5} mrem (4×10^{-7} mSv) and a population dose, to the 6500 people living within 80 km of CP-1, of 2×10^{-4} person-rem (2×10^{-6} person-Sv).

As confirmation of the above results, an AIRDOSE run using the effluents listed in Table 29 yielded a maximum individual dose of 4.2×10^{-5} mrem and a population dose of 1.3×10^{-4} person-rem, an insignificant difference from the atmospheric dispersion calculation.

1986

The noble gas and tritium sampling network (NGTSN) consisted of 17 stations offsite (off the NTS and exclusion areas) in 1986. Krypton-85 concentrations in the Noble Gas and Tritium Sampling Network, averaged 25 pCi/m^3 (0.9 Bq/m^3) consistent with the levels determined since 1981 (Table 29). Krypton-85 concentrations reported previously for 1984-86 were changed in this report to correct an error in the calibration source. Xenon-133 was found in 45 samples with a maximum of 730 pCi/m^3 (26 Bq/m^3) occurring at Groom Lake, Nevada, during the purging of the tunnel in which the Mighty Oak test was conducted. In about 32 of these samples the xenon-133 is attributed to the air emissions from the Chernobyl reactor.

All nuclear detonations during 1986 were conducted underground and were contained, although occasional releases of low-level radioactivity occurred during re-entry drilling, seepage through fissures in the soil or purging of tunnel areas. Table 30 shows the total quantities of radionuclides released to the atmosphere, as reported by the DOE Nevada Operations Office (DOE87). Because these releases occurred throughout the year and because of the distance from the points of releases to the nearest sampling station, only three times any radioactive material detected offsite. Twice when debris from the Chernobyl reactor accident arrived in the Western U. S. and after the tunnel purging following the Mighty Oak test. The maximum activity

detected in air offsite was 430 ± 15 picocuries of ^{133}Xe per cubic meter of air at Medlins Ranch, Nevada. The maximum iodine level detected offsite was 4.6 picocuries of ^{131}I per cubic meter of air at Twin Springs Ranch, Nevada. This was assumed to be attributable to the Chernobyl nuclear accident in the Soviet Union.

Results--

The results from the samples collected by the NGTSN are shown in Appendix A as the maximum, minimum, and average concentration for each station. The average krypton-85 concentration per station ranged from 24 to 26 pCi/m^3. The concentration over the whole network appeared to have a normal distribution with a mean of 25.0 pCi/m^3 (0.92 Bq/m^3) and a standard deviation of 0.5. The weekly averages plus and minus one standard deviation for the network are shown in Figure 19. During the second quarter of 1986 the krypton-85 calibration source was found to be in error. Investigation showed this problem has affected results since 1984. The data in Table 31 has been corrected and replaces all published data for 1984 through 1986. The new values were one to three pCi/m^3 lower than reported previously. The master database has also been corrected. This network average concentration, as shown in Table 31, gradually increased since sampling began in 1972 until 1981.

Table 30. Total Airborne Radionuclide Emissions at the NTS - 1986

Radionuclide	Half-Life (days)	Quantity Released (Ci)
Tritium	4500	120.7
Krypton-85	3920	4.3
Xenon-133	5.24	36,000
Xenon-133m	2.2	0.058
Xenon-135	0.38	0.041
Iodine-131	8.07	2.4
Total		36,127.499

This increase, observed at all stations, reflected the worldwide increase in ambient concentrations resulting from the increased use of nuclear technology. The increase in ambient krypton-85 concentration was projected by Bernhardt, et al., (Be73). However, the measured network average in 1986 was only about 10 percent of the 250 pCi/m^3 (9 Bq/m^3) predicted by Bernhardt. The average concentrations had remained relatively constant since 1981.

Using published data for krypton-85 concentrations in air (NCRP75) and the data from our network (Table 31), the change over time was plotted as shown in Figure 20. Linear correlation analysis indicated that the krypton concentration/time relation was $pCi/m^3 = 6.4 + 0.76\ t$ where t is number of years after 1960. The correlation coefficient, R, is 0.98.

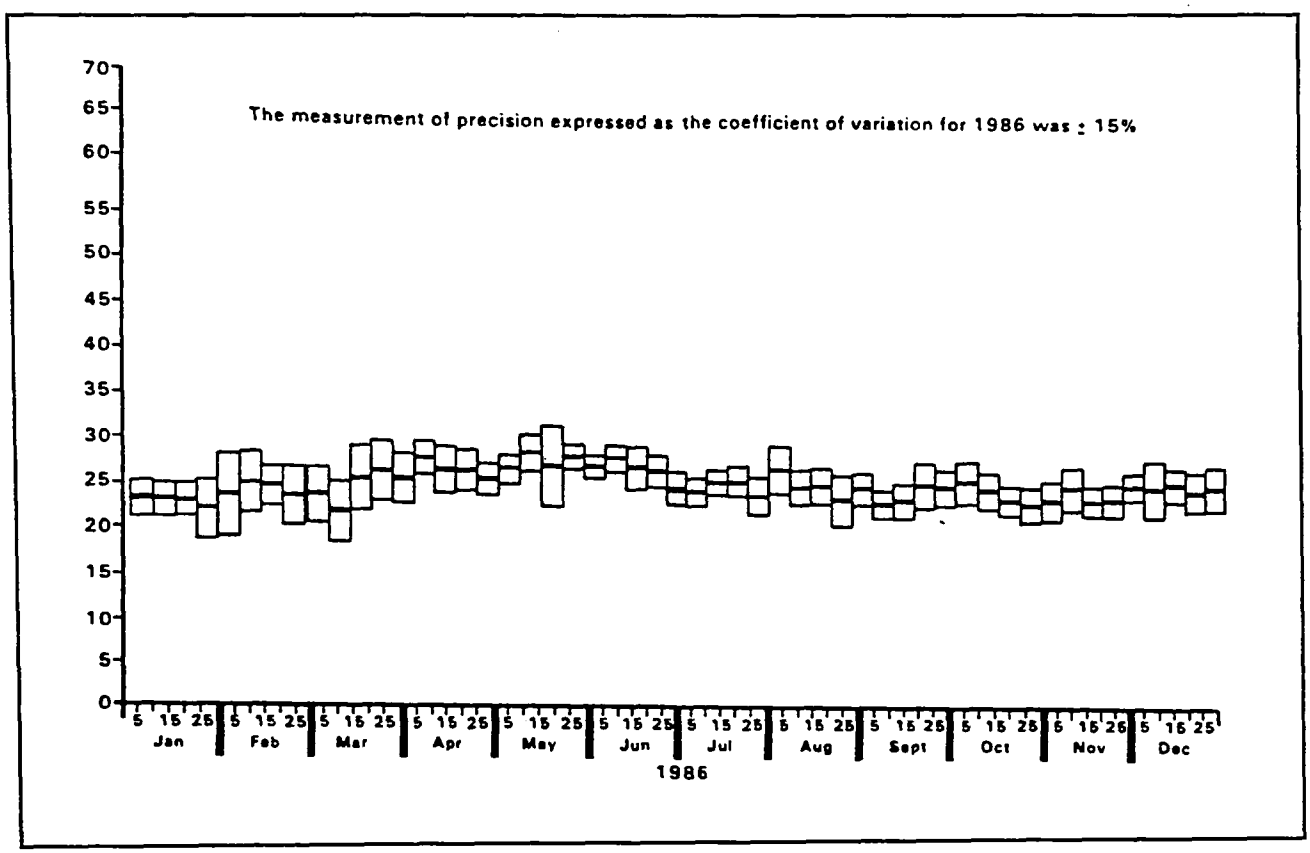

Figure 19. Weekly Average Krypton-85 Concentration in Air - 1986

Detectable levels of xenon-133 were found on three occasions: following a drillback in March, following the Mighty Oak tunnel purging in late April, and following the April accident at Chernobyl in the USSR. Appendix A, lists when and where each sample was collected, the xenon-133 concentration for each sample, and the percent of the concentration guide.

As in the past, tritium concentrations in atmospheric moisture samples from the off-NTS stations were generally below the minimum detectable concentration (MDC) of about 400 pCi/L water (Appendix A). The tritium concentrations observed at off-NTS stations were considered to be representative of environmental background. The mean of the tritium concentration for all offsite stations was 0.45 pCi/m^3 (17 mBq/m^3) of air. Only 11 of the 870 collected samples were above the MDC.

DOSE ASSESSMENT

During calendar year 1986 there were five sources of possible radiation exposure to the population of Nevada, all of which produced negligible exposure possibilities and one of which was due to an accident in a foreign country. The five sources were:

- Normal seepage of radioactivity from the NTS,
- Purging of radioactivity from the tunnel in which the Might Oak test was conducted,
- Radioactivity in migratory deer from drinking in contaminated ponds on the NTS,

° World-wide fallout of strontium in milk, of plutonium in cattle, and krypton-85 in air, and
° Airborne radioactivity from the reactor accident at Chernobyl, USSR.

Table 31. Annual Average Krypton-85 Concentrations in Air, 1976-1986***

Sampling Locations	Kr-85 Concentrations (pCi/m^3)										
	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Alamo, NV	--	--	--	--	--	27	24	25	24	24	24
Austin, NV	--	--	--	--	--	--	24	25	23	25	25
Beatty, NV	20	20	20	19	21	24	25	24	23	25	26
Diablo and Rachel, NV**	19	19	20	19	21	24	26	24	22	24	25
Ely, NV	--	--	--	--	--	--	24	25	22	24	26
Goldfield, NV	--	--	--	--	--	--	25	24	24	24	25
Hiko, NV*	17	19	20	19	21	24	26	--	--	--	--
Indian Springs, NV	20-	20	20	19	21	24	24	25	22	24	26
NTS, Mercury, NV*	19	20	20	19	21	23	--	--	--	--	--
NTS, Groom Lake, NV*	20	19	20	19	21	24	--	--	--	--	--
NTS, BJY, NV*	19	20	20	19	21	23	--	--	--	--	--
NTS, Area 12, NV*	20	19	20	19	21	24	--	--	--	--	--
Tonopah, NV	19	19	20	18	21	25	24	25	23	25	25
Las Vegas, NV	18	20	20	--	--	24	24	24	23	25	25
Death Valley Jct., CA*	20	20	20	19	--	--	--	--	--	--	--
NTS, Area 15, NV*	--	--	--	19	--	--	--	--	--	--	--
NTS, Area 400, NV*	--	--	--	18	21	25	--	--	--	--	--
Lathrop Wells, NV	--	--	--	19	22	24	24	26	22	24	25
Pahrump, NV	--	--	--	--	--	23	24	24	23	25	25
Overton, NV	--	--	--	--	--	26	24	25	23	24	25
Cedar City, UT	--	--	--	--	--	--	25	24	22	24	24
St. George, UT	--	--	--	--	--	--	24	25	23	24	24
Salt Lake City, UT*	--	--	--	--	--	--	25	25	25	25	--
Shoshone, CA	--	--	--	--	--	--	25	25	23	24	25
NETWORK AVERAGE	19	20	20	19	21	24	24	25	23	24	25

*Stations discontinued
** Station at Diablo was moved to Rachel in March 1979.
*** Note changes in 1984 and 1985 values due to new calibration, see text.

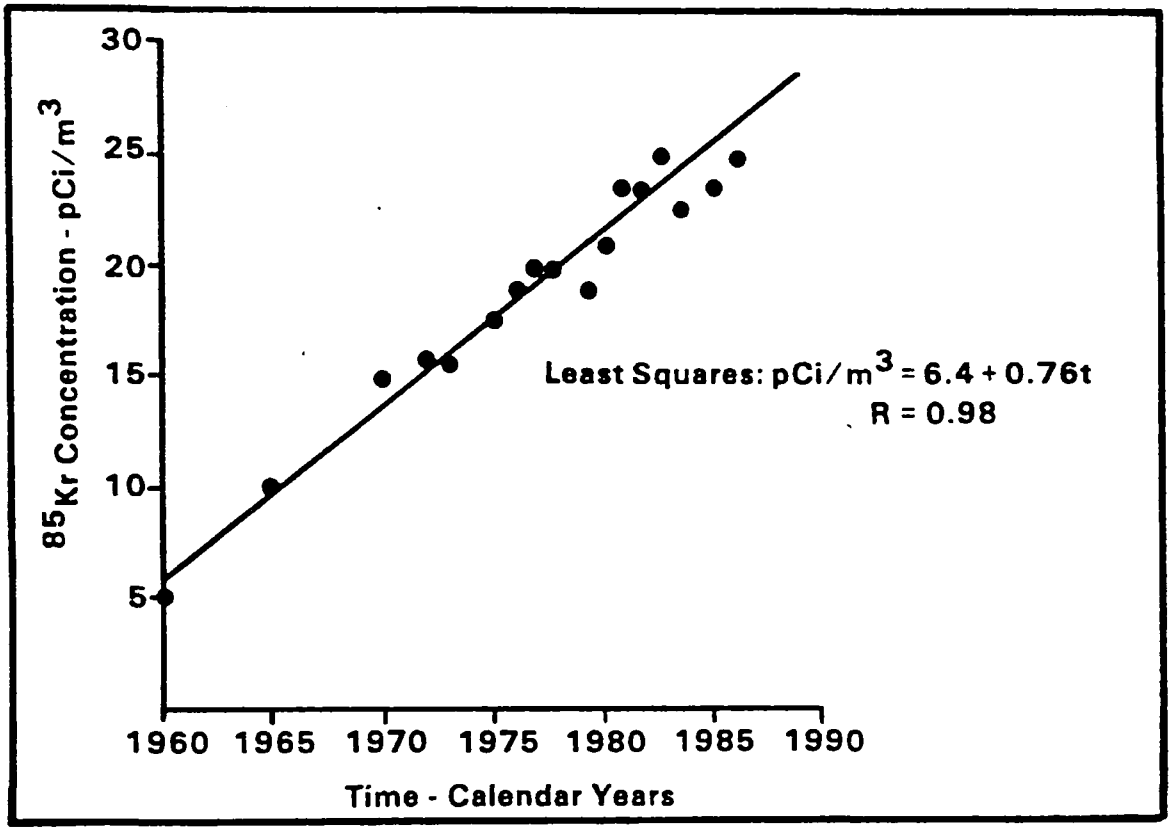

Figure 20. Trend in Annual Average Krypton-85 Concentration

The dose equivalent estimates from these sources for people living near the Nevada Test Site were calculated separately in the following sections.

Estimated Dose from NTS Activities

The estimate of dose equivalent due to NTS activities was based on the total release of radioactivity from the site as listed in Table 30. Since no significant activity of recent NTS origin was detectable offsite by the air, water, milk, TLD or biological monitoring networks, other than as described for Mighty Oak, no significant exposure to the population around the NTS was expected. To confirm this, a simple atmospheric dispersion calculation, using a gaussian plume model and cumulated meteorological data for the NTS, was performed. The maximum individual dose equivalent was calculated to be 1.4 μrem (0.014 μSv) for the year, and the population dose equivalent to the 6360 people living within 80 km of CP-1 was calculated to be 5.7 x 10^{-3} person-rem (5.7 x 10^{-5} person-Sv). When the Table 30 release quantities were tested with the AIRDOS program, the maximum individual dose equivalent became 2.4 μrem (0.024 μSv) and for the population 7.2 x 10^{-3} person-rem (7.2 x 10^{-5} person-Sv).

Estimated Dose from Tunnel Purging

The maximum integrated concentration of xenon-133 during the purging of the tunnel following the Mighty Oak test was 11.5 nCi-hr/m^3 at the Penoyer Farm near Rachel, Nevada. An individual who remained outdoors during the 170 hours of the collection period for the xenon-133 sample would have received an exposure of 0.27 μrem (2.7 x 10^{-3} μSv).

Estimated Dose from World-wide Fallout

From the monitoring networks, the following concentrations of radionuclides were found:

Pu-239 - <0.06 pCi/kg in beef liver

Sr-90 - 0.6 pCi/L (22 mBq/L) in milk

Kr-85 - 25 pCi/m^3 (0.92 Bq/m^3) in air

H-3 - 0.45 pCi/m^3 (17 mBq/m^3) in air

To estimate maximum individual dose equivalents from these findings, the following assumptions (from ICRP-23) and dose conversion factors (from ICRP-30) are used.

° Adult breathing rate = 8400 m^3/yr

° Milk intake (10-year old) = 160 L/yr

° Liver consumption = 1 lb/wk = 23.6 kg/yr

° Meat consumption = 248 g/day = 90.5 kg/yr
subtract liver consumption, balance is 66.9 kg/yr

° Pu-239 - 2.1 x 10^{-6} Sv/Bq = 7.8 x 10^{-3} mrem/pCi

° Sr-90 - 1.9 x 10^{-7} Sv/Bq = 7 x 10^{-4} mrem/pCi

° H-3 9.9 x 10^{-15} Sv/hr per Bq/m^3 = 3.2 x 10^{-7} mrem/yr pCi/m^3

Kr-85 - 4.7 x 10^{-11} Sv/hr per Bq/m^3 = 3.2 x 10^{-3} mrem/yr per pCi/m^3

The dose equivalents were estimated by the following calculations:

Pu-239: (Assume concentration = detection limit)
0.06 pCi/kg x 23.6 kg/yr x 7.8 x 10^{-3} mrem/pCi = 0.011 mrem/yr

Sr-90: 0.6 pCi/L x 160 L/yr x 7 x 10^{-4} mrem/pCi - 0.067 mrem/yr

Kr- 85: 25 pCi/m^3 x 1.5 x 10^{-3} = 0.38 mrem/yr

H-3: 0.45 pCi/m^3 x 3.2 x 10^{-7} = 1.4 x 10^{-7} mrem/yr

These sum to 0.12 mrem/yr (1.2 μSv/yr) compared to the 0.0024 mrem (2.4 x 10^{-2} μSv) from NTS activities.

1987

All nuclear detonations during 1987 were conducted underground and were contained. Although releases of low-level radioactivity occurred during re-entry drilling, seepage through fissures in the soil, or purging of tunnel areas. Table 32 shows the total quantities of radionuclides released to the atmosphere, as reported by the DOE-Nevada Operations Office (DOE88). Because of the distance of these releases to the nearest sampling station, none of the radioactive material listed in this table was detected offsite.

Table 32. Total Airborne Radionuclide Emissions at the NTS 1987

Radionuclide	Half-Life (days)	Quantity Released (Ci)
Tritium	4500	126.4
Krypton-85	3990	5.042
Xenon-127	36.4	0.0003
Xenon-133	5.24	44.02
Xenon-133m	2.2	2.00
Xenon-135	0.38	0.005
Xenon-131m	11.92	1.0
Xenon (Isotopic mixture unknown)		29.0
Cesium-137	11,030.6	0.000017
Argon-37	34.8	1.0
Iodine (Isotopic mixture unknown)		0.101
Total		208.5683

During the calendar year 1987 there were four sources for possible radiation exposure to the population of Nevada, all of which produced negligible exposures. The four sources were:

° Normal 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 strontium-90 in milk, krypton-85 in air etc; and

° Background radiation due to natural sources such as cosmic radiation, natural radioactivity in soil, and berylium-7 in air.

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

Estimated Dose from Worldwide Fallout

From the monitoring networks described in previous sections of this report and the 1987 Offsite EPA report (EPA 600/4-88-021), the following concentrations of radioactivity were found:

Tritium (0.62 pCi/m^3 of air [23 mBq/m^3])
Krypton-85 (25.5 pCi/m^3 of air [0.9 Bq/m^3])
Strontium-90 (1.8 pCi/L in milk [67 mBq/L])
Xenon-133 (1 pCi/m^3 of air [37 mBq/m^3])
Cesium-137 (30 pCi/kg beef muscle [1.1 Bq/kg])
Plutonium-239 (110 fCi/kg beef liver, [4.1 fBq/kg])

The dose was 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 1b/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 were based on the ALI divided by 5000 to convert to becquerels/mrem, then converted to mrem/pCi:

Hydrogen-3 (6.2 X 10^{-8} mrem/pCi)
Strontium-90 (1.8 x 10^{-4} mrem/pCi)
Cesium-137 (4.5 x 10^{-5} mrem/pCi)
Plutonium-239 (9 x 10^{-4} mrem/pCi)
Krypton-85 (1.5 x 10^{-3} mrem/yr per pCi/m^3)
Xenon-133 (6.2 x 10^{-4} mrem/yr per pCi/m^3)

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

0.62 pCi/m^3 x 8400 m^3/yr x 6.2 x
10^{-8} mrem/pCi x 10^3 µrem/mrem = 0.32 µrem

Also:

Strontium-90 ($1.8 \times 160 \times 1.8 \times 10^{-4} \times 10^{-3} = 52$ µrem)
Cesium-137 ($30 \times 78.7 \times 4.5 \times 10^{-5} \times 10^{-3} = 106$ µrem)
Plutonium-239 (110 fCi/kg x 11.8 kg x 10^{-3} pCi/fCi x $9 \times 10^{-3} = 1.2$ µrem)

These sum to an annual dose equivalent of 0.16 mrem.

