DOE/NV/11718--331

National Emission Standards for Hazardous Air Pollutants Submittal - 1998

June 1999

U.S. Department of Energy
Nevada Operations Office
Las Vegas, Nevada

DISCLAIMER

DOE/NV/11718--331

National Emission Standards for Hazardous Air Pollutants Submittal - 1998

Edited By
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June 1999

Work Performed Under
Contract No.
DE-AC08-96NV11718

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LIST OF ACRONYMS

ARL/SORD	Air Resources Laboratory Special Operations and Research Division
ASL	Analytical Services Laboratory
BN	Bechtel Nevada
CAP88-PC	Clean Air Package 1988 (EPA Software Program for Estimating doses)
CFR	Code of Federal Regulations
CY	Calendar Year
DAF	Device Assembly Facility
DOE/NV	U.S. Department of Energy/Nevada Operations Office
DRA	Desert Rock Meteorological Observatory
EDE	Effective Dose Equivalent
EPA	U.S. Environmental Protection Agency
FFACO	Federal Facilities Agreement and Consent Order
HAZMAT	Hazardous Material
HTO	Tritiated Water
LLW	Low-Level Radioactive Waste
MDC	Minimum Detectable Concentration
MEDA	Meteorological Data Acquisition System
MEI	Maximally Exposed Individual
MIDNET	Meteorological Data Network
NAFR	Nellis Air Force Range
NESHAP	National Emission Standard for Hazardous Air Pollutants
NOAA	National Oceanic and Atmospheric Administration
NTS	Nevada Test Site
RWMS	Radioactive Waste Management Site
RWMS-3	Radioactive Waste Management Site, Area 3
RWMS-5	Radioactive Waste Management Site, Area 5
STAR	Stability Array - Grouping of Meteorological Data
TRU	Transuranic - Nuclides with Atomic Numbers Greater than Uranium
UCC	Yucca Flat Meteorological Observatory

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U.S. Department of Energy
Air Emissions Annual Report
(under Subpart H, Title 40 Code of Federal Regulations [CFR] 61.94)
Calendar Year (CY) 1998

Site Name: Nevada Test Site

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SECTION I
FACILITY INFORMATION

SITE DESCRIPTION

The Nevada Test Site (NTS) is operated by the U.S. Department of Energy's Nevada Operations Office (DOE/NV) as the site for nuclear weapons testing, now limited to readiness activities and experiments in support of the national Stockpile Stewardship Management Program. It is located in Nye County, Nevada, with the southeast corner about 105 km (65 mi) northwest of Las Vegas, Nevada. The NTS covers about 3,500 km^2 (1,350 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 Air Force Range [NAFR]) that provide another 24 to 104 km (15 to 65 mi) between the NTS and public lands (Figure 1.0). 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 0.2 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 there is great depth to slow-moving groundwater.

SOURCE DESCRIPTION

The sources of radionuclides include current and previous activities conducted on the NTS. Figure 2.0 is a map of the NTS that shows the areas used for such activities. The NTS was the primary location for testing of nuclear explosives in the Continental U.S. between 1951 and 1992. 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 explosive devices has occurred underground in drilled vertical holes or in mined tunnels (ERDA 1977). No such tests have been conducted since September 1992 (DOE 1994). Limited non-nuclear testing includes spills of hazardous materials (HAZMAT) at the HAZMAT Spill Center and aerospace and demilitarization activities. Processing of radioactive materials is limited to laboratory analyses, and handling is restricted to transport, storage, and assembly of nuclear explosive devices and operation of radioactive waste management sites (RWMSs) for low-level radioactive and mixed waste (DOE 1996a). Monitoring and evaluation of the various activities conducted onsite indicate that the potential sources of offsite radiation exposure in 1998 were releases from (1) evaporation of tritiated water (HTO) from containment ponds that receive drainage water from E Tunnel in Area 12 and from wells used for site characterization studies, (2) onsite radioanalytical laboratories, (3) the Area 5 RWMS (RWMS-5) facility, and (4) diffuse sources of tritium and resuspension of plutonium. The following sections present a general description of the present sources on the NTS.

At the North Las Vegas Facility, operated for DOE/NV by Bechtel Nevada (BN), there was an unusual occurrence in 1995 that led to a very small potential exposure to an offsite person. The incident involved the release of tritium as HTO. The HTO emission has continued (probably deemanation of building materials) at lower levels, even after cleanup activities in November and December 1997. A description of the incident and the method of calculating the effective dose equivalent (EDE) for offsite exposure are set forth in Appendix A.

Ground Seepage of Noble Gases

Ground seepage may be enhanced when changes in ambient pressure act like a pump to bring 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. This has occurred on Pahute Mesa at the NTS. In 1997, there were no significant differences between the sampling locations on Pahute Mesa and on Yucca Flat (background location), so this monitoring was terminated.

Tunnel Operations

Nuclear tests have been conducted within tunnel complexes mined into the Rainier Mesa region. When tests were conducted, purging gases from the tunnel occasionally resulted in releases of radioactivity, and contaminated water drained from the tunnels into containment ponds (ERDA 1977). No such activities have occurred since 1992.

Containment Ponds

Water contaminated with radionuclides seeped from the tunnels in Area 12 and was collected in containment ponds where some evaporated and some seeped into the soil. A photograph of tunnel containment ponds is provided in Figure 3.0. The tunnels have been sealed, but water continues to seep from E Tunnel. The only radiological contaminant which produces a measurable air emission from evaporation of the water is ^{3}H (as HTO). The seepage is expected to cease in the future, as additional remedial actions are implemented. Calculation of the source term for this emission is described in Appendix B.

To characterize the groundwater regime under the NTS, suitable wells are being drilled and existing wells recompleted in the vicinity of certain underground tests and at other locations on the NTS, as determined by hydrologists. During these drilling operations, contaminated water may be pumped from the wells. This water is diverted to lined containment ponds if the tritium level exceeds 2×10^{5} pCi/L, as required by the state and explained in the Underground Test Area Program (DOE 1996d). Calculations for this activity are also described in Appendix B.

Drillbacks

Following underground nuclear tests, slant wells are drilled so core samples can be taken from the cavity formed by the nuclear detonation for analysis and diagnosis. As a result, radioactivity may be discharged to the atmosphere. No tests or drillback activities occurred during 1998.

Laboratories

Radiological analyses are conducted in laboratories located in Building 650, Mercury; Building CP-95A and the Device Assembly Facility in Area 6; and in Building 5-6 at the Waste Management Facility in Area 5. Because these facilities 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 4.0 is a photograph of the Building 650 hood ventilation stacks seen from above. The source term for these laboratories is described in Appendix C. In general, evaporation and spills from samples containing HTO, radioiodines, or noble gases are conservatively estimated by assuming all such materials are released. Radioactive standards are the principal sources for these releases. Non-volatile materials are controlled by keeping their inventory below the possession limits set forth in Appendix E to Title 40 CFR 61 (CFR 1989) as shown in Appendix C.

Radioactive Waste Management Sites

The RWMSs in Area 3 (RWMS-3) and RWMS-5 are used for the disposal of low-level radioactive waste (LLW). The RWMS-5 is also used for accumulation of mixed waste and storage of transuranic (TRU) and mixed TRU wastes. Disposal is accomplished by the use of pits and trenches; concrete pads are used for temporary storage of certain wastes. At RWMS-5, only packaged, dry 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 D. The RWMS-3 LLW site is in a location where surface soil has been contaminated by deposited plutonium, and resuspension of this soil by wind or vehicular activity results in above background levels of plutonium being detected in air samples collected nearby.

Surface Areas Contaminated with Plutonium or Tritium

Surface soils in certain areas on and off of the NTS were contaminated with plutonium or tritium from either nuclear device safety, atmospheric, or the cratering tests, using nuclear explosives. An investigation of these areas during the Nevada Applied Ecology Group studies (DOE 1992), by the Desert Research Institute (DOE 1991), developed the inventories of plutonium shown in Table 1.0. These areas could become sources of plutonium exposure if the contaminated soils were to be resuspended, e.g., during surface cleanup, construction, vehicular travel, or similar activities. Figure 5.0 is a map showing the approximate locations of the nuclear device safety tests on or near the NTS. There are air samplers at or near most 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 two 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 derivation of the source term for and reason for selection of plutonium from contaminated areas is explained in Appendix E.

Tritium emanation from the cratering tests SEDAN and SCHOONER is detectable in atmospheric moisture samples collected on molecular sieves by special air samplers. Derivation of the source term for these locations is described in Appendix D.

