

# National Emission Standards for Hazardous Air Pollutants – Radionuclide Emissions Calendar Year 2015

June 2016

Prepared for

U.S. Department of Energy,  
National Nuclear Security Administration  
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Nevada National Security Site  
&  
North Las Vegas Facility



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Cover photo: Aerial view of subsidence craters at underground nuclear test locations at the Nevada National Security Site

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## **EXECUTIVE SUMMARY**

### **2015 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 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. After 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 actually resides at these onsite locations. Compliance is demonstrated if the measured annual average concentration is less than the NESHAP Concentration Levels (CLs) 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 2015, 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 0.4% to a maximum of 6.4% 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 0.000012 mrem/y, almost six orders of magnitude lower than the 10 mrem/y limit.

#### **NESHAP Compliance for 2015**

<b><u>NNSS: Compliance Demonstrated by the Sum of Fractions at Each Critical Receptor Sampler Being Less Than 1.0</u></b>		
<b>Radionuclides Included: <sup>3</sup>H, <sup>238</sup>Pu, <sup>239+240</sup>Pu, <sup>241</sup>Am</b>		
NNSS Operations Area	Critical Receptor Location	Sum of Fractions of CLs
6	Yucca	0.011
10	Gate 700 S	0.010
16	Substation 3545	0.006
20	Schooner	0.064
23	Mercury	0.005
25	Gate 510	0.004
<b><u>NLVF: Compliance Demonstrated by the Highest Potential Offsite Dose Being Less Than 10 mrem/y</u></b>		
Estimated offsite dose from NLVF = 0.000012 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
Be	beryllium
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
CY	calendar year
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 <sup>3</sup> /min	cubic feet per minute
<sup>3</sup> H	tritium
HTO	tritiated water
JASPER	Joint Actinide Shock Physics Experimental Research
km	kilometer(s)
km <sup>2</sup>	square kilometer(s)
Kr	krypton
L	liter(s)
LATF	Los Alamos Technical Facility
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
mrem/y	millirem per year
µrem/y	microrem per year
m/s	meter(s) per second
N	north or nitrogen (nitrogen if with atomic mass superscript)
NCERC	National Criticality Experiments Research Center
NESHAP	National Emission Standards for Hazardous Air Pollutants

## **List of Acronyms and Abbreviations (continued)**

NLVF	North Las Vegas Facility
NNSA/NFO	U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office
NSS	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
pCi	picocurie(s)
pCi/L	picocurie(s) per liter
pCi/m <sup>3</sup>	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)
Tc	technetium
TRU	transuranic (nuclides with atomic numbers greater than uranium)
U	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) 2015**

**Site Name:** Nevada National Security Site

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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<sup>2</sup>) 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 (50 miles) of the NNSS boundary. The distribution of this population, as demonstrated with LandScan data (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<sup>2</sup>, 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 2015 but was still identified on maps for reference. Two dairies operated within 80 km of the NNSS during 2015. 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. The largest single livestock production operation can be found in North Las Vegas. This swine farm is more than 80 km from the NNSS but is 5.9 km north of the North Las Vegas Facility (NLVF). The farm may have up to 6,000 animals. Food for the pigs comes 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 (<sup>3</sup>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 <sup>3</sup>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 (<sup>60</sup>Co), strontium-90 (<sup>90</sup>Sr), cesium-137 (<sup>137</sup>Cs), and the europium (Eu) isotopes <sup>152</sup>Eu, <sup>154</sup>Eu, and <sup>155</sup>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<sup>(a)</sup>**

Area	Radionuclide inventory (Ci) <sup>(b)</sup>								
	<sup>241</sup> Am	<sup>238</sup> Pu	<sup>239, 240</sup> Pu	<sup>60</sup> Co	<sup>137</sup> Cs	<sup>90</sup> Sr	<sup>152</sup> Eu	<sup>154</sup> Eu	<sup>155</sup> Eu
1	5.7	5.3	24	0.0	4.9	8.1	4.1	0.0	0.0
2	4.3	7.0	22	0.0	13	25	3.8	0.0	0.0
3	7.0	2.5	37	0.0	6.7	18	4.9	0.0	0.0
4	9.2	11	40	0.1	6.7	7.0	2.5	0.0	0.0
5	0.9	0.1	4.8	0.0	0.2	0.5	2.7	0.0	0.0
6	2.2	2.7	8.4	0.0	1.6	1.9	0.0	0.0	0.0
7	3.2	0.5	16	0.0	2.9	5.0	6.0	0.0	0.0
8	24.1	6.5	110	0.2	23	14	1.2	0.0	0.0
9	10.4	1.8	89	0.0	4.8	7.0	6.2	0.0	0.0
10	26.1	16	110	0.3	47	30	0.6	0.0	0.1
11	5.2	0.4	29	0.0	0.3	0.2	0.0	0.0	0.0
12	8.2	7.0	39	0.0	11	9.2	0.0	0.0	0.0
15	12.2	6.4	63	0.0	11	12	0.0	0.0	0.0
16	0.9	1.2	3.7	0.0	1.6	2.0	0.0	0.0	0.0
17	4.0	3.7	18	0.0	8.4	10	0.0	0.0	0.0
18	25.3	4.6	100	0.0	5.6	9.2	0.3	0.0	0.0
19	30.1	26	140	0.0	20	17	0.0	0.0	0.0
20	25.0	25	41	0.3	3.1	2.3	3.5	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	4.1	3.7	14	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, 2015, with ingrowth of <sup>241</sup>Am from <sup>241</sup>Pu included.

