DOE/NV/25946--3237

National Emission Standards for Hazardous Air Pollutants – Radionuclide Emissions Calendar Year 2016

June 2017

Nevada National Security Site
&
North Las Vegas Facility

Prepared for

U.S. Department of Energy,
National Nuclear Security Administration
Nevada Field Office
Under Contract Number
DE-AC52-06NA25946

Prepared by

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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: Steven J. Lawrence,
Manager, NNSA/NFO

Signature: C Kosha for SJL Date: 06/26/17

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EXECUTIVE SUMMARY

2016 RADIOLOGICAL DOSE TO THE PUBLIC BELOW FEDERAL STANDARD

The U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) operates the Nevada National Security Site (NNSS) and the North Las Vegas Facility (NLVF). From 1951 through 1992, the NNSS was the continental testing location for U.S. nuclear weapons. The release of radionuclides from NNSS activities has been monitored since the initiation of atmospheric testing. After 1962, testing was limited to underground detonations, which greatly reduced radiation exposure to the public. Since nuclear testing ended in 1992, radiation monitoring focused on detecting airborne radionuclides from historically contaminated soils. These radionuclides are derived from re-suspension of soil (primarily by wind) and emission of tritium-contaminated soil moisture through evapotranspiration. Low amounts of legacy-related tritium are also emitted to air at the NLVF, an NNSS support complex in North Las Vegas.

To protect the public from harmful levels of man-made radiation, the Clean Air Act, National Emission Standards for Hazardous Air Pollutants (NESHAP) (Title 40 Code of Federal Regulations [CFR] Part 61 Subpart H) (CFR 2010a) limits the release of radioactivity from a U.S. Department of Energy (DOE) facility to that which would cause 10 millirem per year (mrem/y) effective dose equivalent to any member of the public. This limit does not include radiation unrelated to NNSS activities. Unrelated doses could come from naturally occurring radioactive elements, from sources such as medically or commercially used radionuclides, or from sources outside of the United States, such as Japan's Fukushima nuclear power plant, which was damaged in 2011.

NNSA/NFO demonstrates compliance with the NESHAP limit by using environmental measurements of radionuclide air concentrations at critical receptor locations on the NNSS (U.S. Environmental Protection Agency [EPA] and DOE 1995). This method was approved by the EPA in 2001 (EPA 2001a) and has been the sole method used to demonstrate compliance with the 40 CFR 61.92 dose standard since 2005. Six locations on the NNSS have been established to act as critical receptor locations to demonstrate compliance with the NESHAP limit. These locations are actually pseudo-critical receptor stations because no member of the public resides at these onsite locations. Compliance is demonstrated if the measured annual average concentration is less than the NESHAP Concentration Level (CL) for Environmental Compliance listed in 40 CFR 61, Appendix E, Table 2 (CFR 2010a). For multiple radionuclides, compliance is demonstrated when the sum of the fractions (determined by dividing each radionuclide's concentration by its CL and then adding the fractions together) is less than 1.0.

In 2016, the potential dose from radiological emissions to air, resulting from both current and past NNSS activities, was well below the 10 mrem/y dose limit. Air sampling data collected at all air monitoring stations had average concentrations of radioactivity that were a fraction of the CL values. Concentrations ranged from 0.2% to a maximum of 6.0% of the allowed NESHAP limit. Because the nearest member of the public resides about 9 kilometers from potential release points on the NNSS, dose to the public would be a fraction of the value measured on the NNSS. The potential dose to the public from NLVF emissions was also very low at 0.000011 mrem/y, almost six orders of magnitude lower than the 10 mrem/y limit.

NESHAP Compliance for 2016

NNSS: Compliance Demonstrated by the Sum of Fractions at Each Critical Receptor Sampler Being Less Than 1.0		
Radionuclides Included: ^{3}H, ^{137}Cs, ^{238}Pu, $^{239+240}$Pu, ^{241}Am		
NNSS Operations Area	**Critical Receptor Location**	**Sum of Fractions of CLs**
6	Yucca	0.011
10	Gate 700 S	0.017
16	3545 Substation	0.002
20	Schooner	0.060
23	Mercury	0.004
25	Gate 510	0.003
NLVF: Compliance Demonstrated by the Highest Potential Offsite Dose Being Less Than 10 mrem/y		
Estimated offsite dose from NLVF = 0.000011 mrem/y		

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List of Acronyms and Abbreviations

Am	americium
Ar	argon
ARL/SORD	Air Resources Laboratory, Special Operations and Research Division
Au	gold
BEEF	Big Explosives Experimental Facility
C	carbon
°C	degrees Celsius
CAP88-PC	Clean Air Package 1988 (EPA software program for estimating doses)
CFR	Code of Federal Regulations
Ci	curie(s)
Cl	chlorine
CL	Concentration Level
cm	centimeter(s)
Co	cobalt
Cs	cesium
Cu	copper
CY	calendar year
d	day(s)
DAF	Device Assembly Facility
DOE	U.S. Department of Energy
DPF	Dense Plasma Focus
DRA	Desert Rock Meteorological Observatory
DU	depleted uranium
E	east
EDE	effective dose equivalent
EPA	U.S. Environmental Protection Agency
Eu	europium
ft^3/min	cubic feet per minute
h	hour(s)
^3H	tritium
HEPA	high efficiency particulate air
HTO	tritiated water in the form of $^3H^3HO$ or ^3HHO
I	iodine if with atomic mass superscript
In	indium
JASPER	Joint Actinide Shock Physics Experimental Research
K	potassium
km	kilometer(s)
km^2	square kilometer(s)
Kr	krypton
L	liter(s)
LLW	low-level waste
m	meter(s)
mCi	millicurie(s)
mCi/y	millicurie(s)/year
MEDA	Meteorological Data Acquisition
MEI	maximally exposed individual
MIDNET	Meteorological Integrated Data Network
min	minute(s)
mrem/y	millirem per year

List of Acronyms and Abbreviations (continued)

µrem/y	microrem per year
m/s	meter(s) per second
N	north or nitrogen (nitrogen if with atomic mass superscript)
Na	sodium
NCERC	National Criticality Experiments Research Center
NESHAP	National Emission Standards for Hazardous Air Pollutants
NLVF	North Las Vegas Facility
NNSA/NFO	U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office
NNSS	Nevada National Security Site
NOAA	National Oceanic and Atmospheric Administration
NPTEC	Nonproliferation Test and Evaluation Complex
NTTR	Nevada Test and Training Range
O	oxygen
Ops	Operations
P	phosphorus
pCi	picocurie(s)
pCi/L	picocurie(s) per liter
pCi/m^3	picocurie(s) per cubic meter
Pu	plutonium
RIDP	Radionuclide Inventory and Distribution Program
rem	roentgen equivalent man
RNCTEC	Radiological/Nuclear Countermeasures Test and Evaluation Complex
RWMC	Radioactive Waste Management Complex
RWMS	Radioactive Waste Management Site
s	second(s)
S	south
Sr	strontium
STAR	Stability Array (grouping of meteorological data)
TRU	transuranic (nuclides with atomic numbers greater than uranium)
UCC	Yucca Flat Meteorological Observatory
UGTA	Underground Test Area
W	west
Xe	xenon
y	year(s)

Report Information

U.S. Department of Energy
National Nuclear Security Administration
Nevada Field Office
Air Emissions Annual Report
(under Subpart H, Title 40 Code of Federal Regulations [CFR] 61.94)
Calendar Year (CY) 2016

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SECTION I
FACILITY INFORMATION

SITE DESCRIPTION

The Nevada National Security Site (NNSS) is operated by the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) as the site for maintaining and enhancing the safety, security, reliability, and performance of the U.S. nuclear weapons stockpile; reducing global danger from weapons of mass destruction; and responding to nuclear and radiological emergencies in the U.S. and abroad. The NNSS is also an operational site for environmental restoration, low-level radioactive waste management, and groundwater characterization activities. Located in Nye County, Nevada, the site's southeast corner is about 105 kilometers (km) northwest of the major population center, Las Vegas, Nevada. The NNSS covers about 3,523 square kilometers (km^2) and is 46 to 56 km east to west and 64 to 88 km north to south. The NNSS is surrounded, except on the south side, by the Nevada Test and Training Range (NTTR), a public exclusion area that provides another 24 to 104 km between the NNSS and publicly accessible land (Figure 1). The NNSS is characterized by desert valley and Great Basin mountain topography, with climate, flora, and fauna typical of the southwest deserts. Based on the most recent census data (2010), there were 438,544 people residing within 80 km of the NNSS boundary. The distribution of this population, as demonstrated with LandScan data (2014 distribution data from the Geographic Information Science & Technology Group, Oak Ridge National Laboratory 2015), is concentrated in the metropolitan areas of Las Vegas and North Las Vegas to the southeast and in the town of Pahrump to the south (Figure 1). These more populated areas drive the overall average population density up to about 1.2 person/km^2, but the vast majority of the area within 80 km of the NNSS is uninhabited. The nearest populated location to the NNSS boundary is the north end of Amargosa Valley, which extends to within 3.4 km of the southwest corner of the NNSS. Two mines are also relatively near the boundaries of the NNSS: the American Silica mine, 2.7 km east from the southeast edge of the NNSS, and the Cinder Cone Pit mine, 5.5 km west of the southwest corner of the NNSS. The American Silica mine was not in operation during 2016 but was still identified on maps for reference. Two dairies operated within 80 km of the NNSS during 2016. Both are located in Amargosa Valley at a distance of about 16.1 km from the NNSS boundary. Agriculture around the NNSS is sparse and consists primarily of alfalfa fields, which are found mainly in Amargosa Valley, Pahrump, Penoyer Farm, Reed's Ranch, and locations between Alamo and Hiko. There is also a 60-acre orchard/farm in Las Vegas, 73.3 km east-southeast of the NNSS, which sells produce directly to the public. Sparse livestock production may occur in any of these general areas. A 153-acre pig farm in North Las Vegas that normally contained about 2,500 animals, halted operations during 2016. This farm is more than 80 km from the NNSS but is 5.9 km north of the North Las Vegas Facility (NLVF). Food for the pigs came from leftovers supplied by various Las Vegas casino buffets.

The NLVF is an 80-acre complex composed of buildings that house much of the NNSS project management, diagnostic development and testing, design, engineering, and procurement operations. This facility is located along Losee Road in the city of North Las Vegas and is surrounded on the north, south, and east by general industrial zoning. The western border separates the property from fully developed, single-family residential-zoned property.

SOURCE DESCRIPTION

In 1950, the now-named NNSS was established as the primary location for testing the nation's nuclear explosive devices. Such testing took place from 1951 to 1992. Historical testing included (1) atmospheric testing in the 1950s and early 1960s, (2) underground testing between 1951 and 1992, and (3) open-air nuclear reactor and rocket engine testing between 1959 and 1973 (U.S. Department of Energy [DOE] 2013). No nuclear tests have been conducted since September 23, 1992 (DOE 2013). The environmental legacy of nuclear weapons and other testing on the NNSS is a major source of radionuclides that are released into the air. They are characterized as non-point (diffuse) sources and include (1) areas of radioactively contaminated surface soils, (2) contaminated

groundwater that is pumped or flows naturally to the surface, (3) radioactive waste storage and burial sites, and (4) radiologically contaminated structures and materials being decommissioned, demolished, and/or managed.

Surfaces contaminated with plutonium (Pu), americium (Am), tritium (^{3}H), and fission and activation products from past nuclear device safety, atmospheric, or cratering test activities could become sources of radionuclide exposure to the public if the radionuclides were to be re-suspended, for example, through evaporation or transpiration of ^{3}H in water, by windy conditions, surface cleanup, construction, vehicular travel, or similar activities for radionuclides associated with particulates. In 1981, DOE began a project known as the Radionuclide Inventory and Distribution Program (RIDP). After 5 years of field work and 3 years of data analysis, the result was a report that identified the inventory and described the distribution of radionuclides in the soil in parts of the NNSS affected by NNSS operations (DOE 1991) (Table 1). The inventory includes an estimate of the curies (Ci) of the manmade radionuclides detected and reported by the RIDP. Though the inventory includes cobalt-60 (^{60}Co), strontium-90 (^{90}Sr), cesium-137 (^{137}Cs), and the europium (Eu) isotopes ^{152}Eu, ^{154}Eu, and ^{155}Eu, their concentrations in air samples are generally below detection levels and collectively contribute less than 10% to total dose, which is the threshold for required measurement per 40 CFR 61.93(b)(4)(i). Figure 2 shows areas of elevated exposure rates due to radionuclides in NNSS soils as measured by an aerial survey conducted in 1994 (Hendricks and Riedhauser 1999).

Table 1. Inventory of Manmade Radionuclides in NNSS Surface Soil[(a)]

Area	Radionuclide inventory (Ci)[(b)]								
	^{241}Am	^{238}Pu	$^{239, 240}$Pu	^{60}Co	^{137}Cs	^{90}Sr	^{152}Eu	^{154}Eu	^{155}Eu
1	6.0	5.3	24.0	0.0	4.8	7.9	3.9	0.0	0.0
2	4.6	7.0	22.0	0.0	13.1	24.3	3.6	0.0	0.0
3	7.4	2.5	37.0	0.0	6.5	17.4	4.6	0.0	0.0
4	9.6	10.5	40.0	0.0	6.5	6.9	2.3	0.0	0.0
5	1.0	0.1	4.8	0.0	0.2	0.5	2.6	0.0	0.0
6	2.3	2.7	8.4	0.0	1.5	1.9	0.0	0.0	0.0
7	3.4	0.5	16.0	0.0	2.8	4.9	5.7	0.0	0.0
8	25.3	6.5	109.9	0.2	22.9	13.2	1.1	0.0	0.0
9	11.3	1.8	88.9	0.0	4.7	6.9	5.9	0.0	0.0
10	27.2	15.4	109.9	0.3	45.7	29.1	0.6	0.0	0.1
11	5.5	0.4	29.0	0.0	0.3	0.2	0.0	0.0	0.0
12	8.7	6.9	39.0	0.0	10.9	9.0	0.0	0.0	0.0
15	12.8	6.3	63.0	0.0	10.3	11.6	0.0	0.0	0.0
16	1.0	1.2	3.7	0.0	1.6	2.0	0.0	0.0	0.0
17	4.2	3.7	18.0	0.0	8.2	10.0	0.0	0.0	0.0
18	26.4	4.5	99.9	0.0	5.4	9.0	0.3	0.0	0.0
19	31.6	26.0	139.9	0.0	19.6	16.4	0.0	0.0	0.0
20	25.4	24.3	41.0	0.2	3.0	2.3	3.4	0.2	0.1
25	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	4.2	3.7	14.0	0.0	0.8	0.7	0.2	0.0	0.0

(a) Source of inventory from DOE (1991) and includes radionuclides in soil within 0–30 centimeters (cm) of the surface with most activity in the top 5 cm.
(b) Decay corrected to June 15, 2016, with ingrowth of ^{241}Am from ^{241}Pu included.