Federal Facilities Agreement and Consent Order (FFACO)

Under the FFACO between DOE/NV and the state (DOE 1996e), contamination generated by historical NTS activities is being removed. Two surface areas on the NAFR have been remediated so far. This results in a decrease in offsite EDE. Figure 6.0 shows the change in airborne plutonium concentration during and after cleanup operations at the DOUBLE TRACKS site; CLEAN SLATE III is the background location for that site. Other peaks are caused by subsequent activities and/or high winds. The monitoring plan for such activities envisages continued air sampling until the concentration in air returns to background levels. The clean up of DOUBLE TRACKS and CLEAN SLATE I areas resulted in removal of 5.12 Ci and 5.65 Ci of $^{239+240}$Pu, respectively. The amounts removed are within the 95 percent confidence intervals of 1.7 to 6.0 Ci estimated for each of these two locations.

Table 1.0 Summary of Estimated Inventory of $^{239+240}Pu$ in Surface Soil (0 to 5 cm) at Studied Sites

Sites	Area (km^2)	Number Samples	Est. Inventory (Curies)	95% Conf. Interval (Curies)	$^{239+240}Pu$ Air Conc. Annual Avg. ($\overline{X} \pm 2s$) 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 II CLEAN SLATE III [1]	0.47 1.73	63 63	17 37	9.6 - 24 26 - 48	

(1) Safety/transport tests of nuclear devices (DOUBLE TRACKS and CLEAN SLATE I have been cleaned up).
(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 (DOE 1977); NVO-272, pp. 381-429 [DOE 1982] McArthur, DOE/NV10485-02 [DOE 1991]).
(4) Weapons effects test.

SECTION II
AIR EMISSIONS DATA

Each potential source of NTS emissions was characterized by one of the following methods: (1) monitoring methods and procedures previously developed at the NTS; (2) a yearly radionuclide inventory of the source, assuming that volatile radionuclides are released to the environment; (3) 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; (4) use of resuspension calculations; or (5) using a combination of environmental measurements and Clean Air Package 1988 air dispersion model (CAP88-PC) (U.S. Environmental Protection Agency [EPA] 1992) to calculate emissions (generally confirmed by offsite air measurements). Appendices A through E describe the methods used to determine the emissions from the sources listed in Section I. In accordance with Title 40 CFR 61.93.(b).(4), (CFR 1989) no credit was taken for pollution control equipment in determining air emissions.

The emissions for National Emission Standards for Hazardous Air Pollutants (NESHAPs), reporting are listed in Table 2.0. These emissions are very conservative (worst-case) and are used in Section Ill to calculate the EDE to the maximally exposed individual (MEI) offsite. Offsite environmental surveillance data, where available, are used to confirm that calculated emissions are, indeed, conservative.

Table 2.0 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 CP-95A	None	0%	42 km	^{3}H	5.0×10^{-4}
DAF, Area 6	None	0%	40 km	^{3}H	6.13
Building A-1	None	0%	0.1 km	^{3}H	1.6×10^{-2}
Building 5-6	None	0%	42 km	^{3}H	5.0×10^{-5}
Grouped Sources					
Building 650 Laboratory (12)(1)	None	0%	24 km	^{3}H	3.0×10^{-5}
				^{85}Kr 2.7×10^{-6}	
				^{129}I 1.0×10^{-6}	
Containment (2)					
Pond: Area 12	None	0%	56 km	^{3}H	18.2
Area 19/20			36 km	^{3}H	87
Non-Point Sources					
Yucca Flat: (3)					
Area 3	None	0%	54 km	$^{239+240}Pu$	1.2×10^{-2}
Area 9	None	0%	53 km	$^{239+240}Pu$	2.8×10^{-2}
RWMS-5 (3)	None	0%	42 km	^{3}H	0.92
Other Areas	None	0%	42 km	$^{239+240}Pu$	2.0×10^{-1}
SEDAN(3)	None	0%	51 km	^{3}H	140
SCHOONER(3)	None	0%	36 km	^{3}H	45.2

(1) (x) is number of vents or stacks.
(2) Evaporation of all tritiated water effluents is assumed.
(3) Emissions based on environmental surveillance data.

A summary of the NTS total CY 1998 emissions for NESHAP's reporting, by radionuclide, is provided in Table 3.0.

Table 3.0 Total Emissions for CY 1998 (Multiply Ci by 37 to obtain GBq)

Radionuclide	Half-Life (days)	Annual Quantity (Ci)
^{3}H	4510	298
^{85}Kr	3919	2.7×10^{-7}
^{129}I	5.7×10^{9}	1.0×10^{-6}
$^{239+240}Pu$	8.8×10^{6}	2.4×10^{-1}

Note: This table includes all worst-case point and diffuse source releases.

SECTION III
DOSE ASSESSMENTS

SUMMARY OF INPUT PARAMETERS

CAP88-PC was used to calculate EDEs to offsite residents. The input parameters were the radionuclide releases listed in Section II above as determined from effluent monitoring performed by the contractor, evaporation of HTO, and 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 the NTS and NAFR, and HTO detected at the boundary of the RWMS.

To calculate the amount of HTO evaporated, measurements of HTO concentration in the containment pond for the first and fourth quarters of 1995 were compared. These concentrations were equal, i.e., within the measurement error, and the surface area was approximately equal, so all the HTO influent to the pond was assumed to have evaporated (DOE 1996c). This was a conservative estimate, as no allowance for infiltration into the soil column was made. This is assumed to be true for 1998 also. A description of the source term estimated for this emission source is contained in Appendix B.

The source data listed in Table 2.0 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 in Area 5 and 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 Air Resources Laboratory Special Operations and Research Division (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 (DRA). The ARL/SORD assessment is attached as Appendix F. For each of these five STARs there may be a different location for the MEI; but when the contributions of all the NTS sources to a given location are considered, only one location would receive the maximum exposure. In this case, Springdale, Nevada, with a population of 20 persons, received the maximum exposure. See Figure 1.0 for ranches and communities around the NTS.

The EDE, in mrem, to the MEI (a resident in Springdale, 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 4.0. Calculation of this EDE requires summing the contribution from all sources, as shown in Table 5.0. Appendices A through E contain estimates of radionuclides, which have or could have been released in 1998.

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 where possible. Evaporative and resuspension emissions are also compared to EPA suggested methods as a check on the relative values produced.

Table 4.0 Summary of CY 1998 CAP88-PC Calculations of EDE to the MEI Offsite, Springdale, Nevada[a]

Source	Distance to Individual and Direction	EDE (mrem)[b]
Tunnel Pond (Area 12)	56 km WSW	4.3×10^{-5} [c]
Laboratories (Area 23)	78 km WNW	1.9×10^{-8}
Yucca Flat (Area 3)	62 km W	5.0×10^{-3}
(Area 9)	64 km W	1.1×10^{-2}
(Area 10)	65 km WSW	4.0×10^{-4}
RWMS (Area 5)	74 km WNW	1.1×10^{-5}
Areas 19/20	42 km SW	9.1×10^{-4}
Other Areas	---	7.5×10^{-2}

TOTAL EDE
9.2×10^{-2} mrem

(a) Location of residences and communities around the NTS as shown in Figure 1.0.
(b) For mSv, multiply by 10^{-2}.
(c) Assumes evaporation of all tritiated water influents to ponds.

Table 5.0 EDE Tabulation by Location (Multiply mrem by 10^{-2} for Equivalent mSv Units) - 1998

Location	EDE (µrem/year) Due to Releases from:									Collective
	Tritium - Area		Other	AREAS			RWMS-5[a]	Area 10	Total EDE	Pop.[c]	EDE
	12[a]	19/20	Areas[b]	3[a]	9[a]	19/20	Tritium	Tritium	µrem		man-mrem
Alamo			7.4					0.071	7.47	480	3.6
Amargosa Valley	0.043	0.13	47.8	3.7	11.0	0.72	0.011	0.29	63.7	1100	70.1
Ash Meadows			10.1	4.0			0.011		14.1	10	0.141
Ash Springs			1.9						1.9	70	0.133
Beatty	0.039	0.14	62.7	4.9	11	0.75	0.012	0.38	79.9	1600	128
Clark Station			12.0						12	2	0.024
Crystal	0.066		43.0	3.9	7.8		0.012	0.21	55	45	2.48
Death Valley Jct							0.011		0.011	7	7.7×10^{-5}
Corn Creek Sta							0.011		0.011	4	4.4×10^{-5}
Goldfield		0.15	4.1						4.25	550	2.34
Hiko			1.8						1.8	103	0.18
Indian Springs	0.09		14.8	1.4	5.3		0.012	0.26	21.9	1210	27
Lathrop Wells	0.047		62.5	6.8	13	0.72	0.012	0.34	83.4	30	2.5
Lida Junction		0.15	13.7			0.74			14.6	8	0.12
Medlin's Ranch	0.047		27.5	2.4	6.7	0.71	0.011	0.12	37.5	2	0.075

(a) Emissions calculated from surveillance data.
(b) Emissions calculated from engineering data.
(c) Population at that location for 1998.

Note: Blank spaces represent locations farther than 80 km from the source for the column.