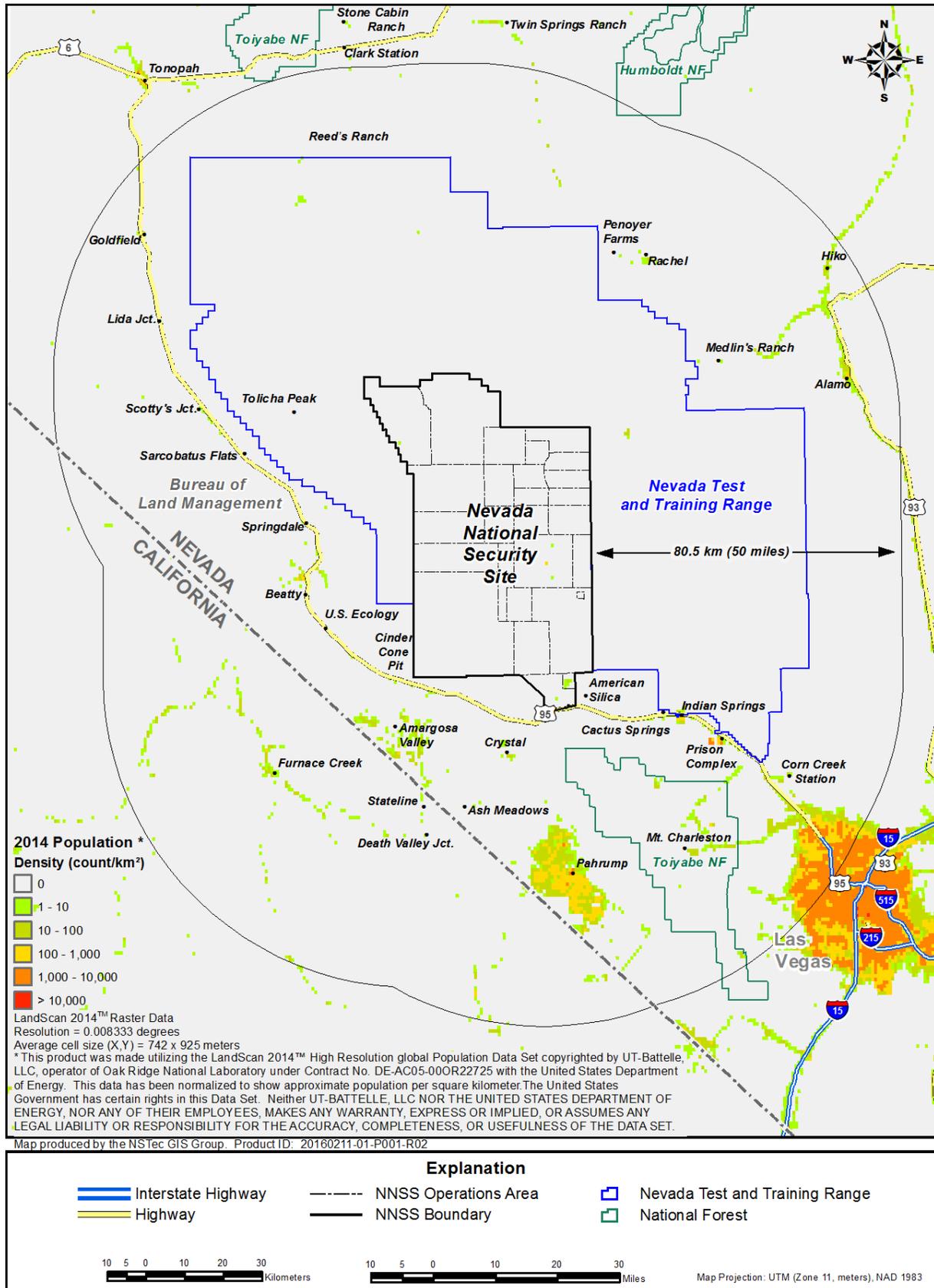


Figure 1. NNSS and Surrounding Populated Area

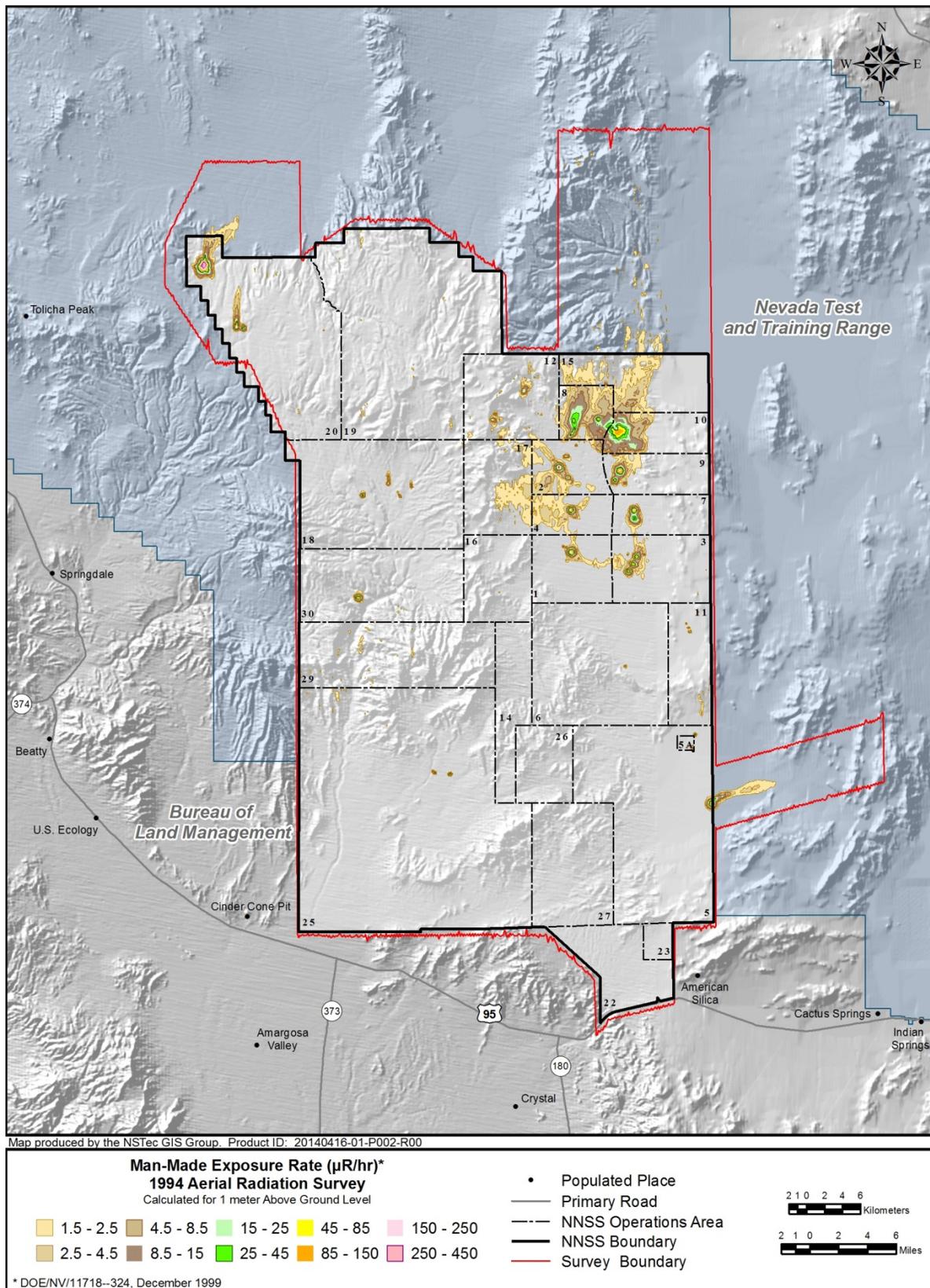


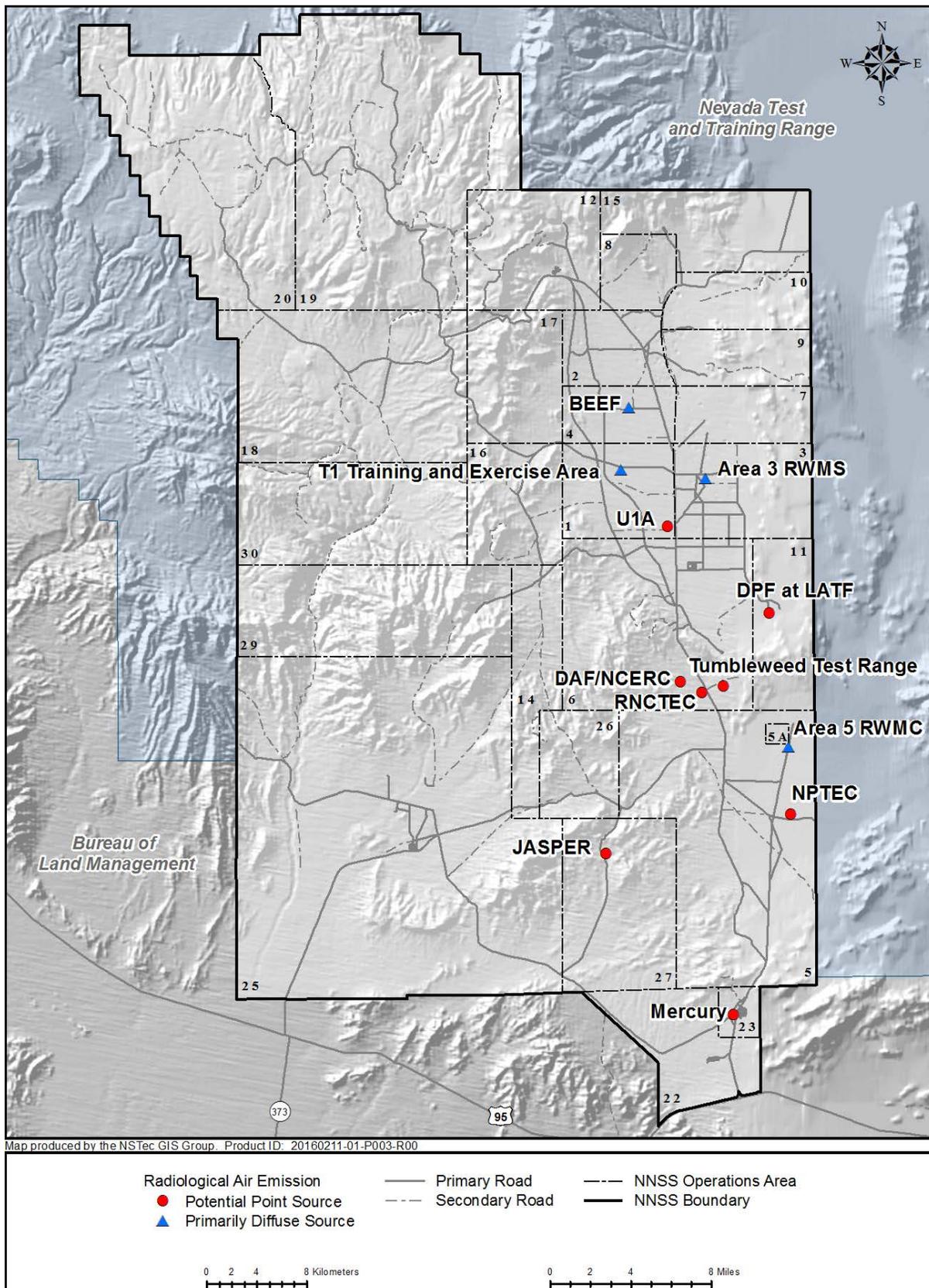
Figure 2. Distribution of Elevated Exposure Rates from Radionuclides in NNSS Soils

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  $^3\text{H}$ ,  $^{60}\text{Co}$ ,  $^{137}\text{Cs}$ , 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:

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

There are also facilities where radioactive material (e.g., environmental samples) are surveyed, processed, and/or analyzed: Occupational Medicine and Radiological Control Building 23-650, Radioactive Materials Control Building 23-180, and the Environmental Monitoring Building 23-652, all in Mercury in Area 23 (Figure 3). Handling of radioactive material in these buildings is limited. In 2015 these activities were dominated by the handling and distillation of environmental samples and laboratory standards containing radioactive material in the lab in Building 23-652. 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) 2015 are listed in Section II, Table 2, and their source information is listed in Appendix A.



**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 2015 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 2015 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 NNSS for  $^3\text{H}$  emissions. The derivation of  $^3\text{H}$  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  $^3\text{H}$  in 1995. Emanation of tritiated water (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 2015 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  $^3\text{H}$  evaporating as HTO. Calculation of this emission source for CY 2015 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  $^3\text{H}$  as HTO. During CY 2015, water containing  $^3\text{H}$  was pumped from the following wells:

- ER-20-5 #1
- ER-20-5 #3
- ER-20-8
- ER-20-12

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

The 1995  $^3\text{H}$  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  $^3\text{H}$  contaminated water. The State of Nevada approved disposing of the contaminated water in 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 2015.

There were no Environmental Restoration demolitions or cleanup projects conducted during CY 2015 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 (located at the LATF), 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 2015 are the NPTEC in Area 5, the NCERC in Area 6, the Tumbleweed Test Range in Area 6, and the DPF at the LATF 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  $^3\text{H}$  as HTO in atmospheric moisture. The calculation of the  $^3\text{H}$  source term for these emissions in CY 2015 is described in Appendix B.

### **Support Facility Operations**

Facilities with laboratories as described at the end of Section I have the potential to emit low quantities of radionuclides from handling contaminated environmental samples or from the preparation of  $^3\text{H}$  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 the laboratory in Building 23-652 was known to use unsealed radioactive materials (standard solutions) regularly in CY 2015; therefore, it is the only facility in this category listed as being an emission source in CY 2015.

Each potential source of NNSS emissions for CY 2015 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 2015 emission sources to the nearest offsite locations of interest are listed in Table 2. Distances ranged from 6 to 80 km from NNSS emission sources and from 0.1 to 0.85 km from the NLVF emission source.