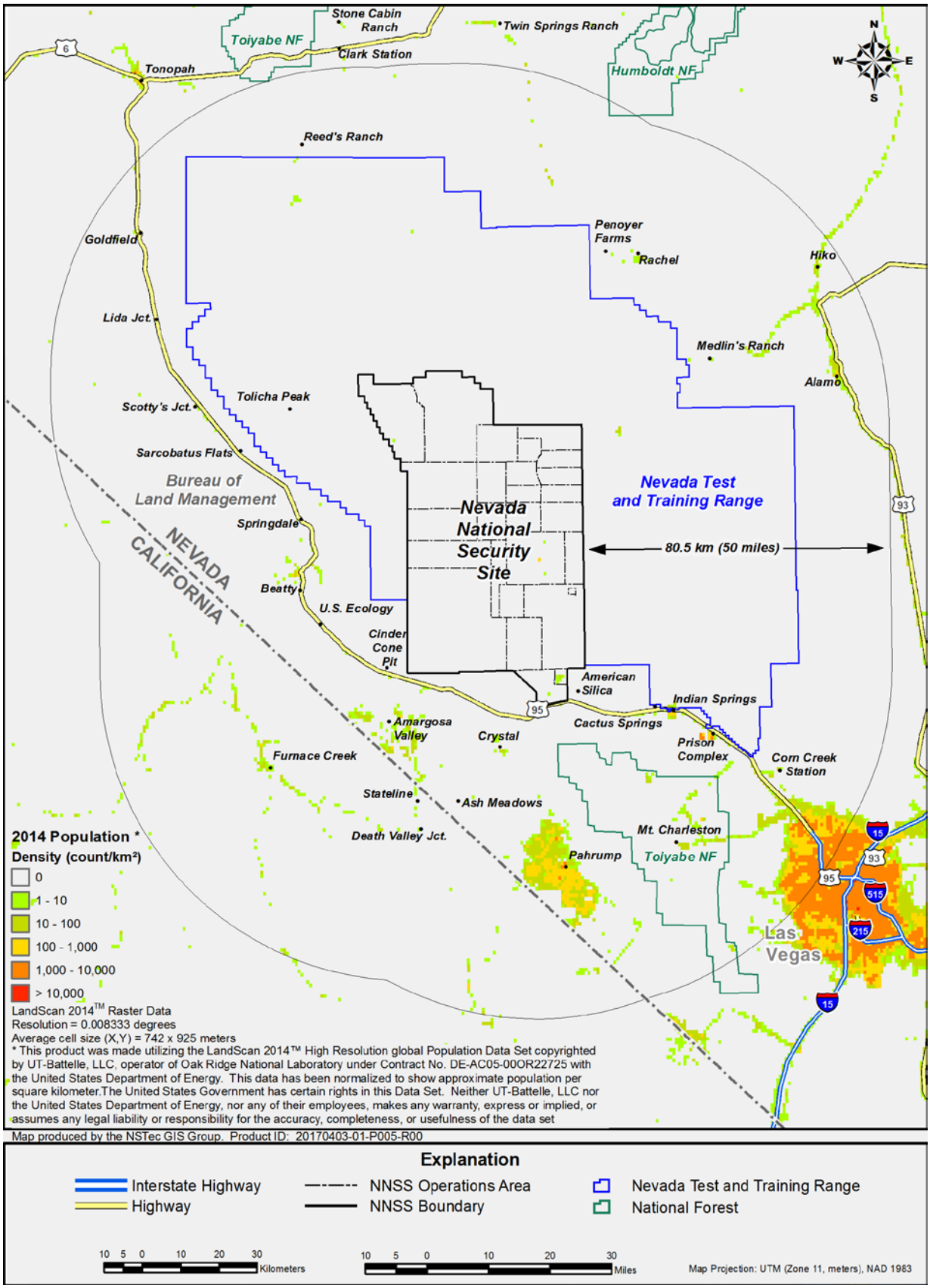

Figure 1. NNSS and Surrounding Populated Area

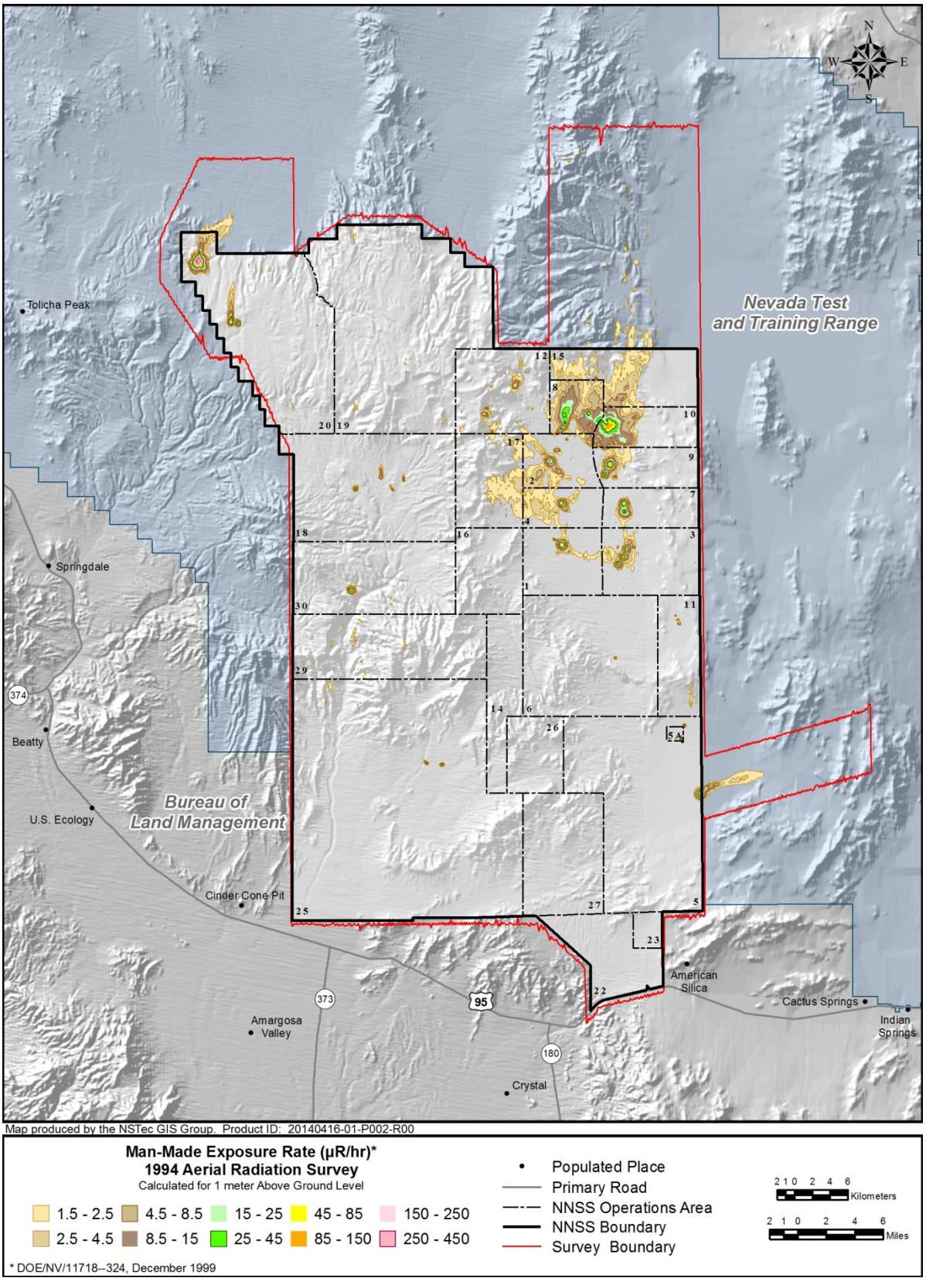

Figure 2. Distribution of Elevated Exposure Rates from Radionuclides in NNSS Soils

Current missions of the NNSS include (1) conducting high-hazard operations in support of defense-related nuclear and national security experiments; (2) providing support for homeland security activities, national security, and nonproliferation technology development and research; (3) characterizing and remediating the environmental legacy of past nuclear testing; and (4) managing and disposing of radioactive wastes. A few programs and experiments at the NNSS use or handle radioactive materials in specific facilities. In all such facilities, radioactive materials are controlled in accordance with Title 10 Code of Federal Regulations (CFR) Part 835, "Occupational Radiation Protection" (CFR 2010b). The primary facilities that have key NNSA/NFO missions that have unsealed radioactive material and are potential sources for radiological air emissions are shown in Figure 3. Radionuclides potentially present at these facilities include various isotopes of Pu, Am, and U, as well as ^{3}H, ^{60}Co, ^{137}Cs, and various short-lived activation products. Radioactive emissions are not necessarily produced from these facilities in a given year, but all have the potential for radioactive emissions. These key facilities that are potential NNSS sources include the following:

- Area 3 Radioactive Waste Management Site (RWMS)
- Area 5 Radioactive Waste Management Complex (RWMC)
- Big Explosives Experimental Facility (BEEF)
- Dense Plasma Focus (DPF) Facility
- Device Assembly Facility (DAF)
- Joint Actinide Shock Physics Experimental Research (JASPER)
- National Criticality Experiments Research Center (NCERC), located inside the DAF
- Nonproliferation Test and Evaluation Complex (NPTEC)
- Radiological/Nuclear Countermeasures Test and Evaluation Complex (RNCTEC)
- T1 Training and Exercise Area
- Tumbleweed Test Range
- U1A Complex

There are also buildings where radioactive material may be surveyed, processed, and/or analyzed: Buildings 23-180, 23-600, 23-650, 23-652, and 23-703, all in Mercury in Area 23 (Figure 3). Handling of radioactive material in these buildings is limited and consists primarily of handling of environmental samples and laboratory standards containing radioactive material. Although the amounts of radioactive material in the environmental samples and laboratory standards are low, and therefore the potential emissions from them are also very low, they are still included as sources.

All facilities and activities from which radionuclides were known to be released to air in calendar year (CY) 2016 are listed in Section II, Table 2, and their source information is listed in Appendix A, Table A.1.

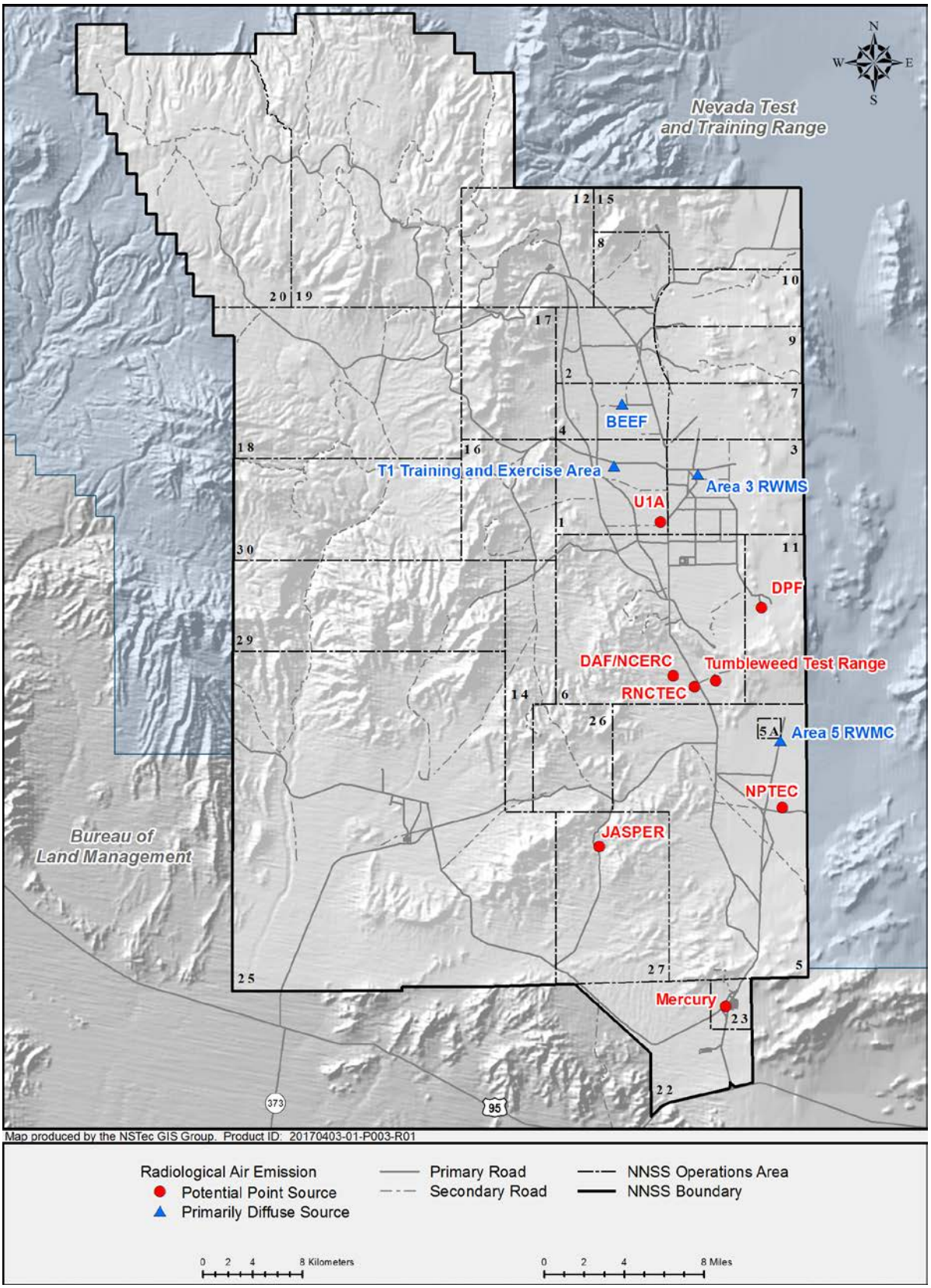

Figure 3. Primary Facilities with Potential to Release Radionuclides to Air

SECTION II
AIR EMISSIONS DATA

Facilities and operations from which radionuclides were released to the atmosphere during CY 2016 are listed in Table 2, and their source information is listed in Appendix A. Their locations are displayed in Figure 4. Releases for the year are grouped into four general source categories: (1) legacy contamination sites; (2) defense, security, and stockpile stewardship; (3) radioactive waste management; and (4) support facility operations. CY 2016 emission sources by category are described below.