Table 5.0 (Effective Dose Equivalent Tabulation by Location [Multiply mrem by 10^{-2} for Equivalent mSv Units] - 1998, cont.)

Location	EDE (µrem/year) Due to Releases from:										Collective
	Tritium -Area 12	19/20	Other Areas[b]	AREAS 3[a]	9[a]	19/20	RWMS-5[a] Tritium	Area 10 Tritium	Total EDE µrem	Pop.[c]	EDE man-mrem
Mt. Charleston							0.011		0.011	960	0.011
Pahrump							0.011		0.011	20000	0.22
Penoyer Farm	0.047	0.12	33.0	2.0	5.3	0.72		0.125	41.3	16	0.66
Rachel	0.047	0.12	29.2	1.9	5.1	0.71		0.117	37	105	3.9
Sarcobatus Flats	0.062	0.17	28.5	1.2		0.76			30.7	40	1.23
S NV Corr. Ctr			1.4	1.2			0.011		2.61	2000	5.22
Springdale	0.043	0.15	75.0	5.0	11.0	0.76	0.011	0.40	92.4	20	1.85
Stateline & Area			11.0	3.2			0.011		14.2	70	0.99
Stone Cabin Rn			8.9						8.9	6	0.053
Tonopah			4.0			3.8			7.8	3300	25.7
Twin Springs Rn			2.4						2.4	6	0.014
U.S. Ecology	0.043	0.13	45.4	4.9	11.0	0.73	0.012	0.28	62.5	35	2.2

Total Population: 31,750 MEI: 0.092 mrem Location of MEI: Springdale, Nevada	Maximum Individual Dose Calculated for Following Sources - mrem					Total Person- 0.27
	Area 12	Other Areas	YUCCA Flat	Area 10	Area 19 and 20	
	0.00009	0.075	0.0201	0.0004	0.00093	

(a) Emissions calculated from surveillance data.
(b) Emissions calculated from engineering data.
(c) Population at that location for 1998.

Note: 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: K. A. Carlson, Manager, Nevada Operations Office

Signature: K A Carlson Date: 6/25/99

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SECTION IV
ADDITIONAL INFORMATION

NEW CONSTRUCTION/MODIFICATION ACTIVITIES AT THE NTS

In 1997, a Waste Examination Facility was constructed in Area 5, adjacent to the RWMS. One use of this facility is for repackaging TRU waste prior to shipment to the Waste Isolation Pilot Plant in New Mexico. Assuming no controls, and that the container with the highest content of TRU waste would release all of it, the maximum EDE offsite, as calculated with CAP88PC would have been only 0.004 mrem.

In 1998, operations began in the Big Explosives Experimental Facility. The operations include use of depleted uranium and tritium in various experimental configurations. These operations were explained in Appendix F of the NTS Environmental Impact Statement (DOE 1996a) along with the calculation of offsite EDEs. The calculations indicated that the MEI would receive much less than 0.1 mrem per year. No experiments that involved tritium were conducted in 1998.

UNPLANNED RELEASES DURING CY 1998

All releases on the NTS during CY 1998 were operational. There was a detectable non-NTS release, at the Atlas Facility, located in North Las Vegas, that was a continuance of a 1995 incident (see Appendix A for a description).

SOURCES OF DIFFUSE OR FUGITIVE EMISSIONS

These sources included evaporation from containment ponds that receive liquid effluents from E Tunnel in Area 12 and from groundwater characterization wells in Areas 19 and 20; $^{239+240}Pu$ resuspension from soil deposits on the NTS in Areas 3, 9, other atmospheric test and safety test areas; and seepage of tritium from the SEDAN and SCHOONER craters and from packages buried at the RWMS-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.

