National Emission Standards for Hazardous Air Pollutants Submittal - 1994

By
Stuart C. Black

June 1995

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National Emission Standards for Hazardous Air Pollutants Submittal - 1994

Edited By
Yvonne E. Townsend

June 1995

MASTER

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LIST OF ACRONYMS

ARL	Air Resources Laboratory, National Oceanic and Atmospheric Administration
BOP	Blowout Preventer
DNA	Defense Nuclear Agency
DRA	Desert Rock Meteorological Observatory
DOE/NV	U.S. Department of Energy Nevada Operations Office
DOE/SAN	U.S. Department of Energy San Francisco Operations Office
EDE	Effective Dose Equivalent
EIS	Effluent Information System
EPA	U.S. Environmental Protection Agency
ES&H	Environment, Safety and Health
FCNV	Field Command, Nevada
GCD	Greater Confinement Disposal
HEPA	High Efficiency Particulate Air - an Air Filter
HTO	Tritiated Water
LANL	Los Alamos National Laboratory
LGFSTF	Liquified Gaseous Fuels Spill Test Facility
LLNL	Lawrence Livermore National Laboratory
LOS	Line-of-Sight
LPG	Liquified Petroleum Gas
MDC	Minimum Detectable Concentration
MEDA	Meteorological Data Acquisition System
MEI	Maximally Exposed Individual
MIDNET	Meteorological Data Network
NESHAP	National Emission Standard for Hazardous Air Pollutants
NOAA	National Oceanic and Atmospheric Administration
NTOD	Nuclear Test Operations Division
NTS	Nevada Test Site
OR	Occurrence Report
Pu	Plutonium
REECo	Reynolds Electrical & Engineering Co., Inc.
RWMS	Radioactive Waste Management Site
SNL	Sandia National Laboratories
SORD	Special Operations and Research Division (Formerly WSNSO)
STAR	Stability Array - Grouping of Meteorological Data
TRU	Transuranic - Nuclides with Atomic Numbers Greater than Uranium

U.S. Department of Energy
Air Emissions Annual Report
(under Subpart H, 40 C.F.R. 61.94)
Calendar Year 1994

Site Name: NEVADA TEST SITE

Operations Office Information

Office: DOE Nevada Operations Office

Address: P. O. Box 98518

                Las Vegas, NV 89193-8518

Contact: Donald R. Elle, Ph. D., Director   Phone: (702) 295-1146

                Environmental Protection Division

Site Information

Operator: Reynolds Electrical & Engineering Co., Inc.

Address: P. O. Box 98521

                Las Vegas, NV 89193-8521

Contact: Leonard S. Sygitowicz, Manager   Phone: (702) 295-6204

                Environmental Management Division

SECTION I
FACILITY INFORMATION

SITE DESCRIPTION

The Nevada Test Site (NTS) is operated by the U.S. Department of Energy Nevada Operations Office, (DOE/NV) as the site for nuclear weapons testing. It is located in Nye County, Nevada, with the southeast corner about 90 km (56 mi) northwest of Las Vegas, Nevada. The NTS covers about 3500 km^2 (1350 mi^2), an area larger than Rhode Island. Its size is about 46 to 56 km (28 to 35 mi) east to west and from 64 to 88 km (40 to 55 mi) north to south. The NTS is surrounded, except on the south side, by public exclusion areas (Nellis Base Range) that provide another 24 to 104 km (15 to 65 mi) between the NTS and public lands (Figure 1, page 13). The NTS is characterized by desert valley and Great Basin mountain topography, with a climate, flora, and fauna typical of the southwest deserts. Population density within 150 km (93 mi) of the NTS is only about 0.5 persons per square kilometer, excluding the Las Vegas area. Restricted access, low population density in the surrounding area, and extended wind transport times are advantageous factors for the activities conducted at the NTS. Surface waters are scarce on the NTS and the depth to slow-moving groundwater is great.

SOURCE DESCRIPTION

Figure 2 (page 14) is a map of the NTS which shows the areas used for nuclear testing and other activities. The NTS has been the primary location for testing of nuclear explosives in the Continental U.S. since 1951. Historical testing has included (1) atmospheric testing in the 1950s and early 1960s, (2) earth-cratering experiments, and (3) open-air nuclear reactor and rocket engine testing. Since the mid 1960s, testing of nuclear devices has occurred underground in drilled vertical holes or in mined tunnels. No nuclear tests have been conducted since September 1992. Limited non-nuclear testing includes spills of hazardous materials at the Liquified Gaseous Fuels Spill Test Facility (LGFSTF). Processing of radioactive materials is limited to laboratory analyses. Handling of these materials is limited to transport and storage of nuclear explosive devices and operation of a radioactive waste management site (RWMS) for low-level radioactive and mixed waste. Monitoring and evaluation of the various activities conducted onsite indicate that the potential sources of offsite radiation exposure in 1994 were releases: (1) from evaporation of tritiated water from containment ponds that receive drainage water from E tunnel in Area 12, (2) from onsite radioanalytical laboratories, (3) from the Area 5 RWMS facility, and (4) from other diffuse sources. The following sections present a general description of the effluent sources on the NTS.

Ground Seepage of Noble Gases

Ground seepage may be enhanced when changes in ambient pressure, pump small amounts of noble gases up through the overburden and into the atmosphere from the cavity created by a nuclear test. This process, sometimes referred to as "atmospheric pumping," creates a diffuse source of radiological effluents. These area sources are rare and therefore not routinely monitored. The phenomenon is usually restricted to events conducted in the Pahute Mesa region of NTS. These seepages are from nuclear tests conducted prior to 1993.

Krypton-85 is generally detected on the NTS at air concentrations consistent with data collected in offsite areas by the Environmental Monitoring Systems Laboratory of the EPA in Las Vegas. During 1994, krypton-85 was detected at all environmental monitoring stations as it has been in previous years. The Area 20 sampler located at DDZ77 detected an average annual concentration 4.8 pCi/m^3 greater than the average concentration outside of Pahute Mesa. A source term can be calculated as shown in Appendix H.

Tunnel Operations

Nuclear tests have been conducted within tunnel complexes mined into the Rainier Mesa region; no such tests were conducted in 1994. Small amounts of contaminated water continues to drain from one tunnel as discussed below. Figure 3 (page 15) is a photograph of a tunnel portal and Appendix C contains the Defense Nuclear Agency (DNA) procedures that were used for monitoring any tunnel effluent. Isokinetic sampling equipment has been installed in P Tunnel to obtain confirmatory measurements of tunnel air emissions and could be reactivated if operations resume.

Containment Ponds

Water contaminated with radionuclides seeps from the tunnels in Area 12 and collects in containment ponds where some evaporates and some seeps into the soil. A photograph of tunnel containment ponds is provided as Figure 4 (page 16). Because some of the tunnels have been sealed, water seeped from N Tunnel only for a short time in 1994 but seeped continuously from E Tunnel. The only radiological contaminant which produces a measurable air emission from evaporation of the water is ^{3}H (as HTO). It is expected to cease completely in a couple of years or so. The calculation of the source term is described in Appendix E.

Drillbacks

Following underground nuclear tests, core samples are taken from the cavity formed by the nuclear detonation, for analysis and diagnosis. This is referred to as core-sampling and is accomplished by drilling into the area of interest and recovering samples using special drilling equipment. Radioactive material may be discharged into the atmosphere during these operations. Because of different engineering designs used by the weapons laboratories, there are two methods for handling potential effluents during drill backs. These are described in Appendices A and B. There was one test of drill back procedures in 1994 in which Lawrence Livermore National Laboratory used ^{133}Xe for instrumental checks.

Laboratories

Radiological analyses are conducted by REECo in a laboratory located in Building 650, and Los Alamos National Laboratory (LANL) conducts similar analyses in Building 701 at Mercury (see Appendix B). Because these facilities primarily process environmental samples, very little radioactivity passes through them. However, there is potential for some radionuclides to be discharged into the atmosphere through the hood ventilation system during sample processing, particularly of spiked samples, or from loss of radioactive standards. Figure 5 (page 17) is a photograph of the Building 650 hood ventilation stacks seen from above. The source term for Building 701 is contained in Appendix B and for Building 650 in Appendix D. In general, evaporation and spills from samples containing HTO, radioiodines, or noble gases are conservatively estimated by assuming all such materials are released. Non-volatile materials are controlled by keeping their inventory below the possession limits set forth in Appendix E to 40 C.F.R. 61.

Radioactive Waste Management Sites

These sites in Areas 3 and 5 are used for the disposal of low-level radioactive waste, and the Area 5 site is used for storage of transuranic (TRU) and mixed TRU wastes, and contains the Greater Confinement Disposal (GCD) Test Unit, and 12 GCD boreholes (only a few have any waste). Disposal is accomplished by the use of pits and trenches; concrete pads are used for temporary storage of certain wastes. At Area 5, only packaged wastes are accepted for disposal. The facility is considered a diffuse source of radiological effluents. The only radioactive effluent detected by the various types of samplers surrounding the site is HTO in atmospheric moisture. The calculation of the HTO source term is explained in Appendix G. The Area 3 LLW site is in a location where surface soil has been contaminated by deposited plutonium, and resuspension of this soil results in above background levels of plutonium being detected in air samples collected nearby.

Plutonium Contaminated Surface Areas

Surface soils in certain areas on and off of the NTS were contaminated with plutonium from either nuclear device safety, atmospheric, or cratering tests (the Plowshare Program) using nuclear explosives. An investigation of these areas during the Nevada Applied Ecology Group studies [a] developed the inventories of plutonium shown in Table 1. These areas could become sources of plutonium exposure if the contaminated soils were to be resuspended, e.g., during surface cleanup, construction, or similar activities. Figure 6 (page 18) is a map showing the approximate locations of the nuclear device safety tests on the NTS. There are air samplers at or near almost all of these onsite areas. Plutonium analyses of the glass-fiber filters from these samplers indicate that the majority of the results are less than the minimum detectable concentration (MDC) and most of those are even less than the 2 standard deviation (2s) counting error. The results that are different are from air samplers in areas where operational activities can cause contaminated surface soil to become resuspended. These areas are considered diffuse sources of radioactive effluents, although plutonium is the only detectable one. The calculation of the source term for plutonium contaminated areas is explained in Appendix F.

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[1] Friesen, H.N., 1992, Summary of the Nevada Applied Ecology Group and Correlative Programs, Report DOE/NV-357, Nevada Field Office, U.S. Dept. of Energy, Las Vegas, Nevada.

Table 1. Summary of Estimated Inventory of $^{239+240}$Pu in Surface Soil (0 to 5 cm) at Studied Sites

SITE (ON NTS)	AREA (km²)	NUMBER SAMPLES	EST. INVENTORY (CURIES)	95% CONF.INTERVAL (CURIES)	$^{239+240}$Pu AIR CONC. ANNUAL AVG. ($\bar{X} \pm 2s$) IN 10^{-18} µCi/mL UNITS
PROJECT 56 (AREA 11)[1]	4.83	205	36	28 - 44	23 ± 39
GMX (AREA 5)[1]	0.125	111	1.5	1.1 - 1.9	5 ± 5
LITTLE FELLER II (Area 18)[4]	0.375	712	32[3]	22 - 41	
PALANQUIN* (AREA 20)[2]	3.895	148	13[3]	6 - 21	1.6 ± 1.2
SEDAN (AREA 10)[2]	28.264		111.2		12 ± 13
T2 SERIES (AREA 2)[4]	30.100		26.7		8 ± 16
VARIOUS TESTS (AREA 9)			89		245 ± 216
AREA 13 [1]	4.02	169	46	28 - 64	
CLEAN SLATE & DOUBLE TRACKS [1]	2.6	236	61.8		

(1) Safety tests of nuclear devices
(2) Plowshare tests (PALANQUIN and CABRIOLET sites in Area 20 combined)
(3) Inventory consists of $^{239+240}$Pu + ^{241}Am
(Gilbert, NVO-181 p. 425; NVO-272, pp. 381-429; McArthur, DOE/NV10162-20)
(4) Weapons effects tests

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SECTION II
AIR EMISSIONS DATA

Each potential source of NTS emissions was characterized by one of the following: (1) by monitoring methods and procedures previously developed at NTS (see Appendices A, B, and C); (2) by a yearly radionuclide inventory of the source, assuming that volatile radionuclides are released to the environment; (3) by the measurement of tritiated water (as HTO or T_2O) concentration in liquid effluents discharged to containment ponds and assuming all the effluent evaporates over the course of the year to become an air emission; or (4) by using a combination of environmental measurements and CAP88-PC to calculate emissions (generally confirmed by offsite air measurements). Appendices A through J describe the methods used to determine the emissions from the sources listed in Section I. In accordance with 40 C.F.R. 61.93.(b).(4), no credit was taken for pollution control equipment in determining air emissions.

These National Emission Standards for Hazardous Air Pollutants (NESHAP) emissions as listed in Table 2, are very conservative (worst-case), are used in Section III to calculate the effective dose equivalent (EDE) to the Maximally Exposed Individual offsite (MEI), and exceed, in some cases, those reported in DOE's Effluent Information System (EIS). The NESHAP's worst-case emissions that exceed the EIS reported emissions are noted by a (1) in Table 2. Offsite environmental surveillance data are used to confirm that calculated emissions are, indeed, conservative.

A summary of the NTS total CY 1994 emissions for NESHAPs reporting, by radionuclide, is provided in Table 3.

Table 2. Summary of Annual Air Emissions Data by Source (Multiply Ci by 37 to obtain GBq)

Point Source	Type of Control	Efficiency	Distance to Nearest Receptor	Nuclide	Quantity (Ci)
Building 701 [1]	None	0%	24 km	^3H	5.0×10^{-4}
				^{131}I	2.0×10^{-6}
				^{133}Xe	4.0×10^{-2}
Drill Back Area 7	None	0%	54 km	^{133}Xe	0.12
Grouped Sources					
Building 650 [1]	None	0%	24 km	^3H	9.7×10^{-5}
Laboratory (12) [4]				^{131}I	1.1×10^{-6}
				^{129}I	3.0×10^{-7}
Containment [2] Pond: Area 12	None	0%	56 km	^3H	47.3
Non-Point Sources					
Yucca Flat: [3]					
Area 3	None	0%	54 km	$^{239+240}Pu$	2.3×10^{-2}
Area 9	None	0%	53 km	$^{239+240}Pu$	4.8×10^{-2}
RWMS-5 [3]	None	0%	42 km	^3H	0.63
Other Areas	None	0%	42 km	$^{239+240}Pu$	0.21
Area 20	None	0%	42 km	^{85}Kr	200

(1) Not on the EIS Report. Potential (worst-case) emissions only.
(2) Evaporation of all tritiated water effluents is assumed.
(3) Emissions based on environmental surveillance data.
(4) (x) is number of vents or stacks.

Table 3. Total Emissions for CY 1994 (Multiply Ci by 37 to obtain GBq)

Radionuclide	Half-Life (days)	Annual Quantity (Ci)
^{3}H	4510	48
^{85}Kr	3900	200
^{129}I	5.7×10^9	3.0×10^{-7}
^{131}I	8.04	1.1×10^{-6}
^{133}Xe	5.24	0.17
$^{239+240}$Pu	8.8×10^6	3.8×10^{-1}

Note: This table includes all worst-case point and diffuse source releases. Actual estimated releases are reported on DOE/NV Effluent Information System reports.

SECTION III
DOSE ASSESSMENTS

SUMMARY OF INPUT PARAMETERS

CAP88-PC was used to calculate effective dose equivalents to offsite residents. The input parameters were the radionuclide releases listed in Section II above as determined from effluent monitoring performed by the NTS operating contractor (REECo), from evaporation of tritiated water, and from calculations of diffuse source emissions that are based on environmental monitoring data. The latter include measurable particulate emissions of $^{239+240}$Pu originating in certain areas of Yucca Flat and HTO detected at the RWMS.

To calculate the amount of HTO evaporated, measurements of HTO concentration in the containment ponds were compared for February 1992 and December 1992 (data used for this year also). These concentrations were equal, i.e., within the measurement error, and the surface areas were approximately equal, so all the HTO influent to the ponds during 1992 was assumed to have evaporated, a conservative estimate as no allowance for infiltration into the soil column is made. This procedure was continued each year. A description of the source term estimated for this emission source is contained in the Appendices.

The source data listed above are used with five stability array (STAR) data files as input to CAP88-PC. The five STARs for the NTS include the files with names NTSYUCCA, AREA05, MEDA20, DESERTRK, and T-Tunnel. NTSYUCCA is used for sources on Yucca Flat (Areas 1,2,3,4,6,7, and 9), AREA05 is used for sources on Frenchman Flat, DESERTRK is used for sources in Mercury, MEDA20 is used for sources in Areas 19 and 20, and T-Tunnel for the tunnel pond sources in Area 12. MEDA20, T-Tunnel and AREA05 were developed by the local weather service office (ARL/SORD) using data obtained from the meteorological stations located near the boundary of Areas 19 and 20 on Pahute Mesa, near the tunnels in Area 12, and at Well 5B in Area 5. The other two files were provided by the National Climatic Data Center in North Carolina based on data from meteorological stations in Yucca Flat and at Desert Rock airstrip. The ARL/SORD assessment is attached as Appendix I. For each of these five STARs there may be a different location for the maximally exposed individual, but, when the contributions of all NTS sources are considered, only one location would receive the maximum exposure, Amargosa Valley (Lathrop Wells), Nevada. See Figure 1 for location of residences and communities around the NTS.

The EDE, in mrem, to the maximally exposed individual (a resident in Lathrop Wells, Nevada) was calculated using CAP88-PC for each of the listed sources in Section II. A summary of sources contributing to the EDE is shown in Table 4. Calculation of this EDE requires summing the contribution from all sources, as shown in Table 5. The sources listed as containment ponds in Area 12, and Laboratory Buildings 650 and 701 (Mercury) were added to the NESHAP program in 1991 for 1990 emissions. Consideration of diffuse sources, such as soils contaminated by safety and other nuclear device tests (as detected by air sampling) were added in the 1992 report to complete the possible sources of emission of radioactivity on the NTS. This year, a resuspension calculation has been used for contaminated areas. Appendices A through G contain estimates of radionuclides, which have or could have been released in 1994. Descriptions and estimations of the errors involved in each step of the process (measurement, monitoring, and calculation), estimations of potential releases, and worst-case scenarios are also included.

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Table 4. Summary of CY 1994 CAP88-PC Calculations of EDE to the Maximally Exposed Offsite Individual - Amargosa Valley (Lathrop Wells), Nevada [a]

Source	Distance to Individual and Direction	Effective Dose Equivalent (mrem)
Tunnel Pond (Area 12)	64 km SSW	1.2×10^{-4} [b]
Laboratories (Area 23)	44 km WSW	2.3×10^{-8}
Yucca Flat (Area 3)	54 km SW	1.3×10^{-2}
(Area 9)	61 km SSW	2.3×10^{-2}
RWMS (Area 5)	44 km WSW	1.1×10^{-5}
Area 20	70 km S	8.4×10^{-7}
Other Areas	---	1.15×10^{-1}
	TOTAL EDE	1.5×10^{-1} mrem

(a) Location of residences and communities around the NTS is shown in Figure 1
(b) For mSv, multiply by 10^{-2}
(c) Assumes evaporation of all tritiated water influents to ponds

COMPLIANCE ASSESSMENT

Table 5. Effective Dose Equivalent Tabulation by Location (Multiply mrem by 10^{-2} for Equivalent mSv Units)

| Location | Pop.[3] | EDE (10^{-6} mrem/year) Due to Releases from: | | | | | | Total EDE 10^{-3} mrem | Collective EDE man-mrem |
		Area 12[1] Tritium	Other Areas[2]	YUCCA Flat Area 3[1]	Area 9[1]	Area 5[1] RWMS	Area 23 Labs[2]		
Amargosa Valley	1200	110	78500	7200	19000	8.6	0.02	105	126
Ash Meadows	10	(see note[4])	20000	7100		5.8	0.016	27.1	0.271
Beatty	1500	100	98000	9400	19000	8.6	0.013	126	190
Crystal	45	170	87000	7500	13000	8.6	0.031	108	4.84
Death Valley Jct	7					6.3	0.011	6.3×10^{-3}	4.4×10^{-5}
Desert Game Range	4					4.6	0.005	4.6×10^{-3}	1.8×10^{-5}
Furnace Creek	200						0.010	1×10^{-5}	2.0×10^{-6}
Indian Springs	1500	230	30000	22800	8800	8.6	0.009	61.8	92.8
Lathrop Wells	30	120	115000	13000	23000	11	0.023	151	4.53
Lida Junction	8		26000					26	0.208
Medlin's Ranch	2	120	50000	4700	11000	5.3		65.8	0.132
Mt. Charleston	500					4.5	0.006	4.5×10^{-3}	2.2×10^{-3}
Pahrump	22000					5.5	0.013	5.5×10^{-3}	0.121
Penoyer Farm	16	120	60000	3800	8800			72.7	1.16

(1) Emissions calculated from surveillance data, included on EIS forms. No data for Pahute Mesa in 1994.
(2) Emissions calculated from engineering data, not included on EIS forms.
(3) Population at that location for 1994.
(4) Blank spaces represent locations farther than 80 km from the source for the column.

COMPLIANCE ASSESSMENT

Table 5. [Effective Dose Equivalent Tabulation by Location (Multiply mrem by 10^{-2} for Equivalent mSv Units), cont.]

Location	Pop.[3]	EDE (10^{-6} mrem/year) Due to Releases from:						Total EDE 10^{-3} mrem	Collective EDE man-mrem
		Area 12[1] Tritium	Other Areas[2]	YUCCA Flat Area 3[1]	Area 9[1]	Area 5[1] RWMS	Area 23 Labs[2]		
Rachel	105	120	54000	3600	8600			66.3	6.96
Sarcobatus Flats	40	160	42000	2300				44.5	1.78
Shoshone	250						0.008	8.0×10^{-6}	2.0×10^{-8}
S NV Corr. Ctr	2000			2300		7.0	0.006	2.3	4.61
Springdale	20	110	116000	9600	19000	7.1	0.012	145	2.89
Stateline & Area	70		21000	6200		6.6	0.014	27.2	1.90
Tonopah	4200		10000		770 0			17.7	74.3
U.S. Ecology	35	110	77000	9400	17000	9.4	0.015	103.5	3.62

Total Population - 33,740	Maximum Individual Dose Calculated for Each Release Point - 10^{-3} mrem					Total Person-rem:
Maximally Exposed Individual: 0.151 mrem	Area 12	Other Areas	YUCCA Flat	Area 5	Mercury	
Location of Max: Lathrop Wells, Nev.	0.23	116	26.1	0.011	3.1×10^{-5}	
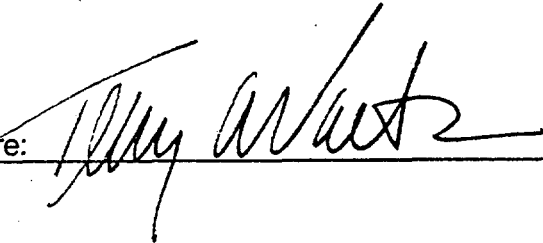
(1) Emissions calculated from surveillance data, included on EIS forms. No data for Pahute Mesa in 1994.
(2) Emissions calculated from engineering data, not included on EIS forms.
(3) Population at that location for 1994.
(4) Blank spaces represent locations farther than 80 km from the source for the column.

Certification

I certify under penalty of law that I have personally examined and am familiar with the information submitted herein and based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine and imprisonment. See 18 U.S.C. 1001.

Name: Terry A. Vaeth, Acting Manager, Nevada Operations Office

Signature: _____   Date: 6/22/95

SECTION IV
ADDITIONAL INFORMATION

NEW CONSTRUCTION/MODIFICATION ACTIVITIES AT THE NTS

No new construction or modification to existing permanent structures that emit radionuclides during normal operations were completed at the NTS in Calendar Year 1994.

UNPLANNED RELEASES DURING THIS CALENDAR YEAR

All releases during calendar year were operational. There were no detectable unplanned releases.

SOURCES OF DIFFUSE OR FUGITIVE EMISSIONS

These sources included evaporation from containment ponds of liquid effluents from E tunnel, resuspension of $^{239+240}$Pu from soil deposits on the NTS in Areas 3, 9, and safety test areas, seepage of noble gases from Pahute Mesa, and seepage of tritium from packages buried at the RWMS in Area 5.

The EDE to the MEI was principally due to the diffuse sources. The EDE from point sources was negligible. The methods used to determine the emissions from these diffuse sources are described in the appendices.