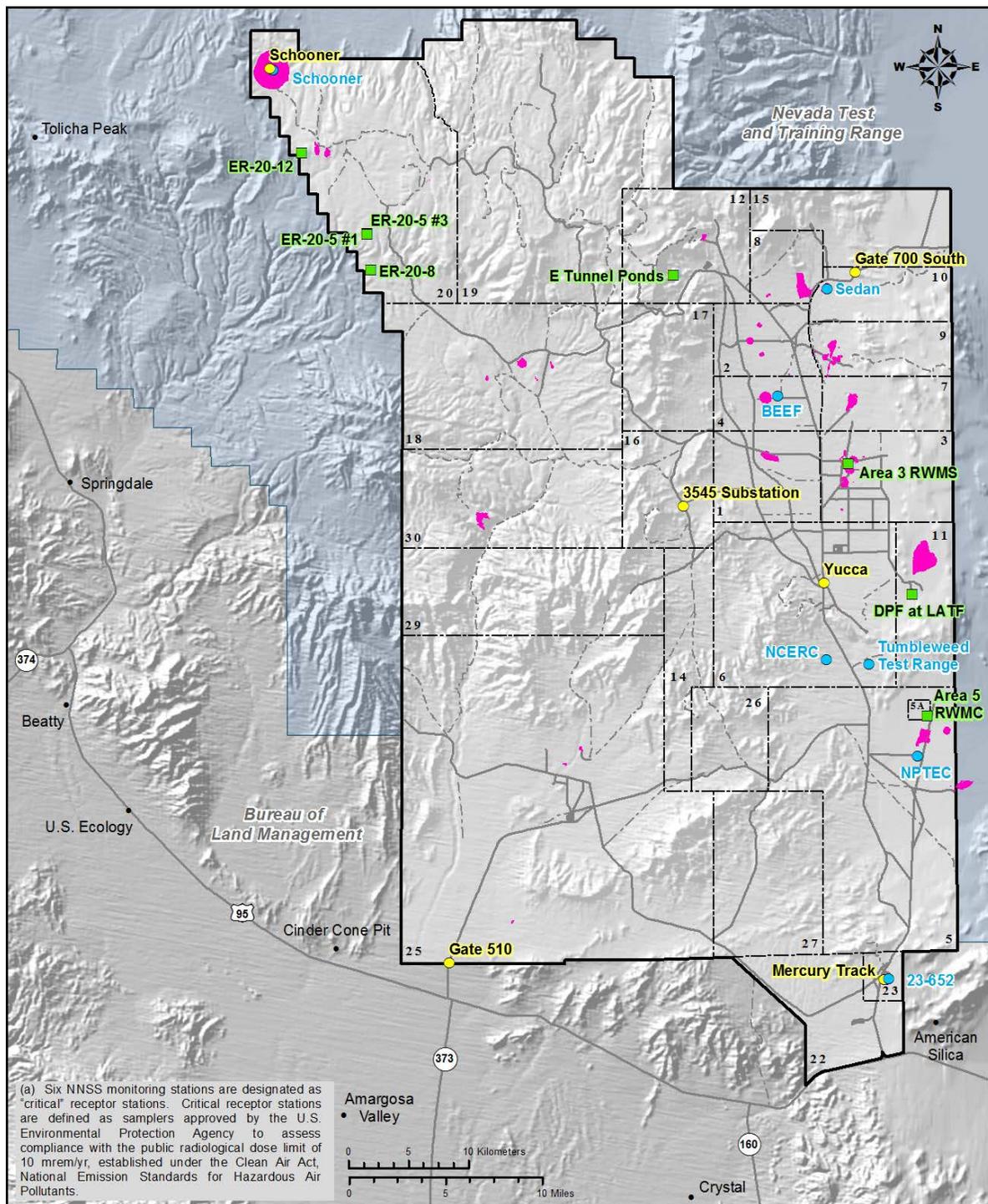
Total CY 2015 emissions, by radionuclide, are shown in Table 3 for the NNSS and in Table 4 for the NLVF. Radionuclide emissions by source are shown in Table 5. The source type, emission control, and description of the nature of each emission are listed in Table A.1 of Appendix A. Appendices B through E describe the methods used to determine the CY 2015 emissions.

A number of radionuclides emitted from the NNSS during CY 2015 have short enough half-lives (ranging from 7 seconds for nitrogen-16 to 55 minutes for chlorine-39) that much of the activity decays away over the time it takes to travel the long distances to offsite receptors (Table 2). Beryllium-7 (<sup>7</sup>Be) has a 54-day half-life but is emitted in quantities much lower than the concentrations of <sup>7</sup>Be produced in the atmosphere by naturally occurring cosmic radiation, so its contribution to offsite dose is negligible. Appendix A shows the range of potential dose these may contribute to maximally exposed individuals offsite.

**Table 2. CY 2015 Radionuclide Emission Sources and Distance to Offsite Locations**

Emission Source	Distance <sup>(a)</sup> and Direction <sup>(b)</sup> to Nearest Offsite Locations		
	Offsite Residence	Offsite Business/Office	Offsite School
<b><u>Legacy Contamination Sites</u></b>			
<b><u>Weapon Test and Plowshare Soil Contamination Sites</u></b>			
Sedan, Area 10	52 km ENE (Medlin’s Ranch)	59 km NNE (Rachel)	80 km ENE (Alamo)
Schooner, Area 20	37 km WSW (Sarcobatus Flat)	21 km WSW (Tolicha Peak)	56 km SSW (Beatty)
Grouped Area Sources – All NNSS	Various locations ranging from 20 to 60 km		
<b><u>Emanation from Building Materials</u></b>			
Building A-01, basement ventilation, NLVF	0.6 km W (N Las Vegas) <sup>(c)</sup>	0.1 km (at north fence of NLVF)	0.85 km W (N Las Vegas) <sup>(c)</sup>
<b><u>Groundwater Characterization/Control or Remediation Activities</u></b>			
<b><u>Environmental Restoration Projects</u></b>			
E-Tunnel Ponds, Area 12	53 km WSW (Springdale)	55 km WNW (Tolicha Peak)	62 km SW (Beatty)
<b><u>UGTA Well Discharges</u></b>			
ER-20-5 #1	32 km SW (Springdale)	29 km WNW (Tolicha Peak)	47 km SSW (Beatty)
ER-20-5 #3	32 km SW (Springdale)	29 km WNW (Tolicha Peak)	47 km SSW (Beatty)
ER-20-8	31 km SW (Springdale)	30 km WNW (Tolicha Peak)	44 km SW (Beatty)
ER-20-12	34 km SW (Springdale)	22 km W (Tolicha Peak)	50 km SSW (Beatty)
<b><u>Defense, Security, and Stockpile Stewardship</u></b>			
DPF (at LATF in Figure 4), 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)
Tumbleweed Test Range, Area 6	43 km SE (Cactus Springs)	31 km SSE (American Silica)	47 km SE (Indian Springs)
<b><u>Radioactive Waste Management</u></b>			
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)
<b><u>Support Facility Operations</u></b>			
Building 23-652 (labeled 23-652 in Figure 4), Area 23	24 km SW (Crystal)	24 km SW (Crystal)	30 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



Radionuclide Air Emission Source		Transportation and Boundaries
■ Primarily Tritium	● Critical Receptor Station <sup>(a)</sup>	— Primary Road
● One or More of: Tritium, Actinides, Activation/Fission Products	● Populated Place	- - - Secondary Road
● Grouped Area Sources: One or More of Tritium, Actinides, Activation/Fission Products		- - - NNSS Operations Area
		— NNSS Boundary

Figure 4. Sources of Radiological Air Emissions on the NNSS in CY 2015

**Table 3. Total Estimated NNSS Emissions for CY 2015**

<b>Radionuclide<sup>(a)</sup></b>	<b>Symbol</b>	<b>Half-life</b>	<b>Total Quantity (Ci)</b>
Tritium	<sup>3</sup> H	12.3 years (y)	361
Beryllium-7	<sup>7</sup> Be	54 days (d)	0.00081
Carbon-11	<sup>11</sup> C	20.5 minutes (m)	65
Depleted uranium	DU	>150,000 y	0.00002
Nitrogen-13	<sup>13</sup> N	10 m	2300
Oxygen-15	<sup>15</sup> O	2.1 m	3700
Nitrogen-16	<sup>16</sup> N	7.1 seconds (s)	12
Oxygen-19	<sup>19</sup> O	26.5 s	0.02
Chlorine-38	<sup>38</sup> Cl	37 m	1.9
Chlorine-39	<sup>39</sup> Cl	55 m	29
Argon-41	<sup>41</sup> Ar	109.6 m	855
Cobalt-60	<sup>60</sup> Co	5.3 y	0.0004
metastable Krypton-85	<sup>85m</sup> Kr	4.5 hours (h)	110
Krypton-85	<sup>85</sup> Kr	10.8 y	0.0011
Strontium-90	<sup>90</sup> Sr	28.8 y	0.056
metastable Xenon-131	<sup>131m</sup> Xe	11.8 d	0.04
metastable Xenon-133	<sup>133m</sup> Xe	2.2 d	1.3
Xenon-133	<sup>133</sup> Xe	5.2 d	20
metastable Xenon-135	<sup>135m</sup> Xe	15.3 m	1800
Xenon-135	<sup>135</sup> Xe	9.1 h	270
Cesium-137	<sup>137</sup> Cs	30.2 y	0.055
Europium-152	<sup>152</sup> Eu	13.5 y	0.011
Europium-154	<sup>154</sup> Eu	8.6 y	0.00012
Europium-155	<sup>155</sup> Eu	4.8 y	0.00011
Plutonium-238	<sup>238</sup> Pu	87.7 y	0.041
Plutonium-239+240	<sup>239+240</sup> Pu	24,110 y	0.29
Americium-241	<sup>241</sup> Am	432.2 y	0.066

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  $\geq 10\%$  of the potential EDE [threshold for required measurement per 40 CFR 61.93(b)(4)(i)].