Legacy Contamination Sites

The environmental legacy of nuclear weapons and other testing on the NNSS is a major source of radionuclides that are released into the air. They are generally characterized as non-point (diffuse) sources and include:

Weapon Test and Plowshare Soil Contamination Sites

Three general soil contamination locations are listed for emission sources in this category. Two of them, Sedan and Schooner, are craters from the Plowshare program, which used nuclear devices to demonstrate their ability to excavate large amounts of earth. They are specifically listed separately from other test locations because they dominate the legacy contamination sites for ^{3}H emissions. The derivation of ^{3}H emission estimates from these locations is described in Appendix B. The third general location, referred to as "Grouped Area Sources," is a grouping of all large areas impacted by past nuclear testing on the NNSS. This grouping is used to report emissions of radionuclides in particulate form due to soil resuspension caused by wind. The derivation of this emission is described in Appendix C.

Emanation from Building Materials

At the NLVF, parts of the Building A-01 basement were contaminated with ^{3}H in 1995. Emanation of tritiated water in the form of $^{3}H^{3}HO$ or ^{3}HHO (collectively referred to as HTO) from these building materials has persisted at continually decreasing levels. These emissions are exhausted from the building through the ventilation system. A description of the incident and the potential effective dose equivalent (EDE) for offsite exposure during CY 2016 are presented in Appendix D.

Groundwater Characterization/Control and Remediation Activities

Groundwater containing radionuclides associated with legacy contamination can be brought to the surface through either groundwater flow through fissures and man-made tunnels or through active pumping.

Environmental Restoration Corrective Action Site 12-59-01, E-Tunnels, has a component consisting of water contaminated from historical nuclear weapons testing flowing into collection ponds (E-Tunnel Ponds). The only radiological contaminant that produces a measurable air emission is ^{3}H evaporating as HTO. Calculation of this emission source for CY 2016 is described in Appendix E.

Underground Test Area (UGTA) activities include the task of characterizing the aquifers at sites of past underground nuclear tests. To characterize the groundwater regime, suitable wells are drilled and existing wells re-completed and sampled as determined by hydrologists. During these drilling and sampling operations, water is pumped to the surface. This water is then available for evaporation. Again, the only contaminant producing a measurable air emission from this evaporating water is ^{3}H as HTO. During CY 2016, water containing ^{3}H was pumped from the following wells:

- ER-2-2, Area 2
- UE-2ce, Area 2
- ER-4-1, Area 4
- RNM #2s, Area 5
- UE-5n, Area 5
- ER-20-12, Area 20

These well locations are displayed in Figure 4. Calculation of the ^{3}H emission from water pumped from them is described in Appendix E.

The 1995 ^{3}H contamination of the NLVF Building A-01 basement mentioned above also affected an inactive radiation source well that had since been filling with water due to the soil bottom in the well and a rise in groundwater. This source well was sealed in 2001 and a pump was installed to remove the residual ^{3}H contaminated water. The State of Nevada approved disposing of the contaminated water near the Area 23 Sewage Lagoons at the NNSS. However, no tritium has been detected in this water since April 2013, so no tritium emission is calculated from this source for CY 2016.

There were no Environmental Restoration demolitions or cleanup projects conducted on the NNSS during CY 2016 that had a potential for radionuclide emissions to air.

Defense, Security, and Stockpile Stewardship

This category consists of activities that make up the bulk of the current mission for the NNSS.

The Defense Experimentation and Stockpile Stewardship Directorate provides unique resources to maintain the integrity of the United States' nuclear weapons stockpile through weapons testing without nuclear detonation. The Nuclear Operations Directorate supports this mission through its nuclear and high-hazard facility management.

Certain experiments conducted under these directorates have the potential for radioactive emissions. Primary facilities for this are DAF, NCERC (located within the DAF), DPF, U1A, BEEF, JASPER, and tunnel facilities.

The Global Security Directorate conducts work to strengthen national security by providing real-world testing, evaluation, and training venues. Certain activities under this directorate have the potential for radioactive emissions. The primary facilities for this are the T1 Training and Exercise Area, RNCTEC, NPTEC, and the Tumbleweed Test Range. Certain experiments using radioactive materials are also conducted in remote locations of the NNSS.

The facilities and projects in this category from which radionuclides were released during CY 2016 are the DU Experiment in Area 2, the NPTEC in Area 5, the NCERC in Area 6, and the DPF in Area 11. BEEF is also a location that includes wide area soil contamination associated with historical testing, so it is included in the "Grouped Area Sources" within the Legacy Weapon Test and Plowshare Soil Contamination Sites category mentioned above.

Radioactive Waste Management

The Area 3 RWMS and the Area 5 RWMC are used for the disposal of packaged, dry, low-level waste in pits and trenches. The Area 5 RWMC also has facilities for waste examination and repackaging activities, the accumulation of mixed waste, and the storage of transuranic (TRU) and mixed TRU wastes. Concrete pads are used for temporary storage of these wastes. The only radioactive emission detected by the various types of samplers located downwind of these sites and attributed to waste operations was ^{3}H as HTO in atmospheric moisture. The calculation of the ^{3}H source term for these emissions in CY 2016 is described in Appendix B.

Support Facility Operations

Facilities with laboratories as described in Section I have the potential to emit low quantities of radionuclides from handling or processing contaminated material (primarily samples) or from the preparation of ^{3}H standards that are used for quality assurance purposes. Also, the Radiological Control Department has the responsibility of conducting receipt surveys of any radioactive materials arriving at

the NNSS. If packaging is damaged, materials must be handled during repackaging, which creates the potential for low-level air emissions. These activities generally take place at Radioactive Materials Control, Building 23-180. Of these support facilities, only operations in Buildings 23-600, 23-652, and 23-703 were known to use unsealed radioactive materials in CY 2016; therefore, they were the only facilities in this category listed as being emission sources in CY 2016.

Each potential source of NNSS emissions for CY 2016 was characterized by one of the following methods:

- Identifying the radionuclide inventory and determining losses of radionuclides that were released to the environment
- Measuring the HTO concentrations in liquid effluents discharged and proceeding as if all the effluent evaporates over the course of the year to become an air emission
- Using re-suspension calculations
- Using a combination of environmental measurements and the Clean Air Package 1988 (CAP88-PC) air dispersion model (EPA 2006) to calculate the emissions

Distances and directions from all CY 2016 emission sources to the nearest offsite locations of interest are listed in Table 2. Distances ranged from 20 to 72 km from NNSS emission sources and from 0.1 to 0.85 km from the NLVF emission source.

Total CY 2016 emissions, by radionuclide, are shown in Table 3 for the NNSS and in Table 4 for the NLVF. Radionuclide emissions by source are shown in Table 5. The source type, emission control (for example, high efficiency particulate air (HEPA) filters), and description of the nature of each emission are listed in Table A.1 of Appendix A. Appendices B through E describe the methods used to determine the CY 2016 emissions.

Radionuclides making up about 49% of the total activity emitted from the NNSS during CY 2016 have very short half-lives. These range from 7 seconds for nitrogen-16 to 37 minutes for chlorine-38. Due to these short half-lives, much of the activity is lost due to physical decay over the time it takes to travel the long distances to offsite receptors (Table 2). The Emission Category listing in Table A.1 in Appendix A shows the range of potential dose these may contribute to maximally exposed individuals offsite.

Table 2. CY 2016 Radionuclide Emission Sources and Distance to Offsite Locations

	Distance[a] and Direction[b] to Nearest Offsite Locations		
Emission Source	**Offsite Residence**	**Offsite Business/Office**	**Offsite School**
Legacy Contamination Sites			
Weapon Test and Plowshare Soil Contamination Sites			
Sedan, Area 10	51 km ENE (Medlin's Ranch)	58 km NNE (Rachel)	72 km WSW (Beatty)
Schooner, Area 20	36 km WSW (Sarcobatus Flat)	20 km WSW (Tolicha Peak)	55 km SSW (Beatty)
Grouped Area Sources – All NNSS	Various locations ranging from 20 to 60 km		
Emanation from Building Materials			
Building A-01, basement ventilation, NLVF	0.6 km W (N Las Vegas)[c]	0.1 km (at north fence of NLVF)	0.85 km W (N Las Vegas)[c]
Groundwater Characterization/Control or Remediation Activities			
Environmental Restoration Projects			
E-Tunnel Ponds, Area 12	53 km WSW (Springdale)	55 km WNW (Tolicha Peak)	62 km SW (Beatty)
UGTA Well Discharges			
ER-2-2, Area 2	55 km ENE (Medlin's Ranch)	63 km NNE (Rachel)	69 km WSW (Beatty)
UE-2ce, Area 2	56 km WSW (Springdale)	60 km WNW (Tolicha Peak)	63 km WSW (Beatty)
ER-4-1, Area 4	56 km NE (Medlin's Ranch)	60 km SSW (Amargosa Valley)	68 km SSE (Indian Springs)
RNM #2s, Area 5	34 km SE (Cactus Springs)	38 km SE (Indian Springs)	38 km SE (Indian Springs)
UE-5n, Area 5	33 km SE (Cactus Springs)	37 km SE (Indian Springs)	37 km SE (Indian Springs)
ER-20-12, Area 20	33 km SW (Springdale)	22 km W (Tolicha Peak)	50 km SSW (Beatty)
Defense, Security, and Stockpile Stewardship			
DPF, Area 11	46 km SSE (Cactus Springs)	49 km SSE (Indian Springs)	49 km SSE (Indian Springs)
NCERC, Area 6	42 km SW (Amargosa Valley)	42 km SW (Amargosa Valley)	49 km SE (Indian Springs)
NPTEC, Area 5	34 km SE (Cactus Springs)	23 km S (American Silica)	38 km SE (Indian Springs)
DU Experiment, Area 2	58 km ENE (Medlin's Ranch)	61 km SSW (Amargosa Valley)	65 km WSW (Beatty)
Radioactive Waste Management			
Area 3 RWMS	56 km SW (Amargosa Valley)	56 km SW (Amargosa Valley)	61 km SSE (Indian Springs)
Area 5 RWMC	36 km SE (Cactus Springs)	40 km SE (Indian Springs)	40 km SE (Indian Springs)
Support Facility Operations			
Building 23-652 (labeled 23-652 in Figure 4), Area 23	24 km SW (Crystal)	24 km SW (Crystal)	30 km ESE (Indian Springs)
Building 23-600 (labeled 23-600 in Figure 4), Area 23	24 km SW (Crystal)	24 km SW (Crystal)	30 km ESE (Indian Springs)
Building 23-703 (labeled 23-703 in Figure 4), Area 23	24 km SW (Crystal)	24 km SW (Crystal)	31 km ESE (Indian Springs)

(a) Distance is shown in km. For miles, multiply by 0.62.
(b) N=north, S=south, E=east, W=west in all direction combinations shown
(c) City of North Las Vegas

