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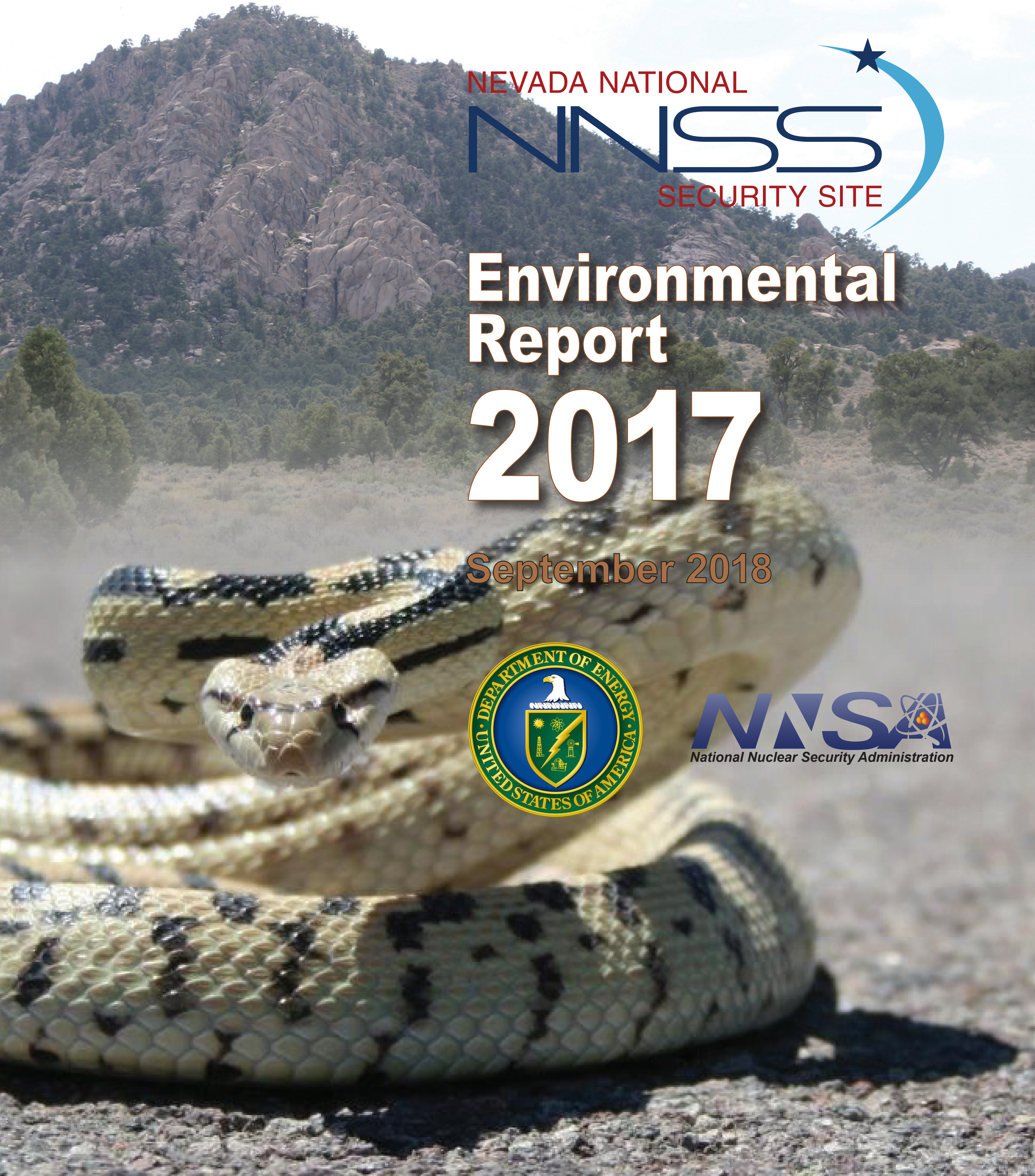
NEVADA NATIONAL
NNSS
SECURITY SITE

Environmental Report 2017

September 2018



National Nuclear Security Administration

A Message from the Manager

The U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) strives to achieve our missions in a safe, secure, sustainable, and environmentally responsible manner. Our staff, our contractor and laboratory partners, as well as other users of the Nevada National Security Site (NNSS) succeed through demonstrated teamwork, innovation, and continuous improvement.

The NNSA/NFO presents this environmental report to summarize actions taken in 2017 to protect the environment and the public while achieving our mission goals. It is prepared for the public and our stakeholders in hopes that it is readily understandable and usable. It is a key component in our efforts to keep the public informed of environmental conditions at the NNSS and its support facilities in Las Vegas, Nevada. The NNSA/NFO ensures the validity and accuracy of the data contained in this report.

We invite you to help us improve the usefulness and readability of this Environmental Report by providing your comments and concerns to nevada@nnsa.doe.gov.

Steven J. Lawrence

Steven J. Lawrence

Nevada Field Office
Manager

DOE/NV/03624--0270

NEVADA NATIONAL SECURITY SITE

Environmental Report 2017

This report was prepared for:

U.S. Department of Energy
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Nevada Field Office

By:

Mission Support and Test Services LLC
Las Vegas, Nevada

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The Environmental, Safety and Health (ES&H) group of Mission Support and Test Services, LLC (MSTS), is responsible for producing this document for the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO). Each year, the production of the annual Nevada National Security Site Environmental Report (NNSSER) requires the knowledge, skill, experience, and cooperation of many people and organizations.

Contributing Subject Matter Experts

More than 30 individuals are subject matter experts from across multiple organizations and authored, co-authored, or contributed information to the chapters within this NNSSER. They are thanked and acknowledged for their support, and are identified at the beginning of each chapter.

Contributing Organizations

MSTS

Multiple departments and groups within MSTS provided subject matter experts across multiple departments to contributed text and data on the annual activities related to onsite radiological and non-radiological monitoring of air, water, and biota; radiological dose assessments; waste management; hazardous materials management; ecological monitoring; site sustainability; and occurrence reporting. MSTS subject matter experts also provided the descriptions of the hydrology, geology, and ecology of the NNSS, which are included in *Attachment A: Site Description* on the compact disc of this report.

Navarro Research and Engineering, Inc. (Navarro)

Navarro provided data and discussion in Chapters 5 and 11 regarding their design, sampling, and analysis results associated with the NNSS Integrated Groundwater Sampling Plan, which addresses the legacy contamination of historical nuclear underground test areas (UGTAs). In Chapter 11, Navarro provided summary information of their characterization and remediation work towards state-approved closure of UGTA, Industrial, and Soils corrective action sites, and post-closure monitoring of Soil corrective action sites. In Chapter 14, Navarro provided data quality assurance information related to collected and analyzed UGTA groundwater samples. In Chapter 10, Navarro provided a description of their activities to verify that a designated percentage of mixed waste and classified hazardous materials and waste are appropriately packaged for receipt at the NNSS.

Desert Research Institute (DRI)

The Division of Hydrologic Sciences of DRI authored Chapters 7 and 15, reporting on their offsite radiological monitoring of air and groundwater within communities surrounding the NNSS, and on their data quality assurance program. The Division of Hydrologic Sciences reported in Chapter 11 on their newly initiated post-closure monitoring of the Frenchman Flat UGTA corrective action unit. Also in Chapter 11, the DRI divisions of Hydrologic Sciences and Atmospheric Sciences reported on their soil and meteorological monitoring at two NNSS Soils corrective action units. The Division of Earth and Ecosystem Sciences of DRI authored Chapter 12, summarizing their annual activities managing cultural resources on the NNSS. Harold Drollinger of the Division of Earth and Ecosystem Sciences provided the synoptic description of the prehistory and history of the NNSS, which is included in *Attachment A: Site Description* on the compact disc of this report.

Nye County

Nye County provided the discussion in Chapter 7 of their sampling of 20 wells under the Nye County Tritium Sampling and Monitoring Program.

National Oceanic and Atmospheric Administration Air Resources Laboratory, Special Operations and Research Division (ARL/SORD)

ARL/SORD provided summary descriptions of the NNSS climate that are included in *Attachment A: Site Description* on the compact disc of this report.

U.S. Geological Survey (USGS)

The USGS provided discussion and data in Chapter 5 regarding their monitoring of NNSS groundwater levels and usage.

EnviroStat

Charles Davis of EnviroStat provided the statistical analyses, interpretation, and graphical presentations of the environmental radiological monitoring data collected by ES&H.

ES&H Support Staff

The following individuals within MSTS ES&H are responsible for the numerous tasks that are integral to the collection, quality assurance, and quality control of much of the environmental data provided in this NNSSER.

Elizabeth Burns was responsible for radiological monitoring data verification, validation, and review; quality assurance oversight; administration of the data management system; and she assisted with field sampling.

Martin D. Cavanaugh, Xianan Liu, and Matthew O. Weaver conducted field sampling and supported work requested from other agencies/departments.

Catherine D. Castaneda was responsible for sample management supporting the sub-contracting of environmental analytical services.

Lynn N. Jaussi managed laboratory operations for sample screening and processing.

Theodore J. Redding provided oversight for radiological monitoring data verification, validation, and review; quality assurance; and sample management.

MSTS Report Production and Distribution Support Personnel

The following individuals were responsible for improving the quality, appearance, and timely production and distribution of this NNSSER.

Ashley Burns and **Chad Ricks** worked with all the authors to produce the high-quality GIS-generated maps and figures (provided in map projection: Universal Transverse Mercator (Zone 11, meters) North American Datum 1983).

Theodore Redding provided a thorough review of this document to ensure spelling, format, grammar, references, tables, figures, acronyms, table of contents, etc., were all in order.

Katina Loo designed the NNSSER cover, CD label, and the layout of the NNSSER Summary.

Pablo Mendez, Jeff Li, and Mark Shaw produced high-quality hard copies and compact discs of the NNSSER and the NNSSER Summary under a tight production schedule.

Margaret Townsend conducted the necessary classification review of this document, and in the process, made numerous improvements to its clarity, readability, and accuracy.

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Chapter 1: Introduction and Helpful Information

Patricia R. Hardesty
Mission Support and Test Services, LLC

Charles B. Davis
EnviroStat

1.1 Site Location

The U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) directs the management and operation of the Nevada National Security Site (NNSS). The NNSS is located in Nye County in south-central Nevada (Figure 1-1). The southeast corner of the NNSS is about 88 kilometers (km) (55 miles [mi]) northwest of the center of Las Vegas in Clark County. By highway, it is about 105 km (65 mi) from the center of Las Vegas to Mercury. Mercury, at the southern end of the NNSS, is the main base camp for worker housing and administrative operations for the NNSS.

The NNSS encompasses about 3,522 square kilometers (km^2) (1,360 square miles [mi^2]) based on the most recent land survey. It varies from 46 to 56 km (28 to 35 mi) in width from west to east and from 64 to 88 km (40 to 55 mi) from north to south. The NNSS is surrounded on all sides by federal lands. It is bordered on the west and north by the Nevada Test and Training Range (NTTR), on the east by an area used by both the NTTR and the Desert National Wildlife Refuge, and on the south and southwest by Bureau of Land Management lands. The combination of the NTTR and the NNSS represents one of the largest unpopulated land areas in the United States, comprising some 14,200 km^2 (5,470 mi^2).

1.2 Environmental Setting

The NNSS is located in the southern part of the Great Basin, the northern-most subprovince of the Basin and Range Physiographic Province. The NNSS terrain is typical of much of the Basin and Range Physiographic Province, characterized by generally north–south trending mountain ranges and intervening valleys. These mountain ranges and valleys, however, are modified on the NNSS by very large volcanic calderas. The principal valleys are Frenchman Flat, Yucca Flat, and Jackass Flats (Figure 1-2). Both Yucca and Frenchman Flat are topographically closed and contain dry lake beds, or playas, at their lowest elevations. Jackass Flats is topographically open, and surface water from this basin flows off the NNSS via the Fortymile Wash. The dominant highlands are Pahute Mesa and Rainier Mesa (high volcanic plateaus), Timber Mountain (a resurgent dome of the Timber Mountain caldera complex), and Shoshone Mountain. In general, the slopes of the highland areas are steep and dissected, and the slopes in the lowland areas are gentle and less eroded. The lowest elevation on the NNSS is 823 meters (m) (2,700 feet [ft]) in Jackass Flats in the southeast, and the highest elevation is 2,341 m (7,680 ft) on Rainier Mesa in the north-central region.

The topography of the NNSS has been altered by historical U.S. Department of Energy (DOE) actions, particularly underground nuclear testing. The principal effect of testing has been the creation of numerous collapse sinks (craters) in Yucca Flat basin and fewer craters on Pahute and Rainier Mesas. Shallow detonations that created surface disruptions were also performed during the ***Plowshare Program*** to explore the potential uses of nuclear devices for large-scale excavation.

The reader is directed to *Attachment A: Site Description*, a file on the compact disc of this report, where the geology, hydrology, climatology, ecology, and cultural resources of the NNSS are described.

> Throughout this document, the definition of word(s) in ***bold italics*** may be found by clicking on the word in the electronic version or by referencing the Glossary, Appendix B. To return from the Glossary, right click and select Previous View.

1.3 Site History

The history of the NNSS, as well as its current missions, directs the focus and design of the environmental monitoring and surveillance activities on and near the site. Between 1940 and 1950, the area known as the NNSS was under the jurisdiction of Nellis Air Force Base and was part of the Nellis Bombing and Gunnery Range. The site was established in 1950 to be the primary location for testing the nation’s nuclear explosive devices. It was

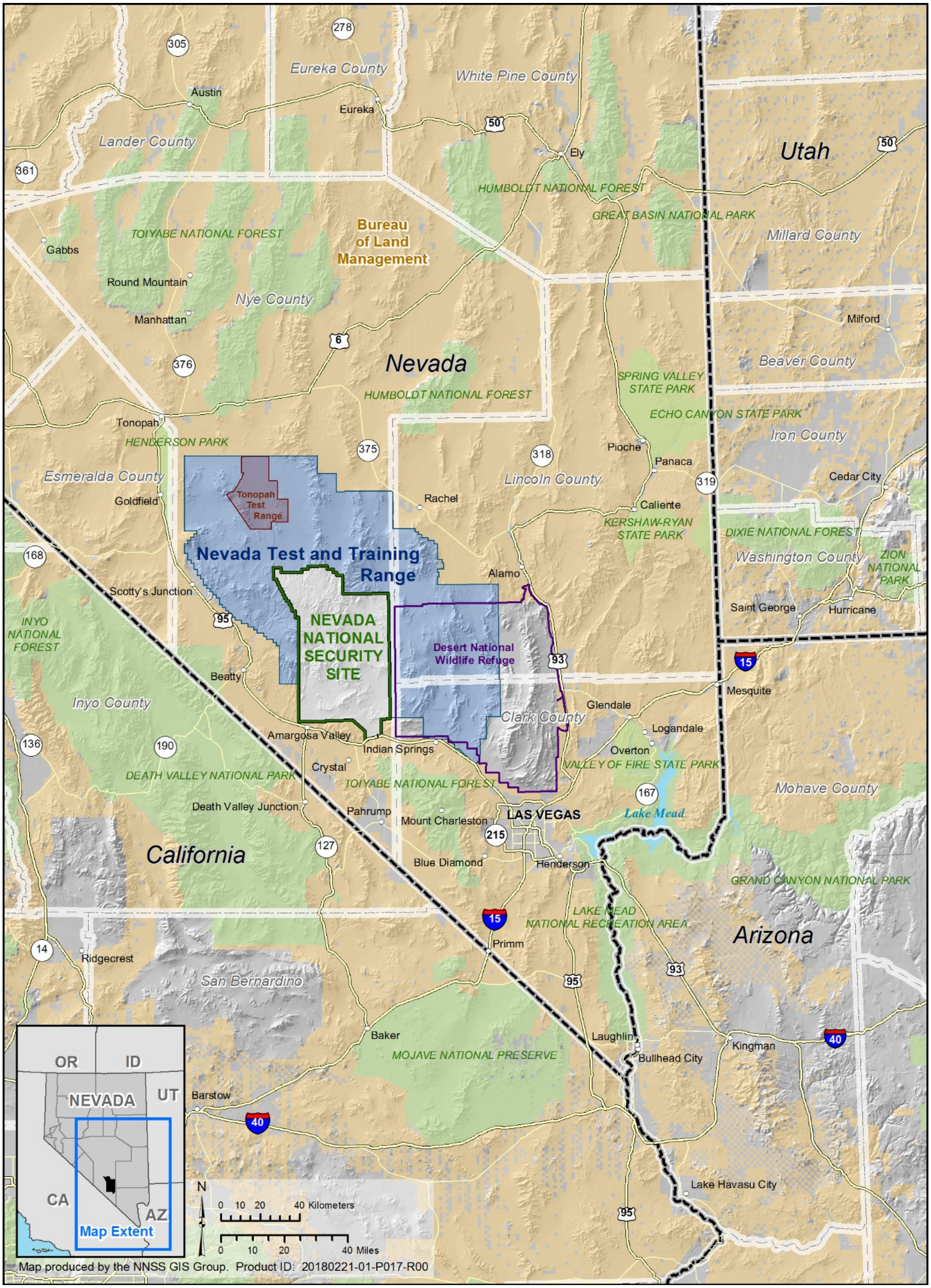


Figure 1-1. NNSS vicinity map

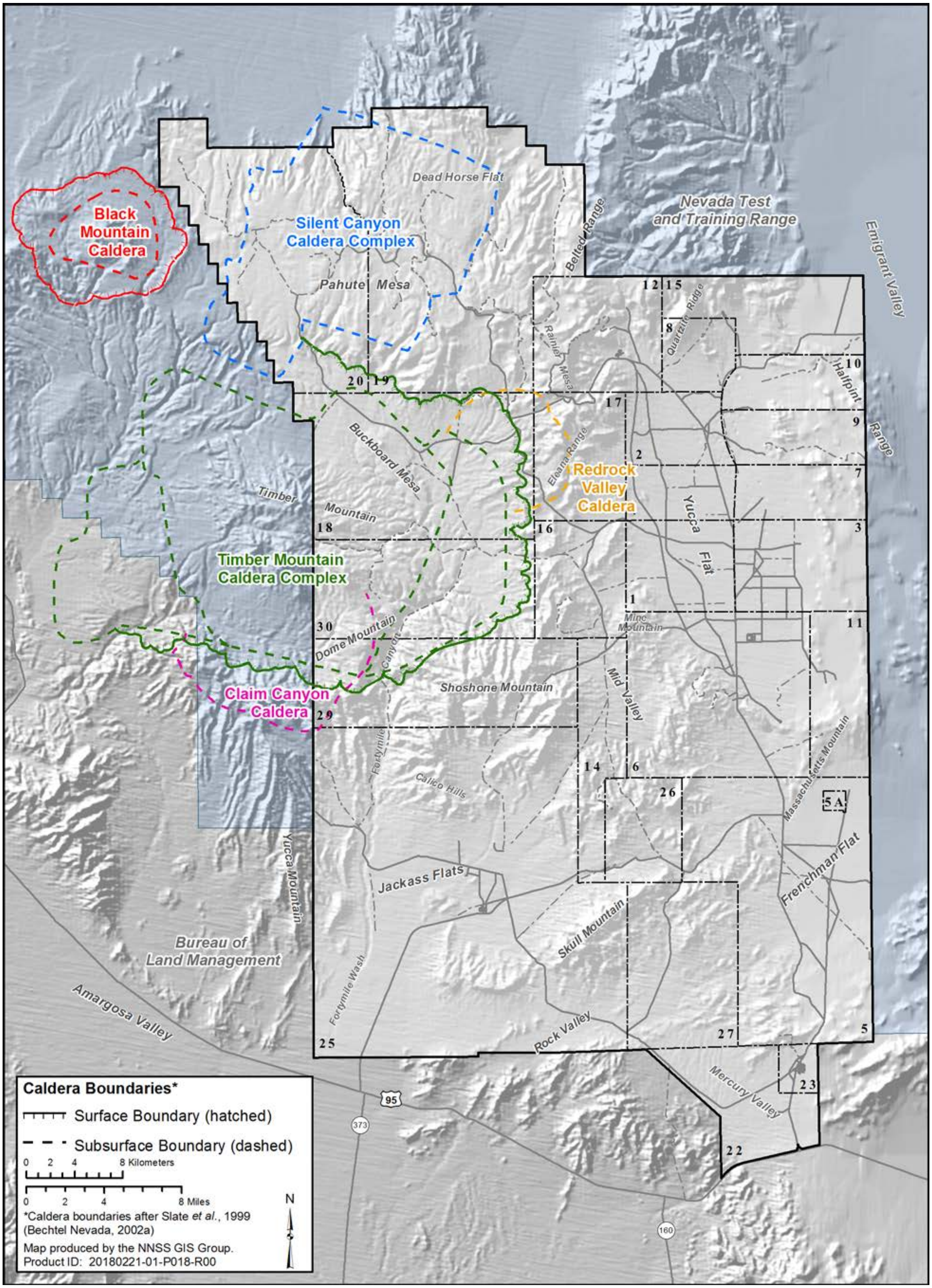


Figure 1-2. Major topographic features and calderas of the NNSS

named the Nevada Test Site (NTS) in 1951 and supported nuclear testing from 1951 to 1992. The types of tests conducted during this period are briefly described below. On August 23, 2010, the NTS was named the NNSS to reflect the diversity of nuclear, energy, and homeland security activities now conducted at the site. Nuclear experiments conducted at the NNSS are currently limited to ***subcritical experiments***.

Atmospheric Tests – Tests conducted through the 1950s were predominantly atmospheric tests. They involved a nuclear explosive device detonated while either on the ground surface, on a steel tower, suspended from tethered balloons, dropped from an aircraft, or placed on a rocket. Several tests were categorized as “safety experiments” and “storage-transportation tests,” involving the destruction of a nuclear device with non-nuclear explosives. Some of these tests resulted in the dispersion of plutonium in the test vicinity. One of these test areas lies just north of the NNSS boundary at the south end of the NTTR, and four others are at the north end of the NTTR.

Underground Tests – The first underground test, a cratering test, was conducted in 1951. The first totally contained underground test was in 1957. Testing was discontinued during a bilateral moratorium that began October 31, 1958, but was resumed in September 1961 after the Union of Soviet Socialist Republics resumed nuclear testing. After late 1962, nearly all tests were conducted in sealed vertical shafts drilled into Yucca Flat and Pahute Mesa or in horizontal tunnels mined into Rainier Mesa and Shoshone Mountain. From 1951 to 1992, a total of 828 underground nuclear tests were conducted at the NNSS. Approximately one-third of them were detonated near or in the ***saturated zone***.

Cratering Tests – Five earth-cratering (shallow-burial) tests were conducted from 1962 through 1968 as part of the Plowshare Program that explored peaceful uses of nuclear explosives. The first and highest yield Plowshare crater test, Sedan, was detonated at the northern end of Yucca Flat on the NNSS. The second highest yield crater test was Schooner, located in the northwest corner of the NNSS. Mixed fission products, ***tritium***, and plutonium from these tests were entrained in the soil ejected from the craters and deposited on the ground surrounding the craters.