Estimated Dose from Radioactivity in NTS Deer

The highest measured concentration of radionuclides in mule deer tissues occurred in deer collected on the NTS. These were:

Tissue	H-3	Cs-137	Pu-239
Liver (pCi/kg)	1×10^7	90	0.05
Muscle (pCi/kg)	1×10^7	90	0.113

Based on past data, in the unlikely event that one such deer was collected by a hunter in offsite areas; with three pounds of liver and 100 pounds of meat and the radionuclide concentrations listed above, the dose equivalents could have been:

Liver: (1.36 kg [1x10-7 x 6.2×10^{-8}]+[90 x 4.5×10^{-5}]+[0.5 x 9×10^{-4}]) = 0.85 mrem and for muscle, a similar calculation yields 28.4 mrem. Thus, approximately 29 mrem would have been delivered to one individual consuming the stated quantity of meat and assuming no radioactivity was lost in food preparation.

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 (potassium-40, uranium and thorium daughters, etc.), there was a contribution from beryllium-7 that was formed in the atmosphere by cosmic ray interactions with oxygen and nitrogen. The annual average Be-7 concentration measured by our air surveillance network was 0.07 pCi/m^3. With a dose conversion factor for inhalation of 2.6×10^{-7} mrem/pCi, this equates to 0.15 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: 2×10^{-3} mrem + 0.16 mrem + 140 mrem = 140.2 mrem (1.4 mSv). Both the NTS and worldwide distributions contributed a negligible amount of exposure compared to background. If that same individual used the NTS deer meat without sharing it with someone else, the exposure would increase to 140 + 29 = 169 mrem (1.69 mSv).

Table 33. Samples and Analyses for Duplicate Sampling - 1987

Surveillance Network	Number of Sampling Locations	Samples Collected This Year	Sets of Duplicate Samples Collected	Number Per Set	Sample Analysis
NGTSN	19	810 (NG) 816 (H-3)	145 97	2	Kr-85, H-3, H_2O, HTO

Table 34. Sampling and Analytical Precision - 1987

Surveillance Network	Analysis	Sets of Replicate Samples Evaluated	Coefficient of Variation (%)
NGTSN	Kr-85	46	9.4
	HTO	*	31
	H_2O	97	34

* Estimate of precision was calculated from the errors in the H-3 conventional analysis and the measurement of atmospheric moisture (H_2O).

To estimate the precision of counting, approximately 10 percent of all samples were counted a second time. These were unknown to the analyst. Since all such replicate counting gave results within the counting error, the precision data in Table 34 represented errors principally in analysis.

1988

The Noble Gas and Tritium surveillance Network (NGTSN) consisted of 18 stations offsite (off the NTS and exclusion area) in 1988 including temporary sampling locations at Mammoth Lake, CA. No NTS-related radioactivity was detected at any offsite station by this network. As in previous years, xenon and tritium levels in samples from the off-NTS stations were generally below the minimum detectable concentration (MDC).

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 35 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 offsite sampling station, none of the radioactive material listed in this table was detected offsite.

Results--

Figure 21 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.

Table 35. Total Airborne Radionuclide Emissions at the NTS - 1988

Radionuclide	Half-life (days)	Quantity Releases (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 results from the samples collected by the NGTSN are shown in Appendix A. This summary consists of the maximum, minimum, and average concentration for each station. The number of samples analyzed was typically less than the expected number (fifty-two) since samples were occasionally lost in the analysis procedure, or insufficient volume was collected, or no sample was collected due to equipment problems. Caliente, NV and Mammoth Lakes, CA had 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 low number of samples analyzed for St. George was due to a combination of two factors.

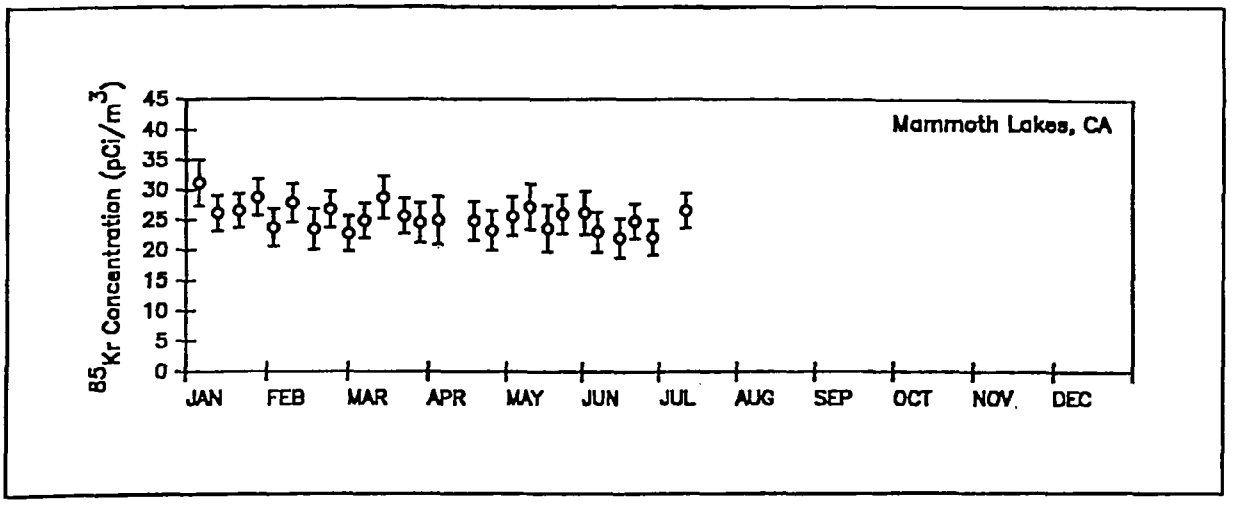

Figure 21. Weekly ^{85}Kr Concentrations in Air by Station, 1988

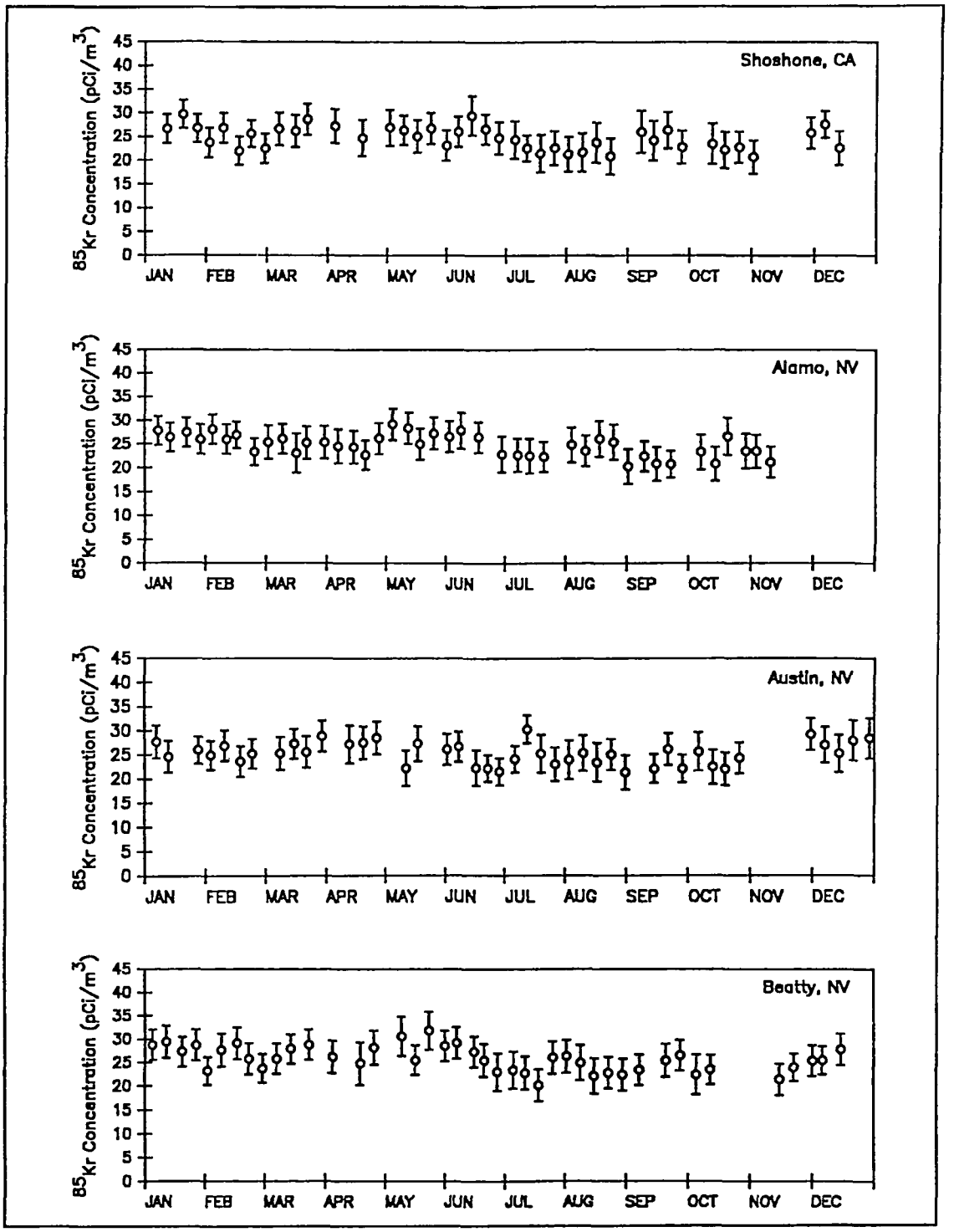

Figure 21. Weekly ^{85}Kr Concentrations in Air by Station, 1988 (continued).

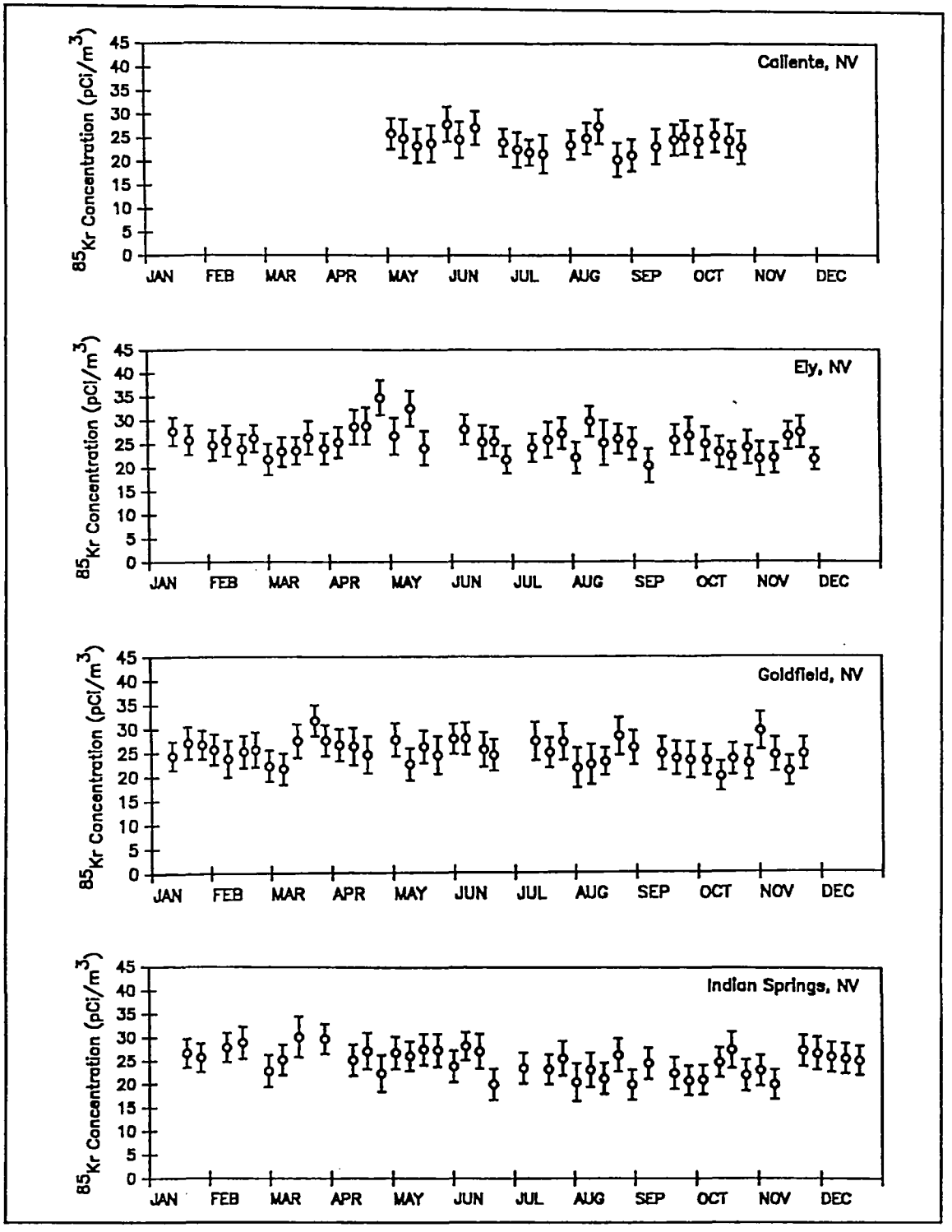

Figure 21. Weekly ^{85}Kr Concentrations in Air by Station, 1988 (continued).

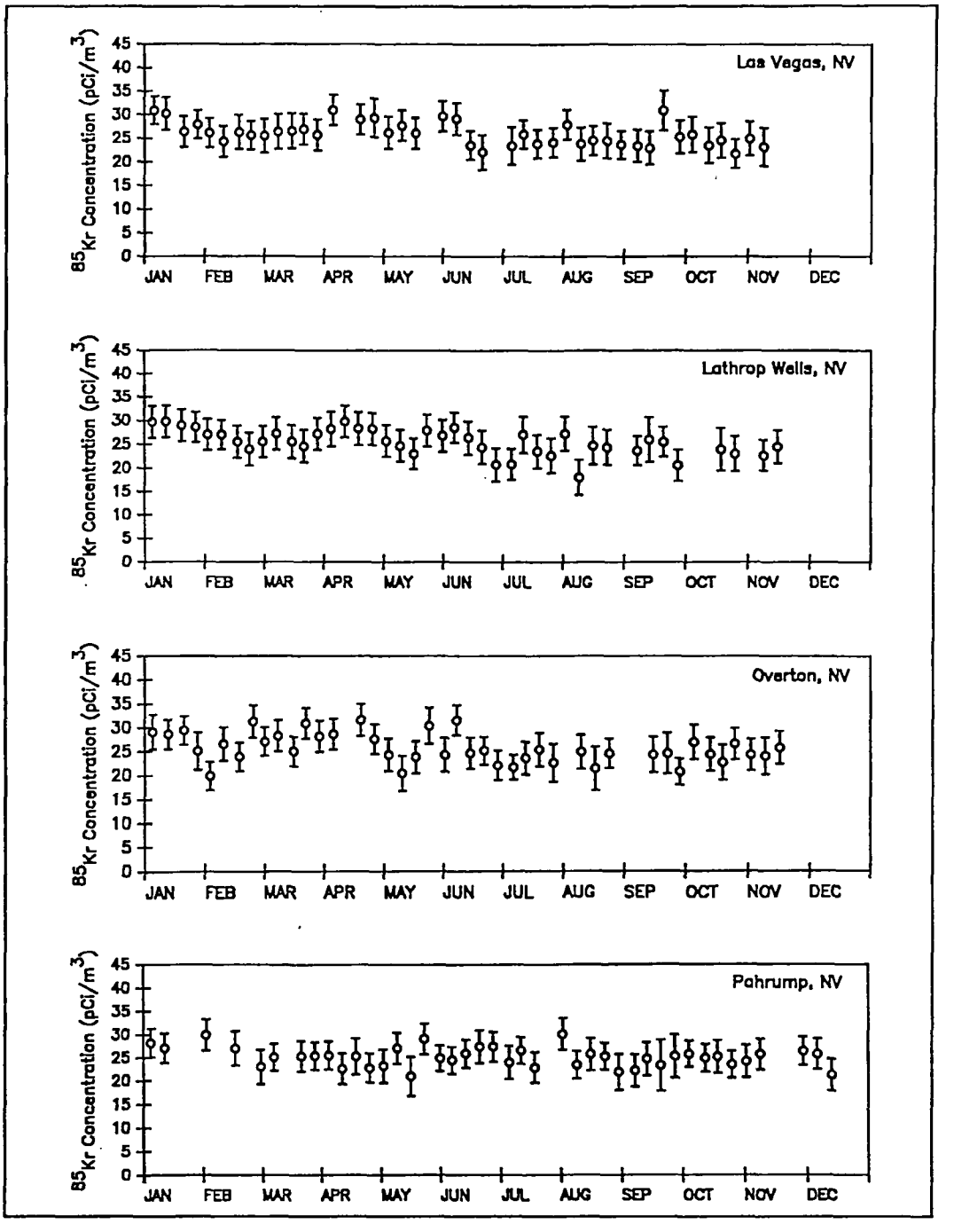

Figure 21. Weekly ^{85}Kr Concentrations in Air by Station, 1988 (continued).

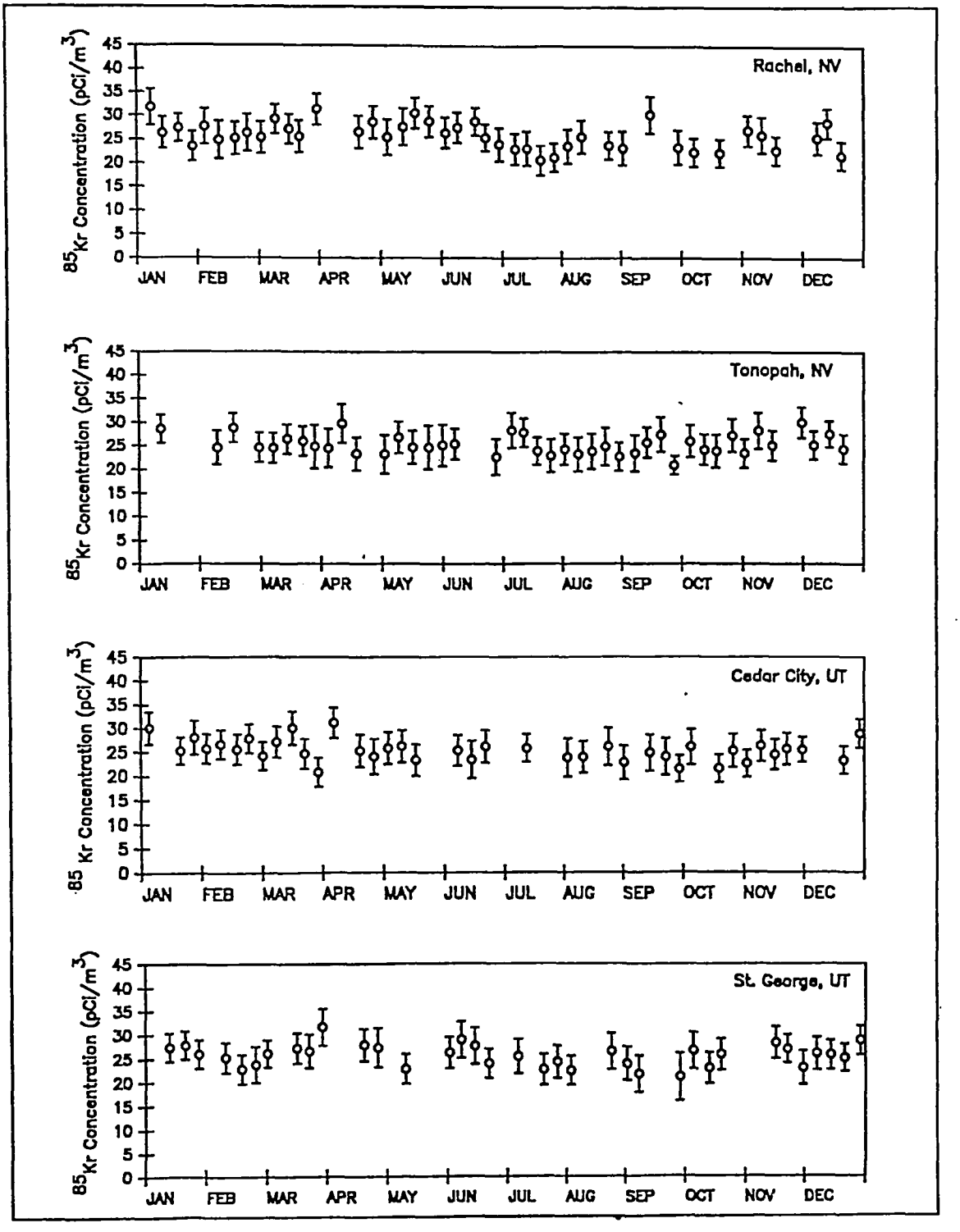

Figure 21. Weekly ^{85}Kr Concentrations in Air by Station, 1988 (continued).