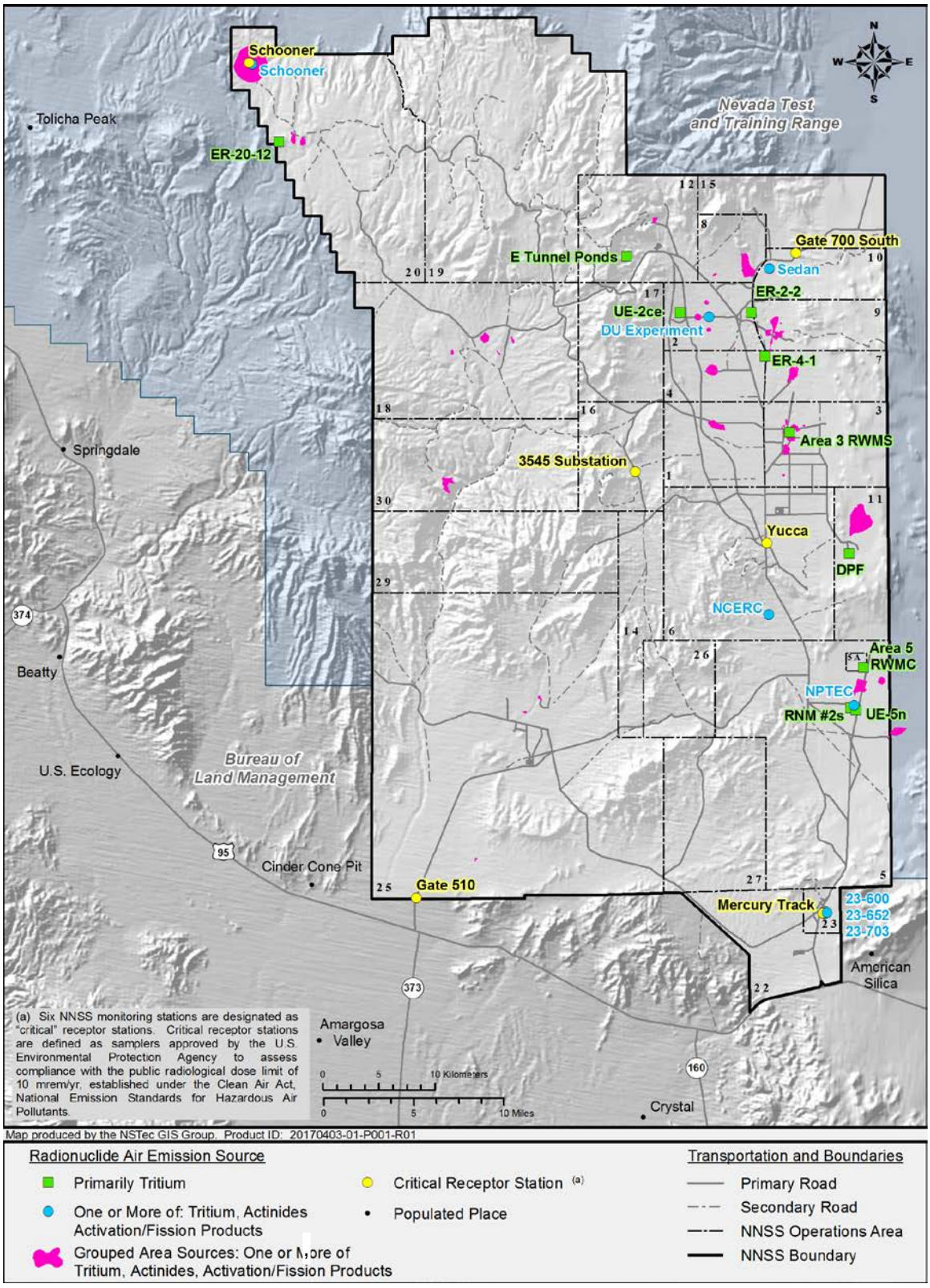

Figure 4. Sources of Radiological Air Emissions and Critical Receptor Air Monitoring Stations on the NNSS in CY 2016

Table 3. Total Estimated NNSS Emissions for CY 2016

Radionuclide[(a)]	Symbol	Half-life	Total Quantity (Ci)
Tritium	^{3}H	12.32 years (y)	210
Carbon-14	^{14}C	5700 y	0.000013
Nitrogen-16	^{16}N	7.13 seconds (s)	1.9
Oxygen-19	^{19}O	26.46 s	0.0034
Sodium-22	^{22}Na	2.60 y	0.00000030
Phosphorus-32	^{32}P	14.26 days (d)	0.0000010
Chlorine-38	^{38}Cl	37 minutes (min)	0.000000026
Argon-41	^{41}Ar	109.61 min	0.73
Potassium-42	^{42}K	12.36 hours (h)	0.000000010
Cobalt-60	^{60}Co	5.27 y	0.00030
Copper-64	^{64}Cu	12.7 h	0.00000045
Krypton-85	^{85}Kr	10.76 y	0.00016
metastable Krypton-85	^{85m}Kr	4.48 h	15
Strontium-90	^{90}Sr	28.79 y	0.055
metastable Indium-115	^{115m}In	4.49 h	0.00000045
Iodine-131	^{131}I	8.02 d	0.00091
Iodine-133	^{133}I	20.8 h	0.016
Iodine-135	^{135}I	6.57 h	0.051
metastable Xenon-131	^{131m}Xe	11.84 d	0.0067
metastable Xenon-133	^{133m}Xe	2.19 d	0.19
Xenon-133	^{133}Xe	5.24 d	2.7
metastable Xenon-135	^{135m}Xe	15.29 min	250
Xenon-135	^{135}Xe	9.14 h	37
Cesium-137	^{137}Cs	30.17 y	0.053
Europium-152	^{152}Eu	13.54 y	0.011
Europium-154	^{154}Eu	8.59 y	0.00010
Europium-155	^{155}Eu	4.76 y	0.00010
Gold-196	^{196}Au	6.18 d	0.00000045
Depleted Uranium	DU	>150,000 y	0.019
Plutonium-238	^{238}Pu	87.7 y	0.041
Plutonium-239+240	$^{239+240}Pu$	24,110 y	0.29
Americium-241	^{241}Am	432 y	0.069

Note: This table includes conservative point and diffuse source release estimates.

(a) Includes all radionuclides with reasonable emission estimates available. Not all of these radionuclides would contribute ≥ 10% of the potential EDE [threshold for required measurement per 40 CFR 61.93(b)(4)(i)].

Table 4. Total Estimated NLVF Emissions for CY 2016

Radionuclide	Total Quantity (Ci)
^{3}H	0.0021

Table 5. Summary of CY 2016 Air Emissions Data by Source

Emission Source[a]		Emissions Control	Radionuclide	Quantity (Ci/y)
Legacy Contamination Sites (Weapon Test and Plowshare Soil Contamination Sites)	Sedan[b]	None	^{3}H	18
	Schooner[b]	None	^{3}H	23
	Grouped Area Sources – All NNSS Areas[c]	None	^{60}Co	0.00030
			^{90}Sr	0.055
			^{137}Cs	0.053
			^{152}Eu	0.011
			^{154}Eu	0.00010
			^{155}Eu	0.00010
			^{238}Pu	0.041
			$^{239+240}$Pu	0.29
			^{241}Am	0.069
Emanation from Building Materials	Building A-01, basement ventilation, NLVF[d]	None	^{3}H	0.0021
Groundwater Characterization/Control or Remediation Activities	Environmental Restoration Projects			
	E-Tunnel Ponds[e]	None	^{3}H	5.1
	UGTA Well Sumps[e]			
	ER-2-2	None	^{3}H	0.78
	UE-2ce	None	^{3}H	0.030
	ER-4-1	None	^{3}H	0.00042
	RNM #2s	None	^{3}H	0.036
	UE-5n	None	^{3}H	0.020
	ER-20-12	None	^{3}H	0.0057
Defense, Security, and Stockpile Stewardship	DPF[f]	None	^{3}H	150
	NCERC[f]	HEPA filter	^{3}H	0.0000052
			^{14}C	0.000013
			^{16}N	1.9
			^{19}O	0.0034
			^{41}Ar	0.73
			^{85}Kr	0.00016
			^{85m}Kr	15
			^{131}I	0.00091
			^{133}I	0.016
			^{135}I	0.051
			^{131m}Xe	0.0067
			^{133}Xe	2.7
			^{133m}Xe	0.19
			^{135}Xe	37
			^{135m}Xe	250
	NPTEC[f]	None	DU	0.00002
	DU Experiment[f]	None	DU	0.019
Radioactive Waste Management	Area 3 RWMS[b]	Soil cover over waste	^{3}H	5.8
	Area 5 RWMC[b]	Soil cover over waste	^{3}H	6.9
Support Facility Operations	Buildings 23-600 and 23-703[f]	None	^{22}Na	0.00000030
			^{32}P	0.0000010
			^{38}Cl	0.000000026
			^{42}K	0.000000010
			^{64}Cu	0.00000045
			^{115m}In	0.00000045
			^{196}Au	0.00000045
	Building 23-652(g)	None	3H	0.0000016

(a) All locations are on the NNSS except for Building A-01.
(b) Emission based on sample results and CAP88-PC software; see Appendix B.
(c) Sum of emissions estimated from soil re-suspension model; see Table C.1 for individual area estimates.
(d) Based on air concentrations and ventilation system flow rate; see Appendix D.
(e) Emission based on HTO discharged into containment pond(s) or onto the ground; see Appendix E.
(f) Emission based on potential release reported by project personnel; see Table A.1.
(g) Based on concentrations in samples and standards used in Building 23-652 lab during 2013 and 2014.

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SECTION III
DOSE ASSESSMENTS

DOSE ASSESSMENT METHOD

The NNSS demonstrates compliance with dose limits using environmental measurements of radionuclide air concentrations near the NNSS borders and near the center of the NNSS. This critical receptor method [40 CFR 61.93(g)] was approved by EPA Region 9 for use on the NNSS in 2001 (EPA 2001a) and has been the sole method used to demonstrate compliance with the 40 CFR 61.92 dose standard since 2005. The six approved critical receptor locations are listed below and displayed in Figure 4 with NNSS emission locations and in Figure 5 along with the entire NNSS air sampling network.

- Area 6, Yucca
- Area 10, Gate 700
- Area 16, 3545 Substation
- Area 20, Schooner
- Area 23, Mercury Track
- Area 25, Gate 510

These can be thought of as worst case for an offsite receptor because these samplers are much closer to emissions sources. Table 6 displays the distances between the critical receptor monitoring stations and points where members of the public potentially live, work, and/or go to school. The distance between the sampling location and the closest onsite emission location is also listed. The shortest distance between where a member of the public resides and a critical receptor monitoring station is 4 km. This is between the Gate 510 sampler, in the SW corner of the NNSS, and the northern edge of the community of Amargosa Valley. Because it is the closest, the results from the Gate 510 sampler are believed to be most representative of air concentrations to which the public is continuously exposed. The shortest distance between an NNSS radionuclide emission source and a critical receptor monitoring station is 0.2 km. This is between the Schooner sampler, in the NW corner of the NNSS, and Schooner Crater. Because this sampler is actually within the area physically affected by the nuclear test (Figure 6), it generally has the highest radionuclide concentrations of the six critical receptor stations. The distance from the Schooner sampler to the closest member of the public (Tolicha Peak) is 20 km, which is 100 times farther than it is from the emission source.

Compliance with the NESHAP public air pathway dose limit of 10 mrem/y is demonstrated if the measured annual average concentration of each detected radionuclide at each of these six critical receptor locations is less than the NESHAP Concentration Level (CL) for Environmental Compliance (40 CFR 61, Appendix E, Table 2). The CL represents the annual average concentration of each radionuclide that would result in an EDE of 10 mrem/y (see Table 7). For multiple radionuclides, compliance with NESHAP is demonstrated when the sum of the fractions (determined by dividing each radionuclide's concentration by its CL and then adding the fractions together) is less than 1.0. The CY 2016 air sampling results from the six compliance stations are presented in Table 7.

COMPLIANCE ASSESSMENT

Table 7 lists the annual average concentrations of detected radionuclides and their fraction of the NESHAP compliance level for each of the six NNSS critical receptor stations. The concentration average for each detected man-made radionuclide was below 1% of the CLs except for the ^{3}H average at the Schooner sampler station, which was about 5.6% of the CL. The average concentration of ^{3}H is high at Schooner because the air sampler is so close to the emission source, as discussed above. The highest sum of the fractions, which was also measured at the Schooner sampler, was 0.060. This is well below 1.0 and therefore in compliance with the NESHAP standard. Scaling the 0.060 sum of fractions to the 10 mrem/y limit gives an estimated EDE of 0.60 mrem/y from the air pathway for a hypothetical individual at this location. This can be thought of as a highly conservative hypothetical maximally exposed individual (MEI). The more representative dose to the public would be from the Gate 510 station. Scaling the 0.0034 sum of fractions for the Gate 510 station to the 10 mrem/y limit gives an estimated EDE of about 0.034 mrem/y from air emissions. For comparison, the fractions of the 10 mrem/y air pathway dose limit from CAP-88 modeled MEI dose estimates from CY 1992 to CY 2004 are displayed in Figure 7 along with the highest critical receptor station monitoring results (Schooner) from CY 2005 to CY 2016.

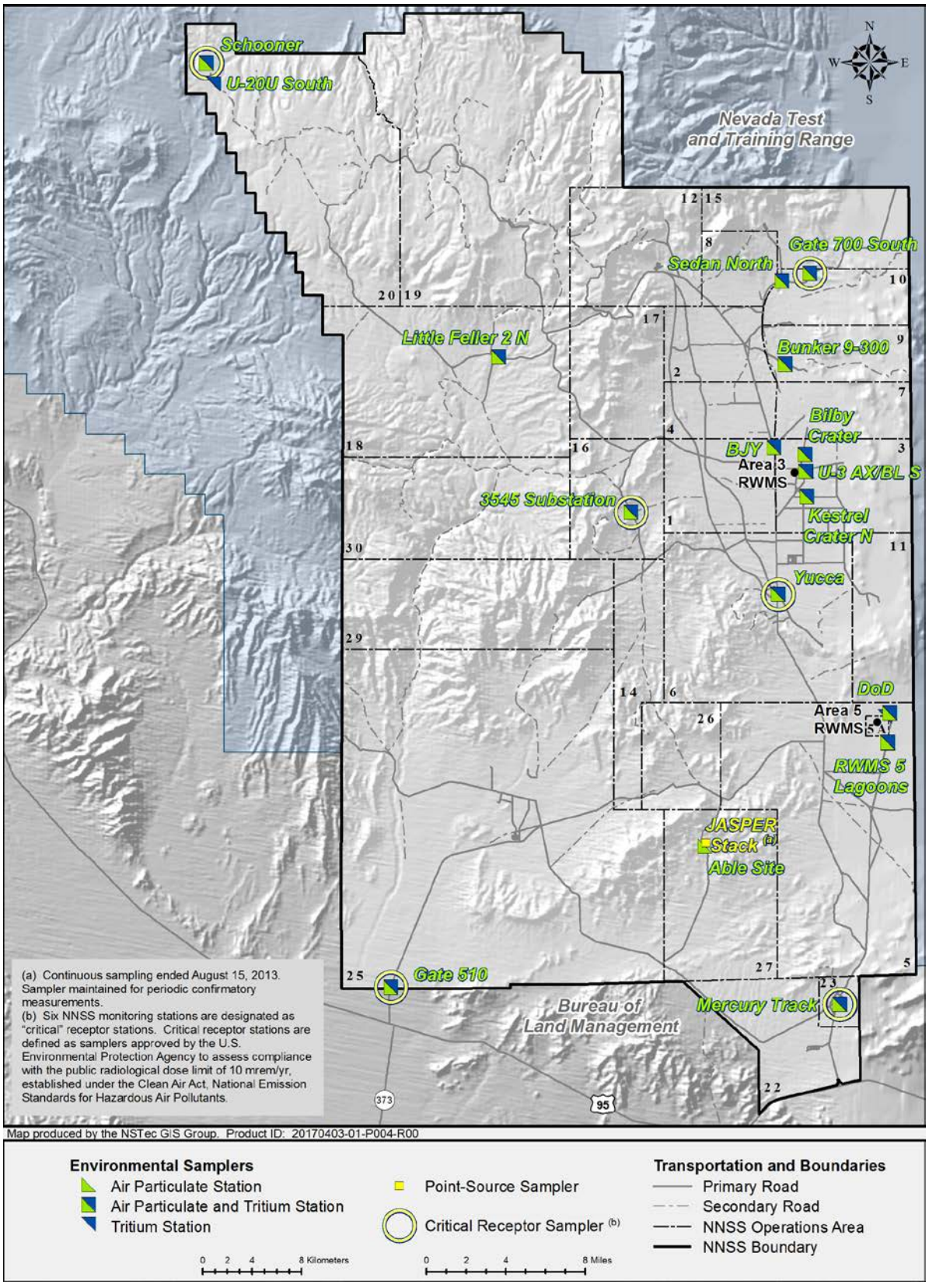

Figure 5. Air Sampling Network on the NNSS

Table 6. Distance Between Critical Receptor Air Monitoring Stations and Nearest Points of Interest