FIGURES
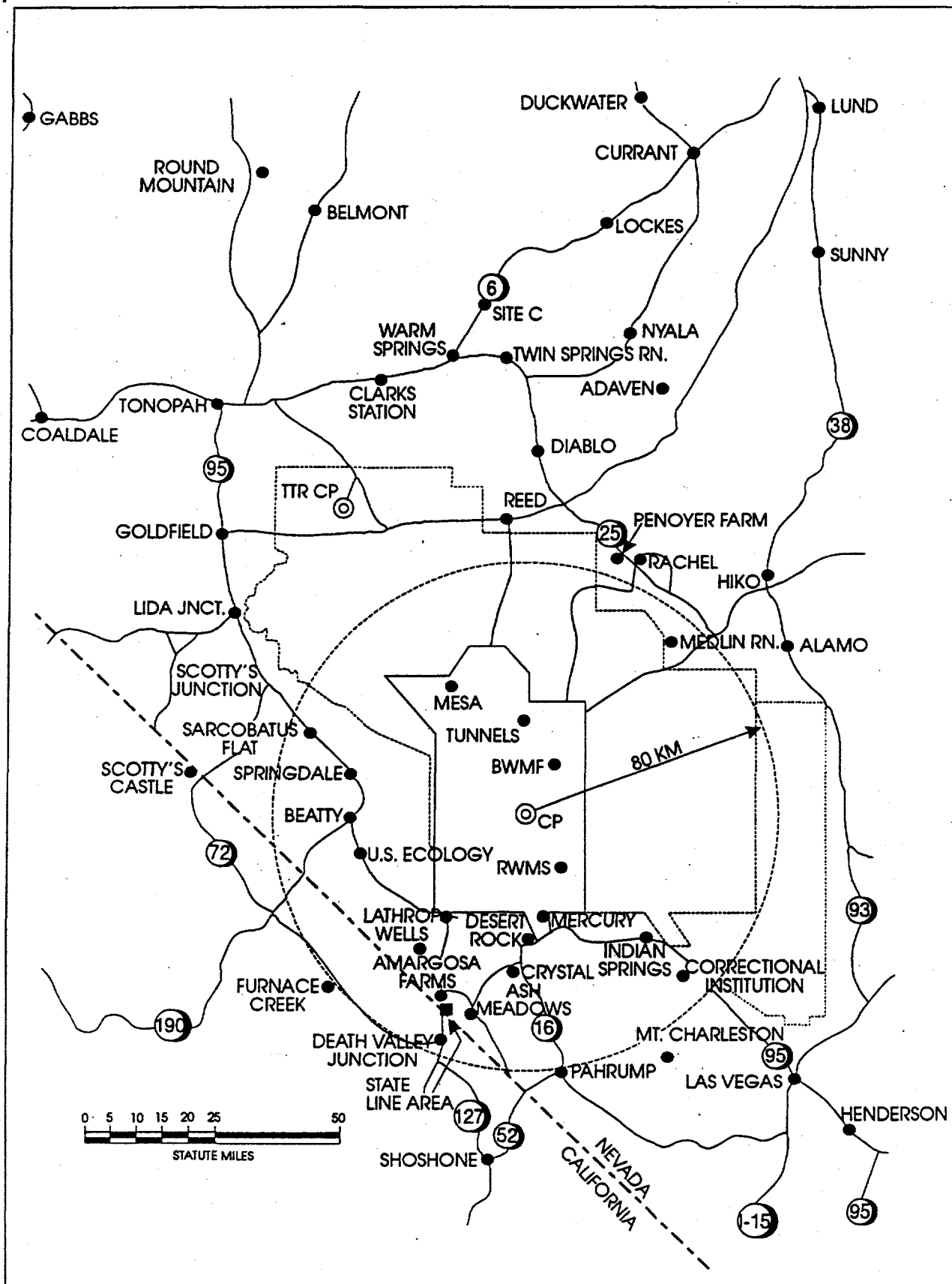
Figure 1. Map of the Area Around the NTS

PAHUTE
MESA

RAINIER
MESA

12 15

8

AREA 12 CAMP

20 19

17

10

BUCKBOARD
MESA

2

9
7

YUCCA
FLAT

4

18

3

AREA 3
RWMS

1

30

16

11

CONTROL POINT ★

29

14 6

RADIOACTIVE WASTE
MANAGEMENT SITE

NEVADA RESEARCH AND
DEVELOPMENT AREA

FRENCHMAN
FLAT

JACKASS
FLATS

26

SPILL TEST FACILITY

25

27 5

MERCURY

23

22

Area Boundary
Paved Road

10   5   0   5   10
MILES
10   5   0   5   10
KILOMETERS

N
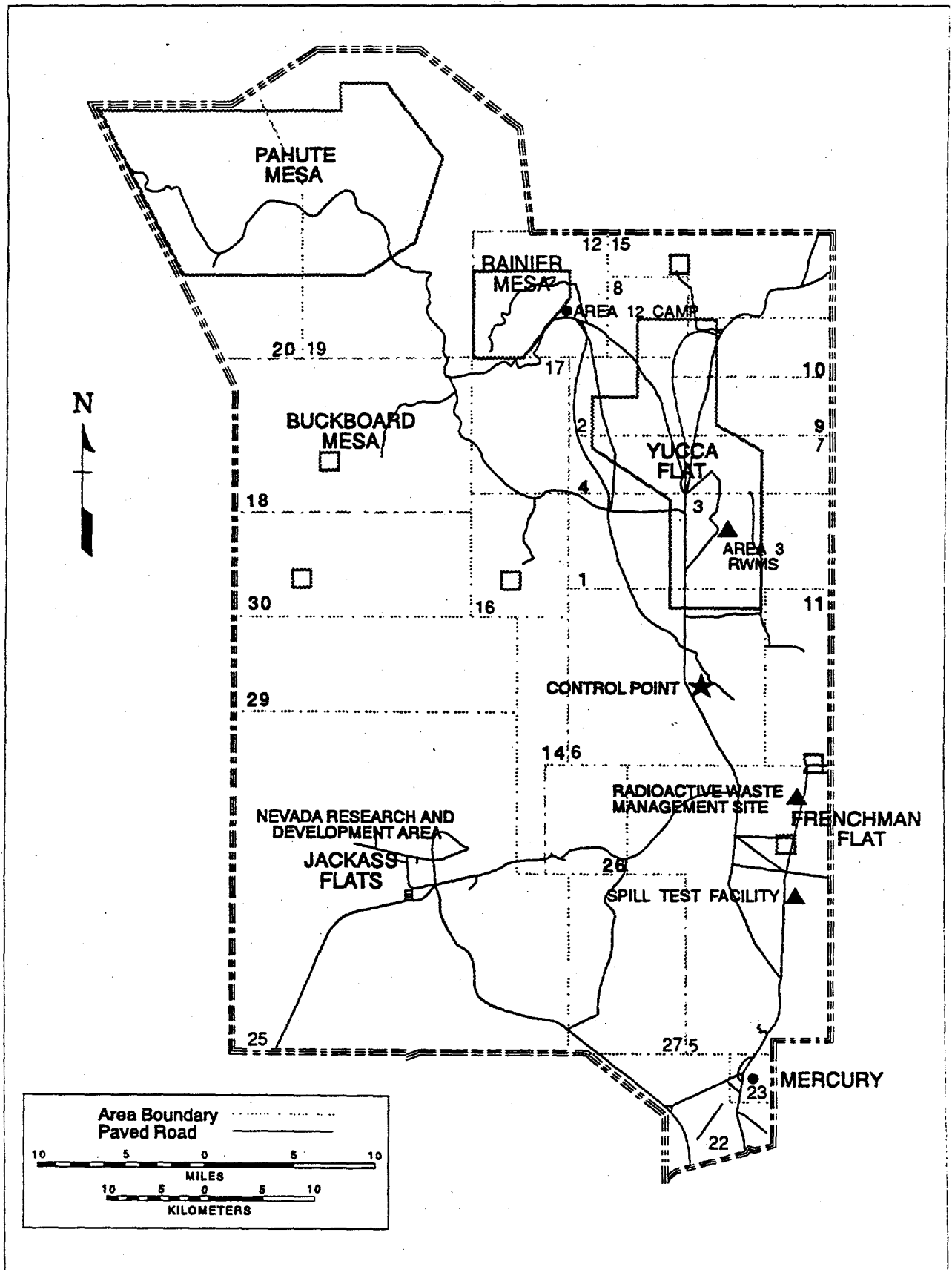
Figure 2. Nuclear Testing Areas on the Nevada Test Site

15
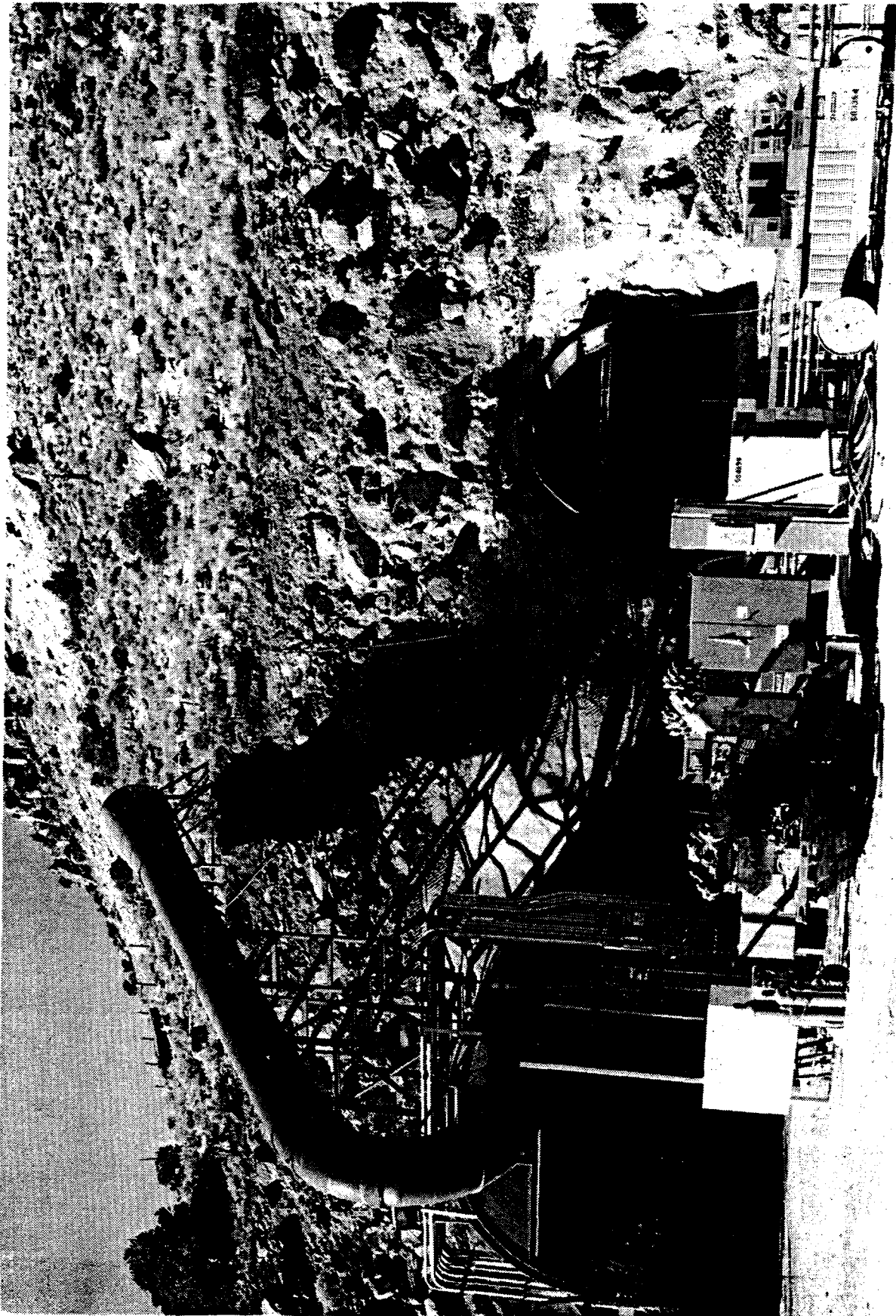
Figure 3. Photograph of a Tunnel Portal

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Figure 4. Photograph of Tunnel Containment Ponds

17
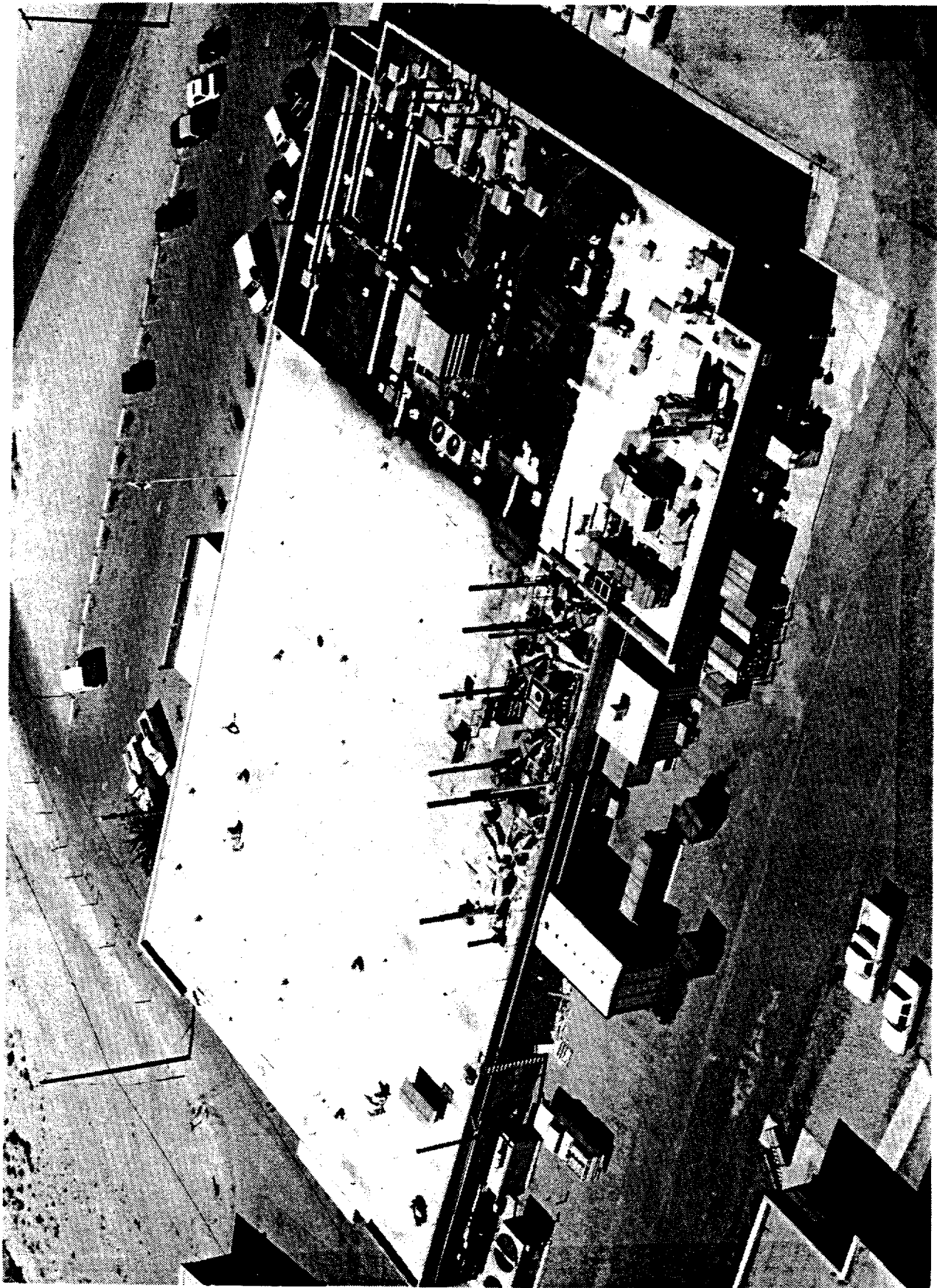
Figure 5. Photograph of the Building 650 Hood Ventilation Stacks Seen from Above
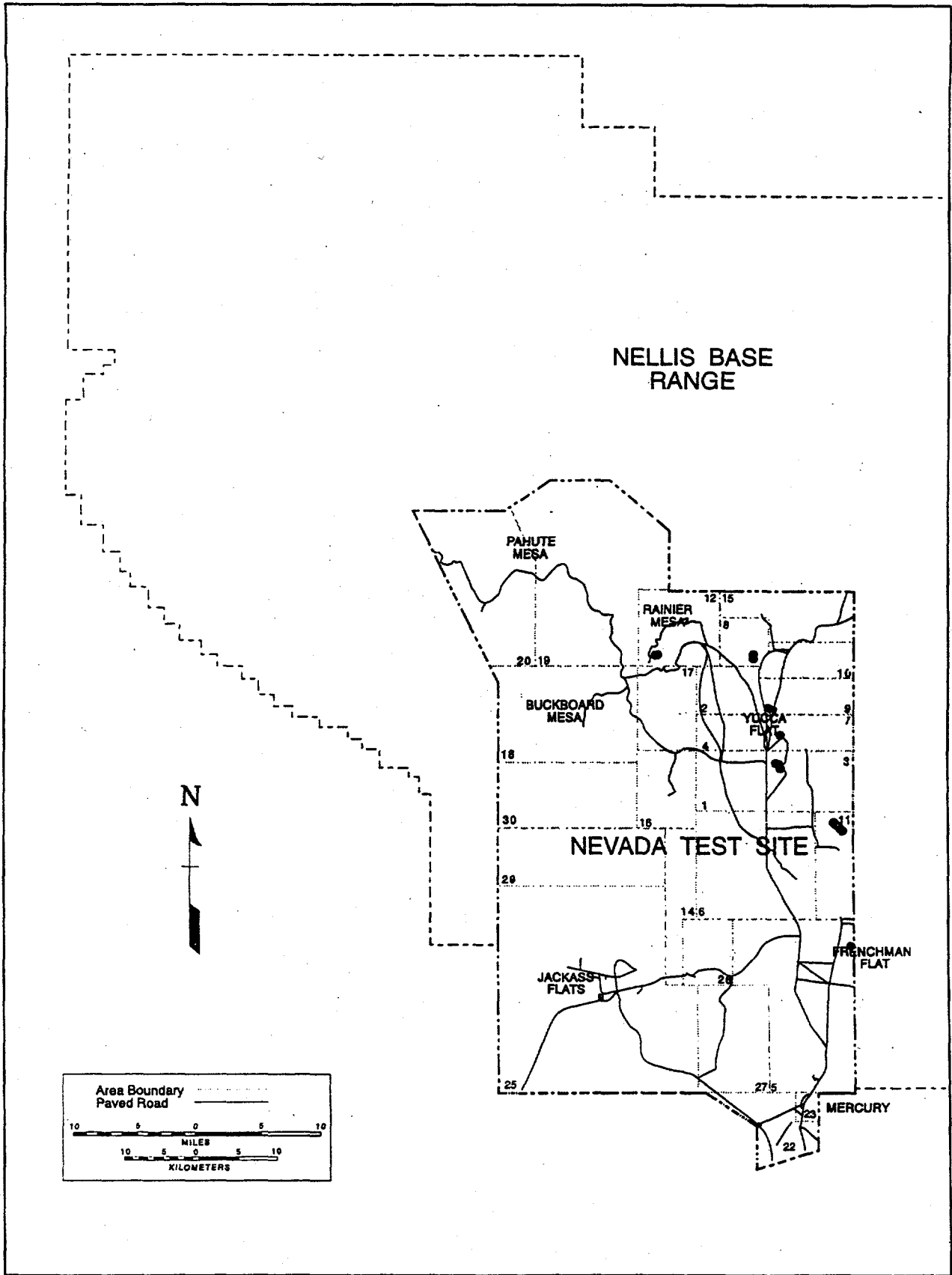
Figure 6. Locations of Nuclear Device Safety Tests (●) on the NTS

APPENDICES
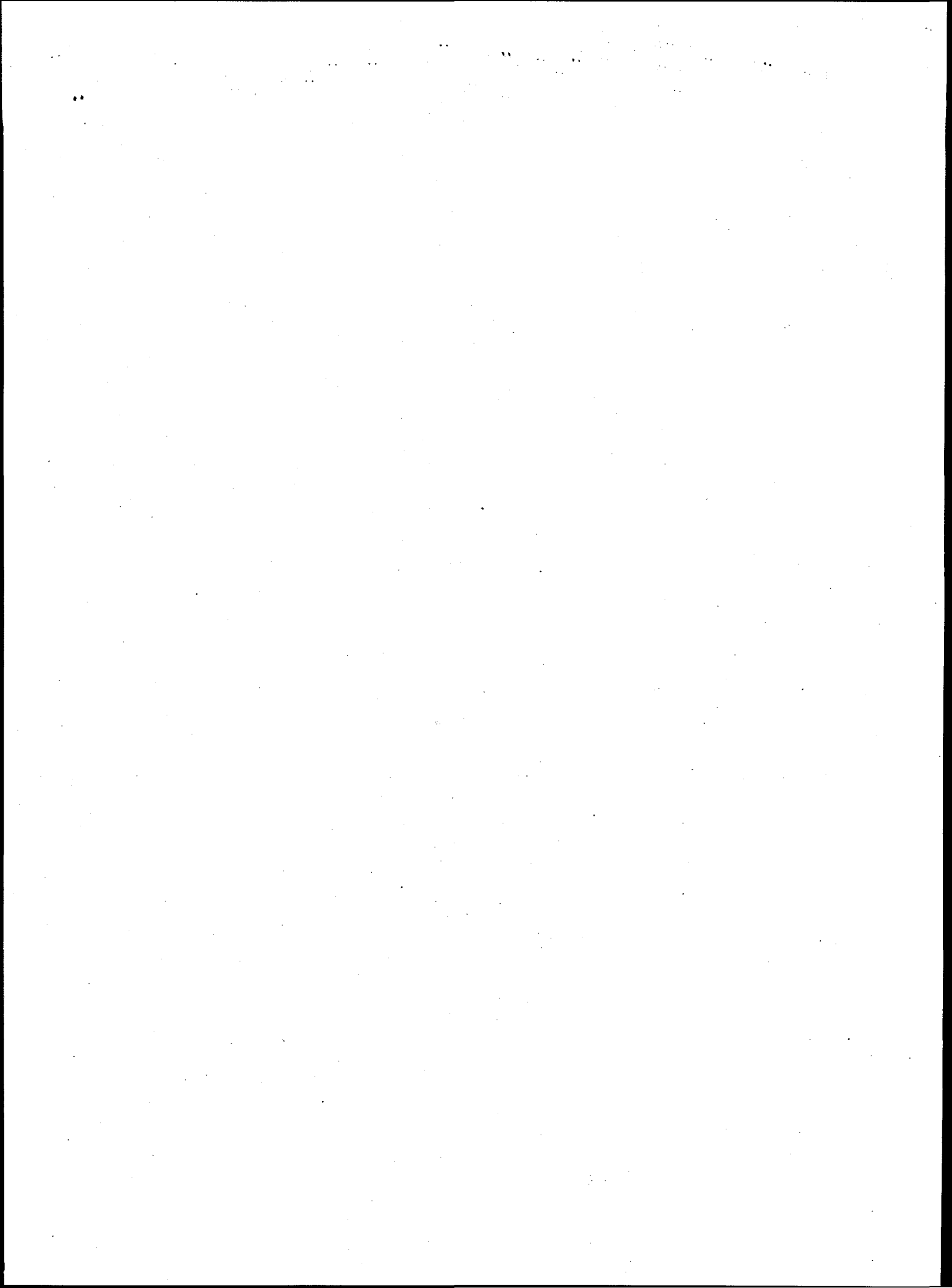
APPENDIX A

ANNUAL NATIONAL EMISSION STANDARDS FOR HAZARDOUS AIR POLLUTANTS EFFLUENT MONITORING REPORT LAWRENCE LIVERMORE NATIONAL LABORATORY NUCLEAR TEST OPERATIONS DEPARTMENT
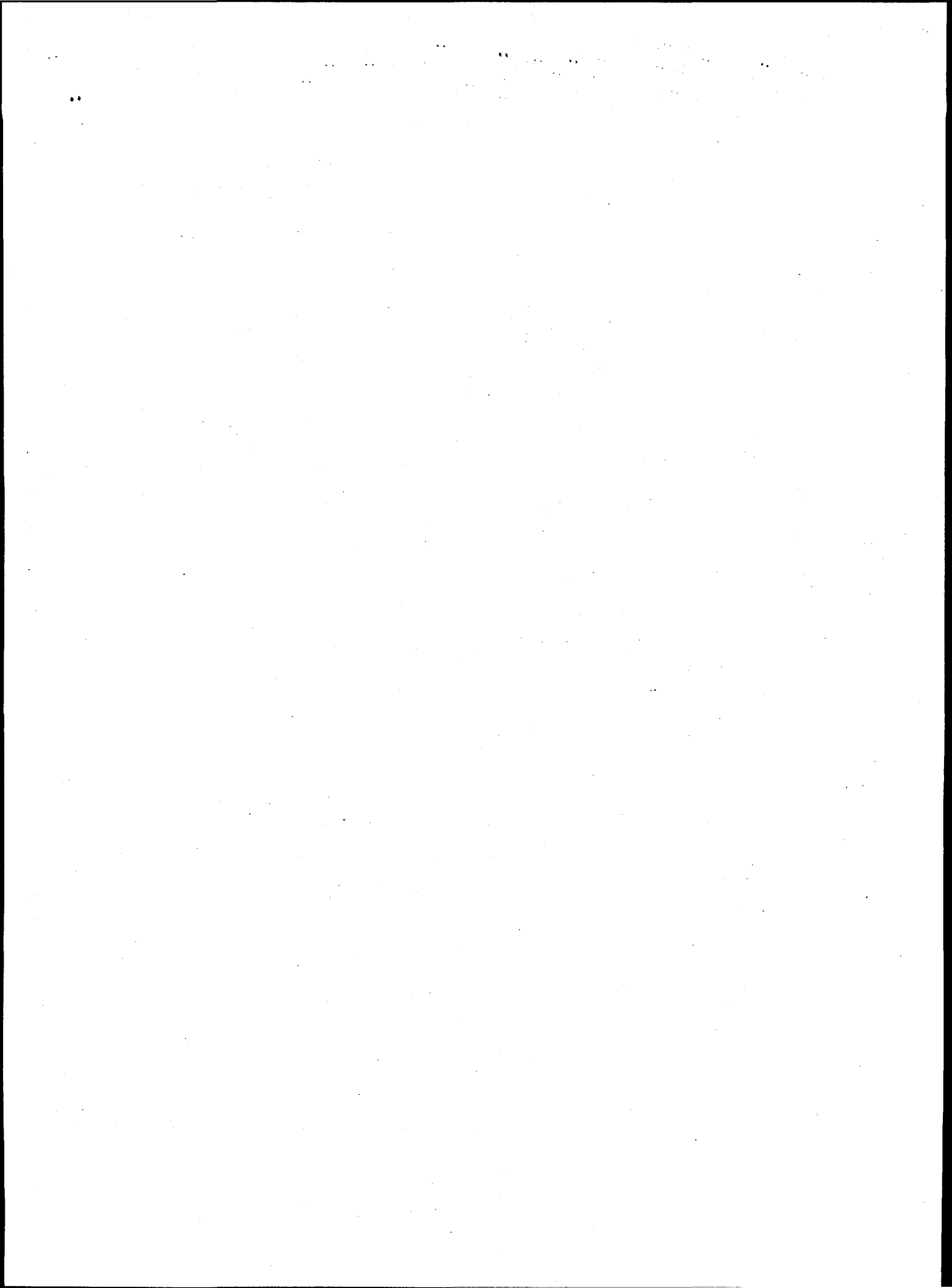
INTRODUCTION

Lawrence Livermore National Laboratory (LLNL) is one of the prime users of the Nevada Test Site (NTS). LLNL only performs effluent monitoring for its NTS projects. This plan includes the organizational structure and responsibility of LLNL, the present system of notification and reports, effluent monitoring programs with a brief discussion of any decisions made, quality assurance, dose calculation, and accuracy of effluent measurements.