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.

The analytical results for the 734 xenon samples counted were all below the MDC which varied, but were 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 (Appendix B, Sample Analysis Procedures). Due to the statistical nature of counting radioactive samples, some samples yielded negative results or results below the MDC. Results below the MDC were not necessarily real but were 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 offsite 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 concentrations measured for that sample was only slightly above the MDC. That sample was collected in Ely, and although there was a detectable amount of ^3H in the atmospheric moisture, the calculated concentration of ^3H in air was less than the calculated MDC for that sample.

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

Table 36. Samples and analyses for Duplicate Sampling Program - 1988

Surveillance Network Locations	Number of Sampling This Year	Samples Collected Collected	Sets of Duplicate Samples Per Set	Number Analysis	Sample
NGTSN	18	710 (^{85}Kr) 734 (^{133}Xe)	54	2	^{85}Kr, ^3H, H_2O, HTO, ^{133}Xe

Table 37. Sampling and Analytical Precision - 1988

Surveillance Network	Analysis	Sets of Replicate Samples Evaluated	Coefficient of Variation (%)
NGTSN	^{85}Kr	53	7.4
	H_2O*	90	3.8

* Measurement of Atmospheric Moisture

1989

In 1989 the Noble Gas and Tritium Surveillance Network (NGTSN) consisted of 20 offsite sampling stations (outside of the NTS and exclusion areas). In addition to 18 Community Radiation Monitoring Program (CRMP) stations, there were stations at Lathrop Wells and Pioche, Nevada. At Pioche and at Salt Lake City, Utah, samples were collected for tritium analysis only. During 1989 no NTS-related radioactivity was detected at any network sampling station. As in previous years, results for xenon and tritium were typically below the minimum detectable concentration (MDC). The results for krypton, although exceeding the MDC, were within the range of worldwide values expected from sampling background levels (see Table 38).

Table 38. Projected Atmospheric Concentrations and Doses Krypton - 85

Year	Atmospheric Inventory (Megacuries)	Atmospheric Concentration pCi/m^3 (STP)	Dose -- microrem/year Whole Body	Surface of Skin	Basal Layer of Skin
1970	50	13	0.18	26	13
1975	98	25	0.35	51	26
1980	395	99	1.41	207	103
1985	1034	260	3.69	541	271
1990	2306	581	8.23	1207	604
1995	4395	1110	15.7	2300	1150
2000	7528	1900	26.9	3940	1970

The sample results are listed in Appendix A. The number of samples analyzed was typically less than the expected number (52) since samples were occasionally lost in the analysis process, an insufficient sample volume was collected for analysis, or a sample was lost or not collected due to equipment failure. Caliente, Nevada had a low count for the number of samples processed because the noble gas sampler was not operational until mid-July. The measured ^{85}Kr concentrations ranged from 20 to 33 pCi/m^3 (0.74 to 1.2 Bq/m^3).

The 1989 average concentration for the network was 26.5 pCi/m^3 (0.98 Bq/m^3). The analysis results for the 737 xenon samples counted were all below the Minimum Detectable Concentration (MDC), which varied, but was generally about 40 pCi/m^3 (1.48 Bq/m^3).

As in the past, ^3H concentrations in atmospheric moisture samples from the sampling stations were generally below the MDC of about 7.0×10^{-7} $\mu Ci/mL$ (0.026 Bq/mL) in water. Of the 924 network samples analyzed in 1989, only three slightly exceeded the MDC. Due to the

Table 39. Radionuclide Emissions on the NTS 1989

Radionuclide	Half-life (years)	Quantity Released (Ci)
Airborne Releases		
^{3}H	12.35	73
^{37}Ar	0.096	15.1
^{39}Ar	269	0.0042
^{85}Kr	10.72	0.21
^{127}Xe	0.10	0.000038
^{129m}Xe	0.022	0.0022
^{131m}Xe	0.0326	0.33
^{133}Xe	0.0144	63
^{133m}Xe	0.0071	1.1
^{135}Xe	0.001	3.9
^{137}Cs	30.17	0.0000073
Tunnel and Radionuclide Migration Ponds		
^{3}H	12.35	2069
^{238}Pu	87.743	0.000017
$^{239+240}Pu$	24065	0.00034
Gross Beta	---	0.20

statistical variations associated with counting radioactive samples, some samples yielded negative results, results between zero and the MDC, or some small percentage of the time even exceeded the MDC, yielding a false positive indication. Results between zero and the MDC were not necessarily real but were below the sensitivity of the method. Results that slightly exceed the MDC may be true indicators of some slight elevation in activity levels or, as previously indicated, could be a result of statistical counting variations only. The range of ^{3}H concentrations observed at sampling stations were considered to be representative of statistical variations in counting background samples and not indicative of the presence of increased ^{3}H levels in the environment.

In conclusion, the sampling network found no detectable increase in noble gas or ^{3}H levels which could be attributed to activities at the NTS.

1990

In 1990 this network consisted of 16 noble gas samplers and 19 tritium-in-air samplers located in the States of Nevada, Utah, and California. The monitoring network detected only background radioactivity from these sampling locations.

As in the past, noble gas samples were collected by compressing air into storage tanks. The equipment continuously sampled air over a seven-day period and stored approximately 21 ft^3 (0.6 m^3) of air in the tanks. The tanks were exchanged weekly and returned to the laboratory for analysis. Analysis started by condensing the samples at liquid nitrogen temperature followed by gas chromatography to separate the gases. The separate fractions of xenon and krypton were dissolved in scintillation cocktails and counted in a liquid scintillation counter.

For ^{3}H sampling, a molecular sieve column was used to collect water from the air. Up to 350 ft^3 (10 m^3) of air were passed through the column over a seven-day sampling period. Water adsorbed on the molecular sieve was recovered, and the concentration of ^{3}H in the water was determined by liquid scintillation counting.

As in previous years, results for xenon and tritium were typically below the minimum detectable concentration (MDC). The results for krypton, although exceeding the MDC, were within the range of worldwide values expected from sampling background levels. The measured ^{85}Kr concentrations ranged from 20 to 33 pCi/m^3 (0.74 to 1.2 Bq/m^3). The annual arithmetic average for ^{85}Kr was 26.4 pCi/m^3, similar to the 1989 level.

Table 40. Radionuclide Emissions on the NTS 1990

Radionuclide	Half-life (years)	Quantity Released (Ci)
Airborne Releases		
^{3}H	12.35	28
^{37}Ar	0.096	2.4
^{39}Ar	269	0.0013
^{85}Kr	10.72	4.4
^{131m}Xe	0.0326	1.2
^{133}Xe	0.0144	30
^{133m}Xe	.0071	0.18
^{135}Xe	0.001	0.08
^{131}I	0.022	0.0013
^{133}I	0.0024	0.0002
Tunnel and Radionuclide Migration Ponds		
^{3}H	12.35	670
^{238}Pu	87.743	0.0000064
$^{239+240}Pu$	24065	0.00026
^{90}Sr	29	0.08
^{131}I	0.022	0.00058
^{137}Cs	30.17	0.012
Gross Beta	---	0.013

The analytical results for the 841 xenon samples were all below the MDC, which varied, but was generally about 14 pCi/m^3 (0.52 Bq/m^3).

As in the past, ^3H concentrations in atmospheric moisture (HTO) samples collected at network sampling stations were generally below the MDC of about 4.6 x 10^{-12} μCi/mL (0.17 Bq/m^3). Of the 981 network samples analyzed in 1990, only six slightly exceeded the MDC.

The range of HTO concentrations observed at sampling stations was considered to be due to statistical variations in counting background samples and not indicative of the presence of actual levels in the environment. In conclusion, there was no evidence in the measured noble gas or HTO levels of any contribution related to activities at the NTS.

1991

In 1991 the Noble Gas and Tritium Surveillance Network (NGTSN) consisted of 21 offsite noble gas-samplers and 22 tritium-in-air samplers, three on standby, located outside the NTS and exclusion areas in the states of Nevada, California, and Utah. During 1991 no radioactivity that could be related to NTS activities was detected at any sampling station.

As in previous years, results for xenon and tritium were typically below the minimum detectable concentration (MDC). The results for krypton, although exceeding the MDC, were within the range of worldwide values expected from sampling background levels and the range was similar to that in 1990.

At the beginning of 1991, the tritium network consisted of 20 routinely operated and two standby stations. Figure 22 depicts the locations of these stations in conjunction with the noble gas sampling network. A number of changes were implemented during 1991, including relocations of the St. George, Utah Community Radiation Monitoring Stations (CRMS) from the high school to Dixie Junior College on September 4, 1991, discontinuation of the Pioche, Nevada station in November, and installation of a station on Fallini's Ranch (Twin Springs, Nevada). In November, the following six stations were converted from routine to standby status (date of last sample collection shown in parentheses): Salt Lake City, Utah (Nov. 1), Shoshone, California and Ely, Nevada (Nov. 12), Austin, Nevada and Cedar City, Utah (Nov. 13), and Caliente, Nevada (Nov. 14). In addition, the two standby stations in Utah (Milford and Delta) were not activated at any time during 1991.

Of the 957 samples collected in 1991, 23 were of insufficient volume to permit analysis and six exceeded the MDC. Of these six samples, three were borderline. One of these was the sample collected March 11 through 18, 1991 at the Salt Lake City, Utah station. This station is located adjacent to the engineering complex housing a nuclear reactor. Two samples from the Las Vegas, Nevada station yielded results greater than the MDC; these two were collected June 24 through July 1, 1991 and July 19 through 22, 1991. This station was located near the EPA Radioanalysis Laboratory. The average HTO concentration for the Las Vegas, Nevada station was 1.7 x 10^{-6} pCi/mL in 1991; the average for that location in 1990 was 4.2 x 10^{-7} pCi/mL. The overall network HTO average for 1991 was 5.0 x 10^{-7} pCi/mL compared to a network average of 5.9 x 10^{-7} pCi/mL in 1990. Summary data results are given in Appendix A.

Table 41. Radionuclide Emissions on the NTS - 1991

Radionuclide	Half-life (years)	Quantity Released (Ci)
Airborne Releases		
^{3}H	12.35	[a]0.68
^{37}Ar	0.096	0.45
^{39}Ar	269	2.1×10^{-4}
^{85}Kr	10.72	0.0066
^{131m}Xe	0.0326	0.007
^{133}Xe	0.0144	0.85
^{133m}Xe	.0071	0.004
^{127}Xe	0.10	6.6×10^{-6}
^{129m}Xe	0.022	5.2×10^{-5}
^{131}I	0.022	[a]1.3×10^{-4}
^{241}Am	458.	[a]8.3×10^{-6}
$^{239+240}Pu$	24065.	[a]6.1×10^{-4}
^{238}Pu	87.74	[a]2.5×10^{-7}
^{137}Cs	30.2	[a]2.6×10^{-7}
Tunnel and Radionuclide Migration Ponds		
^{3}H	12.35	[b]1800
^{238}Pu	87.743	2.7×10^{-5}
$^{239+240}Pu$	24065	2.7×10^{-4}
^{90}Sr	29	5.6×10^{-4}
^{137}Cs	30.17	1.3 c 10^{-2}
Gross Beta	---	4.1×10^{-2}

(a) Includes calculated data from air sampling results and/or loss of laboratory standards.
(b) Assumes total evaporation of all tritiated water effluents.

Samples were analyzed for ^{85}Kr and ^{133}Xe. The locations of the sampling stations are shown in Figure 22.

Noble gases may be released into the atmosphere from research, power reactor facilities, fuel reprocessing facilities, and from nuclear testing. Environmental levels of the xenons, with their very short half-lives, are normally below the MDC. Krypton-85 disperses more or less uniformly over the entire globe because of its half-life, 10.7 years, and the lack of significant sinks (NCRP44 1975). For these reasons, ^{85}Kr results were expected to be above the MDC.

A number of changes were made to the network during 1991 in addition to installing noble gas samplers at two stations. In November, the following five stations were converted from routine to standby status: Austin, Caliente, and Ely, NV; Shoshone, CA; and Cedar City, UT.

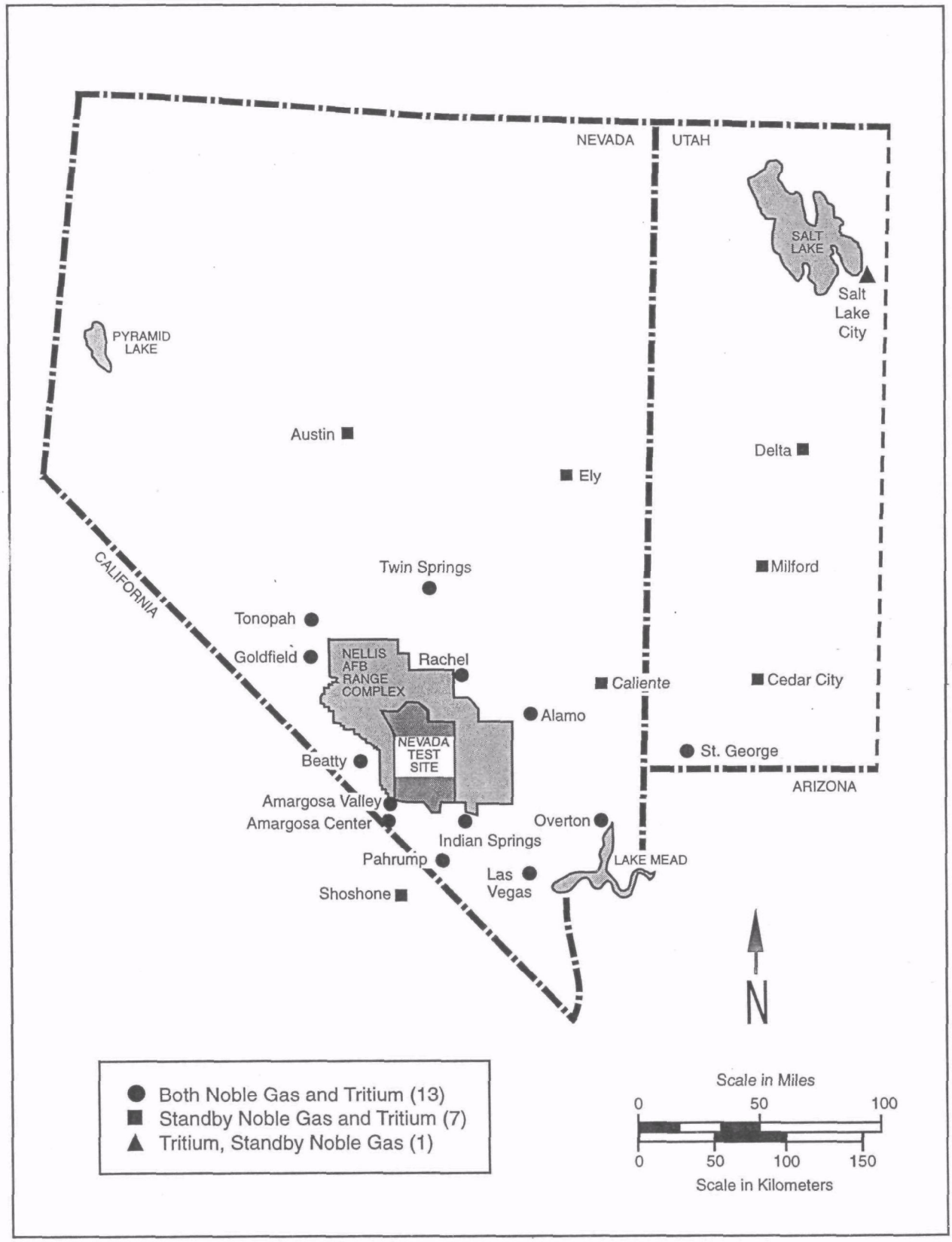

Figure 22. Offsite Noble Gas sampling and Tritium-in-Air Network Stations - 1992.

All of the existing noble gas samplers, used since 1974, were replaced with newly designed samplers in 1991. The first replacement was completed at the Las Vegas station in March. After a successful evaluation period, replacement of the samplers at the remaining stations began in May. An essential part of the development included comparison testing of the old and new model systems to ensure comparability of the data obtained from the two systems. A description of the new system is in Appendix E.

1992

At the beginning of 1992, the tritium network consisted of 14 continuously operated and seven standby stations. The routine stations were adjacent to the NTS to detect atmospheric tritium which could have reached populated centers in the immediate offsite area. In addition, a tritium sampler is routinely operated near the nuclear research reactor in Salt Lake City, Utah. The following five stations were converted from routine to standby status effective with their last sampling collection periods in November 1991: Shoshone, California; Cedar City, Utah; and Austin, Ely, and Caliente, Nevada. Samples were collected approximately once a week from the routine stations and once a quarter from the standby stations. Figure 22 shows the locations of the tritium network sampling stations in conjunction with the noble gas sampling network stations.

Figure 23. Community Monitoring Program Station.

Procedures

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

Results--

Of the 716 routine and 15 standby samples collected in 1992, 15 samplers were not analyzed: five because of broken sieves, three were lost, and seven contained insufficient sample (moisture). An additional seven samples were excluded from data analysis because of indications of operational malfunctions affecting data reliability. These included frozen lines, lack of pump flow, indications of leaks, and overextended sampling interval. Two samples exceeded the analysis MDC. Both samples were collected June 16-24; one from Las Vegas and the other from Overton, Nevada. The average HTO concentration for the Las Vegas stations, located near the EPA Radioanalysis Laboratory, was 1.5×10^{-6} pCi/mL. Summary data results are given in Appendix A. The 1992 tritium data appear to be consistent with data from previous years.

At the beginning of 1992, the Noble Gas Sampling Network consisted of 13 routine (continuously operated) and 8 standby stations. In November 1991, the following 5 stations were converted from routine to standby status: Austin, Caliente, and Ely, Nevada; Shoshone, California; and Cedar City, Utah. Samples were collected approximately once a week from the routine stations and quarterly from the standby stations. Samples collected were analyzed for ^{85}Kr and ^{133}Xe. The locations of the noble gas sampling stations are shown in Figure 22 in conjunction with the tritium stations.

Noble gas samples were collected by compressing air into storage tanks (bottles). Air was continuously sampled over a 7-day period, collecting approximately 0.6 m^3 (21.2 ft^3) of air into a four-bottle system. One bottle was filled over the entire sampling period. The other three bottles were filled consecutively over the same sampling period in 56-hour increments. The bottle containing the sample from the entire sampling period was the only sample which was routinely analyzed. If xenons or abnormally high levels of ^{85}Kr were detected in this sample, then the other three samples would be analyzed. For the analysis, samples were condensed at liquid nitrogen temperature. Gas chromatography was then used to separate the gaseous radionuclide fractions. The radioactive gases were dissolved in liquid scintillation "cocktails," then counted to determine activity.