Critical Receptor Station	Distance[a] and Direction[b] to Nearest Offsite Locations and Onsite Emission Location			
	Offsite Residence	Offsite Business/ Office	Offsite School	NNSS Emission Source
Area 6, Yucca	47 km SW (Amargosa Valley)	38 km SSE (American Silica)	54 km SE (Indian Springs)	6.3 km S (Area 6, NCERC)
Area 10, Gate 700	49 km ENE (Medlin's Ranch)	56 km NNE (Rachel)	75 km SSE (Indian Springs)	2.4 km WSW (Area 10, Sedan Crater)
Area 16, 3545 Substation	46 km SSW (Amargosa Valley)	46 km SSW (Amargosa Valley)	58 km SSW (Amargosa Valley)	14 km ENE (Area 3 Radioactive Waste Management Site)
Area 20, Schooner	36 km WSW (Sarcobatus Flat)	20 km WSW (Tolicha Peak)	56 km SSW (Beatty)	0.2 km SE (Area 20, Schooner Crater)
Area 23, Mercury Track	24 km SW (Crystal)	6.0 km SE (American Silica)	31 km SSW (Indian Springs)	0.2 km ESE (Area 23, Building 652)
Area 25, Gate 510	4 km S (Amargosa Valley)	3.5 km S (Amargosa Valley)	15 km SW (Amargosa Valley)	5.1 km NE (Area 25, nearest portion of the Grouped Area Sources)

(a) Distance is shown in km. For miles, multiply by 0.62.
(b) N=north, S=south, E=east, W=west in all direction combinations shown

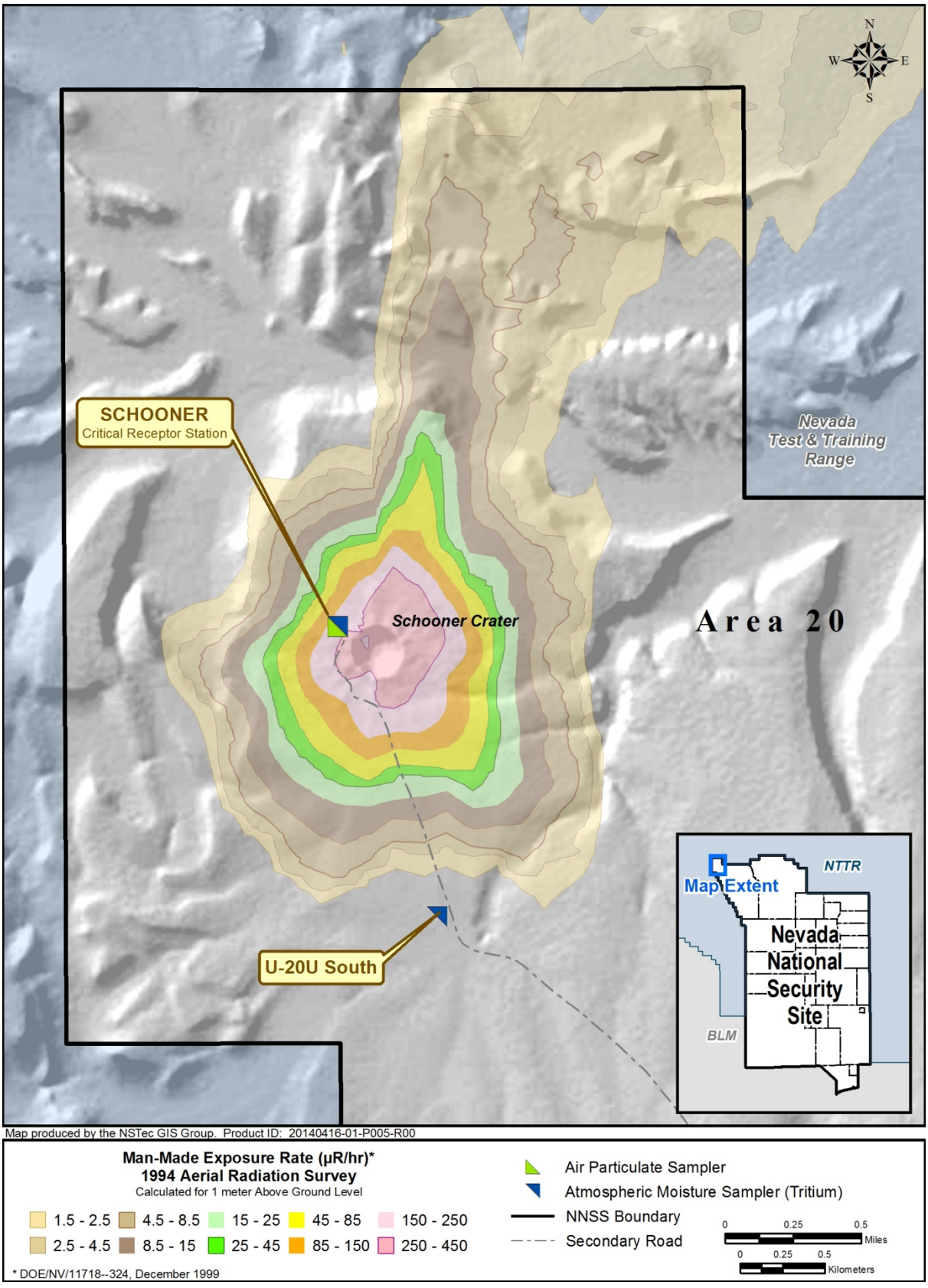

Figure 6. Schooner Critical Receptor Air Sampling Station

Table 7. Average Radionuclide Concentrations at NNSS Critical Receptor Stations and Fraction of Concentration Level (CL) for CY 2016

Location	Radionuclide	Average Concentration in Air (pCi/m^3)[(a)]	CL[(b)] (pCi/m^3)	Average Concentration as Fraction of CL
Yucca	^{3}H	0.25×10^{0}	1500	0.0002
Gate 700 S		0.23×10^{0}		0.0002
3545 Substation		0.11×10^{0}		0.0001
Schooner		83.29×10^{0}		0.0555
Mercury Track		0.05×10^{0}		0.0000
Gate 510		0.16×10^{0}		0.0001
Yucca	^{137}Cs	-8.30×10^{-6}	0.019	-0.0004
Gate 700 S		-3.49×10^{-6}		-0.0002
3545 Substation		-14.14×10^{-6}		-0.0007
Schooner		0.82×10^{-6}		0.0000
Mercury Track		0.91×10^{-6}		0.0000
Gate 510		3.97×10^{-6}		0.0002
Yucca	^{241}Am	5.09×10^{-6}	0.0019	0.0027
Gate 700 S		15.96×10^{-6}		0.0084
3545 Substation		2.12×10^{-6}		0.0011
Schooner		3.38×10^{-6}		0.0018
Mercury Track		2.70×10^{-6}		0.0014
Gate 510		-0.33×10^{-6}		-0.0002
Yucca	^{238}Pu	1.27×10^{-6}	0.0021	0.0006
Gate 700 S		3.02×10^{-6}		0.0014
3545 Substation		1.91×10^{-6}		0.0009
Schooner		2.72×10^{-6}		0.0013
Mercury Track		2.50×10^{-6}		0.0012
Gate 510		3.05×10^{-6}		0.0015
Yucca	$^{239+240}Pu$	14.10×10^{-6}	0.0020	0.0071
Gate 700 S		14.70×10^{-6}		0.0073
3545 Substation		0.35×10^{-6}		0.0002
Schooner		2.79×10^{-6}		0.0014
Mercury Track		2.94×10^{-6}		0.0015
Gate 510		3.25×10^{-6}		0.0016
Yucca	Sum of Fractions by Locations	Sums for analytes listed above, with negative values set to zero.		0.0106
Gate 700 S				0.0173
3545 Substation				0.0023
Schooner				0.0600
Mercury Track				0.0041
Gate 510				0.0034

(a) picocuries per cubic meter (pCi/m^3)

(b) Source: Table 2 in Title 40 CFR 61, Appendix E (Compliance Procedures Methods for Determining Compliance with Subpart I) (CFR 2010a)

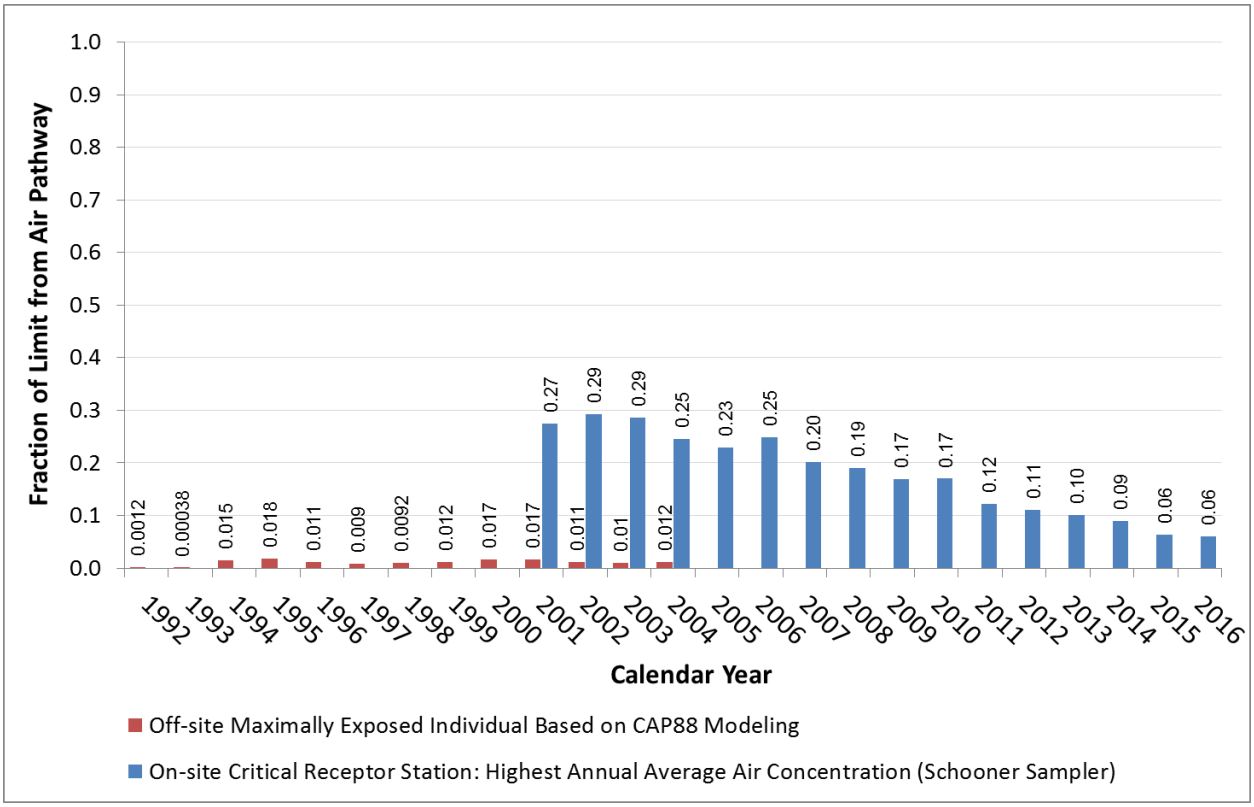

Figure 7. Fraction of the 10 mrem/y Air Pathway Dose Limit for CAP88-PC Modeled MEI Dose and Highest Critical Receptor Station Monitoring Results

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SECTION IV
ADDITIONAL INFORMATION

DOSE EVALUATIONS CONDUCTED DURING CY 2016

This section summarizes radionuclide NESHAP evaluations conducted during CY 2016 for potential radionuclide releases and radiation dose estimates from new projects, construction, modifications, or periodic confirmatory measurements of existing activities. These evaluations were performed in accordance with 40 CFR 61, Subpart H, and are separated into the following general categories: Environmental Restoration Projects, Waste Management Projects, Construction Projects, Research Projects, and Periodic Confirmatory Assessments (Table 8). Sources classified as Category 3 or 4 (see right-most column of Table 8) have a potential dose to the offsite MEI of less than 0.1 mrem/y and do not require monitoring; they only require periodic confirmatory evaluations to confirm low emissions. All of the radiation dose assessments performed during CY 2016 were performed with CAP88-PC modeling software, in accordance with 40 CFR 61.93, using conservative assumptions in the software input parameters to maximize dose estimates. The HotSpot model developed by Lawrence Livermore National Laboratory was additionally used to predict dose from one experiment using explosives (Table 8).