Effluents may result because of an operation whose purpose was to sample the nuclear cavity region resulting from a nuclear explosion. The effluent quantity is small but the frequency of occurrence may be high.

ORGANIZATIONAL STRUCTURE AND RESPONSIBILITY

LLNL's Health, Safety, and Environmental Program is administered through the Associate Director for Nuclear Test-Experimental Science. Although authority is delegated to either the LLNL-Nuclear Test Operations Department (NTOD) head or the Test Director, execution of the program resides with LLNL-NTOD Environment, Safety and Health Group (ES&H).

The line contact for effluent monitoring of LLNL programs at the NTS is the LLNL-NTOD ES&H Group although responsibility may belong to the LLNL-NTOD Head or the LLNL Test Director.

OPERATIONAL AREAS

None of the activities for which the LLNL conducts effluent monitoring are permanent. Since the location of each underground nuclear explosion varies, an effluent monitoring system must be moved to that location. Effluent monitoring only takes place during the operation and at locations designated by DOE/NV as nuclear testing areas. The LLNL nuclear testing areas for underground testing in vertical shafts are Areas 2, 4, 8, 9, 10, 19, and 20. LLNL also has a permanent facility in Area 27 to perform device assemblies. Normally, no effluents result from these operations.

EFFLUENTS

The sources of effluent release from LLNL operations at the NTS, their probability of occurrence, and the range of activity encountered are listed in Table A.1. Additionally, a maximum potential post-shot drilling release can be calculated, e.g., for this maximum potential release it is assumed that: (a) all containment apparatus has failed, (b) the means to shut in the hole do not exist, and (c) the concentration of chimney gas is homogenous. Calculations indicate that 10 μCi/mL x 10^{-6} Ci/μCi x 3.0 x 10^7 mL = 300 Ci, of radioxenons may be released to the atmosphere. If it is additionally assumed that the ventline system does not work (therefore there is no filtering) some 40 mCi of radioiodines are released. It is estimated that the first case has a probability of occurrence of less than 10^{-4} and the second case has a probability of occurrence of less than 10^{-7}.

It is estimated that this would contribute some 7 x 10^{-4} mrem to an individual at 10 km from the release point.

The plans for monitoring this source are detailed in Attachment A.A-1.

Table A.1. List of Radioactive Effluents and Probability of Occurrence

Operation	Type	Probability of Occurrence	Isotopes	Effluent Activity Range
Seep	Air	$< 10^{-2}$	$^{131m, 133}Xe$ ^{85}Kr	5 to 1000 Ci
Post-shot:				
Noble gases	Air	0.4	$^{133, 133m, 135}Xe$	0 to 100 Ci
Iodine	Air	< 0.1	$^{131, 133}I$	0 to 2.0 mCi
Assembly	Air	$< 10^{-7}$	^{3}H	0 to 100 Ci
Post-shot				
Sumps [a]	Liquid	1	MFP	.01 to 5 mCi
Other	Unknown	Unknown	Unknown	Unknown

(a) For post-shot operations after January 31, 1990, this liquid effluent stream was replaced by a containerized waste stream.

EFFLUENT MONITORING PLAN

The late-time seep of radioactive gases through the ground, driven by barometric changes, depends on the surface geology, yield, and barometric pressure. The probability of occurrence can be estimated before the event. No special monitoring is done because of continuous monitoring by the onsite Noble gas network, the low probability of occurrence, and minimal health impact. If a seep of this kind does occur, special monitoring will be requested when the source is identified.

Effluent monitoring of post-shot drilling activities is more complicated because its point of effluent release can vary in an unpredictable manner. For this reason, extensive monitoring is done (see Attachment 1). The majority of releases are through the ventline, which is continuously monitored. The linear flow rate in the ventline is measured hourly. The ventline monitoring system and effluent calculation are explained in the references to Attachment A.A-1.

To preclude any liquid disposal in soil columns, the cellar effluent from post-shot drilling operations is containerized and either reinjected or disposed of in waste burial grounds.

Alarm criteria for post-shot monitoring are set at low levels so that steps to mitigate effluent release can be taken.

Monitoring for nonradioactive effluent during post-shot drilling operations is limited to workplace monitoring using portable instrumentation.

Workplace monitoring during device assembly operations, for both airborne alpha emitters and elemental tritium (when necessary), is continuous during device assembly operations. Alarm levels are set so as to preclude false alarms but provide adequate warning. The probability of

any effluent is almost nonexistent. Therefore, no routine effluent monitoring program is conducted at the assembly facility.

LLNL does perform other experiments which may produce an effluent stream. When such a project is instituted, efforts to measure the effluent (radioactive and/or nonradioactive) with proper meteorological support are taken.

QUALITY ASSURANCE

The QA program for most effluent monitoring devices that LLNL-NTOD uses is administered through the contractors who provide those instruments. For example, the post-shot instrumentation is calibrated and maintained by the REECo HPD. LLNL provides general instructions concerning instrument calibration. Meteorological instruments are calibrated, fielded, and maintained by NOAA.

Performance validation of the post-shot drilling effluent measuring instrument is as follows. The ventline monitor (only used for post-shot operations) is checked with a sealed source of ^{109}Cd or ^{133}Ba (to simulate the low energy of ^{133}Xe) in conditions similar to those seen during post-shot operations. It is also checked with a ^{60}Co source and a pulser before each use and is frequently checked during use. Also, since a linear superposition of xenon isotopes is assumed, verification of xenon ratios is obtained from post-shot gas samples.

DOSE ESTIMATION AND EFFLUENT ERROR

Calculations using CAP88-PC indicate that at 10km (a conservative estimate of distance to the maximally exposed individual) effluent releases of 95,000 Ci of ^{133}Xe or 9.5 Ci of ^{131}I or 2300 Ci of ^{3}H would result in a receptor dose of 0.1 mrem and would require continuous monitoring. Using the maximum numbers in the effluent range given in Table A.1 for post-shot activities and the release figures for CY92 (no releases), the resultant effective dose equivalents are listed in Table A.2. There were no nuclear tests in 1994.

Table A.2. Effective Dose Equivalents

Operation	Isotope	Maximum Dose at 10km	CY92 Dose at 10km
Seep	^{133}Xe	1×10^{-3} mrem	0 mrem
Post-shot	^{133}Xe	1×10^{-4} mrem	0 mrem
Post-shot	^{131}I	2×10^{-5} mrem	0 mrem
Assembly	^{3}H	4×10^{-3} mrem	0 mrem

Because LLNL-NTOD is only responsible for a portion of the NTS, DOE/NV only requires total activity determinations. Dose estimations are done as a part of workplace monitoring and are based on both measurements and external and internal dosimetry data.

Special situations may arise in which dose estimations are made because of effluent releases. However, this estimate is only used for planning purposes. The final dose is based on all measurements made by DOE/NV's contractors and calculated by them.

The calculation of effluent is uncertain because of the type of release (diffuse or point), emanation point(s) of the release, assumptions made, and models used. Every effort is made to reduce this uncertainty by utilizing other onsite detection results. In some cases the releases can be easily defined geometrically and error could be as little as 30 percent. However, if Gaussian transport theory must be relied on, the result may be uncertain by a factor of ten. Effluent calculations done for post-shot releases are less uncertain because transport theory is seldom used.

NOTIFICATION AND REPORTS

The procedure to be followed in notifying LLNL personnel is outlined in the NTS Health and Safety Manual. Notification of DOE personnel is also outlined in the NTS Health and Safety Manual.

It has been the policy of LLNL that upon notification of LLNL-NTOD ES&H, a decision, based on the possible health, safety, and environmental consequences of the incident is made, as to whether or not DOE/NV should be notified immediately. However, LLNL has been directed to notify DOE/NV immediately of instantaneous post-shot releases above 10 curies (required by NTS-SOP-5402, "Radiation Release Surveillance - Notification Procedures," June, 1990). This immediate notification is followed by written documents to DOE/NV. These documents include:

> Daily Reports Generated by the Resident Manager
>
> Individual operational reports generated by LLNL-NTOD ES&H within weeks after completion of the operation.
>
> Completion reports of each fiscal year activity.
>
> Annual Radioactive Effluent and On-Site Discharge Data Reports.
>
> Final event reports (classified because of specific event information).

If an Occurrence Report (OR) or Off-Normal Report is required because of an effluent incident, the affected LLNL organization is responsible for investigating the occurrence and preparing the report. Both DOE/NV and DOE/SAN (San Francisco Operations Office) will receive copies of any OR.

The effluent calculations performed by LLNL-NTOD ES&H results of which are reported, will include those elements required by DOE/NV to perform dose calculations as recommended in DOE Environmental Regulatory Guide, DOE/EH-0173T. Source term calculations shall describe the variables used, conversion factors, identify the source of data, describe the calculational method, and the effluent memo will be signed and dated.

ATTACHMENT A.A-1
LAWRENCE LIVERMORE NATIONAL LABORATORY
POST-SHOT DRILLING/EFFLUENT MONITORING

INTRODUCTION

Monitoring for effluent during post-shot drilling operations is briefly described herein. The approach to effluent calculations is outlined and the reporting procedures discussed. References for this section are internal to LLNL-NTOD. They are:

(1) Post-Shot Ventline Calculations, 1-6-82
(2) Post-Shot Ventline Release Calculations, 1-11-82
(3) Post-Shot Ventline Backup Calculations, 2-9-83
(4) Chemical Composition of Recent Drill String and Tubing Gas Samples, 6-14-89
(5) Post-Shot Instrument Requirements, 2-5-90
(6) Radioactive Effluent Calculational Format, 1-29-90
(7) Procedure No. NTS-113; Occurrence Reporting System, 11-16-90
(8) Post-Shot Drilling Handbook, 1-19-84
(9) OSP-NC-2, Operational and Safety Procedure for Containment on Post-Shot Drilling Operations Conducted at the Nevada Test Site, 01-31-89

GENERAL DESCRIPTION

A brief discussion of post-shot drilling points of effluent and the monitoring of those effluents follows:

The four main types of effluent, monitoring frequency, radioactive isotopes released, and the expected range of activity are shown in Table A.A-1.

Table A.A-1. Effluents and Monitoring

Effluent Point	Effluent Type	Monitor Type	Frequency	Isotopes	Range of Activity
Ventline	Air	Scintillation Detector	Continuous	$^{133, 133m, 135}$Xe	0 - 100 Ci
Platform	Air	Ionization Detector	Continuous	$^{133, 133m, 135}$Xe	0 - 20 Ci
Platform	Air	Rig Filters	Continuous	$^{131, 133}$I	0 - 2 mCi
Blooie Line	Liquid	Ion Detector	Continuous during Operation	Mixed Fission Products	0.01-5 mCi (in sump)
Core Trailer High-Grade Shack	Air	Charcoal	Continuous during Operation	Mixed Fission Products	<1 µCi

Release through ventline is the principal type of release encountered. The ventline is a 20 in O.D. steel pipe conducting air from the post-shot drilling cellar through banks of filters to a point of release to the atmosphere (see Figure A-A.1). Also, releases do occur on the rig platform primarily through the top of the drill string (see Figure A-A.1, reference 8). Minor releases of radioactivity may occur from handling of the core material in the core trailer or the high-grading (sample preparation) shack. Finally, a release of liquid radioactive effluent into the post-shot drilling sump occurs as a result of emptying the contents of the post-shot drilling cellar into the sump. This point of effluent has been eliminated.

The operation and function of each monitoring system used is described in the following:

VENTLINE SYSTEM

It is the purpose of this system to convey any airborne radioactive material not stopped by the drilling containment system away from the drilling area. This stream is diluted by mixing it with air. Particulates are removed by both gravity separation and high efficiency particulate air (HEPA) and charcoal filters. Two detectors monitor the ventline continuously and finally the treated stream is released to the atmosphere.

Pertinent Information:

Ventline: O.D. - 20 in
Thickness of steel - 0.1012 in
Horizontal run - approximately 200 ft
Release height - approximately 15 ft

Flow Rate: Linear - 900 to 1300 feet per minute
Volumetric - 1950 to 2850 CFM

Particulate
Treatment: Vertical separator - 10 ft
HEPA filter
Charcoal filter - One foot in three banks

Detector: Primary - NaI Scintillator
Backup - Neher-White Ionization Chamber

The ventline detection system consists of a NaI scintillator primary detector and a Neher-White ionization chamber backup detector. It is the purpose of this ionization chamber to function at high intensities where the primary detector saturates and to act as a backup detector in case the primary detection system malfunctions. These detectors monitor radioactive effluent flow through the ventline before release to the atmosphere but after the filter bank (see Figure A-A.1). Both systems have readouts, continuous strip chart recorders, and alarms in the core trailer.

Placement of the ventline detection system is predicated on three considerations, i.e., geometrical orientation, minimal interference (within operational constraints), and line source geometry.

Further requirements for performance checks and calibration are detailed in reference 5.

LEGEND

1. Drill Rig
2. Postshot Cellar
3. Rig Filters
4. Core Trailer
5. High Grade Shack
6. Sump
7. Blooie Line and Detector
8. Ventline
9. Access Control Fence
10. Filter Bank
11. Ventline Detector
12. Cyclone Blower
13. Ventline Exhaust
14. Abandonment Valve
15. Blow-Out Preventer
16. Rotating Head
17. Drill Pipe
18. Regan Head
19. Cellar Detector
20. Mast
21. Control Panel
22. Platform Detector
23. Cellar Containment Cover
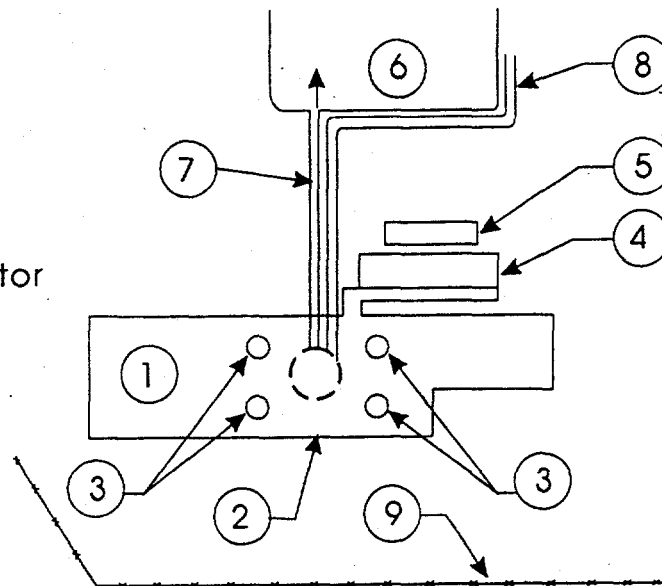
DRILL RIG - PLAN VIEW

VENTLINE EXHAUST
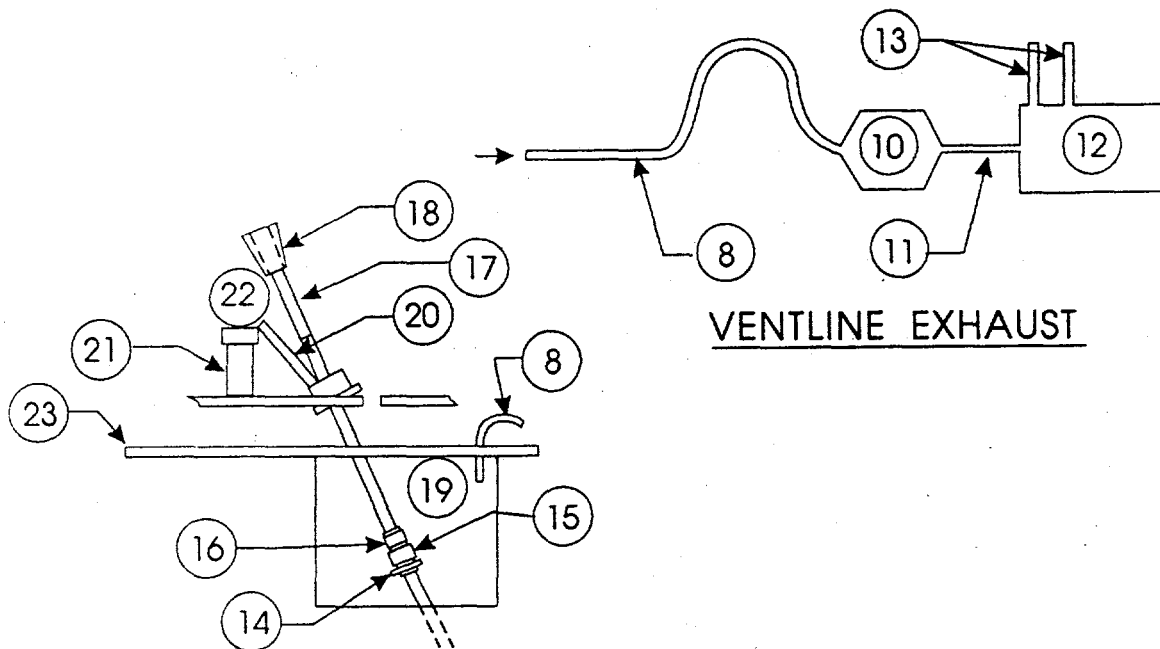
POSTSHOT DRILLING CELLAR

Figure A-A.1. LLNL Containment Hardware

CELLAR DETECTOR

The cellar detector is placed on top of the drilling stack in the post-shot drilling cellar (see Figure A-A.1). Its purpose is to provide the drilling engineer with information concerning radioactive gas concentration in the drill string. Although not used directly in effluent monitoring, it does inform the driller of impending problems. Requirements for installation, performance checks, and calibration are set forth in reference 5.

RIG MONITOR

The rig monitor is a detection system placed on the rig platform (see Figure A-A.1) to continuously monitor the platform exposure rate. Because its primary function is to warn working personnel, it has an audio alarm. It is also used to determine the duration of a platform release.

Requirements for installation, performance checks and calibration are shown in reference 5.

BLOOIE LINE MONITOR

The purpose of the blooie line monitor is to determine gross radiation levels of drill back returns passing through the blooie line. This detector monitors continuously and is recorded on a strip chart in the core trailer. The detector is placed on the blooie line near the blooie line's entrance into the sump (see Figure A-A.1). Requirements for installation, performance checks, and calibration are enumerated in reference 5.

DRILL RIG FILTER SAMPLERS

Drill Rig filter samplers provide information concerning platform operational conditions. They are located on the platform in the primary working areas (see Figure A-A.1). The 4-in diameter filters consist of a paper prefilter and a charcoal filter which are changed every 8 hours after approximately 50 m^3 of air pass through the filters. After removal, the rig filters are counted using gamma spectroscopy to provide after-the-fact isotopic information.

Because of the low sample collection efficiency for Xenon gases, the drill rig filter samples are only used to provide effluent information for platform Iodine releases.

OTHER

Because of the variability of post-shot drilling operations and many operational constraints, it is not always possible to set up permanent detection systems. However, those points that require monitoring are monitored by the use of portable instruments, high volume filter samples, or specially setup sampling equipment.

Platform releases of Xenon gases and evolving gas from core material are the two main types of effluent which are quantified by means of other samplers. Special monitoring equipment may be used for those operations in which either new points of effluent are created or sensitivity to a particular isotope needs to be enhanced.

In addition, grab samples may be collected to aid area control or to supplement effluent monitoring.

The above only addresses radioactive effluent. The only source of non-radioactive effluent is core material (an analysis of the cavity air in post-shot drilling gas samples is provided, see reference 4). Any waste produced by the post-shot drilling operations is sampled and analyzed for non-radioactive constituents, e.g., lead.

POST OPERATION

Upon completion of a post-shot drilling operation, two types of samples are taken. They are cellar integrity samples, to ascertain radioactive concentrations in the post-shot drilling cellar and grab samples, to determine the extent of environmental effect of the operation. Integrity samples are changed every 24 hours and the paper filter and charcoal filter are sent to the REECo Analytical Services Department Laboratory for isotopic analysis. The flow rate of the integrity sampler is approximately 10 CFM.

Grab samples are taken when required and the analysis depends on the reasoning for sampling.

EFFLUENT CALCULATIONS

This section briefly describes the effluent calculation used by LLNL for post-shot drilling. The calculational format needs to be both formal and descriptive (see reference 6).

Effluent calculations for a release through the ventline use three main assumptions. A line source geometry is assumed and it is assumed that the detector signal is a linear superposition of ^{133}Xe, ^{133m}Xe, and ^{135}Xe. It is further assumed that the ratios of isotopes can be obtained from abundance verses time curves for the fissioning of ^{239}Pu. A more detailed description is given in references 1, 2, and 3.

Because ventline release calculations depend linearly on the volumetric flow rate, frequent and accurate measurements of the ventline flow rate are made (see reference 5).

Effluent releases at points other than the ventline must rely on detection systems that are not optimized for the purpose. Portable instruments may give very good information for a point in time, but give little or no time information whereas stationary instruments provide fairly reliable time information but very inaccurate intensity information. A combination of the two may give release information accurate to within 50 percent. Information from the onsite environmental surveillance network may provide an upper limit to the releases.

An exception to the above is a platform iodine release. The point of release is usually known and all that is required is to relate the total quantity on the filter to the point of release.

APPENDIX B

ANNUAL NATIONAL EMISSION STANDARDS FOR HAZARDOUS AIR POLLUTANTS EFFLUENT MONITORING REPORT LOS ALAMOS NATIONAL LABORATORY GROUP HS-12 FIELD TEST SECTION

POTENTIAL EMISSIONS

WEAPONS TEST AREAS - DRILL BACK

There exists the potential to release volatile fission products, notably noble gasses and iodine during the operations required to recover solid samples of the fission product debris. The potential exists to release an estimated 10 Ci of ^{133}Xe and 0.5 mCi of ^{131}I during the operation.

- The 10 Ci estimate is felt to represent an upper limit for the distribution of possible releases. The estimate is derived from LLNL and LANL experience with 16 releases from drill back operations that have occurred over the past few years. These have ranged from 24 μCi to 14 Ci of xenon. This is felt to probably represent, to one significant figure, the upper end of the spread of estimates. It is further estimated that about 4 curies of xenon were seen in the containment system during the BEXAR cement back in 1991, and about one half curie was released.

- The method of using actual experience is felt to be superior to a theoretical treatment of the subject. The LANL documentation of release includes the value for xenon. This element is held up by the cleanup system, but not retained. The values for release would be the same even if the cleanup system was not operational. The iodine value is the theoretical value, assuming the mix as reported in LA-3420-MS, "Analysis of Underground Weapon Test Effluent Samples," for the amount of xenon seen, and a delay time of about 1 week.

- From Yucca Flat, the Maximally Exposed Individual lives in Crystal, at a distance of 52 km due south. Assuming a release of 10 Ci of ^{133}Xe and 0.5 Ci of ^{131}I, the Effective Dose Equivalent for all radionuclides and all pathways would be 1.7 x 10^{-6} mrem.

  Based on these data, no effluent monitoring is required to meet the standards. LANL will continue to monitor this potential source of emissions as a matter of Best Management Practices for Health Physics. The information generated is of great interest to both the resident Health Physicist and the drilling engineers.

BUILDING 701 RADIO-ANALYTICAL LABORATORY

Maximum emissions are estimated to be 40 mCi of ^{133}Xe, 2 μCi of ^{131}I, and 500 μCi of tritium.