Results--

Of the 699 samples collected in 1992, analyses were not performed on 74 samples (10.6 percent) due to insufficient volume collected or sampler malfunctions. Twelve quarterly samples

were collected from standby samplers; none were collected from Milford and Salt Lake City, Utah. As expected, all ^{85}Kr results exceeded the MDC and all ^{133}Xe results were below the MDC. The annual averages for the continuously operated samplers were 26.2 pCi/m^3 for ^{85}Kr and -17.7 pCi/m^3 for ^{133}Xe and for the standby samplers, 25.8 pCi/m^3 for ^{85}Kr and -27.4 pCi/m^3 for ^{133}Xe.

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

At the beginning of 1992, the Noble Gas Sampling Network consisted of 13 routinely operated and three standby stations. Of the 699 samples collected in 1992, analyses were not performed on 74 samples (10.6 percent) due to insufficient volume collected or sampler malfunctions. Twelve quarterly samples were collected from standby samplers; none were collected from Milford and Salt Lake City, Utah. As expected, all ^{85}Kr results were above the MDC and were within the range anticipated from sampling background levels and all ^{133}Xe results were below the MDC.

1993

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

As in previous years, results for ^{133}Xe and HTO were typically below the minimum detectable concentration (MDC). The annual average results for ^{85}Kr, 28 pCi/m^3, although above the MDC, were within the range of worldwide values expected from sampling background levels and the range was similar to the 1992 levels.

About five percent of the total number of samples collected were invalid due to malfunctioning equipment, power outages during collection, frozen lines, insufficient sample volumes, etc. Results exceeded the analysis MDC in three instances, but this could be due to simple counting statistics. The annual HTO network average was 3.0 x 10^{-7} pCi/mL (0.011 Bq/m^3).

All samples were analyzed for ^{85}Kr and ^{133}Xe and the summary results are given in Appendix A for the routine stations. Eight standby stations were operated quarterly to ascertain operational status but the samples were not analyzed. Of the 676 samples collected in 1993, analyses were not performed on 63 samples (9.3 percent) due to either insufficient volume collected or sampler malfunction. As expected, all ^{85}Kr results exceeded the MDC and all ^{133}Xe results were below the MDC. The annual averages for the continuously operated samplers were 28 pCi/m^3 (1.0 Bq/m^3) for ^{85}Kr and -21 pCi/m^3 (-0.8 Bq/m^3) for ^{133}Xe. On February 9, the station

at Las Vegas was relocated to the front of the EPA Executive Center. An anomalously high ^{85}Kr result of 250 pCi/m^3 (9.2 Bq/m^3) occurred at this time.

1994

In 1994, this network consisted of 13 routine noble gas and tritium-in-air samplers, plus seven on standby, located in the States of Nevada, Utah, and California. In addition, a tritium sampler was routinely operated near a nuclear research reactor in Salt Lake City, Utah.

The HTO network average for the first nine months of 1994 was 2.9 x 10^{-7} pCi/mL (0.018 Bq/m^3). Results are given in Appendix A. The mean MDC was 3.4 x 10^{-5} pCi/mL. No samples from the Tritium Surveillance Network exceeded the MDC.

All samples were analyzed for ^{85}Kr and ^{133}Xe and the summary results are given in Table 42. Eight standby stations were operated quarterly to ascertain operational status but the samples were not analyzed. The annual averages for the continuously operated samplers were 2 pCi/m^3 (1.0 Bq/m^3) for ^{85}Kr and -5 pCi/m^3 (-2.0 Bq/m^3) for ^{133}Xe. As expected, all ^{133}Xe results were below the average MDC of 18 pCi/m^3. The ^{85}Kr results were all above the average MDC of 5 pCi/m^3.

Data quality objectives for precision and accuracy are; by necessity, less stringent for values near the MDC so confidence intervals around the input data are broad. The concentrations of radioactivity detected by the monitoring networks and used in the calculation of potential CEDEs are shown in Table 43.

The concentrations given in Table 43 are expressed in terms of activity per unit volume or weight. These concentrations are converted to a dose by using the assumptions and dose conversion factors described below. The dose conversion factors assume continuous presence at a fixed location and no loss of radioactivity in meat and vegetables through storage and cooking.

DOSE ASSESSMENT

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

- ^3H: 6.4 x 10^{-8} mrem/pCi (ingestion or inhalation)

- ^{85}Kr: 1.5 x 10^{-5} mrem/yr per pCi/m^3 (submersion)

The algorithm for the internal dose calculation is:

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

As an example calculation, the following is the result of breathing tritium in air:

° $(2 \times 10^{-1}$ pCi/m^3) x (8400 m^3/yr) x (6.4×10^{-8} mrem/pCi) = 1.1×10^{-4} mrem/yr

However, in calculating the inhalation CEDE from ^{3}H, the value must be increased by 50 percent to account for skin absorption. The total dose in one year, therefore, is 1.1×10^{-4} mrem/yr x 1.5 = 1.6×10^{-4} mrem/yr. Dose calculations from ORSP data are summarized in Table 43.

The extensive offsite environmental surveillance system operated around the NTS by EPA's EMSL-LV detected no radiological exposures that could be attributed to recent NTS operations, but a calculated EDE of 0.015 mrem can be obtained if certain assumptions were made.

Calculation with the CAP88-PC model, using estimated or calculated effluents from the NTS during 1994, resulted in a maximum dose of 0.15 mrem (1.5×10^{-3} mSv) to a hypothetical resident of Amargosa Valley, NV, 3 km (1.9 mi) SE of the NTS boundary. Based on monitoring network data, this dose was calculated to be 0.015 mrem. This latter EDE was about 10% of the dose obtained from CAP88-PC calculation. This maximum dose estimate is less than 1 percent of the International Commission on Radiological Protection (ICRP) recommendation that an annual effective dose equivalent for the general public not exceed 100 mrem/yr (ICRP 1985). The calculated population dose (collective effective dose equivalent) to the approximately 33, 740 residents living with 80 km (50 mi) of each of the NTS airborne emission sources was 0.52 person-rem (5.2×10^{-3} person-Sv). Background radiation would yield a CEDE of 3210 person-rem (32.1 person-Sv).

Data from the PIC gamma monitoring indicated a 1994 dose of 124 mrem from background gamma radiation measured in Amargosa Valley. The CEDE calculated from the monitoring networks or the model as discussed above was a negligible amount by comparison. The uncertainty (2σ) for the PIC measurement at the 124 mrem exposure level was approximately 5 percent. Extrapolating to the calculated annual exposure at Amargosa Valley, Nevada, yielded a total uncertainty of approximately 6 mrem which was greater than either of the calculated EDEs. Because the estimated dose from NTS activities was less than 1 mrem no conclusions could be made regarding the achieved data quality as compared to the DQOs for this insignificant dose.

1995

In FY 1995 the entire Noble Gas and Tritium Network was placed on standby. DOE felt that there was no potential for release of these radionuclides into the offsite area and stopped funding this program.

Table 42. Offsite Noble Gas Results for Routine Samplers - 1994

^{85}Kr Concentration (10^{-12} µCi/mL)

Sampling Location	Number	Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as %DCG
Alamo, NV	30	32	24	29	1.9	0.005
Amargosa Valley, NV	34	33	22	29	2.6	0.005
Amargosa Valley Community Center, NV	25	33	26	30	1.6	0.005
Beatty, NV	30	33	25	28	1.7	0.005
Goldfield, NV	32	31	23	28	1.9	0.005
Indian Springs, NV	34	33	25	30	2.3	0.005
Las Vegas, NV	37	33	22	28	2.6	0.005
Overton, NV	35	32	23	29	1.9	0.005
Pahrump NV	33	34	25	29	2.4	0.005
Rachel, NV	34	32	21	28	2.8	0.005
Tonopah, NV	34	32	24	28	2.1	0.005
Twin Springs, NV Fallini's Ranch	37	32	23	29	2	0.005
St. George, UT	34	31	23	28	1.8	0.005

Mean MDC: 5.9 pCi/m^3 Standard Deviation of Mean MDC: 0.9 pCi/m^3

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

Sampling Location	Number	Maximum	Minimum	Arithmetic Mean	Standard Deviation	Mean as %DCG
Alamo, NV	29	5.7	-23.0	-6.8	7.2	NA
Amargosa Valley, NV	34	5.9	-17.0	-3.9	5.2	NA
Amargosa Valley Community Center, NV	25	6.9	-17.0	-6.0	6.6	NA
Beatty, NV	30	5.4	-22.0	-5.3	5.9	NA
Goldfield, NV	33	4.9	-31.0	-7.4	8.2	NA
Indian Springs, NV	34	6.4	-16.0	-3.3	5.3	NA
Las Vegas, NV	37	7.2	-11.0	-3.4	3.8	NA
Overton, NV	36	5.6	-21.0	-6.2	6.5	NA
Pahrump NV	33	4.7	-16.0	-3.3	5.0	NA
Rachel, NV	34	8.2	-37.0	-8.9	8.8	NA
Tonopah, NV	35	4.9	-23.0	-6.9	6.6	NA
Twin Springs, NV Fallini's Ranch	37	7.6	-21.0	-6.4	6.2	NA
St. George, UT	35	3.3	-19.0	-5.7	5.6	NA

Mean MDC: 18.0 pCi/m^3 Standard Deviation of Mean MDC: 7.0 pCi/m^3

DCG Derived Concentration Guide; Established by DOE Order as 3 X 10^{-7} for ^{85}Kr, 5 x 10^{-8} for Xe. Multiply table value by 0.037 to obtain Bq/m^3, e.g., 32 x 0.037 = 1.2 Bq/m^3.

NA Not applicable, result is MDC.

Table 43. Monitoring Networks Data used in Dose Calculations

Medium	Radionuclide	Concentration	mrem\year	Comment
Animals				
Beef Liver	$^{239+240}Pu$	1.56×10^{-1} (5.8×10^{-3})[a]	6.6×10^{-4}	Concentrations are the median for each tissue type
Deer Muscle	$^{239+240}Pu$	2.8×10^{-2} (1.0×10^{-3})[a]	4.7×10^{-4}	
Deer Liver	$^{239+240}Pu$	4.3×10^{-2} (1.6×10^{-3})[a]	4.4×10^{-6}	
Milk	^{90}Sr	0.44 (0.016)[b]	6.8×10^{-3}	Concentration is the average of all network results
	^{3}H	85 (3.1)[b]	6.0×10^{-4}	Concentration is the average of all network results
Drinking Water	^{3}H	1.4 (0.05)[b]	6.5×10^{-5}	Concentration is the average from Amargosa Valley Well
Vegetables				
Beets	$^{239+240}Pu$	3.5×10^{-2} (1.3×10^{-3})[a]	2.1×10^{-4}	Observed concentrations
Apples	$^{239+240}Pu$	3.3×10^{-2} (1.2×10^{-3})[a]	2.0×10^{-4}	
	^{238}Pu	2.7×10^{-2} (1.0×10^{-13})[a]	1.6×10^{-4}	
Air	^{3}H	0.2 (0.007)[c]	1.6×10^{-4}	Concentrations are average or median network results
	^{7}Be	0.29 (0.011)[c]	6.3×10^{-4}	
	^{85}Kr	29 (1.1)[c]	4.4×10^{-4}	
	$^{239+240}Pu$	1.8×10^{-6} (6.7×10^{-8})[c]	4.7×10^{-3}	

TOTAL (Air = 5.9 x 10-3, Liquids = 7.5 x 10-3, Veg. = 5.7 x 10-4, Meat = 1.1 x 10-3) = 1.5 x 10-2 mrem/yr

(a) Units are pCi/kg and Bq/kg
(b) Units are pCi/L and Bq/L
(c) Units are pCi/m^3 and Bq/m^3

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APPENDIX A.

California

CA-1. Death Valley Jct., California

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1972		208.7	Kr-85	25	10	15.6
		236.6	Xe	<2	<2	<2.0
		238.7	HTO in Air	7.1	1.0	<2.9
		221.6	CH_3T	<5	<4	<4.9
1973		316.3	Kr-85	19	12	15
		342.3	Xe-133	12	<2.0	<2.2
		342.6	HTO in Air	3.7	<0.56	<1.4
		328.3	CH_3T	<5.0	<5.0	<5.0
1974		328.0	Kr-85	29	13	18
		335.0	Total Xe	<5.4	<2.0	<3.3
		344.0	HTO in Air	6.2	<0.23	<2.0
		344.0	CH_3T	9.4	<1.3	<3.1
		352.0	HT	12	<0.14	<2.6
1975		340.2	Kr-85	27	11	17
		340.2	Total Xe	<7	<4	<5
		318.9	HTO in Air	6.1	<0.4	<2
		340.2	CH_3T	<3	<2	<2
		326.0	HT	9.4	<0.4	<3
1976		357.5	Kr-85	25	12	20
		357.5	Total Xe	<7	<4	<5
		321.7	HTO in Air	29	<0.2	<3
		357.5	CH_3T	7.0	<2	<3
		328.6	HT	5.3	<0.4	<2
1977		325.7	Kr-85	25	14	20
		349.6	Total Xe	15	<4	<6
		315.5	HTO in Air	<5	0.5	<2
		342.7	CH_3T	10	<2	<3

CA-1. Death Valley Jct., California (continued)

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
		308.5	HT	2.3	<0.2	<0.7
1978		342.6	Kr-85	24	17	20
		342.6	Xe-133	<20	<3	<3
		308.9	HTO in Air	4.9	<0.6	1.4
		342.6	CH_3T	<20	<2	<2
		285.7	HT	4.1	<0.3	0.77
1979		138.7	Kr-85	23	15	19
		138.7	Xe-133	<6	<3	<3
		131.8	HTOinAir	<4	<2	<2

CA-2. Mammoth Lakes, California

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1987	22/2*		Kr-85	29	22	26
	24/0*		Xe-133	8.3	-6.2	1.5
1988	26		Kr-85	31	22	25
	27		Xe-133	12	-8.2	2.1

*positive/negative

CA-3. Shoshone, California

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1982		268.4	Kr-85	33	20	25
		254.5	Xe-133	<30	<6	3.6
		335.7	HTO in Air	<8	<2	0.49
1983	42/10*		Kr-85	31	19	26
	41/11*		Xe-133	47	-6.9	2.8
	50/1*		HTO in Air	4.8	-2.5	0.43
1984	47/6*		Kr-85	N/A	N/A	23
	41/12*		Xe-133	27	-9.3	5.3
	52/0*		HTO in Air	2.5	-1.4	0.31
1985	48/4*		Kr-85	N/A	N/A	24
	46/6*		Xe-133	18	-7.2	4.5
	51/0*		HTO in Air	4.5	-1.3	0.78
1986	43/9*		Kr-85	33	17	25
	44/8*		Xe-133	29	-4.5	3.0
	51/0*		HTO in Air	4.2	-4.1	0.29
1987	50/2*		Kr-85	31	19	26
	50/2*		Xe-133	7.1	-7.8	0.77
	49/0*		HTO in Air	6.7	-5.3	0.63
1988	43		Kr-85	30	21	25
	46		Xe-133	8.8	-9.3	0.17
	49		HTO in Air	6.9	-8.4	-0.17
1989	48		Kr-85	31	21	27
	48		Xe-133	7.7	-6.7	1.1
	52		HTO in Air	3.6	-2.1	0.44
1990	49		Kr-85	33	20	26
	49		Xe-133	4.5	-14	-0.20
	53		HTO in Air	5.4	-4.6	0.50

*positive/negative

CA-3. Shoshone, California (continued)

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1991	38		Kr-85	29	20	26
	39		Xe-133	3.8	-9.2	-1.5
	45		HTO in Air	2.9	-4.6	0.12
1992	2		Kr-85	29	26	28
	2		Xe-133	0.88	0.29	0.58
	4		HTO in Air	2.6	0.45	1.4
1993	3		HTO in Air	0.3	-1.3	-0.7

Colorado

CO-1. Project Rulison Five Highest Atmospheric Moisture Samples

Station	Location*	Date	Tritium Concentration (pCi/m^3) Time	Result
A-IX	52°,0.8 mi	10/05/70	0840-1040	290
A-X	65°,0.6 mi	10/05/70	0835-1035	240
A-V11	15°,0.8 mi	10/05/70	1452-1553	220
A-X	65°,0.6 mi	10/05/70	1450-1550	180
A-IX	52°,0.8 mi	10/05/70	1455-1555	150

*Azimuth and distance from the test well.

CO-2. Project Rulison Five Highest Compressed Air Samples

		Kr-85 Concentration (pCi/m^3)		
Station	Location*	Date	Time	Result
Old Control Point Pad*	325°,2.4 mi	10/28/70	0645-0710	47
D-1	286°,4.6 mi	12/06/70	0851-0916	27
D-11	328°,4.2 mi	12/03/70	1955-2025	20
D-29	76°,16.5 mi	10/27/70	1720-1750	14
3 mile S of Rifle Airport	65°,13.0 mi	12/07/70	1535-1600	12

*Azimuth and distance from the test well

Nevada

NV-1. Adaven (Canfield) Nevada

				Radioactivity Concentration (pCi/m^3)		
Year	Number of Samples	Days Detected	Radionuclide	Maximum	Minimum	Average
1982		2	Kr-85	23	23	23
		2	Xe-133	<50	<50	20

NV-2. Alamo, Nevada

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1981		42.9	Kr-85	31	22	26
		42.9	Xe-133	<19	<11	<11
		42.9	HTO in Air	<2.1	1.3	<1.3
1982		344.8	Kr-85	31	20	24
		317.8	Xe-133	< 30	< 7	4.9
		349	HTO in Air	< 9	< 2	0.40
1983	41/11*		Kr-85	33	19	25
	39/13*		Xe-133	18	-9.1	1.7
	52/0*		HTO in Air	3.8	-2.2	0.47
1984	44/7*		Kr-85	N/A	N/A	24
	43/8*		Xe-133	37	-6.6	7.7
	52/0*		HTO in Air	4.5	-1.3	0.43
1985	46/6*		Kr-85	N/A	N/A	24
	44/8*		Xe-133	58	-2.1	9.1
	53/0*		HTO in Air	3.4	-3.4	0.21
1986	49/2*		Kr-85	31	16	24
	47/4*		Xe-133	40	-8.7	3.5
	52/0*		HTO in Air	5.6	-5.1	0.07
1987	47/5*		Kr-85	30	21	26
	46/6*		Xe-133	9.3	-13	1.1
	47/2*		HTO in Air	7.5	6.6	63
1988	49		Kr-85	29	20	25
	52		Xe-133	20	-9.7	0.58
	50		HTO in Air	5.3	-6.8	0.26
1989	45		Kr-85	32	22	27
	47		Xe-133	8.1	-16	-0.02
	51		HTO in Air	6.6	-24	-0.09

*positive/negative

NV-2. Alamo, Nevada (continued)

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1990	50		Kr-85	31	21	26
	51		Xe-133	8.3	-16	0.25
	50		HTO in Air	6.6	-24	-0.09
1991	44		Kr-85	31	22	26
	45		Xe-133	13	-12	1.1
	52		HTO in Air	7.2	-4.3	0.79
1992	48		Kr-85	30	22	26.2
	49		Xe-133	4.2	18	-2.6
	48		HTO in Air	4.3	-3.5	0.6
1993	44		Kr-85	32	21	27
	44		Xe-133	8.6	-13	-1.6
	46		HTO in Air	5.2	-2.3	0.6
1994	30		Kr-85	32	24	27
	29		Xe-133	5.7	-23	-6.8
	38		HTO in Air	2.4	-3.7	0.1

NV-3. Alamo (Sherri's), Nevada

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1984	1		Kr-85	33	33	33
	1		Xe-133	6.8	6.8	6.8