ENVIRONMENTAL RESTORATION PROJECTS

Under the *Federal Facility Agreement and Consent Order* (1996) between DOE, the U.S. Department of Defense, and the State of Nevada, radioactive soil contamination generated by historical NNSS activities is addressed. NNSS Environmental Restoration projects that involve the removal and haulage of materials and soil containing low concentrations of radioactivity are evaluated for potential radionuclide emissions to air and potential dose offsite. No environmental restoration activities (soil remediation or facility deactivation and decommissioning) with potential for radionuclide air emissions were conducted on the NNSS during CY 2016; therefore, no radiation dose assessments were performed in this category.

WASTE MANAGEMENT PROJECTS

The Area 5 Radioactive Waste Management Complex (RWMC) actively received and buried waste throughout the year. Waste cells are excavated when needed. The Area 3 Radioactive Waste Management Site (RWMS) did not receive waste during 2016. Continuous air monitoring occurs at two predominant downwind directions from each of the Area 3 RWMS and Area 5 RWMC. Radionuclide emissions from waste management sites are discussed in Appendix B.

CONSTRUCTION PROJECTS

No construction projects with potential for radionuclide emissions were initiated during CY 2016.

RESEARCH PROJECTS

NESHAP dose evaluations were completed for five research projects during CY 2016. A summary of these is listed in Table 8. All of these projects were determined to be Category 3 or 4 emission sources (ANSI/HPS 13.1-2011 potential impact categories [American National Standards Institute 2011]).

Table 8. NESHAP Dose Evaluations Conducted during CY 2016

Project Description	NNSS Operational Area	Emission Year	Radionuclide Emissions	MEI Dose (mrem/y) and Location	Emission Category[(a)]
An explosives experiment which included a quantity of depleted uranium (DU) was conducted in Area 2 of the NNSS. Prior to operations, the CAP88-PC and HotSpot models were used with conservative parameters (e.g. wind blowing 100 percent of the time towards receptors) to predict dose to the public from this release.	Area 2	2016	DU	0.0086 (CAP88-PC) 0.023 (HotSpot) U.S. Air Force personnel 28.1 km ENE	3
Radioactive material was machined in an inert atmosphere inside a sealed glovebox in the DAF in Area 6 of the NNSS. A HEPA filtered ventilation system was used. Prior to operations the potential emission was modeled as if no pollution controls were used. The CAP88-PC model was used to predict the dose to the public from potential emissions from this project.	Area 6	2016	Pu	0.0044 Cactus Springs 45.4 km SE	3
The Underground Nuclear Explosion Signature Experiment, Tunnel Test Bed Project, will determine if trace quantities of radioactive noble gases injected approximately 900 feet underground can be detected as they seep to the surface in order to improve the United States' capability to detect and characterize potential underground nuclear testing by foreign states. Prior to operations, the potential emission was modeled using CAP88-PC.	Area 12	2017-2018	^{37}Ar and ^{127}Xe	0.0010 Penoyer Farm, 54.5 km NNE	4
As part of a nuclear accident dosimetry laboratory inter-comparison program, radioactive samples will be processed and analyzed in a lab in Buildings 23-600 and 23-703, both in Area 23 of the NNSS.	Area 23	2017	^{32}P, ^{115m}In, ^{64}Cu, ^{196}Au, ^{42}K, ^{38}Cl, and ^{22}Na	0.00000026 Crystal, 24.2 km SW	4
Radioactive laboratory standards will be made in Building 23-652 for quality assurance purposes for analysis of environmental samples. Infrared spectral measurements will also be made of existing radioactive standards in Building 23-650. Both of these buildings are in Area 23 of the NNSS. The CAP88-PC model was used to predict dose to the public from potential emissions from this planned activity.	Area 23	2017	^{90}Sr, ^{90}Y, ^{239}Pu, ^{241}Am	0.00000026 Crystal, 24.4 km SW	4

(a) Based on ANSI/HPS 13.1-2011 potential impact categories (American National Standards Institute 2011): Category 1 refers to annual dose > 5 mrem; Category 2 refers to annual dose > 0.1 mrem and ≤ 5 mrem; Category 3 refers to annual dose > 0.001 mrem and ≤ 0.1 mrem; and Category 4 refers to annual dose ≤ 0.001 mrem.

PERIODIC CONFIRMATORY MEASUREMENTS

NESHAP regulations require periodic confirmatory measurements for minor release sources (Category 3 or 4 sources) to verify low emissions [40 CFR 61.93 (e)]. Furthermore, a Memorandum of Understanding between the EPA and DOE states that "engineering calculations and/or representative measurements may be used to comply with periodic confirmatory measurement requirements" (EPA and DOE 1995). This section lists the periodic confirmatory measurements that were conducted during CY 2016.

Joint Actinide Shock Physics Experimental Research (JASPER)

A sample of stack effluents was taken, February 1-3, 2016, during a test using special nuclear material. It was analyzed for ^{238}Pu, $^{239+240}$Pu, and ^{241}Am. No radionuclides were detected in the sample. There is no evidence of radionuclide emissions from JASPER operations, which confirms the assessment of this being a minor emission source (National Security Technologies, LLC, 2013a).

North Las Vegas Facility (NLVF), Building A-01

Biannual measurements of ^{3}H concentrations in air in Building A-01 are made as a best management practice. The potential dose from Building A-01 emissions is calculated each year based on this monitoring information. The emissions during CY 2016 were analogous to the past few years and the resultant dose (0.000011 mrem/y) was well below the 0.1 mrem/y level specified in 40 CFR 61.96. A summary of this is presented in Appendix D.

UNPLANNED RELEASES

There were no known unplanned radionuclide releases during CY 2016.

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APPENDICES

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Appendix A

Radionuclide Air Emission Sources

Table A.1 Facilities or Areas from Which Radionuclides Were Released to Air in Calendar Year (CY) 2016

Facility or Area	Emission Type	Radionuclide(s) Emitted	Handling/ Processing	Nature of Emissions	Effluent Controls	Emission Category[a]	Distance[b] and Direction[c] to Nearest Air Sampler(s)
Legacy Contamination Sites							
Weapon Test and Plowshare Soil Contamination Sites							
Sedan Crater (Plowshare), Area 10	Diffuse	Tritium (^{3}H) as tritiated water (HTO), americium (Am), plutonium (Pu), activation and fission products	None	^{3}H as HTO through evaporation from soil or transpiration from plants and suspension of contaminated soil by wind	None	3	• Sedan North: 0.8 kilometers (km) to the N • Critical receptor sampler (Gate 700 S): 2.4 km to the ENE
Schooner Crater (Plowshare), Area 20	Diffuse	^{3}H as HTO, Am, Pu, activation and fission products	None	^{3}H as HTO through evaporation from soil or transpiration from plants and suspension of contaminated soil by wind	None	2	• Critical receptor sampler (Schooner): 0.2 km to the NW
Grouped Area Sources – All Nevada National Security Site (NNSS) Areas	Diffuse	Am, Pu, activation and fission products (^{3}H as HTO as well, but the vast majority is emitted from Sedan and Schooner—see above)	None	Wind causing suspension of soil containing small amounts of historical fallout/legacy radioactive materials	None	2	• See Figure 4 and Table 6

Table A.1 Facilities or Areas from Which Radionuclides Were Released to Air in Calendar Year (CY) 2016 (continued)

Facility or Area	Emission Type	Radionuclide(s) Emitted	Handling/ Processing	Nature of Emissions	Effluent Controls	Emission Category[a]	Distance[b] and Direction[c] to Nearest Air Sampler(s)
Legacy Contamination Sites (continued)							
Emanation from Building Materials							
NLVF, Building A-01	Point	Parts of the basement were contaminated with ^{3}H in 1995 including a vacant radiation source well	Air flow through building ventilation system	^{3}H as HTO through emanation from building materials into the air and exhausted from the building through the ventilation system	None	4	• Biannual sampling inside room that was contaminated
Groundwater Characterization/Control or Remediation Activities							
Environmental Restoration Projects							
E-Tunnel Ponds, Area 12	Diffuse	^{3}H in groundwater flowing from fissures in historical nuclear tests tunnel system	Controlled drainage and containment of groundwater from the tunnel in a series of earthen ponds	^{3}H as HTO through evaporation or transpiration from plants	None	4	• Little Feller 2N: 11.9 km to the WSW • Critical receptor sampler (Gate 700 S): 15 km to the E
Underground Test Area (UGTA) Wells							
ER-2-2, Area 2	Diffuse	^{3}H as HTO	Groundwater pumped to the surface	Evaporation of ^{3}H as HTO	None	4	• Bunker 9-300: 2.8 km to the SE • Critical receptor sampler (Gate 700 S): 6.7 km to the NE
UE-2ce, Area 2	Diffuse	^{3}H as HTO	Groundwater pumped to the surface	Evaporation of ^{3}H as HTO	None	4	• Bunker 9-300: 8.5 km to the ESE • Critical receptor sampler (Gate 700 S): 11.6 km to the ENE

Table A.1 Facilities or Areas from Which Radionuclides Were Released to Air in Calendar Year (CY) 2016 (continued)

Facility or Area	Emission Type	Radionuclide(s) Emitted	Handling/ Processing	Nature of Emissions	Effluent Controls	Emission Category[a]	Distance[b] and Direction[c] to Nearest Air Sampler(s)
Legacy Contamination Sites (continued)							
Groundwater Characterization/Control or Remediation Activities (continued)							
ER-4-1, Area 4	Diffuse	^{3}H as HTO	Groundwater pumped to the surface	Evaporation of ^{3}H as HTO	None	4	• Bunker 9-300: 2.0 km to the NNE • Critical receptor sampler (Gate 700 S): 9.6 km to the NNE
RNM #2s, Area 5	Diffuse	^{3}H as HTO	Groundwater pumped to the surface	Evaporation of ^{3}H as HTO	None	4	• RWMS 5 Lagoons: 3.1 km to the NNE • Critical receptor sampler (Yucca): 16.5 km to the NNW
UE-5n, Area 5	Diffuse	^{3}H as HTO	Groundwater pumped to the surface	Evaporation of ^{3}H as HTO	None	4	• RWMS 5 Lagoons: 3.1 km to the NNE • Critical receptor sampler (Yucca): 16.9 km to the NNW
ER-20-12, Area 20	Diffuse	^{3}H as HTO	Groundwater pumped to the surface	Evaporation of ^{3}H as HTO	None	4	• U-20U South: 5.7 km to the NNW • Critical receptor sampler (Schooner): 7.6 km to the NNW
Defense, Security, and Stockpile Stewardship							
Dense Plasma Focus, Area 11	Point	^{3}H	Production of neutrons using a deuterium-^{3}H reaction	^{3}H gas released through a stack exhaust	None	3	• Critical receptor sampler (Yucca): 7.4 km to the west-northwest
National Criticality Experiments Research Center, Area 6	Point	Various activation and fission products (see Table 5)	Critical mass assembly machines at very low power (< 1 watt)	Activation and fission products in gas form	Exhaust goes through HEPA filtration	4	• Critical receptor sampler (Yucca): 6.4 km to the N

Table A.1 Facilities or Areas from Which Radionuclides Were Released to Air in Calendar Year (CY) 2016 (continued)

Facility or Area	Emission Type	Radionuclide(s) Emitted	Handling/ Processing	Nature of Emissions	Effluent Controls	Emission Category[a]	Distance[b] and Direction[c] to Nearest Air Sampler(s)
Defense, Security, and Stockpile Stewardship (continued)							
Nonproliferation Test and Evaluation Complex, Area 5	Diffuse	DU	Handling of powder compounds	Suspension of particulates	None	3	• Sugar Bunker North: 2.5 km north-northeast • Critical receptor sampler (Yucca): 16.4 km to the NNW
DU Experiment, Area 2	Point	DU	Research project	Use of explosives and DU	None	3	• Bunker 9-300: 6.0 km ESE • Critical receptor sampler (Gate 700 S): 9.6 km to the NE
Radioactive Waste Management							
Area 3 Radioactive Waste Management Site (RWMS)	Diffuse	^{3}H as HTO (only radionuclide attributable to the low-level waste [LLW])	Subsurface burial of waste (no active burial during CY 2016)	^{3}H as HTO through evaporation from soil or transpiration from plants	Soil cover	3	• U-3ax/bl South: < 0.3 km in multiple directions; near the center of the Area 3 RWMS • Critical receptor sampler (Yucca): 10 km SSW
Area 5 Radioactive Waste Management Complex (RWMC)	Diffuse	^{3}H as HTO (only radionuclide attributable to LLW, mixed LLW)	Subsurface burial of waste	^{3}H as HTO through evaporation from soil or transpiration from plants	Soil cover	4	• DoD: 0.4 km from NE edge of the Area 5 RWMC • Critical receptor sampler (Yucca): 14 km to the NNW
Support Facility Operations							
Environmental Monitoring Building 23-652, Area 23	Point	^{3}H as HTO	Distillation or drying	^{3}H emission during distillation of samples and preparation of standards	None	4	• Critical receptor sampler (Mercury Track): 0.2 km to the east-southeast

(a) Based on ANSI/HPS 13.1-2011 potential impact categories (American National Standards Institute 2011): Category I refers to annual dose > 5 mrem, Category 2 refers to annual dose > 0.1 mrem and ≤ 5 mrem, Category 3 refers to annual dose > 0.001 mrem and ≤ 0.1 mrem, and Category 4 refers to annual dose ≤ 0.001 mrem.
(b) Distance is shown in km. For miles, multiply by 0.62.
(c) N=north, S=south, E=east, W=west in all direction combinations shown.