Other Tests – Other nuclear-related experiments at the NNSS have included the BREN [Bare Reactor Experiment–Nevada] series in the early 1960s conducted in Area 4. These tests were performed with a 14-million electron volt neutron generator mounted on a 465 m (1,527 ft) steel tower to produce neutron and gamma radiation for the purpose of estimating the radiation doses received by survivors of Hiroshima and Nagasaki. The tower was moved in 1966 to Area 25 and used for conducting Operation HENRE [High-Energy Neutron Reactions Experiment], jointly funded by the U.S. Department of Defense (DoD) and the Atomic Energy Commission (AEC) to provide information for the AEC’s Division of Biology and Medicine. From 1959 through 1973, a series of open-air nuclear reactor, nuclear engine, and nuclear furnace tests was conducted in Area 25, and a series of tests with a nuclear ramjet engine was conducted in Area 26. Erosion of metal cladding on the reactor fuel released some fuel particles that caused negligible deposition of ***radionuclides*** on the ground. Most of the radiation released from these tests was gaseous in the form of radio-iodines, radio-xenons, and radio-kryptons.

Fact sheets on many of the historical tests mentioned above can be found at http://www.nnss.gov/pages/resources/library/FactSheets.html. All nuclear device tests are listed in *United States Nuclear Tests, July 1945 through September 1992* (NNSA/NFO 2015).

1.4 Site Mission

NNSA/NFO directs the facility management and program operations at the NNSS North Las Vegas Facility (NLVF), and Remote Sensing Laboratory–Nellis (RSL-Nellis) in Nevada and directs selected operations at four sites outside of Nevada that include RSL-Andrews in Maryland, Livermore Operations in California, Los Alamos Operations in New Mexico, and the Special Technologies Laboratory in California. Los Alamos National Laboratory, Lawrence Livermore National Laboratory, and Sandia National Laboratories are the principal organizations that sponsor and implement the nuclear weapons programs at the NNSS. National Security Technologies, LLC, was the Management and Operations (M&O) contractor through November 30, 2017, at which time Mission Support and Test Services, LLC, became the M&O contractor accountable for the successful execution of work and ensuring that work is performed in compliance with environmental regulations. The three major NNSS missions currently include National Security/Defense, Environmental Management, and Nondefense. The programs that support these missions are listed in the text box below.

NNSS Missions and Programs

National Security/Defense Missions

Stockpile Stewardship and Management Program – Conducts high-hazard operations in support of defense-related nuclear and national security experiments and maintains the capability to resume underground nuclear weapons testing, if directed.

Nuclear Emergency Response, Nonproliferation, and Counterterrorism Programs – Provides support facilities, training facilities, and capabilities for government agencies involved in emergency response, nonproliferation technology development, national security technology development, and counterterrorism activities.

Strategic Partnership Projects – Provides support facilities and capabilities for other DOE programs and federal agencies/organizations involved in defense-related activities.

Environmental Management Missions

Environmental Restoration Program – Characterizes and remediates the environmental legacy of nuclear weapons and other testing at NNSS and NTTR locations, and develops and deploys technologies that enhance environmental restoration.

Waste Management Program – Manages and safely disposes of ***low-level waste***, ***mixed low-level waste***, and classified waste/matter received from DOE- and DoD-approved facilities throughout the U.S. and wastes generated in Nevada by NNSA/NFO. Safely manages and characterizes ***hazardous*** and ***transuranic wastes*** for offsite disposal.

Nondefense Missions

General Site Support and Infrastructure Program – Maintains the buildings, roads, utilities, and facilities required to support all NNSS programs and to provide a safe environment for NNSS workers.

Conservation and Renewable Energy Programs – Operates the pollution prevention program and supports renewable energy and conservation initiatives at the NNSS.

Other Research and Development – Provides support facilities and NNSS access to universities and organizations conducting environmental and other research unique to the regional setting.

1.5 Primary Facilities and Activities

The NNSS facilities or centers that support the National Security/Defense missions include the U1a Complex, Big Explosives Experimental Facility (BEEF), Device Assembly Facility (DAF), Dense Plasma Focus (DPF) Facility (located within the Los Alamos Technical Facility [LATF]), Joint Actinide Shock Physics Experimental Research (JASPER) Facility, Nonproliferation Test and Evaluation Complex (NPTEC), the National Criticality Experiments Research Center (NCERC; located within the DAF), the Radiological/Nuclear Countermeasures Test and Evaluation Complex (RNCTEC), and the Radiological/Nuclear Weapons of Mass Destruction Incident Exercise Site (known as the T-1 Site). NNSS facilities that support Environmental Management missions include the currently active ***Area 5 Radioactive Waste Management Complex (RWMC)*** and the Area 3 Radioactive Waste Management Site (RWMS), which is in cold standby (Figure 1-3).

The primary NNSS activity in 2017 was helping to ensure that the U.S. stockpile of nuclear weapons remains safe and reliable. Other 2017 NNSS activities included experiments aimed at improving arms control and nonproliferation treaty verification; weapons of mass destruction first responder training; the controlled release of hazardous material at NPTEC; remediation of legacy contamination sites; processing of waste destined for the Waste Isolation Pilot Plant in Carlsbad, New Mexico, or the Idaho National Laboratory in Idaho Falls, Idaho; and disposal of low-level and mixed low-level radioactive waste. Land use by each of the NNSS missions occurs within designated zones (Figure 1-4).

1.6 Scope of Environmental Report

This report summarizes data and the compliance status of the NNSA/NFO environmental protection and monitoring programs for calendar year 2017 at the NNSS and at its two support facilities, the NLVF and RSL-Nellis. This report also addresses environmental restoration (ER) projects conducted by the Environmental Management Nevada Program Office at the Tonopah Test Range (TTR).

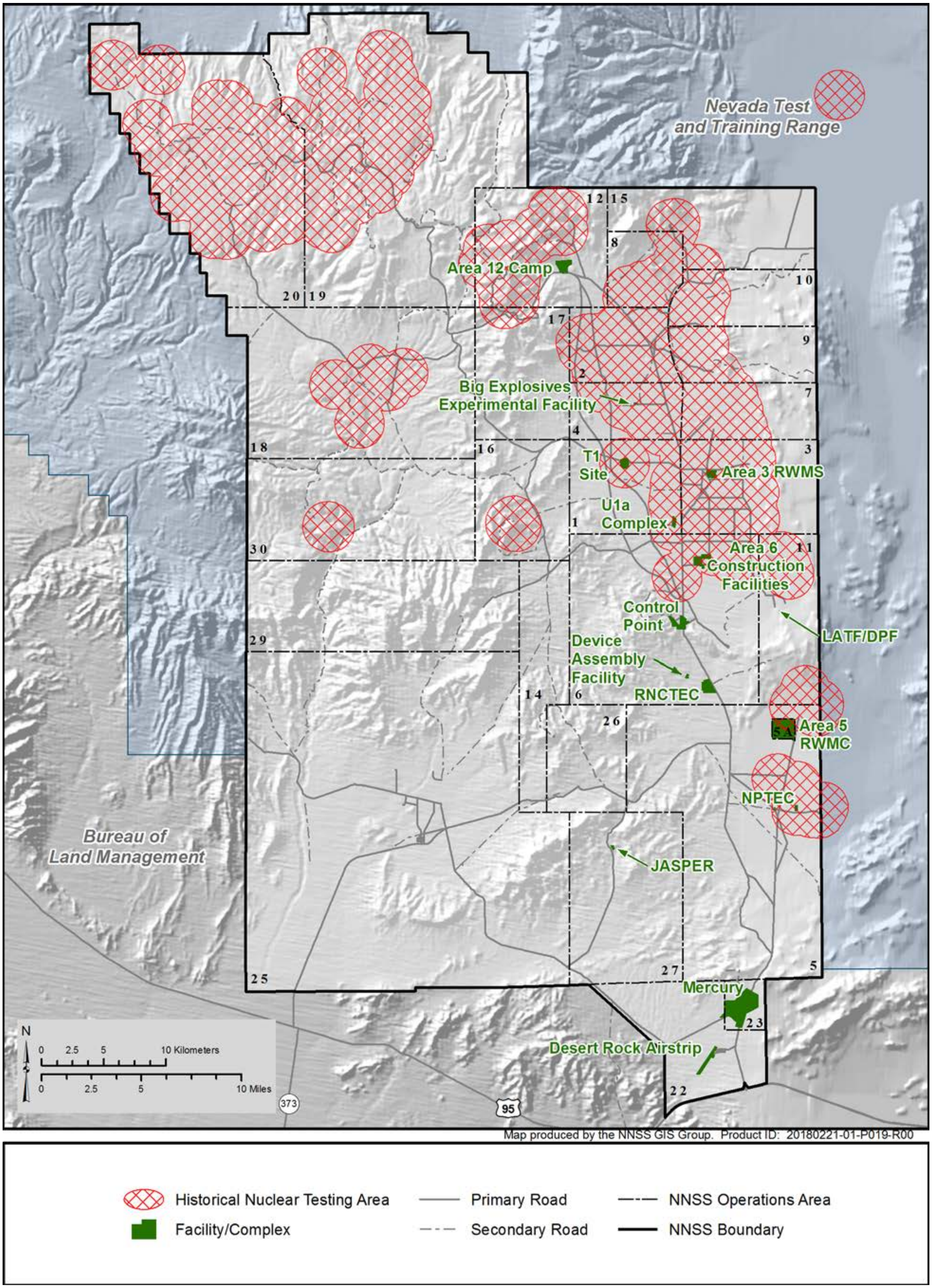


Figure 1-3. NNSS operational areas, principal facilities, and past nuclear testing areas

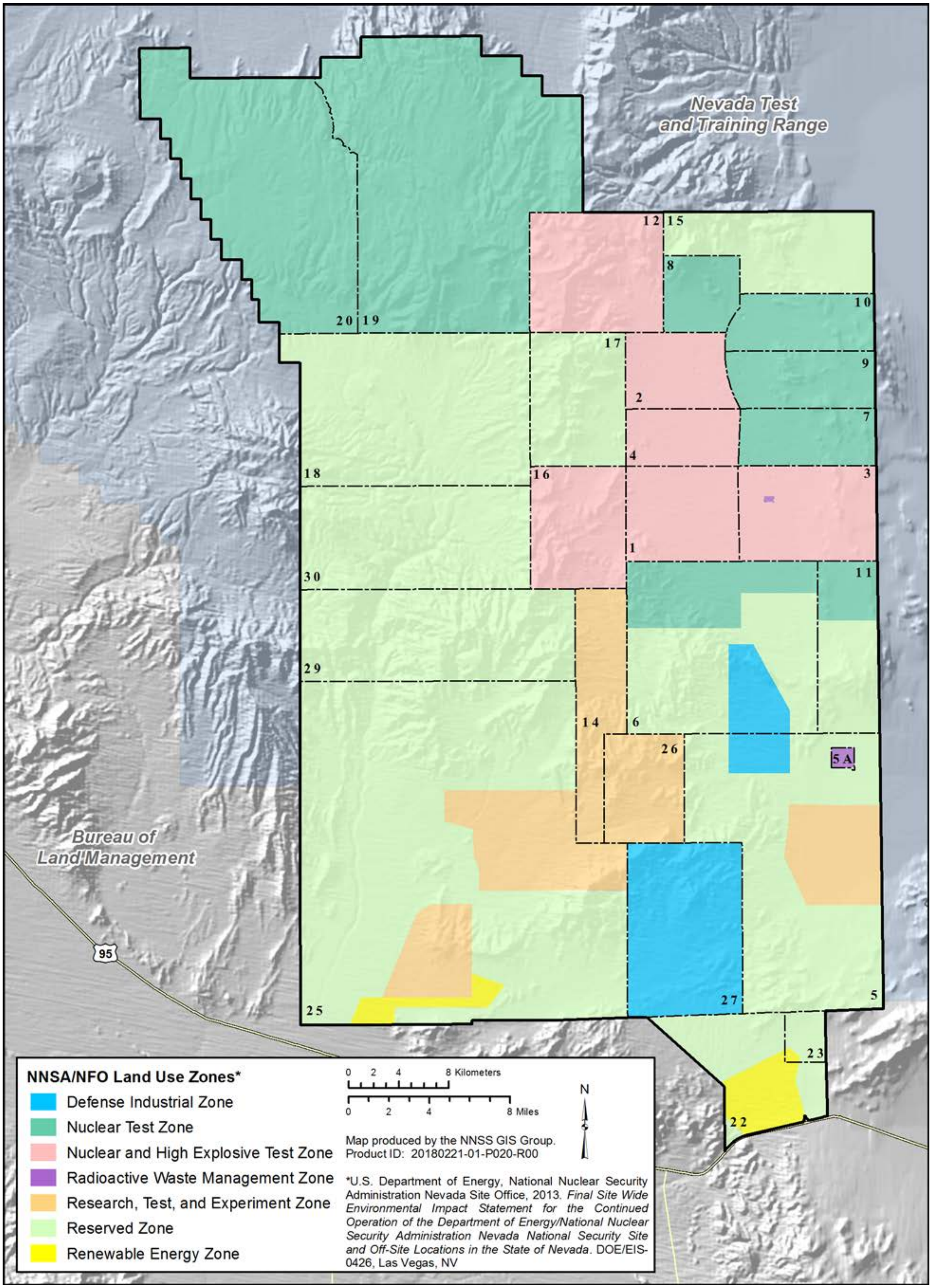


Figure 1-4. NNSS land-use map

The Environmental Management Nevada Program office is responsible for addressing environmental restoration sites on the NTTR and TTR if they are listed in the Federal Facility Compliance Act Order (FFACO). The U.S. Department of Energy, National Nuclear Security Administration Sandia Field Office (NNSA/SFO produces the TTR annual site environmental reports, which are posted at http://www.sandia.gov/news/publications/environmental/index.html.

1.7 Populations Near the NNSS

The population of the area surrounding the NNSS is predominantly rural. The most recent population estimates for Nevada communities are for 2017 and are provided by the Nevada State Demographer's Office (2018). The most recent population estimate for Nye County is 46,390, and the largest Nye County community is Pahrump (39,023), located approximately 80 km (50 mi) south of the NNSS Control Point facility (near the center of the NNSS). Other Nye County communities include Tonopah (2,311), Amargosa (1,344), Beatty (961), Round Mountain (772), Gabbs (218), and Manhattan (126). Lincoln County to the east of the NNSS includes a few small communities including Caliente (1,066), Pioche (784), Panaca (797), and Alamo (673). Clark County, southeast of the NNSS, is the major population center of Nevada and has an estimated population of 2,193,818. The total annual population estimate for all Nevada counties, cities, and towns is 2,986,656.

The Mojave Desert of California, which includes Death Valley National Park, lies along the southwestern border of Nevada. This area is still predominantly rural; however, tourism at Death Valley National Park swells the population to more than 5,000 on any particular day during holiday periods when the weather is mild.

The extreme southwestern region of Utah is more developed than the adjacent portion of Nevada. The latest population estimates for Utah communities are for 2017 taken from the U.S. Census Bureau (2018) of the U.S. Department of Commerce. Southern Utah's largest community is St. George, located 220 km (137 mi) east of the NNSS, with an estimated population of 84,405. The next largest town, Cedar City, is located 280 km (174 mi) east-northeast of the NNSS and has an estimated population of 31,806.

The northwestern region of Arizona is mostly rangeland except for that portion in the Lake Mead recreation area. In addition, several small communities lie along the Colorado River. The largest towns in the area are Bullhead City, 165 km (103 mi) south-southeast of the NNSS, with an estimated population of 40,551, and Kingman, 280 km (174 mi) southeast of the NNSS, with an estimated population of 29,600 (Arizona Department of Administration 2018).

1.8 Understanding Data in this Report

1.8.1 Scientific Notation

Scientific notation is used in this report to express very large or very small numbers. A very small number is expressed with a negative exponent, for example 2.0×10^{-5}. To convert this number from scientific notation to a more traditional number, the decimal point must be moved to the left by the number of places equal to the exponent (5 in this case). The number thus becomes 0.00002.

Very large numbers are expressed in scientific notation with a positive exponent. The decimal point should be moved to the right by the number of places equal to the exponent. The number 1,000,000,000 could be presented in scientific notation as 1.0×10^{9}.

Table 1-1. Unit prefixes

Prefix	Abbreviation	Meaning
mega-	M	1,000,000 (1×10^{6})
kilo-	k	1,000 (1×10^{3})
centi-	c	0.01 (1×10^{-2})
milli-	m	0.001 (1×10^{-3})
micro-	µ	0.000001 (1×10^{-6})
nano-	n	0.000000001 (1×10^{-9})
pico-	p	0.000000000001 (1×10^{-12})

1.8.2 Unit Prefixes

Units for very small and very large numbers are commonly expressed with a prefix. The prefix signifies the amount of the given unit. For example, the prefix k, or kilo-, means 1,000 of a given unit. Thus 1 kg (kilogram) is 1,000 g (grams). Other prefixes used in this report are listed in Table 1-1.

1.8.3 Units of Radioactivity

Much of this report deals with levels of ***radioactivity*** in various environmental media. The basic unit of radioactivity used in this report is the ***curie*** (Ci) (Table 1-2). The curie describes the amount of radioactivity present, and amounts are usually expressed in terms of fractions of curies in a given mass or volume (e.g., picocuries per liter). The curie is historically defined as the rate of nuclear disintegrations that occur in 1 gram of the radionuclide radium-226, which is 37 billion nuclear disintegrations per second. For any other radionuclide, 1 Ci is the quantity of the radionuclide that decays at this same rate. Nuclear disintegrations produce spontaneous emissions of ***alpha*** or ***beta*** particles, ***gamma radiation***, or combinations of these.

Table 1-2. Units of radioactivity

Symbol	Name
Ci	curie
cpm	counts per minute
mCi	millicurie (1×10^{-3} Ci)
μCi	microcurie (1×10^{-6} Ci)
nCi	nanocurie (1×10^{-9} Ci)
pCi	picocurie (1×10^{-12} Ci)

1.8.4 Radiological Dose Units

The amount of ***ionizing radiation*** energy absorbed by a living organism is expressed in terms of radiological ***dose***. Radiological dose in this report is usually written in terms of ***effective dose equivalent (EDE)*** and reported numerically in units of millirem (mrem) (Table 1-3). Millirem is a term that relates ionizing radiation to biological effect or risk to humans. A dose of 1 mrem has a biological effect similar to the dose received from an approximate 1-day ***exposure*** to natural ***background radiation***. An acute (short-term) dose of 100,000 to 400,000 mrem can cause radiation sickness in humans. An acute dose of 400,000 to 500,000 mrem, if left untreated, results in death approximately 50% of the time. Exposure to lower amounts of radiation (1,000 mrem or less) produces no immediate observable effects, but long-term (delayed) effects are possible. The average person in the United States receives an annual dose of approximately 300 mrem from exposure to naturally produced radiation. Medical and dental X-rays, air travel, and tobacco smoking add to this total.

Table 1-3. Units of radiological dose

Symbol	Name
mrad	millirad (1×10^{-3} rad)
mrem	millirem (1×10^{-3} rem)
R	roentgen
mR	milliroentgen (1×10^{-3} R)
μR	microroentgen (1×10^{-6} R)

The unit "***rad***," for radiation ***absorbed dose***, is also used in this report. The rad is a measure of the energy absorbed by any material, whereas a "***rem***," for "roentgen equivalent man", relates to both the amount of radiation energy absorbed by humans and its consequence. A ***roentgen (R)*** is a measure of radiation exposure. Generally speaking, 1 R of exposure will result in an EDE of 1 rem. Additional information on radiation and dose terminology can be found in the Glossary (Appendix B).

1.8.5 International System of Units for Radioactivity and Dose

In some instances in this report, radioactivity and radiological dose values are expressed in other units in addition to Ci and rem. These units are the ***becquerel*** (Bq) and the ***sievert*** (Sv), respectively. The Bq and Sv belong to the ***International System of Units (SI)***, and their inclusion in this report is mandated by DOE. SI units are the internationally accepted units and may eventually be the standard for reporting both radioactivity and radiation dose in the United States. One Bq is equivalent to one nuclear disintegration per second.

Table 1-4. Conversion table for SI units

To Convert From	To	Multiply By
becquerel (Bq)	picocurie (pCi)	27
curie (Ci)	becquerel (Bq)	3.7×10^{10}
gray (Gy)	rad	100
millirem (mrem)	millisievert (mSv)	0.01
millisievert (mSv)	millirem (mrem)	100
picocurie (pCi)	becquerel (Bq)	0.03704
rad	gray (Gy)	0.01
sievert (Sv)	rem	100

The unit of radiation absorbed dose (rad) has a corresponding SI unit called the ***gray*** (Gy). The roentgen measure of radiation exposure has no SI equivalent. Table 1-4 provides the multiplication factors for converting to and from SI units.

1.8.6 Radionuclide Nomenclature

Radionuclides are frequently expressed with the one- or two-letter chemical symbol for the element. Radionuclides may have many different ***isotopes***, which are shown by a superscript to the left of the symbol. This number is the atomic weight of the isotope (the number of protons and neutrons in the nucleus of the ***atom***). Radionuclide symbols, many of which are used in this report, are shown in Table 1-5 along with the ***half-life*** of each radionuclide. The half-life is the time required for one-half of the radioactive atoms in a given amount of material to decay. For example, after one half-life, half of the original atoms will have decayed; after two half-lives, three-fourths of the original atoms will have decayed; and, after three half-lives, seven-eighths of the original atoms will have decayed, and so on. The notation $^{226+228}$Ra and similar notations in this report (e.g., $^{239+240}$Pu) are used when the analytical method does not distinguish between the isotopes, but reports the total amount of both.

Table 1-5. Radionuclides and their half-lives (in alphabetical order by symbol)

Symbol	Radionuclide	Half-Life [(a)]
^{241}Am	americium-241	432.2 yr
^{7}Be	beryllium-7	53.22 d
^{14}C	carbon-14	5.70×10^{3} yr
^{36}Cl	chlorine-36	3.01×10^{5} yr
^{134}Cs	cesium-134	2.1 yr
^{137}Cs	cesium-137	30.2 yr
^{51}Cr	chromium-51	27.7 d
^{60}Co	cobalt-60	5.3 yr
^{152}Eu	europium-152	13.5 yr
^{154}Eu	europium-154	8.6 yr
^{155}Eu	europium-155	4.8 yr
^{3}H	tritium	12.3 yr
^{129}I	iodine-129	1.6×10^{7} yr
^{131}I	iodine-131	8 d
^{40}K	potassium-40	1.3×10^{8}yr
^{85}Kr	krypton-85	10.8 yr
^{212}Pb	lead-212	10.6 hr
^{238}Pu	plutonium-238	87.7 yr
^{239}Pu	plutonium-239	2.4×10^{4} yr
^{240}Pu	plutonium-240	6.5×10^{3} yr
^{241}Pu	plutonium-241	14.4 yr
^{226}Ra	radium-226	1.6×10^{3} yr
^{228}Ra	radium-228	5.75 yr
^{220}Rn	radon-220	56 s
^{222}Rn	radon-222	3.8 d
^{103}Ru	ruthenium-103	39.3 d
^{106}Ru	ruthenium-106	373.6 d
^{125}Sb	antimony-125	2.8 yr
^{113}Sn	tin-113	115 d
^{90}Sr	strontium-90	28.8 yr
^{99}Tc	technetium-99	2.1×10^{5} yr
^{232}Th	thorium-232	1.4×10^{10} yr
U [(b)]	uranium total	- - - [(c)]
^{234}U	uranium-234	2.4×10^{5} yr
^{235}U	uranium-235	7×10^{8} yr
^{238}U	uranium-238	4.5×10^{9} yr
^{65}Zn	zinc-65	244.1 d
^{95}Zr	zirconium-95	63.98 d

(a) Source: International Commission on Radiological Protection (2008)
(b) Total uranium may also be indicated by U-natural (U-nat) or U-mass
(c) Natural uranium is a mixture dominated by ^{238}U; thus, the half-life is approximately 4.5×10^{9} years

1.8.7 Units of Measurement

Both metric and non-metric units of measurement are used in this report. Metric system and U.S. customary units and their respective equivalents are shown in Table 1-6 on the following page.