NV-4. Amargosa Center, Nevada

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1990	8		HTO in Air	8.3	-2.7	0.8
1991	24		Kr-85	31	24	27
	26		Xe-133	16	-13	-2.4
	51		HTO in Air	6.1	-9.2	0.47
1992	35		Kr-85	30	21	26
	36		Xe-133	21.0	-17.3	-2.10
	51		HTO in Air	6.5	-4.5	0.55
1993	41		Kr-85	32	23	27
	41		Xe-133	8.6	-16	-2.8
	49		HTO in Air	7.7	-5.3	0.5
1994	25		Kr-85	33	26	30
	25		Xe-133	6.9	-17	-6.0
	36		HTO in Air	4.3	-3.0	0.4

NV-5. Amargosa Valley, Nevada

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1990	50		HTO in Air	5.3	-3.1	0.2
1991	42		Kr-85	30	24	26.5
	41		Xe-135	4.1	-7.3	-1.4
	49		HTO in Air	2.7	-3.0	0.27
1992	44		Kr-85	30	22	26
	44		Xe-133	7.2	-15	-2.1
	51		HTO in Air	5.0	-2.0	0.89
1993	49		Kr-85	31	24	28
	49		Xe-133	4.7	-10	-1.9
	52		HTO in Air	23	-3.4	0.7
1994	34		Kr-85	33	22	29
	34		Xe-133	5.9	-17	-3.9
	38		HTO in Air	2.4	-1.9	0.2

NV-6. Austin, Nevada

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1982		219.9	Kr-85	32	16	24
		212.9	Xe-133	<40	<7	4.8
		236.0	HTO in Air	<6	<2	0.68
1983	49/3*		Kr-85	30	19	25
	45/7*		Xe-133	24	-12	2.1
	52/0*		HTO in Air	2.9	-1.1	0.55
1984	50/2*		Kr-85	N/A	N/A	23
	45/7*		Xe-133	32	-14	5.5
	52/0*		HTO in Air	2.5	-1.6	0.15
1985	41/11*		Kr-85	N/A	N/A	25
	40/12*		Xe-133	19	-31	4.2
	53/0*		HTO in Air	2.6	-2.3	0.13
1986	51/1*		Kr-85	30	20	25
	48/4*		Xe-133	54	-5.8	3.7
	52/0*		HTO in Air	4.1	-3.7	0.26
1987	39/13*		Kr-85	31	21	25
	39/13*		Xe-133	15	-10	0.89
	46/3*		HTO in Air	3.2	3.1	0.50
1988	42		Kr-85	30	21	25
	43		Xe-133	11	-12	-0.95
	51		HTO in Air	3.0	-5.9	-0.0061
1989	45		Kr-85	31	21	27
	45		Xe-133	11	-18	-0.55
	52		HTO in Air	3.2	-9.3	-0.16
1990	49		Kr-85	31	21	27
	49		Xe-133	11	-9.4	0.21
	52		HTO in Air	4.6	-2.3	0.5

*positive/negative

NV-6. Austin, Nevada (continued)

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1991	32		Kr-85	31	22	26
	32		Xe-133	9.5	-19	-2.1
	46		HTO in Air	4.0	-2.0	0.50
1992	2		Kr-85	26	24	25
	2		Xe-133	0.000	-12	-6.1
	2		HTO in Air	0.49	-0.52	-0.02
1993	3		HTO in Air	1.1	-1.7	-0.5

NV-7. Beatty, Nevada

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1972		190.7	Kr-85	22	12	16
		210.5	Xe-133	17	<2	<2.6
		225.7	HTO in Air	9.4	0.86	<4.1
		182.5	CH_3T	<5	<5	<5.0
1973		342.0	Kr-85	21	12	16
		356.0	Xe	<2.0	<2.0	<2.0
		327.5	HTO in Air	5.2	<0.49	<2.0
		349.0	CH_3T	16	<5.0	<5.2
1974		356.0	Kr-85	27	12	17
		363.0	Xe-133	140	<2.0	<7.4
		363.0	HTO in Air	6.1	<0.56	<2.5

NV-7. Beatty, Nevada (continued)

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
		363.0	CH_3T	<5.0	<1.7	<3.0
		363.0	HT	10	<0.42	<2.3
1975		368.4	Kr-85	25	11	19
		368.4	Total Xe	<7	<4	<5
		348.4	HTO in Air	8.4	<0.5	<3
		368.4	CH_3T	<3	<2	<2
		341.5	HT	9.3	<0.4	<3
1976		363.3	Kr-85	24	15	20
		363.3	Total Xe	<7	<4	<5
		328.5	HTO in Air	21	<0.2	<2
		363.3	CH_3T	11	<2	<3
		328.5	HT	5.0	<0.2	<3
1977		337.6	Kr-85	26	15	20
		337.6	Xe-133	14	<4	<6
		324.7	HTO in Air	<4	0.2	<2
		337.6	CH_3T	12	<2	<3
		324.7	HT	1.2	<0.1	<0.6
1978		343.6	Kr-85	25	17	20
		343.6	Xe-133	<30	<3	<3
		296.7	HTO in Air	13	<0.3	1.5
		343.6	CH_3T	<20	<2	<2
		295.7	HT	<3	<0.5	<0.5
1979		348.3	Kr-85	24	14	19
		348.4	Xe-133	<20	<3	<3
		364.5	HTO in Air	5.7	<0.3	<1
1980		346.4	Kr-85	26	16	21
		346.5	Xe-133	54	<3	<3
		321.5	HTO in Air	12	<0.9	1.6
1981		352.6	Kr-85	31	18	24

NV-7. Beatty, Nevada (continued)

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
		337.2	Xe-133	<45	<6.2	<6.2
		363.8	HTO in Air	11	<0.78	1.8
1982		348.5	Kr-85	31	17	25
		320.5	Xe-133	<100	<7	8.0
		362.6	HTO in Air	<6	<1	0.63
1983	46/6*		Kr-85	30	20	24
	45/7*		Xe-133	23	-12	2.9
	52/0*		HTO in Air	2.2	-1.3	0.48
1984	46/5*		Kr-85	N/A	N/A	23
	39/12*		Xe-133	31	-19	6.0
	51/1*		HTO in Air	2.1	-1.7	0.34
1985	38/15*		Kr-85	N/A	N/A	25
	38/15*		Xe-133	47	-25	6.6
	53/0*		HTO in Air	1.9	-1.5	0.27
1986	41/10*		Kr-85	37	19	26
	37/14*		Xe-133	52	-6.9	6.4
	52/0*		HTO in Air	9.6	-4.7	0.51
1987	39/13*		Kr-85	30	21	26
	40/12*		Xe-133	33	-14	1.1
	48/0*		HTO in Air	6.1	-2.6	0.64
1988	44		Kr-85	32	20	26
	45		Xe-133	17	-11	1.4
	50		HTO in Air	4.6	-7.5	0.27
1989	50		Kr-85	32	20	27
	51		Xe-133	11	-10	1.8
	51		HTO in Air	11	-11	0.52

*positive/negative

NV-7. Beatty, Nevada (continued)

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1990	52		Kr-85	32	21	26
	52		Xe-133	9.0	-9.2	-0.09
	51		HTO in Air	3.3	-1.8	0.2
1991	52		Kr-85	31	22	26
	52		Xe-133	7.1	-14	-0.88
	51		HTO in Air	3.8	-1.0	0.60
1992	50		Kr-85	31	21	26
	51		Xe-133	6.0	-15	-21
	51		HTO in Air	1..9	-1.3	0.30
1993	48		Kr-85	33	23	27
	49		Xe-133	6.8	-14	-2.3
	44		HTO in Air	3.2	-2.2	0.2
1994	30		Kr-85	33	25	28
	30		Xe-133	5.4	-22.0	-5.3
	37		HTO in Air	4.2	-2.6	0.2

NV-8. Caliente, Nevada

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1987	17/0*		HTO in Air	7.0	-4.1	-0.08
1988	23		Kr-85	28	20	24
	23		Xe-133	14	-20	-3.8
	48		HTO in Air	6.5	-2.3	0.42
1989	18		Kr-85	29	25	27
	18		Xe-133	5.7	-17	-1.4
	52		HTO in Air	4.1	-2.9	0.30
1990	46		Kr-85	32	21	26
	47		Xe-133	11	-12	-0.23
	51		HTO in Air	8.3	-2.7	1.3
1991	37		Kr-85	30	22	26
	37		Xe-133	13	-21	-2.5
	46		HTO in Air	9.7-10.2	0.42	
1992	2		Kr-85	28	23	26
	2		Xe-133	0.33	-0.44	-0.06
	1		HTO in Air	-1.2	-1.2	-1.2
1993	3		HTO in Air	2.0	-0.3	0.7

*positive/negative

NV-9. Diablo (Reveille), Nevada

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1972		210.3	Kr-85	22	12	16
		210.3	Xe-133	33	<2	<2.9
		220.6	HTO in Air	13	<0.92	<4.20
		204.6	CH_3T	<5	<5	<5.00
1973		343.2	Kr-85	22	12	16
		357.1	Xe-133	30	<2.0	<3.1
		356.5	HTO in Air	<6.6	<0.69	<2.0
		350.2	CH_3T	5.1	<5.0	<5.0
1974		356.0	Kr-85	29	13	17
		356.0	Xe-133	17	<2.0	<3.7
		357.0	HTO in Air	7.2	<0.82	<2.3
		349.0	CH_3T	5.6	<1.4	<3.0
		357.0	HT	5.7	0.25	<1.5
1975		346.2	Kr-85	29	11	18
		346.3	Xe-133	25	<4	<6
		347.4	HTO in Air	22	<0.2	<3
		346.2	CH_3T	<3	<2	<2
		347.4	HT	8.2	<0.4	<2
1976		341.4	Kr-85	25	12	19
		341.4	Total Xe	<8	<4	<5
		320.6	HTO in Air	5.8	<0.4	<2
		335.4	CH_3T	<3	<2	<2
		320.6	HT	2.7	<0.3	<0.8
1977		350.4	Kr-85	29	12	19
		350.4	Xe-133	12	<4	<5
		325.4	HTO in Air	<5	<0.5	<2
		343.4	CH_3T	5	<2	<3
		325.4	HT	1.9	0.4	<0.7
1978		344.7	Kr-85	26	17	20
		336.7	Xe-133	65	<2	3.1

NV-9. Diablo (Reveille), Nevada (continued)

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
		322.9	HTO in Air	8.6	<1	1.5
		344.7	CH_3T	<20	<2	<2
		307.0	HT	6.0	<0.6	0.97
1979		75.9	Kr-85	26	18	21
		75.9	Xe-133	<3	<2	<2
		68.9	HTO in Air	6.1	<0.9	<2
1982		2.6	Kr-85	22	22	22
		2.6	Xe-133	<30	<30	16

NV-10. Ely, Nevada

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1982		279.7	Kr-85	32	17	24
		253.6	Xe-133	<30	<5	3.5
		306.1	HTO in Air	6.2	<2	0.74
1983	48/4*		Kr-85	31	19	25
	45/7*		Xe-133	24	-2.9	3.8
	52/0*		HTO in Air	3.1	-2.7	0.46
1984	48/4*		Kr-85	N/A	N/A	-22
	42/10*		Xe-133	23	-13	4.9
	49/2*		HTO in Air	2.3	-1.3	0.40
1985	47/6*		Kr-85	N/A	N/A	24
	44/9*		Xe-133	48	-14	6.9
	53/0*		HTO in Air	3.8	-2.3	0.29
1986	52/0*		Kr-85	31	19	25

*positive/negative

NV-10. Ely, Nevada (continued)

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1986	52/0*		Xe-133	36	-7.7	3.2
	52/0*		HTO in Air	7.5	-3.7	0.11
1987	48/4*		Kr-85	30	20	25
	47/5*		Xe-133	20	-11	1.9
	47/2*		HTO in Air	14	-6.6	0.97
1988	45		Kr-85	35	20	26
	46		Xe-133	11	-16	0.51
	50		HTO in Air	7.7	-4.8	0.36
1989	43		Kr-85	30	22	26
	43		Xe-133	10	-16	0.42
	52		HTO in Air	3.9	-11	0.045
1990	50		Kr-85	32	20	27
	50		Xe-133	11	-13	0.34
	51		HTO in Air	7.5	-1.5	0.7
1991	38		Kr-85	31	21	26
	38		Xe-133	12	-19	-14
	45		HTO in Air	4.4	-4.3	0.50
1992	1		Kr-85	24	24	24
	1		Xe-133	-3.2	-3.2	-3.2
	1		HTO in Air	-0.55	-0.55	0.55
1993	4		HTO in Air	1.6	-0.2	0.5

*positive/negative

NV-6. Austin, Nevada

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1982		219.9	Kr-85	32	16	24
		212.9	Xe-133	<40	<7	4.8
		236.0	HTO in Air	<6	<2	0.68
1983	49/3*		Kr-85	30	19	25
	45/7*		Xe-133	24	-12	2.1
	52/0*		HTO in Air	2.9	-1.1	0.55
1984	50/2*		Kr-85	N/A	N/A	23
	45/7*		Xe-133	32	-14	5.5
	52/0*		HTO in Air	2.5	-1.6	0.15
1985	41/11*		Kr-85	N/A	N/A	25
	40/12*		Xe-133	19	-31	4.2
	53/0*		HTO in Air	2.6	-2.3	0.13
1986	51/1*		Kr-85	30	20	25
	48/4*		Xe-133	54	-5.8	3.7
	52/0*		HTO in Air	4.1	-3.7	0.26
1987	39/13*		Kr-85	31	21	25
	39/13*		Xe-133	15	-10	0.89
	46/3*		HTO in Air	3.2	3.1	0.50
1988	42		Kr-85	30	21	25
	43		Xe-133	11	-12	-0.95
	51		HTO in Air	3.0	-5.9	-0.0061
1989	45		Kr-85	31	21	27
	45		Xe-133	11	-18	-0.55
	52		HTO in Air	3.2	-9.3	-0.16
1990	49		Kr-85	31	21	27
	49		Xe-133	11	-9.4	0.21
	52		HTO in Air	4.6	-2.3	0.5

*positive/negative

NV-6. Austin, Nevada (continued)

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1991	32		Kr-85	31	22	26
	32		Xe-133	9.5	-19	-2.1
	46		HTO in Air	4.0	-2.0	0.50
1992	2		Kr-85	26	24	25
	2		Xe-133	0.000	-12	-6.1
	2		HTO in Air	0.49	-0.52	-0.02
1993	3		HTO in Air	1.1	-1.7	-0.5

NV-10. Ely, Nevada

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1982		279.7	Kr-85	32	17	24
		253.6	Xe-133	<30	<5	3.5
		306.1	HTO in Air	6.2	<2	0.74
1983	48/4*		Kr-85	31	19	25
	45/7*		Xe-133	24	-2.9	3.8
	52/0*		HTO in Air	3.1	-2.7	0.46
1984	48/4*		Kr-85	N/A	N/A	-22
	42/10*		Xe-133	23	-13	4.9
	49/2*		HTO in Air	2.3	-1.3	0.40
1985	47/6*		Kr-85	N/A	N/A	24
	44/9*		Xe-133	48	-14	6.9
	53/0*		HTO in Air	3.8	-2.3	0.29
1986	52/0*		Kr-85	31	19	25
	52/0*		Xe-133	36	-7.7	3.2
	52/0*		HTO in Air	7.5	-3.7	0.11
1987	48/4*		Kr-85	30	20	25
	47/5*		Xe-133	20	-11	1.9
	47/2*		HTO in Air	14	-6.6	0.97
1988	45		Kr-85	35	20	26
	46		Xe-133	11	-16	0.51
	50		HTO in Air	7.7	-4.8	0.36
1989	43		Kr-85	30	22	26
	43		Xe-133	10	-16	0.42
	52		HTO in Air	3.9	-11	0.045
1990	50		Kr-85	32	20	27
	50		Xe-133	11	-13	0.34
	51		HTO in Air	7.5	-1.5	0.7

*positive/negative

NV-10. Ely, Nevada (continued)

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1991	38		Kr-85	31	21	26
	38		Xe-133	12	-19	-1445
			HTO in Air	4.4	-4.3	0.50
1992	1		Kr-85	24	24	24
	1		Xe-133	-3.2	-3.2	-3.2
	1		HTO in Air	-0.55	-0.55	0.55
1993	4		HTO in Air	1.6	-0.2	0.5

NV-11. Goldfield, Nevada

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1982		333.3	Kr-85	34	17	25
		319.3	Xe-133	<30	<8	6.0
		293.8	HTO in Air	<6	<2	0.55
1983	50/2*		Kr-85	30	20	24
	50/2*		Xe-133	11	-8.2	1.0
	52/0*		HTO in Air	2.3	-1.1	0.33
1984	48/4*		Kr-85	N/A	N/A	24
	43/9*		Xe-133	30	-14	5.2
	51/0*		HTO in Air	2.3	-2.3	0.06
1985	46.6*		Kr-85	N/A	N/A	24

*positive/negative

NV-11. Goldfield, Nevada (continued)

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1985	42/10*		Xe-133	30	-5.8	6.6
	52/0*		HTO in Air	4.7	-3.4	0.26
1986	49/2*		Kr-85	31	17	25
	44/7*		Xe-133	45	-13	3.4
	51/1*		HTO in Air	1.7	-1.4	0.11
1987	42/10*		Kr-85	29	21	25
	47/5*		Xe-133	26	-16	1.8
	46/3*		HTO in Air	3.9	-3.4	0.23
1988	46		Kr-85	32	20	25
	46		Xe-133	15	-21	0.32
	50		HTO in Air	8.3	-6.2	-0.063
1989	51		KR-85	32	21	26
	51		Xe-133	12	-14	0.82
	52		HTO in Air	4.3	-11	0.23
1990	50		Kr-85	32	20	27
	52		Xe-133	8.0	-12	0.32
	50		HTO in Air	16	-9.1	0.4
1991	51		Kr-85	31	23	27
	51		Xe-133	9.8	-11	-0.86
	53		HTO in Air	14	-7.0	0.42
1992	49		Kr-85	31	-21	-26
	48		Xe-133	13	-16	-1.4
	52		HTO in Air	2.9	-2.7	0.49
1993	47		Kr-85	32	23	27
	47		Xe-133	7.5	-11	-2.7
	48		HTO in Air	3.4	-13	0.2
1994	32		Kr-85	31	23	28
	33		Xe-133	4.9	-31	-7.4
	37		HTO in Air	3.2	-3.1	-0.0

*positive/negative

NV-11. Goldfield, Nevada (continued)

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1994	33		Xe-133	4.9	-31	-7.4
	37		HTO in Air	3.2	-3.1	-0.0

*positive/negative

NV-12. Hiko, Nevada

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1972		189.9	Kr-85	19	12	16
		195.8	Xe-133	570	<2	<33
		205.0	HTO in Air	13	<1.0	<4.4
		153	CH_3T	<5	<5	<5.0
1973		337.9	Kr-85	19	12	16
		335.8	Xe-133	9	<2.0	<2.1
		349.5	HTO in Air	6.3	<0.48	<1.7
		349.9	CH_3T	7.5	<5.0	<5.1
1974		348.0	Kr-85	22	12	17
		348.0	Total Xe	<6.2	<2.0	<3.2
		298.0	HTO in Air	4.4	<0.48	<1.8
		341.0	CH_3T	<5.0	<1.7	<3.0
		298.0	HT	2.7	<0.37	<0.88
1975		346.5	Kr-85	23	10	17
		353.4	Xe-133	20	<4	<5
		313.6	HTO in Air	11	<0.4	<2
		353.4	CH_3T	<3	<2	<2
		313.6	HT	6.7	<0.3	<2

NV-12. Hiko, Nevada (continued)

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1976		349.4	Kr-85	25	11	17
		349.4	Total Xe	<8	<4	<5
		321.5	HTO in Air	3.4	<0.3	<2
		349.4	CH_3T	6.1	<2	<3
		321.5	HT	1.3	<0.2	<0.6
1977		358.6	Kr-85	23	13	19
		364.5	Xe-133	11	<4	<5
		329.3	HTO in Air	<5	0.7	<2
		364.4	CH_3T	<2	<2	<2
		329.3	HT	26	<0.3	<2
1978		357.7	Kr-85	26	14	20
		357.7	Xe-133	<20	<3	<3
		321.8	HTO in Air	<5	<0.8	0.73
		357.7	CH_3T	<20	<2<2	
		293.0	HT	4.0	<0.4	0.94
1979		327.5	Kr-85	30	14	19
		334.5	Xe-133	<7	<3	<3
		357.6	HTO in Air	12	<0.7	<2
1980		334.4	Kr-85	27	15	21
		348.9	Xe-133	<20	<3	<3
		200.0	HTO in Air	8.6	<0.5	0.53
1981		318.8	Kr-85	31	14	24
		318.8	Xe-133	<37	<7.0	<7.0
		296.8	HTO in Air	6.6	0.64	1.0
1982		2.6	Kr-85	26	26	26
		2.6	Xe-133	<6	<6	1.9