- The iodine and xenon values are based on sample measurements during the BEXAR cement back, and estimated possible numbers of samples. For the BEXAR cement back there were approximately 14 sets of samples with four samples containing ^{131}I in each set. The average concentration was of the order of 10^{-10} Ci/m^3, with a sample volume of 50 m^3. This implies an average value of 5 x 10^{-9} Ci per sample or 0.3 μCi for the whole operation. Assuming six such operations per year, the total inventory would be 2 μCi. No credit is taken for the fact that this iodine is very securely held on the charcoal cartridges on which it is collected. The whole amount is treated as a gas. For calibration purposes, ^{133}Xe is purchased in glass vials containing up to 20 mCi each. Accidents could result in a couple of these vials being broken during the year, thus releasing about 40 mCi. Tritium is received at the laboratory as HTO in 500 mL bottles. Concentrations as high as 50,000 μCi/mL have been measured (25 μCi per sample). It is assumed that no more than 20 of

these would be on hand in the Laboratory during any time during the year. The total inventory would then be no more than 500 µCi at any time.

- This method of estimating release from the laboratory is in compliance with Appendix D, with very adequate margins of conservatism.

- From Mercury, the Maximally Exposed Individual lives in Pahrump, at a distance of 51 km due south. Using the maximum activity for the radioisotopes in the Laboratory, the Effective Dose Equivalent for all radionuclides and all pathways would be 8 X 10^{-9} mrem. This is well below the threshold requiring effluent monitoring.

WEAPONS AREA - EVENT TIME

The potential for accidental release of radioactive material is either as a "prompt massive venting" or as a "seep release".

ASSEMBLY AREA

There is no potential for the accidental release of radioactive material to the atmosphere aside from an accident.

POTENTIAL SOURCES

Potential sources of radioactive effluents are: (a) Weapons Test Area - Zero Time, accidental releases only; (b) Weapons Test Area - Drill Back Operations, operational as well as accidental releases; (c) Assembly Area, accidental releases only; and (d) Building 701 Analytical Laboratory, accidental as well as operational releases.

SUMMARIZED DESCRIPTION OF DRILL BACK RESPONSIBILITIES AND PROCEDURES

The Test Group Director is responsible for all Los Alamos National Laboratory operations on the NTS, including drill backs. This includes HS&E responsibility for the area for which that responsibility has been specifically transferred. The specific responsibility for the preparation, setup, operation, and cleanup of the drill back location is delegated to a senior drilling engineer in LANL Field Engineering Group, J-6. Radiological safety responsibility is delegated to a senior health physicist in the LANL Radiation Protection Group, HS-12. The Field Test Section Leader, in HS-12, is responsible for the collection, reduction, and interpretation of all health and effluent data.

A detailed description of the LANL Post-Shot Drilling Operations is given in "Los Alamos National Laboratory Post-Shot Drill Back Operations and Responsibilities," March 1990 Edition. This summary is extracted from that document. The containment system consists of the blowout preventer (BOP) located in the cellar under the drillrig, the recirculation trailer (housing the blowers and valving to generate and direct air flow through the containment system), the hoses connecting the BOP to the containment trailer, and the containment control panel used to operate the containment system. Once the surface casing is installed and cemented in place (cement pumped down the surface casing and forced up around the casing to create the cellar floor), the BOP is installed, and the containment trailer and recirculation system are made operational and connected to the BOP. The annulus pressure air line, used to blow air from the cellar down the annulus after the loss of mud circulation and the test line

used during testing of the BOP and to monitor the gas in the annulus after circulation is lost, are connected at appropriate points on the BOP and the recirculation system. A schematic of the containment system from the published procedures is attached.

The Rad Lab trailer radiation and explosive gas detection and alarm systems are calibrated and connected to the appropriate sampling points on the containment system (the annulus pressure line to sample cellar air and the test line to sample annulus air). The details of these procedures are included in a collection of documents for specific parts of the operation.

The containment equipment test procedure (pressure check) is completed by the J-6 engineer as described in the procedures. This procedure checks the system for leaks in various configurations at pressures of 5 and 25 psig. The operation of the valves and indicators is checked.

Drilling commences only after the above setups and checks have been successfully completed. Initially, drilling fluid is returned to the surface through the mud flowline. Cuttings and debris are removed at the shaker table and the mud is recirculated downhole. During this phase of drilling, air is drawn from the cellar and exhausted up the mast through the containment system. This air is monitored for radioactive and explosive gasses by the equipment in the Rad Lab trailer, even though the path to the cavity is effectively blocked by a standing column of drilling fluid in the hole. Air samples are taken at four points on the drillrig floor and just outside the cellar door and are changed every eight hours to correspond to the workers' shifts.

When the drilling fluid begins to flow into fissures and voids in the formation, the fluid is no longer circulated back to the surface (loss of circulation). After loss of circulation, the mud return line is closed and cellar air is now blown down the annulus through the containment system annulus pressure air line. Radioactive and explosive gasses are now monitored both in the recirculation air and in the annulus.

Once the total required depth has been reached, drilling is discontinued and sidewall samples are collected through a sampling port in the drill string. Small amounts of drilling fluid may be pumped down the drill pipe to help control gas flow up the inside of the pipe. Air continues to be monitored and blown down the annulus through the containment system. Additional air samples are collected in the core sampling and handling areas adjacent to the rig.

When sampling is completed, the drill pipe is removed from the hole and the ball valve in the BOP is closed. The containment recirculation system and the Rad Lab monitoring systems are shut down, and the air sampling effort is reduced to a single sampler just outside the cellar door. The filters on this sampler are changed once a day until operations are resumed at the location.

After post-shot drilling and sampling activities are completed, the hole is cemented to the surface. During this operation drillrig floor sampling is resumed as is monitoring through the Rad Lab Trailer. The containment recirculation system is activated and cellar air is blown downhole through the annulus pressure air line. The ball valve is opened and a bridge plug is run into the hole and set below a predefined minimum depth. The hole is then cemented to the surface in stages. At some point in this process, air can no longer be blown down hole,

B-3

and the recirculation system is secured. Once the cement has been tagged at a satisfactory depth, the hole is considered secured and the BOP is removed.

MONITORING EQUIPMENT AND PROCEDURES

The Los Alamos National Laboratory hardware is designed to completely contain all chimney gas. During active drilling and sampling operations, air is drawn from the cellar, sampled, and returned to the annulus below the containment hardware. This provides a column of air moving down the annulus to keep gas from the cavity from reaching the containment hardware. This method of containment is used after drilling fluid no longer returns to the surface (loss of circulation), and before the hole is closed by either closing the ball valve or by the use of sufficient cement during the cement back. Figure B.1 shows the hardware configured to contain the gasses.

When the air from the cellar cannot be blown down hole, it is exhausted up the mast. This happens before loss of circulation and after the hole is plugged with cement. The valve shown in Figure B.1 can be rotated to cause this switch.

As long as the system is running, a sample of the air is analyzed for the presence of radionuclides emitting gamma rays with energies above 60 keV. The characteristic gamma ray of ^{133}Xe is about 80 keV. The system has been calibrated in terms of total ^{133}Xe in the system. A few vials of National Institute of Standards and Technology (NIST) traceable ^{133}Xe were obtained from DuPont/New England Nuclear. These vials were used to determine the activity in about 25 other vials that were released into the system under normal operating conditions, and the response of the detection system was thus calibrated. The few trials precludes a detailed treatment of error, but the data available suggest that the precision is probably better than a factor of two. In the event chimney gas is detected by the system, the procedures set forth in "Field Test Health Physics Section Detailed Procedure for Estimation of Activity in the Containment System" are used. While the system is in the containment mode, the result is simply the ^{133}Xe captured. When the system is in the mast exhaust mode, the result is the release of ^{133}Xe. The release of ^{131}I is then inferred from the ^{133}Xe and the age of the gasses using the data presented in LA-3420-MS, Analysis of Underground Weapons Test Effluent Samples.

In the event that chimney gas is detected on the air samples collected on the platform, the procedures set forth in "Field Test Health Physics Section Detailed Procedure for Estimation of Release Using Health Samples" are used. This technique is based on the experience at the LOCKNEY drill back. Chimney gas was exhausted into the cellar after having been through the containment system. This allowed for the measurement of the source using the calibrated system. The measured concentration of iodine on all sample heads and the length of the sampling period are used to estimate the release, using LOCKNEY as an analogue.

The measured ^{131}I values are used, since the samplers collect iodine almost quantitatively. Since this is a single point "calibration" of the technique, a detailed treatment of error is not possible. The results of applying the technique to other events indicate that the precision is probably better than an order of magnitude, and is probably close to a factor of three. The data in LA-3420-MS are again used to infer the ^{133}Xe.
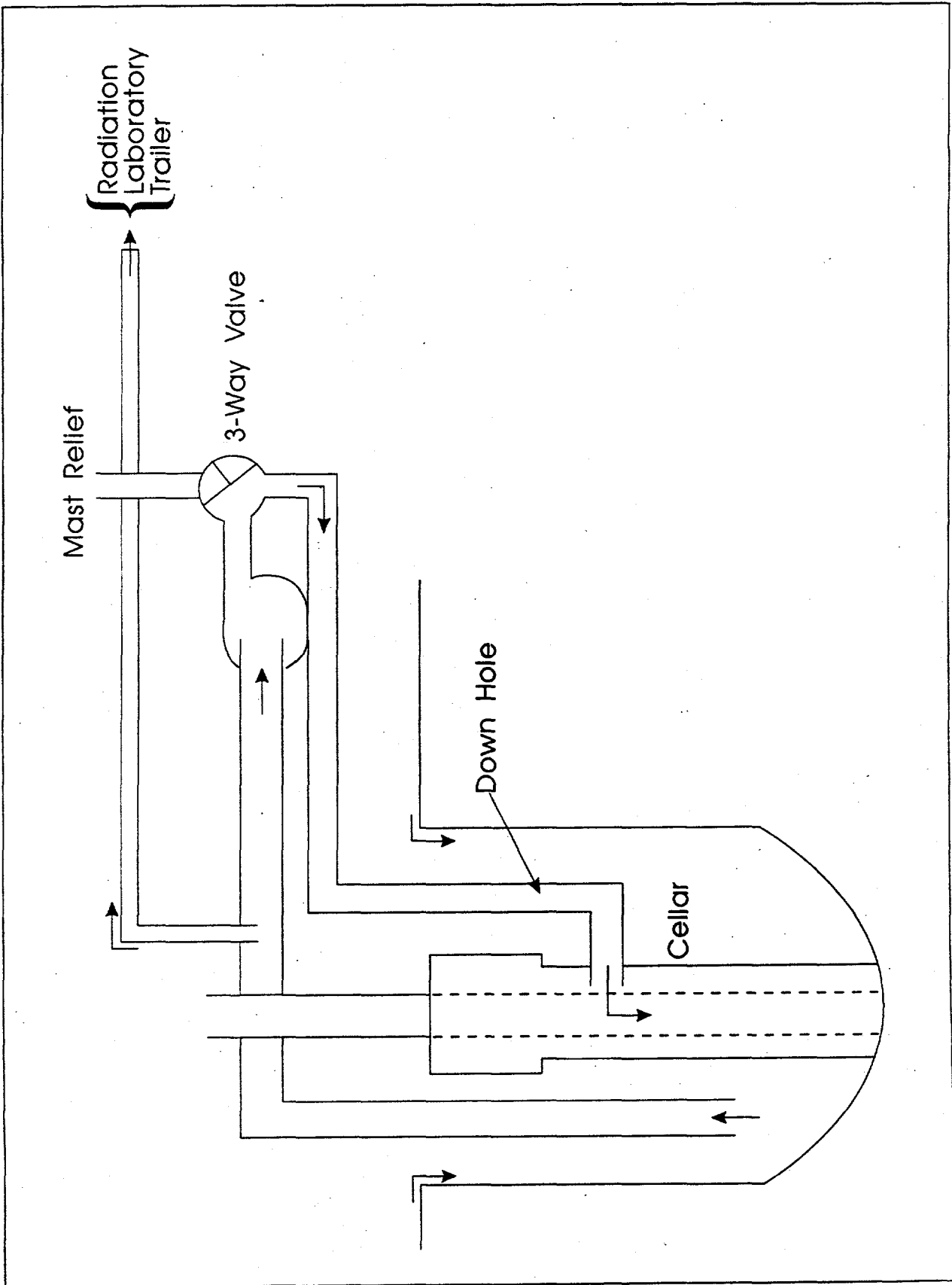
Figure B.1. LANL Containment Hardware

When the cement back does not directly follow the drill back, the containment hardware is closed, the recirculating air shut off, and a single sample is collected in the cellar. This sample verifies that the hole is properly closed. If chimney gas is detected on this sample an estimate of release is generated, again using LOCKNEY as an analogue. The technique is given in "Field Test Health Physics Section Detailed Procedure for Interpretation of Cellar Samples." Since this is a single point "calibration" of the technique a detailed treatment of error is not possible. The precision of this technique is probably not much better than an order of magnitude, depending on the material detected by the sampler. The data in LA-3420-MS are again used to infer the composition.

OTHER SOURCES

There were no other sources.

INVENTORY OF RADIONUCLIDES

For 1994 the inventory of tritium, iodine and xenon in Building 701 was calculated as:

Tritium 5×10^{-05} Ci; (NIST Standard) (All other samples trivial).
Iodine 1×10^{-07} Ci; Calculated from reported concentrations and volumes.
Xenon 4×10^{-01} Ci; Xenon standard gas used for Radiological Laboratory calibration.

REPORTS

HS-12, NTS/Offsite Operations Section is responsible for the collection and interpretation of all health and effluent data. The results generated during drill backs and cement backs are reported to the Test Group Director at various times and in various forms during the course of the operations. At the completion of the operation, a report entitled, "Release and Health Sample Documentation for (EVENT NAME)" from HS-12 to the J Division Leader is generated that combines and summarizes the results generated. This report is distributed to the HS Division Office, the Test Group Director(s), the HS-12 Group Office, and the J-6 Group Office. These data are distributed as "Activity Released from (EVENT), Final Report" by the LANL J Division Office to Nuclear Test Organization, Test Controller, Attention: Chief, OMB CP-1, with copies to: NVOO Manager, LANL/ADNWT, and LANL/J-DO.

Annually, all results are combined and reported as "Effluent Information (EIS) and Onsite Discharge Information (ODIS) for CY-(year) to Waste Reduction Operations," EG&G Idaho, Inc. Copies of this report are sent to: DOE/NV/ERWM, REECo/HPD, LANL/HS-DO, LANL/HS-12, LANL/EM-8, and, LANL/J-DO.

APPENDIX C

EMISSIONS DATA AND MONITORING PROCEDURES FOR THE DEFENSE NUCLEAR AGENCY COMPLIANCE WITH THE NATIONAL EMISSION STANDARDS FOR HAZARDOUS AIR POLLUTANTS (NESHAP)

INTRODUCTION

The weapons effects testing program, conducted in NTS tunnels has the possibility of releasing some radioactive effluent into the tunnel ventilation system during several of the operations associated with executing a test and the subsequent tunnel reentry activities. The tunnel ponds and Test Support Compound may also release radioactive effluent to the atmosphere.

Modeling of these potential sources, using CAP88-PC, indicates that the dose to the maximally exposed individual (MEI) in the offsite area is well below 0.1 mrem/year; thus these sources are classified as small releases and the release point does not need to be continuously monitored. However, periodic measurements must be made to verify the small releases. These confirmatory measurements do not necessarily need to be made at the point of discharge.

ORGANIZATION

Figure C.1 shows the DNA organization at the Nevada Test Site, and identifies the FCNV personnel responsible for each operation. The Chief, Field Command Nevada Operations (FCNV) maintains overall responsibility for underground nuclear weapons effects tests conducted by DNA. However, FCNV personnel depend on the expertise provided by the DNA health physics advisor for identifying and estimating radionuclides released during each operation. Table C.1 lists the FCNV divisions responsible for each operation.

Table C.1. Operational Responsibilities by FCNV Division

| NVCE	NVTO
Preparation of the Test Bed	Device Detonation
Initial Tunnel Reentries and	Test Support Compound
Purging of the Tunnel	
Data Recovery	
Removal of Containment Plugs	
Experiment Recoveries,	
Instrumentation Removal and	
Cleanup Activities	
Gas Sampling Operations	
Reentry Mining	
Assessment of Mechanical	
Closure Performance	
Atmospheric Pumping	
Tunnel Ponds	
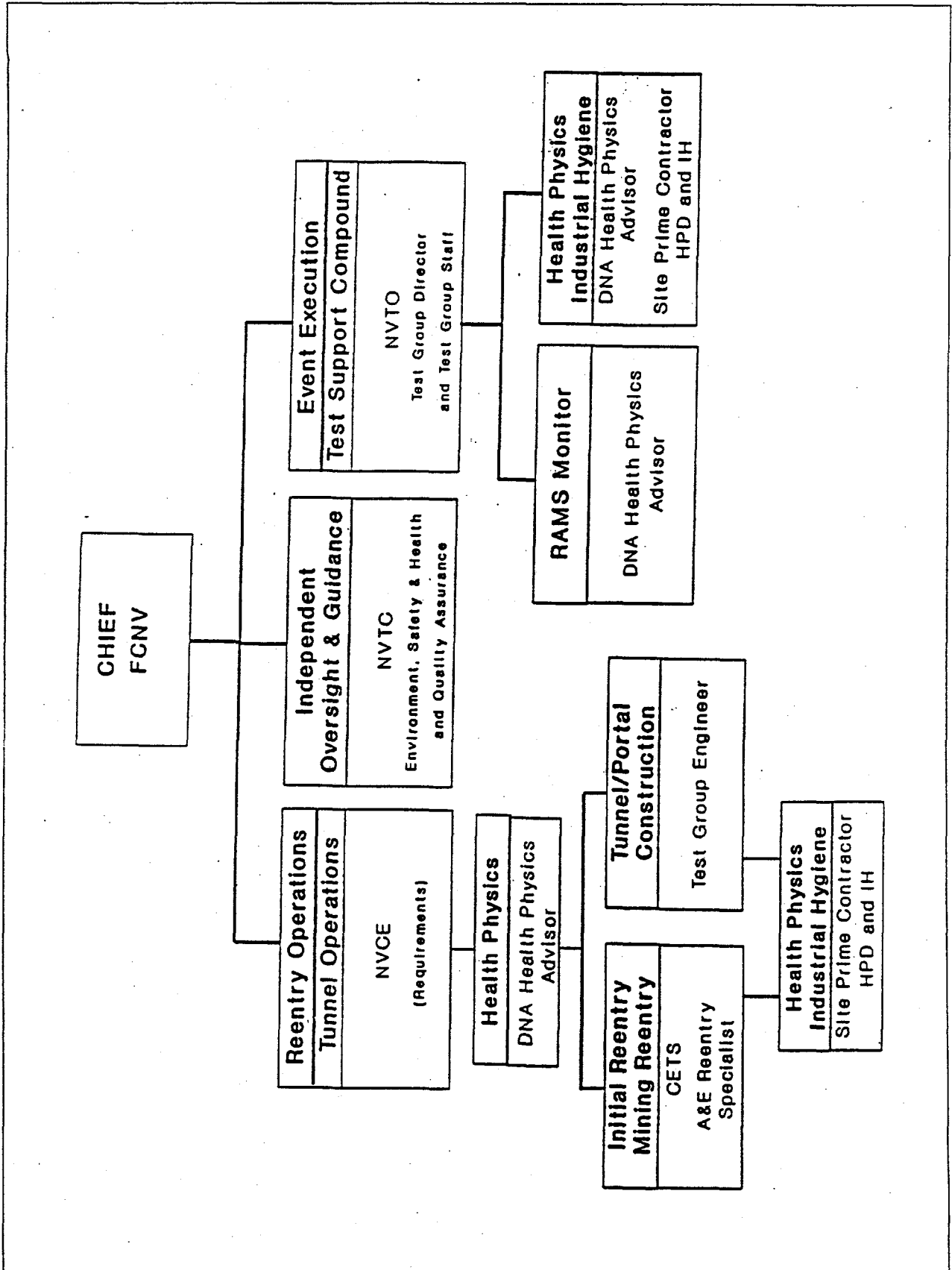
Figure C.1. FCNV Organization and Operational Responsibilities

DESCRIPTION OF OPERATIONS

TUNNEL ACTIVITIES

It should be noted that although the tunnel ventilation systems are operated continuously while a tunnel is active, the release of radioactive effluent is possible only during specific operations associated with a particular test, except for the release of radon and thoron and their associated decay products. It is recognized that radon and thoron and their progeny are being continuously released from the NTS tunnels, but monitoring for these natural radioactivities in this type of facility is excluded by both the EPA NESHAP and by DOE Orders. Therefore, these emissions will not be addressed further in this document.

The tunnels last used for nuclear testing were N and P tunnels. E, G, and T tunnels are also inactive, but are maintained in various states of readiness in case these areas are needed to support nuclear tests. The ventilation systems in the tunnels are not being operated at this time, so there is no airborne effluent from these tunnels.

Similar activities have been conducted in both N and P tunnels, so the descriptions given in this document are pertinent to both tunnels. However, since the points of discharge are different, the distance to the maximally exposed individual offsite might vary slightly.

The ventilation systems in all NTS tunnels are operated in the exhaust mode. This means that fresh air is drawn in through the portal or adit of the tunnel, sweeps through the tunnel complex, and is exhausted through the ventilation lines from the active regions of the tunnel. Thus, any radioactive effluent released any place in the tunnel complex is drawn toward the end of the ventilation line, where it is picked up and removed from the tunnel. Therefore, samples of the air taken before the air stream enters the ventilation line represent the maximum concentration of radioactivity which can be discharged through that ventilation system.

PREPARATION OF THE TEST BED

The fielding of a typical tunnel event is initiated with the mining of the test bed according to the engineered design for that particular test. An experiment drift and parallel bypass drift are mined off of the main tunnel. Instrumentation alcoves and associated access drifts are also mined. Figure C.2 contains a diagram of a typical tunnel complex. A tapered line-of-sight (LOS) pipe is installed in the experiment drift which provides a path for the prompt radiation from the source device to various experiments located internal to the pipe. The experiments to be exposed are installed in the LOS pipe by personnel from the various agencies associated with the test, and cables are emplaced from the experiments to the data recording instrumentation located in the instrumentation alcoves. The region of the LOS drift between the pipe and tunnel wall, as well as the bypass drift for some fixed distance, is filled with various grout mixtures to meet the containment criteria for the test. A simplified diagram of an LOS pipe is shown in Figure C.3.