**Table 4. Total Estimated NLVF Emissions for CY 2015**

<b>Radionuclide</b>	<b>Total Quantity (Ci)</b>
<sup>3</sup> H	0.0024

Table 5. Summary of CY 2015 Air Emissions Data by Source

Emission Source <sup>(a)</sup>	Type of Emissions		Radionuclide	Annual Quantity (Ci)		
		Control				
<b>Legacy Contamination Sites</b> (Weapon Test and Plowshare Soil Contamination Sites)	Sedan <sup>(b)</sup>	None	<sup>3</sup> H	7.0		
	Schooner <sup>(b)</sup>	None	<sup>3</sup> H	9.3		
	Grouped Area Sources – All NNSS Areas <sup>(c)</sup>	None	<sup>60</sup> Co	0.00040		
			<sup>90</sup> Sr	0.056		
			<sup>137</sup> Cs	0.055		
			<sup>152</sup> Eu	0.011		
			<sup>154</sup> Eu	0.00012		
			<sup>155</sup> Eu	0.00011		
			<sup>238</sup> Pu	0.041		
			<sup>239+240</sup> Pu	0.29		
<sup>241</sup> Am	0.066					
<b>Emanation from Building Materials</b>	NLVF, Building A-01, basement ventilation, NLVF <sup>(d)</sup>	None	<sup>3</sup> H	0.0024		
<b>Groundwater Characterization/Control or Remediation Activities</b>	<u>Environmental Restoration Projects</u>					
	E-Tunnel Ponds <sup>(e)</sup>	None	<sup>3</sup> H	5.3		
	<u>UGTA Well Sumps<sup>(e)</sup></u>					
	ER-20-5 #1	None	<sup>3</sup> H	4.1		
	ER-20-5 #3	None	<sup>3</sup> H	0.0084		
	ER-20-8	None	<sup>3</sup> H	0.0028		
	ER-20-12	None	<sup>3</sup> H	0.056		
<b>Defense, Security, and Stockpile Stewardship</b>	DPF <sup>(f)</sup>	None	<sup>3</sup> H	330		
	NCERC <sup>(f)</sup>	HEPA	<sup>16</sup> N	12		
			<sup>19</sup> O	0.02		
			<sup>41</sup> Ar	4.8		
			<sup>85m</sup> Kr	109		
			<sup>85</sup> Kr	0.0011		
			<sup>131m</sup> Xe	0.04		
			<sup>133m</sup> Xe	1.3		
			<sup>133</sup> Xe	20		
			<sup>135m</sup> Xe	1800		
			<sup>135</sup> Xe	270		
			NPTEC <sup>(f)</sup>	None	DU	0.00002
			Tumbleweed Test Range <sup>(f)</sup>	None	<sup>7</sup> Be	0.00081
					<sup>11</sup> C	65
					<sup>13</sup> N	2300
<sup>15</sup> O	3700					
<sup>38</sup> Cl	1.9					
<sup>39</sup> Cl	29					
	<sup>41</sup> Ar	850				
<b>Radioactive Waste Management</b>	Area 3 RWMS <sup>(b)</sup>	Soil cover over waste	<sup>3</sup> H	3.2		
	Area 5 RWMC <sup>(b)</sup>	Soil cover over waste	<sup>3</sup> H	3.5		
<b>Support Facility</b>	Building 23-652 <sup>(g)</sup>	None	<sup>3</sup> H	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 IX 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, Substation 3545
- 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 Levels (CLs) for Environmental Compliance (40 CFR 61, Appendix E, Table 2). The CLs represent 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 2015 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 2% of the CLs except for the  $^3\text{H}$  average at the Schooner sampler station, which was about 6.1% of the CL. The average concentration of  $^3\text{H}$  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 0.064. This is well below 1.0 and therefore in compliance with the NESHAP standard. Scaling the 0.064 sum of fractions to the 10 mrem/y limit gives an estimated EDE of 0.64 mrem/y from the air pathway for a hypothetical individual living year-round at this station. 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 0.0036 sum of fractions for the Gate 510 station to the 10 mrem/y limit gives an estimated EDE of about 0.04 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 2015.

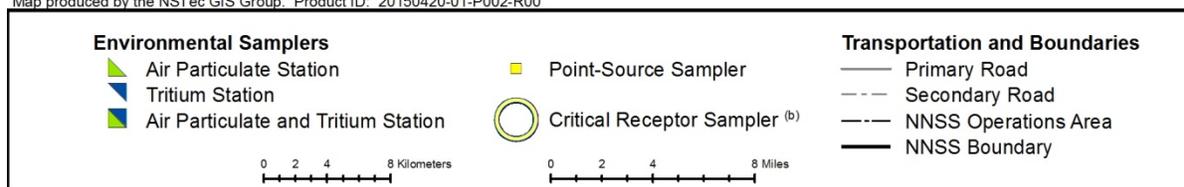
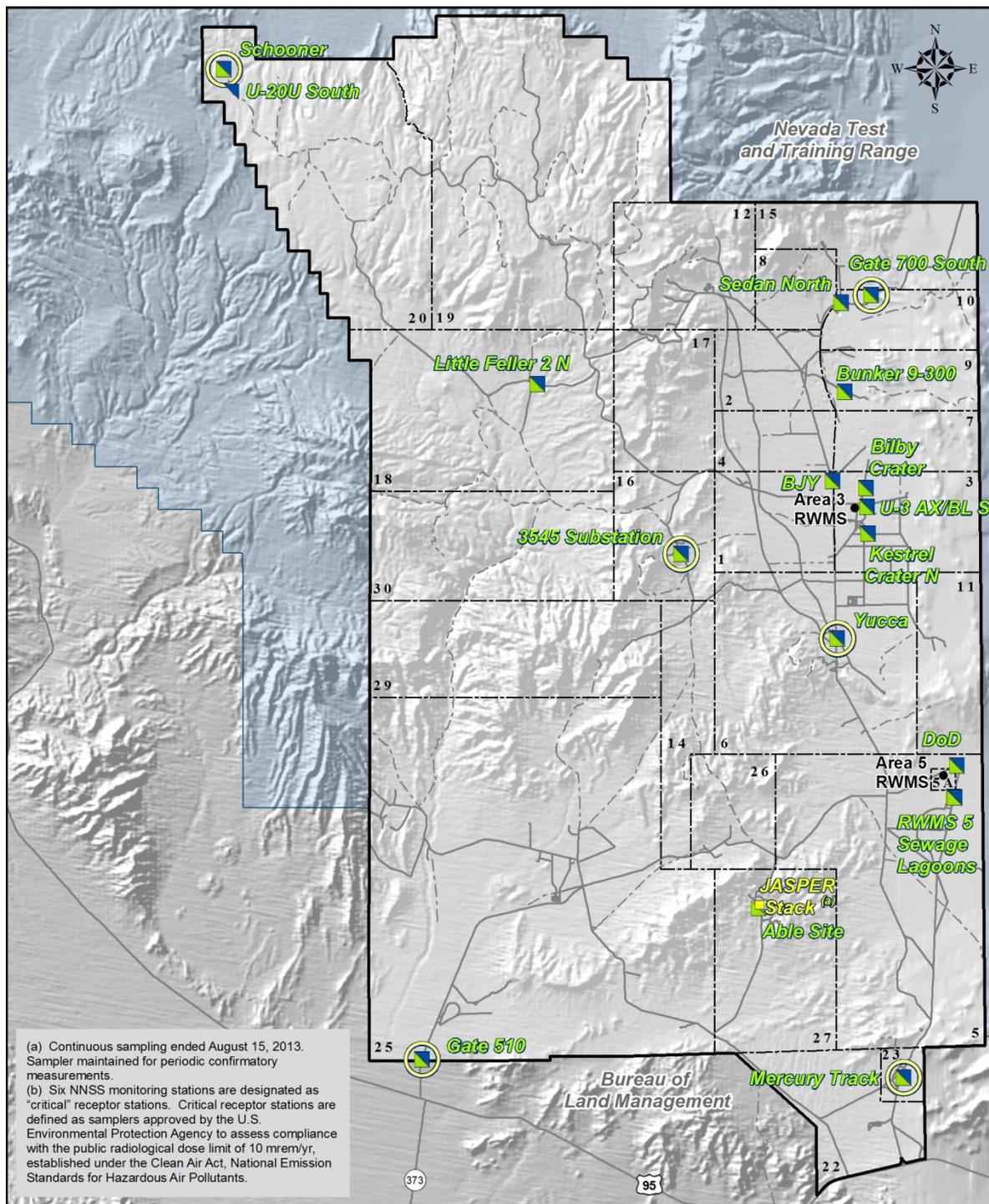


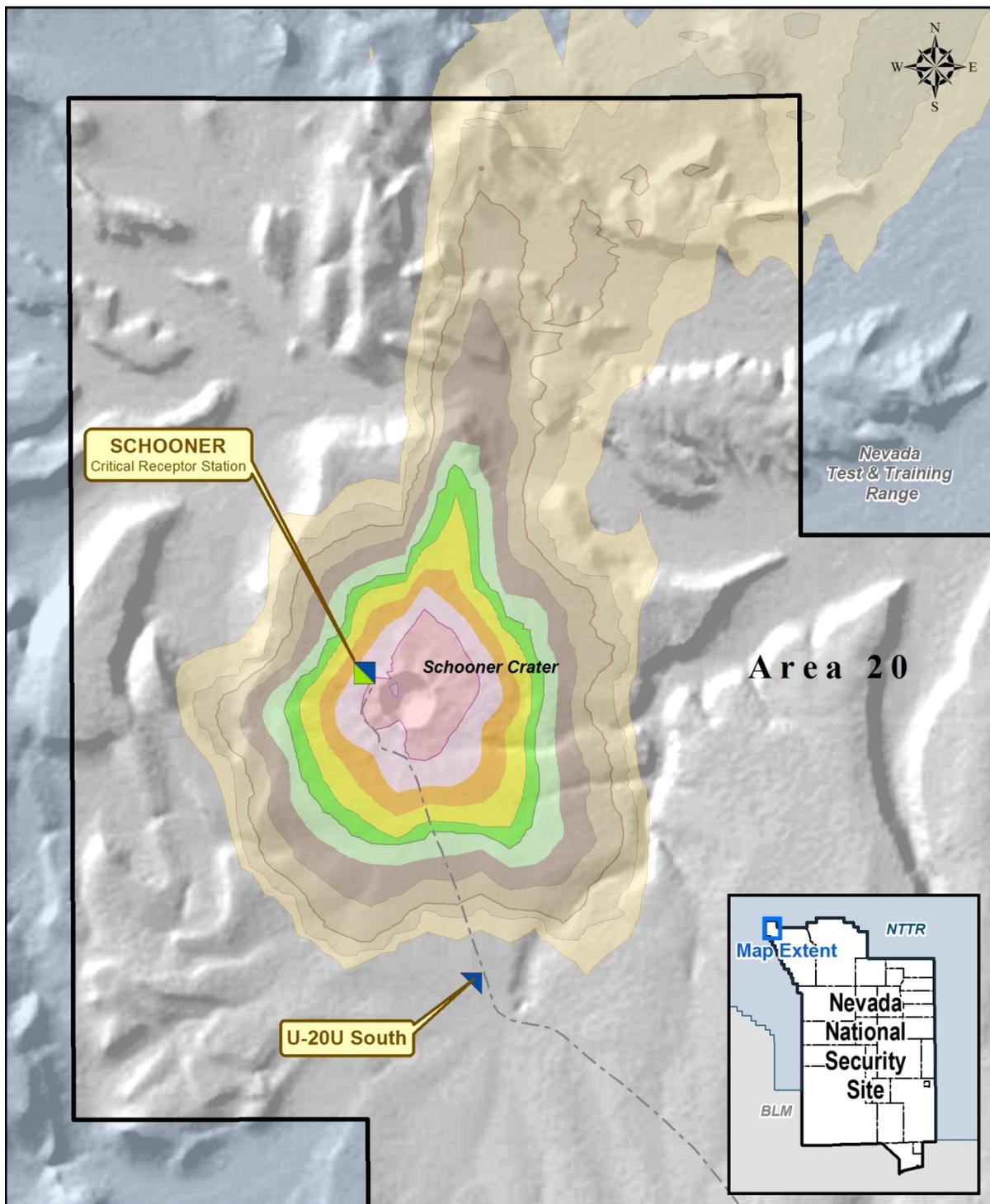
Figure 5. Air Sampling Network on the NNSS