NV-13. Indian Springs, Nevada

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1975		252.7	Kr-85	30	9	20
April-		259.7	Xe-133	12	<4	<5
December		259.7	HTO in Air	7.5	<0.2	<3
		259.7	CH_3T	<3	<2	<2
		259.7	HT	6	0.42	2.5
1976		350.6	Kr-85	26	12	20
		357.6	Total Xe	<8	<4	<4
		335.7	HTO in Air	12	<0.2	<2
		363.6	CH_3T	18	<2	<3
		328.7	HT	7.6	<0.2	<2
1977		350.2	Kr-85	30	14	20
		350.2	Total Xe	<6	<4	<5
		316.5	HTO in Air	3.6	<0.5	<2
		350.2	CH_3T	14	<2	<3
		316.5	HT	3.2	<0.2	<0.9
1978		344.4	Kr-85	25	16	20
		363.6	Xe-133	<5	<3	<3
		334.6	HTO in Air	<4	<0.8	0.83
		356.5	CH_3T	20	<2	<2
		300.5	HT	24	<0.5	1.8
1979		333.5	Kr-85	23	16	19
		362.4	Xe-133	<20	<3	<3
		355.5	HTO in Air	7.5	<1	<1
1980		346.5	Kr-85	29	15	21
		356.6	Xe-133	<30	<3	<3
		328.8	HTO in Air	20	<0.5	1.5
1981		361.6	Kr-85	31	18	24
		361.6	Xe-133	<40	<7.6	<7.6
		342.7	HTO in Air	5.1	0.56	0.80

NV-13. Indian Springs, Nevada (continued)

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1982		307.8	Kr-85	32	17	24
		307.8	Xe-133	<40	<5	3.9
		355.7	HTO in Air	<6	<0.6	0.31
1983	44/8*		Kr-85	31	19	25
	44/8*		Xe-133	8.8	-25	1.2
	52/0*		HTO in Air	3.7	-4.4	0.34
1984	46/6*		Kr-85	N/A	N/A	22
	41/11*		Xe-133	33	-19	5.3
	53/0*		HTO in Air	4.1	-0.96	0.30
1985	48/4*		Kr-85	N/A	N/A	24
	47/5*		Xe-133	41	-8.5	5.0
	51/0*		HTO in Air	3.1	-2.4	0.21
1986	44/7*		Kr-85	30	21	26
	46/5*		Xe-133	43	-14	3.3
	50/2*		HTO in Air	2.9	-2.9	0.37
1987	42/11*		Kr-85	34	20	26
	44/9*		Xe-133	27	-7.0	0.98
	49/0*		HTO in Air	8.4	-2.3	0.88
1988	41		Kr-85	30	20	25
	41		Xe-133	7.1	-7.9	-0.54
	48		HTO in Air	3.5	-3.0	0.41
1989	49		Kr-85	32	21	26
	49		Xe-133	13	-5.5	0.75
	50		HTO in Air	4.9	-1.8	0.37
1990	52		Kr-85	30	21	27
	52		Xe-133	8.4	-8.1	0.26
	48		HTO in Air	2.8	-5.0	0.1

*positive/negative

NV-13. Indian Springs, Nevada (continued)

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1991	48		Kr-85	31	21	27
	49		Xe-133	5.3	-6.9	-0.64
	48		HTO in Air	9.2	-3.7	0.86
1992	50		Kr-85	30	22	26
	50		Xe-133	6.0	-12	-1.8
	49		HTO in Air	4.8	-4.3	0.74
1993	49		Kr-85	32	23	28
	50		Xe-133	11	-10.0	1.5
	50		HTO in Air	2.9	-1.8	0.3
1994	34		Kr-85	33	25	30
	34		Xe-133	6.4	-16	-3.3
	38		HTO in Air	2.7	-1.9	0.2

NV-14. Las Vegas, Nevada

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1981		77.8	Kr-85	30	16	24
		84.6	Xe-133	<81	<6.1	<8.0
		90.9	HTO in Air	4.0	<1.3	<1.3
1982		317.5	Kr-85	32	18	24
		310.5	Xe-133	<20	<4	3.0
		357.8	HTO in Air	<8	<0.8	0.35

NV-14. Las Vegas, Nevada (continued)

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1983	46/6*		Kr-85	31	20	24
	44/8*		Xe-133	30	-28	1.3
	51/1*		HTO in Air	5.0	-2.3	0.58
1984	47/6*		Kr-85	N/A	N/A	23
	43/10*		Xe-133	35	-7.96.5	
	50/3*		HTO in Air	3.3	-1.1	0.45
1985	45/7*		Kr-85	N/A	N/A	25
	43/9*		Xe-133	66	-12	7.1
	52/0*		HTO in Air	15	-2.7	2.1
1986	46/5*		Kr-85	33	18	25
	46/5*		Xe-133	67	-15	3.3
	50/1*		HTO in Air	21	-8.1	2.3
1987	47/5*		Kr-85	30	20	26
	48/4*		Xe-133	7.3	-6.9	1.1
	49/0*		HTO in Air	4.2	-6.2	0.50
1988	49		Kr-85	31	22	26
	50		Xe-133	8.8	-11	0.93
	51		HTO in Air	5.2	-8.1	0.39
1989	49		Kr-85	31	21	26
	49		Xe-133	12	-12	1.1
	52		HTO in Air	2.6	-1.7	0.40
1990	47		Kr-85	33	20	26
	47		Xe-133	4.5	-5.6	-0.28
	53		HTO in Air	2.8	-2.1	0.4
1991	45		Kr-85	31	22	27
	47		Xe-133	14	-7.6	-0.84
	53		HTO in Air	15	-2.9	1.7

*positive/negative

NV-14. Las Vegas, Nevada (continued)

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1992	51		Kr-85	31	21	26
	51		Xe-133	4.6	-18	-1.5
	52		HTO in Air	9.5	-4.9	1.5
1993	51		Kr-85	32	2327	
	51		Xe-133	5.9	-8.1	-1.8
	51		HTO in Air	3.2	-2.1	0.5
1994	37		Kr-85	33	22	28
	37		Xe-133	7.2	-11	-3.4
	33		HTO in Air	4.0	-4.0	0.2

NV-15. Las Vegas, NV00, Nevada

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1972		207.3	Kr-85	18	10	16
		234.5	Xe-133	<2	<2	<2.0
		260.0	HTO in Air	12	<0.33	<4.7
		201.7	CH_3T	<5	<5	<5.0
1973		314.3	Kr-85	20	12	16
		335.1	Xe-133	15	<2.0	<2.5
		354.6	HTO in Air	6.8	<0.31	<1.5
		335.1	CH_3T	7.0	<5.0	<5.0
1974		295.0	Kr-85	21	13	17
		290.0	Total Xe	<6.9	<2.0	<3.4
		342.0	HTO in Air	<5.9	<0.45	<2.0

NV-15. Las Vegas, NV00, Nevada

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1974		297.0	CH_3T	<5.0	<1.7	<2.8
		342.0	HT	<18	<0.28	<1.2
1975		361.4	Kr-85	30	9.6	18
		361.5	Xe-133	11	<4	<5
		354.6	HTO in Air	4.4	<0.4	<2
		361.4	CH_3T	<3.0	<2.0	<2.0
		354.6	HT	4.7	<0.3	<1
1976		340.5	Kr-85	29	12	18
		340.5	Total Xe	<7	<3	<5
		342.4	HTO in Air	17	<0.4	<2
		340.5	CH_3T	7.0	<2	<3
		342.4	HT	1.8	<0.2	<0.6
1977		345.2	Kr-85	23	15	20
		352.2	Xe-133	10	<4	<5
		303.1	HTO in Air	4.5	<0.3	<2
		352.2	CH_3T	<6	<2	<3
		303.1	HT	2.2	<0.3	<0.7

NV-15. Las Vegas, NV00, Nevada

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1978		329.7	Kr-85	24	16	20
		336.6	Xe-133	<20	<3	<3
		321.6	HTO in Air	<7	<0.7	<1.6
		336.7	CH_3T	<30	<2	<2
		285.7	HT	7.9	<0.6	0.89
1979	NO DATA					

NV-16. Lathrop Wells, Nevada

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1979		217.6	Kr-85	23	13	19
		225.8	Xe-133	<20	<3	<3
		203.6	HTO in Air	4.4	<2	<2
1980		342.4	Kr-85	27	15	22
		342.5	Xe-133	34	<3	<3
		2.1	Xe-135	360	360	
		318.6	HTO in Air	17	<2	<2.5
1981		368.8	Kr-85	31	16	23
		360.7	Xe-133	<78	<5.8	<5.8
		327.7	HTO in Air	4.8	<1.3	1.4
1982		361.5	Kr-85	29	19	24
		340.6	Xe-133	<200	<7	8.0
		338.5	HTO in Air	<7	<0.9	0.69
1983	50/2*		Kr-85	32	19	26
	49/3*		Xe-133	26	-9.9	4.8
	52/0*		HTO in Air	2.8	-2.1	0.54
1984	49/3*		Kr-85	N/A	N/A	22
	43/9*		Xe-133	51	-21	7.1
	50/2*		HTO in Air	4.0	-1.1	0.46
1985	49/4*		Kr-85	N/A	N/A	24
	47/6*		Xe-133	29	-7.2	6.6
	53/0*		HTO in Air	5.8	-2.0	0.40
1986	51/1*		Kr-85	32	19	25
	48/4*		Xe-133	84	-5.8	5.3
	51/0*		HTO in Air	18	-4.3	1.5
1987	46/6*		Kr-85	30	20	25
	44/8*		Xe-133	7.7	-15	0.24

*positive/negative

NV-16. Lathrop Wells, Nevada (continued)

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1987	47/2*		HTO in Air	16	-4.4	1.3
1988	47		Kr-85	30	18	26
	47		Xe-133	8.6	-14	-0.03
	48		HTO in Air	6.3	-12	-0.53
1989	43		Kr-85	30	21	26
	44		Xe-133	9.4	-7.5	0.16
	50		HTO in Air	4.7	-2.4	28
1990	50		Kr-85	33	22	26
	50		Xe-133	12	-10	0.17

*positive/negative

NV-18. NTS, Area 15, Nevada

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1979		210.8	Kr-85	24	14	19
		217.7	Xe-133	<40	<3	<3
		155.7	HTO in Air	62	<2	<17
1980		364.5	Kr-85	29	16	21
		357.5	Xe-133	<40	<4	<4
		3.0	Xe-135	64	64	-
		322.7	HTO in Air	57	6.9	26
1981		356.9	Kr-85	33	18	25
		356.9	Xe-133	<130	<4.9	<4.9
		341.7	HTO in Air	90	<2.1	25

NV-19. Area 51, (Groom Lake), Nevada

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1981		350.5	Kr-85	32	18	24
		343.5	Xe-133	<62	<2.2	4.2
		277	HTO in Air	25	0.63	2.5

NV-20. NTS, Area 400, Nevada

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1979		201.6	Kr-85	23	11	18
		218.4	Xe-133	<14	<3	<3
		176.5	HTO in Air	7.7	2.0	<3
1980		367.5	Kr-85	33	17	21
		367.4	Xe-133	<50	<3	<3
		213.9	HTO in Air	7.3	<0.30	1.1
1981		278.9	Kr-85	33	15	23
		278.9	Xe-133	<63	<3.1	3.5
		345.7	HTO in Air	10	<1.1	1.7

NV-21. NTS, BJY, Nevada

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1972		278.6	Kr-85	23	12	17
		291.7	Xe-133	530	<2	<36
		284.8	HTO in Air	75	<0.26	<20
		284.8	CH_3T	<5	<5	<5.0
1973		358.2	Kr-85	27	13	18
		351.3	Xe-133	240	<2.0	<30
		357.6	HTO in Air	120	0.66	<25
		358.2	CH_3T	17	<5.0	<6.1
1974		327.0	Kr-85	32	13	19
		340.0	Xe-133	1000	<2.0	<44
		355.0	HTO in Air	59	10	13
		340.0	CH_3T	20	<1.7	<3.5
		355.0	HT	34	<0.34	<4.1
1975		363.4	Kr-85	38	9.8	19
		363.4	Xe-133	31	<4	<6
		363.4	HTO in Air	20	<1	<7
		363.4	CH_3T	<3	<2	<2
		363.4	HT	9.2	<0.4	<1
1976		356.4	Kr-85	27	13	20
		355.4	Total Xe	<6	<4	<5
		356.6	HTO in Air	51	<0.6	<7
		363.4	CH_3T	4.0	<2	<3
		356.6	HT	<8	<0.2	<2
1977		306.4	Kr-85	35	13	21
		336.6	Xe-133	100	<2	<7
		323.2	HTO in Air	35	<2	<11
		330.5	CH_3T	6	<2	<3
		317.3	HT	7.7	<0.5	<2
1978		335.6	Kr-85	29	19	22
		356.5	Xe-133	14,000	<2	240

NV-21. NTS, BJY, Nevada (continued)

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1978		329.6	HTO in Air	110	1.2	13
		356.5	CH_3T	<20	<2	<2
		322.6	HT	37	<0.2	2.7
1979		336.8	Kr-85	33	15	21
		337.8	Xe-133	24	<2	<2
		307.5	HTO in Air	27	1.5	<7
1980		363.6	Kr-85	32	14	23
		348.6	Xe-133	2,100	<3	32
		3.0	Xe-135	39,000	39,000	39,000
		361.7	HTO in Air	32	0.68	9.6
1981		311.6	Kr-85	39	18	26
		320.9	Xe-133	1,500	<3.2	45
		340.7	HTO in Air	32	1.7	12

NV-22. NTS, Building 790, Nevada

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1975		343.2	Kr-85	34	8.2	18
		349.3	Xe-133	13	<4	<5
		341.3	HTO in Air	6.3	<0.4	<2
		349.3	CH_3T	<3	<2	<3
		341.3	HT	5.4	0.23	<2

NV-23. NTS, Desert Rock, Nevada

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1972		237.4	Kr-85	25	12	16
		250.5	Xe-133	30	<2	<2.8
		223.4	HTO in Air	15	0.71	<3.8
		223.6	CH_3T	<5	<5	<5.0
1973		335.0	Kr-85	21	13	16
		342.1	Xe-133	13	<2.0	<2.5
		357.7	HTO in Air	5.0	<0.50	<1.9
		342.0	CH_3T	13	<5.0	<5.3
1974		355.0	Kr-85	31	12	18
		368.0	Xe-133	53	<2.0	<4.2
		368.0	HTO in Air	15	<0.74	<2.6
		361.0	CH_3T	<8.8	<1.5	<3.0
		368.0	HT	9.2	<0.36	<1.4

NV-24. NTS, Gate 700, Nevada

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1972		252.4	Kr-85	23	13	16
		246.4	Xe-133	<2	<2	<2.0
		201.7	HTO in Air	15	<0.83	<5.2
		217.7	CH_3T	<5	<5	<5.0
1973		323.1	Kr-85	20	13	16
		344.2	Xe-133	16	<2.0	<3.3
		327.6	HTO in Air	7.9	<0.59	<2.5
		337.2	CH_3T	8.3	<5.0	<5.2
1974		348.0	Kr-85	22	12	17
		348.0	Total Xe	6.3	<2.0	<3.3

NV-24. NTS, Gate 700, Nevada (continued)

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
		356.0	HTO in Air	35	0.64	<3.6
		342.0	CH_3T	6.3	<1.7	<3.1
		356.0	HT	<14	0.58	<3.7

NV-25. NTS, Mercury, Nevada

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1976		340.5	Kr-85	29	12	18
		340.5	Total Xe	<7	<3	<5
		342.4	HTO in Air	17	<0.4	<2
		340.5	CH_3T	7.0	<2	<3
		342.4	HT	1.8	<0.2	<0.6
1977		345.6	Kr-85	24	13	20
		358.5	Xe-133	7.1	<2	<5
		323.6	HTO in Air	7.6	<0.3	<2
		358.6	CH_3T	9	<2	<3
		323.6	HT	4.5	<0.3	<0.8
1978		350.5	Kr-85	28	15	20
		363.5	Xe-133	170	<3	5.7
		323.6	HTO in Air	32	<0.7	1.8
		356.5	CH_3T	<20	<2	<2
		303.7	HT	6.4	<0.60.8	
1979		347.6	Kr-85	25	13	19
		362.6	Xe-133	<9	<0.4	<0.4
		312.7	HTO in Air	6.5	0.77	<2
1980		350.6	Kr-85	30	15	21

NV-25. NTS, Mercury, Nevada

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1980		335.6	Xe-133	<40	<3	<3
		313.6	HTO in Air	22	<0.5	1.6
1981		302.3	Kr-85	30	16	23
		316.3	Xe-133	<40	<2.8	4.6
		355.7	HTO in Air	9.6	1.3	2.0

NV-26. Overton, Nevada

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1981		7.0	Kr-85	26	26	26
		7.0	Xe-133	<13	<13	<13
		23.0	HTO in Air	<3.1	<1.5	<1.5
1982		307.3	Kr-85	30	18	24
		281.2	Xe-133	<60	<6	5.5
		254.4	HTO in Air	<8	<2	0.15
1983	48/4*		Kr-85	30	19	25
	47/5*		Xe-133	35	-11	5.3
	51/1*		HTO in Air	4.7	-1.7	0.44
1984	42/12*		Kr-85	N/A	N/A	23
	39/15*		Xe-133	20	-18	5.8
	48/4*		HTO in Air	4.3	-1.6	0.13
1985	48/4*		Kr-85	N/A	N/A	24
	47/5*		Xe-133	17	-4.7	4.4
	51/1*		HTO in Air	4.2	-3.3	0.13
1986	49/3*		Kr-85	32	17	25
	47/5*		Xe-133	31	-11	2.4

*positive/negative

NV-26. Overton, Nevada (continued)

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1986	50/2*		HTO in Air	5.3	-5.2	0.17
1987*	47/5		Kr-85	33	20	25
	48/4		Xe-133	16	-12	0.49
	47/2		HTO in Air	17	-11	0.92
1988	48		Kr-85	32	20	26
	51		Xe-133	8.2	-10	1.1
	50		HTO in Air	15	-3.8	0.68
1989	49		Kr-85	31	21	26
	49		Xe-133	10	-13	0.41
	52		HTO in Air	4.5	-3.1	0.17
1990	50		Kr-85	32	22	26
	51		Xe-133	9.2	-12	0.15
	52		HTO in Air	7.2	-3.3	0.9
1991	53		Kr-85	32	21	26
	53		Xe-133	13	-9.7	-1.5
	53		HTO in Air	2.8	-3.9	0.40
1992	52		Kr-85	31	21	26
	52		Xe-133	8.2	-22	-2.6
	51		HTO in Air	5.7	-4	0.85
1993	50		Kr-85	32	22	27
	50		Xe-133	11	-20	-3.8
	52		HTO in Air	4.5	-6.2	0.4
1994	35		Kr-85	32	23	29
	36		Xe-133	5.6	-21	-6.2
	38		HTO in Air	7.8	-3.7	0.2