1.8.8 Measurement Variability

There is always ***uncertainty*** associated with the measurement of environmental contaminants. For radioactivity, a major source of uncertainty is the inherent randomness of ***radioactive decay*** events.

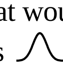
Uncertainty in analytical measurements is also the consequence of variability related to collecting and analyzing the samples. This variability is associated with reading or recording the result, handling or processing the sample, calibrating the counting instrument, and numerical rounding.

The uncertainty of a measurement is denoted by following the result with an uncertainty value, which is preceded by the plus-or-minus symbol, ±. This uncertainty value gives information on what the measurement might be if the same sample were analyzed again under identical conditions. The uncertainty value implies that approximately 95% of the time, the average of many measurements would give a value somewhere between the reported value minus the uncertainty value and the reported value plus the uncertainty value. If the reported concentration of a given constituent is smaller than its associated uncertainty (e.g., 40 ± 200), then the sample may not contain that constituent.

Table 1-6. Metric and U.S. customary unit equivalents

Metric Unit	U.S. Customary Equivalent Unit	U.S. Customary Unit	Metric Equivalent Unit
Length			
1 centimeter (cm)	0.39 inches (in.)	1 inch (in.)	2.54 centimeters (cm)
1 millimeter (mm)	0.039 inches (in.)		25.4 millimeters (mm)
1 meter (m)	3.28 feet (ft)	1 foot (ft)	0.3048 meters (m)
	1.09 yards (yd)	1 yard (yd)	0.9144 meters (m)
1 kilometer (km)	0.62 miles (mi)	1 mile (mi)	1.6093 kilometers (km)
Volume			
1 liter (L)	0.26 gallons (gal)	1 gallon (gal)	3.7853 liters (L)
1 cubic meter (m^3)	35.32 cubic feet (ft^3)	1 cubic foot (ft^3)	0.028 cubic meters (m^3)
	1.31 cubic yards (yd^3)	1 cubic yard (yd^3)	0.765 cubic meters (m^3)
Weight			
1 gram (g)	0.035 ounces (oz)	1 ounce (oz)	28.35 gram (g)
1 kilogram (kg)	2.21 pounds (lb)	1 pound (lb)	0.454 kilograms (kg)
1 metric ton (mton)	1.10 short ton (2,000 lb)	1 short ton (2,000 lb)	0.90718 metric ton (mton)
Area			
1 hectare	2.47 acres	1 acre	0.40 hectares
1 square meter (m^2)	10.76 square feet (ft^2)	1 square foot (ft^2)	0.09 square meters (m^2)
Radioactivity			
1 becquerel (Bq)	2.7×10^{-11} curie (Ci)	1 curie (Ci)	3.7×10^{10} becquerel (Bq)
Radiation dose			
1 rem	0.01 sievert (Sv)	1 sievert (Sv)	100 rem
Temperature			
°C = (°F − 32)/1.8		°F = (°C × 1.8) + 32	

1.8.9 Mean and Standard Deviation

The mean of a set of data is the usual average of those data. The standard deviation (SD) of sample data relates to the variation around the mean of a set of individual sample results; it is defined as the square root of the average squared difference of individual data values from the mean. This variation includes both measurement variability and actual variation between monitoring periods (weeks, months, or quarters, depending on the particular analysis). The sample mean and standard deviation are estimates of the average and the variability that would be seen in a large number of repeated measurements. If the distribution shape were "normal" (i.e., shaped as ), about 67% of the measurements would be within the mean ± SD, and 95% would be within the mean ± 2 SD.

1.8.10 Standard Error of the Mean

Just as individual values are accompanied by counting uncertainties, mean values (averages) are accompanied by uncertainty. The standard deviation of the distribution of sample mean values is known as the standard error of the mean (SE). The SE conveys how accurate an estimate the mean value is based on the samples that were collected and analyzed. The ± value presented to the right of a mean value is equal to 2 × SE. The ± value implies that approximately 95% of the time, the average of many calculated means will fall somewhere between the reported value minus the 2 × SE value and the reported value plus the 2 × SE value.

1.8.11 Median, Maximum, and Minimum Values

Median, maximum, and minimum values are reported in some sections of this report. A median value is the middle value when all the values are arranged in order of increasing or decreasing magnitude. For example, the median value in the series of numbers, 1 2 3 3 4 5 5 5 6, is 4. The maximum value would be 6 and the minimum value would be 1.

1.8.12 Less Than (<) Symbol

The “less than” symbol (<) is used to indicate that the measured value is smaller than the number given. For example, <0.09 would indicate that the measured value is less than 0.09. In this report, < is often used in reporting the amounts of nonradiological contaminants in a sample when the measured amounts are less than the analytical laboratory’s reporting limit for that contaminant in that sample. For example, if a measurement of benzene in sewage lagoon pond water is reported as <0.005 milligrams per liter, this implies that the measured amount of benzene present, if any, was not found to be above this level, given the sample and analysis methods used. For some constituents, the notation “ND” is also used to indicate that the constituent in question was not detected. For organic constituents, in particular, this could mean that the compound could not be clearly identified, the level (if any) was lower than the reporting limit, or (as often happens) both. In (many chapters of) this report measurements of radionuclide concentrations are reported whether or not they are below the usual reporting limit called the ***minimum detectable concentration (MDC)***.

1.8.13 Negative Radionuclide Concentrations

There is always a small amount of natural radiation in the environment. The instruments used in the laboratory to measure radioactivity in environmental media are sensitive enough to measure the natural, or background, radiation along with any contaminant radiation in a sample. To obtain an unbiased measure of the contaminant level in a sample, the natural, or background, radiation level must be subtracted from the total amount of radioactivity measured by an instrument. Because of the randomness of radioactive emissions and the very low concentrations of some contaminants, it is possible to obtain a background measurement that is larger than the actual contaminant measurement. When the larger background measurement is subtracted from the smaller contaminant measurement, a negative result is generated. The negative results are reported because they are useful when conducting statistical evaluations of the data.

1.9 References

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Chapter 2: Compliance Summary

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Environmental regulations pertinent to operations on the Nevada National Security Site (NNSS), the North Las Vegas Facility (NLVF), and the Remote Sensing Laboratory–Nellis (RSL-Nellis) include federal, state, and local environmental regulations; site-specific permits; and binding interagency agreements. The environmental regulations dictate how the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) conducts operations to ensure the protection of the environment and the public. In 2017, NNSA/NFO operated in compliance with most of the requirements defined in this framework. Instances of noncompliance are reported to regulatory agencies and corrected; they are also reported in this chapter.

As in previous years, radiological air emissions from NNSA/NFO current and past operations were well below the U.S. Environmental Protection Agency ***dose***[1] limit set for the public, and the U.S. Department of Energy (DOE) dose limits set for the public and for plants and animals on or adjacent to the NNSS. Emissions of non-radiological air pollutants from permitted equipment/facilities at NNSS, NLVF, and RSL-Nellis were all within permit limits.

No man-made ***radionuclides*** were detected in any of the three state-permitted ***public water systems*** (PWSs) on the NNSS. Water samples from the NNSS PWSs met National Primary Drinking Water Standards (health standards) and met all Nevada Secondary Drinking Water Standards (related to taste, odor, and visual aspects).

Required groundwater monitoring at three NNSS wells near the ***Area 5 Radioactive Waste Management Site (RWMS)*** continued to demonstrate that the permitted low-level radioactive waste disposal operations at the site are not affecting groundwater quality. All wastewater discharges at NNSS, NLVF, and RSL-Nellis met site-specific state permit requirements, including those of a National Pollutant Discharge Elimination System (NPDES) permit issued for groundwater pumping activities at the NLVF.

The Nevada Division of Environmental Protection (NDEP) issued a Finding of Alleged Violation (FOAV) and Order to NNSA/NFO in October 2017. It identifies NNSA/NFO's potential noncompliance with Resource Conservation Recovery Act (RCRA) which requires a waste disposal facility operator to obtain sufficient chemical or physical analysis from an offsite waste generator to ensure it matches the identity of the waste being received. This FOAV is related to the receipt and burial of 93 containers of low-level radioactive waste at the Area 5 Radioactive Waste Management Complex (RWMC) which had been received from Nuclear Fuel Services in Tennessee but mislabeled. In 2016, the containers were determined to be mixed waste (due to the presence of chromium) and should have been disposed in a separate mixed-waste disposal cell at the RWMC instead of in the low-level disposal cell actually used. Based on environmental, safety, and security requirements, the current recommended approach is to leave the 93 containers in place. A Corrective Action Plan to prevent recurrence was submitted to NDEP in March 2018.

Twenty one hazardous substance spills occurred in 2017: 19 at the NNSS, 1 at the NLVF, and 1 at RSL-Nellis. The spills were small–volume releases either to containment areas or to other surfaces. All spills were cleaned up. None of these spills were of sufficient quantities to require reporting to regulatory agencies.

Ten environmental inspections were conducted in 2017 by external regulatory agencies. These inspections included the NNSS ***hazardous waste (HW)*** management and disposal facilities, RSL underground storage tanks, NNSS ***solid waste*** landfills, NNSS and RSL air quality, NNSS drinking water and wastewater facilities, NNSS

[1] The definition of word(s) in ***bold italics*** may be found by clicking on the word in electronic version or by referencing the Glossary, Appendix B. To return from the Glossary, right click and select Previous View.

radionuclide air emissions program, and one NNSS facility registered under Nevada's Chemical Accident Prevention Program. No incidences of regulatory non-compliance were noted during the inspections.

2.1 Compliance with Requirements

The federal, state, and local environmental statutes and regulations under which NNSA/NFO operates are summarized in Table 2-1 along with a discussion of NNSA/NFO's compliance status with each. Table 2-1 also references other chapters, sections, and/or tables in this document where compliance activities for each requirement are more fully described and/or where data supporting compliance are presented (listed where applicable). In addition, the U.S. Environmental Protection Agency (EPA) offers the Enforcement and Compliance History Online (ECHO) website to search for facilities and assess their compliance with environmental regulations and to investigate pollution sources, examine and create enforcement-related maps, or explore the state's performance (https://echo.epa.gov/).

Abbreviations for Regulators

Federal

ACHP	Advisory Council on Historic Preservation
CEQ	Council on Environmental Quality
DOE	U.S. Department of Energy
DOI	U.S. Department of Interior
EPA	U.S. Environmental Protection Agency
FWS	U.S. Fish and Wildlife Service

State/County

CCDAQ	Clark County Department of Air Quality
NDEP	Nevada Division of Environmental Protection
NDOA	Nevada Department of Agriculture
NDOF	Nevada Department of Forestry
NDOW	Nevada Department of Wildlife
NSHPO	Nevada State Historic Preservation Office

Table 2-1. Federal, state, and local environmental laws and regulations applicable to NNSA/NFO

Description of Law/Regulation [(a)(b)]	2017 Compliance Status
General Environmental Protection, Management, and Sustainability	
National Environmental Policy Act (NEPA), 42 USC 4321 et seq. (1969) **• CEQ: 40 CFR 1500-1508 • DOE: 10 CFR 1021, DOE O 451.1B Change 3**	
NEPA requires federal agencies to consider environmental and related social and economic effects and reasonable alternatives before making a decision to implement a major federal action. Part 10 CFR 1021 establishes procedures that the DOE shall use to comply with NEPA. DOE O 451.1B, Change 3, *National Environmental Policy Act Compliance Program,* established DOE internal requirements and responsibilities for implementing NEPA. It was replaced on December 21, 2017 with DOE Policy DOE P 451.1, *National Environmental Policy Act Compliance Program*.	The NNSA/NFO NEPA Compliance Officer reviews Environmental Evaluation Checklists, which are required for all proposed projects/activities on the NNSS and determines if the activity's environmental impacts require NEPA analysis and documentation. In 2017, 70 proposed projects/activities required analysis and documentation under NEPA compliance procedures, and 70 were exempt from any further NEPA review (Section 2.3).
Departmental Sustainability (DOE O 436.1)	
DOE O 436.1 implements Executive Order EO 13963, *Planning for Sustainability in the Next Decade*. DOE publishes goals outlined in the EO in a *DOE Strategic Sustainability Performance Plan* (SSPP). The order requires DOE to use an Environmental Management System (EMS) to establish and track site-specific sustainability programs and objectives, develop and implement Site Sustainability Plans, and use alternative financing to the maximum extent possible for sustainability projects. National Security Technologies, LLC (NSTec), the management and operating (M&O) contractor for the NNSS up until December 1, 2017, implemented an EMS, certified through June 2017 under International Organization for Standardization 14001:2004.	The EMS contributes to achieving the DOE Sustainable Environmental Stewardship goals outlined in DOE's most current SSPP and incorporated into NNSA/NFO's Site Sustainability Plan. In December 2017, progress toward reaching 2017 goals was reported in the 2018 NNSA/NFO Site Sustainability Plan. EMS progress was monitored and reported through the EMS Compliance Reporting procedure using the FedCenter.gov database. NNSA/NFO met 24 of the 32 long-term DOE sustainability goals in 2017 and continues to work toward achieving the remaining eight (Chapter 3).
Air Quality	
Clean Air Act (CAA), 42 USC 7401 et seq. (1970) **• EPA: 40 CFR 50, 60, 61, 63, 80, 82, and 98 • NDEP: Nevada Administrative Code (NAC) 445B**	
The CAA and Nevada's Air Control laws regulate air pollutant release through permits and air quality limits. Radionuclide emissions are regulated via CAA National	No major source of air pollutants occurs at the NNSS. Federal and state air quality regulations are met through a State of Nevada Class II Air Quality Operating Permit and

Description of Law/Regulation [(a)(b)]	2017 Compliance Status
Emission Standards for Hazardous Air Pollutants (NESHAP) authorizations. Emissions of ***criteria pollutants*** are regulated via National Ambient Air Quality Standards (NAAQS) authorizations. Criteria and ***designated pollutants*** emitted from various industrial categories of facilities are regulated via New Source Performance Standards (NSPS) authorizations. The CAA also establishes production limits and a schedule for the phase-out of ***ozone depleting substances (ODS)***. **NAC 445B, *Air Controls***, enforces CAA regulations and requires fugitive dust control and open burn authorizations.	various project-specific state-issued permits (Table 2-2). NESHAP compliance activities include radionuclide air monitoring; reporting asbestos abatement; monitoring/reporting emissions from generators and boilers; and, management of gasoline/diesel storage tanks. NAAQS emission limits (except ozone and lead) are based on published values for similar industries and operational data specific to the NNSS. Some screens, conveyor belts, bulk fuel storage tanks, and generators are subject to NSPS. At the NLVF and RSL-Nellis, air quality regulations are met through Clark County Minor Source permits. NNSA/NFO pays annual state fees based on all sources' "***potential to emit***." Nevada's Bureau of Air Pollution Control inspects permitted NNSS facilities and Clark County inspects NLVF and RSL-Nellis permitted equipment. All approvals, notifications, requests for additional information, and reports required under the CAA are submitted to NDEP, Clark County, and/or EPA Region 9. In 2017, monitored radioactive air emissions were below NESHAP limits (Section 4.1.5). All non-radiological air emission limits, monitoring, record keeping, training, and reporting requirements of state and county air permits were met at the NNSS (Section 4.2), and at the NLVF and RSL-Nellis.
Water Quality	
Clean Water Act (CWA), 33 USC 1251 et seq. (1972) **• EPA: 40 CFR 109-140, 230, 231, 401, and 403 • NDEP: NAC 444, 445A, and 534**	
The CWA and Nevada's Water Pollution Control laws seek to improve surface water quality by establishing standards and a system of permits. They prohibit the discharge of contaminants from ***point sources*** to waters of the U.S. without a National Pollutant Discharge Elimination System (NPDES) permit. **NACs 444, *Sanitation (Sewage Disposal)***, and **445A, *Water Controls (Water Pollution Control)***, regulate the collection, treatment, and disposal of wastewater and sewage. **NAC 534, *Underground Water and Wells***, regulates the drilling, construction, and licensing of new wells and the reworking of existing wells to prevent the waste and contamination of groundwater. NLVF and RSL-Nellis implement a Spill Prevention, Control, and Countermeasure Plan required by the EPA to ensure that petroleum and non-petroleum oil products do not pollute waters of the U.S. via discharge into the Las Vegas Wash. In addition to federal and state laws, the NLVF and RSL-Nellis are regulated by the City of North Las Vegas (CNLV) and the Clark County Water Reclamation District (CCWRD) respectively.	NNSA/NFO does not hold a NPDES permit for NNSS operations because there are no discharges to waters of the U.S. on or off the NNSS from NNSA/NFO activities. Wastewater discharges are managed on the NNSS in accordance with NDEP-issued permits that include the E Tunnel Waste Water Disposal System (Section 5.1.3.7.2), active and inactive sewage lagoons (Section 5.2.3), septic tanks, septic tank pumpers, and a septic tank pumping contractor's license (Section 5.2.2). NNSA/NFO reports unplanned releases of hazardous substances to NDEP as required under NAC 445A. No such releases occurred in 2017 (Section 2.5). NDEP issues underground injection control (UIC) permits for various investigations. A noble gas migration study in borehole U-20az PS#1A and a similar study in Area 12 P Tunnel are both conducted under a UIC permit. No underground injections occurred in 2017. NNSA/NFO complies with NAC 534 for Underground Test Area (UGTA) activities. UGTA wells maintain compliance with the CWA and are regulated by the state through the *UGTA Fluid Management Plan*, an agreement between NNSA/NFO and NDEP. In 2017, UGTA well drilling fluids were monitored and managed in accordance with the plan (Section 5.1.3.7.3). NLVF operates under a Class II Authorization to Discharge Permit issued by the CNLV for sewer discharges, a NPDES DeMinimis permit for surface water discharge, and a No Exposure Waiver for exclusion from NPDES storm water

Description of Law/Regulation (a)(b)	2017 Compliance Status
	permitting. Storm water is not contaminated by exposure to industrial activities or materials (Section A.1.2). The CCWRD determined the annual submission of a Zero Discharge Form for RSL-Nellis is sufficient to verify compliance with the CWA (Section A.2.2). In 2017, all water chemistry parameters and contaminants that required monitoring in wastewater discharges and sewage lagoons were within permit limits, all required inspections of wastewater systems were conducted.
Safe Drinking Water Act (SDWA) 42 USC 300f et seq. (1974) **• EPA: 40 CFR 141-149 • NDEP: NAC 445A**	
The SDWA protects the quality of drinking water in the U.S. and authorizes the EPA to establish safe standards of purity. It requires all owners or operators of ***public water systems*** (PWSs) to comply with National Primary Drinking Water Standards (health standards). State governments are authorized to set Secondary Standards related to taste, odor, and visual aspects. **NAC 445A, *Water Controls***, requires that PWSs meet both primary and secondary water quality standards. The SDWA standards for radionuclides currently apply only to PWSs designated as ***community water systems.*** Although not required under the SDWA, all potable water supply wells on the NNSS are monitored for radionuclides in compliance with DOE O 458.1, *Radiation Protection of the Public and the Environment.*	The NNSS supplies drinking water from onsite wells that comply with all applicable federal and state water quality standards. Three PWSs on the NNSS are permitted by the state as ***non-community water systems.*** Each source is sampled according to a monitoring cycle which identifies specific contaminants and sampling frequency, ranging from monthly, quarterly, or once every 1, 3, 6, or 9 years. NDEP also permits two potable water-hauling trucks on the NNSS. The trucks are monitored monthly for coliform bacteria and results are submitted to NDEP throughout the year as they are acquired. In 2017, no man-made radionuclides from NNSA/NFO activities were detected in NNSS drinking water wells, the PWSs met all applicable primary and secondary drinking water standards, and potable water hauling trucks tested negative for coliform bacteria (Sections 5.1.3.6 and 5.2.1). Water used at both the NLVF and RSL-Nellis is supplied by the CNLV and meets or exceeds federal drinking water standards; no monitoring or reporting of water quality is required.
Energy Independence and Security Act of 2007 (EISA) (Pub. L. 110-140)	
Section 438 of the EISA addresses storm water management and requires any development/redevelopment project involving a federal facility with a footprint over 5,000 gross square feet (gsf) maintain or restore, to the maximum extent feasible, the predevelopment hydrology of the property with regard to the rate, temperature, volume, and duration of storm water flow.	One such qualifying building, 12-930 in Area 12 of the NNSS, was constructed in 2017. Storm water management strategies were addressed and incorporated into site design and building construction to meet EISA requirements.
Radiation Protection	
Radiation Protection of the Public and the Environment (DOE O 458.1 Change 3) **• DOE-STD-1196-2011 and DOE-STD-1153-2002**	
DOE O 458.1 Change 3 requires DOE/NNSA sites to implement an environmental radiological protection program. It establishes requirements for (1) measuring ***radioactivity*** in the environment, (2) documenting the ***ALARA*** [as low as reasonably achievable] process for operations, (3) using mathematical models for estimating doses, (4) releasing property having residual radioactive material, and (5) maintaining records to demonstrate compliance. The EPA's ***Clean Air Package 1988 (CAP88)*** (version 4.0) and the ***Derived Concentration Standards (DCSs)***, defined in **DOE-STD-1196-2011, *Derived Concentration Technical***	NNSA/NFO has in place a radiological monitoring program and protection procedures that satisfy the requirements for a site-specific radiological protection program. Routine radiological monitoring of air, water, and biota as well as project-specific monitoring and NESHAP evaluations of projects, are conducted. Monitoring and evaluation results document NNSA/NFO's compliance with the radiological dose limits set by DOE for the public and biota from several exposure pathways that include predominately inhalation and the ingestion of hunted NNSS game animals. Results of radiological monitoring and protective measures are described in this report throughout several chapters.