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FIGURES

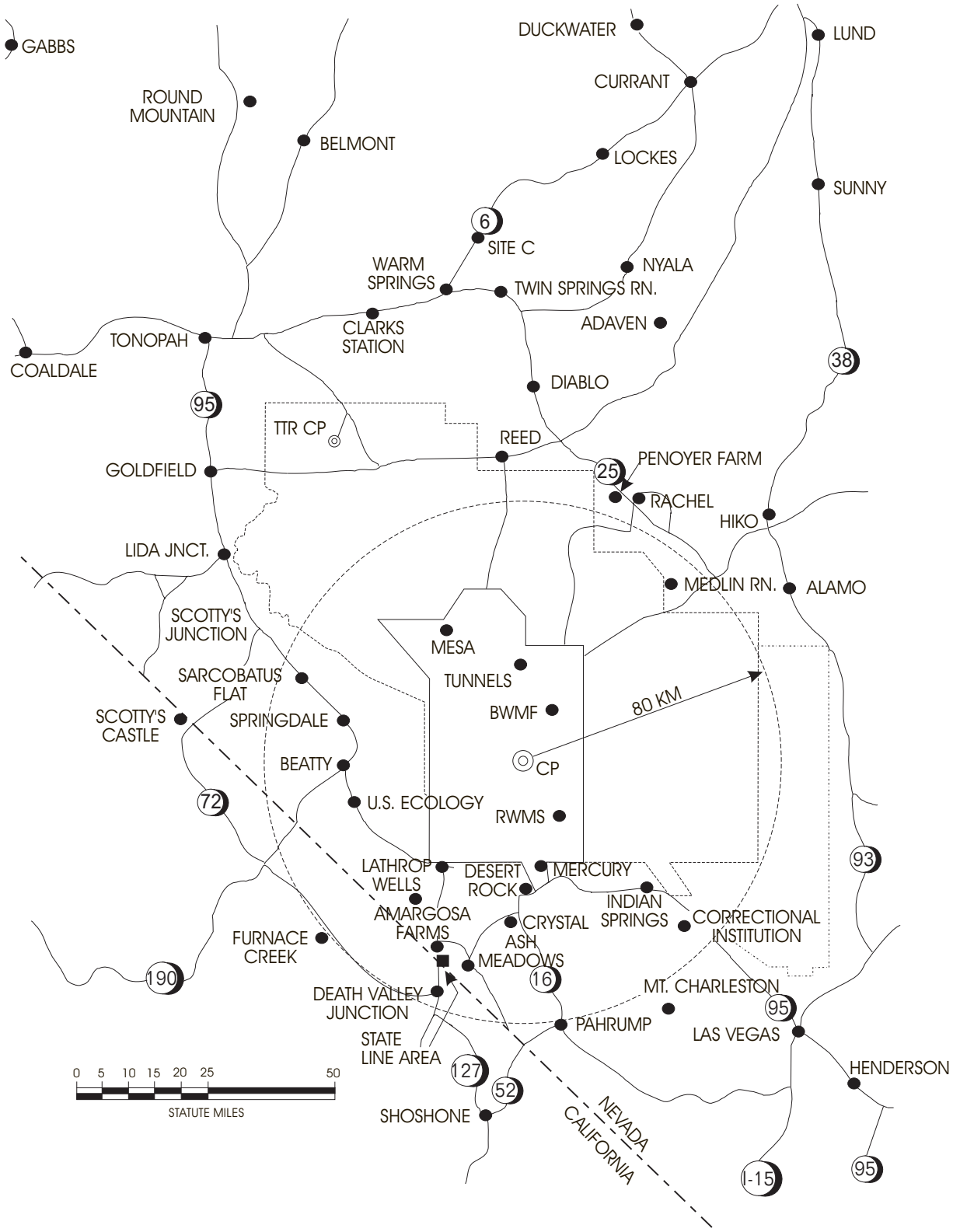

Figure 1.0 Map of the NTS and Surrounding Areas

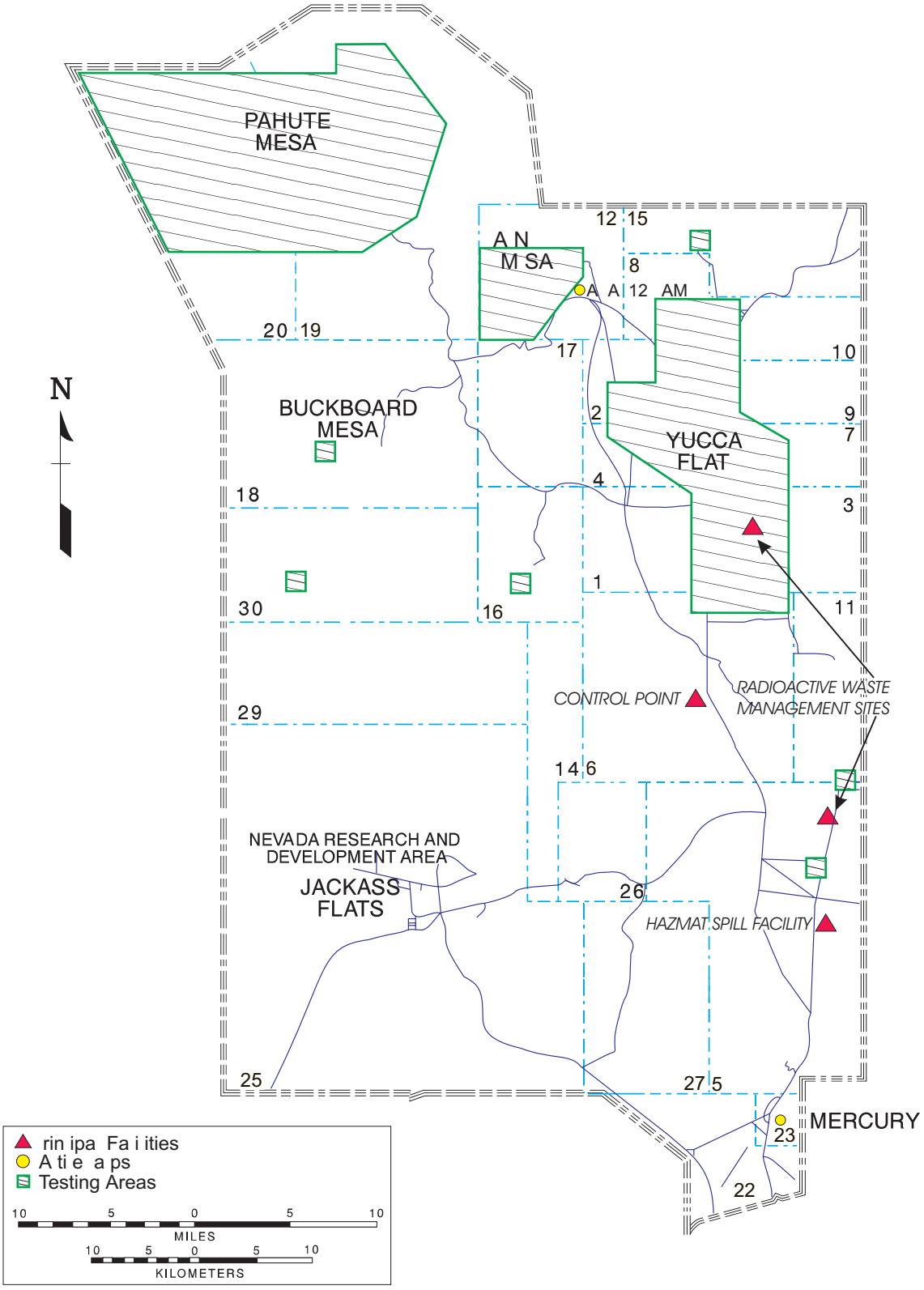

Figure 2.0 Nu ear Testing Areas on the NTS

Figure 3.0 Photograph of Tunnel Containment Ponds (Photo Date Not Available)

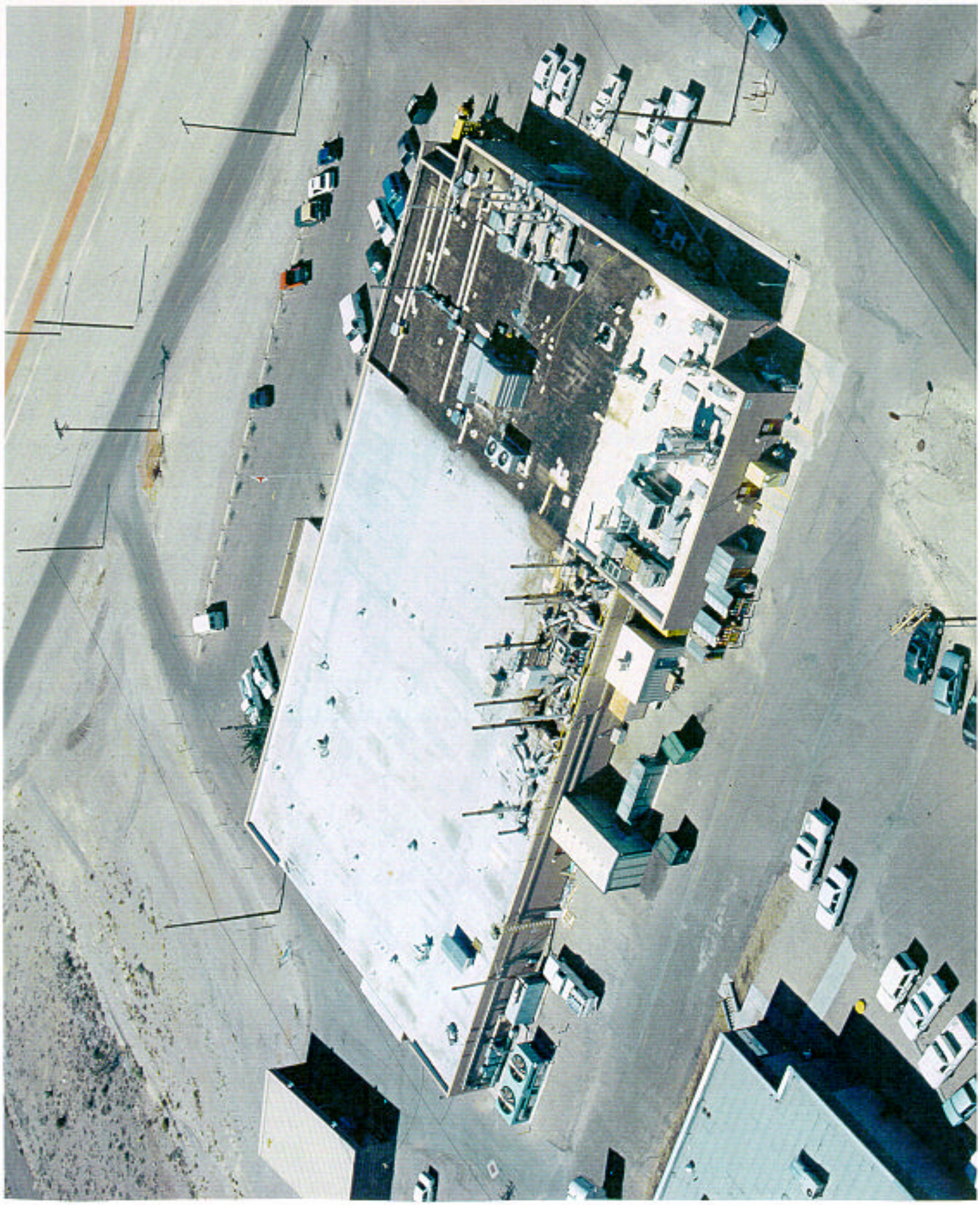

Figure 4.0 Photograph of the Building 650 Hood Ventilation Stacks Seen from Above (Photo Date Not Available)