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

Critical Receptor Station	Distance <sup>(a)</sup> and Direction <sup>(b)</sup> 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)	77 km ENE (Alamo)	2.4 km WSW (Area 10, Sedan Crater)
Area 16, Substation 3545	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



Map produced by the NSTec GIS Group. Product ID: 20140416-01-P005-R00



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 2015**

Location	Radionuclide	Average Concentration in Air (pCi/m <sup>3</sup> ) <sup>(a)</sup>	CL <sup>(b)</sup> (pCi/m <sup>3</sup> )	Average Concentration as Fraction of CL
Yucca	<sup>3</sup> H	0.32 x 10 <sup>0</sup>	1500	0.0002
Gate 700 S		0.05 x 10 <sup>0</sup>		0.0000
Substation 3545		-0.02 x 10 <sup>0</sup>		0.0000
Schooner		91.74 x 10 <sup>0</sup>		0.0612
Mercury Track		-0.08 x 10 <sup>0</sup>		-0.0001
Gate 510		0.07 x 10 <sup>0</sup>		0.0000
Yucca	<sup>137</sup> Cs	-3.93 x 10 <sup>-6</sup>	0.019	-0.0002
Gate 700 S		10.11 x 10 <sup>-6</sup>		0.0005
Substation 3545		26.60 x 10 <sup>-6</sup>		0.0014
Schooner		-1.74 x 10 <sup>-6</sup>		-0.0001
Mercury Track		33.98 x 10 <sup>-6</sup>		0.0018
Gate 510		17.13 x 10 <sup>-6</sup>		0.0009
Yucca	<sup>241</sup> Am	3.31 x 10 <sup>-6</sup>	0.0019	0.0017
Gate 700 S		2.30 x 10 <sup>-6</sup>		0.0012
Substation 3545		2.81 x 10 <sup>-6</sup>		0.0015
Schooner		1.03 x 10 <sup>-6</sup>		0.0005
Mercury Track		1.94 x 10 <sup>-6</sup>		0.0010
Gate 510		1.00 x 10 <sup>-6</sup>		0.0005
Yucca	<sup>238</sup> Pu	2.10 x 10 <sup>-6</sup>	0.0021	0.0010
Gate 700 S		5.02 x 10 <sup>-6</sup>		0.0024
Substation 3545		1.82 x 10 <sup>-6</sup>		0.0009
Schooner		2.51 x 10 <sup>-6</sup>		0.0012
Mercury Track		1.77 x 10 <sup>-6</sup>		0.0008
Gate 510		2.13 x 10 <sup>-6</sup>		0.0010
Yucca	<sup>239+240</sup> Pu	15.29 x 10 <sup>-6</sup>	0.0020	0.0076
Gate 700 S		11.12 x 10 <sup>-6</sup>		0.0056
Substation 3545		3.87 x 10 <sup>-6</sup>		0.0019
Schooner		2.37 x 10 <sup>-6</sup>		0.0012
Mercury Track		2.46 x 10 <sup>-6</sup>		0.0012
Gate 510		2.14 x 10 <sup>-6</sup>		0.0011
Yucca	Sum of Fractions by Locations	Sums for analytes listed above, with negative values set to zero.		0.0106
Gate 700 S				0.0097
Substation 3545				0.0057
Schooner				0.0641
Mercury Track				0.0049
Gate 510				0.0036

(a) picocuries per cubic meter (pCi/m<sup>3</sup>)

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

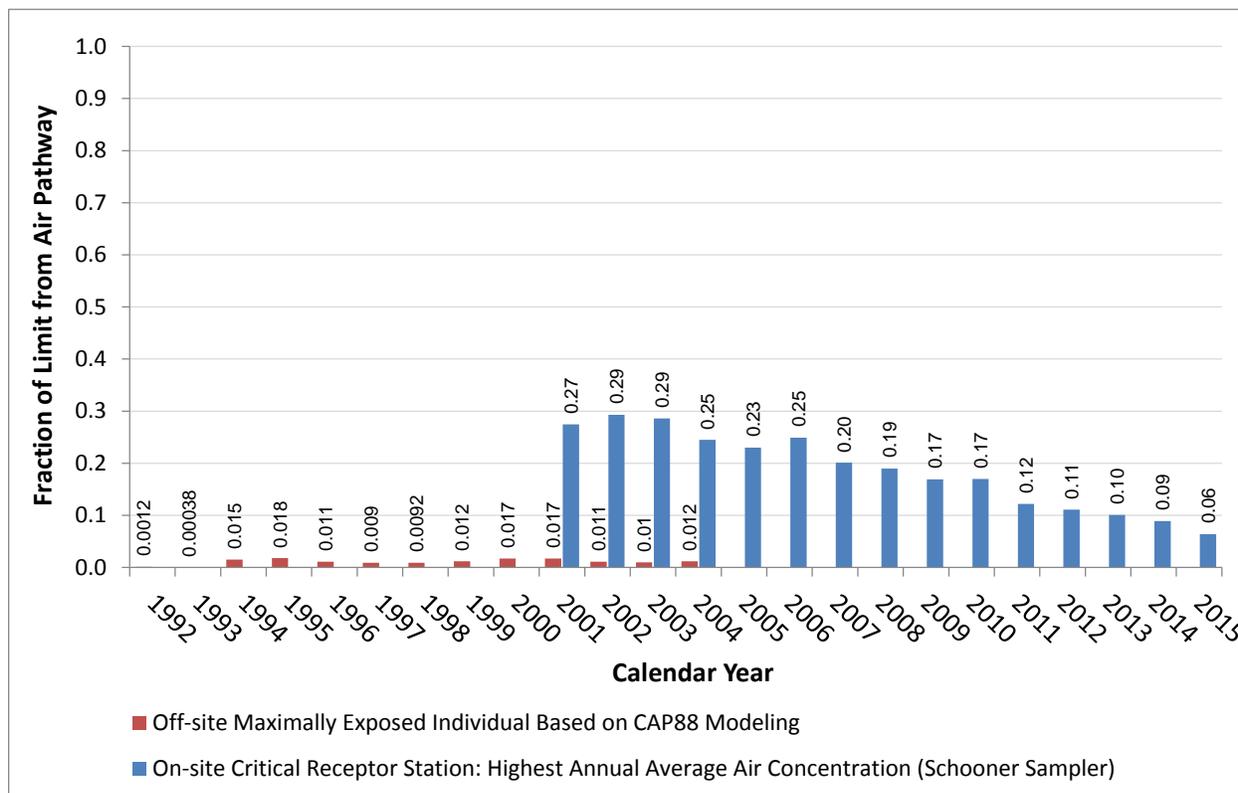


Figure 7. Fraction of the 10 mrem/y Air Pathway Dose Limit for CAP88-PC Modeled MEI Dose and Highest Critical Receptor Station Monitoring Results

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## **SECTION IV ADDITIONAL INFORMATION**

### **DOSE EVALUATIONS CONDUCTED DURING CY 2015**

This section summarizes radionuclide NESHAP evaluations conducted during CY 2015 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 III or IV (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 2015 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.

#### **ENVIRONMENTAL RESTORATION PROJECTS**

Under the *Federal Facility Agreement and Consent Order*, as amended (March 2010) 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 during CY 2015; therefore, no radiation dose assessments were performed in this category.

#### **WASTE MANAGEMENT PROJECTS**

No construction/modification activities took place at waste management facilities during CY 2015. 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 2015.

#### **RESEARCH PROJECTS**

NESHAP dose evaluations were completed for two research projects during CY 2015. A summary of these is listed in Table 8. Both of these projects were determined to be Category IV emission sources (ANSI/HPS 13.1-2011 potential impact categories [American National Standards Institute 2011]).

**Table 8. NESHAP Dose Evaluations Conducted during CY 2015**

<b>Project Description</b>	<b>NNSS Operational Area</b>	<b>Emission Year</b>	<b>Radionuclide Emissions</b>	<b>MEI Dose (mrem/y) and Location</b>	<b>Emission Category<sup>(a)</sup></b>
Conservative assumptions were made to determine dose from handling uranium during a project conducted at the Nonproliferation Test and Evaluation Complex (NPTEC).	Area 5	CY 2015	<sup>233</sup> U, <sup>234</sup> U, <sup>235</sup> U, and <sup>238</sup> U	0.00015 Cactus Springs, 34.2 km SE	IV
Off-site dose from potential emissions from National Criticality Experiments Research Center (NCERC) operations	Area 6	CY 2015	Various activation and fission products (see Table 5)	0.001 Cactus Springs, 45.3 km SE	IV

(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 II refers to annual dose > 0.1 mrem and ≤ 5 mrem;  
Category III refers to annual dose > 0.001 mrem and ≤ 0.1 mrem; and Category IV refers to annual dose ≤ 0.001 mrem.