Description of Law/Regulation (a)(b)	2017 Compliance Status
Standard, are used in the design and conduct of environmental radiological protection programs. The order sets a radiation dose limit of 100 mrem/yr (1 mSv/yr) above ***background*** levels to individuals in the general public from all pathways of ***exposure*** combined. It also calls for the protection of aquatic and terrestrial plants and animals from radiological impacts through the use of **DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota***.	As in previous years, the calculated dose to the public and to the biota from NNSA/NFO operations in 2017 were below all DOE dose limits set by DOE O 458.1 and DOE-STD-1153-2002, respectively. CAP88 and RESRAD-Biota models and DCSs defined in DOE-STD-1196-2011 were used to estimate dose to humans and biota based on radiological monitoring results (Sections 4.1 and 5.1, Chapters 6–9).
Waste Management and Environmental Restoration	
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 USC 9601 et seq (1980) **• EPA: 40 CFR 300, 302, and 355**	
CERCLA provides a framework for the cleanup of waste sites containing hazardous substances and an emergency response program in the event of a release of a hazardous substance to the environment (Emergency Planning and Community Right-to-Know Act).	No hazardous waste cleanup operations on the NNSS are regulated under CERCLA. Instead, they are regulated under the Resource Conservation Recovery Act (listed below). NNSA/NFO complies with the Emergency Planning and Community Right-to-Know Act under CERCLA (listed below).
Resource Conservation Recovery Act (RCRA), 42 USC 6901 et seq. (1976) **• EPA: 40 CFR 259-282 • NDEP: NAC 44.570-7499, 444.850-8746, and 459.9921-999**	
The RCRA and Nevada laws **NAC 444.850–8746, *Disposal of Hazardous Waste*;** **NAC 444.570–7499, *Solid Waste Disposal***; and, **NAC 459.9921–999, *Storage Tanks*** regulate the generation, storage, transportation, treatment, and disposal of solid and hazardous wastes to prevent contaminants from leaching into the environment from landfills, underground storage tanks (USTs), surface impoundments, and hazardous waste (HW) disposal facilities. RCRA also requires HW generators to have a program to reduce the amount and toxicity of HW, and federal facilities to have a procurement process to ensure that they purchase product types that satisfy the EPA-designated minimum percentages of recycled material.	NNSA/NFO generates hazardous waste (HW) (which includes ***mixed low level waste [MLLW]***) and operates a permitted HW management facility under RCRA Part B Permit NEV HW0101 issued by NDEP (Section 10.2). In accordance with the permit, NNSA/NFO also monitors groundwater from three wells downgradient of mixed low level waste (MLLW) disposal cells (Section 10.1.7) and conducts post-closure monitoring for HW sites that were closed under RCRA prior to enactment of the Federal Facility Agreement and Consent Order (FFACO) (Section 11.4). NNSA/NFO prepares a Hazardous Waste Report of all HW and MLLW volumes generated and disposed annually at the NNSS. All of these RCRA Part B Permit NEV HW0101 requirements were met in 2017. NDEP issued a Finding of Alleged Violation (FOAV) and Order to NNSA/NFO for potential violation of RCRA and state regulations regarding containers of ***low-level waste (LLW)*** which were determined to be mixed waste and which had been received from an off-site generator for disposal at the NNSS from 2009 to 2015 (Table 2-7).
Federal Facility Agreement and Consent Order (FFACO), as amended **• FFACO • NDEP**	
FFACO was agreed to by the State of Nevada, DOE Environmental Management, the U.S. Department of Defense, and DOE Legacy Management in1996. Pursuant to Section 120(a) (4) of CERCLA and to Sections 6001 and 3004(u) of RCRA, the FFACO addresses the environmental restoration of historically contaminated sites for which the NNSA/NFO is responsible for cleanup and closure.	The Environmental Management (EM) Nevada Program is responsible for the cleanup and closure of over 3,000 corrective action sites (CASs) identified in Nevada. Program activities follow a formal work process described in the FFACO. The State of Nevada is a participant throughout the closure process, and the Nevada Site Specific Advisory Board is kept informed of the progress made. The board is a formal volunteer group of interested citizens who provide informed recommendations to NNSA/NFO. In 2017, NNSA/NFO closed 16 CASs and met all of the 2017 FFACO milestones for the characterization, remediation, closures, and post-closure monitoring and

Description of Law/Regulation [(a)(b)]	2017 Compliance Status
	inspection of historically contaminated CASs. To date, 2,145 of the 3,039 CASs have been closed (Chapter 11).
<u>Radioactive Waste Management (DOE-O-435.1, Change 1)</u> **• DOE M 435.1-1, Change 2**	
DOE O 435.1, Change 1 requires all DOE radioactive waste be managed in a manner that is protective of the worker, public health and safety, and the environment. It directs how radioactive waste management operations are conducted on the NNSS. **DOE M 435.1-1, Change 2, *Radioactive Waste Management Manual***, specifies that operations at radioactive waste management facilities must not contribute a dose to the general public in excess of 10 mrem/yr through the air pathway and 25 mrem/yr through all exposure pathways.	The Area 3 and Area 5 RWMS operate as Category II Non-Reactor Nuclear Facilities. Both are designed and operated to manage and safely dispose of LLW, MLLW, and HW generated by NNSA/NFO, other DOE and selected U.S. Department of Defense operations, and to manage and safely store ***transuranic*** and mixed transuranic wastes generated on the NNSS for eventual shipment to the Waste Isolation Pilot Plant in New Mexico. In accordance with this order, ***Performance Assessments (PAs)*** and ***Composite Analyses (CAs)*** for both RWMSs are reviewed annually to assess their adequacy, and results are submitted annually to the DOE Office of Environmental Management. The Disposal Authorization Statements for both RWMSs also require annual reviews tracking of secondary or minor unresolved issues to resolution. Waste Acceptance Criteria for radioactive wastes received at the RWMSs are maintained and the volumes of LLW and MLLW disposed at the RWMSs are tracked. Although not required by this DOE order, ***vadose zone*** monitoring at both RWMSs is performed to validate the performance assessment criteria of the RWMSs. In 2017, all key documents and analyses were current and all required management practices were followed (Section 10.1). The radiological dose to the public in 2017 from the Area 3 and 5 RWMSs from all pathways was negligible (Section 10.1.9).
Hazardous Materials Control and Management	
<u>Emergency Planning and Community Right-to-Know Act (EPCRA), 42 USC 11001 et seq. (1986)</u> **• EPA: 40 CFR 300, 302, 355, 370, and 372**	
EPCRA requires that federal, state, and local emergency planning authorities be provided information regarding the presence and storage of hazardous substances and their planned and unplanned environmental releases, including provisions and plans for responding to emergency situations involving hazardous materials. EPCRA identifies the threshold quantities of chemicals released or stored which trigger the reporting of this information to these authorities.	Some NNSA/NFO facilities store or use chemicals in quantities exceeding threshold quantities under EPCRA. NNSA/NFO complies with all reporting and emergency planning requirements under EPCRA and with the requirements of several state-issued hazardous materials permits: a site-wide NNSS permit, one for the Nonproliferation Test and Evaluation Complex on the NNSS, one for NLVF, and one for RSL-Nellis. In 2017, NNSA/NFO adhered to all EPCRA reporting requirements (Section 2.4.4.1). The Nevada Combined Agency Report, containing updated chemical inventories for NNSA/NFO facilities, was submitted to the State Fire Marshal, and a Toxic Release Inventory Report was submitted to EPA identifying the types and quantities of toxic chemicals that were either released by NNSA/NFO operations into the environment or released for disposal or recycling. Toxic chemicals released from the NNSS in 2017 included lead, mercury, ***polychlorinated biphenyls (PCBs)***, and polycyclic aromatic hydrocarbons (PACs) (Section 2.4.4.1). No releases at NLVF or RSL-Nellis exceeded reportable thresholds in 2017 (Sections A.1.5 and A.2.4).

Description of Law/Regulation [(a)(b)]	2017 Compliance Status
State of Nevada Chemical Catastrophe Prevention Act (NRS 459.380–3874) **• NDEP: NAC 459.952-95528**	
This act directs NDEP to develop and implement a program called the Chemical Accident Prevention Program (CAPP). It requires registration of facilities with highly hazardous substances above listed thresholds.	The Nonproliferation Test and Evaluation Complex (NPTEC) in Area 5 of the NNSS is registered as a CAPP facility. NNSA/NFO submits an annual CAPP Registration report to the state, whether or not a threshold was exceeded. In 2017, no highly hazardous substance was stored at NPTEC in quantities that exceeded reporting thresholds. The annual compliance inspection at NPTEC conducted by NDEP found the facility was meeting regulatory requirements, except for two findings (Section 2.4.4.2).
Toxic Substances Control Act (TSCA), 15 USC 2601 et seq. (1976) **• EPA: CFR 700-763 • NDEP: NAC 444.842-8746**	
TSCA regulates the manufacture, use, and distribution of chemical substances that enter the consumer market. Because the NNSS does not produce chemicals, compliance is primarily directed toward the management of PCBs. **NAC 444, *Sanitation*,** enforces the federal requirements for the handling, storage, and disposal of PCBs and contains record keeping requirements for PCB activities.	At the NNSS, remediation activities and maintenance of fluorescent light ballasts can result in the onsite disposal of PCB-contaminated waste or the offsite disposal of larger quantities of PCB waste. NNSS also receives radioactive waste for onsite disposal that may contain regulated levels of PCBs. The onsite disposal of all PCB wastes and recordkeeping requirements for PCB activities are regulated by the state. In 2017, PCBs were managed in compliance with TSCA and state regulations. No ***PCB bulk product waste*** was disposed of in the Area 9 U10c Solid Waste Disposal Site; 28.3 pounds of radioactive LLW containing PCBs were disposed in Cell 18 at the Area 5 RWMS; and 0.02 pounds were shipped offsite for disposal (Section 2.4.2).
Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), 7 USC 136 et seq. (1996) **• EPA: CFR 162-171 • NDOA: NAC 555**	
FIFRA governs the manufacture, use, storage, and disposal of pesticides (including herbicides and other biocides) as well as the pesticide containers and residuals. It specifies procedures and requirements for pesticide registration, labeling, classification, and certification of applicators. **NAC 555, *Nevada Control of Insects, Pests, and Noxious Weeds***, regulates the certification of registered pesticide and herbicide applicators in Nevada. The Nevada Department of Agriculture (NDOA) has the primary role to enforce FIFRA in Nevada.	The use of pesticides classified as "restricted-use pesticides" is regulated. Beginning in 2015, only non-restricted-use pesticides are applied under the direction of a State of Nevada–certified applicator. In 2017, NNSA/NFO complied with all FIFRA requirements (Section 2.4.3).
Cultural Resources	
National Historic Preservation Act (NHPA), as amended, 54 USC 300101 et seq. (1966) **• ACHP: 36 CFR 800**	
The NHPA, as amended, identifies, evaluates, and protects historic properties eligible for listing in the National Register of Historic Places (NRHP). Such properties can be archeological sites, historic structures, documents, records, or objects. The act requires federal agencies to develop and implement a Cultural Resources Management Plan, to identify and evaluate the eligibility of historic properties for long-term management as well as for future project-specific planning, and to maintain archaeological collections and their associated records at professional standards.	NNSA/NFO has established a Cultural Resources Management (CRM) program at the NNSS, which is implemented by the Desert Research Institute (DRI). The CRM program ensures compliance with all regulations pertaining to cultural resources on the NNSS. Before initiating land-disturbing activities or building and structure modifications, archaeologists conduct surveys and historical evaluations to identify important cultural resources, evaluate significance, and assess potential impacts. Native American representatives also conduct assessments of proposed land disturbances to identify resources that may be of spiritual or cultural significance. NNSA/NFO's long-term management

Description of Law/Regulation [a][b]	2017 Compliance Status
	strategy includes (1) monitoring NRHP-listed and eligible properties to determine if environmental factors or NNSA/NFO activities are affecting the integrity or other aspects of eligibility, and (2) taking corrective actions or identifying alternative approaches as necessary. Determinations of NRHP eligibility, effect, and mitigation are conducted in consultation with the Nevada State Historic Preservation Office (NSHPO), the Consolidated Group of Tribes and Organizations (CGTO) and, in some cases, the federal Advisory Council on Historic Preservation. To date, more than 1,400 NRHP eligible sites/ facilities on the NNSS have been identified. In 2017, field surveys and historical evaluations for 18 NNSS projects were conducted, 118 cultural resources were identified, 103 of which were determined eligible to the NRHP (Sections 12.1 and 12.2).
Archaeological Resources Protection Act (ARPA), as amended (16 USC 470aa–mm) **• DOI: 18 CFR 1312, 36 CFR 79, and 43 CFR 7**	
The ARPA, as amended, protects archaeological resources that remain in or on federal and American Indian lands and ensures that their confidentiality and characteristics are maintained. It requires the issuance of a federal archaeology permit to qualified archaeologists to inventory, excavate, or remove archaeological resources and requires notification to American Indian tribes of these activities.	Archaeologists working at the NNSS meet federal standards for qualifications and work under a permit issued by NNSA/ NFO. Procedures are in place to maintain the confidentiality of site locations and other information. In the event of vandalism, NNSA/ NFO investigates any impacts that may occur. The CRM program curates archaeological collections from the NNSS in accordance with 36 CFR 79, *Curation of Federally Owned and Administered Archeological Collections*, and conducts American Indian consultations related to places and items of importance to the CGTO (Section 12.4).
American Indian Religious Freedom Act, as amended (42 USC 1996)	
This law established the government policy to protect and preserve for American Indians their inherent right of freedom to believe, express, and exercise the traditional religions, including but not limited to access to sites, use and possession of sacred objects, and the freedom to worship through ceremonial and traditional rites.	Locations exist on the NNSS that have religious significance to Western Shoshone, Southern Paiute and Owens Valley Paiute and Shoshone. Access is provided by NNSA/NFO in accordance with safety and health standards (Section 12.5).
Native American Graves Protection and Repatriation Act (NAGPRA), as amended (25 USC 3001–3013) **• DOI: 43 CFR 10**	
The NAGPRA, as amended, requires federal agencies to return certain types of Native American cultural items to lineal descendants and culturally affiliated American Indian tribes. The specified cultural items include human remains, funerary objects, sacred objects, and objects of cultural patrimony.	The NNSS artifact collection is subject to NAGPRA. The required inventory and summary of NNSS cultural materials accessioned into the NNSS Archaeological Collection was completed in the 1990s. The inventory list and summary was distributed to the tribes affiliated with the NNSS and adjacent lands. Consultations followed, and all artifacts the tribes requested were repatriated to them. This repatriation process was completed in 2002; it will be repeated for any new additions to the collection (Sections 12.4 and 12.5).
Biological Resources	
Endangered Species Act (ESA), 16 USC 1531-1544 (1973) **• FWS: 50 CFR 17**	
The ESA provides a program for the conservation of threatened and endangered plants and animals and the habitats in which they are found. The law also prohibits any	The threatened desert tortoise is the only species protected under the ESA that may be impacted by NNSS operations. NNSS activities within tortoise habitat are conducted so as to comply with the terms and conditions of a Biological

Description of Law/Regulation [(a)(b)]	2017 Compliance Status
action that causes ***incidental take*** of any listed species of endangered fish or wildlife.	Opinion (BO) issued by the U.S. Fish and Wildlife Service (FWS) to NNSA/NFO. The allowable cumulative take under the BO (2009-2019) is 22 tortoises killed/injured, 194 moved, and 2,710 acres of habitat disturbed. In 2017, cumulative take totals were 12 killed on roads, 153 moved out of harm's way, and 51 acres disturbed. All FWS requirements of the BO were met (Section 13.1).
Nevada Department of Wildlife (NDOW) **• NDOW: NAC 503 •NDOF: NAC 527**	
NDOW regulations identify protected and unprotected Nevada animal species and prohibits the harm of protected species without special permit. NAC 503 also identifies game animals, which are managed by the state. Nevada Department of Forestry (NDOF) regulations prohibits removal or destruction of state protected plants without special permit.	Other state-managed and state-protected species are monitored under the Ecological Monitoring and Compliance (EMAC) Program. Some species are collected for ecological studies under an NDOW scientific collection permit. In 2017, monitoring of raptors, wild horses, and mule deer was conducted. NNSS biologists assisted other agency biologists with desert bighorn and mountain lion studies on and near the NNSS (Section 13.3).
Migratory Bird Treaty Act (MBTA), 16 USC 703-712 (1918) **• FWS: 50 CFR 21 •NDOW: NRS 503.050**	
The MBTA implements various treaties and conventions between the U.S. and Canada, Japan, Mexico, and the former Soviet Union for the protection of migratory birds. It prohibits the purposeful harming of any migratory bird, their nest, or eggs without authorization by the Secretary of the Interior. Memorandum M-37050 issued December 22, 2017 by the U.S. Department of the Interior, Office of the Solicitor, ruled that the incidental harm to migratory birds from otherwise legal activities do not violate this act. Nevada wildlife laws protect birds included under the MBTA from purposeful harm.	Although not required under the MBTA, the EMAC Program reviews construction and demolition projects and conducts field surveys to reduce any incidental harm to migratory birds and their nests/eggs. Biologists periodically collect game birds for radiological analysis under an FWS-issued migratory bird scientific collection permit. Migratory birds found injured or dead are reported to regulators. Biologists transfer injured raptors, upon direction from the FWS, to a licensed rehabilitator, and mitigation measures to reduce accidental mortalities are pursued. In 2017, 45 migratory birds were found dead; 33 of the deaths were due to human activities (e.g., electrocution on power lines) (Section 13.3).
Responsibilities of Federal Agencies to Protect Migratory Birds **• EO 13186**	
This EO directs federal agencies to take certain actions to further implement the MBTA if agencies have, or are likely to have, a measurable negative effect on migratory bird populations. It also directs federal agencies to conduct actions, as practicable, to benefit the health of migratory bird populations.	The Power Group installed bird guards, protective covers, and other retrofits on 64 power poles to reduce avian mortality, with additional poles planned for retrofit in 2018. Biologists finalized an Avian Protection Plan in cooperation with the FWS. The focus of the plan is to reduce operational and avian risks from avian interactions with electric transmission and distribution lines on the NNSS as well as other non-electric sources of mortality (e.g., vehicle collisions, habitat disturbance) (Section 13.3).
The Bald and Golden Eagle Protection Act (BGEPA), 16 USC 668a-d, 703-712 **• FWS: 50 CFR 22 •NDOW: NRS 503.050**	
The BGEPA prohibits any form of possession or taking of both bald and golden eagles. Eagles are also protected under Nevada wildlife laws.	Compliance with the BGEPA is documented under the EMAC Program. Eagles that are occasionally electrocuted on NNSS powerlines are transferred to the FWS under an FWS special purpose possession permit. Fourteen golden eagles and 16 other birds were electrocuted in 2017 (Section 13.3).

Description of Law/Regulation (a)(b)	2017 Compliance Status
Wild Free-Roaming Horses and Burros Act (Pub. L. 92–195)	
This act makes it unlawful to harm wild horses and burros. It directs the U.S. Bureau of Land Management (BLM) and the U.S. Forest Service (FS) to protect, manage, and control wild horses and burros on BLM and FS administered lands in a manner that is designed to achieve and maintain a thriving natural ecological balance.	The NNSS is not within a ***BLM active herd management area***. A Five-Party Cooperative Agreement exists, however, between NNSA/NFO, Nevada Test and Training Range (NTTR), FWS, BLM, and the State of Nevada, which calls for cooperation in conducting resource inventories, developing resource management plans, and maintaining favorable habitat for wild horses and burros on federally withdrawn lands. NNSA/NFO consults with BLM on NNSS horse management, and NNSS biologists conduct periodic wild horse surveys for abundance, recruitment (i.e., survival to reproductive age), and distribution (Section 13.3).
Invasive Species **• EO 13112**	
EO 13112 directs federal agencies to act to prevent the introduction of, or to monitor and control, invasive (non-native) species; to provide for restoration of native species; and to exercise care in taking actions that could promote the introduction or spread of invasive species.	Land-disturbing activities on the NNSS have resulted in the spread of numerous invasive plant species. Habitat reclamation and other controls are evaluated and conducted, when feasible, to control such species and meet the purposes of this EO (Section 13.4).
Environmental Activities and Occurrence Reporting	
Environment, Safety and Health Reporting **• DOE O 231.1B**	
This order requires the timely collection, reporting, analysis, and dissemination of information on environment, safety, and health as required by law or regulations or as needed to ensure that DOE is kept fully informed on a timely basis about events that could adversely affect the health and safety of the public, workers, the environment, the intended purpose of DOE facilities, or the credibility of the DOE. It requires DOE and NNSA sites to prepare an annual calendar year report, referred to as the Annual Site Environmental Report (ASER).	NNSA/NFO prepares an ASER called the NNSS Environmental Report (NNSSER, i.e., this report) and provides data for DOE to prepare annual NEPA summaries and other Safety, Fire Protection, and Occupational Safety and Health Administration (OSHA) reports. The NNSSER demonstrates compliance with DOE internal standards and requirements, such as the radiation protection requirements of DOE O 458.1, and documents DOE's environmental performance to members of the public living near the NNSS and to other stakeholders.
Occurrence Reporting and Processing of Operations Information **• DOE O 232.2A**	
This order requires DOE and NNSA be informed about events that could adversely affect the health and safety of the public, workers, environment, DOE missions, or the credibility of the DOE. It sets reporting criteria for unplanned environmental releases of pollutants, hazardous substances, petroleum products, and sulfur hexafluoride at DOE/NNSA sites and facilities. It also requires sites/facilities to report to DOE/NNSA any written notification received from an outside agency that the site/facility is non-compliant with a schedule or requirement.	NNSA/NFO contractors enter environmental occurrences, identified as reportable in accordance with this order, into DOE's Occurrence Reporting and Processing System (ORPS). Reported information includes report level of the identified event, notifications, and if applicable, causal factors, and corrective actions based on the report level of the event. Reportable environmental events that occurred in 2017 are presented in Table 2-7 and Section 2.5.
Quality Assurance	
Quality Assurance **• DOE 10 CFR 830, Subpart A and DOE O 414.1D, Change 1**	
The objective of this order is to establish an effective management system using the performance requirements of this order, coupled with consensus standards, where appropriate, to ensure 1) products and services meet or exceed customers' expectations; 2) there is management support for planning, organization, resources, direction, and control; 3)	NNSA/NFO has QAPs in place to implement quality management methodology in adherence to this DOE order. The QAPs ensure that all environmental monitoring data meet ***quality assurance (QA)*** and ***quality control (QC)*** requirements. Samples are collected to meet quality assurance and quality control requirements. Samples are

Description of Law/Regulation [(a)(b)]	2017 Compliance Status
performance and quality improvements occur by means of thorough, rigorous assessments and corrective actions; and 4) environmental, safety, and health risks and impacts associated with work processes are minimized while maximizing reliability and performance of work products. Using a graded approach, DOE/NNSA sites must develop a quality assurance plan (QAP) to establish additional process-specific quality requirements and implement the approved QAP.	collected and analyzed using standard operating procedures to ensure representative samples and reliable, defensible data. Quality control in sub-contracted analytical laboratories is maintained through instrument calibration, efficiency and background checks, and testing for precision and accuracy. Data are verified and validated according to project-specific quality objectives before they are used to support decision making (Chapters 14 and 15).

(a) For federal laws, a reference to its implementing regulation, which was written by the identified federal regulatory agency, is given. The regulation is identified by its ***Code of Federal Regulations (CFR)*** Title and Part (e.g., 10 CFR 1021 means, "Title 10 Part 1021"). CFR references can be accessed at www.ecfr.gov/cgi-bin/ECFR?page=browse. If no implementing regulations have been written, then N/A (not applicable) is entered. For more explanatory information on ***federal citations***.
For Nevada State laws, either the Nevada Administrative Code (NAC) or the Nevada Revised Statute (NRS) reference is given. NACs can be accessed http://search.leg.state.nv.us/NAC/NAC.html. NRSs can be accessed http://search.leg.state.nv.us/NRS/NRS.html.