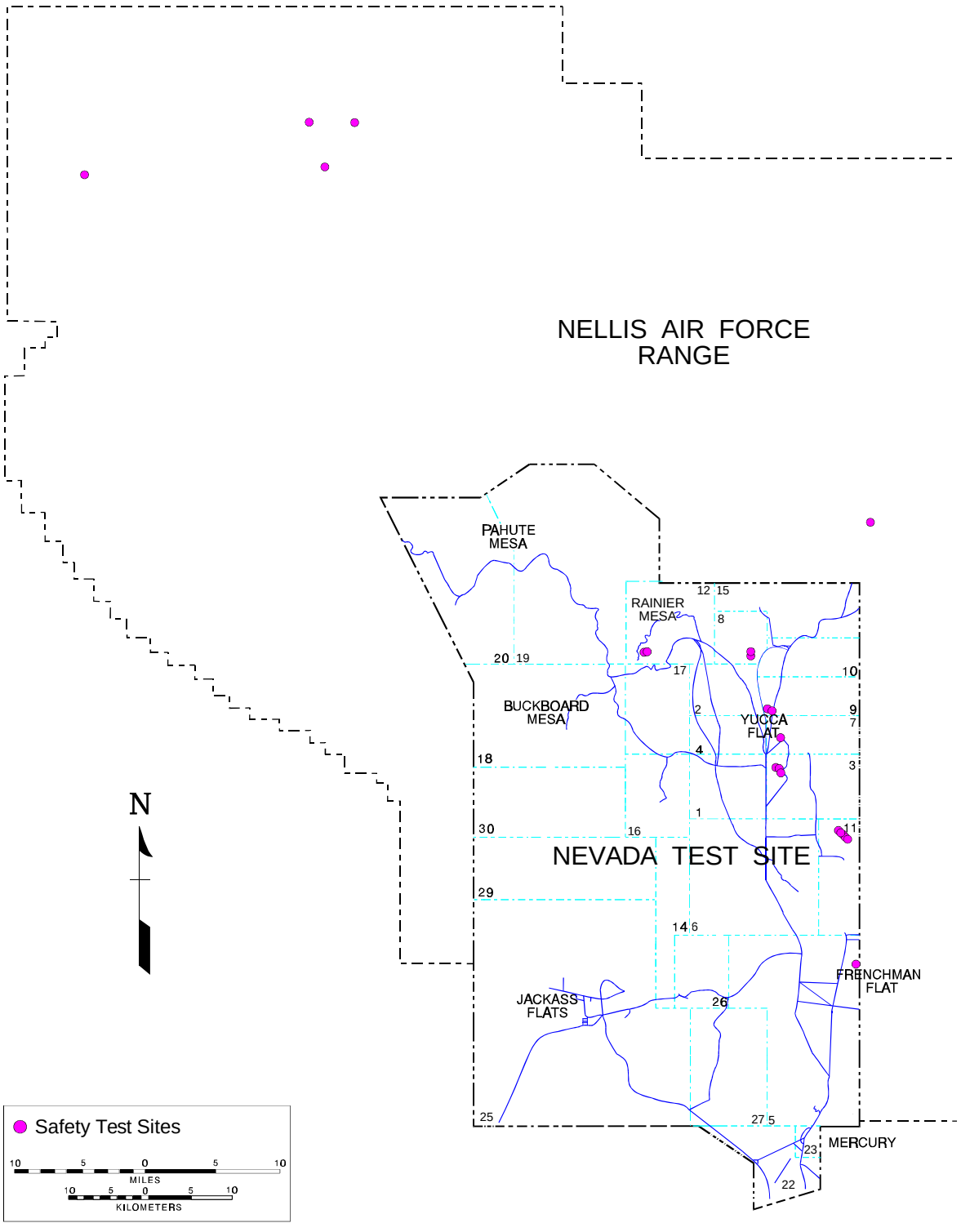

Figure 5.0 Location of Nuclear Device Safety Tests on and Near the NTS

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APPENDICES

APPENDIX A

PUBLIC DOSE CALCULATIONS FOR THE ATLAS TRITIUM INCIDENT

ENVIRONMENTAL SURVEILLANCE

As reported in the 1995 NESHAPs report (DOE 1996c), a container of tritium foils was opened in the Atlas Facility at the North Las Vegas Operations area that emitted about a Ci of ^{3}H into a basement area used as a fixed radiation source range. Environmental surveillance began with notification on Friday, July 14, 1995, that the tritium leak had occurred. Environmental HTO samplers were installed at three locations outside the facility. Later, a HTO sampler was installed in the basement so that progress on cleanup of the spill could be monitored. After cleanup began, the environmental samplers were removed, but the basement air sampler continued operation.

The 1996 and 1997 results and offsite EDEs were reported in the respective annual NESHAPs reports. After a cleanup operation during November and December of 1997, monitoring was reduced to a two-week sample, collected each quarter of 1998. The data accumulated for 1998 are shown in Table A-1 and indicate continued emission of HTO into Building A-1.

The EDE for offsite locations was obtained by using the air sampler results to calculate a total emission from the facility. The method was described in the 1996 NESHAPs report as follows:

- The 1995 data contained results for the environmental samplers and the basement sampler, so a ratio was constructed relating basement air results to the environmental sampler results (1.87×10^{-4}).
- This ratio was used to calculate an average concentration for the sampling at the location where the environmental sampler was located in 1995.
- The dose conversion factor for tritium inhalation (6.4×10^{-8} mrem/pCi), multiplied by 1.5 to correct for skin absorption, and by 8,400 m^3/yr of air breathed by a normal adult, gives an EDE for that sampler location.
- A 1 mCi release was used in CAP88PC, D stability Las Vegas wind data, to obtain an EDE at the location of the air sampler.
- Dividing the calculated EDE from monitoring data, as in step three, by the EDE/mCi from CAP88PC in step four, yields an estimated release in mCi.

As an example of this calculation, use the calculated average data from Table A-1 for the basement sampler (5.1×10^{-9} µCi/mL = 5,100 pCi/m^3) multiplied by the ratio (N sampler/basement sampler = 1.87×10^{-4}) to obtain 0.95 pCi/m^3.

$$EDE = 0.95\ pCi/m^3 \times 1.5 \times 8400\ m^3/yr \times 6.4 \times 10^{-8}\ mrem/pCi$$
$$= 0.00077\ mrem.$$

A CAP88PC run with 1 *mCi release yields* 4.8×10^{-5} *mrem at the sampler position.*

$$\therefore \text{ the estimated effluent would be: } \frac{0.00077\ mrem}{4.8 \times 10^{-5}\ mrem/mCi}$$
$$= 16\ mCi.$$

The CAP88PC run with a 1 mCi emission of tritium also yielded data for other locations around the site, such as the data for the nearest building of 4.8×10^{-6} mrem/mCi released. Assuming there is a person at that location, that individual would be the MEI and the EDE would be 16 mCi x 4.8×10^{-6} mrem/mCi = 7.7×10^{-5} mrem or 0.08 µrem.

CONCLUSION: The best estimate of offsite EDE to the MEI in 1998 from tritium emission from Building A-1 is 0.08 µrem. For comparison, the NESHAPs specifies a limit of 10 mrem to the MEI, far exceeding the calculated exposure.

Table A.1 HTO in Air at the Atlas Facility During 1998

Collection Period (1998)	Building A-11 (µCi/mL)	Building A-1 Basement (µCi/mL)	Building A-11 (pCi/m^3)	Building A-1 (pCi/m^3)
01/05 to 02/02	6.55×10^{-13}		0.7	
02/02 to 02/17	2.43×10^{-12}	4.69×10^{-09}	2.4	4700
02/17 to 03/03	1.81×10^{-12}		1.8	
03/03 to 03/17	4.28×10^{-12}		4.3	
03/17 to 04/06	1.51×10^{-13}		0.2	
04/06 to 04/27	2.37×10^{-12}		2.4	
04/27 to 05/11	-6.54×10^{-13}		-0.7	
05/11 to 06/08	6.26×10^{-13}	5.54×10^{-09}	0.6	5540
06/08 to 06/22	-3.63×10^{-12}		-3.6	
06/15 to 06/29	---	4.65×10^{-09}	---	4650
06/22 to 07/06	2.42×10^{-12}		2.4	
07/06 to 07/20	2.03×10^{-11}		[(a)]20.0	
07/20 to 08/03	2.22×10^{-12}	5.71×10^{-09}	2.2	5710
08/03 to 08/17	1.86×10^{-12}		1.9	
08/31 to 09/14	4.00×10^{-11}		[(a)]40.0	
09/14 to 09/28	2.85×10^{-12}		2.8	
Average			5.3	5100

(a) Elevated levels from drying swamp-cooler pads.

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APPENDIX B

EMISSIONS FROM CONTAINMENT PONDS

EMISSION FROM TUNNELS, PONDS, ETC.

Effluent water from the Area 12 E Tunnel and any containment ponds that receive that water were sampled monthly. These water samples are analyzed for radionuclides by gamma spectroscopy, for gross beta and for tritium (as HTO). Less frequently, other samples are collected for analysis of plutonium and strontium. The flow rate of water discharged from the tunnels was also measured monthly. 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, based on the monthly flow-rate measurements.

In order to calculate doses using CAP88-PC, an airborne source term must be known. By assuming that the total amount of tritium (as HTO) measured in the liquid effluent during the year evaporates and becomes airborne, a conservative estimate of the airborne source term is obtained. It is unlikely that this is a true source term for the containment pond, 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 (see 1995 report) lends credence to this calculation. Despite efforts to seal it, E Tunnel is still a source of HTO to tunnel ponds. The curies of HTO discharged are shown in Table B-1.

In 1998, four wells on Pahute Mesa (Areas 19 and 20) were pumped, and the tritiated water that was pumped from them was discharged to lined containment ponds. The volume and tritium concentration were measured with the results as shown in Table B-1.

Table B-1 Tritium Water Effluents in 1998

Location	Area (m^2)	Total ^3H Discharged (Ci)
Area 12, E Tunnel Pond	336	18.2
Area 19, Well U-19q PS No. 1A	--	1.6
Area 20, Well ER-20-6	--	0.0029
Area 20, Well ER-20-5	--	15.6
Area 20, Well U-20n PS No. 1ddh	--	69.6
Total Effluent		105.0

The MEI for the Area 12 emission resides in Indian Springs, Nevada and would receive an EDE of 6.8×10^{-4} mrem (6.8×10^{-6} mSv).

The MEI for the Area 3 emission resides in Springdale, Nevada and would receive an EDE of 3.6×10^{-6} mrem (3.6×10^{-8} mSv).

A calculation was performed in the 1995 NESHAPs report to estimate tritium emission from the E Tunnel pond during 1994, using the 1992 EPA methods for estimating diffuse emissions. It was concluded that the EPA's methods seriously underestimated the effluent source term; therefore, the calculation was not repeated. For reference, the equation used for that calculation is repeated below. Use of the equation resulted in a source term of 2.4 Ci for 1995 when total evaporation would yield a more conservative source term estimate of 260 Ci.