Appendix B

NNSS Tritium Emissions Estimated from Air Sampling Data

BACKGROUND INFORMATION

Diffuse emissions of tritiated water (HTO) from the Nevada National Security Site (NNSS) include evaporation from containment ponds, evapotranspiration of soil moisture diffusing through waste covers at the Area 3 Radioactive Waste Management Site (RWMS), the Area 5 Radioactive Waste Management Complex (RWMC), and evapotranspiration of HTO from soil contaminated by atmospheric or near-surface nuclear weapon testing conducted in the past. Locations that make up the majority of diffuse tritium (^{3}H) emissions on the NNSS are the Schooner and Sedan nuclear test areas, the Area 3 RWMS, the Area 5 RWMC, and the containment ponds at E-Tunnel. Emissions from the E-Tunnel ponds were not estimated from air sampling data because the total volume of water and ^{3}H concentration of the water was known, allowing for an estimate described in Appendix E. For the remaining sites listed, emissions were estimated by scaling concentrations of ^{3}H in air predicted by a modeled 1 curie (Ci) release to concentrations measured at nearby sampling stations. Figure 5 of this report shows the current NNSS air sampling station locations, and Table B.1 lists the samplers near the major diffuse ^{3}H emission locations.

SOURCE TERM ESTIMATES

For each major ^{3}H emission location, the Clean Air Package 1988 (CAP88-PC) model was used to estimate the ^{3}H concentration that would be expected at nearby air samplers if 1 Ci of ^{3}H were released from the center of the source location. The total annual emission from each source was then calculated by dividing the annual average concentration of ^{3}H measured at each sampling location adjacent to the source by the CAP88-PC predicted annual average concentration for a 1 Ci release at each of the same sampling locations. Table B.1 lists the estimated emissions for each source location.

Table B.1 Tritium Emissions from Airborne Tritium Sampling Results during CY 2016

Emission Source	Air Sampler	Average Tritium Concentration (pCi/m^3)[(a)]	CAP88-PC Concentration for 1 Ci Emission (pCi/m^3)	Predicted Tritium Emission (Ci)	Emission Source Average (Ci)[(b)]
Area 3 RWMS	Bilby Crater	0.329	0.077	4.3	5.8
	Kestrel Crater N	0.926	0.127	7.3	
Area 5 RWMC	DOD	1.088	0.223	4.9	6.9
	RWMS 5 Lagoons	1.592	0.180	8.8	
Area 10, Sedan	Gate 700 South[(c)]	0.378	0.0179	21.1	18.1
	Sedan North	3.194	0.211	15.1	
Area 20, Schooner	North Schooner	4.329	0.189	22.9	22.9

(a) pCi/m^3 = picocuries per cubic meter for May through October – the period when vast majority of tritium is emitted.
(b) Average of emissions predicted by samplers for an emission source
(c) Critical Receptor Station

Appendix C

Emissions of Radionuclides from Diffuse Legacy Sites Based on Historical Soil Survey Data and Soil Re-suspension Model

BACKGROUND INFORMATION

Operations (Ops) Areas 1 through 12 and 15 through 30 on the Nevada National Security Site (NNSS) contain diffuse sources of radionuclides. Historical soil surveys have identified the location of these sources on the NNSS and provided estimates of the amounts of radionuclides that remain in the surface soils (U.S. Department of Energy [DOE] 1991; see Table 1 of this report). The soil, and associated radionuclides, may become airborne due to wind. Results from air samples from these areas indicate that only americium-241 (^{241}Am) and plutonium-239+240 ($^{239+240}$Pu) are routinely detected, and those are in concentrations only slightly above the minimum detectable concentrations. The total emissions (in curies [Ci]) produced each year from all known manmade radionuclides in soil at legacy sites on the NNSS are estimated with a mathematical re-suspension model. This appendix describes all the calculations involved in producing the emission estimates.

RE-SUSPENSION CALCULATIONS

These calculations are needed to estimate how much of the radionuclides in surface soils could actually become airborne (re-suspended) and therefore become an emission. A conservative estimate of emissions from diffuse sources is obtained by the use of a re-suspension equation with parameters derived from actual studies at the NNSS. In NUREG/CR-3332 (U.S. Nuclear Regulatory Commission 1983), pages 5–30, an equation for calculating a suspension rate (fraction re-suspended per second [s]) is given as follows:

$$S = K \times V_g$$

where: S = fractional re-suspension rate (per s), or the fraction of the inventory re-suspended per s
K = re-suspension factor (per meter [m])
V_g = deposition velocity (meters per second [m/s])

The values of K and V_g used in this re-suspension equation are taken from DOE (1992), with values of K provided on page 75. An average of the values is 2×10^{-10}/m. Ranges in V_g of 0.01 to 0.05 m/s, presented in DOE (1992), are used as conservative estimates. When these values are used in the above equation, S is between 2×10^{-12} and 1×10^{-11} per s. To be conservative, the higher fractional re-suspension rate of 1×10^{-11}/s is used. For example, the emission rate in picocuries (pCi)/s for $^{239+240}$Pu from Area 3 is calculated from the product of the $^{239+240}$Pu inventory (37 Ci from Table 1) and S as shown below. The estimated total annual emission is expressed in millicuries per year (mCi/y).

$$37\ Ci \times \frac{10^{-11}}{s} \times \frac{3600\ s}{hour} \times \frac{24\ hours}{day} \times \frac{365\ days}{yr} = \frac{1.17 \times 10^{-2} Ci}{yr}\ or\ \frac{11.7\ mCi}{yr}$$

This method was used for calculating the emissions of man-made radionuclides from all other areas. The results are shown in Table C.1.

Table C.1 Emission Estimates from Inventories[(a)] of Manmade Radionuclides in NNSS Surface Soil

Area	Annual Emission (mCi) using Emission factor of 1 x 10^{-11} s^{-1}								
	^{60}Co	^{90}Sr	^{137}Cs	^{152}Eu	^{154}Eu	^{155}Eu	^{238}Pu	$^{239+240}$Pu	^{241}Am
1	0.01	2.50	1.51	1.22	0.00	0.00	1.66	7.56	1.89
2	0.01	7.67	4.12	1.14	0.00	0.00	2.20	6.93	1.44
3	0.01	5.50	2.06	1.46	0.00	0.00	0.79	11.66	2.34
4	0.02	2.17	2.06	0.74	0.00	0.00	3.33	12.60	3.03
5	0.01	0.15	0.07	0.81	0.01	0.00	0.03	1.51	0.31
6	0.00	0.58	0.48	0.00	0.00	0.00	0.84	2.65	0.73
7	0.01	1.53	0.89	1.79	0.01	0.00	0.15	5.04	1.08
8	0.06	4.17	7.21	0.36	0.00	0.00	2.05	34.66	7.97
9	0.01	2.17	1.49	1.87	0.01	0.00	0.56	28.05	3.56
10	0.09	9.17	14.42	0.18	0.01	0.03	4.86	34.66	8.58
11	0.00	0.05	0.09	0.00	0.00	0.00	0.13	9.14	1.74
12	0.01	2.83	3.43	0.00	0.00	0.00	2.17	12.29	2.73
15	0.00	3.67	3.26	0.00	0.00	0.00	2.00	19.85	4.04
16	0.00	0.62	0.50	0.00	0.00	0.00	0.38	1.17	0.31
17	0.01	3.17	2.57	0.00	0.00	0.00	1.15	5.67	1.31
18	0.01	2.83	1.72	0.09	0.00	0.01	1.43	31.51	8.32
19	0.01	5.17	6.18	0.00	0.00	0.00	8.19	44.12	9.96
20	0.08	0.72	0.94	1.06	0.06	0.03	7.67	12.92	8.01
25	0.00	0.02	0.03	0.03	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.01	0.22	0.26	0.06	0.00	0.00	1.15	4.41	1.33
Total (mCi/y)	**0.35**	**55**	**53**	**11**	**0.11**	**0.09**	**41**	**290**	**69**

(a) Radioactive inventories from Table 5 in DOE/NV/10845--02 (DOE 1991) and decay corrected to June 15, 2016, with inclusion of ingrowth of ^{241}Am from ^{241}Pu.

As shown in Table C.1, the estimated total emissions from soil inventory data and from the re-suspension model are reported to two significant figures (mCi/y). These are shown in Table 3 of this report (as Ci/y), which summarizes all measured or computed emissions from the NNSS in calendar year 2016. The spatial relation between these diffuse emission locations and the critical receptor stations can be seen in Figure 4.

Appendix D

Potential Radionuclide Emissions and Dose from the North Las Vegas Facility

As discussed in the 1995 National Emission Standard for Hazardous Air Pollutants (NESHAP) report (U.S. Department of Energy 1996), a container of tritium-aluminum foils was opened in Building A-01 at the North Las Vegas Facility (NLVF) and emitted at least 1 curie (Ci) of tritium into a basement area used as a fixed radiation source range. Environmental surveillance began on the day notification of the tritium leak occurred. Environmental tritiated water (HTO) samplers were installed at three locations outside the facility. Later, an HTO sampler was installed in the basement and operated continuously so that progress on cleanup of the spill could be monitored. After cleanup, the environmental samplers were removed, but the basement air sampler continued operation through January 5, 1998, at which time samples were collected one to four times annually. From 1995 to the present, results and the effective dose equivalent (EDE) to the maximally exposed individual (MEI) offsite at the perimeter fence have been reported in the annual NESHAP reports.

During the years 1999 through 2016, air sampling for HTO in the basement was conducted intermittently. For CY 2016, the results of two atmospheric moisture samples were 234 picocuries per cubic meter (pCi/m^3) for the sample collected April 13–20, 2016, and 195 pCi/m^3 for the sample collected September 13–20, 2016. The average of these sample results (214 pCi/m^3) was multiplied by the room ventilation rate (673 cubic feet per minute [ft^3/min]) to determine the total annual emission rate as shown below. The estimated total annual emission is expressed in millicuries per year (mCi/y).

$$\frac{214\ pCi}{m^3} \times \frac{673\ ft^3}{min} \times \frac{0.02832\ m^3}{ft^3} \times \frac{525{,}600\ min}{y} \times \frac{1\ \times 10^{-9}\ mCi}{pCi} = \frac{2.14\ mCi}{y}$$

A dose coefficient of 5.0×10^{-6} millirem per year per millicurie (mrem/y/mCi) released is used to determine dose to the MEI from NLVF tritium emissions. This is based on earlier results from the Clean Air Package 1988 model using conservative assumptions to maximize dose and observed tritium emissions. This coefficient multiplied by the tritium emission for CY 2016 gave the estimated EDE to the nearest member of the public outside the perimeter fence shown below in both mrem/y and microrem per year (µrem/y).

$$\frac{2.14\ mCi}{y} \times \frac{5.0\ \times 10^{-6} mrem}{mCi} = \frac{0.000011\ mrem}{y}\ or\ \frac{0.011\ \mu rem}{y}$$

A comparison of the emission rates and radiation dose to the MEI since 2005 are presented in Table D.1.

Table D.1. Comparison of Tritium Emission Rates from Building A-01, NLVF from 2005 to 2016

Year	Tritium Emission Rate (mCi/y)	EDE to MEI (µrem/y)
2005	20	0.10
2006	13.2	0.07
2007	12.3	0.06
2008	11.1	0.06
2009	8.7	0.044
2010	6.45	0.032
2011	4.83	0.024
2012	4.74	0.024
2013	2.27	0.011
2014	1.72	0.0086
2015	2.39	0.012
2016	2.14	0.011

Appendix E

Calculation of Tritium Emissions from Contaminated Groundwater Discharges

The calendar year (CY) 2016 air emissions (in curies [Ci]) of tritium, as tritiated water from contaminated groundwater sources, were conservatively estimated. Emissions were computed as the product of the volume of water (in liters [L]) either pumped or naturally emerging to the surface and the tritium concentration (as picocuries per liter [pCi/L]) measured in that water using the following formula. It was assumed that all of the tritiated water evaporated.

$$Water\ Concentration\ \left(\frac{pCi}{L}\right)\ x\ Water\ Volume\ (L)\ x\ \frac{1\ x\ 10^{-12}\ Ci}{pCi}$$

Water flow-rate from the E-Tunnel is measured monthly and the tritium concentration in the water is measured annually in support of Water Pollution Control Permit NEV 96021. The total volume of water is determined by multiplying the flow-rate by the number of days in the month when the measurement was taken, then summed for all 12 months. Because the tritium concentration is decreasing over time, the value used to determine the emission was the average of the CY 2015 and CY 2016 samples (one sample each year).

The volume of contaminated water pumped from wells is measured throughout the purging and sampling process. Samples are collected for analysis of tritium throughout the time during which water is pumped from the wells. The tritium concentration used to determine the emission is an average representative of all water pumped to the surface.

The tritium concentration and volume of groundwater discharges during 2016 are listed in Table E.1. The volume of water multiplied by the tritium concentration yields the estimated tritium emission to air during 2016 under the assumption that all of the water evaporated during 2016.

Table E.1 Tritium Concentrations, Water Volumes, and Estimated 2016 Tritium Emissions from Contaminated Groundwater Brought to the Surface

Location	Tritium Concentration (pCi/L)	Water Volume[(a)] (L)	Tritium Emission (Ci)
E-Tunnel Ponds	341,000 [(b)]	14,866,906	5.1
Well ER-2-2	1,486,278	524,230	0.78
Well UE-2ce	136,117	221,625	0.030
Well ER-4-1	16,118.90	26,044	0.00042
Well RNM #2s	76,333	472,722	0.036
Well UE-5n	133,500	148,895	0.020
Well ER-20-12	26,801	213,035	0.0057

(a) All water was assumed to evaporate during CY 2016.

(b) Average of results from October 2015 and October 2016 samples

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Appendix F

Identification and Justification for the Development of Meteorological Data Used as Input to Clean Air Package 1988 (CAP88-PC)

Meteorological support, observations, and climatological services for the Nevada National Security Site (NNSS) are provided to the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) by the Air Resources Laboratory, Special Operations and Research Division (ARL/SORD). The ARL/SORD is a National Oceanic and Atmospheric Administration (NOAA) office and supports NNSA/NFO programs under the authority of an Interagency Agreement between NOAA and NNSA/NFO.