(b) For federal laws, the name of the law and its reference in the ***United States Code (USC)*** by Title and Section is given (e.g., 42 USC 4321 et seq. means, "Title 42 Section 4321 and the following." USC references can be accessed http://uscode.house.gov/. If there is not a USC reference, the public law (Pub. L.) number is given.

2.2 Environmental Permits

Table 2-2 presents the complete list of all federal and state permits active during 2017 for NNSS, NLVF, and RSL-Nellis operations. The table includes those pertaining to air quality monitoring, operation of drinking water and sewage systems, hazardous materials and HW management and disposal, and endangered species protection. Reports associated with permits are submitted to the appropriate designated state or federal office. Copies of reports may be obtained upon request.

Table 2-2. Environmental permits required for NNSA/NFO operations at NNSS, NLVF, and RSL-Nellis

Permit	Permit Name or Description	Expiration Date	Report
	Air Quality		
	NNSS		
AP9711-2557	NNSS Class II Air Quality Operating Permit	June 25, 2014 (permit renewal submitted in 2014 and not yet issued)	Annual
16-27 and 17-16	NNSS Open Burn Authorization, Fire Extinguisher Training (Various Locations)	March 22, 2018	None
16-28 and 17-17	NNSS Open Burn Authorization, Simulated Vehicle Burns, A-23, Facility #23-T00200 (NNSS Fire & Rescue Training Center)	March 22, 2018	None
	UGTA Offsite		
AP9711-2659.01	NTTR Class II Air Quality Operating Permit, Surface Area Disturbance, Wells ER-EC-13 and ER-EC-15	March 4, 2020	Annual
AP9711-2824	NTTR Class II Air Quality Operating Permit, Surface Area Disturbance, Well ER-EC-14	June 14, 2021	Annual
	NLVF		
Source 657	Clark County Minor Source Permit	August 11, 2020	Annual
	RSL-Nellis		
Source 348	Clark County Minor Source Permit	June 28, 2022	Annual
	Drinking Water		
	NNSS		
NY-0360-NTNC	Areas 6 and 23	September 30, 2017/2018	None
NY-4098-NC	Area 25	September 30, 2017/2018	None
NY-4099-NC	Area 12	September 30, 2017/2018	None
NY-0835-NP	NNSS Water Hauler #84846	September 30, 2017/2018	None
NY-0836-NP	NNSS Water Hauler #84847	September 30, 2017/2018	None
	Septic Systems/Pumpers		
	NNSS		
NY-1054	Septic System, Area 3, Waste Management Offices – inactive	None	None

Table 2-2. Environmental permits required for NNSA/NFO operations at NNSS, NLVF, and RSL-Nellis

Permit	Permit Name or Description	Expiration Date	Report
	Septic Systems/Pumpers		
	NNSS		
NY-1069	Septic System, Area 18 (Pahute Airstrip)[(a)]	None	None
NY-1077	Septic System, Area 27 (Baker Compound)[(a)]	None	None
NY-1079	Septic System, Area 12, U12g Tunnel - inactive	None	None
NY-1080	Septic System, Area 23 (Building 23-1103)[(a)]	None	None
NY-1081	Septic System, Area 6, Control Point-170 - inactive	None	None
NY-1082	Septic System, Area 22 (Building 22-1)[(a)]	None	None
NY-1083	Septic System, Area 5 (Area 5 RWMC)[(a)]	None	None
NY-1084	Septic System, Area 6, Device Assembly Facility - inactive	None	None
NY-1085	Septic System, Area 25 (Central Support Area)[(a)]	None	None
NY-1086	Septic System, Area 25 (Reactor Control Point)[(a)]	None	None
NY-1087	Septic System, Area 27 (Able Compound)[(a)]	None	None
NY-1089	Septic System, Area 12 (Area 12)[(a)]	None	None
NY-1090	Septic System, Area 6 (LANL)[(a)]	None	None
NY-1091	Septic System, Area 23 (Gate 100)[(a)]	None	None
NY-1103	Septic System, Area 22 (Desert Rock Airstrip)[(a)]	None	None
NY-1106	Septic System, Area 5 (NPTEC)[(a)]	None	None
NY-1110-HAA-A	Individual Sewage Disposal System, A-12, Building 12-910 - inactive	None	None
NY-1112	Commercial Sewage Disposal System (U1a Complex)[(a)]	None	None
NY-1113	Commercial Sewage Disposal System, Area 1, Building 121 - inactive	None	None
NY-1124	Commercial Individual Sewage Disposal System (RNCTEC)[(a)]	None	None
NY-1128	Commercial Individual Sewage Disposal System (Yucca Lake Airfield)[(a)]	None	None
NY-1130	Commercial Individual Sewage Disposal System (Building 06-950)[(a)]	None	None
NY-17-06839	Septic Tank Pumper E 106785	July 31, 2017/2018	None
NY-17-06839	Septic Tank Pumper E 107105	July 31, 2017/2018	None
NY-17-06839	Septic Tank Pumper E-105918	July 31, 2017/2018	None
NY-17-06839	Septic Tank Pumping Contractor (one unit)	July 31, 2017/2018	None
NY-17-06839	Septic Tank Pumper E-106169	July 31, 2017/2018	None
NY-17-06839	Septic Tank Pumper E-107103	July 31, 2017/2018	None
	Wastewater Discharge		
	NNSS		
GNEV93001Rv XI	Water Pollution Control General Permit	August 5, 2020	Quarterly
NEV96021	Water Pollution Control for E Tunnel Waste Water Disposal System and Monitoring Well ER-12-1	October 1, 2018	Annual
	NLVF		
Class II ID# 036555-02	Authorization to Discharge	None	None
NV201000 Project ID DDP-42723	NPDES DeMinimis	July 30, 2018	Annual
Site Number: ISW-40564	Stormwater No Exposure Waiver	September 3, 2020	None
	RSL-Nellis		
Not applicable	Annual certification statement of zero discharge	None	January
	Underground Injection Control		
	NNSS		
UNEV2012203	NNSS Underground Injection Control Permit	July 1, 2022	Semi-annual
	Hazardous Materials		
	NNSS		
74173	NNSS Hazardous Materials Permit	February 28, 2019	Annual

Table 2-2. Environmental permits required for NNSA/NFO operations at NNSS, NLVF, and RSL-Nellis

Permit	Permit Name or Description	Expiration Date	Report
	Hazardous Materials		
	NNSS		
74188	Nonproliferation Test and Evaluation Complex Hazardous Materials Permit	February 28, 2019	Annual
	NLVF		
74195	NLVF Hazardous Materials Permit	February 28, 2019	Annual
	RSL-Nellis		
74199	RSL-Nellis Hazardous Materials Permit	February 28, 2019	Annual
	Hazardous Waste		
	NNSS		
NEV HW0101	RCRA Permit for NNSS Hazardous Waste Management (Area 5 Mixed Waste Disposal Unit, Area 5 Mixed Waste Storage Unit, Hazardous Waste Storage Unit, and Explosive Ordnance Disposal Unit)	December 10, 2020	Biennual and annual
	Waste Management		
	NNSS		
SW 523	Area 5 Asbestiform Low-Level Solid Waste Disposal Site	Post-closure[(b)]	Annual
SW 13 097 02	Area 6 Hydrocarbon Disposal Site	Post-closure	Annual
SW 13 097 03	Area 9 U10c Solid Waste Disposal Site	Post-closure	Annual
SW 13 097 04	Area 23 Solid Waste Disposal Site	Post-closure	Biannual
	RSL-Nellis		
PR0064276	RSL-Nellis Waste Management Permit-Underground Storage Tank	December 31, 2018	None
	Endangered Species/Wildlife		
File Nos. 84320-2008-F-0416 and 84320-2008-B-	FWS Desert Tortoise Incidental Take Authorization (Biological Opinion for Programmatic NNSS Activities)	February 12, 2019	Annual
MB-008695-0/-1	FWS Migratory Bird Salvage and Collection	February 9, 2017	Annual
TE84209B-0	FWS Native Threatened Species Recovery	August 22, 2021	Annual
261454	NDOW Scientific Collection of Wildlife Samples	December 31, 2017	Annual

(a) Name in parenthesis is name of the septic system shown on Figure 5-6 of Chapter 5
(b) Permit expires 30 years after closure of the landfill

2.3 National Environmental Policy Act Assessments

The National Environmental Policy Act (NEPA) regulations require federal agencies to evaluate the environmental effects of proposed major federal activities. The prescribed evaluation process ensures that the proper level of environmental review is performed before an irreversible commitment of resources is made. NNSA/NFO performs environmental reviews with the aid of a NEPA Environmental Evaluation Checklist (Checklist), which is required for all proposed projects or activities on the NNSS. The Checklist is reviewed by the NNSA/NFO NEPA Compliance Officer to determine if the activity's environmental impacts have been addressed in a previous NEPA assessment. If a proposed project has not been covered under any previous NEPA analysis and it does not qualify for a "Categorical Exclusion" (per 10 CFR 1021), then a new NEPA analysis is initiated. The analysis may result in preparation of a new Environmental Assessment, Environmental Impact Statement, or supplemental document to the existing programmatic *Site-Wide Environmental Impact Statement for the Nevada National Security Site and Offsite Locations in Nevada* (NNSS SWEIS) (U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office 2013). The NEPA Compliance Officer must approve each Checklist before a project proceeds. Table 2-3 presents a summary of how NNSA/NFO complied with NEPA in 2017.

Table 2-3. NNSS NEPA compliance activities conducted in 2017

Results of NEPA Checklist Reviews/NEPA Compliance Activities
70 NEPA Checklists were reviewed
20 projects were exempted from further NEPA analysis because they were of Categorical Exclusion[(a)] (CX) status
50 projects were exempted from further NEPA analysis due to their inclusion under previous analysis in the NNSS SWEIS

(a) "Categorical exclusion" means a category of actions which do not individually or cumulatively have a significant effect on the human environment and which have been found to have no such effect in procedures adopted by a Federal agency in implementation of these regulations (Sec. 1507.3) and for which, therefore, neither an environmental assessment nor an environmental impact statement is required . . . 40 CFR 1508.4

2.4 Hazardous Materials Control and Management

2.4.1 Hazardous Substance Inventory

Hazardous materials used or stored on the NNSS are controlled and managed through the use of a chemical inventory module of an enterprise asset management software system called Maximo, which was implemented in 2015. Hazardous substances used or stored by contractors and subcontractors of the NNSA/NFO are entered into this database. Contractors and subcontractors are required to comply with the operational and reporting requirements of the Toxic Substances Control Act; the Federal Insecticide, Fungicide, and Rodenticide Act; the Emergency Planning and Community Right-to-Know Act; and the Nevada Chemical Catastrophe Prevention Act. Chemicals to be purchased are subject to a requisition compliance review process. Hazardous substance purchases are reviewed to ensure that toxic chemicals and products are not purchased when less hazardous substitutes are commercially available. Requirements and responsibilities for the use and management of hazardous/toxic chemicals are provided in company documents.

The inventory management system allows the tracking of chemicals from the moment they arrive at NNSS, NLVF, or RSL-Nellis to when they are disposed, and provides an accurate account of chemicals on site. It provides chemical owners with additional information including purchase dates, Safety Data Sheets, storage locations, and expiration dates. The system allows for chemical inventories to be utilized for emergency planning and planning for operational needs. The tracking system reduces the quantities of chemicals purchased and stored through the chemical custodian's awareness of the chemicals currently in inventory. Chemical compatibility and proper storage is routinely evaluated and has improved NNSA/NFO's safety posture in regards to the control and management of chemicals. In 2017, the NNSS managed more than 5,000 chemicals in over 50,000 containers.

2.4.2 Polychlorinated Biphenyls

The storage, handling, and use of ***polychlorinated biphenyls (PCBs)*** are regulated under the Toxic Substance and Control Act (TSCA). There are no known pieces of PCB–containing electrical equipment (transformers, capacitors, or regulators) at the NNSS. The TSCA program consists mainly of properly characterizing, storing, and disposing of various PCB wastes generated on site through remediation activities at corrective action sites (Chapter 11) and maintenance of fluorescent lights. PCB bulk product waste (i.e., contaminated building materials) from corrective action sites and light ballasts removed during normal maintenance are disposed of in the Area 9 U10c Solid Waste Disposal Site with prior State of Nevada approval. Soil and other remediation wastes contaminated with PCBs and large volumes of light ballasts are sent off site to an approved PCB disposal facility. Radioactive waste received from offsite waste generator facilities that contain regulated quantities of PCBs are disposed of at the Area 5 RWMS (Section 10.1.1) in accordance with RCRA hazardous waste management permit NEV HW0101. Offsite waste generators bringing PCB wastes to the NNSS for disposal are issued a Certificate of Disposal for PCBs. Onsite PCB records are maintained as required by the EPA, and PCB management activities are documented herein annually. If any generated PCB wastes that are above threshold levels are released, they are also reported in the Toxic Release Inventory (TRI) Report (Section 2.4.4.1, Table 2-7).

NNSS remediation activities generated one drum of PCB oil in 2016, which weighed 179 kilograms (kg) (394 pounds [lb]). In 2017, it was shipped off site from the Area 5 Hazardous Waste Storage Unit (HWSU) for treatment and disposal. The EPA did not conduct any TSCA inspections at the NNSS in 2017.

2.4.3 Pesticides

The storage and application of pesticides (e.g., insecticides, rodenticides, and herbicides) are regulated under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). Several oversight functions are performed each year to ensure FIFRA compliance. They include the screening of all purchase requisitions for restricted-use pesticides; the review of operating procedures for handling, storing, and applying pesticide products; and monthly inspections of stored pesticides. On the NNSS, pesticides are applied under the direction of a State of Nevada–certified applicator. This service is provided by Solid Waste Operations (SWO). Pesticide applications in NNSS food service facilities are also conducted by SWO. Beginning in mid-2014, the application of restricted-use pesticides was discontinued on the NNSS. Only pesticides categorized as non-restricted-use (i.e., available for purchase and application by the general public) are used. Monthly inspections conducted in 2017 found that no restricted-use pesticides were used and all pesticides were stored in accordance with their labeling. The State of Nevada did not conduct an inspection of restricted-use pesticide storage or use in 2017.

2.4.4 Release and Inventory Reporting

2.4.4.1 The Emergency Planning and Community Right-to-Know Act

The Emergency Planning and Community Right-to-Know Act (EPCRA) requires that facilities report inventories and releases of certain chemicals that exceed specific thresholds. Table 2-4 identifies the reporting requirements under EPCRA Sections 302, 304, 311, 312, and 313. Table 2-5 summarizes the applicability of the regulations to NNSA/NFO operations in 2017.

Table 2-4. Reporting criteria of the Emergency Planning and Community Right-to-Know Act

Section	CFR Part	Reporting Criteria	Agencies Receiving Report
302	40 CFR 355: Emergency Planning Notifications	The presence of an extremely hazardous substance (EHS) in a quantity equal to or greater than the threshold planning quantity at any one time.	SERC[(a)], LEPC[(b)]
		Change occurring at a facility that is relevant to emergency planning.	LEPC
304	40 CFR 355: Emergency Release Notifications	Release of an EHS or a CERCLA hazardous substance[(c)] in a quantity equal to or greater than the reportable quantity.	SERC, LEPC
311	40 CFR 370: Safety Data Sheet Reporting	The presence at any one time at a facility of an OSHA hazardous chemical[(d)] in a quantity equal to or greater than 4,500 kg (10,000 lb) or an EHS in a quantity equal to or greater than the threshold planning quantity or 230 kg (500 lb), whichever is less.	SERC, LEPC, Local Fire Departments
312	40 CFR 370: Tier Two Report	Same as Section 311 reporting criteria above.	State Fire Marshal, SERC, LEPC, Local Fire Departments
313	40 CFR 372: Toxic Release Inventory (TRI) Report	Manufacture, process, or otherwise use at a facility, any listed TRI chemical in excess of its threshold amount during the course of a calendar year. Thresholds are 11,300 kg (25,000 lb) for manufactured or processed and 4,500 kg (10,000 lb) for otherwise used, except for persistent, bio-accumulative, toxic chemicals, which have thresholds of 45 kg (100 lb) or less.	EPA, NDEP

(a) SERC = State Emergency Response Commission
(b) LEPC = Local Emergency Planning Commission
(c) Hazardous substance as defined in CERCLA, 40 CFR 302.4
(d) Hazardous chemical as defined in the Occupational Safety and Health Act, 29 CFR 1910.1200

Table 2-5. Compliance with EPCRA reporting requirements

EPCRA Section	Description of Reporting	2017 Status[(a)]
Section 302	Emergency Planning Notification	Yes
Section 304	EHS Release Notification	Not required
Section 311–312	MSDS/Chemical Inventory	Yes
Section 313	TRI Reporting	Yes

(a) "Yes" indicates that NNSA/NFO reported under the requirements of the EPCRA section specified (Table 2-4).

NNSA/NFO produces the Nevada Combined Agency (NCA) Report, which satisfies EPCRA Section 302, 311, and 312 reporting requirements. The State Fire Marshal issues permits to store hazardous chemicals at the NNSS, NPTEC, NLVF, and RSL-Nellis based on the NCA Report. The 2017 chemical inventory for NNSS facilities was updated and submitted to the State of Nevada in the NCA Report on February 22, 2018. No EPCRA Section 304 reporting was required in 2017 because no accidental or unplanned release of an extremely hazardous substance occurred at the NNSS, NLVF, or RSL-Nellis.

NNSA/NFO produces an annual TRI Report, as necessary, to comply with EPCRA Section 313 reporting. It identifies the reportable quantities of TRI chemicals released to the environment through air emissions, landfill disposal, and recycling. TRI chemicals that are recovered during NNSS remediation activities or become "excess" to operational needs (e.g., lead bricks, lead shielding) are sent off site for recycling, reuse, or proper disposal. Mixed wastes generated at other DOE facilities that contain TRI chemicals and are sent to the NNSS for disposal are included in the TRI Report. In 2017, reportable quantities of lead, mercury, and PCBs and PACs were released as a result of NNSS activities (Table 2-6). No releases at NLVF or RSL-Nellis exceeded reportable thresholds in 2017. On June 13, 2018, NNSA/NFO submitted the TRI Report for calendar year 2017 to the EPA and the State Emergency Response Commission. No EPCRA inspections were performed by outside regulators in 2017.

Table 2-6. Summary of 2017 reported releases under EPCRA Section 313

	Quantity[(a)] (pounds [lb])			
Reported Release	**Lead**	**Mercury**	**PCB**	**PACs**
Air Emissions[(b)]	1.7646	0.0396	0	3.67
Onsite Disposal[(c)]	144,140.46	8082.82	28.28	0
Onsite Release [(d) (g)]	2043.53	0	0	330
Offsite Recycling[(e)]	50809.7022	0.012	0	0
Offsite Disposal[(f)]	31.3047	0.0052	0.0205	0
Cleanup Activities One-time Events	0	0	0	0
Totals	146,224.76	8082.8768	28.3005	333.67
EPCRA Reporting Thresholds	**100**	**10**	**10**	**100**

(a) The weight of the chemical released, not the weight of the waste material containing the toxic chemical. Weights in the TRI Report vary from two to four decimal places.

(b) Fugitive airborne releases of lead include from weapons firing at the Mercury Firing Range, chemical releases and detonations, and from stack air emissions. All airborne releases of mercury were from stack air emissions. PACs, which are in asphalt, were released to the air as part of a road reconstruction project and resurfacing activities.

(c) MLLW or HW containing lead, mercury, or PCB that was received and disposed in Cell 18 at the Area 5 RWMS (Section 10.1.1).

(d) Lead from spent ammunition left on the ground during firing at the Mercury Firing Range. When the firing range is closed, ammunition will be collected for recycling.

(e) Lead was recycled from three waste streams: lead-acid batteries, miscellaneous lead items and offsite waste treatment. Mercury was recycled from lamps and field test kits.

(f) Lead was from lead-contaminated debris and other routinely generated waste. Mercury was from lamps and test kits. PCBs were from transformer oil.

(g) PACs, which are in asphalt, were released to the ground as part of a road reconstruction project and resurfacing activities.

2.4.4.2 Nevada Chemical Catastrophe Prevention Act

This act directs NDEP to develop and implement a program called the Chemical Accident Prevention Program (CAPP). It requires registration of facilities storing or processing highly hazardous substances above listed thresholds. The NPTEC in Area 5 of the NNSS is registered as a CAPP facility because of its use of the highly hazardous chemical oleum. On August 15, 2017, NDEP conducted an annual site inspection of NPTEC and identified two findings. The oleum release work package had not been certified to be current and accurate by the permit holder. In the second finding identified that the permit holder had not certified CAPP procedures and practices were developed, implemented and evaluated on a triennial basis. On December 14, 2017 NFO submitted certifications to NDEP, thereby closing the findings.

On November 29, 2017, a Permit to Construct Application for Temporary Flammable Materials Storage at the NNSS was submitted to the NDEP. The permit would allow for the storage and transport of flammable liquid. U.S. Department of Transportation-compliant vehicles will be used to transport the flammable material.

NNSA/NFO is required to submit an annual CAPP Registration report to the State of Nevada for the NPTEC oleum release process. The CAPP Registration report for NPTEC operations from June 2016 through May 2017 was signed on June 12, 2018 and submitted to NDEP. The Registration reported that oleum was not present at NPTEC during 2017.

2.4.4.3 Continuous Releases

Section 103(a) of CERCLA, and EPA's implementing regulation (40 CFR 302.8), require that federal authorities be notified immediately whenever a reportable quantity of a hazardous substance is released into the environment, so that government response officials can evaluate the need for a response action. CERCLA Section 103(f) (2) provides relief from these immediate reporting requirements for releases of hazardous substances from facilities or vessels that are ***continuous*** and are predictable and regular in the amount and rate of emission. No continuous releases of hazardous substances are known to occur at the NNSS, NLVF, or RSL-Nellis.

2.5 Environmental Occurrences

DOE O 232.2A, *Occurrence Reporting and Processing of Operations Information*, sets reporting criteria for unplanned environmental releases of pollutants, hazardous substances, extremely hazardous substances, petroleum products, and sulfur hexafluoride at DOE sites and facilities. It also requires sites/facilities to report to DOE any written notification received from an outside regulatory agency that the site/facility is in noncompliance with a schedule or requirement.

In 2017, there was one NNSA/NFO environmental occurrence that was reportable under the requirements of this DOE order (Table 2-7). Twenty one hazardous substance spills occurred in 2017, which were not reportable under DOE O 232.2A: 19 at the NNSS, 1 at the NLVF, and 1 at RSL-Nellis. The spills consisted of small–volume releases either to containment areas or to other surfaces. All spills were cleaned up. There are no continuous releases on the NNSS, nor at the NLVF and RSL-Nellis.