During device detonation, ionizing radiation from the source device travels down the LOS pipe to expose the experiments inside the pipe. Several mechanical closures in the pipe, string seal the pipe immediately after the nuclear detonation. This design, utilizing the mechanical
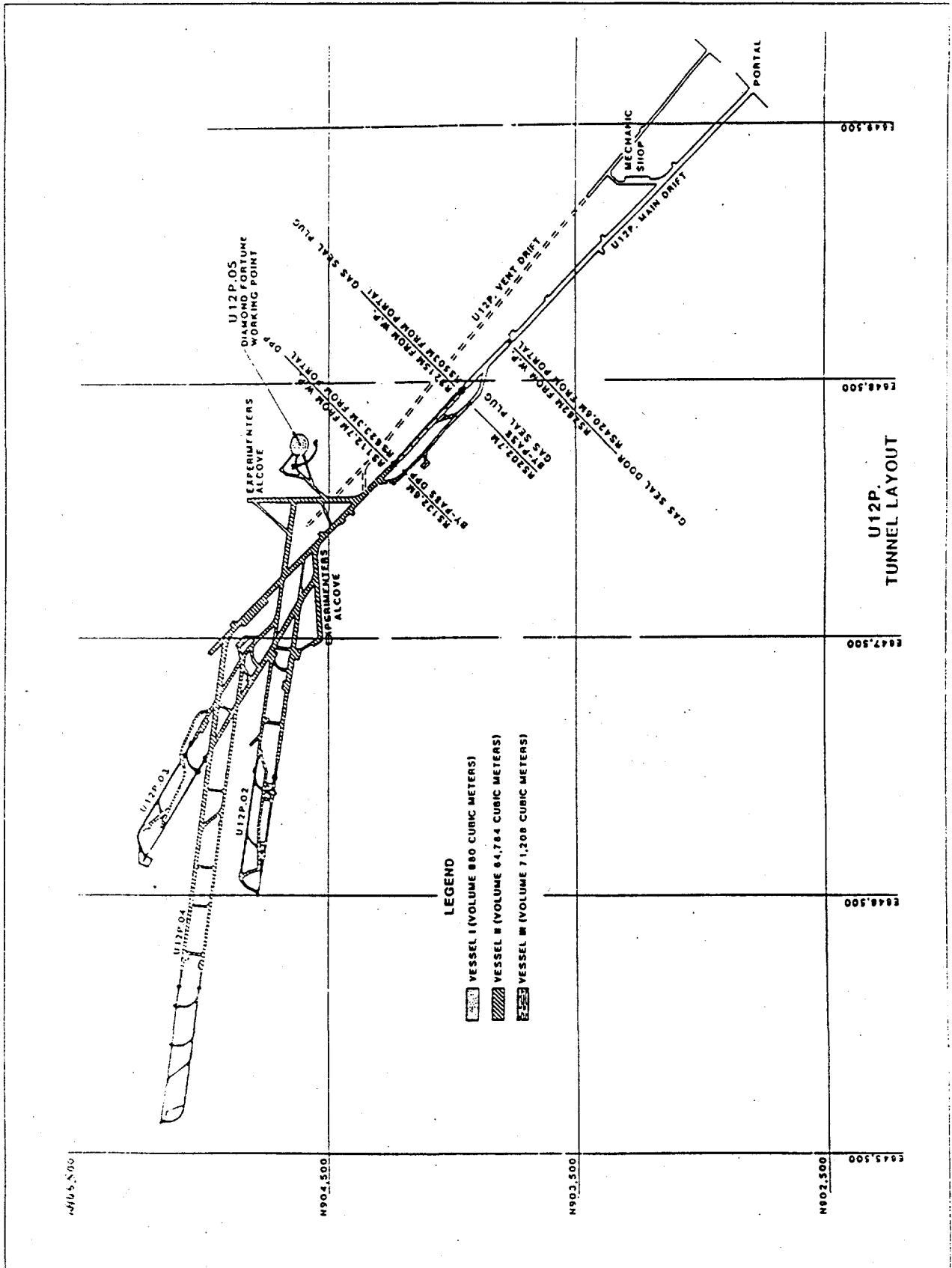
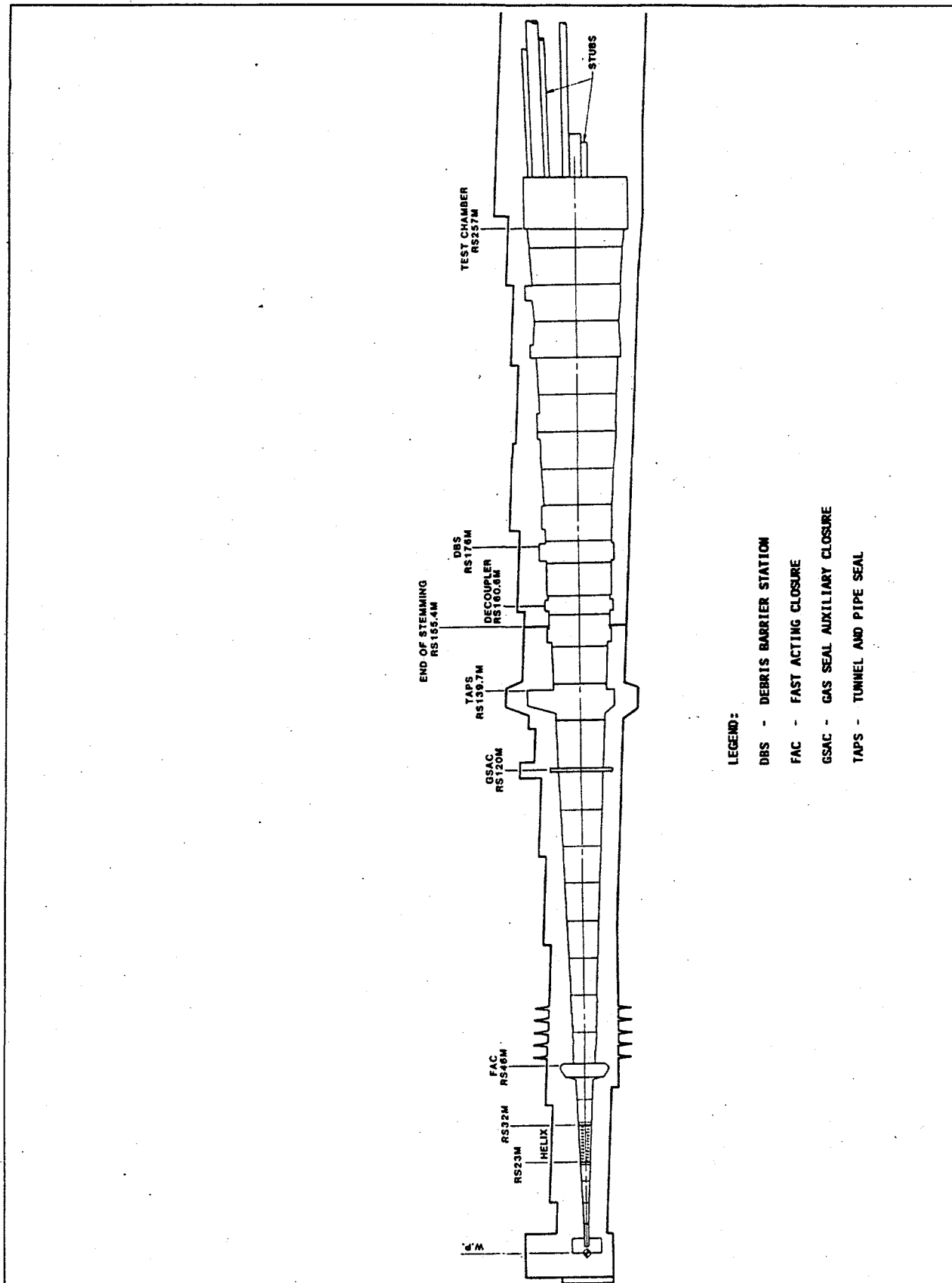Figure C.2. Typical Tunnel Layout for Nuclear Tests (1000 ft grid)

Figure C.3. LOS Pipe Layout (from WP to TAPS Typically 400 - 500 ft)

LEGEND:

DBS - DEBRIS BARRIER STATION

FAC - FAST ACTING CLOSURE

GSAC - GAS SEAL AUXILIARY CLOSURE

TAPS - TUNNEL AND PIPE SEAL

closures and the associated back-fill materials, protects the experiments in the pipe from high velocity debris and also provides containment of the fission products produced by the detonation of the device.

In addition to tests conducted in a horizontal LOS configuration, some tests are executed in preconstructed hemispherical cavities without the use of an LOS pipe. In these tests, various detectors and experiments are placed in the walls and floor of the cavity. The source device is placed in the center of the cavity, and the access drifts are back filled with various grout mixtures to contain the detonation products in the cavity region. Data from the test instrumentation are again recorded in the instrumentation alcoves.

During the mining and preparation of the test bed, and during experiment installation activities, no radioactive effluent is produced, so no radioactive effluent is released through the tunnel ventilation system.

DEVICE DETONATION

In general, an underground nuclear explosion initiates a series of events which culminate in the formation of a relatively large cavity-chimney structure in the rock. The initial cavity formation process includes the vaporization and melting of large quantities of rock and expendable experimental equipment. The containment process utilizes the energy of the device to squeeze part of the LOS pipe closed, thereby containing the detonation products in the cavity region. Much of the fission products produced is incorporated in the melted rock as it resolidifies, immobilizing this debris in the "puddle" produced at the bottom of the cavity.

Eventually the cavity gases cool and condense, which reduces pressure and allows the formation of a rubble chimney. The chimney forms by the successive collapse of overlying rock into the glass lined cavity void. Depending on the yield, the height of the chimney may reach several hundred feet above the working point before the expansion process involved in chimney formation reaches equilibrium.

As a part of the containment design, several large concrete and steel plugs are constructed at strategic points within the tunnel complex. These plugs form a system of nested vessels which incorporate increasingly larger volumes of the tunnel. If containment of the detonation products within the cavity region is not completely successful, any radioactive debris which might be released into the experiment area of the test bed will be contained within one of these vessels. Since the ventilation system is shut down and sealed off at this time, there is no release to the environment. All releases associated with tunnel tests since 1971 have initially been completely contained within the tunnel complex, and releases have only occurred during controlled purging of the tunnel complex in order to restore the complex to normal operation.

The potential exists for a release to occur from the point of detonation to the surface by seepage through the overlying rock. However, tunnel tests are considerably over buried for the yields involved. No tunnel test conducted in the tuffaceous rocks of the Rainier Mesa test locations has released radioactivity to the atmosphere via this mechanism.

Although the potential exists for radioactive gases to be released into the working areas of the tunnel, this debris is expected to be contained within one of the nested containment vessels, and no radioactive effluent is expected to be released to the environment. Remote area monitors (radiation detectors) located within the tunnel complex and on the surface outside the tunnel confirm containment within the tunnel and indicate the movement of fission gases within the underground complex.

INITIAL TUNNEL REENTRIES AND PURGING OF THE TUNNEL

While the tunnel complex is being secured prior to detonation of the device, the ventilation line is disconnected at each containment plug and the penetration through the plug is sealed. Thus, it is necessary to reenter the tunnel in order to reestablish ventilation through the various containment plugs. If radioactive gases are present in a portion of the complex, it may be necessary to purge these gases from the tunnel. These gases, along with the toxic and explosive gases also produced, must be removed from the experiment areas before data and experiment recovery can begin. It is during these purging operations that the major potential exists for release of radioactive materials to the atmosphere.

DATA RECOVERY

After the initial reentries have been completed, personnel from the experimenting agencies are allowed into the instrumentation alcoves and other areas to recover film, data tapes and activation foils. As the purging operations have already removed the gaseous fission products from the complex, there are no releases of radioactive materials to the atmosphere associated with data recovery.

REMOVAL OF CONTAINMENT PLUGS

After data recovery is complete, the mining department begins removal of the containment plugs in order to reestablish the railroad track through the plugs. During this time, electrical power and lights are also being restored into the experiment area so that the experiments can be removed from the LOS pipe. During this preparation phase, all potential safety hazards (loose rock, damaged rail and/or ventilation line, etc.) are removed or repaired. There is no potential for the release of radioactive material during this phase of the operation.

EXPERIMENT RECOVERIES, INSTRUMENTATION REMOVAL AND CLEANUP ACTIVITIES

The experiments from inside the LOS pipe are removed to allow visual observation of the condition of each experiment following exposure to the radiation from the source device. These physical assessments of the experiments allow correlation to be made between the condition of the experiment and the active measurements made on the experiment at the time of the exposure. These observations make interpretation of the data easier and more meaningful.

During experiment recovery, some radioactive dust may become airborne and entrained in the exhaust air removed from the tunnel. This dust is the result of the deposition of the radiation energy in the experiment components and the resultant spall of the exposed surfaces

(a phenomenon referred to as blow off). This dust may be radioactive as the result of neutron activation of the materials exposed, and may also contain some particulate fission products if the device debris was not completely contained. Releases during this phase of tunnel operations are composed of airborne dust which contains activation products and, occasionally, particulate daughters of the noble gases which were not contained. Removal of instrumentation from alcoves and cleanup of the test bed region generally do not generate any radioactive effluent.

GAS SAMPLING OPERATIONS

Gas samples are occasionally taken from the chimney region after a nuclear test to provide information useful in understanding containment phenomenology. Prior to the test, containers of tracer gases may be located in various stemming regions and in drill holes in the insitu rock around ground zero. Some time after device detonation (usually 30 days or more) a hole is drilled into the chimney region through which samples of the cavity gases can be withdrawn. These gases are analyzed in the laboratory, and the data are used to provide a better understanding of cavity formation and growth, and thus increase our knowledge about containment mechanics.

During gas sampling operations, some excess gas is produced for which disposal is required. This gas is passed through a HEPA/charcoal filter combination, and then discharged into the tunnel ventilation system. Releases associated with gas sampling operations may occur both during the drilling of the sampling hole and during the actual gas sampling operations.

REENTRY MINING

Reentry mining is effected on many events to assess the performance of the mechanical closures and to determine the size and shape of the chimney formed by the nuclear detonation. This is accomplished by mining a reentry drift, typically from the end of stemming in the bypass drift and parallel to the LOS drift. At points of interest, crosscuts are mined from the reentry heading to the LOS drift to expose the LOS pipe and the various closures. If the rock and associated grouting materials near the LOS pipe have become contaminated, some radioactive dust may become airborne and be removed from the work area by the ventilation system.

ASSESSMENT OF MECHANICAL CLOSURE PERFORMANCE

One of the goals of post-shot activities and reentry mining is to assess the performance of the mechanical closures which close off the LOS pipe. Gases (toxic, explosive, and sometimes radioactive) may be trapped in the LOS pipe between these various closures. In order to enter the LOS pipe to observe the closures, it is necessary to remove the gases from the regions of interest. After sampling and analysis of the gases so contained, this material is purged from the LOS pipe and discharged into the tunnel ventilation system.

ATMOSPHERIC PUMPING

The only time this phenomenon is observed in the tunnels is when reentry mining has progressed to a point near the chimney region (within 50-70 feet) and probe holes are drilled

into the chimney to define chimney size and shape. Current practice is to grout these holes as soon as possible after the radiation and temperature logs have been completed. If barometric pressure drops while the hole is open, the hole may breathe, releasing noble gases into the tunnel where the radioactivity is picked up by the ventilation system. This is a very insignificant source of release to the atmosphere from a tunnel test.

TEST SUPPORT COMPOUND

The Test Support Compound (TSC) is a facility within Area 12 Base Camp used by DNA-sponsored experimenters/contractors to prepare experiments before fielding, and to disassemble experiments after post event recovery. Due to the proprietary or classified nature of some experiments, this facility is a fenced area that may have (depending on operations) round-the-clock security personnel controlling access.

Experiments are usually placed in cassettes, which are often metal boxes designed to hold shielding material to protect the experiment during the event. The cassettes are then installed in the LOS Pipe for exposure. Following the event the cassettes are taken back to the TSC where experimenters disassemble the cassettes to retrieve their experiments. Disassembly usually takes place on down-draft tables fitted with high-efficiency particulate aerosol (HEPA) filters to capture particulates.

During disassembly, some radioactive dust may become airborne and entrained in the down-draft table exhaust. This dust is the result of the deposition of the radiation energy in the experiment components and the resultant spall of the exposed surfaces (a phenomenon referred to as blow off). This dust may be radioactive as the result of neutron activation of the materials exposed, and may also contain some particulate fission products if the device debris was not completely contained. Releases during disassembly at the TSC are composed of airborne dust, which contains activation products and occasionally, particulate daughters of the noble gases which were not contained. In the past, only radon and thoron daughters were seen.

TUNNEL PONDS

Tunnel ponds are located at the portals of E, N, and T-tunnels. Because of the test moratorium, the tunnels are inactive but ponds at E and N still received some water produced by gravity drainage of the tunnel complexes. Perched water in rock fractures exposed within the tunnel complex is the common water source.

As a result of an underground nuclear detonation, any water in the vicinity of the nuclear cavity may become radioactively contaminated. Reentry mining near the cavity may allow this contaminated water to seep into the reentry drifts; it is then drained from the tunnel into the ponds. The ponds are unlined so the water may seep into the subsurface as well as evaporate. The water may contain many radionuclides, but only tritium (as HTO) will evaporate.

RADIONUCLIDES WHICH COULD BE RELEASED DURING EACH PHASE OF THE OPERATION

TUNNEL ACTIVITIES

The various phases of preparation, device detonation, and post event operations involve different probabilities of emission of radioactivity as follows:

- Preparation of the Test Bed - No releases except naturally occurring gases.

- Device Detonation - No probable releases.

- Initial Tunnel Reentries and Purging of the Tunnel - If a release into the tunnel complex occurs, purging of the tunnel may release noble gases (^{85,85m,88}Kr and ^{131m,133,133m,135}Xe) and perhaps small quantities of ^{133}I and ^{131}I. Typical release scenarios may involve diffusion through the rock and/or stemming materials, which removes most iodines which may be present. A release during this phase of the operation is typically of the order of 100 Ci or less of noble gases, with microcurie to millicurie quantities of the radioiodines (although the highest during the past twenty years was 36,000 Ci of noble gases associated with purging of tunnel complex following the MIGHTY OAK event).

- Data Recovery - No probable releases.

- Removal of Containment Plugs - No probable releases.

- Experiment Recoveries, Instrumentation Removal and Cleanup Activities - Experiment recoveries may generate small quantities of radioactive dust which might contain activation products, and there may also be volatile fission products and some particulate fission products which are the daughters of the noble gases. Releases during this phase of the operation are typically in the millicurie and less range.

- Gas Sampling Operations - Typically a few curies of noble gases may be released during sampling operations. Some possibility exists for the release of microcurie amounts of radioiodines and rutheniums.

- Reentry Mining - Reentry mining produces dust which is removed from the reentry heading by the tunnel ventilation system. This dust may contain activation products produced by neutron activation of the LOS pipe and some particulate fission products. These releases are in the millicurie range.

- Assessment of Mechanical Closure Performance - Releases associated with purging the LOS pipe between the various LOS closure systems usually contain noble gases (0.5 to 1.0 Ci), and may also include microcurie quantities of ^{131}I and the particulate, ^{137}Cs.

- Atmospheric Pumping - Reentry mining to the region of the cavity usually takes several months. Only long-lived noble gases are released by this mechanism; the other noble gases have usually decayed to insignificant amounts.

TEST SUPPORT COMPOUND

Experiment disassembly on down-draft tables may generate small quantities of radioactive dust which might contain the activation products ^{24}Na, ^{54}Mn, ^{60}Co, ^{124}Sb, and ^{182}Ta. In addition, some particulate fission products, which are the daughters of the noble gases, may be released (^{89}Sr, ^{90}Sr, ^{137}Cs and ^{140}Ba/La). Releases during the disassembly operation are typically in the millicurie and less range.

TUNNEL PONDS

The ponds receive several radioisotopes in the discharge water that include ^{238}Pu, ^{239}Pu, ^{3}H, ^{137}Cs, ^{125}Sb, and ^{106}Ru. During evaporation of the pond water, tritium vapor (^{3}H) is the most likely to be released to the atmosphere. Only E Tunnel emitted a liquid effluent during 1994.

PROCEDURES USED FOR ESTIMATING QUANTITIES OF RADIONUCLIDES RELEASED

RATIONALE

The following procedures used for estimating the quantities of radionuclides released are based on the historical level of releases, established performance of current and experimental measurement systems, and cost benefit considerations.

The highest potential for a release from normal tunnel operations may occur during the purging of noble gases from the tunnel complex following an event. In 1985, an array of portable noble gas samplers was placed on the mesa, in addition to the existing air sampling network at the site. Following tunnel purging operations, analysis of gas samples from this experimental array showed no significant difference in the amount of noble gases detected by the array versus current procedures for estimating quantities of radionuclides released.

TUNNEL ACTIVITIES
GENERAL

When the Remote Area Monitoring system is on line, typically for five to ten days following device detonation, radiation readings from these detectors may be used to provide either an estimate of activity within the tunnel, or an estimate of activity released through the ventilation system, or an estimate of the activity released directly to the environment in the unlikely event that this should occur. The reading of the radiation detector is utilized along with the volume of the tunnel affected, or the ventilation flow rate, or the wind speed and standard atmospheric diffusion parameters, respectively, to provide an estimate of the radioactivity involved using standard calculational models. The models used are described in the document SC-RR-68-559, "The Determination of the Quantity of Radioactivity Contained in a Gaseous Effluent at the Nevada Test Site Using Gamma Dose-Rate Measurements." The error associated with using these radiation detectors for release calculations ranges from a factor of two to about a factor of ten. The larger errors are associated with a release directly to the environment, a situation which is rarely experienced using current containment designs.

PURGING OF THE TUNNEL

Noble gases which seep into the tunnel complex after detonation of the nuclear device are contained within a specific volume of the tunnel as defined by the various containment plugs. Volumes of these different regions of the complex are accurately known from the as built

drawings for the facility. The specific volume of tunnel affected by a particular release is defined by indications of the presence of radiation by the remote area monitors fielded for the test. Samples of the gas are taken from the tunnel using the remote gas sampling system. These samples are analyzed in the laboratory, providing the concentration of gases in the tunnel. Knowing the volume containing the radioactive gases, and the concentration of same, one can calculate the activity present in the tunnel available to be released through the ventilation system [Activity (Ci) = Volume (mL) x Concentration (Ci/mL)]. The ventilation system is equipped with HEPA and charcoal filters when purging radioactive gases.

The largest error associated with this procedure is the assumption that the gases are uniformly mixed within the volume of tunnel affected. Typical sampling locations are selected such that the noble gas concentration in the samples obtained are usually high with respect to the average concentration. Data from the remote area monitors indicate that uniform mixing has not occurred, and past experience has shown that this technique over estimates the radioactivity released, usually by a factor of approximately two.

EXPERIMENT RECOVERIES

During experiment recovery operations, air samples are taken from inside the LOS pipe and from the experiment bagging area outside the pipe. These samples are taken using Whatman 41 filter paper backed up with a 1 inch charcoal filter. A vacuum pump is used to pull the sample through the filter assembly, and a low pressure gas (LPG) meter is used to measure the total amount of air sampled. The samples are analyzed in the laboratory, and the concentration of radionuclides detected is reported.

Since the tunnel makeup air sweeps the recovery area before exiting the tunnel through the ventilation system, these air samples would represent the maximum concentration levels which could be released at the point of discharge. Additionally, the ventilation air from the recovery area is diluted by air from other branches of the ventilation system before release, further lowering the concentration at the point of discharge. Air samples taken from the ventilation line near the point of release seldom indicate the presence of any activation or fission products during recovery operations. Although these vent line samples are not taken isokinetically, they do at least confirm that the emission sources are indeed small.

Although the vent line samples are not currently used to project effluent releases during recovery operations, these samples could provide estimates that are accurate to within approximately a factor of two. Release estimates made using air samples taken in the recovery area would probably overestimate a potential release by at least a factor of ten. Either technique would assure that effluent releases during recovery operations are well within NESHAP guidelines. Isokinetic sampling is being tested to provide confirmation of these estimates.

GAS SAMPLING OPERATIONS

During gas sampling operations, gas from the cavity region is pumped through a calibrated mass flow meter before being discharged into the tunnel ventilation system. A representative sample of the gas is taken and analyzed in the laboratory. The concentration of radionuclides thus determined multiplied by the total volume of gas discharged gives an estimate of the

radioactivity released. This estimate is accurate to within ten percent since the only errors are in the measurement of the volume of gas pumped into the ventilation line and the errors associated with sample analysis.

REENTRY MINING

Air samples are taken continuously in the reentry heading using the techniques described in the above section on Experiment Recoveries. These samples are taken as close to the end of the vent line as is possible, and are analyzed in the laboratory. Samples are also taken from the ventilation line at the point of discharge. Again, these vent line samples are not taken under isokinetic conditions, but do confirm that any releases during mine-back activities are small. Drierite samples are taken in the reentry heading near the end of the ventilation line at least weekly to determine if any tritium is present as water vapor. These samples are analyzed in the laboratory, and indicate that tritium releases associated with reentry mine-back operations are also quite small.

As soon as the reentry operation is complete, current practice is to construct a plug in the reentry drift. No further releases from the reentry operation can occur once the plug has been completed.

ASSESSMENT OF MECHANICAL CLOSURE PERFORMANCE

During these operations, a sample of the gas inside the LOS pipe between various closure systems is taken and is analyzed in the laboratory. The volume of the LOS pipe between closures is accurately known, so the activity of the gas available to be released can be easily and accurately determined [Activity (Ci) = Volume (mL) x Concentration (Ci/mL)]. The error in this estimate should be less than ten percent.

ATMOSPHERIC PUMPING

If a release occurs from a tunnel as a result of falling barometric pressure, a sample of the gas is taken from the drill hole in a vacutainer and sent to the laboratory for analysis. An estimate of the flow rate from the hole is made (or the flow rate is measured if the proper instrumentation is available), and the volume of gas discharged is calculated from the flow rate and the length of time the release occurred. This volume multiplied by the concentration of the sample taken gives the activity discharged.

The error of the estimate in this situation is primarily determined by how well the flow rate from the drill hole is known. Since the estimate of the flow rate could be in error by a factor of ten, the calculated effluent release as the result of atmospheric pumping is no better than a factor of ten. However, the concentration of gases in the chimney region during the time that this phenomenon might be observed is quite low so releases associated with atmospheric pumping in the tunnels are also quite low.

TEST SUPPORT COMPOUND

During experiment disassembly operations, air samples are taken from the down draft table vent stacks and at several locations in each building. These samples are taken using Whatman 41 filter paper backed up with a 1 inch charcoal filter. A vacuum pump is used to pull the sample through the filter assembly, and a LPG meter is used to measure the total amount of air sampled. The samples are analyzed in the laboratory, and the concentration of radionuclides detected is reported.

Since the air sweeps down onto the table and over the disassembled experiments before exiting through the vent stack, these air samples would represent the maximum concentration levels which could be released at the point of discharge. Air samples taken from the ventilation stack near the point of release seldom indicate the presence of any activation or fission products during experiment disassembly operations. Although these vent stack samples are not taken isokinetically, they do at least confirm that the emission sources are indeed small.

Although the vent stack samples are not currently used to project effluent releases during experiment disassembly operations, these samples could provide estimates that are accurate to within approximately a factor of two. Release estimates made using air samples taken in the disassembly area and table vent stack would probably overestimate a potential release by at least a factor of ten. Either technique would assure that effluent releases during disassembly operations are well within NESHAP guidelines.

TUNNEL PONDS

Grab samples of discharge water and water in the ponds are taken monthly. These samples are analyzed for tritium and gross beta, and by gamma spectrometry. Every quarter the samples are analyzed for plutonium, and once each year the samples are analyzed for strontium. Tritium releases, in the form of water vapor, are estimated by assuming the entire tunnel water discharge evaporates. Currently, this is a very conservative method and probably overestimates the releases by about 50 percent. All discharges from N and T tunnels were eliminated during 1994.