METEOROLOGICAL OBSERVATIONS

The ARL/SORD manages, operates, and maintains a meteorological monitoring program that is designed and used to support the NNSA/NFO-authorized activities on the NNSS. This vital program consists of many meteorological monitoring systems that have been brought together under the Meteorological Integrated Data Network (MIDNET). The MIDNET includes a Meteorological Data Acquisition (MEDA) network of 21 meteorological towers located on the NNSS (Figure F.1) and one on Yucca Mountain. The MIDNET consists of communications systems, local area networks, and surface-based instrumentation used to measure wind direction and speed, temperature, relative humidity, atmospheric pressure, and precipitation. The MIDNET has been operated on the NNSS for more than 40 years, has undergone several modernizations and upgrades, and serves as a solid basis for deriving climatological information.

Upper-air observations (radiosondes) were taken twice daily from Desert Rock Meteorological Observatory (DRA; elevation 1007 meters [m], located 4.8 kilometers southwest of Mercury, Nevada [Station 30 in Figure F.1]) but were discontinued in October 2010. Upper-air data are currently collected at the National Weather Service office in Las Vegas. DRA had been in operation since May 1978 and was built to replace a similar observatory that was located at the Yucca Flat Meteorological Observatory (UCC; elevation 1,196 m) from January 1962 through mid-May 1978. Consequently, surface and upper-air observations are also available from UCC for 1962–1978.

A key component of the MIDNET system is the MEDA station. A MEDA station consists of a 10-m tower, a data-logger, meteorological sensors, and a radio transmitter. The 22 MEDA stations located on or near the NNSS (Figure F.1) provide surface weather data for climatology, weather forecasts, and warnings for NNSS operations and emergency response activities. MEDA station locations were selected based on criteria to support NNSS consequence assessment activities, compliance reporting requirements, and general weather and forecasting needs.

Wind and temperature data have been collected on the NNSS for more than 40 years. These and other meteorological data have been compiled into a comprehensive climatological database for the NNSS. The MEDA data are especially useful in assessing boundary layer flow regimes on the NNSS.

The wind speed and direction sensor is located 10 m above the ground. Wind direction is measured to ±5 degrees of azimuth, and wind speed is accurate to 0.5 knots. Wind data are collected as 15-minute averages and are transmitted via radio and sent over the NNSS intranet to a central processor every 15 minutes. These data are reviewed by ARL/SORD and are stored and archived for climatological purposes.

Ambient temperature and relative humidity sensors are located approximately 1.5 m above ground level. MEDA temperature data are accurate to ±0.2 degrees Celsius (°C) (absolute range for the NNSS is −29°C to 46°C). Temperature and relative humidity measurements are 15-minute averages and are also transmitted via radio to a computer server for processing, review, display, and archiving.

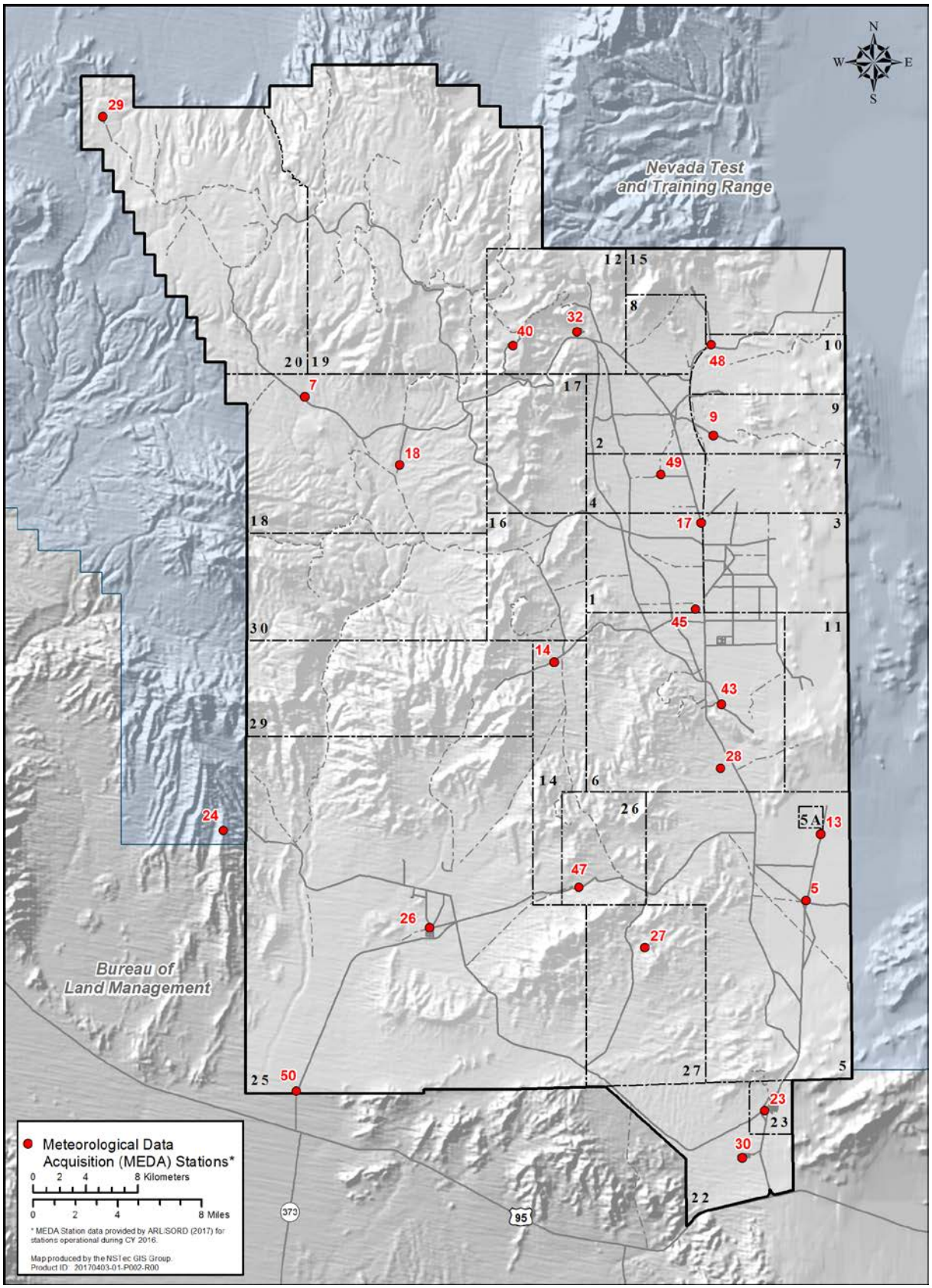

Figure F.1 Locations of MEDA Stations on the NNSS at end of CY 2016

Cloud cover observations are needed to create the Stability Array (STAR) files with the STAR program. In order to use the most representative meteorological data available for NNSS, cloud observations from DRA are melded with MEDA winds. Cloud data are available for DRA (1978–present) and for UCC (1962–1978). Based on the available data, the cloud cover climatology from DRA and UCC are quite compatible. For example, UCC experienced 192 clear days annually, while DRA has 191 days. In addition, the average annual sky cover from sunrise to sunset for both stations was/is 0.39 daily. The total number of cloudy days for UCC is 81 days and 82 days for DRA, annually. Therefore, the cloud cover observations from DRA and UCC may be considered as representative for most areas of the NNSS.

APPLICATION TO CAP88-PC INPUT

Based on the above considerations and on the limitations of the Clean Air Package 1988 (CAP88-PC) computer program, the cloud cover data from DRA are considered to be representative of the NNSS. Therefore, atmospheric soundings and cloud cover observations from DRA were melded with MEDA surface wind data for input to the STAR program to provide the best data for calculating transport and dispersion processes. The STAR file is a matrix that includes seven Pasquill stability categories (A through G), six wind speed categories, and 16 wind sectors from wind roses calculated for each specified MEDA station on the NNSS. The STAR files are used by a CAP88-PC utility program to create WIND files that are used by CAP88-PC to model emissions from diffuse tritium sources on the NNSS (Appendix B).

Calendar year 2016 data from the MEDA stations for the NNSS areas were used by ARL/SORD personnel to prepare the following STAR files listed in Table F.1.

Table F.1 MEDA System Locations Used to Create STAR Files for Use in Determining Tritium Emissions from the NNSS Sources

STAR File	MEDA Station	MEDA Location (NNSS Operations Area)	Area of Emission
48Meda16.str	48	10	10
13Meda16.str	13	5	5
29Meda.str	29	20	20
45Meda16.str	45	1	3

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Appendix G

Supplemental Information

COLLECTIVE EFFECTIVE DOSE EQUIVALENT

The U.S. Environmental Protection Agency has approved the use of critical receptor monitoring locations on the Nevada National Security Site (NNSS) to demonstrate National Emission Standards for Hazardous Air Pollutants (NESHAP) compliance in lieu of using the Clean Air Package 1988 (CAP88-PC) computer software to calculate the radiation doses received by offsite residents within 80 kilometers (km) of NNSS emission sources. The U.S. Department of Energy (DOE) agreed that there is little benefit in doing CAP88-PC calculations just for the collective dose (DOE 2004). The collective dose was calculated for the years 1992–2004, and the results were consistently below 0.6 person-rem [roentgen equivalent man] per year (y), indicating that it is unlikely that it will exceed 1 person-rem/y (Figure G.1). However, if operations at the NNSS change whereby radionuclide emissions significantly increase, this change will be reconsidered and calculation of collective dose likely resumed. Because there was not an increase in radionuclide emissions from the NNSS or population surrounding the NNSS during calendar year (CY) 2016 that would result in the collective dose approaching 1 person-rem, this calculation was not performed for CY 2016.

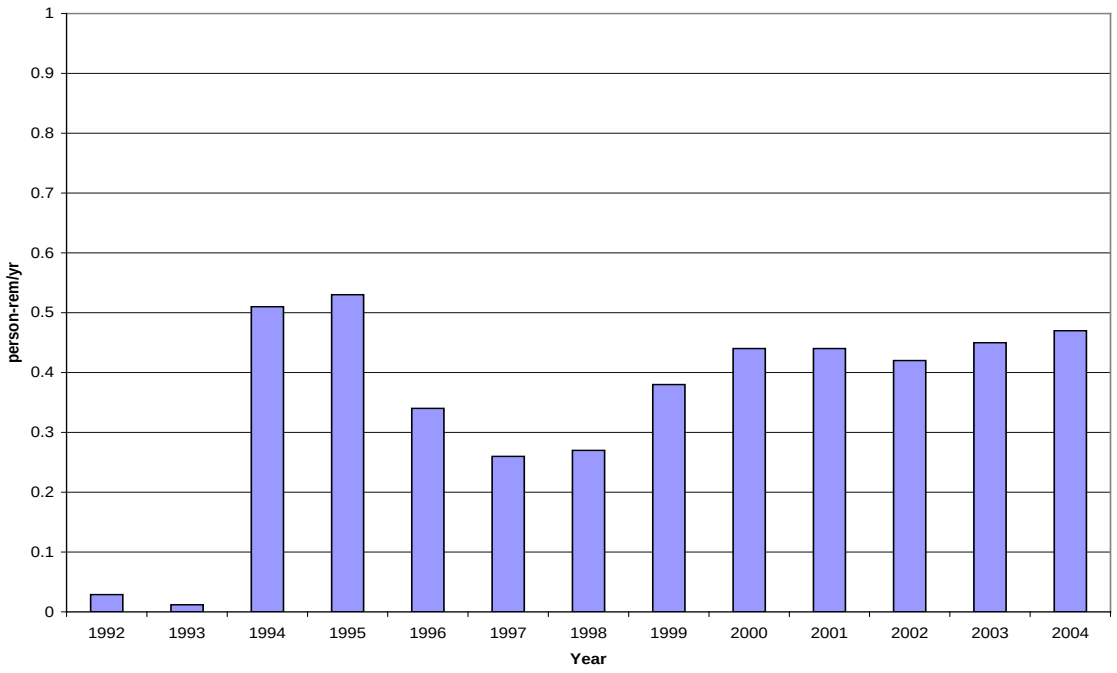

Figure G.1 Collective Dose to Populations within 80 km (50 miles) of Emission Sources

COMPLIANCE WITH 40 CFR 61, SUBPARTS Q AND T

The NNSS is regulated by Title 40 Code of Federal Regulations (CFR) Part 61, Subpart H (National Emission Standards for Emissions of Radionuclides Other than Radon from DOE Facilities) but not Q (National Emission Standards for Radon Emissions from DOE Facilities) or T (National Emission Standards for Radon Emissions from the Disposal of Uranium Mill Tailings) (CFR 2010a). However,

U.S. Department of Energy Order DOE O 435.1, "Radioactive Waste Management" (DOE 1999a) does include limits on radon flux from waste disposal facilities. Therefore, radon flux measurements are routinely made at the Area 3 Radioactive Waste Management Site and at the Area 5 Radioactive Waste Management Complex. This is done to confirm that radon fluxes are well below the standard of 20 picocuries per square meter per second required by U.S. Department of Energy Manual DOE M 435.1-1, "Radioactive Waste Management Manual" (DOE 1999b). The results of the most recent study (National Security Technologies, LLC, 2015) showed that the radon flux was not significantly different from background levels. An assessment of the potential risks posed by the Area 5 Radioactive Waste Management Complex to the public projected that the in-growth of radon-222 from the decay of thorium-230 in thorium wastes would not exceed the standard for approximately 4,200 years (National Security Technologies, LLC, 2013b).

NON-DISPOSAL/NON-STORAGE SOURCES OF RADON EMISSIONS

None of these sources exist on the NNSS.

QUALITY ASSURANCE PROGRAM FOR NESHAP COMPLIANCE

The quality assurance program for samples collected and analyzed for NESHAP compliance is documented in an environmental monitoring plan (DOE 2003). The applicable requirements of 40 CFR 61, Appendix B, Method 114, "Test Methods for Measuring Radionuclide Emissions from Stationary Sources" (U.S. Environmental Protection Agency 2001b) and of DOE O 414.1D, "Quality Assurance" (DOE 2011) have been implemented in this plan.