Table 2-7. Environmental occurrence in 2017 reportable under DOE O 232.2A

Description of Occurrence	Reporting Criteria[(a)]	Corrective Actions Taken
Report Number/Date of Occurrence: EM--NVSO-NST-NTS-2017-0007, October 26, 2017 **Occurrence Title: Finding of Alleged Violation (FOAV)**		
On October 26, 2017, NDEP issued a FOAV and Order to NNSA/NFO for potential violation of RCRA and State of Nevada regulations on 93 containers of low-level waste which were determined to be mixed waste (due to the presence of chromium) which had been received from Nuclear Fuel Services (NFS) in Tennessee for disposal at the Area 5 Radioactive Waste Management Complex (RWMC) from 2009 to 2015. The FOAV requires NNSA/NFO to address the allegations in a show-cause meeting followed by a formal written response and submission of a Corrective Action Plan to prevent recurrence. The containers should have been disposed in a separate mixed-waste disposal cell which has a double geo-synthetic liner to further isolate waste. The 93 containers are not readily retrievable. Following identification of this issue in June 2016, NNSA/NFO suspended all NFS waste shipments and has examined options to address these 93 containers. Based on environmental, safety and security requirements, the current recommended approach is to leave the 93 containers in place. The FOAV identifies potential noncompliance with RCRA section 40 CFR 264.13(a)(1) which requires a waste disposal facility operator to obtain sufficient chemical or physical analysis from an offsite waste generator to ensure it matches the identity of the waste being received. This enforcement action parallels a similar action conducted by the State of Tennessee against NFS for violation of RCRA requirements on these 93 containers.	9(1) - Any written notification from an outside regulatory agency that a site/facility is considered to be in noncompliance with a schedule or requirement.	NNSA/NFO, NSTec (the previous M&O contractor), and the EM Nevada Program coordinated on all corrective actions. A show-cause meeting was held November 8, 2017. Information on the issue was presented, actions to prevent re-occurrence were discussed, and the meeting transcript was recorded. A formal written response was submitted to the State of Nevada in January 2018, and a draft Corrective Action Plan that addresses actions to prevent recurrence was submitted in March.

(a) Reporting requirements provided in DOE O 232.2A can be found at https://www.directives.doe.gov/directives-documents/200-series/0232.2-BOrder-A, as accessed on January 3, 2018.

2.6 Environmental Reports Submitted to Regulators

Numerous reports were prepared to meet regulation requirements or to document compliance for NNSA/NFO activities. These reports and the federal or state regulators to whom they were submitted are listed in Table 2-8.

Table 2-8. List of environmental reports submitted to regulators for 2017 NNSA/NFO activities

Regulator(s)	Report
Air Quality	
EPA Region 9	National Emission Standards for Hazardous Air Pollutants – Radionuclide Emissions, Calendar Year 2017
NDEP, EPA Region 9	Annual Asbestos Abatement Notification Form, submitted to NDEP and to EPA Region 9
NDEP	Calendar Year 2017 Actual Production/Emissions Reporting Form, submitted to NDEP

Table 2-8. List of environmental reports submitted to regulators for 2017 NNSA/NFO activities

Regulator(s)	Report
Air Quality	
NDEP	Quarterly Summary Emissions Reports for Nonproliferation Test and Evaluation Complex (NPTEC) and Big Explosives Experimental Facility (BEEF)
	Quarterly Class II Air Quality Reports
	Nonproliferation Test and Evaluation Complex (NPTEC) Pre-test and Post-test Reports
CCDAQ	Department of Air Quality Annual Emission Inventory Reporting Form for North Las Vegas Facility
	Department of Air Quality Annual Emission Inventory Reporting Forms for Remote Sensing Laboratory
Water Quality	
NDEP	Quarterly Monitoring Reports for Nevada National Security Site Sewage Lagoons
	Results of water quality analyses for PWSs, sent to the state throughout the year as they were obtained from the analytical laboratory
	Water Pollution Control Permit NEV 96021, Quarterly Monitoring Reports (for first, second, and third quarters of 2017 for E Tunnel effluent monitoring)
	Water Pollution Control Permit NEV 96021, Quarterly Monitoring Report and Annual Summary Report for E Tunnel Wastewater Disposal System
Waste Management	
NDEP	Nevada National Security Area 5 Solid Waste Disposal Annual Report for CY 2017
	NNSS Quarterly Volume Reports (for all active LLW and MLLW disposal cells), April, July, and October 2017, and January 2018
	4th Quarter Transportation Report FY2017, Radioactive Waste Shipments to and from the Nevada National Security Site
	RCRA Permit for a Hazardous Waste Management Facility Permit Number NEV HW0101 – Annual Summary/Waste Minimization Report Calendar Year 2017
	Nevada National Security Site 2017 Data Report: Groundwater Monitoring Program Area 5 Radioactive Waste Management Site
	Nevada National Security Site 2017 Waste Management Monitoring Report - Area 3 and Area 5 Radioactive Waste Management Site
	Post-Closure Report for Closed Resource Conservation and Recovery Act Corrective Action Units, Nevada National Security Site, Nevada, for Fiscal Year 2017 (October 2016–September 2017)
	Annual Soil Moisture Monitoring Report for the Area 9 U10c Landfill, Nevada National Security Site, Nevada, for the Period January – December 2017
	January–June 2017 Biannual Solid Waste Disposal Site Report for the Nevada National Security Site Area 23 Sanitary Landfill
	July–December 2017 Biannual Solid Waste Disposal Site Report for the Nevada National Security Site Area 23 Sanitary Landfill
	Annual Soil Moisture Monitoring Report for the Area 6 Hydrocarbon Landfill, Nevada National Security Site, Nevada, for the Period January – December 2017
	The 2017 Biennial Hazardous Waste Report for the Nevada National Security Site
Environmental Restoration	
NDEP	CAU 5: Landfills – Record of Technical Change 1 (ROTC) for the Final Closure Report (CR)
	CAU 97: Yucca Flat/Climax Mine – Final Completion Report for Well ER-2-2
	CAU 97: Yucca Flat/Climax Mine – Final Completion Report for Well ER-3-3
	CAU 97: Yucca Flat/Climax Mine – Final Completion Report for Well ER-2-2, Revision 1
Environmental Restoration	
NDEP	CAU 97: Yucca Flat/Climax Mine – Final Corrective Action Decision Document/Corrective Action Plan (CADD/CAP)
	CAU 98: Frenchman Flat – Final Post-Closure Monitoring Report for Calendar Year 2016
	CAU 107: Low Impact Soils Sites – ROTC 1 for the Final CR
	CAU 107: Low Impact Soil Sites – ROTC 2 for the Final CR
	CAU 374: Area 20 Schooner Unit Crater – ROTC 2 for the Final Corrective Action Decision Document/Closure Report
	CAU 415: Project 57 No. 1 Plutonium Dispersion (NTTR) – Final CR
	CAU 568: Area 3 Plutonium Dispersion Sites – Final CR
	CAU 573: Alpha Contaminated Sites – Final CR
	Final Post-Closure Report for the Tonopah Test Range for Calendar Year 2016
	Final Post-Closure Report for Closed Resource Conservation and Recovery Act (RCRA) Corrective Units on the
	Final Post-Closure Inspection Letter Report for Corrective Action Unites on the Nevada National Security Site (NNSS)
	CAU 5: Landfills – Record of Technical Change 1 (ROTC) for the Final Closure Report (CR)
	CAU 97: Yucca Flat/Climax Mine – Final Completion Report for Well ER-2-2

Table 2-8. List of environmental reports submitted to regulators for 2017 NNSA/NFO activities

Regulator(s)	Report
Environmental Restoration	
NDEP	CAU 97: Yucca Flat/Climax Mine – Final Completion Report for Well ER-3-3
	CAU 97: Yucca Flat/Climax Mine – Final Completion Report for Well ER-2-2, Revision 1
	CAU 97: Yucca Flat/Climax Mine – Final Completion Report for Well ER-4-1
Hazardous Materials Management	
State Fire Marshal	Nevada Combined Agency Hazmat Facility Report – Calendar Year (CY) 2017
EPA, NDEP	Toxic Release Inventory Report, Form R for CY 2017
NDEP	Chemical Accident Prevention Program 2017 Registration
Cultural and Natural Resources	
NSHPO	A Cultural Resources Inventory of the RWMC Expansion, Area 5, Nevada National Security Site, Nye County, Nevada
	A Cultural Resources Inventory of the DOE Point Roundabout, Area 12, Nevada National Security Site, Nye County, Nevada
	A Cultural Resources Inventory for the Proposed DAG Test Pad Project, Area 2, Nevada National Security Site, Nye County, Nevada
	A Cultural Resources Inventory of the Proposed Backfill Project, Area 27, Nevada National Security Site, Nye County, Nevada
	Monitoring of Site 26NY15513, A Recording/Instrument Station at UGTA Well ER-4-1, Area 4, Nevada National Security Site, Nye County, Nevada
	A Cultural Resources Inventory of the Proposed LLNL Field Experiment Location, Area 2, Nevada National Security Site, Nye County, Nevada
	A Cultural Resources Inventory of the Proposed Performance Optimized Data Center, Area 6, Nevada National Security Site, Nye County, Nevada
	A Cultural Resources Inventory of the Proposed Dense Plasma Focus Facility Research and Development Project, Area 11, Nevada National Security Site, Nye County, Nevada
	A Cultural Resources Inventory for the Removal of the Debris Pile at the Hamilton Atmospheric Test Location, Area 5, Nevada National Security Site, Nye County, Nevada
	Cultural Resources Preliminary Assessment of Corrective Action Unit 576, Miscellaneous Radiological Sites and Debris, Areas 2,3,5,8 and 9, Nevada National Security Site, Nye County, Nevada
	A Cultural Resources Inventory of the Proposed Wildland Fire Training Area, Area 23, Nevada National Security Site, Nye County, Nevada
	A Cultural Resources Inventory of the Proposed UNESE Drill Hole Project, Area 12, Nevada National Security Site, Nye County, Nevada
	A Cultural Resources Inventory for the Proposed Frey 2 Project, Areas 3 and 7, Nevada National Security Site, Nye County, Nevada
	A Section 106 Evaluation of Building CP-1, Area 6, Nevada National Security Site, Nye County, Nevada
	A Section 106 Evaluation of the Mercury Bowling Alley, Area 23, Nevada National Security Site, Nye County, Nevada
FWS	Annual Report of Actions Taken under Authorization of the Biological Opinion on NNSS Activities (File Nos. 84320-2008-F-0416 and 84320-2008-B-0015) – January 1, 2017, through December 31, 2017
	Annual Report for Federal Migratory Bird Scientific Collecting Permit SCCL-008695-0
NDOW	Annual Report for Handling Permit S36422
Public Notifications/Reports	
DOE	Nevada National Security Site Environmental Report 2016
Environmental Occurrences	
	See Table 2-7 for ORPS Reports

2.7 References

U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office, 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, Las Vegas, NV.

Chapter 3: Environmental Management System

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The U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) conducts activities on the Nevada National Security Site (NNSS) while ensuring the protection of the environment, the worker, and the public. This is accomplished, in part, through the implementation of an Environmental Management System (EMS). An EMS is a business management practice that incorporates concern for environmental performance throughout an organization, with the ultimate goal being continual reduction of the organization's impact on the environment. An EMS ensures that environmental issues are systematically identified, controlled, and monitored, and it provides mechanisms for responding to changing environmental conditions and requirements, reporting on environmental performance, and reinforcing continual improvement.

National Security Technologies, LLC (NSTec), the Management and Operating (M&O) contractor for the NNSS up until November 30, 2017, designed an EMS to meet the requirements of the globally recognized International Organization for Standardization (ISO) 14001:2004 Environmental Management Standard. The NSTec EMS initially received ISO 14001:2004 certification in June 2008, and was re-certified in 2014 for a 3-year period. An imminent change in the M&O contractor resulted in a lapse of ISO 14001:2004 certification in June 2017. Despite the lapse, the new contractor, Mission Support and Test Services, LLC (MSTS), continued implementing the same program requirements put in place by NSTec. In 2018, MSTS will continue to develop and implement an EMS that meets current standards.

This chapter describes the 2017 progress made towards improving overall environmental performance under the EMS and discusses the MSTS Sustainability Program. The Program has the specific mission to support and track the U.S. Department of Energy's (DOE) complex-wide sustainability goals. Reported progress applies to operations on the NNSS as well as support activities conducted at the NNSA/NFO-managed North Las Vegas Facility (NLVF) and Remote Sensing Laboratory–Nellis (RSL-Nellis). NNSA/NFO uses this annual environmental report as the mechanism to communicate to the public the components and status of the EMS and the Sustainability Program.

3.1 Environmental Policy

The cornerstone of an EMS is a commitment to environmental protection at the highest levels of an organization. MSTS's environmental commitments are incorporated into an Environmental Policy approved by NNSA/NFO. The policy applies to all MSTS operations, projects, facilities, and personnel, including subcontractors. The EMS implements this policy and is incorporated into MSTS's Integrated Safety Management System (ISMS). The MSTS policy is to:

- Protect environmental quality and human welfare by implementing EMS practices.
- Identify and comply with all applicable DOE orders and federal, state, and local environmental laws and regulations.
- Identify and mitigate environmental aspects early in project planning.
- Establish environmental objectives, targets, and performance measures.
- Collaborate with employees, customers, subcontractors, and key suppliers on sustainable development and pollution prevention efforts.
- Communicate and instill an organizational commitment to environmental excellence in company activities through processes of continual improvement.

3.2 Planning

The ISO 14001:2004 Standard planning phase requires NNSA/NFO to identify the environmental aspects and impacts of its activities, products, and services; to evaluate applicable legal and other requirements; to establish objectives and targets; and to create action plans or management programs to achieve the objectives and targets.

3.2.1 Environmental Aspects

An "environmental aspect" is any element of an organization's activities, products, and services that can impact the environment. MSTS evaluates its operations, identifies aspects that can impact the environment, and determines which of those impacts are significant.

Operations are evaluated to determine if they have any environmental aspects by performing Hazard Assessments, preparing Health and Safety Plans and Execution Plans, and preparing and reviewing National Environmental Policy Act documents. A list of aspects is compiled and ranked in order of importance to determine which aspects are significant. Factors considered include the potential for adverse environmental impact; the potential for noncompliance with regulations; the ability to meet permit requirements, contract and performance objectives, and DOE order requirements; and, the potential to result in bad publicity. The likelihood of occurrence and severity of each of these factors is considered. Operations are evaluated annually to account for changing activities, regulations/DOE orders, and management priorities. For 2017, the following environmental aspects were identified:

Significant environmental aspects:

- Air quality
- Drinking water quality
- Industrial chemical use and storage
- Hazardous, radioactive, and mixed waste generation and management
- Groundwater Protection

Other environmental aspects:

- Building demolition
- Recycling of materials and equipment
- Surface and storm water runoff
- Wastewater management
- Energy and fuel use
- Water usage
- Greenhouse gas emissions
- Environmental restoration
- Building construction and renovation
- Resource protection
- Non-hazardous waste generation and management
- Sustainable acquisition of goods and services

3.2.2 Legal and Other Requirements

MSTS has a system in place to review changes in federal, state, and local environmental regulations and to communicate those changes to affected staff. Executive Order EO 13693, "Planning for Federal Sustainability in the Next Decade," sets reduction targets for energy use intensity, water use intensity, and greenhouse gas (GHG) emissions, and prescribes other sustainability goals for the DOE through fiscal year (FY) 2025 (October 1, 2024–September 20, 2025). DOE publishes updated goals and targets annually in a DOE Strategic Sustainability Performance Plan and goals are pursued and tracked under the MSTS Sustainability Program (Section 3.3.1).

3.2.3 Environmental Objectives and Targets

To address the significant environmental aspects associated with NNSA/NFO operations, an Environmental Working Group (EWG) selects objectives and targets, determined on an FY basis. Targets are tracked by various responsible operational groups and reported quarterly to NNSA/NFO. Five FY 2017 EMS targets were identified and tracked (Table 3-1). Two of the targets overlap with DOE's sustainability goals (Table 3-2).

Table 3-1. EMS targets and performance in FY 2017

Environmental Aspect and Target	FY 2017 Performance
Targets in green are met or exceeded	
Air quality and Non-hazardous Waste Generation and Management	
Increase the Environmental Program's oversight of air quality and waste aspects of NNSA/NFO operations.	Target met: Air quality and waste regulators identified no findings. 11 non-compliances were self-identified and corrected; a 10% increase from FY 2016.
Industrial Chemical Storage and Use	
Reduce the number of chemical containers across the NNSS, NLVF, and RSL-Nellis facilities by 5% compared to FY 2015.	Target met: The chemical footprint was reduced; storage areas were consolidated and no new chemicals ordered prior to confirming available supplies (avoiding duplicate inventory).
Sustainable Acquisition of Goods and Services	
Evaluate products in select "Just-in-Time" (JIT) product catalogs and identify opportunities to increase purchases of sustainable and biobased products.	Target met: Opportunities to replace non-biobased and non-sustainable products were identified.
Energy Use	
Reduce energy intensity 2.5% from FY 2015.	Continuing to work toward target: Energy intensity increased 3% from FY 2015.
Energy and Water Use/Building Renovation	
Achieve High Performance Sustainable Buildings (HPSBs) certification for buildings representing 86,464 gross square feet (gsf).	Continuing to work toward target: Two facilities representing 16,205 gsf are pending certification; two representing 22,378 gsf are in an improvement identification/planning phase.

3.3 Environmental Management System Programs

3.3.1 Sustainability Program

The Sustainability Program (formerly known as the Energy Management Program [EMP] under NSTec) has the specific mission to support and track DOE's complex-wide sustainability goals. The program strives to ensure continuous life-cycle, cost-effective improvements to increase energy efficiency; increase the effective management of energy, water, and transportation fleets; and increase the use of clean energy sources for NNSA/NFO operations. NNSA/NFO currently uses electricity, fuel oil, and propane at the NNSS and RSL-Nellis facilities. At the NLVF, electricity, fuel oil, and natural gas are used. NNSA/NFO vehicles and equipment are powered by unleaded gasoline, diesel, bio-diesel, E-85, and jet fuel. All water used at the NNSS is groundwater, and water used at the NLVF and RSL-Nellis is predominately surface water from Lake Mead.

Each FY, the Sustainability Program produces a NNSA/NFO Site Sustainability Plan (SSP) (MSTS 2018). The SSP identifies how NNSA/NFO will meet DOE's sustainability goals (DOE 2017), which were first published in the 2010 Strategic Sustainability Performance Plan (SSPP) (DOE 2010). The SSP also satisfies the requirement of EO 13693 for an Energy Management Plan. The SSP describes the program, planning, and budget assumptions as well as NNSA/NFO's performance for the previous year for each DOE goal, and planned actions to meet each goal during the next year. To implement the SSP, an Energy Management Council (EMC) meets bimonthly to track requirements and progress and facilitate goal achievement. The EMC and the EWG coordinate to ensure all EMS-tracked objectives and targets mirror overlapping annual goals in the SSP. Table 3-2 includes a summary of the DOE goals and NNSA/NFO's FY 2017 performance.

Table 3-2. DOE sustainability goals and performance in FY 2017

DOE Goal[(a)]	NNSA/NFO FY 2017 Performance
Goals in green are met or exceeded	
GHG Reduction	
50% reduction of Scope 1 and 2 GHG emissions [(b)] by FY 2025, from the FY 2008 baseline (FY 2017 target is 22% reduction).	Emissions were 30,196 metric tons of carbon dioxide equivalent ($MtCO_2e$), a 54% decrease from the FY 2008 baseline of 65,632 $MtCO_2e$[(c)], exceeding the FY 2017 goal.
25% reduction in Scope 3[(b)] GHG emissions by FY 2025, from the FY 2008 baseline (FY 2017 target is 7% reduction).	Emissions were 14,651 $MtCO_2e$, a 66% decrease from the FY 2008 baseline of 43,259 $MtCO_2e$[(c)], exceeding the FY 2017 goal.

Table 3-2. DOE sustainability goals and performance in FY 2017

DOE Goal[(a)]	NNSA/NFO FY 2017 Performance
Goals in green are met or exceeded	
Sustainable Buildings	
25% reduction of energy intensity (British Thermal Units [BTUs] per gsf) in goal-subject buildings, achieving 5% reductions annually by FY 2025 from the FY 2015 baseline. ***(Also identified as the FY 2017 EMS target)***	Continuing to work toward goal: Energy intensity decreased 2.7% from the FY 2015 baseline.
Energy and water assessments conducted for 25% of all facilities covered under Section 432 of the Energy Independence and Security Act (EISA) to ensure 100% of covered facilities are assessed every 4 years.	68 energy audits/assessments were conducted, meeting this goal. They identified energy conservation measures (ECMs) for the facilities evaluated. Efficient Mobile Audit Technology software and equipment was purchased and installed and will improve EISA audit data quality and efficiencies in the identification and development of energy projects.
Meter all individual buildings for electricity, natural gas, water, and steam where cost-effective and appropriate.	Continuing to work toward goal: Based on a 2017 assessment of appropriate buildings, 81% are metered for electricity, 89% for natural gas, 0% for chilled water, 18% for potable water, and 100% for hot water. No steam is used.
At least 17% (by building count or gsf) of existing buildings ≥ 5,000 gsf to be compliant with the revised Guiding Principles for High Performance Sustainable Buildings (HPSBs) by FY 2025, with progress to 100% thereafter. ***(Also identified as the FY 2017 EMS target)***	68% or 13 of NNSA/NFO's current enduring buildings > 5,000 gsf are certified as HPSBs. Six facilities were certified in FY 2017. An HPSB Implementation Plan for the NLVF was updated; it identifies progress and future plans to reach 100% HPSB certification site-wide.
Identify efforts to increase regional and local planning coordination and involvement.	Continued coordination with the Regional Transportation Center Park and Ride Facilities and with the Club Ride program for NNSS employees.
1% of existing buildings above 5,000 gsf to be energy, waste, or water net-zero buildings by FY 2025.	Continuing to work toward goal: No NNSA/NFO existing buildings are net zero. Began site preparation for installation of a solar photovoltaic (PV) system at Mercury Fire Station No. 1 in order to become an energy net-zero building. Options for waste net zero at the fire station are being assessed for feasibility.
All new buildings larger than 5,000 gsf entering the planning process designed to achieve energy net zero beginning in FY 2020.	Planning continued for the proposed Mission Operations Center to assess its net zero energy feasibility. The center will be on the planned new NNSS Consolidated Mercury Campus to begin construction in the FY 2018-2021 timeframe. Development continued of an optimized design/construction process to attain net-zero facilities.
Clean and Renewable Energy	
Not less than 10% of DOE's total electric and thermal energy consumption in FY 2016–2017 shall be accounted for by renewable and alternative sources, working towards 25% by FY 2025 ("Clean Energy" requirement).	No new onsite renewable and/or alternative energy generation projects were identified (1% of power produced on site is from small solar or reused oil sources). A contract was awarded for the installation of solar PV arrays at Mercury Fire Station No. 1. Renewable energy credits (RECs) were purchased, resulting in 16.5% of NNSA/NFO's total electric and thermal energy consumption being from renewable and alternative sources.
Not less than 10% of DOE's total electric consumption in FY 2016-2017 shall be renewable electric energy, working towards 30% by FY 2025 ("Renewable Electric Energy" requirement).	No new renewable electric energy projects were identified. A contract was awarded for the installation of solar PV arrays at Mercury Fire Station No. 1. RECs were purchased, resulting in 18.5% of NNSS/NFO's total electric consumption being from renewable sources.
Water Use Efficiency and Management	
36% reduction in potable water intensity (gallons used per gsf) by FY 2025 from the FY 2007 baseline (FY 2017 target is 20% reduction).	Water intensity across all NNSA/NFO facilities was 47.62 gsf, a 32% reduction from the FY 2007 baseline of 70.42 gal/ft^2, exceeding the FY 2017 goal.
30% reduction in consumption of industrial, landscaping, and agricultural (ILA) water by FY 2025 from the FY 2010 baseline (FY 2017 target is 14% reduction).	ILA water production was 43,897,500 gal, a 20% reduction from the FY 2010 baseline of 54,913,300 gal, exceeding the FY 2017 goal.