SUMMARY

There are a number of operations associated with weapons effects tests conducted in NTS tunnels which have the possibility of releasing some airborne radioactive effluent. This document has attempted to describe the various operations associated with a tunnel test, the radionuclides which might be released, and the procedures currently used to verify that the releases are indeed small. It is believed that all potential airborne release pathways have been identified, and that the dose to the maximally exposed individual in the offsite area is well below 0.1 mrem/year. As these small releases lead to exposures well below the guidelines for exposures to offsite people, only periodic confirmatory measurements are required to demonstrate continuing compliance with NESHAP. It is the DNA's contention that monitoring at the source of production of the potential effluent provides such confirmation.

REPORTS RELATED TO EFFLUENT MEASUREMENTS AND MONITORING

- SC-RR-68-559; "The Determination of the Quantity of Radioactivity Contained in a Gaseous Effluent at the Nevada Test Site Using Gamma Dose Rate Measurements," P. O. Matthews, December, 1968.

- Event Effluent Documentation Reports - Distribution: Bernard F. Eubank, REECo; P. K. Fitzsimmons, DOE/NV; J. W. LaComb, DNA; D. A. Bedsun, DNA; F. D. Ferate, REECo; SNL Division 7713 Files.

- Water Pollution Control Permit Applications & Periodic Monitoring Reports for Waste Water Discharges from E, N, & T Tunnels - Distribution: J.W. LaComb, DNA; Paul Liebendorfer, Nevada Department Environmental Protection; D.R. Elle, DOE/NV; W.G. Flangas, REECo.

APPENDIX D

BUILDING 650 ANALYTICAL LABORATORY RADIONUCLIDE INVENTORY
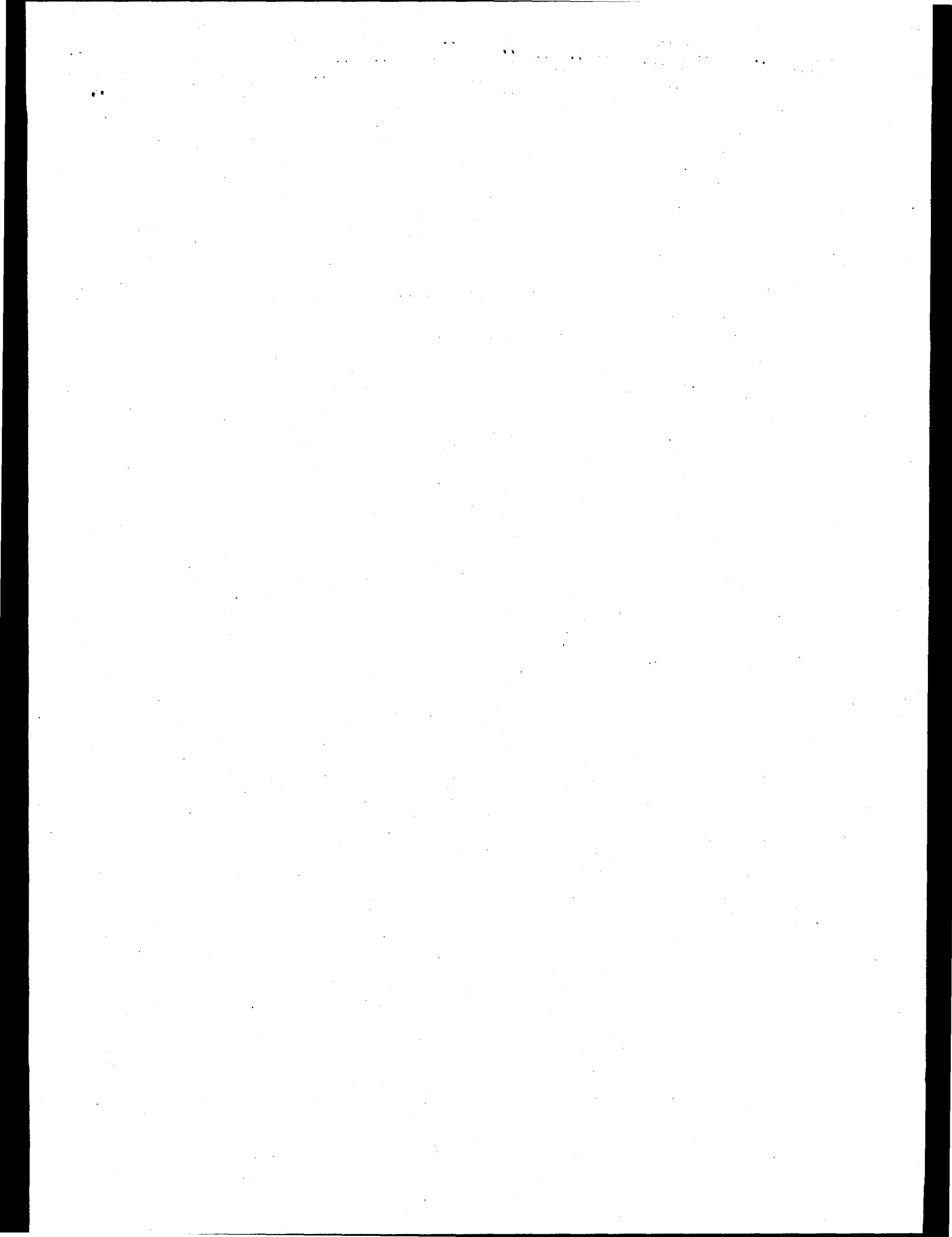
INTRODUCTION

The inventory of radionuclides in the Health Physics (HP) Laboratory located in Building 650, Nevada Test Site was estimated by inventorying the standards, check sources, and tracer solutions. The activity contained in these sources, was orders of magnitude above that contained in samples (based on data collected in previous years) so they are listed in Table D.1 below where they are compared to possession limits.

From the inventory, only two of the items are volatile and may become a source of air emissions. These are ^{3}H (as HTO) and I isotopes and are listed in Table 2, above. The remainder of the standards are compared to the possession limits set forth in 40 C.F.R. 61, Appendix E, and all are less than one percent of those limits.

Table D.1. Building 650 Health Physics Laboratory Inventory Compared to NESHAP

Radionuclide	Annual Inventory (Ci/Year)	Possession Limit (Ci/year Liquid Form)	Ratio %
^{3}H	9.7×10^{-5}	1.5×10^4	6.4×10^{-9}
^{14}C	1.1×10^{-6}	2.9×10^2	3.8×10^{-9}
^{36}Cl	2.2×10^{-8}	6.5×10^2	3.4×10^{-11}
^{60}Co	5.5×10^{-7}	1.6×10^{-2}	3.4×10^{-5}
^{51}Cr	2.8×10^{-6}	6.3×10^1	4.0×10^{-6}
^{89}Sr	2.2×10^{-7}	2.1×10^1	1.0×10^{-6}
^{90}Sr	1.7×10^{-7}	5.2×10^{-1}	3.2×10^{-7}
^{99}Tc	6.8×10^{-6}	9.0×10^0	7.6×10^{-5}
^{129}I	3.0×10^{-7}	2.6×10^{-1}	1.2×10^{-3}
^{131}I	1.1×10^{-6}	6.7×10^0	1.6×10^{-5}
^{137}Cs	8.4×10^{-10}	2.3×10^{-2}	3.6×10^{-8}
^{155}Eu	1.7×10^{-5}	5.2×10^{-1}	3.3×10^{-5}
^{229}Th	4.6×10^{-9}	4.9×10^{-4}	9.4×10^{-4}
^{230}Th	8.4×10^{-9}	3.2×10^{-3}	2.6×10^{-6}
^{232}U	5.6×10^{-9}	1.3×10^{-3}	4.3×10^{-4}
^{238}U	1.2×10^{-8}	8.6×10^{-3}	1.4×10^{-4}
^{237}Np	1.3×10^{-8}	1.8×10^{-3}	7.2×10^{-4}
^{239}Pu	2.9×10^{-6}	2.5×10^{-3}	1.2×10^{-3}
^{241}Pu	2.0×10^{-8}	1.3×10^{-1}	1.5×10^{-5}
^{242}Pu	8.2×10^{-9}	2.5×10^{-3}	3.3×10^{-4}
^{241}Am	2.2×10^{-8}	2.3×10^{-3}	9.6×10^{-6}
^{244}Cm	1.0×10^{-3}	4.2×10^{-3}	2.4×10^{-1}
Mixed Gamma Sources	1.1×10^{-5}		
Alpha Emitters[1]	1.0×10^{-3}	4.2×10^{-3}	2.4×10^{-1}
Beta Emitters[2]	1.8×10^{-5}	5.2×10^{-1}	3.6×10^{-5}
Gamma Emitters[3]	1.4×10^{-5}	1.6×10^{-2}	8.8×10^{-4}

(1) Alpha emitters include Th, U, and transuranics. The possession limit is that for ^{244}Cm (40 C.F.R. 61 Appendix E, Table 1).

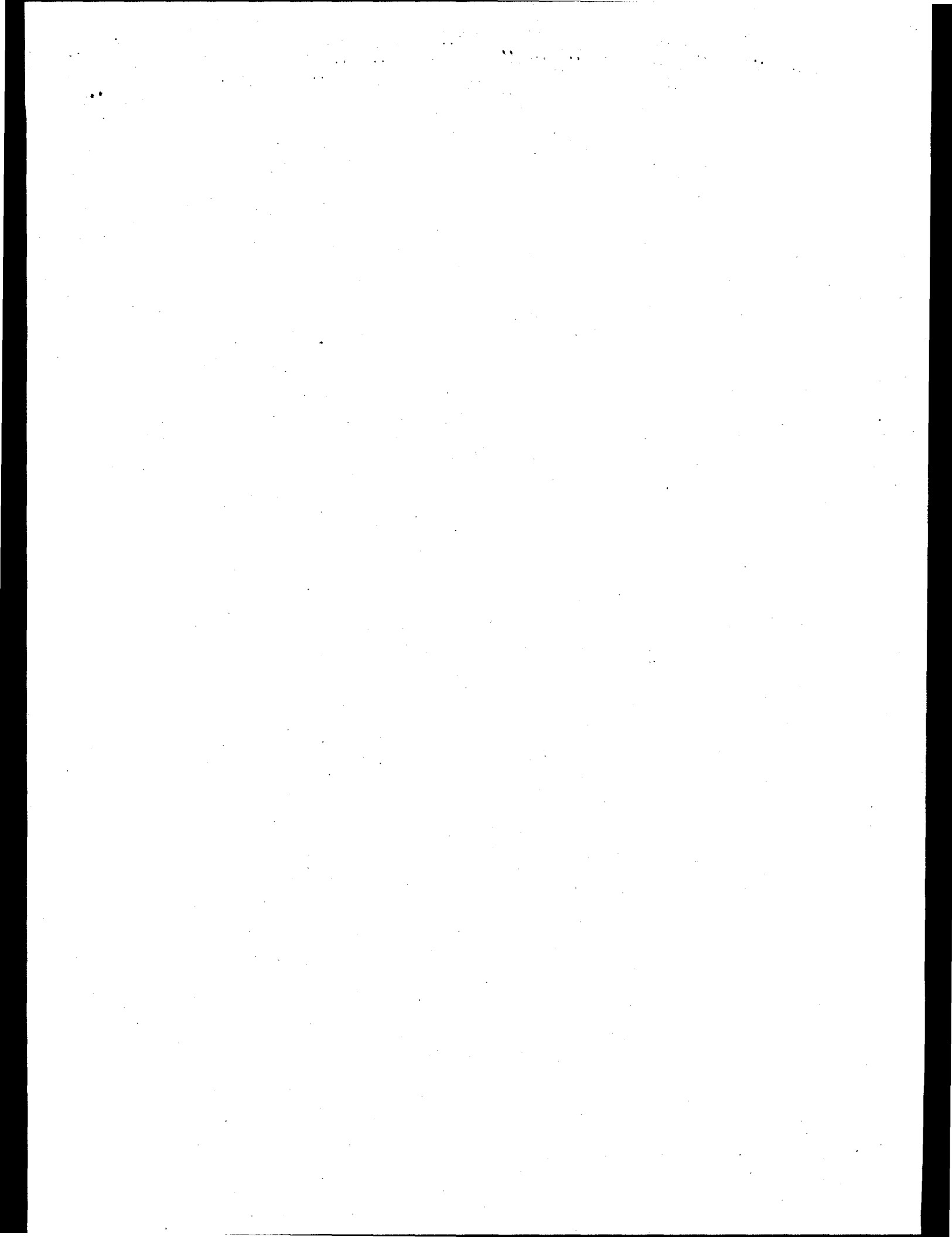(2) Beta emitters include the sum of ^{14}C, ^{36}Cl, ^{89}Sr, ^{90}Sr, ^{99}Tc. and ^{155}Eu and are compared to the ^{90}Sr annual possession quantity (40 C.F.R. 61 Appendix E, Table 1).

(3) Gamma emitters is the sum of cobalt, chromium, and the mixed gamma sources, and the possession limit is for ^{60}Co (40 C.F.R. 61 Appendix E, Table 1).
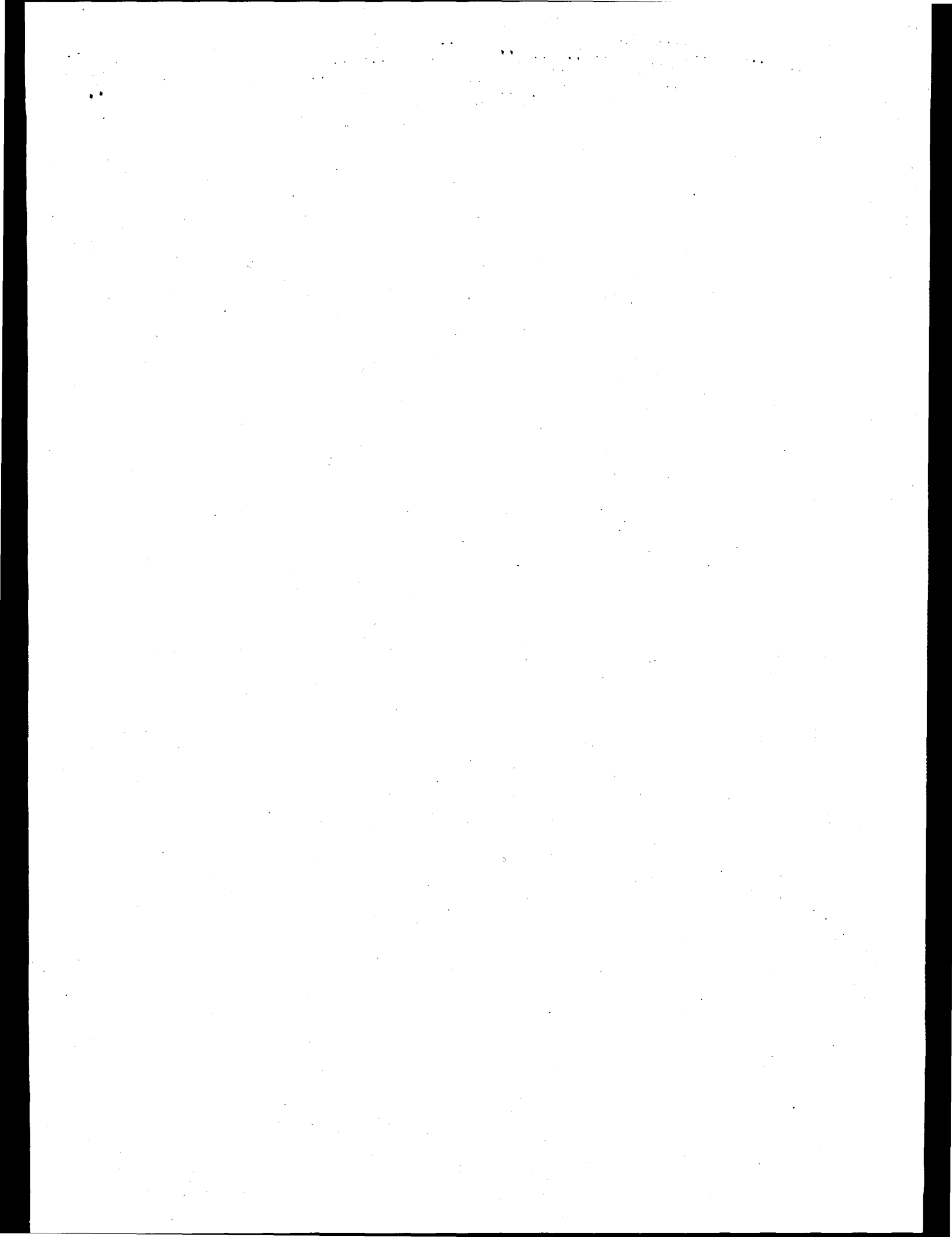
APPENDIX E

EMISSIONS FROM CONTAINMENT PONDS

EMISSION FROM THE TUNNELS AND PONDS

Effluent water and the containment ponds located at the Area 12 tunnel complexes that receive that water were sampled once each month. These water samples are analyzed for radionuclides by gamma spectroscopy, for gross beta, and for tritium. Less frequently, other samples are collected for analysis of plutonium and strontium. The total amount of radioactive liquid effluent from the tunnels is calculated from the concentration of radionuclides in the water and the total volume of water discharged during the year. The volume of water discharged from the tunnels was measured by use of a weir.

In order to calculate doses using CAP88-PC, an airborne source term must be known. As described above, the total liquid effluent volume is measured and the radionuclide concentrations are determined from analysis of monthly samples. By assuming that the total amount of tritium (as HTO) measured in the liquid effluent during the year evaporates and becomes airborne, an airborne source term is obtained. It is unlikely that this is a true source term for the containment ponds but it is an upper limit of the effluents which could be released. The fact that the concentration of tritium in the ponds at the beginning and end of the year has been relatively constant[1] lends credence to this calculation. The tunnels are in the process of being sealed so the effluents are decreasing. T Tunnel was sealed, N Tunnel water seeped for a few weeks in the first quarter, so E Tunnel is now the only source of HTO.

Table E.1 below, lists the total quantity of tritium discharged into the containment ponds (and assumed to be released as airborne effluents) as measured during CY-1994.

Table E.1. Tritium Effluents into Containment Ponds - 1994

Location	Area (m^2)	Total ^{3}H Discharged (Ci)
Area 12, N Tunnel	1120	0.026
Area 12, E Tunnel	336	47.3
	Total Effluent	47.33

The MEI for this emission resides in Indian Springs, Nevada and would receive an EDE of 0.23 µrem (2.3×10^{-6} mSv). The offsite network average HTO in air was 0.36 pCi/m^3 but was only 0.3 pCi/m^3 at Indian Springs so the tunnel pond emission was not detected.

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1 - For example: Tunnel Pond & No.	Result ($\overline{X} \pm S$)	Mo./Yr.
N No. 2	$8.5 \pm 1.3 \times 10^{-5}$	02/92
	$2.8 \pm 1.9 \times 10^{-4}$	12/92
T No. 2	$4.9 \pm 0.5 \times 10^{-2}$	02/92
	$5.6 \pm 0.4 \times 10^{-2}$	12/92

The following calculation was performed to estimate tritium emission from the E Tunnel Pond during 1994 using the methods for estimating diffuse emissions in the U.S. Environmental Protection Agency (EPA) report dated July 1994 for comparison with the above method.

EVAPORATION OF WATER - EPA's RECOMMENDATION

The following is the formula on page 26 of the EPA report that is recommended for estimating water evaporation from a circular pool:

$$E = \frac{20.73 \times P_s \times A^{0.9} \times U^{0.8}}{T^{1.47}}$$

where E = evaporation rate, g/s P_s = equilibrium water vapor pressure at
       A = surface area of pond, m^2 ambient temp., mm Hg
       U = wind speed, m/s $T = {}^{\circ}K = {}^{\circ}C + 273.2$

If tritium concentration (a = pCi/g) is known, then the emission rate is $R = a \times E$, pCi/s.

Weather information in terms of 2-hourly readings with monthly weighted average data was obtained from SORD/ARL, courtesy of Douglas Soulè.

The area of the E Tunnel Pond, roughly square, was obtained from Sandia as 3620 ft^2. 3620 x 0.0929 (m^2/ft^2) = 336 m^2.

The average quarterly tunnel effluent in pCi/mL was obtained from Performance Indicator Reports. The results for the first thru the fourth quarter were 1.86, 1.75, 1.86, and 0.507 nCi/mL, respectively.

The weighted average wind speeds are listed in Table E.2. The vapor pressure in mm Hq were obtained using the ${}^{\circ}K$ in the table and data in the Chemical Rubber Handbook.

The calculations were first performed with monthly weighted averages. The sum of the 12 calculations was 2.29 Ci of tritium evaporated. Calculating average daytime and nighttime temperatures, 12 hr each, gives 24 calculations per year, and the total evaporated was 2.36 Ci (cf. 2.29). The calculations are shown in Table E.2, below.

An example of total emission for a daylight period, using March daylight hours (31 days x 12 hr x 3600 s/hr = 1.379 x 10^6 s), first quarter effluent = 1.86 x 10^3 pCi/g:

36.21 g/s x 1.86 x 10^3 pCi/g x 1.379 x 10^6 s = 9.29 x 10^{10} pCi/0.5 month.

Assuming all influent to the pond evaporates yields of 47.3 Ci (the total in Table E.1) or about 20 times the above calculated amount, then this latter method is more conservative.

In 1994, 47.3 Ci of ${}^3H$ were influent to the tunnel ponds. CAP88 calculated an EDE of 0.23 µrem at Indian Springs. The EMSL-LV measurement of HTO in air, at Indian Springs in 1994 was 0.2 pCi/m^3 as an annual average. The 0.23 µrem implies 0.44 pCi/m^3 of HTO in air at that location, a factor of 2 higher than actually measured, suggesting that total evaporation is sufficiently conservative.