*positive/negative

NV-27. Pahrump, Nevada

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1981		95.6	Kr-85	29	15	23
		95.6	Xe-133	<43	<6.4	6.5
		99.7	HTO in Air	5.3	<1.1	1.5
1982		337.5	Kr-85	30	20	24
		344.7	Xe-133	<40	<6	3.9
		363.7	HTO in Air	<8	<0.9	0.39
1983	42/10*		Kr-85	30	18	24
	39/13*		Xe-133	7.6	-9.2	1.9
	52/0*		HTO in Air	3.5	-3.5	0.25
1984	45/8*		Kr-85	N/A	N/A	23
	41/12*		Xe-133	29	-16	5.9
	52/1*		HTO in Air	2.4	-2.4	0.22
1985	47/5*		Kr-85	N/A	N/A	25
	46/6*		Xe-133	24	-8.3	4.4
	51/0*		HTO in Air	11	-3.5	0.37
1986	48/4*		Kr-85	30	19	25
	47/5*		Xe-133	24	-9.2	2.2
	51/0*		HTO in Air	5.9	-4.7	0.28
1987	50/1*		Kr-85	30	21	26
	49/2*		Xe-133	18	-7.4	1.0
	49/0*		HTO in Air	3.3	-5.2	0.09
1988	44		Kr-85	30	21	25
	44		Xe-133	10	-11	0.67
	50		HTO in Air	6.7	-8.1	0.18
1989	47		Kr-85	31	20	26
	48		Xe-133	4.5	-8.0	0.23

*positive/negative

NV-27. Pahrump, Nevada (continued)

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1989	51		HTO in Air	4.3	-2.0	0.29
1990	49		Kr-85	30	21	26
	50		Xe-133	7.7	-9.4	0.06
	52		HTO in Air	12	-5.2	0.5
1991	46		Kr-85	31	21	26
	47		Xe-133	4	-7.9	-1.4
	52		HTO in Air	5.9	-3.0	-0.26
1992	47		Kr-85	30	22	27
	47		Xe-133	5.8	-15	-1.1
	51		HTO in Air	6.5	-2.2	0.10
1993	48		Kr-85	33	21	28
	48		Xe-133	5.5	-13	-2.1
	49		HTO in Air	4.8	-2.7	0.1
1994	33		Kr-85	34	25	29
	33		Xe-133	4.7	-16	-3.3
	36		HTO in Air	2.9	-2.3	0.4

NV-28. Pioche, Nevada

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1985	10/0*		Kr-85	34	29	31
	10/0*		Xe-133	22	-4.1	8.0
	32/0*		HTO in Air	3.4	-1.9	0.35
1986	13/1*		Kr-85	30	21	26
	12/2*		Xe-133	9.4	-3.2	2.4
	52/0*		HTO in Air	2.7	-6.4	-0.57
1987	9/0*		Kr-85	29	25	26
	9/0*		Xe-133	9.7	-5.4	-0.18
	48/1*		HTO in Air	4.9	-4.7	0.82
1988	51		HTO in Air	4.7	-5.1	0.27
1989	52		HTO in Air	3.5	-2.6	0.22
1990	51		HTO in Air	5.1	-6.2	0.6
1991	46		HTO in Air	8.4	-3.1	0.61

*positive/negative

NV-30. Rachel, Nevada

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1979		280.6	Kr-85	21	14	18
		283.7	Xe-133	<7	<3	<3
		275.7	HTO in Air	<6	<0.8	<0.8
1980		340.4	Kr-85	28	15	21
		327.1	Xe-133	<50	<3	<3
		347.9	HTO in Air	11	<1	1.6
1981		304.2	Kr-85	33	13	24
		297.2	Xe-133	<78	<4.5	4.7
		361.4	HTO in Air	<5.0	<1.3	<1.3
1982		347.7	Kr-85	31	19	26
		326.6	Xe-133	<40	<5	4.2
		361.9	HTO in Air	<7	<0.6	0.48
1983	45/6*		Kr-85	31	20	24
	44/7*		Xe-133	16	-56	0.74
	52/0*		HTO in Air	4.4	-1.1	0.71
1984	48/4*		Kr-85	N/A	N/A	22
	47/5*		Xe-133	38	-16	6.2
	50/2*		HTO in Air	3.0	-1.4	0.33
1985	45/7*		Kr-85	N/A	N/A	22
	45/7*		Xe-133	24	-10	4.3
	53/0*		HTO in Air	5.1	-2.1	0.33
1986	50/2*		Kr-85	31	19	25
	48/4*		Xe-133	45	-7.6	3.5
	52/0*		HTO in Air	14	-1.9	1.3
1987	44/7*		Kr-85	29	20	25
	47/4*		Xe-133	9.2	-13	0.35
	46/3*		HTO in Air	5.6	-5.7	0.29

*positive/negative

NV-30. Rachel, Nevada (continued)

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1988	43		Kr-85	32	21	26
	48		Xe-133	12	-17	0.41
	50		HTO in Air	5.0	-5.0	0.34
1989	48		Kr-85	32	21	27
	48		Xe-133	9.0	-10	0.47
	52		HTO in Air	4.2	-15	0.02
1990	49		Kr-85	32	21	27
	52		Xe-133	10	-14	-0.46
	51		HTO in Air	10	-4.0	0.5
1991	45		Kr-85	30	22	27
	46		Xe-133	15	-15	-1.1
	50		HTO in Air	2.4	-4.6	0.40
1992	44		Kr-85	31	20	26
	44		Xe-133	7.2	-15	-2.6
	48		HTO in Air	2.3	-2.3	0.38
1993	41		Kr-85	31	20	27
	41		Xe-133	8.4	-14	-2.4
	47		HTO in Air	2.8	-2.6	0.1
1994	34		Kr-85	32	21	28
	34		Xe-133	8.2	-37.0	-8.9
	38		HTO in Air	4.1	-2.1	0.6

NV-31. Tonopah, Nevada

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1972		234.9	Kr-85	21	12	16
		259.4	Xe	<2	<2	2.0
		252.6	HTO in Air	7	<0.64	<3.0
		251.4	CH_3T	<5	<5	<5.0
1973		350.8	Kr-85	21	13	16
		356.9	Xe-133	<2.0	<2.0	<2.0
		357.4	HTO in Air	4.7	<0.78	<1.6
		349.9	CH_3T	18	<5.0	<5.5
1974		344.0	Kr-85	25	11	18
		356.0	Total Xe	<6.9	<2.0	<3.7
		357.0	HTO in Air	<5.2	<0.59	<2.0
		350.0	CH_3T	<5.0	<1.7	<2.8
		364.0	HT	4.5	<0.41	<1.9
1975		355.4	Kr-85	24	10	17
		361.3	Total Xe	<9	<4	<5
		368.3	HTO in Air	5.6	<0.4	<2
		361.3	CH_3T	<3	<2	<2
		368.3	HT	4.2	<0.2	<2
1976		363.3	Kr-85	25	13	19
		363.3	Total Xe	<7	<5	<5
		363.5	HTO in Air	13	<0.3	<2
		363.3	CH_3T	4.0	<2	<2
		357.5	HT	4.3	<0.2	<0.8
1977		357.8	Kr-85	23	14	19
		364.5	Xe-133	15	<4	<5
		336.7	HTO in Air	<5	<0.7	<2
		356.6	CH_3T	<7	<2	<3
		329.7	HT	1.8	<0.4	<0.8
1978		336.6	Kr-85	27	15	20
		349.6	Xe-133	<20	<4	<3

NV-31. Tonopah, Nevada(continued)

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1978		329.7	HTO in Air	4.2	<0.9	1.1
		349.6	CH_3T	<20	<2	<2
		315.5	HT	<20	<0.5	0.5
1979		359.4	Kr-85	23	14	18
		364.5	Xe-133	<10	<3	<3
		335.7	HTO in Air	6.2	<0.5	<0.8
1980		355.5	Kr-85	28	16	21
		348.5	Xe-133	<40	<3	<3
		329.0	HTO in Air	16	<2	<2
1981		339.1	Kr-85	31	17	25
		338.0	Xe-133	<50	<6.4	<6.4
		350.0	HTO in Air	5.8	<0.83	1.1
1982		355.3	Kr-85	31	16	24
		348.3	Xe-133	<60	<7	6.0
		355.6	HTO in Air	<5	<2	0.45
1983	44/7*		Kr-85	32	21	25
	42/9*		Xe-133	54	-13	3.4
	52/0*		HTO in Air	2.5	-2.2	0.47
1984	48/4*		Kr-85	N/A	N/A	23
	43/9*		Xe-133	41	-11	6.5
	52/0*		HTO in Air	2.3	-1.6	0.14
1985	49/4*		Kr-85	N/A	N/A	25
	48/5*		Xe-133	47	-16	4.8
	52/1*		HTO in Air	3.4	-2.2	0.20
1986	48/4*		Kr-85	30	18	25
	47/5*		Xe-133	57	-5.6	4.4
	52/0*		HTO in Air	4.4	-4.5	0.03

*positive/negative

NV-31. Tonopah, Nevada(continued)

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1987	45/6*		Kr-85	30	20	26
	43/8*		Xe-133	9.3	-9.5	1.8
	48/1*		HTO in Air	5.0	-3.5	0.77
1988	43		Kr-85	30	21	25
	43		Xe-133	16	-12	1.0
	51		HTO in Air	8.5	-6.0	-0.10
1989	49		Kr-85	33	22	27
	51		Xe-133	11	-13	-0.15
	48		HTO in Air	3.9	-7.1	-0.14
1990	49		Kr-85	31	22	26
	51		Xe-133	16	-11	-0.66
	52		HTO in Air	10	-4.6	0.9
1991	46		Kr-85	31	21	26
	46		Xe-133	7.2	-14	-1.4
	52		HTO in Air	12	-6.1	0.79
1992	45		Kr-85	31	20	26
	46		Xe-133	8.8	-16	-1.2
	51		HTO in Air	4.9	-2.4	0.55
1993	48		Kr-85	31	22	27
	49		Xe-133	12	-19	-1.4
	52		HTO in Air	2.5	-4.5	0.2
1994	34		Kr-85	32	24	28
	35		Xe-133	4.9	-23	-6.9
	52		HTO in Air	2.4	-4.2	0.1

*positive/negative

NV-32. Twin Springs Ranch, Nevada

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1982		2.6	Kr-85	27	27	27
		2.6	Xe-133	<200	<200	55
1988	1		Kr-85	24	24	*
	1		Xe-133	9.2	9.2	*
1991	28		Kr-85	30	22	27
	27		Xe-133	5.9	-15	-2.6
	6		HTO in Air	2.2	-1.6	0.14
1992	43		Kr-85	30	22	26
	43		XE-133	4	-13	-0.94
	50		HTO in Air	5.6	-4.0	0.44
1993	47		Kr-85	32	23	28
	47		Xe-133	12	-15	-2.7
	52		HTO in Air	2.4	-2.7	0.3
1994	37		Kr-85	32	23	29
	37		Xe-133	7.6	21	-6.4
	37		HTO in Air	2.3	-2.1	0.2

* Insufficient data to calculate average.

Utah

NV-1. Cedar City, Utah

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1982		279.5	Kr-85	32	20	25
		251.5	Xe-133	<50	<5	6.8
		336.0	HTO in Air	<7	<2	0.35
1983	46/6*		Kr-85	28	18	24
	42/10*		Xe-133	16	-6.7	2.3
	52/0*		HTO in Air	2.8	-1.2	0.46
1984	49/4*		Kr-85	N/A	N/A	22
	46/7*		Xe-133	33	-58	5.7
	50/2*		HTO in Air	1.9	-2.3	0.06
1985	47/5*		Kr-85	N/A	N/A	24
	44/8*		Xe-133	27	-12	4.6
	52/0*		HTO in Air	3.0	-2.0	0.31
1986	44/8*		Kr-85	30	19	24
	39/13*		Xe-133	33	-4.9	3.9
	52/0*		HTO in Air	5.9	-5.9	0.16
1987	42/10*		Kr-85	31	21	26
	44/8*		Xe-133	15	-7.2	1.5
	48/1*		HTO in Air	5.6	-5.5	0.30
1988	39		Kr-85	31	21	25
	42		Xe-133	13	-9.0	2.5
	49		HTO in Air	3.8	-4.2	0.22
1989	48		Kr-85	30	20	26
	48		Xe-133	11	-8.8	0.52
	52		HTO in Air	4.9	-1.8	-0.44
1990	49		Kr-85	32	21	26

*positive/negative

NV-1. Cedar City, Utah (continued)

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1990	49		Xe-133	9.0	-11	-0.13
	52		HTO in Air	5.0	-4.9	0.4
1991	33		Kr-85	29	22	26
	33		Xe-133	5.5	-14	-2.2
	45		HTO in Air	3.9*	-7.0	0.11
1992	4		Kr-85	28	21	26
	4		Xe-133	1.7	-17	-4.6
	3		HTO in Air	0.88	-1.4	-0.32
1993	35		HTO in Air	2.1	-1.3	0.1

*positive/negative

UT-2. Delta, Utah

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1991	4		Kr-85	30	25	27
	4		Xe-133	10	6.2	8.5
1992	1		Kr-85	28	28	28
	1		Xe-133	0.00	0.00	0.00
	1		HTO in Air	-0.40	-0.40	-0.40
1993	4		HTO in Air	0.8	-0.2	0.2

UT-3. Milford, Utah

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1991	3		Kr-85	28	22	26
	3		Xe-133	8.9	-6.7	-1.2
1992	1		HTO in Air	1.6	1.6	1.6
1993	4		HTO in Air	1.3	-0.1	0.5

UT-4. Salt Lake City, Utah

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1982		224.1	Kr-85	32	19	25
		208.1	Xe-133	<40	<4	5.1
		224.1	HTO in Air	<8	<3	0.67
1983	31/15*		Kr-85	34	18	25
	29/17*		Xe-133	32	-6.3	2.6
	47/4*		HTO in Air	4.4	-1.8	0.75
1984	38/12*		Kr-85	N/A	N/A	25
	32/18*		Xe-133	60	-9.8	12
	39/12*		HTO in Air	3.6	-2.0	0.56
1985	9/15*		Kr-85	N/A	N/A	25
	8/16*		Xe-133	16	-31	4.2
	44/7*		HTO in Air	4.9	-2.0	0.54
1986	50/2*		HTO in Air	8.7	-3.2	1.0
1987	43/9*		HTO in Air	4.8	-8.9	0.70

*positive/negative

UT-4. Salt Lake City, Utah

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1988	50		HTO in Air	4.9	-6.2	0.33
1989	51		HTO in Air	4.2	-3.5	0.40
1990	49		HTO in Air	6.4	-2.0	0.6
1991	1		Kr-85	24	24	24
	1		Xe-133	-1.6	-1.6	-1.6
	41		HTO in Air	10	03.3	0.97
1992	38		HTO in Air	2.4	-3.5	0.19
1993	49		HTO in Air	3.6	-2.9	0.3
1994	30		HTO in Air	5.2	-0.9	1.1

UT-5. St. George, Utah

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1982		294.6	Kr-85	30	19	24
		287.7	Xe-133	<30	<7	4.6
		336.6	HTO in Air	<7	<0.9	0.33
1983	47/5*		Kr-85	32	19	25
	44/8*		Xe-133	11	-11	0.61
	49/2*		HTO in Air	3.6	-2.5	0.62
1984	41/11*		Kr-85	N/A	N/A	23
	39/3*		Xe-133	31	-8.8	5.7

*positive/negative

UT-5. St. George, Utah (continued)

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
	52/1		HTO in Air	4.0	-2.4	0.29
1985	49/3*		Kr-85	N/A	N/A	24
	45/7*		Xe-133	24	-3.2	5.5
	50/1*		HTO in Air	3.3	-3.1	0.39
1986	40/12*		Kr-85	30	19	24
	41/11*		Xe-133	16	-16	2.9
	50/2*		HTO in Air	7.2	-10	-0.18
1987	41/10*		Kr-85	31	20	25
	42/9*		Xe-133	13	-11	0.41
	41/8*		HTO in Air	6.1	-3.1	0.60
1988	35		Kr-85	32	21	26
	39		Xe-133	9.6	-13	-0.05
	45		HTO in Air	4.9	-8.3	0.01
1989	47		Kr-85	30	20	26
	48		Xe-133	8.3	-14	0.08
	52		HTO in Air	7.8	-3.5	0.51
1990	48		Kr-85	31	20	27
	49		Xe-133	6.3	-7.8	-0.48
	51		HTO in Air	4.5	-2.3	0.6
1991	46		Kr-85	30	21	26
	49		Xe-133	14	-12	-2.2
	51		HTO in Air	5.2	-2.6	0.36

* positive/negative

UT-5. St. George, Utah (continued)

Year	Number of Samples	Days Detected	Radionuclide	Radioactivity Concentration (pCi/m^3) Maximum	Minimum	Average
1992	49		Kr-85	31	20	26
	49		Xe-133	7.7	-11	-1.0
	51		HTO in Air	8.8	-7.9	0.69
1993	46		Kr-85	33	21	27
	47		Xe-133	19	-19.0	-0.9
	45		HTO in Air	3.4	-5.1	0.3
1994	34		Kr-85	31	23	28
	35		Xe-133	3.3	-19	-5.7
	36		HTO in Air	2.8	-2.8	0.2

APPENDIX B.
REPLICATE SAMPLING PROGRAM

Purpose

The program was initiated for the purpose of routinely assessing the errors due to sampling replication error and analytical/counting errors associated with the collection and analysis of samples obtained from the surveillance networks maintained around the Nevada Test Site and other sites designated by the Nevada Operation Office, Energy Research and Development Administration.

Procedure

The program involved the collection and analysis of replicate samples from the Noble Gas and Tritium Surveillance Network (NG&TSN).

At least 40 duplicate samples from each network were collected and analyzed over the report period.

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 confidence interval of the expected population geometric variance for each type of sample analysis. The expressions used are as follows:

$$s\tilde{}_{\overline{2}} =$$

The 99% upper confidence limit for the total error (sampling + analytical/counting errors) of the geometric mean of any group of samples collected from a given network was then determined as the geometric mean +2.57

The following table summarizes the antilogarithm of the results for the 99% confidence limits on the expected geometric standard deviation of the total error, compares the confidence limits of the total error with the ranges in geometric standard deviations observed from the data of each network, and lists the 99% upper confidence limit (UCL) expected from the sampling/analytical/counting errors for the geometric mean of any Network samples.

UPPER CONFIDENCE LIMITS OF SAMPLING AND ANALYTICAL/ COUNTING ERRORS

Surveillance Network	Analysis	From Evaluation of Replicate Samples: No. of Replicate Samples	99% Confidence Limits For Expected Geometric Standard Deviation: $LCL_{0.995}$		$UCL_{0.005}$	Observed Geometric Std Dev From Network Data: Min	Max	99%UCL of Total Error
NG&TSN	^{85}Kr	40	1.20	1.26	1.38	1.2	1.2	1.8
	^{3}H	12	1.41	1.69	1.81	1.4	5.1	3.8
	HTO	12	1.52	1.90	3.56	1.8	5.2	5.2
	HT	8	1.20	1.34	1.98	1.7	2.6	2.2

From a comparison of the observed geometric standard deviation with the counting errors, one can see that the surveillance data exceed the variance to the sampling for the ^{85}Kr data and the environmental radiation TLD. The majority of variations in ^{85}Kr concentrations are as the result of the sampling and analytical/counting errors.