Table 3-2. DOE sustainability goals and performance in FY 2017

DOE Goal[(a)]	NNSA/NFO FY 2017 Performance
Goals in green are met or exceeded	
Fleet Management	
20% reduction in fleet annual petroleum consumption by FY 2015, relative to the FY 2005 baseline; maintain 20% reduction thereafter (FY 2017 target is 20%).	Petroleum consumption was 302,346 gal, a 73% reduction from the FY 2005 baseline of 1,328,957 gal, exceeding the FY 2017 goal.
10% increase in annual fleet alternative fuel consumption by FY 2015, relative to the FY 2005 baseline; maintain 10% increase thereafter (FY 2017 target is 10%).	Alternative fuel consumption was 448,143 gal, a 358% increase above the FY 2005 baseline of 125,090 gal, exceeding the FY 2017 goal.
30% reduction in fleet-wide, per-mile GHG emissions by FY 2025 from the FY 2014 baseline (FY 2017 target is 3% reduction).	Fleet-wide GHG emissions in FY 2017 were 300.35 grams of carbon dioxide equivalents per mile (gCO_2e/mile), a 39% reduction from the FY 2014 baseline of 489.09 gCO_2e/mile, exceeding the FY 2017 goal.
75% of light duty vehicle acquisitions must consist of alternative fuel vehicles (AFVs).	86% of all light duty vehicle acquisitions (103 of 120 vehicles) were AFVs, exceeding this goal.
50% of passenger vehicle acquisitions to consist of zero emission or plug-in hybrid electric vehicles by FY 2025 (FY 2017 target is 4%).	Continuing to work toward goal: NNSA/NFO has been acquiring such vehicles since 2012 and currently has 17. Of the 120 vehicles acquired in 2017, 4 (3.3%) were plug-in hybrid electric.
Sustainable Acquisition	
Promote sustainable acquisition and procurement to the maximum extent practicable, ensuring biopreferred and biobased provisions and clauses are included in 95% of applicable contracts.	100% of applicable contracts contained provisions for biopreferred and biobased products; in FY 2017, existing non-biobased and non-recycled products were evaluated for replacement with sustainable products.
Pollution Prevention and Waste Reduction	
Divert at least 50% of non-hazardous ***solid waste***, excluding construction and demolition materials and debris, from disposal.	Continuing to work toward goal: 37% of non-hazardous solid waste was diverted from disposal. Meetings were held to coordinate a 2-year waste diversion initiative for the site. Cardboard recycling collection bins were added at various warehouse and shop locations.
Divert at least 50% of construction and demolition materials and debris from disposal.	Continuing to work toward goal: 3% of construction waste was diverted from disposal. Plans are being made to include diversion of such materials/debris in all construction contracts and investigate local available companies/programs for diversion or reuse.
Energy Performance Contracts	
Identify annual targets for acquiring ***Energy Savings Performance Contracts (ESPCs)***[1] and Utility Energy Service Contracts to be implemented in FY 2017 and annually thereafter.	Continuing to work toward goal: No new ESPCs were pursued due to M&O contract transition. Provided measurement and verification support to an existing ESPC project. Finalized a prioritized list of potential candidates for building control projects in order to prepare for another ESPC.
Electronic Stewardship	
95% of eligible electronics acquisitions are U.S. Environmental Protection Agency (EPA) Electronic Product Environmental Assessment Tool (EPEAT)-registered products.	All eligible electronic acquisitions continue to be EPEAT-registered, meeting this goal.
100% of eligible personal computers, laptops, and monitors have power management enabled.	With the exception of one system that has been granted a Cyber Security exemption, all eligible devices have power management enabled, meeting this goal.
100% of eligible computers and imaging equipment have automatic duplexing enabled.	All multi-function printing devices are configured for automatic duplexing and a new policy stating this requirement is in place.
100% of used electronics are reused or recycled using environmentally sound disposition options.	All electronic equipment that passed excess screening in 2017 was sold for reuse, meeting this goal.

[1] The definition of word(s) in ***bold italics*** may be found by clicking on the word in electronic version or by referencing the Glossary, Appendix B. To return from the Glossary, right click and select Previous View.

Table 3-2. DOE sustainability goals and performance in FY 2017

DOE Goal[(a)]	NNSA/NFO FY 2017 Performance
Goals in green are met or exceeded	
Electronic Stewardship	
Establish a power usage effectiveness (PUE)[(d)] target in the range of 1.2–1.4 for new data centers, and less than 1.5 for existing data centers.	Continuing to work toward goal: PUE estimate was 3.2 for the three data centers (two at the NNSS, one at the NLVF). Installation began on a Performance Optimized Data Center at the NNSS in order to meet this goal.
Climate Change Resilience	
Update policies to incentivize planning for, and addressing the impacts of, climate change.	The Sustainability Program revaluated and researched applicable climate change orders, attended a local climate meeting discussion on Climate Change and Drought in Southern Nevada, and evaluated current projects for climate change resilience.
Update emergency response procedures and protocols to account for projected climate change, including extreme weather events.	Response policies and procedures have been updated to include extreme weather events and other natural phenomena.
Ensure workforce protocols and policies reflect projected human health and safety impacts of climate change.	Procedures are in place to notify workers of potential weather related hazards; NNSS policies and procedures related to health, safety, and the environment have been updated.
Ensure site/lab management demonstrates commitment to adaptation efforts through internal communications and policies.	Coordination meetings were held on path forward to complete a vulnerability screening activity completed in January of FY 2018.
Ensure site/lab climate adaptation and resilience policies and programs reflect best available current climate change science, updated as necessary.	NNSA/NFO partners with the NOAA ARL/SORD[(e)] through an Interagency Agreement to provide a comprehensive meteorology program for the NNSS that includes monitoring current climate, storing climate data, and updating NNSS climatology reports. Through ARL/SORD, NNSA/NFO works with additional NOAA climate monitoring organizations to provide information to a broader regional, national, and global climate scope.

(a) The DOE goals listed are identified in the FY 2018 DOE Site Sustainability Plan Guidance Document (DOE 2017) which is based on DOE's SSPP (DOE 2010) and EO 13693.

(b) The GHGs targeted for emission reductions are carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride (SF6). Scope 1 GHG emissions include direct emissions from sources that are owned or controlled by a federal agency. Scope 2 includes direct emissions resulting from the generation of electricity, heat, or steam purchased by a federal agency. Scope 3 includes emissions from sources not owned or directly controlled by a federal agency but related to agency activities, such as vendor supply chains, delivery services, employee business air and ground travel, employee commuting, contracted solid waste disposal, contracted waste water discharge, and transmission and distribution losses related to purchased electricity. Fugitive GHG emissions are uncontrolled or unintentional releases from equipment leaks, storage tanks, loading, and unloading.

(c) The FY 2008 baselines for Scope 1 and 2 GHGs and for Scope 3 GHGs were revised in 2017 to meet the current DOE reporting requirements.

(d) PUE is determined by dividing the amount of power entering a data center by the power used to run the computer infrastructure within it. PUE is expressed as a ratio; efficiency improves as the quotient approaches 1.

(e) NOAA ARL/SORD stands for the National Oceanic and Atmospheric Administration Air Resources Laboratory, Special Operations and Research Division, which operate a network of mobile meteorological towers on the NNSS.

3.3.2 Pollution Prevention and Waste Minimization (P2/WM)

The P2/WM Program has initiatives to eliminate or reduce the generation of waste, the release of pollutants to the environment, and the use of Class I and Class II ***ozone-depleting substances (ODS)***. These initiatives are pursued through source reduction, reuse, segregation, and recycling, and by procuring recycled-content materials and environmentally preferable products and services. The initiatives also ensure that proposed methods of treatment, storage, and waste disposal minimize potential threats to human health and the environment. These initiatives address the goals and the requirements of the DOE SSPP, DOE orders, and federal and state regulations applicable to operations at the NNSS, NLVF, and RSL-Nellis (Table 2.1). Strategies to meet P2/WM goals include:

Source Reduction – The preferred method of waste minimization is source reduction, i.e., to minimize or eliminate waste before it is generated by a project or operation. NNSA/NFO's ISMS requires every project/operation to identify waste minimization opportunities during the planning phase and allocate adequate funds for waste minimization activities.

Source reduction is used to comply with the EPA's phase-out of ODS production and import by 2030. Class I ODS have been completely phased out, and the current Class II ODS phase-out schedule allows use only in equipment manufactured before January 1, 2020. Since 2009, environmentally preferable alternatives to Class I and Class II

ODS have been purchased whenever possible. Existing ODS refrigerants in equipment are being phased out as equipment is drained for repair or replaced by new equipment with approved alternative refrigerants. At the NLVF, failed air conditioning units using R-22, a Class II ODS, are replaced with units using a non-ozone depleting refrigerant, R-427A.

Recycling/Reuse – NNSA/NFO maintains a recycling program for some recyclable waste streams. Items routinely recycled include cardboard; mixed paper (office paper, shredded paper, newspaper, magazine, color print, glossy paper); plastic bottles; plastic grocery bags; elastic/plastic stretch pack; milk jugs; Styrofoam; tin and aluminum cans; glass containers; toner cartridges; cafeteria food waste; computers; software; scrap metal; rechargeable batteries; lead-acid batteries; electric lamps (fluorescent, mercury vapor, metal halide, and high-pressure sodium); used oil, antifreeze, and tires.

An Excess Property Program also exists to provide excess property to NNSA/NFO employees or subcontractors, laboratories, other DOE sites, other federal agencies, state and local government agencies, universities, and local schools. If new users are not found, excess property is made available to the public for recycle/reuse through periodic Internet sales. In 2011, an Excess Integrated Project Team was formed with members from radiological operations, materials management, and property management. The team continues to evaluate useable equipment and facilities that can be diverted from the landfill and excessed or reused. As needed, this team pulls in additional subject matter experts.

Environmentally Preferable Purchasing – The Resource Conservation and Recovery Act (RCRA), as amended, requires federal agencies to develop and implement an affirmative procurement program (APP). NNSA/NFO's APP stimulates a market for recycled-content products and closes the loop on recycling. The EPA maintains a list of items containing recycled materials and what the minimum content of recycled material should be for each item. Federal facilities are required to ensure, where possible, that 100% of purchases of items on the EPA-designated list contain recycled materials at the specified minimum content. The U.S. Department of Agriculture (USDA) designates types of materials that have a required minimum amount of bio-based chemicals. Products that meet this requirement are being added to procurement lists and tracked.

A 2017 EMS target was to evaluate products in select JIT product catalogs and identify opportunities to increase purchases of sustainable and biobased products. A survey was conducted of hand cleaners used in 2017. Six hand cleaners were tested by the fleet maintenance personnel. For each, product information about the relative price, personal likes or dislikes and if it was USDA biopreferred were captured. One popular hand cleaner was a biobased product that was effective at removing grease, did not leave hands dry, and rinsed easily. In October 2017, a USDA biopreferred report was prepared and documented that during FY 2017, $1,523.54 was spent on janitorial and automotive biobased products. The amount spent on these products in FY 2017 was about 25% less than the amount spent in FY 2016.

3.4 EMS Competence, Training, and Awareness

EMS awareness is included as part of the orientation training required for all new M&O employees. Ongoing EMS awareness is accomplished by publishing environmental articles in electronic employee newsletters. Focused environmental briefings are given at tail-gate meetings in the field prior to work with high or non-routine environmental risk.

3.5 Audits and Operational Assessments

In calendar year 2017 the M&O contract was in the process of transitioning from NSTec to MSTS. Because of this, the ISO 14001 annual surveillance was not conducted. The new contract requires MSTS to develop a plan to become ISO 14001-2015 certified. In the interim, MSTS continues the programs and processes certified under the ISO 14001:2004.

The M&O contractor conducts internal management assessments and compliance evaluations. These assessments and evaluations determine the extent of compliance with environmental regulations and identify areas for overall improvement. In FY 2017, the M&O contractor conducted four internal management assessments and 50 compliance evaluations.

3.6 EMS Effectiveness and Reporting

The ISO 14001:2004 certification of the EMS program has enabled NNSA/NFO to declare that they have met executive and DOE order requirements. After the April 2014 recertification assessment, the ISO 14001certifying organization stated that the EMS program remains effective, and the EMS program's certification was renewed in June 2014 for another 3 years.

EMS training and awareness has improved the overall environmental knowledge of the workforce. Many employees identify problems and recommend preventive or corrective actions. These actions, driven by the EMS program, have improved performance and reduced costs.

The establishment of annual environmental EMS targets assist in reducing water, fuel, and energy usage; avoiding waste production; recycling wastes generated from environmental restoration activities; purchasing EPP products; and making infrastructure improvements on environmental systems such as water lines and boilers.

One of the benefits of the EMS program is communication between MSTS and NNSA/NFO regarding current environmental matters and the status of EMS objectives and targets. MSTS prepares and distributes EMS slide presentations to facilitate communication and support, and topics include assessment findings, status of corrective actions, emerging concerns, environmental metrics, and opportunities for improvement. The EMS program is continuously being evaluated, and improvements are implemented and documented. A summary report is presented to senior management annually, documenting performance and improvements, and documenting the determination that the program continues to be suitable, adequate and effective.

In January 2018, the 2017 Facility EMS Annual Report Data for the NNSS was entered into the DOE Headquarters EMS database, accessed through the FedCenter.gov website (http://www.fedcenter.gov/programs/ems/). This database gathers information in several EMS areas from all DOE sites to produce a combined report reflecting DOE's overall performance compared to other federal agencies. The report includes a scorecard section, which is a series of questions regarding a site's EMS effectiveness in meeting the objectives of federal EMS directives. The NNSS scored "green," the highest score.

3.7 Awards, Recognition, and Outreach

The NNSS' Fleet, Fuel and Equipment (FFE) department landed in the top three of the Flexy awards, recognizing fleet excellence. FFE was nominated in the Excellence in Fleet Sustainability (Corporate), alongside Holman Parts Distribution in New Jersey and Safelite AutoGlass Fleet Department in Ohio. The Flexy, the National Association of Fleet Administrators' (NAFA's) awards program, is a true fleet management industry award. NAFA is a non-profit professional society for member professionals who manage fleets of automobiles, SUVs, trucks, vans, and specialized mobile equipment in the U.S. and Canada.

In addition to periodic announcements encouraging the three R's, "reduce, reuse, and recycle". The GREEN Reaper and EMP held an Earth Day event for employees on April 19, 2017. Employees learned about how they could minimize their impact on the environment by diverting waste from landfills. Earth Day events included a clothes-swapping event, a DIY all-purpose non-toxic cleaner demonstration, and a waste diversion video. A total of 345 pounds of clothing items and shoes were diverted from the landfill by donating them to Safe Nest. Club Ride encouraged employees to participate in the Club Ride rewards program and to use alternative types of commuting. Safe Nest exchanged information with employees on how they could divert items from going to the landfill by donating gently-used clothes or small household items to the Safe Nest Donation Center. The Habitat for Humanity ReStore shared information about their donation store and the services they provide to divert hundreds of tons from the landfill each year.

3.8 References

DOE, see U.S. Department of Energy.

MSTS, see Mission Support and Test Services, LLC.

Mission Support and Test Services, LLC, 2018. *FY 2018 NNSA/NFO Site Sustainability Plan*, Las Vegas, NV.

U.S. Department of Energy, 2010. *2010 Strategic Sustainability Performance Plan*. Report to the White House Council on Environmental Quality. Available at: http://energy.gov/sites/prod/files/2014/03/f11/doe_sspp.pdf, as accessed on June 6, 2016.

———, 2017. *FY 2018 DOE Site Sustainability Plan Guidance Document*, U.S. Department of Energy Sustainability Performance Office, September 8, 2017. Available at: https://doegrit.energy.gov/SustainabilityDashboard/PDF/FY%202018%20SSP%20Guidance-%20FINAL.pdf as accessed on January 11, 2018.

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Chapter 4: Air Monitoring

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Section 4.1 presents the results of radiological air monitoring conducted on the Nevada National Security Site (NNSS) by the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) to verify compliance with radioactive air emission standards. Measurements of ***radioactivity***[1] in air are also used to assess the radiological ***dose*** to the general public from inhalation. The assessed dose to the public from all ***exposure*** pathways is presented in Chapter 9. Section 4.2 presents the results of nonradiological air quality assessments that are conducted to ensure compliance with NNSS air quality permits.

NNSA/NFO has also established an independent Community Environmental Monitoring Program (CEMP) to monitor ***radionuclides*** in air in communities adjacent to the NNSS. It is managed by the Desert Research Institute (DRI) of the Nevada System of Higher Education. DRI's offsite air monitoring results are presented in Chapter 7.

4.1 Radiological Air Monitoring and Assessment

The sources of radioactive air emissions on the NNSS include the following: (1) tritiated water evaporated from containment ponds; (2) tritiated water vapor diffusion from soil at the Area 3 Radioactive Waste Management Site (RWMS), the Area 5 Radioactive Waste Management Complex (RWMC), and historical surface or near-surface nuclear device test locations (particularly Sedan and Schooner craters); (3) resuspension of contaminated soil at historical surface or near-surface nuclear device test locations; and (4) radionuclides from current operations. Figure 4-1 shows locations of all known historical and 2017 radiological air emission sources. Areas of soil contamination related to historical weapon tests are depicted in Figure 4-1 as "Grouped Area Sources." The NNSS air monitoring network consists of samplers near sites of soil contamination, at facilities that may produce radioactive air emissions, and along the NNSS boundaries. The objectives and design of the network are described in the *Routine Radiological Environmental Monitoring Plan* (Bechtel Nevada 2003).

Monitored ***analytes*** include radionuclides most likely to be present in air as a result of past or current NNSS operations, based on inventories of radionuclides in surface soil (McArthur 1991) and the volatility and availability of radionuclides for resuspension (Table 1-5 lists the ***half-lives*** of these radionuclides). Uranium is included because uranium (primarily ***depleted uranium [DU]***) has been, or currently is, used during exercises in specific areas of the NNSS. Samples from locations near these areas are analyzed for uranium. ***Gross alpha*** and ***beta*** readings are used in air monitoring as a relatively rapid screening measure.

Radiological Air Monitoring Goals	*Analytes Monitored*
Monitor air at or near historical or current operation sites to (1) detect and identify local and site-wide trends, (2) quantify radionuclides emitted to air, and (3) detect accidental and unplanned releases. Conduct ***point-source*** operational monitoring required under National Emission Standards for Hazardous Air Pollutants (NESHAP) for any facility with the potential to emit radionuclides to the air and cause a dose greater than 0.1 millirem per year (mrem/yr) (0.001 millisievert per year [mSv/yr]) to any member of the public. Determine if the air pathway dose to the public from past or current NNSS activities complies with the Clean Air Act (CAA) NESHAP standard of 10 mrem/yr (0.1 mSv/yr). Determine if the total radiation dose to the public from all pathways (air, water, and food) complies with the 100 mrem/yr standard set by U.S. Department of Energy (DOE) Order DOE O 458.1, "Radiation Protection of the Public and the Environment."	Americium-241 (^{241}Am) Gamma ray emitters (includes Cesium-137 [^{137}Cs]) ***Tritium (^{3}H)*** Plutonium-238 (^{238}Pu) Plutonium-239+240 ($^{239+240}$Pu) Uranium-233+234 ($^{233+234}$U) Uranium-235+236 ($^{235+236}$U) Uranium-238 (^{238}U) Gross alpha radioactivity Gross beta radioactivity

[1] The definition of word(s) in ***bold italics*** may be found by clicking on the word in electronic version or by referencing the Glossary, Appendix B. To return from the Glossary, right click and select Previous View.

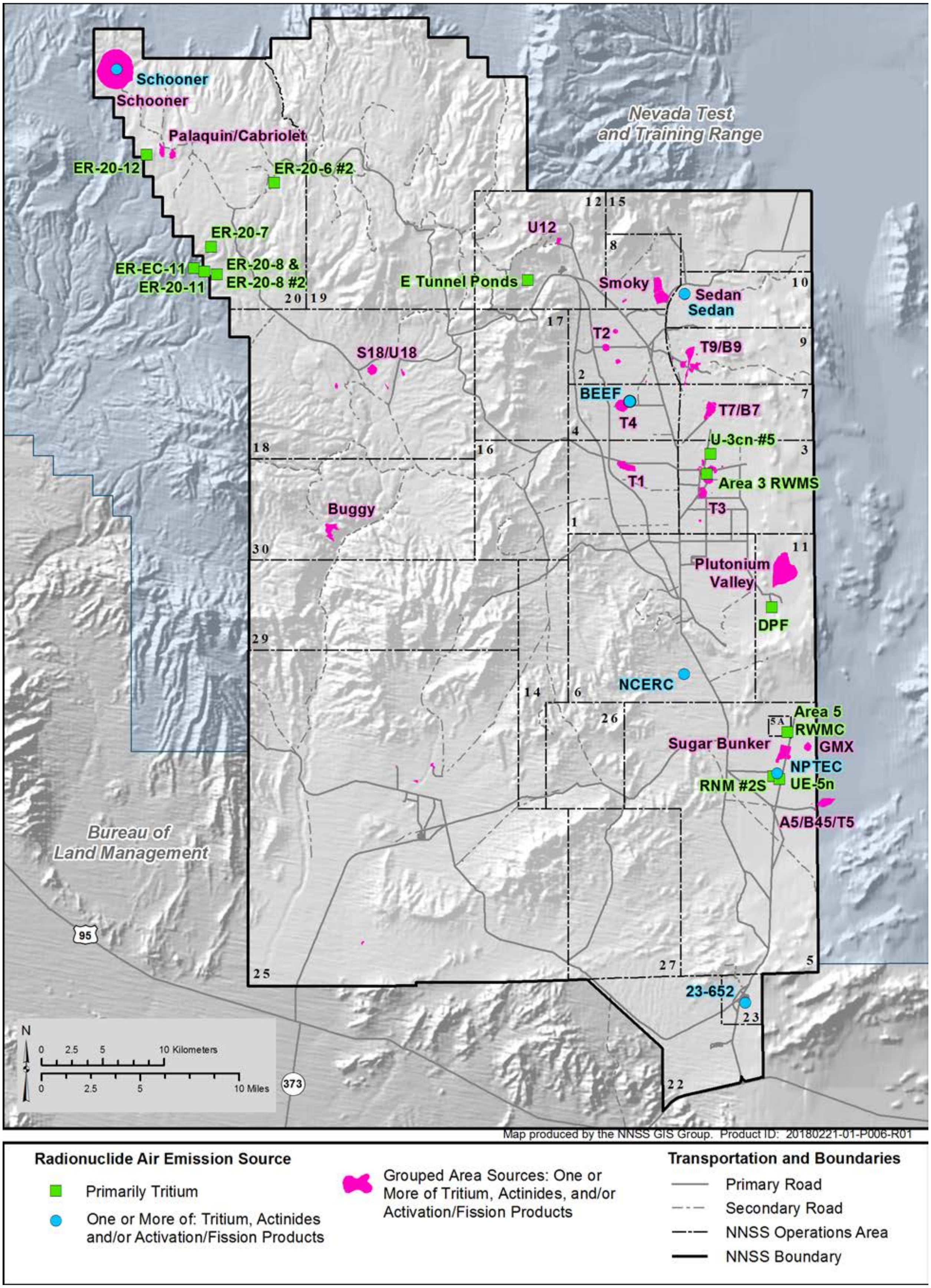

Figure 4-1. Sources of radiological air emissions on the NNSS in 2017

4.1.1 Monitoring System Design

Environmental Samplers – A total of 18 environmental sampling locations operated on the NNSS in 2017 (Figure 4-2). Of these, 15 have both air particulate and ^{3}H (atmospheric moisture) samplers, 1 has only an air particulate sampler, and 2 have only ^{3}H samplers. One of the tritium-only samplers (U-20u South in Area 20) was decommissioned as of May 31, 2017; another (North Schooner, also in Area 20) was deployed April 29, 2017. Air samplers are positioned in predominant downwind directions from sources of radionuclide air emissions and/or are positioned between NNSS contaminated locations and potential offsite receptors. Wind rose data, showing predominant wind directions on the NNSS, are presented in Section A.3 of *Attachment A: Site Description*.[2] Most radionuclide air emission sources are ***diffuse sources*** that include areas with (1) radioactivity in surface soil that can be resuspended by the wind, (2) ^{3}H in water (tritiated water) transpiring or evaporating from plants and soil at the sites of past nuclear tests, and (3) tritiated water evaporating from ponds receiving water either from contaminated wells or from tunnels that cannot be sealed. Sampling and analysis of air particulates and ^{3}H were performed at these locations (Section 4.1.2). Radionuclide concentrations measured at these samplers are used for trending, determining ambient ***background*** concentrations in the environment, and monitoring for unplanned releases of radioactivity.