Table E.2 Calculation of Evaporative Emissions from E Tunnel Pond - 1994

Month	Temp	Temp	Temp	Wind Sp.	Wind Sp.	Pressure	E (evap)	R (rate)	Total
	°F	°C	°K	knots	m/s	mm Hg	g/s	pCi/s	pCi x 10^{10}
Jan N	32.5	0.3	273.5	8	4.11	4.61	14.55	27.1×10^3	3.63
Day	37.1	2.8	276.0	8	4.11	5.60	17.44	32.4×10^3	4.34
Feb N	33.3	0.72	273.9	8	4.11	4.82	15.18	28.2×10^3	3.41
Day	39.2	4.0	277.2	8	4.11	6.10	18.87	35.1×10^3	4.24
Mar N	43.9	6.6	279.8	10	5.14	7.31	26.68	49.6×10^3	6.84
Day	52.7	11.5	284.7	10	5.14	10.18	36.21	67.4×10^3	9.29
Apr N	50.7	10.4	283.6	13	6.68	9.46	41.74	73.0×10^3	9.46
Day	58.7	14.8	288.0	13	6.68	12.62	54.44	95.3×10^3	12.4
May N	57.2	14	287.2	11	5.65	11.99	45.42	79.5×10^3	10.96
Day	68.5	20.3	293.5	11	5.65	17.85	65.49	114.6×10^3	15.8
Jun N	62.1	16.7	289.9	12	6.17	14.26	57.17	100×10^3	12.96
Day	74.0	23.3	296.5	12	6.17	21.45	83.19	145.6×10^3	18.87
Jul N	70.4	21.3	294.5	11	5.65	19.0	69.36	129×10^3	17.79
Day	82.3	27.9	301.1	11	5.65	28.18	99.58	185.2×10^3	25.54
Aug N	68.8	20.4	293.6	10	5.14	17.97	61.1	113.6×10^3	15.66
Day	80.6	27.0	300.2	10	5.14	26.74	88.0	163.7	22.57
Sep N	63.5	17.5	290.7	10	5.14	15.0	51.7	96.2×10^3	12.47
Day	75.4	24.1	297.3	10	5.14	22.51	75.14	139.8	18.12
Oct N	52.2	11.2	284.4	10	5.14	9.98	35.56	$18.O \times 10^3$	2.5
Day	62.0	16.7	289.9	10	5.14	14.26	49.4	25.0×10^3	3.45
Nov N	38.7	3.7	276.9	10	5.14	5.97	22.12	11.2×10^3	1.45
Day	46.2	7.9	281.1	10	5.14	7.99	28.96	14.7×10^3	1.90
Dec N	34.0	1.1	274.3	8	4.11	4.96	15.58	7.9×10^3	1.09
Day	40.8	4.9	278.1	8	4.11	6.50	20.01	10.1×10^3	1.39
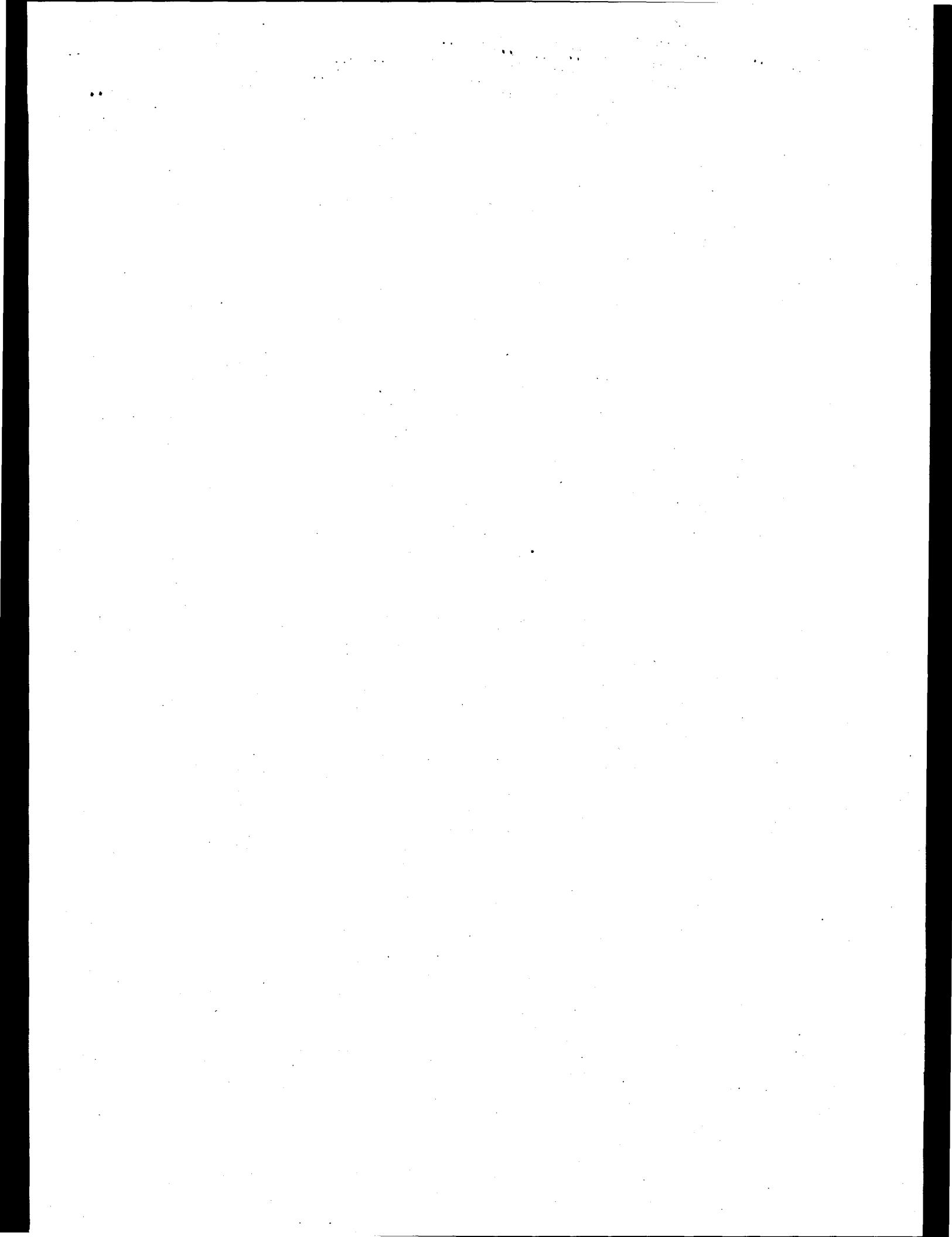
APPENDIX F

RESUSPENDED PLUTONIUM FROM YUCCA FLAT
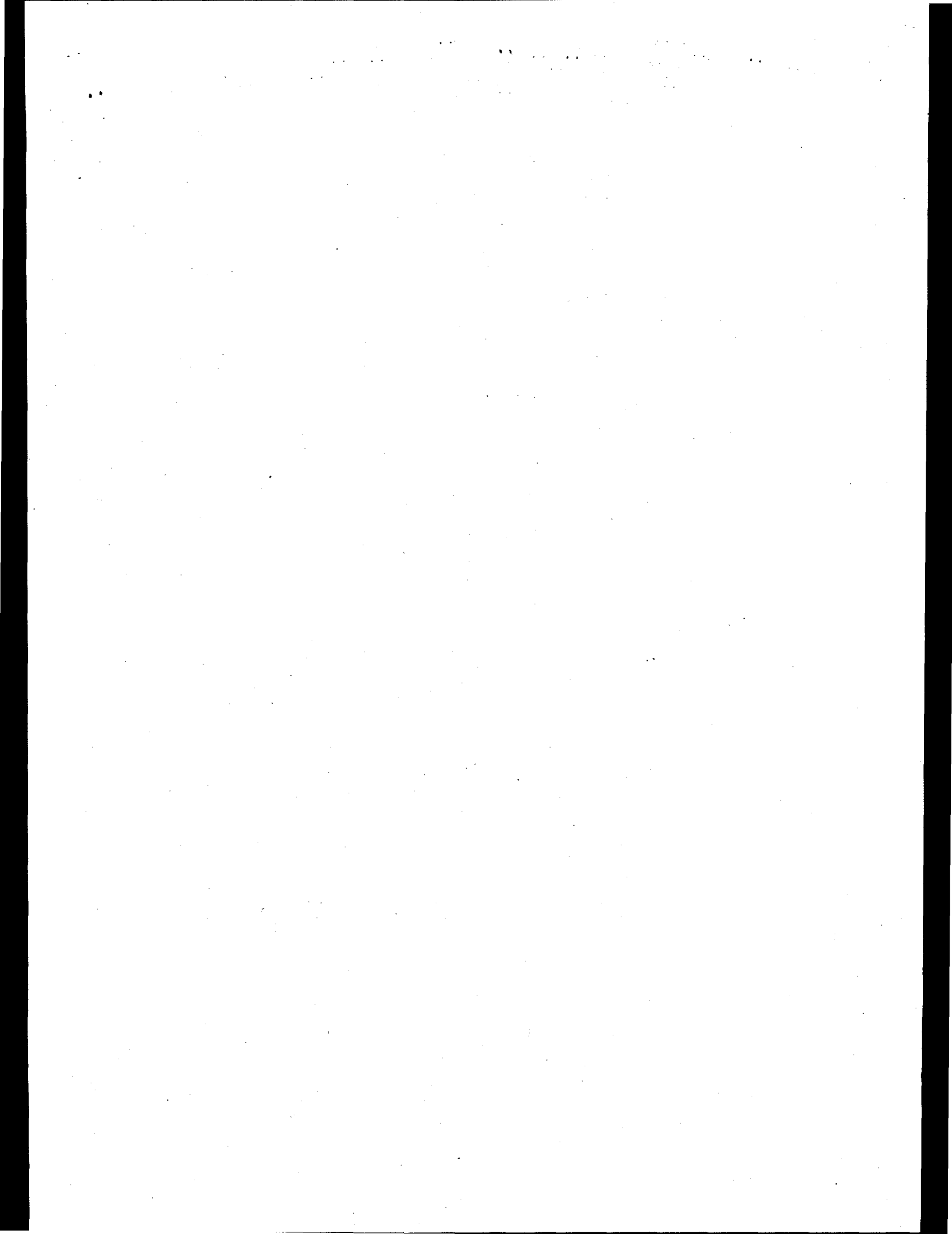
BACKGROUND INFORMATION

As previously described, Area 3 is a diffuse source of radionuclide effluents. Due to operational activities, such as vehicular traffic, equipment operation, etc., some plutonium becomes airborne. Results from the air samplers in the area indicate that only $^{239+240}$Pu is routinely detected and only in concentrations slightly above the MDC. Only a few of the 54 air sampler locations had concentrations exceeding the network average by three standard deviations.

Measurements of airborne $^{239+240}$Pu in Area 3, during CY-1994, are provided in Table F.1. This table displays the number of samples analyzed, the median value and the standard deviation of the 10 to 12 values. Because Area 3 is an area source, it is difficult to measure the volume of air discharged. Therefore, the source term must be estimated. In order to obtain a source term in Ci/yr from the area, the measured $^{239+240}$Pu concentration was used in conjunction with CAP88-PC in order to back calculate a source term. For convenience, the source was assumed to be an area in the center of a circle that touches the four sampling locations (worst-case assumption).

Table F.1. Airborne $^{239+240}$Pu Detected by Area 3 Air Samplers

Location	Number of Samples	(μCi/mL x 10^{-18}) Median	1 Standard Deviation
Area 03 Complex	10	94	64
Area 03 Complex No. 2	10	160	210
Area 03 Mud Plant	10	220	160
Area 03 U3ah/at (4 Samplers)	12	100	120

SOURCE TERM

It is estimated that 36 mCi (1.3 GBq)of $^{239+240}$Pu may have been emitted from Area 3. This source term is only probable, because it is a worst-case value that is based on calculations and an assumed location rather than on monitored values. The method used to calculate this quantity is described below.

The CY-1994 median concentration of $^{239+240}$Pu at the Area 3 samplers was tabulated as above. Using the dose conversion factor of 330 rem/μCi derived from ICRP EDE limits (using class Y) and 8400 m^3 annual average air intake per person, an EDE can be calculated for a person remaining all year at that sampler location.

A trial run of CAP88-PC using a 1 Ci release from the center of the samplers gives an EDE at each of them. When the calculated EDE at each sampler, using that sampler's annual average concentration, is divided by the EDE/Ci from the CAP88-PC run, then an estimate of the curies released can be obtained.

The following shows a typical calculation, using the first sample in Table F.1 (μCi/mL x 10^{12} = pCi/m^3:

$$9.4 \times 10^{-5} \ pCi/m^3 \times 8400 \ m^3/yr \times 0.33 \ mrem/pCi = 0.26 \ mrem$$

A CAP88 run using 1 Ci and 670 m distance indicates an EDE of 520 mrem at the location of the sampler. The ratio of 0.26 mrem (measured) to 520 gives 5.0×10^{-4} Ci as an emission. Using the data in the above table indicates the maximum emission (based on the Mud Plant sampler) would be 2.8 mCi (104 MBq). Wind transport has only extended the boundaries of the plutonium contaminated areas a few meters since the 1960s, and of the amount resuspended only a fraction would be in particle sizes small enough to be carried very far by the wind.

A more conservative calculation is to use the resuspension equation as is done below for the plutonium deposit in Area 9. In that case the emission would be 23 mCi per year. This would yield an EDE of 0.013 mrem to a person in Amargosa Valley (Lathrop Wells), the offsite MEI.

ERROR TERM

The errors in the measurements are listed in Table F.1 as a standard deviation, so the EDE is most likely between 0 and 7.4×10^{-4} mrem (0 and 7.4 nSv). However, the errors that occur in estimating a source term, as described above, are very difficult to assess.

CALCULATION OF PLUTONIUM RESUSPENSION FROM AREA 9

There is an air sampler in Area 9 at one end of a ground deposit of plutonium that usually collects air samples having a higher concentration than the NTS average, but it would require too many assumptions to use the above method. MacArthur in DOE/NV/10845-02 estimates a $^{238+240}$Pu deposit of 75.6 Ci on 7.5 mi^2 there. If the rate of resuspension of that material can be calculated, then a source term would be available.

In the report "Radiological Assessment" by J. E. Till and H. R. Meyer, page 30, an equation for calculating a suspension rate (fraction resuspended per second) is as follows:

$$S = K \times V_g$$

where: S = suspension rate (sec^{-1}) - fraction of the deposit resuspended/sec
K = resuspension factor (m^{-1})
V_g = deposition velocity (m/s)

On page 75 of report DOE/NV-357, values of K are given for the NTS. An average of the values given is 2×10^{-10} per m. Deposition velocities in the range of 0.01 to 0.1 m/s will be used as conservative estimates. If these values are put into the above equation, the rate of suspension is between 2×10^{-12} and 2×10^{-11} per second, and the source term becomes:

$$75.6 \ Ci \times 10^{12} \ pCi/Ci \times 2 \times 10^{-11} /s = 1500 \ pCi/s$$

$$1 \ year = 3600 \ s/hr \times 24 \ hr/day \times 365 \ days/yr = 3.15 \times 10^{7} \ s/yr$$

Annual source term = 1500 pCi/s x 3.15 x 10^7 s/yr = 4.72 x 10^{10} pCi/yr (47.2 mCi/yr)
or, with other value, 4.72 x 10^9 pCi/yr (4.72 mCi/yr).

Therefore, using the above suspension rate, the emission is between 4.72 and 47.2 mCi/yr. Using the larger value, this emission was input to the CAP88 program using the Area 9-300 bunker as the midpoint of the source.

A similar calculation was performed for other plutonium contaminated areas on the NTS.

Using the equation in EPA's Methods for Estimating Diffuse Emissions (July 1994 draft), another calculation can be done.

WIND EROSION CALCULATION FOR AREA 9 - COMPARISON WITH NTS NESHAP REPORT

The equation used is on page 18 of the EPA report:

$$E' = k \cdot a \cdot I \cdot K \cdot C \cdot L' \cdot V' \cdot A \cdot c$$

where: E' = soil particles lost (tons/yr)
k = particle size factor
a = total suspended fraction lost to wind erosion
I = soil erodibility (tons/acre-yr)
K = surface roughness factor
C = climatic factor - C = 0.345 {mph^3/PE^2} where PE = 0.83
L' = unsheltered field width factor
V' = vegetative cover factor
A = site area (m^2) - use high density of 75.6 Ci on 7.5 mi^2
c = conversion factor tons/acre to kg/m^2 = 0.224

Inputs: Yucca Flat is typical high plain desert with sparse vegetation
Average wind speed is 6.0 knots = 6 x 0.514 m/s = 3.08 m/s = 11.1 km/hr = 6.9 mph
k = 0.5 (fraction of resuspended soil that is PM_{10})
a = 0.025 portion of total erosion that is suspended particulates
I = 28 (silty clay loam from Table 7-1, desert pavement decreases erodibility)
K = 1 (surface roughness - desert is smooth)
C = 164 (climatic factor calculated from C = $0.345(mph)^3/(0.83)^2$)
L' = 0.3 as read from Fig. 7-5 (IK = 28 x 0.6=17, L=500 from Table 7-3)
V' = 0.95 (read from Fig. 7-6 using V=100 from Table 7-3 and IKCL' = 790)
A = 7.5 mi^2 = 1.9 x 10^7 m^2 from McArthur's report

so E' = 0.5 x 0.025 x 28 x 1 x 164 x 0.3 x 0.95 x 0.224 = 3.7 kg/m^2-yr

Area 9 : From McArthur, 75.6 Ci on 7.5 mi^2 (7.5 x 2.59 x 10^6 m^2/mi^2) or 1.9 x 10^7 m^2

Total Emission = 3.7 kg/m^2-yr x 1.9 x 10^7 m^2 = 7.0 x 10^7 kg/yr

Pu concentration in dust: 1.9 x 10^7 m^2 x 10^4 cm^2/m^2 x 2 cm deep x 1.5 g/cm^3 = 5.7 x 10^{11} g

75.6 Ci x 10^{12} pCi/Ci ÷ 5.7 x 10^{11} g = 133 pCi/g or 133 nCi/kg

and the source-term becomes 133 x 10^{-9} Ci/kg x 7.0 x 10^7 kg/yr = 9.3 Ci/yr.

Fortunately there are two methods for checking the calculations above.

1) If the total deposit in Area 9 is 75.6 Ci and the E' calculation performed above is correct, then 75.6 Ci ÷ 9.3 Ci/yr yields a deposit duration of 8.1/yr so all the Pu would have been lost many years ago.

The resuspension equation calculation (0.047 Ci/yr) would require about 1600 years to deplete the deposit.

2) Enter the amounts into CAP88PC to obtain the EDE for an offsite individual where Pu in air measurements are made, and compare the two results.

EMSL-LV continuous air sampling at Lathrop Wells in 1993 yielded an annual average Pu concentration of 3 ±12 x 10^{-18} µCi/mL or 3 ± 12 x 10^{-6} pCi/m³ (effectively 0 pCi/m³).

CAP88 results at Lathrop Wells for a source in Area 9, NTS, emitting about 9.3 Ci of Pu as calculated by the diffusion equation above gives 4.4 mrem.

4.4 mrem ÷ 0.33 mrem/pCi = 13 pCi as the amount inhaled (at 8400 m³) per year or 1.5 x 10^{-3} pCi/m³. This is 500 times higher than measured.

If the emission rate were really 0.047 Ci/yr, the EDE at Lathrop Wells would be 0.023 mrem. The calculated annual average air concentration for this EDE would be:

0.023 ÷ (8400 x 0.33) = 8.3 x 10^{-6} pCi/m³ or just about 2.8 times that measured last year, not counting the contribution from other areas. This is sufficiently conservative for a dose calculation.

A resuspension factor of 10^{-9}, as frequently used, would make the calculated offsite concentration much greater than actually measured.

Conclusion: Both checks of the results from the use of the two methods confirm that the resuspension equation is superior to the soil erosion equation for calculating air entrainment and offsite dispersion of plutonium from the Nevada Test Site.

APPENDIX G

DIFFUSE SOURCE ATMOSPHERIC TRITIUM EMISSIONS
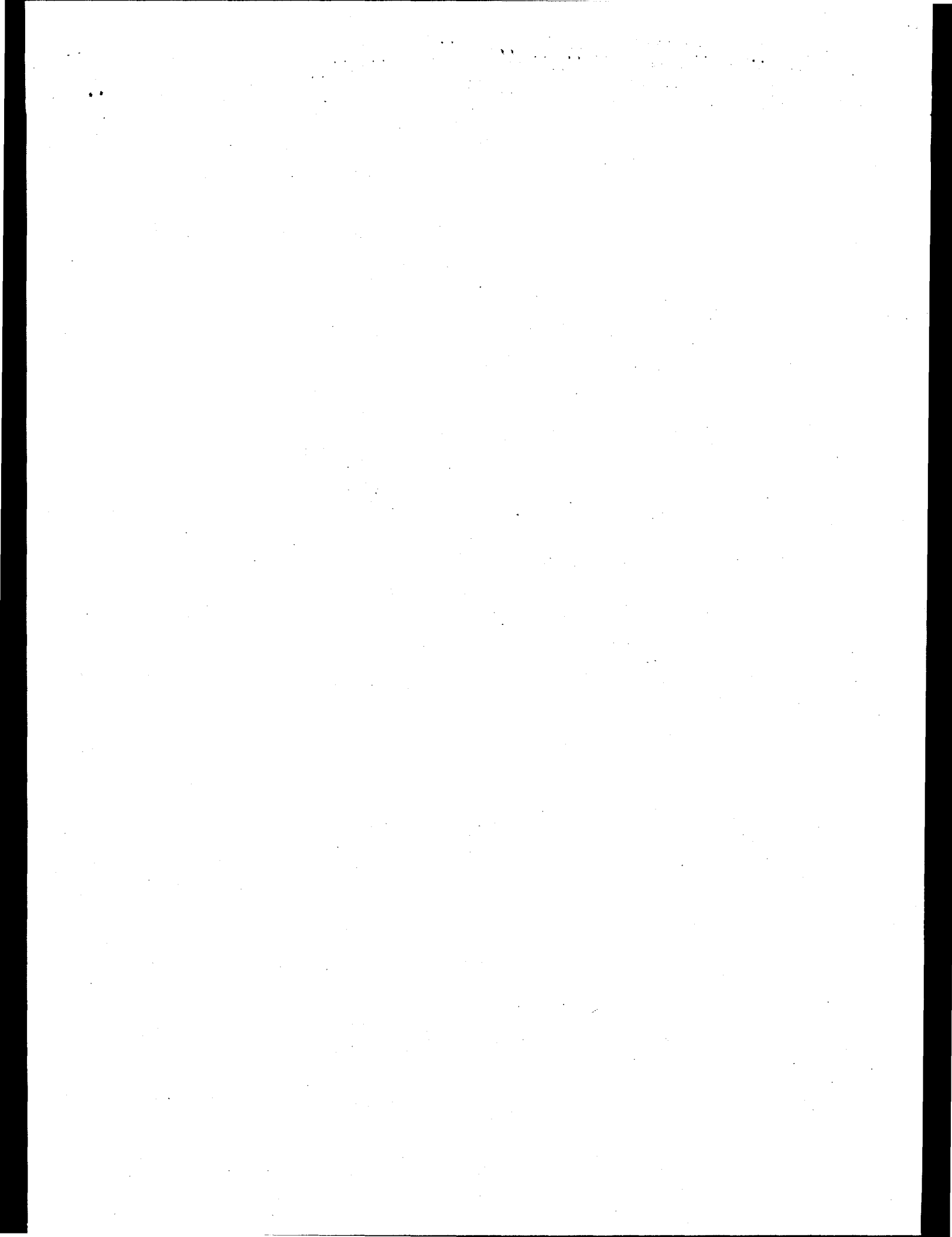
BACKGROUND INFORMATION

Environmental monitoring for tritium in atmospheric moisture is conducted at 17 locations spread around the NTS. There are 9 air samplers around the RWMS perimeter in RWMS-5 because many curies of ^3H are buried at that facility. Some of these samplers collect tritium concentrations that are higher than background levels. This year, also, the monitor at the EPA Farm in Area 15 collected the next to highest tritium concentration. The monitoring results from these sampling stations are provided in Table G.1, Airborne Tritium Sampling Results during CY-1994. The other CY-1994 monitoring data indicate that gross beta and $^{239+240}Pu$ concentrations in air at RWMS-5 are not statistically different from site wide NTS levels.

SOURCE TERM

It is estimated that 0.63 Ci (23 GBq) of ^3H is emitted annually from the RWMS. This source term is calculated to give an EDE of 11 nrem (0.11 nSv) to an individual residing in Lathrop Wells, Nevada. As in Appendix F, this is the location of the MEI for a source in Area 5. The method used to calculate this quantity is described below.

Once again, only environmental monitoring data were available and there was no information on the volume of air discharged from the RWMS. Considering that the RWMS processes packaged waste, it is not likely that an air volume or discharge can be determined. However, a source term can be calculated using a method similar to that described for Yucca Flat in Appendix F, and the result for the MEI offsite can be compared with measured values obtained at that offsite location.

The median annual airborne HTO concentrations from the RWMS tritium samplers surrounding the site were used along with the DOE/EH-0071 dose conversion factors to calculate a dose at each sampler location. For example, an individual breathing 3.9×10^{-12} µCi/mL of HTO for one year receives 3.05 µrem EDE when skin absorption is included[b], doses are calculated similarly for the other sampler locations. The result of a CAP88-PC run, assuming a 1 Ci release of ^3H at the center of the RWMS, is that an individual 381 meters to the SE would receive a EDE of 14 µrem per year. Therefore, 3.05 µrem measured at that sampler divided by 14 µrem/Ci equals an estimated annual release of 0.22 Ci. This calculation was performed for all sampler locations, as shown in Table G.1 and a release of 0.63 Ci (23 GBq) was the maximum estimate as shown in the last column of Table G.1. This calculated release was reported to the EIS/ODIS data bank.

Lathrop Wells, Nevada is located WSW of the RWMS at 44 km. Use of CAP88-PC results in an EDE of 11×10^{-6} mrem to an individual residing in Lathrop Wells if 0.63 curies of HTO were released from the RWMS-5.

The other sampler with elevated median concentration of HTO in air is the one at the Area 15 Farm. The possible emission sources for this result are the Farm, the tunnels and ponds in Area 12, and the SEDAN crater. The ^3H experiments at the farm used only mCi amounts in the early

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[2] The following equation was used to calculate an EDE at each sampler location

$$EDE = pCi/m^3 \times 8400 \ m^3/yr \ (inhaled) \times 1.5 \ (skin \ abs.) \times 6.2 \times 10^{-8} \ mrem/pCi$$
where pCi/m^3 is the annual average HTO concentration.

1970s so it is unlikely to be a source. Since only 47 Ci (versus 700 Ci in 1993) was evaporated from E Tunnel Pond in 1994, it appears unlikely to be a major source. The emission from the SEDAN crater (calculated as above) is shown in the table.

It also appears unlikely that 180 Ci of HTO are being emitted from the SEDAN crater. However, there is no other likely source of the tritium in atmospheric moisture measured at the Area 15 Farm. Therefore, the RWMS-5 and the SEDAN crater are considered to be the detectable sources of HTO on the NTS.

Table G.1. Airborne Tritium Sampling Results During CY-1994

Sampler Number	Direction[1] from Center		Median μCi/mL	bq/m^3	Average Standard Deviation $10^{-12}\mu$Ci/mL	Ratio to 1Ci Emission[2]
05915 No. 1	SE	381m	3.9×10^{-12}	0.14	2.7	0.22
05908 No. 2	ESE	366m	3.1×10^{-12}	0.11	3.6	0.17
05911 No. 3	E	305m	2.9×10^{-12}	0.11	5.5	0.09
05700 No. 4	NE	418m	9.7×10^{-12}	0.36	12.1	0.63
05707 No. 5	N	305m	2.7×10^{-12}	0.10	2.8	0.06
05708 No. 6	NW	418m	2.6×10^{-12}	0.10	3.4	0.12
05709 No. 7	W	305m	2.7×10^{-12}	0.00	1.8	0.05
05714 No. 8	SW	418m	1.6×10^{-12}	0.06	2.2	0.08
05716 No. 9	S	305m	4.9×10^{-12}	0.18	3.4	0.13
15115 Farm of SEDAN	N	3500m	8.9×10^{-12}	0.33	6.9	180

(1) Sampler direction and distance from center of suspected source
(2) This ratio = number curies emitted from RWMS that would give the sampler result.