EVAPORATION OF WATER - EPA's RECOMMENDATION

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

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

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

APPENDIX C

RADIONUCLIDE INVENTORY OF RADIOANALYTICAL LABORATORIES

Analytical Services Laboratory (ASL)

The inventory of radionuclides in the ASL of BN, located in Building 650 at the NTS, 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), and are listed in Table C.1 on the next page.

From the inventory, only three of the items are volatile and may become a source of air emissions. These are ^{3}H (as HTO), ^{129}I, and ^{85}Kr and are listed in Table 2.0. All of the standards and solutions are compared to the possession limits set forth in Title 40 CFR 61 Appendix E, and all are less than 1 percent of those limits as shown in the last column of Table C.1.

Los Alamos National Laboratory

In previous years, this laboratory maintained standards of radioactivity containing ^{133}Xe, ^{131}I, and ^{3}H. Due to the test moratorium that began in 1992, the need for standards was reduced and the only standard of significance for airborne emission maintained in 1998 was 500 µCi of tritium (5×10^{-4} Ci). This quantity is assumed to evaporate over the course of the year and adds to the amount listed above for the ASL.

Device Assembly Facility (DAF) Laboratory

The DAF laboratory is located in Building 301, room 103. It contains about 6.1 Ci of ^{3}H in gaseous form and an insignificant amount in liquid form as HTO.

Radioactive Waste Management Site (RWMS) Laboratory

This laboratory is located in Building 5-6, Area 5. It presently contains 50 µCi of ^{3}H.

Source Term

The source term for these laboratories is calculated by assuming that all the volatile substances are completely released over the course of the year to become an airborne source of exposure.

Table C.1 Building 650 ASL Inventory Compared to NESHAPs Limits

Radionuclide	Annual Inventory (µCi/Year)	Possession Limit (Ci/Year Liquid Form)	Ratio %
H-3	202.000	15000.000	1.3×10^{-6}
C-14	5.100	290.000	1.8×10^{-6}
Fe-55	6.400	140.000	4.6×10^{-6}
Cr-51	0.000	63.000	0.0
Co-57	0.075	1.600	4.7×10^{-6}
Co-60	0.700	0.016	4.4×10^{-3}
Ni-63	6.490	140.000	4.6×10^{-6}
Kr-85	18600.000	840.000	2.2×10^{-3}
Sr-85	0.036	1.900	1.9×10^{-6}
Sr-89	0.190	21.000	9.0×10^{-7}
Sr-90	0.350	0.520	6.7×10^{-5}
Y-88	0.290	0.250	1.2×10^{-4}
Tc-99	6.940	9.000	7.7×10^{-5}
Cd-109	3.200	5.000	6.4×10^{-5}
Sn-113	0.430	1.900	2.3×10^{-5}
I-129	1.510	0.260	5.8×10^{-4}
I-131	0.000	6.700	0.0
Te-123	0.045	1.200	1.3×10^{-6}
Cs-137	0.720	0.023	3.1×10^{-3}
Pb-210	0.500	0.055	9.1×10^{-4}
Ra-226	10.100	0.006	1.8×10^{-1}
Ra-228	0.015	0.013	1.2×10^{-4}
Th-229	0.050	0.001	1.0×10^{-2}
Th-230	0.008	0.003	2.5×10^{-4}
Th-Nat	0.009		--
U-232	0.013	0.001	1.0×10^{-3}
U-Nat	0.120	0.009	1.4×10^{-3}
Np-237	0.013	0.002	7.2×10^{-4}
Pu-238	0.055	0.003	2.2×10^{-3}
Pu-241	0.040	0.130	3.1×10^{-5}
Pu-242	0.006	0.003	2.4×10^{-4}
Am-241	1.420	0.002	6.2×10^{-2}
Am-243	0.001	0.002	2.6×10^{-5}
Cm-244	0.000	0.004	0.0
Alpha Emitters [(a)]	12	0.004	2.8×10^{-1}
Beta Emitters [(b)]	15	0.520	2.9×10^{-3}
Gamma Emitters [(c)]	6	0.016	3.8×10^{-2}

(a) Alpha emitters include thorium, uranium, and TRU waste. The possession limit is that for ^{244}Cm (Title 40 CFR 61 Appendix E, Table 1).

(b) 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 (Title 40 CFR 61 Appendix E, Table 1).

(c) Gamma emitters include the sum of cobalt, chromium, and the mixed gamma sources; the possession limit is for ^{60}Co (Title 40 CFR 61 Appendix E, Table 1).

APPENDIX D

DIFFUSE SOURCE ATMOSPHERIC TRITIUM EMISSIONS

BACKGROUND INFORMATION

Environmental monitoring for tritium in atmospheric moisture was conducted at 12 locations on the NTS during 1998. There were three air samplers around the perimeter of RWMS-5 because many curies of ^{3}H are buried at that facility. Some of these samplers collect HTO at concentrations that are higher than background levels. In 1998, the monitors at the tunnel pond area, near the SEDAN crater, at SCHOONER, and at the Area 15 Farm measured HTO at slightly higher than background concentrations. The monitoring results from these sampling stations are provided in Table D.1. The other CY 1998 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 0.92 Ci (34 Gbq) of ^{3}H were emitted from RWMS-5 during 1998. This source term is calculated to give an EDE of 12×10^{-6} mrem (12×10^{-8} mSv) to an individual residing in Amargosa Valley (Lathrop Wells), Nevada. This is the location of the MEI for a source in Area 5. The method used to calculate this quantity is described below.

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 only 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 E.

The mean annual airborne HTO concentrations from the tritium samplers surrounding the RWMS were used along with the DOE/EH-0071 dose conversion factors to calculate a dose at each sampler location. For example, an individual breathing 14×10^{-12} µCi/mL of HTO (at RWMS No. 4) for one year receives 11×10^{-6} mrem EDE when skin absorption is included[1]. Doses are calculated similarly for the other sampler locations. The result of a CAP88-PC run, assuming a 1 Ci release of ^{3}H at the center of the RWMS, is that an individual 418 m to the northeast (at HTO sampler RWMS No. 4) would receive an EDE of 12×10^{-6} mrem per year. Therefore, 11 measured at that sampler divided by 12/Ci (from CAP88PC) equals an estimated annual release of 0.92 Ci. This calculation was performed for all sampler locations, as shown in Table D.1 and a release of 0.92 Ci (34 GBq) was the maximum from RWMS-5, as shown in the ratio column of Table D.1.

Amargosa Valley, Nevada is located west-southwest of the RWMS at 44 km. Use of CAP88-PC results in an EDE of 12×10^{-6} mrem to an individual residing in Amargosa Valley if 0.92 Ci of HTO were released from the RWMS-5.

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(1) The following equation was used to calculate an EDE at each sampler location.

EDE = $pCi/m^3 \times 8{,}400\ m^3/yr$ (inhaled) x 1.5 (skin abs.) $\times 6.4 \times 10^{-8}$ mrem/pCi
where pCi/m^3 is the annual average HTO concentration.

The other samplers with elevated mean concentration of HTO in air are at the Area 10 SEDAN crater, Area 20 SCHOONER, and the E Tunnel Pond. The E Tunnel Pond emission is calculated in Appendix B. The emission from the SEDAN crater (calculated from air sampler data as above) is shown in the table, assuming SEDAN is the source. It appears unlikely that as much as 140 Ci of HTO are being emitted from the SEDAN crater. However, there is no other likely source for the tritium measured in atmospheric moisture in that area. Therefore, the RWMS-5, SEDAN crater, and SCHOONER are considered to be sources for emission of HTO on the NTS. The sampler at the Decon Pad was only 9 to 12 feet away from the source; therefore, the emission was very small compared to the others and is neglected.

Table D.1 Airborne Tritium Sampling Results During CY - 1998

Sampler Number	Coordinates[a]	Mean µCi/mL	Mean Bq/m^3	Ratio to 1Ci Emission[b]	Comment
BJY		1.0×10^{-12}	0.037		Historical samples
RWMS No. 4	NE 418m	14.0×10^{-12}	0.520	0.94	
RWMS No. 7	W 305m	1.5×10^{-12}	0.055	0.10	
RWMS No. 9	S 305m	2.2×10^{-12}	0.081	0.15	
Well 5B		0.2×10^{-12}	0.009		Background
WEF SW		1.8×10^{-12}	0.067	0.12	
WEF NE		1.4×10^{-12}	0.052	0.10	
Decon Pad		37.0×10^{-12}	1.4	---	Sampler too close
SEDAN Crater	N 1290m	8.5×10^{-12}	0.31	140	
E Tunnel Pond		15.0×10^{-12}	0.56		Use evaporation
Stake T-18		0.1×10^{-12}			
Area 15 Farm		8.8×10^{-12}	0.33		SEDAN effluent
SCHOONER	WNW 269m	140.0×10^{-12}	5.2	45.2	

(a) Sampler direction and distance from center of suspected source.
(b) This ratio equals the number of curies emitted from the source that would give the sampler result.