## **PERIODIC CONFIRMATORY MEASUREMENTS**

NESHAP regulations require periodic confirmatory measurements for minor release sources (Category III or IV 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 2015.

### **Joint Actinide Shock Physics Experimental Research (JASPER)**

A sample of stack effluents was taken during a test using special nuclear material on June 9, 2015. This was analyzed for <sup>238</sup>Pu, <sup>239+240</sup>Pu, and <sup>241</sup>Am. No radionuclides were detected in the sample. There is no evidence of radionuclide emissions from JASPER operations. This 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 <sup>3</sup>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 2015 were analogous to the past few years and the resultant dose (0.000012 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 2015.

### **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: Steven J. Lawrence,  
Manager, NNSA/NFO

---

Signature: Steven J. Lawrence

Date: 6.27.16

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## **REFERENCES**

- American National Standards Institute, 2011. *Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stacks and Ducts of Nuclear Facilities*. ANSI N13.1-2011. American National Standards Institute, Inc., Washington, D.C.
- CFR, see Code of Federal Regulations.
- Code of Federal Regulations, 2010a. National Emission Standards for Hazardous Air Pollutants: Radionuclides, Title 40, Part 61, U.S. Environmental Protection Agency, Washington, D.C.
- Code of Federal Regulations, 2010b. Occupational Radiation Protection, Title 10, Part 835, U.S. Department of Energy, Washington, D.C.
- DOE, see U.S. Department of Energy.
- EPA, see U.S. Environmental Protection Agency.
- Geographic Information Science & Technology Group, Oak Ridge National Laboratory, 2015. LandScan 2014 Global Population Database at 30 arc-seconds (1 km or finer). Oak Ridge National Laboratory, Oak Ridge, TN.
- Hendricks, T. J., and S. R. Riedhauser, 1999. *An Aerial Radiological Survey of the Nevada Test Site*, DOE/NV/11718--324, U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV.
- National Security Technologies, LLC, 2013a. *National Emission Standards for Hazardous Air Pollutants – Radionuclide Emissions Calendar Year 2012*, DOE/NV/25946--1796, U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office, Las Vegas, NV.
- National Security Technologies, LLC, 2013b. *Special Analysis for the Disposal of the Consolidated Edison Uranium Solidification Project Waste Stream at the Area 5 Radioactive Waste Management Site, Nevada National Security Site, Nye County, Nevada*, DOE/NV/25946--1678, U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office, Las Vegas, NV.
- National Security Technologies, LLC, 2015. *Nevada National Security Site 2014 Waste Management Monitoring Report, Area 3 and Area 5 Radioactive Waste Management Sites*, DOE/NV/25946--2516, U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office, Las Vegas, NV.
- U.S. Department of Energy, 1991. *Radionuclides in Surface Soil at the Nevada Test Site*, DOE/NV/10845--02, Water Resources Center, Desert Research Institute, University of Nevada System, Las Vegas, NV.
- U.S. Department of Energy, 1992. *Summary of the Nevada Applied Ecology Group and Correlative Programs*, DOE/NV--357, Raytheon Services Nevada, Las Vegas, NV.
- U.S. Department of Energy, 1996. *National Emission Standards for Hazardous Air Pollutants Submittal - 1995*, DOE/NV/11718--032, U.S. Department of Energy, Nevada Operations Office, Las Vegas, NV.
- U.S. Department of Energy, 1999a. Radioactive Waste Management, DOE O 435.1, Chg 1, Office of Environmental Management, Washington, D.C.

- U.S. Department of Energy, 1999b. Radioactive Waste Management Manual, DOE M 435.1-1, Chg 2, Office of Environmental Management, Washington, D.C.
- U.S. Department of Energy, 2003. *Routine Radiological Environmental Monitoring Plan*, DOE/NV/11718--804, U.S. Department of Energy, Nevada Site Office, Las Vegas, NV.
- U.S. Department of Energy, 2004. Email from Gustavo Vazquez, DOE/EH-41, to Bruce W. Hurley, NNSA/NSO, dated April 1, 2004.
- U.S. Department of Energy, 2013. *Final Site-Wide Environmental Impact Statement for the Continued Operation of the Department of Energy/National Nuclear Security Administration Nevada National Security Site and Off-Site Locations in the State of Nevada*. DOE/EIS-0426, U.S. Department of Energy, Nevada Site Office, Las Vegas, NV.
- U.S. Department of Energy, 2011. Quality Assurance, DOE O 414.1D, April 25, 2011, Washington, D.C.
- U.S. Environmental Protection Agency, 2001a. Approval Letter for the NNSS Use of Critical Receptor Monitoring. Letter from Jack P. Broadbent, EPA Region IX Director, Air Division, to Kenneth A. Hoar, DOE Nevada Field [Operations] Office, Environmental, Safety & Health Division, July 23, 2001.
- U.S. Environmental Protection Agency, 2001b. Test Methods for Measuring Radionuclide Emissions from Stationary Sources, Title 40 Code of Regulations, Part 61, Appendix B, Method 114, July 1, 2001 Edition.
- U.S. Environmental Protection Agency, 2006. Updated User's Guide for CAP88-PC, Version 3.0, Office of Radiation and Indoor Air, Washington, D.C.
- U.S. Environmental Protection Agency and U.S. Department of Energy, 1995. Memorandum of Understanding Between the U.S. Environmental Protection Agency and the U.S. Department of Energy Concerning the Clean Air Act Emission Standards for Radionuclides 40 CFR Part 61, Including Subparts H, I, Q & T. Signed by Mary D. Nichols, EPA Assistant Administrator for Air and Radiation, September 29, 1994. Signed by Tara O'Toole, DOE Assistant Secretary for Environment, Safety, and Health, April 5, 1995.
- U.S. Nuclear Regulatory Commission, 1983. *Radiological Assessment*, NUREG/CR-3332, Till, J. E., and H. R. Meyer, Editors, Office of Nuclear Reactor Regulation, Washington, D.C.

## **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) 2015**

Facility or Area	Emission Type	Radionuclide(s) Emitted	Handling/ Processing	Nature of Emissions	Effluent Controls	Emission Category <sup>(a)</sup>	Distance and Direction to Nearest Air Sampler(s)
<b>Legacy Contamination Sites</b>							
<b><u>Weapon Test and Plowshare Soil Contamination Sites</u></b>							
Sedan Crater (Plowshare), Area 10	Diffuse	Tritium (3H) as tritiated water (HTO), americium (Am), plutonium (Pu), activation and fission products	None	3H as HTO through evaporation from soil or transpiration from plants and suspension of contaminated soil by wind	None	III	<ul style="list-style-type: none"> <li>Sedan North: 0.8 kilometers (km) to the north (N)</li> <li>Critical receptor sampler (Gate 700 S): 2.4 km to the east-northeast (ENE)</li> </ul>
Schooner Crater (Plowshare), Area 20	Diffuse	3H as HTO, Am, Pu, activation and fission products	None	3H as HTO through evaporation from soil or transpiration from plants and suspension of contaminated soil by wind	None	II	<ul style="list-style-type: none"> <li>Critical receptor sampler (Schooner): 0.2 km to the northwest (NW)</li> </ul>
Grouped Area Sources – All Nevada National Security Site (NNS) Areas	Diffuse	Am, Pu, activation and fission products (3H 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	II	<ul style="list-style-type: none"> <li>See Section III, Table 6</li> </ul>

**Table A.1 Facilities or Areas from Which Radionuclides Were Released to Air in Calendar Year (CY) 2015 (continued)**

Facility or Area	Emission Type	Radionuclide(s) Emitted	Handling/ Processing	Nature of Emissions	Effluent Controls	Emission Category <sup>(a)</sup>	Distance and Direction to Nearest Air Sampler(s)
<b>Legacy Contamination Sites (continued)</b>							
<b><u>Emanation from Building Materials</u></b>							
NLVF, Building A-01	Point	Parts of the basement were contaminated with <sup>3</sup> H in 1995 including a vacant radiation source well	Air flow through building ventilation system	<sup>3</sup> H as HTO through emanation from building materials into the air and exhausted from the building through the ventilation system	None	IV	<ul style="list-style-type: none"> <li>• Biannual sampling inside room that was contaminated</li> </ul>
<b><u>Groundwater Characterization/Control or Remediation Activities</u></b>							
<b><u>Environmental Restoration Projects</u></b>							
E-Tunnel Ponds, Area 12	Diffuse	<sup>3</sup> 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	<sup>3</sup> H as HTO through evaporation or transpiration from plants	None	IV	<ul style="list-style-type: none"> <li>• Little Feller 2N: 11.9 km to the west-southwest (WSW)</li> <li>• Critical receptor sampler (Gate 700 S): 15 km to the east</li> </ul>
<b><u>Underground Test Area (UGTA) Wells</u></b>							
ER-20-5 #1, Area 20	Diffuse	<sup>3</sup> H as HTO	Groundwater pumped to the surface	Evaporation of <sup>3</sup> H as HTO	None	IV	<ul style="list-style-type: none"> <li>• U-20U South: 14.2 km to the north-northwest (NNW)</li> <li>• Critical receptor sampler (Schooner): 16.0 km to the NNW</li> </ul>
ER-20-5 #3, Area 20	Diffuse	<sup>3</sup> H as HTO	Groundwater pumped to the surface	Evaporation of <sup>3</sup> H as HTO	None	IV	<ul style="list-style-type: none"> <li>• U-20U South: 14.2 km to the NNW</li> <li>• Critical receptor sampler (Schooner): 16.1 km to the NNW</li> </ul>