APPENDIX H

SEEPAGE CALCULATION FOR PAHUTE MESA

NOBLE GAS SEEPAGE ON PAHUTE MESA

Previous environmental surveillance and test monitoring results on Pahute Mesa have suggested that the noble gas, ^{85}Kr, seeps up from nuclear test cavities to be emitted at ground surface with the result that the concentration in environmental surveillance samples is increased when compared to ambient levels measured in other locations. The process evidently requires a lengthy period of time because ^{133}Xe, 5.25 days half-life, is not normally detected in these samples.

In 1992, additional permanent noble gas sampling locations were established in Areas 18, 19, and 20 to increase the number of monitoring stations by 3. The locations are shown in Figure H.1. At each station air is pumped into steel pressure tanks for weekly periods. The noble gases are extracted from the compressed air in these tanks using a cryogenic technique, dissolved in a scintillation cocktail and counted in a liquid scintillation counter. Because of equipment and laboratory failures, and inaccessibility during winter, fewer than 52 results are obtained for each station. The 1994 noble gas sampling results are shown in Table H.1.

The results from the Area 20 samplers frequently have been higher than the results from the other NTS samplers. This also appears to be true for the 1994 results. The average of the 8 stations other than Area 20 was 24.9 pCi/m^3 (0.92 Bq/m^3), while the results for the Area 20 DDZ77 sampler were 29.7 pCi/m^3, or an annual average of 4.8 pCi/m^3 (0.18 Bq/m^3) higher. The wind roses shown on Figure H.2 suggest that, for the DDZ77 sampler, the source is to the S or SSE.

The nearest emplacement hole used for a device test is U-20k, about 10,000 ft (3050 m) to the south. Using a procedure similar to that in Appendices F and G, and also using a CAP88-PC run with an assumed release of 1 Ci (37 GBq) of ^{85}Kr, yields a result of 200 Ci (7.4 PBq) emission from ground seepage on Pahute Mesa. The calculation for this emission is shown on the following page. The dose conversion factor (DCF) for ^{85}Kr is obtained from the DAC for submersion given in ICRP Report 30. The DCF is multiplied by the krypton concentration to obtain the effective dose equivalent (EDE) at the sampler location. To determine the emission

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Table H.1. ^{85}Kr Concentrations on the NTS in 1994 (pCi/m^3)

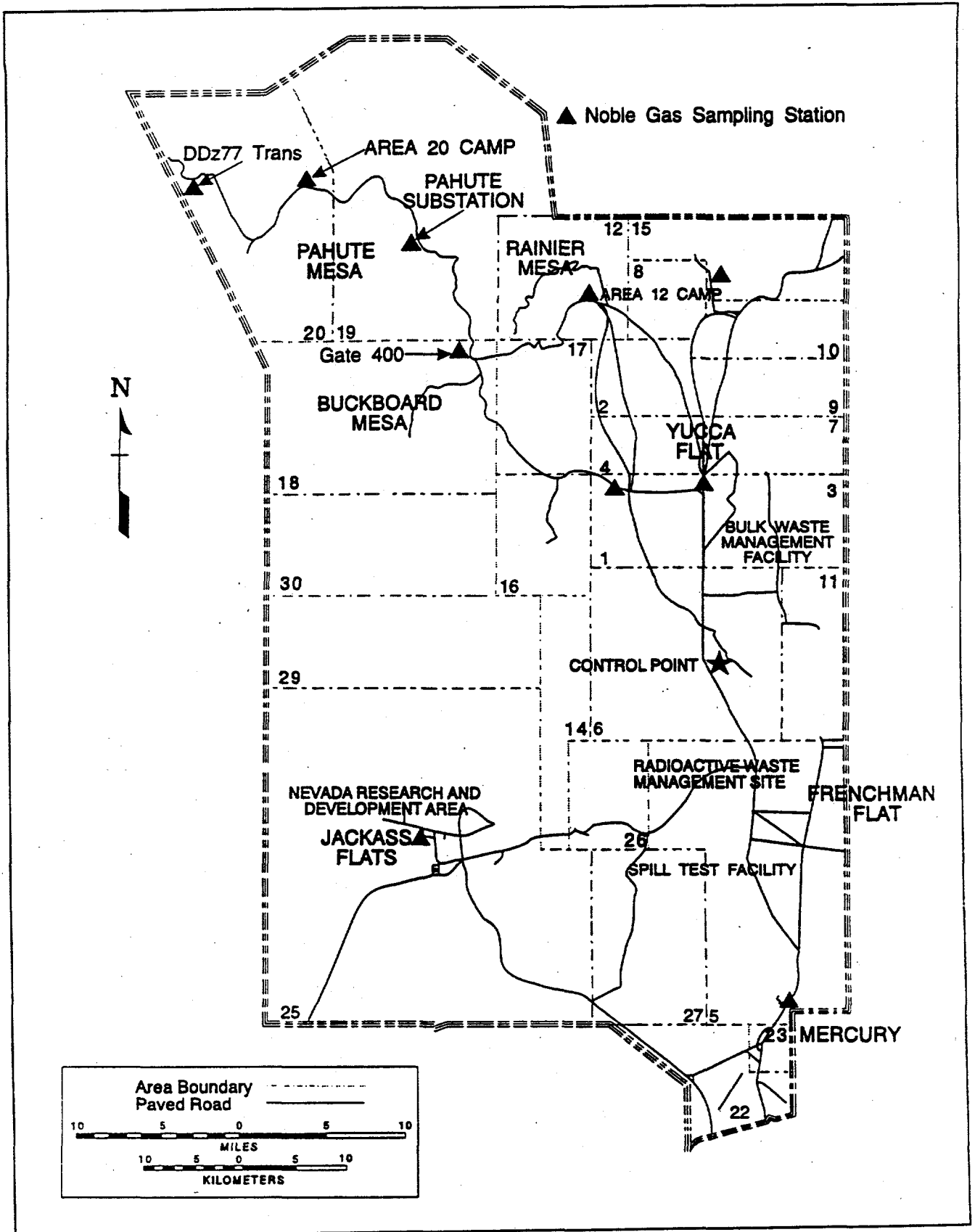| Station Location	Number	Arithmetic Average	Standard Deviation
BJY	49	25.3	11.1
Gravel Pit	48	26.1	8.4
Gate 200	45	23.8	10.7
Area 12 Camp	44	24.3	6.5
EPA Farm	43	26.0	9.4
Area 20 Camp	30	26.5	11.0
E-MAD	48	25.8	8.4
Pahute Substation	31	23.1	9.2
Gate 400	43	24.6	8.3
DDZ77 Trans.	27	29.7	7.8

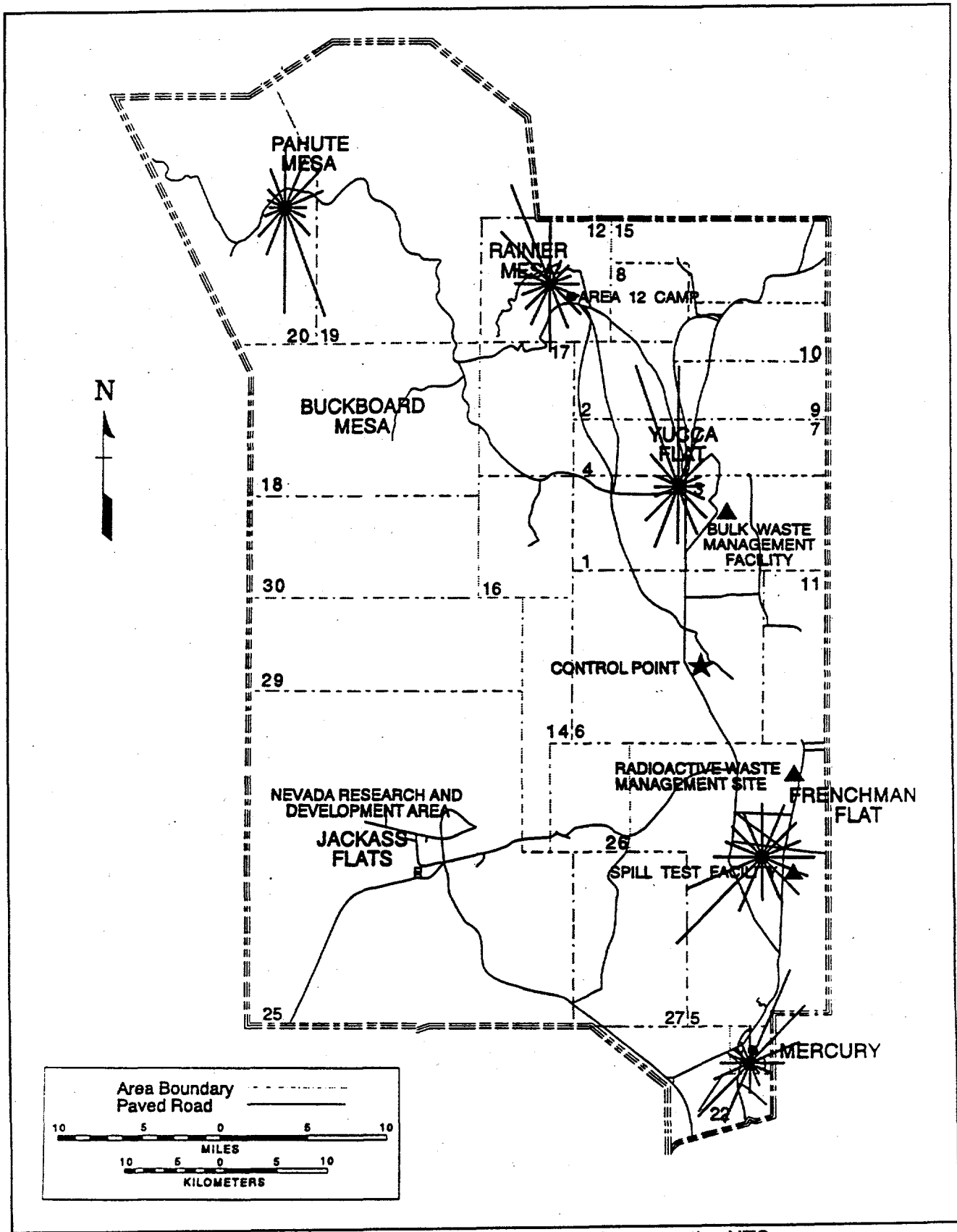Figure H.1. Noble Gas Sampling Sites on the NTS

Figure H.2. Wind Roses for the Various Areas on the NTS

necessary to cause this EDE, an assumed emission of 1 Ci (37 GBq), the distance to the sampler (3050 m), and the STAR (stability array) meteorology for Pahute Mesa were entered into the CAP88-PC program. At a distance of 3050 m to the north, the CAP88-PC run with 1 Ci (37 GBq) indicates an EDE of 3.8×10^{-7} mrem/yr (3.8 pSv) at the sampler location. The calculations are displayed in the following three equations:

$$DCF \text{ for } Kr^{85} = 1.6x10^{-5} \text{ mrem/yr per } pCi/m^3$$

$$[EDE \text{ at sampler}] \quad 3.8 \text{ } pCi/m^3 \times 1.6x10^{-5} = 7.7 \times 10^{-5} \text{ mrem/yr}$$

$$[\frac{EDE \text{ at sampler}}{CAP88 \text{ } EDE}] \quad \frac{7.7 \times 10^{-5} \text{ mrem/yr}}{3.8 \times 10^{-7} \text{ mrem/Ci}} = 200 \text{ } Ci/yr$$

APPENDIX I

IDENTIFICATION AND JUSTIFICATION FOR THE DEVELOPMENT OF METEOROLOGICAL DATA USED AS INPUT TO CAP88-PC

INTRODUCTION

The Nevada Test Site (NTS) is located in southern Nevada, approximately 90 km (65 mi) northwest of Las Vegas, and encompasses an approximate rectangular area of 1500 sq mi (see Figure I.1). Topography is complex with generally north-south oriented ridges and valleys typical of Nevada. Terrain elevations range from near 2700 ft in the extreme southwest corner of the NTS (Station No. 25) to near 7700 ft on Rainier Mesa in the northern part of the NTS (Station No. 12).

In general, terrain slopes gently into broad valleys. In the few areas where steep canyons or cliffs exist, adequate wind and temperature data have been collected and analyzed to provide thorough documentation of the existence of typical up-slope and down-slope wind regimes as a function of time of day.

Meteorological support, observations, and climatological services for the NTS are provided to the DOE Nevada Operations Office (DOE/NV) by the Special Operations & Research Division, Air Resources Laboratory, (ARL /SORD). ARL/SORD is a National Oceanic and Atmospheric Administration (NOAA) office and supports DOE/NV programs under the authority of an Interagency Agreement between NOAA and DOE/NV.

An arid climate exists over the NTS. Annual precipitation ranges from 4.5 inches per year at Station No. 25 to 6.9 inches per year in Yucca Flat (Station No. 6) to 7.6 inches at Desert Rock, to 9.5 inches per year on Rainier Mesa (Station No. 12).

METEOROLOGICAL OBSERVATIONS

ARL/SORD manages, operates, and maintains a meteorological monitoring program that is designed and used to support DOE/NV authorized activities on the NTS. This vital program consists of many meteorological monitoring systems that have been brought together under the acronym MIDNET, or Meteorological Data Network. This network has been operated on the NTS for over 25 years, has undergone several modernizations and upgrades, and serves as a solid basis for deriving climatological information.

MIDNET consists of communications systems, local area networks, upper air sounding stations, and surface based instrumentation used to measure wind direction and speed, temperature, relative humidity, and precipitation. Routine and special surface observations are collected by trained SORD personnel 24 hours per day, 365 days per year at the Desert Rock Meteorological Observatory (DRA, elevation 3304 ft) located three miles southwest of Mercury, Nevada (Station No. 23). Upper air observations (radiosondes) are taken twice daily from DRA. DRA has been in operation since June 1978. DRA was built to replace a similar observatory that was located in Yucca Flat (UCC, elevation 3924 ft, Station No. 6) from January 1962 through April 1978. Consequently, surface and upper air observations are also available from UCC for 1962-1978.

A key component of the MIDNET system is the Meteorological Data Acquisition System (MEDA). MEDA consists of an enclosed trailer, a portable 10-m tower, an electric generator (where needed), a microprocessor, and a microwave radio transmitter. Wind speed and direction sensors are located on booms oriented into the prevailing wind direction and at a minimum distance of two tower widths from the tower. Wind sensors are located 10 m above the ground.

Wind and temperature data have been collected on the NTS for more than 25 years. These and other meteorological data have been compiled into a comprehensive climatological database for the NTS. The MEDA data are specially useful in assessing boundary layer flow regimes on the NTS. MEDA station distribution and density (see Figure I.1) are sufficient to document individual basin flow regimes and potential interbasin air exchanges.

Ambient temperature and relative humidity sensors are located at the 3-m level. A total of 40-50 MEDA stations are located on or around the NTS (Figure I.1) to ensure that meteorological conditions are thoroughly documented for the complex terrain environment found on the NTS.

Wind direction is measured to two degrees of azimuth and wind speed is accurate to 0.15 mph. Wind data are collected as 4-minute averages and are transmitted via microwave to a central processor every 15 minutes. These data are checked operationally by the duty forecaster and quality control is assured by the ARL/SORD climatologist. Plotted wind products are generated every 15 minutes for operational use. The data are stored and archived for climatological purposes.

MEDA temperature is accurate to 0.035 percent between 0°C and 40°C. Temperature measurements are instantaneous and are taken every 15 minutes at all MEDA stations. These data are also transmitted via microwave to a computer for processing, display, and archiving.

To utilize the most representative meteorological data available for NTS sources, cloud observations from DRA were melded with the concomitant MEDA winds from Mercury and Pahute Mesa. Similarly, the cloud observations from UCC were melded with MEDA wind data from Yucca and Frenchman Flats. The straight-line distance from DRA to Mercury is 3 miles; from UCC to Frenchman Flat, 12 miles; and from DRA to Pahute Mesa, 40 miles.

Cloud cover observations needed as input to the STAR (Stability Array) program are available from DRA (1978-present) and from UCC (1962-1978). Based on the available data, the cloud cover climatology from DRA and UCC are quite compatible. For example, UCC experiences 192 clear days annually while DRA has 191 days. In addition, the average annual sky cover, in tenths, from sunrise to sunset for both stations is 3.9 tenths. The total number of cloudy days for UCC is 81 days and 88 days for DRA, annually. Therefore, the cloud cover observations from DRA and UCC can be considered as representative for most of the NTS.

In a study of precipitation on the NTS, Quiring (1983) found that the northwest part of the NTS, including Pahute Mesa, is clearly an area of diminished precipitation for the given elevation (6500 ft). Furthermore, the total annual precipitation for Pahute Mesa (9.5 inches) is more compatible with that from DRA (7.6 inches) than from UCC (6.9 inches). Consequently, assuming that cloud cover is directly related to precipitation, it logically follows that the cloud cover for Pahute Mesa is better represented climatologically by the cloud observations from DRA.

CONCLUSIONS

Based on the above considerations and on the limitations of CAP88; the cloud cover data from DRA were considered to be representative of Pahute Mesa. Therefore, atmospheric soundings and cloud cover observations from DRA were melded with MEDA surface wind data from Pahute Mesa for input to the STAR program to provide the very best data for calculating transport and dispersion processes.
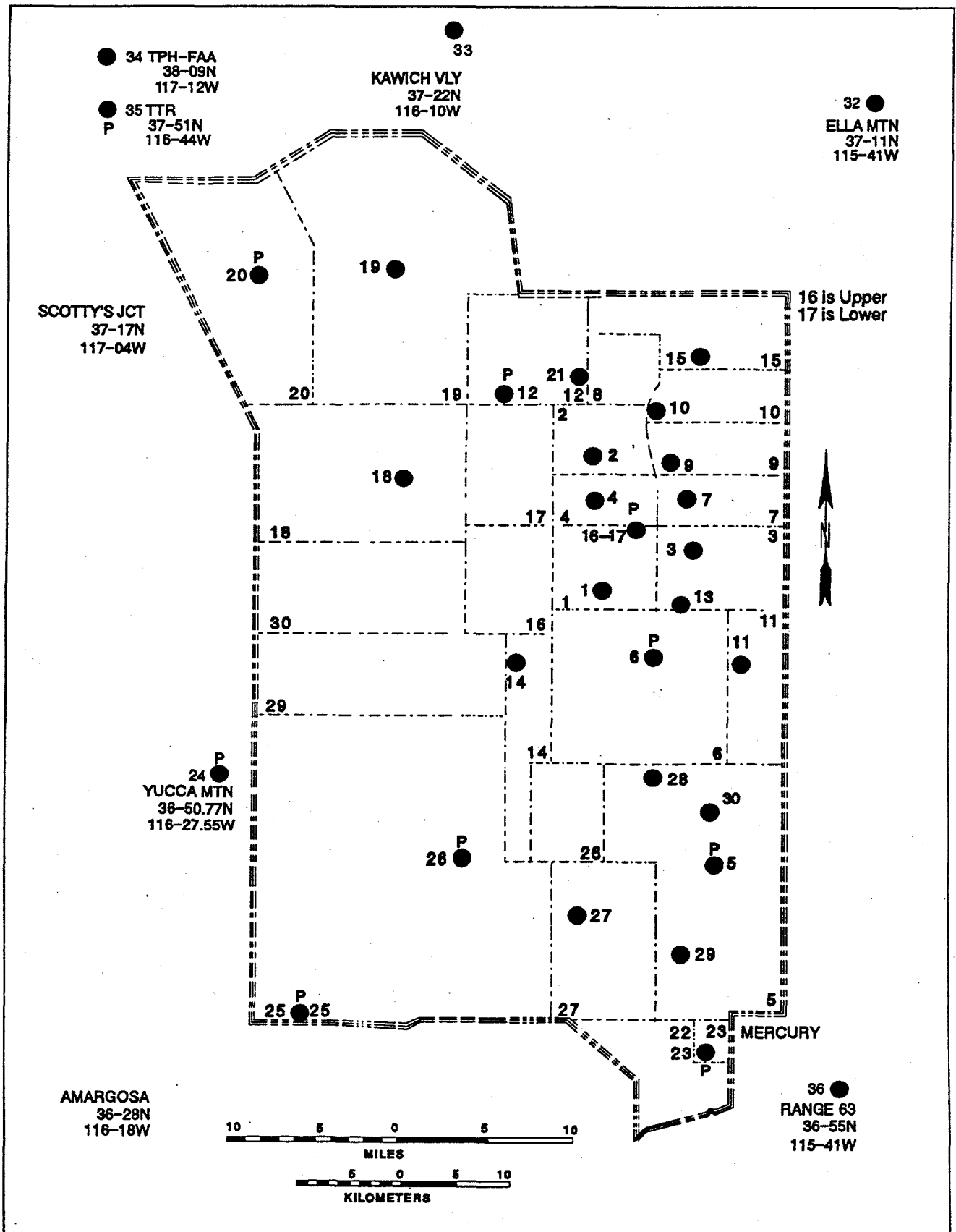
Figure I.1. Location of MEDA Stations on the NTS

For sources in Yucca Flat and Frenchman Flat, the cloud cover data from UCC were considered to be the most representative. Yucca Flat and Frenchman Flat are adjoining valleys of similar soil and vegetation types and similar meteorological and climatological conditions.

For sources at Mercury, the cloud observations from DRA are representative. DRA is only 3 miles from Mercury.

The STAR file is a matrix that includes six Pasquill stability categories (A through F), six wind speed categories, and 16 wind sectors from wind roses calculated for each specified MEDA station on the NTS.

Reference: Quiring, R.F., "Precipitation Climatology for the Nevada Test Site," NOAA/WSNSO, Las Vegas, NV, WSNSO 351-88, 34 pp., 1983.

APPENDIX J

SUPPLEMENTAL INFORMATION

COMPARISON WITH PREVIOUS YEAR'S DATA

Maximum Potential Individual EDE:
    1994 - 1.5×10^{-1} mrem (1.5 µSv)
    1993 - 3.8×10^{-3} mrem (38 nSv)
    1992 - 1.2×10^{-2} mrem (120 nSv)
    1991 - 8.6×10^{-3} mrem (86 nSv)
    1990 - 5.8×10^{-3} mrem (58 nSv)

In 1990 containment pond evaporation of HTO was added to the NTS source term, the tritiated water effluents from the tunnels were 3 times higher in 1991. In 1992, there was a 15 percent increase in HTO effluents and the STAR for the tunnel area was developed that slightly changed the offsite distribution of the effluent. In 1993 tunnel effluents began decreasing because of sealing the tunnel drainage systems. This year, resuspension of plutonium from surface deposits was calculated.

COLLECTIVE EFFECTIVE DOSE EQUIVALENT

The maximum potential collective effective dose equivalent to the 33,740 people who live within 80 km of the NTS emission sources was 0.46 person-mrem in 1994 due mostly to calculated plutonium exposure. Tritium exposure was less than last year because of the reduced emissions from the tunnel ponds. The collective EDE data are based on distance and direction from each of the sources of emission on the NTS and nearby areas. These data are displayed in the very last column of Table 5. The collective EDE is the sum of the EDE to the community from each emission source multiplied by the population of the community.

Maximum Potential Collective EDE
(person-mrem) by NTS Source:

Areas 3,9	164
Area 5	0.18
Area 12	0.66
Other Areas	351
Mercury	0.00037
	516 person-mrem
	(0.52 person-rem)

The higher potential population doses from plutonium areas are due to the conservative assumptions about resuspension of plutonium from deposited material in those areas. The extent of overestimation can be assessed as follows: calculate the concentration of ^{239}Pu necessary to cause the CAP88-PC estimate of EDE. The CAP88-PC EDE was 0.15 mrem at Lathrop Wells due to resuspension. Using a dose conversion factor of 0.33 rem/µCi (from DOE/EH-0071) and an inhalation intake of 8400 m^3 per year, divide the 0.15 mrem by 0.33 mrem/µCi and 8400 to obtain a concentration of 54×10^{-5} pCi/m^3. This is higher than the 3×10^{-6} pCi/m^3 measured at Lathrop Wells and indicates the conservatism in the calculation.

COMPLIANCE WITH NESHAP

DOE/NV was in compliance with 40 C.F.R. 61, Subpart H, during Calendar Year 1994. Periodic confirmatory measurements and analysis of the NTS environs are provided in Appendices A through G. These measurements and analysis are the methods of determining NTS effluents presented in the April 24, 1991, meeting between Region 9 and DOE/NV and documented in the 1990, 1991, and 1993 DOE/NV annual reports.

COMPLIANCE WITH SUBPARTS Q AND T, 40 C.F.R. 61

The NTS is regulated by Subpart H. Measurements of radon-220 and -222 have not been made. Short-lived radon daughters would be detectable on particulate filters from air samplers deployed around the Radioactive Waste Management Facility.

RADON EMISSIONS FROM U-238 AND TH-232 SOURCES

Material from Mound Applied Technologies is stored in cargo containers at the waste management site in Area 5. TLDs placed around the containers have not detected an increase in gamma exposure that would occur as radon daughters accumulate in the cargo containers.

NON-DISPOSAL/NON-STORAGE SOURCES OF RADON EMISSION

None of these sources exist on the NTS.

NESHAP QA PROGRAM

Provisions in Method 114 described in Appendix B of 40 C.F.R. 61 are related to continuous monitoring of major sources. The NTS has only minor sources.

APPENDIX K

DISTRIBUTION LIST

DISTRIBUTION

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