APPENDIX E

RESUSPENDED PLUTONIUM FROM YUCCA FLAT AND OTHER AREAS

BACKGROUND INFORMATION

Areas 3, 9, 10, 11, 18, 19, and 20 on the NTS, Area 13 on the NAFR, and the CLEAN SLATE sites on the NAFR at the Tonopah Test Range are diffuse sources of radionuclide effluents. Due to operational activities, such as vehicular traffic, equipment operation, etc., some contaminated soil becomes airborne. Results from the air samplers in the areas indicate that $^{239+240}$Pu is routinely detected, but only in concentrations slightly above the MDC. Only a few of the 30 air sampler locations on the NTS had concentrations exceeding the background level by four standard deviations (the criterion used for a high result).

Measurements of airborne $^{239+240}$Pu in Area 3, during CY 1998, are provided in Table E.1. This table displays the number of samples analyzed, the mean value, and the standard deviation of the 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 curies per year 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 five sampling locations (worst-case assumption).

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

		(μCi/mL x 10^{-18})	
Location	Number of Samples	Mean	1 Standard Deviation
Bunker 3-300	11	48	67
U-3ah/at N	15	56	41
U-3ah/at S	12	46	42
U-3bh N	6	22	15
U-3bh S	6	23	14

SOURCE TERM

It is estimated that 12 mCi (0.42 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 effluent monitoring. The method used to calculate this quantity is described below.

The CY 1998 mean 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 the International Commission on Radiological Protection Annual Limits of Intake (using class Y) and 8,400 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 mCi 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/mCi from the CAP88-PC run, then an estimate of the curies released can be obtained.

The following shows a typical calculation, using the second datum in Table E.1 ($\mu Ci/mL \times 10^{12} = pCi/m^3$):

$$56 \times 10^{-6}\ pCi/m^3 \times 8400\ m^3/yr \times 0.33\ mrem/pCi = 0.16\ mrem$$

A CAP88 run using 1 mCi and 1,110 m distance indicates an EDE of 0.097 mrem at the location of the sampler. The ratio of 0.16 mrem (measured) to 0.097 gives 1.6×10^{-3} Ci as an emission. Using the data in the above table indicates the maximum emission (based on the U-3ah/at samplers) would be 1.6 mCi (59 MBq). Wind transport has only extended the boundaries of the plutonium contaminated areas a few meters since the 1960s so it is not very mobile, and, of the amount resuspended, only a fraction would be in particle sizes small enough to be carried very far by the wind. This suggests that the calculated emission may be greater than the actual amount.

Another 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 12 mCi per year. This would yield an EDE of 0.005 mrem to a person in Springdale, Nevada, the offsite MEI.

ERROR TERM

The errors in the measurements are listed in Table E.1 as a standard deviation, so the EDE is most likely between zero and twice the calculated value. 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 for calculating emission. McArthur (DOE 1991) estimates a $^{238+240}Pu$ deposit of 75.6 Ci on 7.5 mi^2 in that area. If the rate of resuspension of that material could be calculated, then a source term would be available.

In NUREG/CR-3332 (NRC 1983), page 5-30, an equation for calculating a suspension rate (fraction resuspended per second) is given 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 (DOE 1992), 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 0.05 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 1×10^{-11} per second, and the source term rate becomes:

$$75.6\ Ci \times 10^{12}\ pCi/Ci \times 1 \times 10^{-11}\ /s = 756\ pCi/s$$

Since 1 year = 3,600 s/hr x 24 hr/day x 365 days/yr = 3.15 x 10^7 s/yr, the annual source term becomes:

756 pCi/s x 3.15 x 10^7 s/yr = 2.38 x 10^{10} pCi/yr (24 mCi/yr)

or, with other suspension rates:

4.76 x 10^9 pCi/yr (4.8 mCi/yr)

Therefore, using the above suspension rate, the emission is between 4.8 and 24 mCi/yr. Using the larger value, this emission was input into the CAP88 program using the Area 9-300 bunker as the midpoint of the source. A similar calculation was performed for all other plutonium contaminated areas on the NTS and the NAFR. That is, the estimate of plutonium deposition on each area, from McArthur, is used with the resuspension equation to obtain the source terms shown in Table E-2.

OTHER ISOTOPES

There are other isotopes that have been found in soil samples in the various areas on the NTS. The predominant isotopes are ^{241}Am, ^{238}Pu, and ^{137}Cs. The cesium isotope is neglected because it migrates readily and, in eight to ten years after assessment in the soil, only a fraction will remain in the surface layer. The other two isotopes are not considered since their contribution is included in the conservative estimates of $^{239+240}$Pu emissions. To illustrate the latter consideration, use data from the 1998 NESHAPs report as follows:

EDE at Amargosa Valley (Table 5.0, total EDE column) = 6.37 x 10^{-2} mrem

$$\frac{0.064\ mrem/yr}{8{,}400\ m^3/yr\ x\ 0.31\ mrem/pCi} = 2.46\ x\ 10^{-5}\ pCi/m^3 = 24.6\ x\ 10^{-18}\ \mu Ci/mL$$

The resulting value should be measured at Amargosa Valley. Table 4.15, in the associated document NTS Annual Site Environmental Report - 1998, shows a value of:

1.9 x 10^{-18} µCi/mL.

So, the calculated value of 24.6 x 10^{-18} µCi/mL is about 13 times the measured value, which is enough to justify ignoring the other isotopes.

Using the equation in EPA's Methods for Estimating Diffuse Emissions (unpublished), a wind erosion calculation for Area 9 as compared with the NTS NESHAPs report calculation can be done. To illustrate this calculation, the equation on page 18 of the EPA report is used:

E' = k· a · I ·K ·C·L' ·V' ·A ·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 = 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 Figure 7-5 (IK = 28 x 0.6=17, L=500 from Table 7-3)
V' = 0.95 (read from Figure 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)

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 in "DOE/NV/10485-02"): 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

Plutonium concentration in dust (assuming all plutonium is in top 5 cm):

1.9 x 10^7 m^2 x 10^4 cm^2/m^2 x 5 cm deep x 1.5 g/cm^3 = 1.4 x 10^{12} g
75.6 Ci x 10^{12} pCi/Ci ÷ 1.4 x 10^{12} g = 53 pCi/g or 53 nCi/kg

and the source-term becomes:

53 x 10^{-9} Ci/kg x 7.0 x 10^7 kg/yr = 3.7 Ci/yr

If the total deposit in Area 9 is 75.6 Ci and the E' calculation performed above is correct, then 75.6 Ci ÷ 3.7 Ci/yr = 20.4 suggests that deposit would be depleted in little more than 20 years.

The resuspension equation calculation (0.0238 Ci/yr) would require about 3,200 years to deplete the deposit.

Table E.2 Offsite EDE Calculated from Resuspension of Plutonium for Areas Sited - 1998 (10^{-3} mrem)

Location	Population	Area 3	Area 9	Area 10	Area 11	Area 13	Area 18	Area 19	CLEAN SLATE	SUM mrem
	Deposit ☞	37 Ci	89 Ci	220 Ci	36 Ci	46 Ci	100 Ci	181 Ci	54 Ci	
Alamo	480			5.8		1.6				0.0074
Amargosa Valley	30	6.8	13	30	6.5		15	11.4		0.0823
Amargosa Center	1100	3.7	11	24	4.0		9.4	9.9		0.062
Ash Meadows	10	4.0			4.1		6			0.0141
Ash Springs	70					1.9				0.0019
Beatty	1600	4.9	11	26	3.8		3.8	29.1		0.076
Clarks Station	2								12	0.012
Crystal	45	3.9	7.8	17	7		19			0.0547
Goldfield	550								4.1	0.0041
Goldpoint	15									0
Hiko	103					1.8				0.0018
Indian Springs	1210	1.4	5.3	11	3.8					0.0215
Lida	15									0
Lida Junction	8							5.2	8.5	0.0137
Medlin's Ranch	2	2.4	6.7	13	2.3	6	2.6	3.6		0.0366
Mercury	550	9.7	12	29	10	3.8	29	5.7		0.0992
Pahrump	20,080									
Penoyer Farm	16	2	5.3	16	1.5	5.5	2.7	7.3	0.85	0.0412

Table E.2 (Offsite EDE Calculated from Resuspension of Plutonium for Areas Sited - 1998 [10^{-3} mrem], cont.)