APPENDIX C
Summary of Analytical Procedures

Type of Analysis	Analytical Equipment	Counting Period (min)	Analytical Procedures	Sample Size	Approximate Detection Limit[a]
^{3}H	Automatic liquid scintillation counter with output printer.	300	Sample prepared by distillation.	5 to 10 mL for water.	300 to 700 x 10^{-9} µCi/mL (11-26 Bq/L)[c]
^{85}Kr, ^{133}Xe	Automatic liquid scintillation counter with output printer.	200	Separation by gas chromatography; dissolved in toluene "cocktail" for counting.	0.4 to 1.0m^3 for air.	^{85}Kr, ^{133}Xe = 4x 10^{-12} µCi/mL (1.5 x 10^{-1} Bq/m^3)

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

APPENDIX D

Announced United States Nuclear Tests

Event Name	Date	Location	Purpose
Yannigan-Red, -Blue, -White	02/26/70	NTS	Weapons Related
Cyathus	03/06/70	NTS	Weapons Related
Snubber	04/21/70	NTS	Weapons Effects
Hod-A (Green), -B (Red)	05/01/70	NTS	Weapons Related
Mint Leaf	05/05/70	NTS	Weapons Effects
Diamond Dust	05/12/70	NTS	Vela Uniform
Manzanas	05/21/70	NTS	Weapons Related
Hudson Moon	05/26/70	NTS	Weapons Effects
Flask-Green, -Yellow, -Red	05/26/70	NTS	Plowshare
Piton-C	05/28/70	NTS	Weapons Related
Piton-A and Piton-B	05/28/70	NTS	Weapons Related
Arnica-Violet	06/26/70	NTS	Weapons Related
Scree-Acajou, -Alhambra	10/31/70	NTS	Weapons Related
Truchas-Chamisal	10/28/70	NTS	Safety Experiment
Avens-Cream	12/16/70	NTS	Weapons Related
Carpetbag	12/17/70	NTS	Weapons Related
Baneberry	12/18/70	NTS	Weapons Related
Harebell	06/24/71	NTS	Weapons Related
Camphor	06/29/71	NTS	Weapons Effects
Miniata	07/08/71	NTS	Plowshare
Bracken	07/09/71	NTS	Weapons Related
Diagonal Line	11/24/71	NTS	Weapons Effects
Dianthus	02/17/72	NTS	Weapons Related
Sappho	03/23/72	NTS	Weapons Related

Continued

Kara	05/11/72	NTS	Weapons Related
Zinnia	05/17/72	NTS	Weapons Related
Merida	06/07/72	NTS	Weapons Related
Atarque	07/25/72	NTS	Weapons Related
Cebolla	08/09/72	NTS	Weapons Related
Arsenate	11/09/72	NTS	Weapons Related
Solanum	12/14/72	NTS	Weapons Related
Miera	03/08/73	NTS	Weapons Related
Gazook	03/23/73	NTS	Weapons Related
Angus	04/25/73	NTS	Weapons Related
Velarde	04/25/73	NTS	Weapons Related
Colmor	04/26/73	NTS	Weapons Related
Starwort	04/26/73	NTS	Weapons Related
Mesita	05/09/73	NTS	Weapons Related
Kashan	05/24/73	NTS	Weapons Related
Potrillo	06/21/73	NTS	Weapons Related
Portulaca	06/28/73	NTS	Weapons Related
Waller	10/02/73	NTS	Weapons Related
Bernal	11/28/73	NTS	Weapons Related
Pajara	12/12/73	NTS	Weapons Related
Seaform	12/13/73	NTS	Weapons Related
Elida	12/19/73	NTS	Weapons Related
Pinedrops-Bayou	01/10/74	NTS	Weapons Related
Hulsea	03/14/74	NTS	Weapons Related
Grove	05/22/74	NTS	Weapons Related
Fallon	05/23/74	NTS	Joint US-UK
Jara	06/06/74	NTS	Weapons Related
Escabosa	07/10/74	NTS	Weapons Related

Continued

Crestlake-Tansan, -Briar	07/18/74	NTS	Weapons Related
Puye	08/14/74	NTS	Weapons Related
Hybla Fair	10/28/74	NTS	Weapons Effects
Temescal	11/02/74	NTS	Weapons Related
Portola, Portola-Larkin	02/06/75	NTS	Weapons Related
Bilge	02/19/75	NTS	Weapons Related
Cabrillo	03/07/75	NTS	Weapons Related
Kasseri	10/28/75	NTS	Weapons Related
Esrom	02/04/76	NTS	Weapons Related
Shallows	02/26/76	NTS	Weapons Related
Colby	03/14/76	NTS	Weapons Related
Rivoli	05/20/76	NTS	Weapons Related
Billet	07/27/76	NTS	Weapons Related
Banon	08/26/76	NTS	Joint US-UK
Dofino, Dofino-Lawton	03/08/77	NTS	Weapons Related
Marsilly	04/05/77	NTS	Weapons Related
Carnelian	07/28/77	NTS	Weapons Related
Gruyere-Gradino	08/16/77	NTS	Weapons Related
Flotost	08/16/77	NTS	Weapons Related
Coulommiers	09/27/77	NTS	Weapons Related
Bobstay	10/26/77	NTS	Weapons Related
Hybla Gold	11/01/77	NTS	Weapons Effects
Farallones	12/14/77	NTS	Weapons Related
Campos	02/13/78	NTS	Weapons Related
Reblochon	02/23/78	NTS	Weapons Related
Karab	03/16/78	NTS	Weapons Related
Satz	07/07/78	NTS	Weapons Related
Quargel	11/18/78	NTS	Joint US-UK

Continued

Farm	12/16/78	NTS	Weapons Related
Kloster	02/15/79	NTS	Weapons Related
Pepato	06/11/79	NTS	Weapons Related
Fajy	06/28/79	NTS	Weapons Related
Burzet	08/03/79	NTS	Weapons Related
Nessel	08/29/79	NTS	Joint US-UK
Tarko	02/28/80	NTS	Weapons Related
Norbo	03/08/80	NTS	Weapons Related
Liptauer	04/03/80	NTS	Weapons Related
Pyramid	04/16/80	NTS	Weapons Related
Colwick	04/26/80	NTS	Joint US-UK
Canfield	05/02/80	NTS	Weapons Related
Flora	05/22/80	NTS	Weapons Related
Kash	06/12/80	NTS	Weapons Related
Huron King	06/24/80	NTS	Weapons Effects
Tafi	07/25/80	NTS	Weapons Related
Verdello	07/31/80	NTS	Weapons Related
Bonarda	09/25/80	NTS	Weapons Related
Riola	09/25/80	NTS	Weapons Related
Dutchess	10/24/80	NTS	Joint US-UK
Miners Iron	10/31/80	NTS	Weapons Effects
Dauphin	11/14/80	NTS	Weapons Related
Serpa	12/17/80	NTS	Joint US-UK
Baseball	01/15/81	NTS	Weapons Related
Clairette	02/05/81	NTS	Weapons Related
Seco	02/25/81	NTS	Weapons Related
Vide	04/30/81	NTS	Weapons Related
Aligote	05/29/81	NTS	Weapons Related

Continued

Harzer	06/06/81	NTS	Weapons Related
Niza	07/10/81	NTS	Weapons Related
Pineau	07/16/81	NTS	Weapons Related
Harvarti	08/05/81	NTS	Weapons Related
Islay	08/27/81	NTS	Weapons Related
Trebbiano	09/04/81	NTS	Weapons Related
Cernada	09/24/81	NTS	Weapons Related
Paliza	10/01/81	NTS	Weapons Related
Tilci	11/11/81	NTS	Weapons Related
Rousanne	11/12/81	NTS	Joint US-UK
Akavi	12/03/81	NTS	Weapons Related
Caboc	12/16/81	NTS	Weapons Related
Jornada	01/28/82	NTS	Weapons Related
Molbo	02/12/82	NTS	Weapons Related
Hosta	02/12/82	NTS	Weapons Related
Tenaja	04/17/82	NTS	Weapons Related
Gibne	04/25/82	NTS	Joint US-UK
Kryddost	05/06/82	NTS	Weapons Related
Bouschet	05/07/82	NTS	Weapons Related
Kesti	06/16/82	NTS	Weapons Related
Nebbiolo	06/24/82	NTS	Weapons Related
Monterey	07/29/82	NTS	Weapons Related
Atrisco	08/05/82	NTS	Weapons Related
Queso	08/11/82	NTS	Weapons Related
Cerro	09/02/82	NTS	Weapons Related
Huron Landing	09/23/82	NTS	Weapons Effects
Diamond Ace	09/23/82	NTS	Weapons Effects
Frisco	09/23/82	NTS	Weapons Related

Continued

Borrego	09/29/82	NTS	Weapons Related
Seyval	11/12/82	NTS	Weapons Related
Manteca	12/10/82	NTS	Weapons Related
Coalora	02/11/83	NTS	Weapons Related
Cheedam	02/17/83	NTS	Weapons Related
Cabra	03/26/83	NTS	Weapons Related
Turquoise	04/14/83	NTS	Weapons Related
Armada	04/22/83	NTS	Joint US-UK
Crowdie	05/05/83	NTS	Weapons Related
Mini Jade	05/26/83	NTS	Weapons Effects
Fahada	05/26/83	NTS	Weapons Related
Danablu	06/09/83	NTS	Weapons Related
Laban	08/03/83	NTS	Weapons Related
Sabado	08/11/83	NTS	Weapons Related
Chancellor	09/01/83	NTS	Weapons Related
Tomme/Midnight Zephyr	09/21/83	NTS	Weapons Effects
Techado	09/22/83	NTS	Weapons Related
Romano	12/16/83	NTS	Weapons Related
Gorbea	01/31/84	NTS	Weapons Related
Midas Myth/Milagro	02/15/84	NTS	Weapons Effects
Tortugas	03/01/84	NTS	Weapons Related
Agrini	03/31/84	NTS	Weapons Related
Mundo	05/01/84	NTS	Joint US-UK
Caprock	05/31/84	NTS	Weapons Related
Duoro	06/20/84	NTS	Weapons Related
Kappeli	07/25/84	NTS	Weapons Related
Correo	08/02/84	NTS	Weapons Related
Dolcetto	08/30/84	NTS	Weapons Related

Continued

Breton	09/13/84	NTS	Weapons Related
Villita	11/10/84	NTS	Weapons Related
Egmont	12/09/84	NTS	Joint US-UK
Tierra	12/15/84	NTS	Weapons Related
Vaughn	03/15/85	NTS	Weapons Related
Cottage	03/23/85	NTS	Weapons Related
Hermosa	04/02/85	NTS	Weapons Related
Misty Rain	04/06/85	NTS	Weapons Effects
Towanda	05/02/85	NTS	Weapons Related
Salut	06/12/85	NTS	Weapons Related
Ville	06/12/85	NTS	Weapons Related
Maribo	06/26/85	NTS	Weapons Related
Serena	07/25/85	NTS	Weapons Related
Chamita	08/17/85	NTS	Weapons Related
Ponil	09/27/85	NTS	Weapons Related
Mill Yard	10/09/85	NTS	Weapons Effects
Diamond Beech	10/09/85	NTS	Weapons Effects
Roquefort	10/16/85	NTS	Weapons Related
Kinibito	12/05/85	NTS	Joint US-UK
Goldstone	12/28/85	NTS	Weapons Related
Glencoe	03/22/86	NTS	Weapons Related
Mighty Oak	04/10/86	NTS	Weapons Effects
Jefferson	04/22/86	NTS	Weapons Related
Panamint	05/21/86	NTS	Weapons Related
Tajo	06/05/86	NTS	Weapons Related
Darwin	06/25/86	NTS	Joint US-UK
Cybar	07/17/86	NTS	Weapons Related
Cornucopia	07/24/86	NTS	Weapons Related

Continued

Aleman	09/11/86	NTS	Weapons Related
Labquark	09/30/86	NTS	Weapons Related
Belmont	10/16/86	NTS	Weapons Related
Gascon	11/14/86	NTS	Weapons Related
Bodie	12/13/86	NTS	Weapons Related
Hazebrook	02/03/87	NTS	Weapons Related
Tornero	02/11/87	NTS	Weapons Related
Middle Note	03/18/87	NTS	Weapons Effects
Delamar	04/18/87	NTS	Weapons Related
Presidio	04/22/87	NTS	Weapons Related
Hardin	04/30/87	NTS	Weapons Related
Brie	06/18/87	NTS	Weapons Related
Mission Ghost	06/20/87	NTS	Weapons Effects
Panchuela	06/30/87	NTS	Weapons Related
Midland	07/16/87	NTS	Joint US-UK
Tahoka	08/13/87	NTS	Weapons Related
Lockney	09/24/87	NTS	Weapons Related
Borate	10/23/87	NTS	Weapons Related
Waco	12/01/87	NTS	Weapons Related
Mission Cyber	12/02/87	NTS	Weapons Effects
Kernville	02/15/88	NTS	Weapons Related
Abilene	04/07/88	NTS	Weapons Related
Schellbourne	05/13/88	NTS	Weapons Related
Laredo	05/21/88	NTS	Weapons Related
Comstock	06/02/88	NTS	Weapons Related
Rhyolite	06/22/88	NTS	Weapons Related
Nightingale	06/22/88	NTS	Safety Experiment
Alamo	07/07/88	NTS	Weapons Related

Continued

Kearsarge	08/17/88	NTS	Weapons Related
Bullfrog	08/30/88	NTS	Weapons Related
Dahlhart	10/13/88	NTS	Weapons Related
Misty Echo	12/10/88	NTS	Weapons Effects
Texarkana	02/10/89	NTS	Weapons Related
Kawich	02/24/89	NTS	Weapons Related
Ingot	03/09/89	NTS	Weapons Related
Palisade	05/15/89	NTS	Weapons Related
Tulia	05/26/89	NTS	Weapons Related
Contact	06/22/89	NTS	Weapons Related
Amarillo	06/27/89	NTS	Weapons Related
Disko Elm	09/14/89	NTS	Weapons Effects
Hornitos	10/31/89	NTS	Weapons Related
Muleshoe	11/15/89	NTS	Weapons Related
Barnwell	12/08/89	NTS	Joint US-UK
Whiteface	12/20/89	NTS	Weapons Related
Metropolis	03/10/90	NTS	Weapons Related
Bullion	06/13/90	NTS	Weapons Related
Austin	06/21/90	NTS	Weapons Related
Mineral Quarry	07/25/90	NTS	Weapons Effects
Sundown	09/20/90	NTS	Weapons Related
Ledoux	09/27/90	NTS	Weapons Effects
Tenabo	10/12/90	NTS	Weapons Related
Houston	11/14/90	NTS	Joint US-UK
Coso	03/08/91	NTS	Weapons Related
Bexar	04/04/91	NTS	Weapons Related
Montello	04/16/91	NTS	Weapons Related
Floydada	08/15/91	NTS	Weapons Related

Continued

Hoya	09/14/91	NTS	Weapons Related
Distant Zenith	09/19/91	NTS	Weapons Effects
Lubbock	10/18/91	NTS	Weapons Related
Bristol	11/26/91	NTS	Weapons Related
Junction	03/26/92	NTS	Joint US-UK
Diamond Fortune	04/30/92	NTS	Weapons Effects
Victoria	06/19/92	NTS	Weapons Related
Galena	06/23/92	NTS	Weapons Related
Hunters Trophy	09/18/92	NTS	Weapons Effects
Divider	09/23/92	NTS	Weapons Related

APPENDIX E

NGSS Theory of Operation

The NGSS is a programmable controlled device that collects and stores air in sample tanks at a constant volumetric flow rate over a preset time period.

Constant volumetric flow through an orifice or nozzle happens when the differential pressure across the orifice is sufficient to create a critical flow condition.

This condition is when flow through the orifice does not increase with decrease in downstream pressure, and upstream pressure remains constant. When air flows through an orifice, the critical condition is obtained if the upstream pressure is approximately two times the downstream pressure. The equation for critical flow through a nozzle or orifice is:

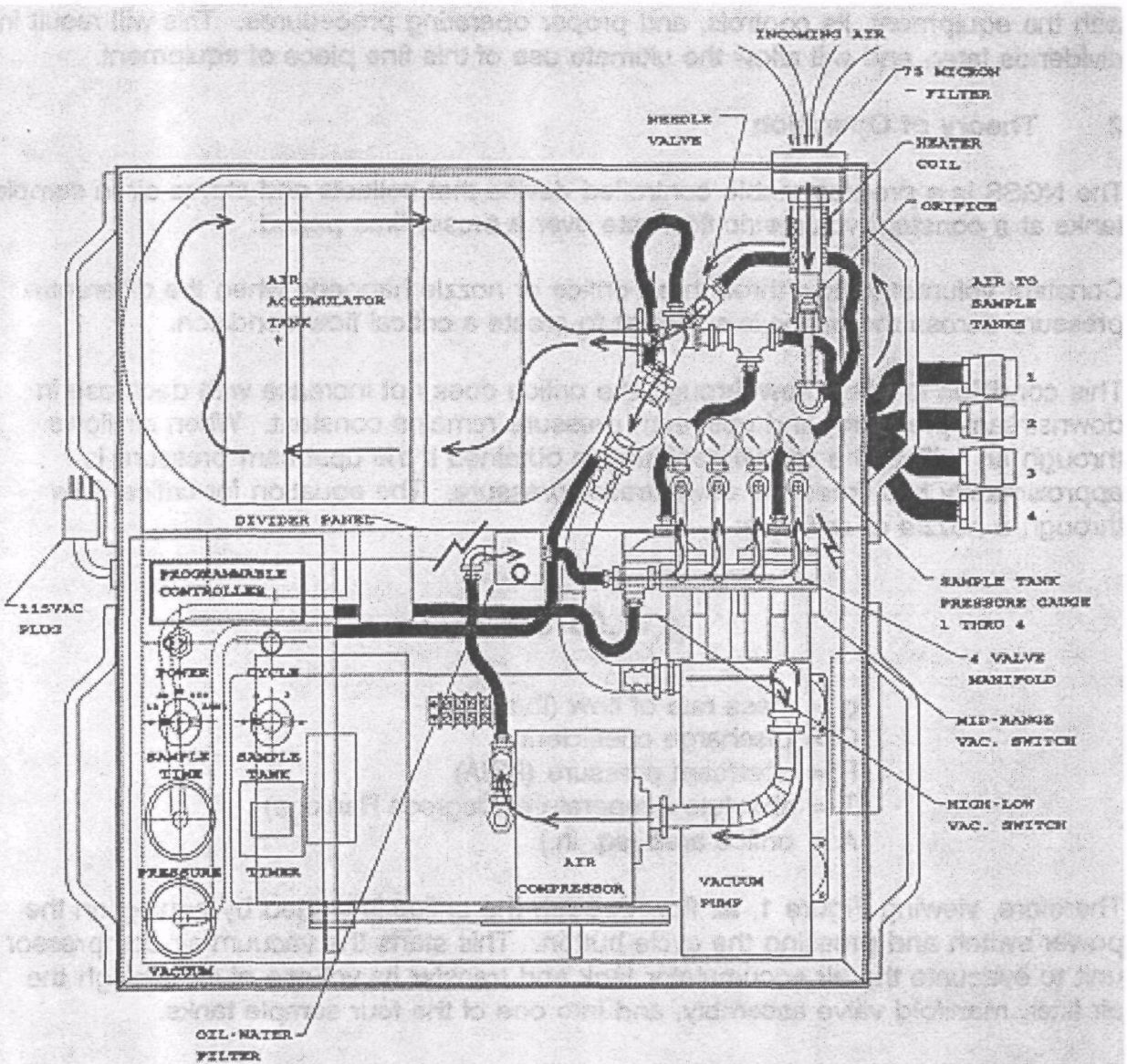
$$g = .53\ CP\ AI\sqrt{T}$$

g = mass rate of flow (lb/sec)
C = discharge coefficient
P = upstream pressure (PSIA)
T = absolute temperature (degrees Rankine)
A = orifice area (sq. in.)

Therefore, viewing Figure 1, air flow through the orifice is started by turning on the power switch and pressing the cycle button. This starts the vacuum-air compressor unit to evacuate the air accumulator tank and transfer its volume of air through the air filter, manifold valve assembly, and into one of the four sample tanks.

Pumping will continue until the vacuum in the accumulator tank reaches 22" of Mercury (Hg), at which time the high vacuum switch activates, turning the pumping system off. The moment the system was started, incoming air flowed through the 75 micron (.0029") filter, heater coil tube, orifice and into the accumulator tank. The accumulator tank continues to receive air which causes the vacuum pressure to decrease. When the vacuum reaches 15" of Hg, still maintaining critical flow at the orifice, the low vacuum switch activates restarting the vacuum-compressor unit.

Air accrued in the accumulator tank is again transferred to the sample tanks. This cyclic operation continues until the preset run time has expired. The figure shows direction of air flow through the NGSS.


INCOMING AIR
75 MICRON FILTER
NEEDLE VALVE
HEATER COIL
ORIFICE
AIR ACCUMULATOR TANK
AIR TO SAMPLE TANKS
1
2
3
4
DIVIDER PANEL
PROGRAMMABLE CONTROLLER
115VAC PLUG
POWER
CYCLE
SAMPLE TIME
SAMPLE TANK
PRESSURE
TIMER
VACUUM
SAMPLE TANK PRESSURE GAUGE 1 THRU 4
4 VALVE MANIFOLD
MID-RANGE VAC. SWITCH
HIGH-LOW VAC. SWITCH
AIR COMPRESSOR
VACUUM PUMP
OIL-WATER FILTER