**Table A.1 Facilities or Areas from Which Radionuclides Were Released to Air in Calendar Year (CY) 2015 (continued)**

Facility or Area	Emission Type	Radionuclide(s) Emitted	Handling/ Processing	Nature of Emissions	Effluent Controls	Emission Category <sup>(a)</sup>	Distance and Direction to Nearest Air Sampler(s)
<b>Legacy Contamination Sites (continued)</b>							
<b>Groundwater Characterization/Control or Remediation Activities (continued)</b>							
ER-20-8, Area 20	Diffuse	<sup>3</sup> H as HTO	Groundwater pumped to the surface	Evaporation of <sup>3</sup> H as HTO	None	IV	<ul style="list-style-type: none"> <li>• Little Feller 2N: 16.8 km to the east-southeast (ESE)</li> <li>• Critical receptor sampler (Schooner): 18.8 km to the NNW</li> </ul>
ER-20-12, Area 20	Diffuse	<sup>3</sup> H as HTO	Groundwater pumped to the surface	Evaporation of <sup>3</sup> H as HTO	None	IV	<ul style="list-style-type: none"> <li>• U-20U South: 5.7 km to the NNW</li> <li>• Critical receptor sampler (Schooner): 7.6 km to the NNW</li> </ul>
<b>Defense, Security, and Stockpile Stewardship</b>							
Dense Plasma Focus, Area 11	Point	<sup>3</sup> H	Production of neutrons using a deuterium- <sup>3</sup> H reaction	<sup>3</sup> H gas released through a stack exhaust	None	III	<ul style="list-style-type: none"> <li>• Critical receptor sampler (Yucca): 7.4 km to the west-northwest</li> </ul>
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	IV	<ul style="list-style-type: none"> <li>• Critical receptor sampler (Yucca): 6.4 km to the N</li> </ul>
Nonproliferation Test and Evaluation Complex, Area 5	Diffuse	DU	Handling of powder compounds	Suspension of particulates	None	III	<ul style="list-style-type: none"> <li>• Sugar Bunker North: 2.5 km north-northeast</li> <li>• Critical Receptor sampler (Yucca): 16.4 km to the NNW</li> </ul>

Table A.1 Facilities or Areas from Which Radionuclides Were Released to Air in Calendar Year (CY) 2015 (continued)

Facility or Area	Emission Type	Radionuclide(s) Emitted	Handling/ Processing	Nature of Emissions	Effluent Controls	Emission Category <sup>(a)</sup>	Distance and Direction to Nearest Air Sampler(s)
<b>Defense, Security, and Stockpile Stewardship (continued)</b>							
Tumbleweed Test Range, Area 6	Point and Diffuse	<sup>3</sup> H, <sup>7</sup> Be, <sup>11</sup> C, <sup>13</sup> N, <sup>15</sup> O, <sup>38</sup> Cl, <sup>39</sup> Cl, and <sup>41</sup> Ar	None; activation products resulting from operations	Activation products in air are produced in the vicinity of an electron linear accelerator	None	III	<ul style="list-style-type: none"> <li>• DOD: 7.1 km SE</li> <li>• Critical Receptor sampler (Yucca): 7.3 km to the NNW</li> </ul>
<b>Radioactive Waste Management</b>							
Area 3 Radioactive Waste Management Site (RWMS)	Diffuse	Bulk low-level waste (LLW)	Subsurface burial of waste (no active burial during CY 2015)	<sup>3</sup> H as HTO through evaporation from soil or transpiration from plants	Soil cover	III	<ul style="list-style-type: none"> <li>• U-3ax/bl South: &lt; 0.3 km in multiple directions; near the center of the Area 3 RWMS</li> <li>• Critical receptor sampler (Yucca): 10 km SSW</li> </ul>
Area 5 Radioactive Waste Management Complex (RWMC)	Diffuse	LLW, mixed low-level waste, and transuranic waste	Subsurface burial of waste	Evaporation from soil or transpiration from plants of <sup>3</sup> H as HTO	Soil cover	IV	<ul style="list-style-type: none"> <li>• DoD: 0.4 km from NE edge of the Area 5 RWMC</li> <li>• Critical receptor sampler (Yucca): 14 km to the NNW</li> </ul>
<b>Support Facility Operations</b>							
Environmental Monitoring Building 23-652, Area 23	Point	<sup>3</sup> H as HTO, fission products, Am, and Pu in environmental samples	Distilling or handling samples to prepare for submission to analytical laboratories	<sup>3</sup> H emission during distillation of samples and preparation of standards	None	IV	<ul style="list-style-type: none"> <li>• Critical receptor sampler (Mercury Track): 0.2 km to the east-southeast</li> </ul>

(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 II refers to annual dose > 0.1 mrem and ≤ 5 mrem, Category III refers to annual dose > 0.001 mrem and ≤ 0.1 mrem, and Category IV refers to annual dose ≤ 0.001 mrem.

## **Appendix B**

### **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 ( $^3\text{H}$ ) 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  $^3\text{H}$  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  $^3\text{H}$  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  $^3\text{H}$  emission locations.

#### **SOURCE TERM ESTIMATES**

For each major  $^3\text{H}$  emission location, the Clean Air Package 1988 (CAP88-PC) model was used to estimate the  $^3\text{H}$  concentration that would be expected at nearby air samplers if 1 Ci of  $^3\text{H}$  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  $^3\text{H}$  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 2015**

<b>Emission Source</b>	<b>Air Sampler</b>	<b>Annual Average Tritium Concentration (pCi/m<sup>3</sup>)<sup>(a)</sup></b>	<b>CAP88-PC Concentration for 1 Ci Emission (pCi/m<sup>3</sup>)</b>	<b>Predicted Tritium Emission (Ci)</b>	<b>Emission Source Average (Ci)<sup>(b)</sup></b>
Area 3 RWMS	Bilby Crater	0.191	0.0521	3.66	3.2
	Kestrel Crater N	0.320	0.114	2.81	
Area 5 RWMC	DOD	1.071	0.314	3.41	3.5
	RWMS 5 Sewage Lagoons	0.803	0.230	3.49	
Area 10, Sedan	Gate 700 South <sup>(c)</sup>	0.0458	0.00969	4.73	7.0
	Sedan North	1.681	0.180	9.34	
Area 20, Schooner	U-20U South	0.143 <sup>(d)</sup>	0.0154	9.29	9.3

(a) pCi/m<sup>3</sup> = picocuries per cubic meter

(b) Average of emissions predicted by samplers for an emission source

(c) Critical Receptor Station

(d) Average for February through October

## 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 ( $^{241}\text{Am}$ ) and plutonium-239+240 ( $^{239+240}\text{Pu}$ ) 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  $2 \times 10^{-10}/\text{m}$ . 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  $2 \times 10^{-12}$  and  $1 \times 10^{-11}$  per s. To be conservative, the higher fractional re-suspension rate of  $1 \times 10^{-11}/\text{s}$  is used. For example, the emission rate in picocuries (pCi)/s for  $^{239+240}\text{Pu}$  from Area 3 is calculated from the product of the  $^{239+240}\text{Pu}$  inventory (37 Ci from Table 1) and  $S$  as shown below. The estimated total annual emission is expressed in millicuries per year (mCi/y).

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

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<sup>(a)</sup> of Manmade Radionuclides in NNSS Surface Soil**

Area	Annual Emission (mCi) using Emission factor of $1 \times 10^{-11} \text{ s}^{-1}$								
	<sup>60</sup> Co	<sup>90</sup> Sr	<sup>152</sup> Eu	<sup>137</sup> Cs	<sup>154</sup> Eu	<sup>155</sup> Eu	<sup>238</sup> Pu	<sup>239+240</sup> Pu	<sup>241</sup> Am
1	0.0123	2.5620	1.2838	1.5459	0.0041	0.0038	1.6761	7.5630	1.8095
2	0.0132	7.8572	1.1984	4.2157	0.0000	0.0032	2.2176	6.9329	1.3712
3	0.0110	5.6367	1.5408	2.1079	0.0041	0.0038	0.7994	11.6598	2.2220
4	0.0177	2.2204	0.7789	2.1079	0.0000	0.0016	3.3523	12.6053	2.8947
5	0.0066	0.1536	0.8559	0.0703	0.0082	0.0000	0.0259	1.5125	0.2892
6	0.0022	0.5979	0.0000	0.4920	0.0000	0.0000	0.8508	2.6471	0.7029
7	0.0110	1.5714	1.8830	0.9133	0.0082	0.0022	0.1548	5.0420	1.0246
8	0.0631	4.2703	0.3765	7.3775	0.0000	0.0047	2.0628	34.6641	7.6125
9	0.0079	2.2204	1.9688	1.5282	0.0082	0.0022	0.5673	28.0465	3.2668
10	0.1075	9.3943	0.1883	14.7551	0.0120	0.0388	4.8994	34.6641	8.2180
11	0.0000	0.0511	0.0000	0.0880	0.0000	0.0000	0.1290	9.1388	1.6493
12	0.0132	2.9038	0.0000	3.5131	0.0000	0.0000	2.1918	12.2899	2.5998
15	0.0035	3.7578	0.0000	3.3375	0.0000	0.0000	2.0114	19.8532	3.8341
16	0.0013	0.6320	0.0000	0.5093	0.0000	0.0000	0.3869	1.1659	0.2949
17	0.0110	3.2454	0.0000	2.6348	0.0000	0.0000	1.1605	5.6724	1.2513
18	0.0079	2.9038	0.0943	1.7566	0.0041	0.0063	1.4440	31.5130	7.9937
19	0.0123	5.2949	0.0000	6.3236	0.0000	0.0000	8.2517	44.1182	9.4961
20	0.0874	0.7345	1.1126	0.9663	0.0646	0.0372	7.7358	12.9203	7.8821
25	0.0000	0.0170	0.0344	0.0350	0.0000	0.0000	0.0000	0.0000	0.0000
26	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
30	0.0088	0.2220	0.0599	0.2636	0.0041	0.0016	1.1605	4.4119	1.2826
<b>Total (mCi)</b>	<b>0.40</b>	<b>56</b>	<b>11.38</b>	<b>54.54</b>	<b>0.12</b>	<b>0.11</b>	<b>41</b>	<b>290</b>	<b>66</b>