Location	Population	Area 3	Area 9	Area 10	Area 11	Area 13	Area 18	Area 19	CLEAN SLATE	SUM mrem
Deposit ☞		37 Ci	75.6 Ci	220 Ci	36 Ci	46 Ci	100 Ci	181 Ci	54 Ci	
Rachel	105	1.9	5.1	15	1.6	6	2.6	4		0.0362
Sarcobatus Flat	40	1.2					8.1	16	4.4	0.0297
Silver Peak	200									0
S NV Corr Inst	2000	1.1			1.4					0.0025
Springdale	20	5	11	27	3.8		4.3	37	2.9	0.091
Stateline	70	3.2			4.1		6.9			0.0142
Stone Cabin	6								8.9	0.0089
Tonopah	3300		3.8						4.0	0.0078
Twin Springs	6								2.4	0.0024
US Ecology	35	4.9	10	21	4.2		5.2	15		0.0603
Calculated Emission - mCi		12	28	69	11	14	32	57	17	240

APPENDIX F

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

INTRODUCTION

The NTS is located in southern Nevada, approximately 105 km (65 mi) northwest of Las Vegas, Nevada and encompasses an approximate rectangular area of 1,350 mi^2 (see Figure F.1). Topography is complex with generally north-south oriented ridges and valleys typical of Nevada. Terrain elevations range from almost 2,700 ft in the extreme southwest corner of the NTS (Station No. 25) to almost 7,700 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/NV by the ARL/SORD. The 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 in/yr at Station No. 25 to 6.9 in/yr at Yucca Flat (Station No. 6) to 7.6 in/yr at Desert Rock, to 9.5 in/yr on Rainier Mesa (Station No. 12).

METEOROLOGICAL OBSERVATIONS

The ARL/SORD manages, operates, and maintains a meteorological monitoring program that is designed and used to support the 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 ARL/SORD personnel 24 hr/day, 365 days/yr at the Desert Rock Meteorological Observatory (DRA, elevation 3,304 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 the Yucca Flat Meteorological Observatory (UCC, elevation 3,924 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). The 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 F.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 (see Figure F.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 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 daily. 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 (6,500 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.

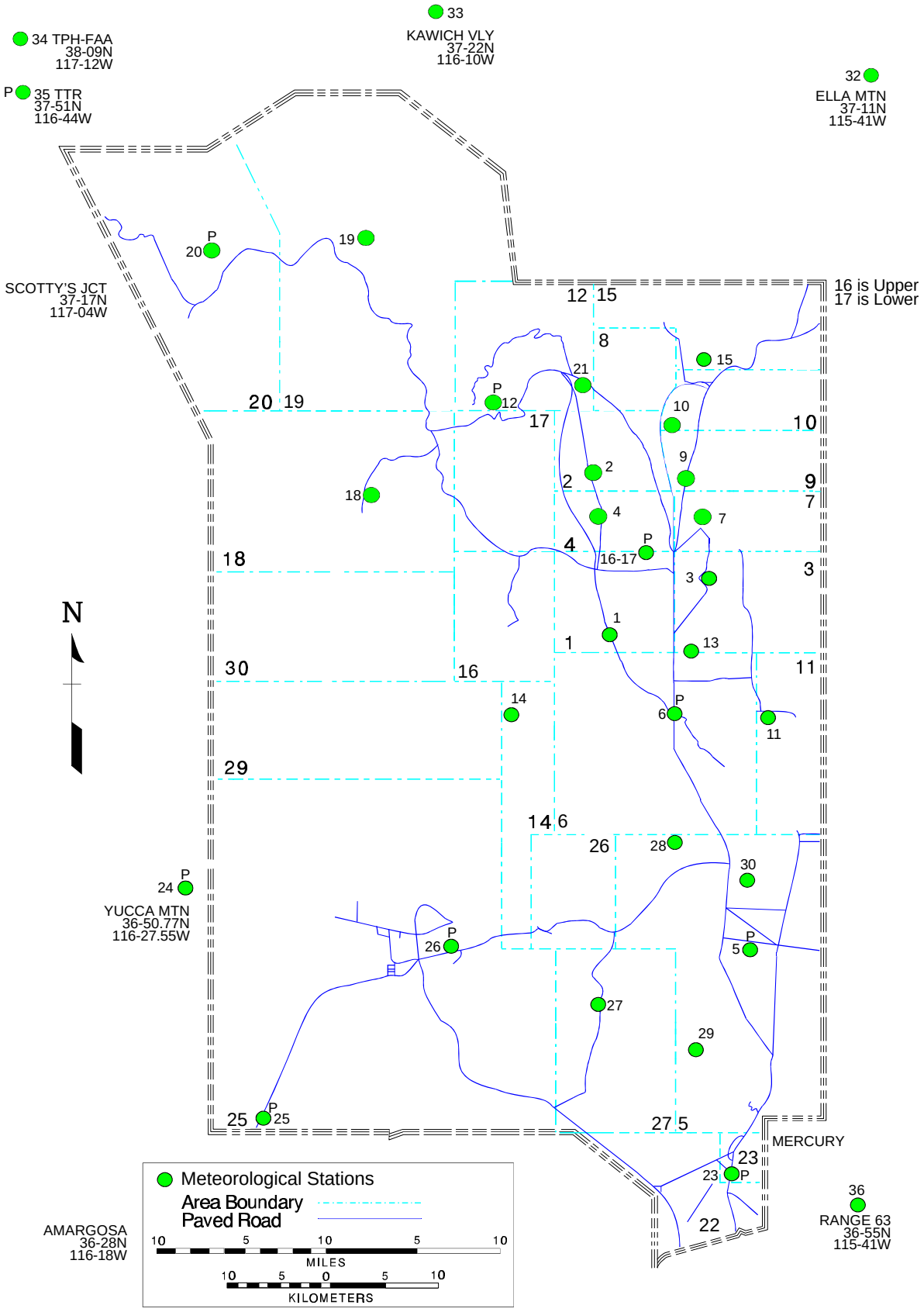

Figure F.1 Location of MEDA Stations on the NTS

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.

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 6 Pasquill stability categories (A through F), 6 wind speed categories, and 16 wind sectors from wind roses calculated for each specified MEDA station on the NTS.

APPENDIX G

SUPPLEMENTAL INFORMATION

COMPARISON WITH PREVIOUS YEARS' DATA

Maximum Potential Individual EDE:
1998 - 9.2 x 10^{-2} mrem (0.92 µSv)
1997 - 9.0 x 10^{-2} mrem (0.9 µSv)
1996 - 1.1 x 10^{-1} mrem (1.1 µSv)
1995 - 1.8 x 10^{-1} mrem (1.8 µSv)
1994 - 1.5 x 10^{-1} mrem (1.5 µSv)
1993 - 3.8 x 10^{-3} mrem (38.0 nSv)
1992 - 1.2 x 10^{-2} mrem (0.12 µSv)

In 1993, tunnel effluents began decreasing because of sealing the tunnel drainage systems. In 1994, resuspension of plutonium from surface deposits was calculated. Area 20 emissions increased this year (krypton seepage and HTO from characterization wells). The 1996 decrease is due to decreased emissions and cleanup of areas. The 1997 decrease was due to decreased emissions, cleanup of areas, and a slight population decrease. The small increase for 1998 is due to increased emissions of tritium.

COLLECTIVE EFFECTIVE DOSE EQUIVALENT

The maximum potential collective effective dose equivalent to the 31,850 people who live within 80 km of the NTS emission sources was 0.27 person-mrem in 1998 due mostly to calculated resuspended plutonium exposure. Tritium exposure was more in 1997 because of the increase in effluent from wells and craters. 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 last column of Table 5.0. 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	67.80
Area 5	0.30
Area 10	1.29
Area 12	0.23
Areas 19/20	2.66
Other Areas	202.14
	274 person-mrem
	(0.27 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 is shown by the calculation displayed in Appendix E, above. The resuspension calculation indicates that 24.6 x 10^{-18} µCi/mL should be measured at Amargosa Valley, whereas only 1.9 x 10^{-18} µCi/mL was actually measured at that location. The calculated value for resuspension is higher by a factor of 13.

COMPLIANCE WITH NESHAPs

DOE/NV was in compliance with Title 40 CFR 61, Subpart H, during CY 1998. Periodic confirmatory measurements and analyses of the NTS environs are provided in Appendices A through E. These measurements and analyses 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 through 1997 annual NESHAPs reports of DOE/NV.

COMPLIANCE WITH SUBPARTS Q AND T, Title 40 CFR 61

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

RADON EMISSIONS FROM ^{238}U AND ^{232}Th SOURCES

Material from Mound Applied Technologies was stored in cargo containers at the RWMS in Area 5. Thermoluminescent dosimeters placed around the containers did not detect any increase in gamma exposure that would have occurred as radon daughters accumulated in the cargo containers. These materials were shipped offsite in 1997 for recycling.

NON-DISPOSAL/NON-STORAGE SOURCES OF RADON EMISSION

None of these sources exist on the NTS.

NESHAP QUALITY ASSURANCE PROGRAM

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

APPENDIX H

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