(a) Radioactive inventories from Table 5 in DOE/NV/10845--02 (DOE 1991) and decay corrected to June 15, 2015, with inclusion of ingrowth of <sup>241</sup>Am from <sup>241</sup>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 2015. 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 2015, air sampling for HTO in the basement was conducted intermittently. For CY 2015, the results of two atmospheric moisture samples were 129 picocuries per cubic meter (pCi/m<sup>3</sup>) for the sample collected April 6–13, 2015, and 350 pCi/m<sup>3</sup> for the sample collected September 8–15, 2015. The average of these sample results (239 pCi/m<sup>3</sup>) was multiplied by the room ventilation rate (673 cubic feet per minute [ft<sup>3</sup>/min]) to determine the total annual emission rate as shown below. The estimated total annual emission is expressed in millicuries per year (mCi/y).

$$\frac{239 \text{ pCi}}{\text{m}^3} \times \frac{673 \text{ ft}^3}{\text{min}} \times \frac{0.02832 \text{ m}^3}{\text{ft}^3} \times \frac{525,600 \text{ min}}{\text{y}} \times \frac{1 \times 10^{-9} \text{ mCi}}{\text{pCi}} = \frac{2.39 \text{ mCi}}{\text{y}}$$

A dose coefficient of  $5.0 \times 10^{-6}$  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 results from the Clean Air Package 1988 model using conservative assumptions to maximize dose and observed tritium emissions from 1996 through 2001. This coefficient multiplied by the tritium emission for CY 2015 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 ( $\mu\text{rem/y}$ ).

$$\frac{2.39 \text{ mCi}}{\text{y}} \times \frac{5.0 \times 10^{-6} \text{ mrem}}{\text{mCi}} = \frac{0.000012 \text{ mrem}}{\text{y}} \text{ or } \frac{0.012 \mu\text{rem}}{\text{y}}$$

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

**Table D.1. Comparison of Tritium Emission Rates from Building A-01, NLVF from 1995 to 2015**

<b>Year</b>	<b>Tritium Emission Rate (mCi/y)</b>	<b>EDE to MEI (µrem/y)</b>
1995	123	0.96
1996	52	0.25
1997	110	0.53
1998	16	0.08
1999	301	1.4
2000	370	1.8
2001	200	0.96
2002	(not sampled)	Not Estimated
2003	9.3	Not Estimated
2004	11	Not Estimated
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

## Appendix E

### Calculation of Tritium Emissions from Contaminated Groundwater Discharges

The calendar year (CY) 2015 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.

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

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 2014 and CY 2015 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 2015 are listed in Table E.1. The volume of water multiplied by the tritium concentration yields the estimated tritium emission to air during 2015 under the assumption that all of the water evaporated during 2015.

**Table E.1 Tritium Concentrations, Water Volumes, and Estimated 2015 Tritium Emissions from Contaminated Groundwater Brought to the Surface**

Location	Tritium Concentration (pCi/L)	Water Volume <sup>(a)</sup> (L)	Tritium Emission (Ci)
E-Tunnel Ponds	361,250 <sup>(b)</sup>	14,645,664	5.3
Well ER-20-5 #1	22,547,950	181,714	4.1
Well ER-20-5 #3	61,768	136,657	0.008
Well ER-20-8	5,440	508,556	0.003
Well ER-20-12	13,993	3,995,143	0.056

(a) All water was assumed to evaporate during CY 2015.

(b) Average of results from October 2014 and October 2015 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  $\pm 5$  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  $\pm 0.2$  degrees Celsius ( $^{\circ}\text{C}$ ) (absolute range for the NNSS is  $-29^{\circ}\text{C}$  to  $46^{\circ}\text{C}$ ). 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.

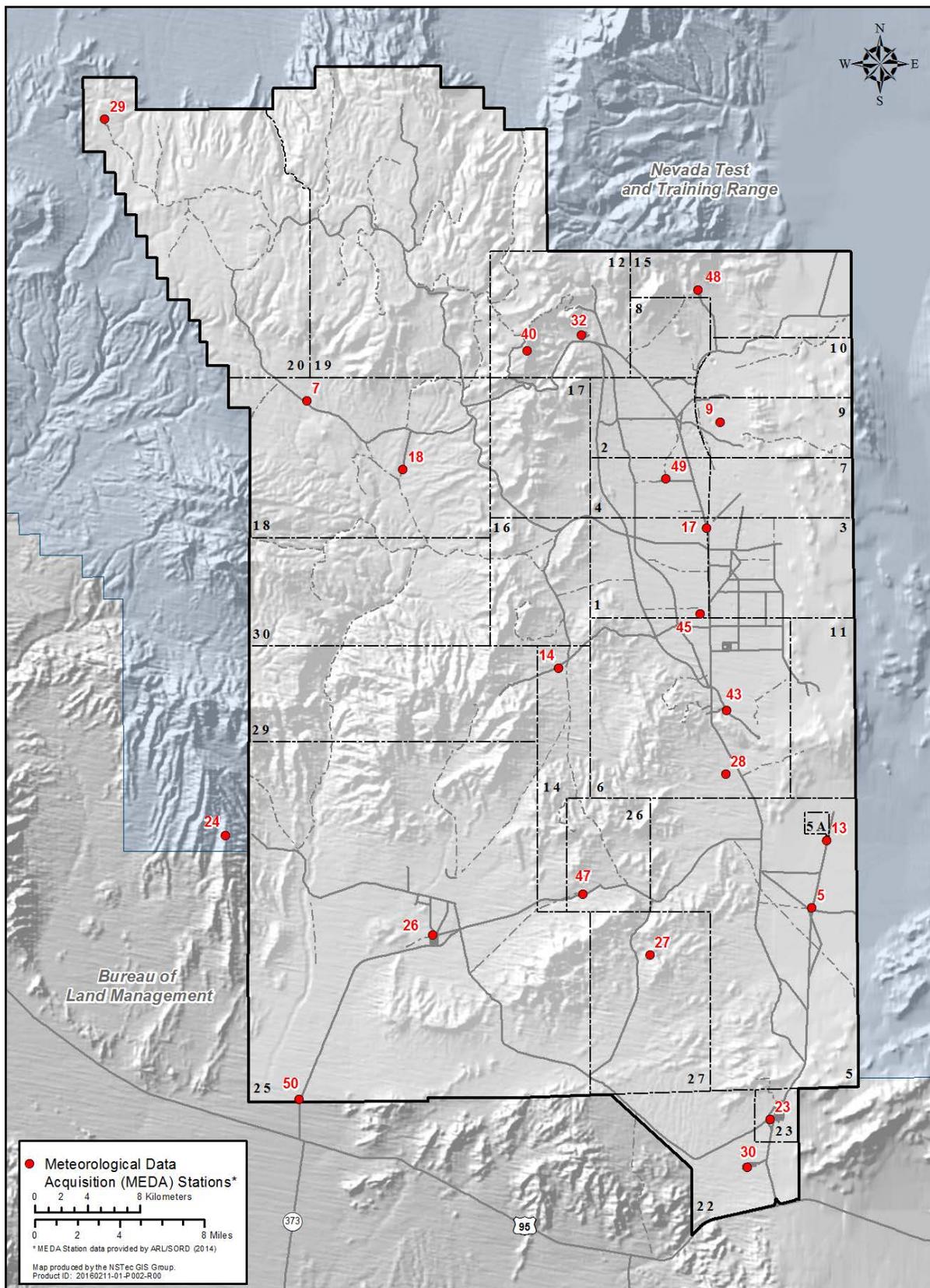


Figure F.1 Locations of MEDA Stations on the NNSS at end of CY 2015

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 2015 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**

<b>STAR File</b>	<b>MEDA Station</b>	<b>MEDA Location (NNSS Operations Area)</b>	<b>Area of Emission</b>
Meda09_2015_stab.str	9	9	10
Meda13_2015_stab.str	13	5	5
Meda29_2015_stab.str	29	20	20
Meda45_2015_stab.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) 2015 that would result in the collective dose approaching 1 person-rem, this calculation was not performed for CY 2015.

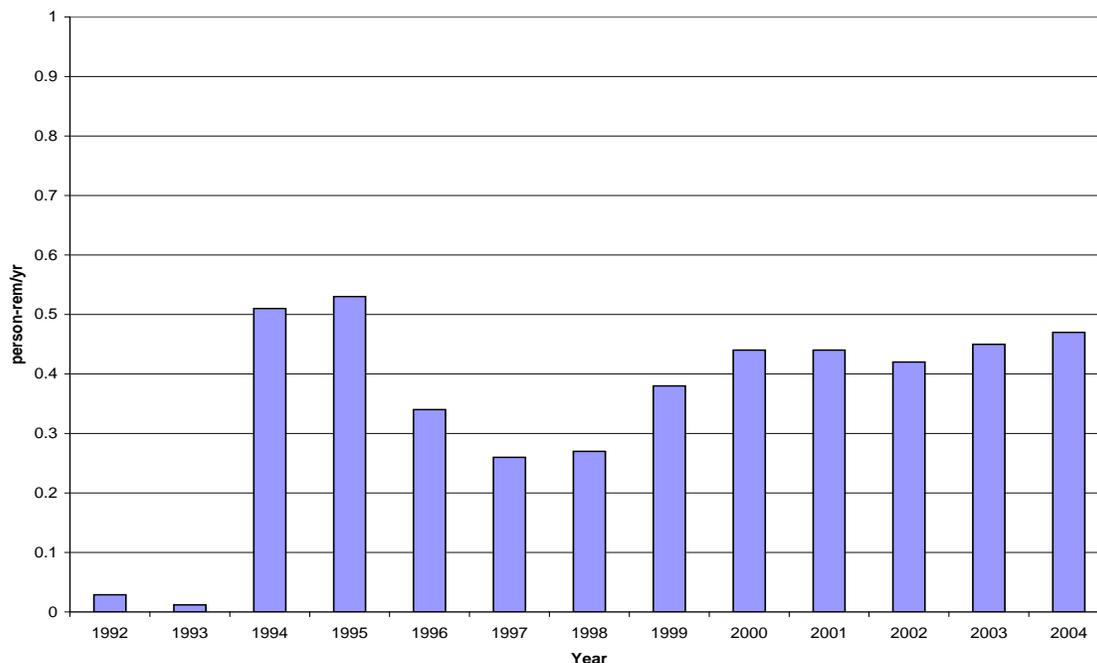


Figure G.1 Collective Dose to Populations within 80 km (50 miles) of Emission Sources

#### 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). 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.