Critical Receptor Samplers – Six of the sampling locations with both air particulate and ^{3}H samplers are approved by the U.S. Environmental Protection Agency (EPA) Region 9 as ***critical receptor samplers***. They are located near the boundaries and in the center of the NNSS (Figure 4-2). Radionuclide concentrations measured at these samplers are used to assess compliance with the NESHAP public dose limit of 10 mrem/yr (0.1 mSv/yr). The annual average concentrations from each sampler are compared with the NESHAP Concentration Levels for Environmental Compliance (***compliance levels [CLs]***) listed in Table 4-1. 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 at all samplers.

Table 4-1. Regulatory concentration limits for radionuclides in air

Radionuclide	Concentration (× 10^{-15} microcuries/milliliter [µCi/mL]) NESHAP Concentration Level for Environmental Compliance (CL)[(a)]	10% of Derived Concentration Standard (DCS)[(b)]
^{241}Am	1.9	4.1
^{137}Cs	19	9,800
^{3}H	1,500,000	1,400,000
^{238}Pu	2.1	3.7
^{239}Pu	2	3.4
^{233}U	7.1	39
^{234}U	7.7	40
^{235}U	7.1	45
^{236}U	7.7	44
^{238}U	8.3	47

(a) From Table 2, Appendix E of Title 40 ***Code of Federal Regulations (CFR)*** Part 61 (2010)

(b) From DOE-STD-1196-2011, *Derived Concentration Technical Standard*

In addition to CLs, air concentrations measured at all locations are also compared with ***Derived Concentration Standard (DCS)*** values. They represent the annual average air concentrations that would result in a ***total effective dose equivalent (TEDE)*** of 100 mrem/yr (the federal dose limit to the public from all radiological exposure pathways). Ten percent of the DCS (third column of Table 4-1) represents a 10 mrem/yr dose and is analogous to the CLs. Differences between the CLs and 10% of the DCS are because the DCS values are based only on inhalation of radionuclides in air while the CLs consider external dose and ingestion of radionuclides deposited from air.

[2] Attachment A, *Site Description*, is a separate file on the compact disc version of this report and is also accessible on the NNSA/NFO web page at http://www.nnss.gov/pages/resources/library/NNSSER.html.

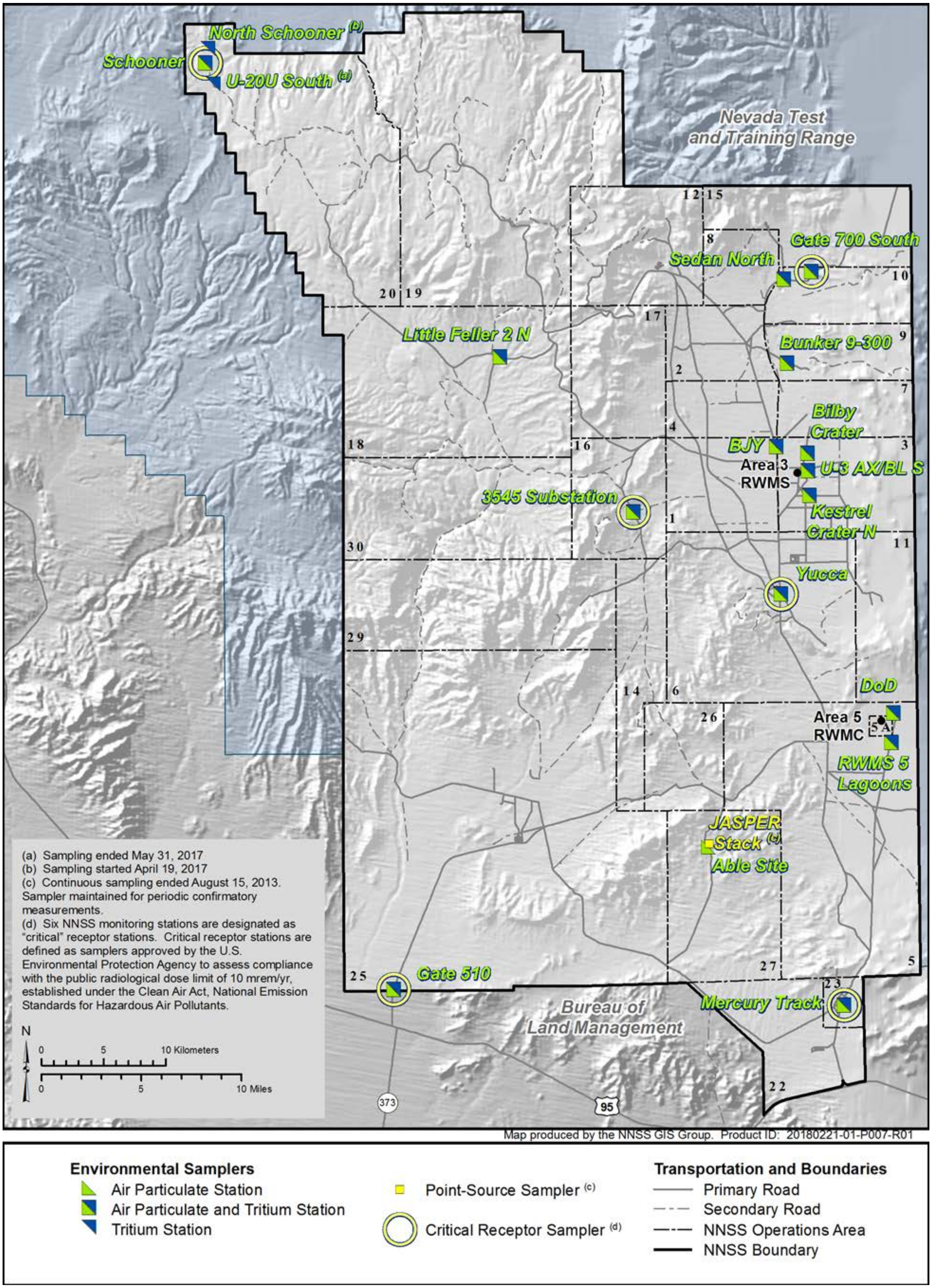

Figure 4-2. Radiological air sampling network on the NNSS in 2017

Because of this, the CLs are generally the more conservative of the two and are used to demonstrate compliance. Air concentrations approaching 10% of the CLs are investigated for causes that may be mitigated in order to ensure that regulatory dose limits are not exceeded.

Point-Source (Stack) Sampler – Continuous stack monitoring has been conducted in the past at one facility on the NNSS, the Joint Actinide Shock Physics Experimental Research (JASPER) facility in Area 27 (Figure 4-2).

In 2013, the potential air emissions from the facility were re-evaluated and determined to result in a potential dose that is much less than the 0.1 mrem/yr threshold at which stack monitoring is required under NESHAP. Therefore, only periodic sampling is recommended to verify low emissions. In 2017, one sample was taken from January 18 to January 25 for this purpose. No man-made radionuclides were detected in the sample, which confirms continued low emissions.

4.1.2 Air Particulate and Tritium Sampling Methods

A sample is collected from each air particulate sampler by drawing air through a 10-centimeter (cm) (4-inch [in]) diameter glass-fiber filter at a flow rate of about 85 liters (3 cubic feet [ft^3]) per minute. The particulate filter is mounted in a filter holder that faces downward at a height of 1.5 meters (m) (5 feet [ft]) above ground. A timer measures the operating time. The run time multiplied by the flow rate yields the volume of air sampled, which is about 1,720 cubic meters (m^3) (60,000 ft^3) during a typical 14-day sampling period. The air sampling rates are measured using mass-flow meters that are calibrated annually. The filters are collected every 2 weeks.

Filters are analyzed for gross alpha and gross beta radioactivity after an approximate 5-day holding time to allow for the decay of naturally occurring ***radon progeny***. They are then composited quarterly for each sampler. The composite samples are analyzed for gamma-emitting radionuclides (which includes ^{137}Cs) by gamma ***spectroscopy*** and for ^{238}Pu, $^{239+240}$Pu, and ^{241}Am by alpha spectroscopy after chemical separation. Samples from locations relatively near potential sources of uranium emissions are also analyzed for uranium isotopes by alpha spectroscopy. These sampling locations had been RWMS 5 Lagoons (Area 5), Yucca (Area 6), Gate 700 S (Area 10), 3545 Substation (Area 16), Gate 510 (Area 25), and Able Site (Area 27) through the second quarter of 2016. Starting with the third quarter of 2016 three additional locations were added: BJY (Area 1), Bunker 9-300 (Area 9), and Sedan Crater N (Area 10).

Tritiated water vapor in the form of $^3H^3HO$ or ^3HHO (collectively referred to as HTO) is sampled continuously at each ^{3}H sampling location. Tritium samplers are operated with elapsed time meters at a flow rate of about 566 cubic centimeters per minute (1.2 ft^3 per hour). The total volume sampled is determined from the product of the sampling period and the flow rate (about 11 m^3 [388 ft^3] over a 2-week sampling period). The HTO is removed from the airstream by a molecular sieve desiccant that is exchanged biweekly. An aliquot of the total moisture collected is extracted from the desiccant and analyzed for ^{3}H by liquid scintillation counting. In all cases, measured activity in units per sample is converted to units per volume of air prior to reporting in the following sections.

Quality control air samples (e.g., duplicates, blanks, and spikes) are also routinely incorporated into the analytical suites. Chapter 14 contains a discussion of ***quality assurance/quality control*** protocols and procedures.

4.1.3 Presentation of Air Sampling Data

The 2017 annual average radionuclide concentrations at each air sampling location are presented in the following sections. The annual average concentration for each radionuclide is estimated from uncensored analytical results for individual samples; i.e., values less than their analysis-specific ***minimum detectable concentrations (MDCs)*** are included in the calculation. $^{239+240}$Pu, $^{233+234}$U, and $^{235+236}$U are reported as the sum of isotope concentrations because the analytical method cannot readily distinguish the individual ***isotopes***. Where field duplicate measurements are available, plots and summaries use the average of the regular and field duplicate measurements.

In graphs of concentration data in the following figures, the CL (second column of Table 4-1) or a fraction of the CL is included as a dashed green horizontal line. For graphs displaying individual measurements, the CL or fraction thereof is shown for reference only; assessment of NESHAP compliance is based on annual average concentrations rather than individual measurements.

4.1.4 Air Sampling Results

Radionuclide concentrations in the air samples shown in the following tables and graphs are attributed to the resuspension of legacy contamination in surface soils, the upward flux of ^{3}H from the soil at sites of past nuclear tests, buried low-level radioactive waste, and NNSS operations.

4.1.4.1 Gross Alpha and Gross Beta

Gross alpha and gross beta radioactivity measurements in air samples collected in 2017 are summarized in Tables 4-2 and 4-3. CL values do not exist for gross alpha and gross beta concentrations in air because these radioactivity measurements include naturally occurring radionuclides (such as ^{40}K, ^{7}Be, uranium, thorium, and the ***daughter isotopes*** of uranium and thorium) in uncertain proportions. However, these analyses are useful in that results can be economically obtained just 5 days after sample collection to identify any increases requiring investigation.

Overall, the distribution of mean gross alpha results across the network is comparable with those of the past few years with somewhat higher values toward the end of the year at some locations. These are generally associated with higher ^{241}Am and $^{239+240}Pu$ (Sections 4.1.4.2 and 4.1.4.4) and are within the range of values observed in the past from resuspension of soils. The gross beta measurements also resemble those of prior years, excluding the briefly elevated values in March 2011 due to the Fukushima Daiichi nuclear power plant event.

Table 4-2. Gross alpha radioactivity in air samples collected in 2017

			Gross Alpha (x 10^{-16} µCi/mL)			
Area	Sampling Station	Number of Samples	Mean	Standard Deviation	Minimum	Maximum
1	BJY	26	35.48	16.31	8.64	65.61
3	Bilby Crater	26	35.16	14.77	7.36	59.88
3	Kestrel Crater N	26	33.79	14.63	-2.83	55.78
3	U-3ax/bl S	26	36.48	14.98	10.02	62.20
5	DoD	26	31.35	11.61	12.72	54.60
5	RWMS 5 Lagoons	26	32.37	13.07	6.48	57.77
6	Yucca*	26	32.02	16.51	-0.73	61.66
9	Bunker 9-300	26	74.74	41.54	6.49	159.12
10	Gate 700 S*	26	30.49	13.36	3.64	55.83
10	Sedan N	26	29.66	13.59	2.91	49.54
16	3545 Substation*	26	29.34	13.08	0.73	51.69
18	Little Feller 2 N	26	33.92	31.28	8.83	174.30
20	Schooner*	26	28.15	14.18	-1.44	54.81
23	Mercury Track*	26	30.48	14.07	5.35	51.66
25	Gate 510*	26	33.03	13.12	7.00	52.11
27	ABLE Site	26	29.37	12.97	5.78	54.27
All Environmental Locations		416	34.74	21.04	-2.83	174.30
* EPA-approved Critical Receptor Station						

Table 4-3. Gross beta radioactivity in air samples collected in 2017

			Gross Beta (x 10^{-15} µCi/mL)			
Area	Sampling Station	Number of Samples	Mean	Standard Deviation	Minimum	Maximum
1	BJY	26	23.44	5.69	12.34	35.93
3	Bilby Crater	26	22.66	5.78	10.70	34.08
3	Kestrel Crater N	26	23.21	5.74	9.68	34.48
3	U-3ax/bl S	26	23.29	5.18	12.74	33.02
5	DoD	26	24.03	5.84	12.44	32.51
5	RWMS 5 Lagoons	26	24.63	5.96	13.05	36.31
6	Yucca*	26	23.65	5.97	10.19	32.60
9	Bunker 9-300	26	23.12	5.75	11.12	33.12
10	Gate 700 S*	26	23.88	5.99	12.13	34.16
10	Sedan N	26	22.57	5.35	12.22	31.37
16	3545 Substation*	26	22.51	5.91	11.27	33.16
18	Little Feller 2 N	26	22.42	5.86	10.64	31.38
20	Schooner*	26	23.09	5.95	12.35	37.25
23	Mercury Track*	26	23.33	6.04	11.64	32.93
25	Gate 510*	26	24.35	5.50	11.56	34.14
27	ABLE Site	26	22.82	5.74	12.18	31.54

Table 4-3. Gross beta radioactivity in air samples collected in 2017

Area	Sampling Station	Number of Samples	Gross Beta (x 10^{-15} µCi/mL)			
			Mean	Standard Deviation	Minimum	Maximum
All Environmental Locations		416	23.31	5.70	9.68	37.25

* EPA-approved Critical Receptor Station

4.1.4.2 *Americium-241*

The mean ^{241}Am concentration for environmental sampler locations was 14.87 × 10^{-18} µCi/mL in 2017. This is not a significant change from recent years; the annual means were 13.91, 11.67, 8.55, 10.09, 12.74, 15.99, 6.99, and 6.33 × 10^{-18} µCi/mL in 2016 through 2009, respectively. The 2017 average concentration is 0.8% of the CL (shown at the bottom of Table 4-4). As usual, the highest concentrations were found at the Bunker 9-300 sampler location in Area 9 (Table 4-4, Figure 4-3). This sampler is located within areas of known soil contamination from past nuclear tests, available for re-suspension on windy days; see similar results for $^{239+240}$Pu in Section 4.1.4.4. The annual mean concentration at Bunker 9-300 is 128.0 × 10^{-18} µCi/mL, 6.7% of the CL. Locations with mildly elevated mean concentrations are Little Feller 2 N (Area 18), BJY (Area 1), and Kestrel Crater N and U-3ax/bl S (Area 3), all adjacent to areas with soil contamination. Figure 4-3 shows measurements at these and other Area 1 and Area 3 locations which often have higher ***actinide*** values individually. Figure 4-3 also shows the means of quarterly concentrations at other sampler locations, with vertical bars extending from the lowest to the highest values for each monitoring event.

Table 4-4. Concentrations of ^{241}Am in air samples collected in 2017

Area	Sampling Station	Number of Samples	^{241}Am (x 10^{-18} µCi/mL)			
			Mean	Standard Deviation	Minimum	Maximum
1	BJY	4	14.87	13.96	3.81	33.99
3	Bilby Crater	4	8.95	7.49	2.52	18.14
3	Kestrel Crater N	4	13.38	9.57	4.61	25.17
3	U-3ax/bl S	4	11.84	12.49	2.27	30.20
5	DoD	4	3.33	1.54	1.80	5.34
5	RWMS 5 Lagoons	4	6.11	10.65	-1.20	21.93
6	Yucca*	4	2.20	2.32	0.60	5.64
9	Bunker 9-300	4	127.99	104.16	12.35	225.79
10	Gate 700 S*	4	3.88	1.63	1.94	5.69
10	Sedan N	4	9.66	4.08	5.19	15.09
16	3545 Substation*	4	1.18	1.21	-0.48	2.41
18	Little Feller 2 N	4	29.54	53.25	1.72	109.39
20	Schooner*	4	2.95	1.90	0.31	4.83
23	Mercury Track*	4	0.91	1.44	-0.71	2.76
25	Gate 510*	4	-0.24	2.39	-2.31	2.74
27	ABLE Site	4	1.30	1.84	-1.20	2.75
All Environmental Locations		64	14.87	40.05	-2.31	225.79

CL = 1900 x 10^{-18} µCi/mL
* EPA-approved Critical Receptor Station

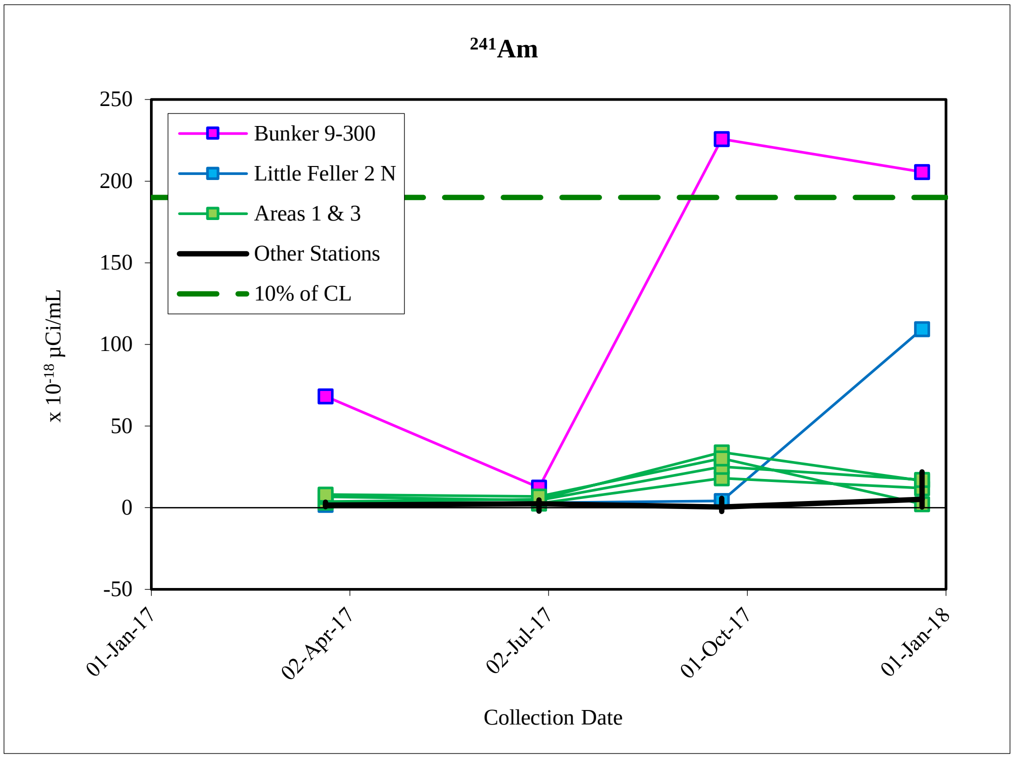

Figure 4-3. Concentrations of ^{241}Am in air samples collected in 2017

4.1.4.3 Cesium-137

^{137}Cs was detected in one sample during 2017 at a level slightly (13%) above its MDC, in the first quarter at RWMS 5 Lagoons. All measured concentrations were very low (Table 4-5, Figure 4-4). The highest single sample measurement (at RWMS 5 Lagoons) was 1.3% of the CL; the highest annual mean (at Bunker 9-300) was 0.2% of the CL.

Table 4-5. Concentrations of ^{137}Cs in air samples collected in 2017

			^{137}Cs (x 10^{-17} µCi/mL)			
Area	Sampling Station	Number of Samples	Mean	Standard Deviation	Minimum	Maximum
1	BJY	4	-4.90	13.72	-22.25	9.80
3	Bilby Crater	4	3.12	7.77	-4.20	10.87
3	Kestrel Crater N	4	-15.54	31.44	-61.41	8.92
3	U-3ax/bl S	4	0.38	15.21	-20.50	12.89
5	DoD	4	-6.89	10.72	-19.12	4.18
5	RWMS 5 Lagoons	4	-8.79	37.24	-61.56	25.37
6	Yucca*	4	2.66	4.74	-1.74	8.92
9	Bunker 9-300	4	4.05	4.99	-1.21	8.50
10	Gate 700 S*	4	0.53	6.79	-5.59	9.58
10	Sedan N	4	0.17	12.59	-12.08	12.96
16	3545 Substation*	4	2.39	8.05	-8.25	10.05
18	Little Feller 2 N	4	-8.83	8.43	-17.64	0.21
20	Schooner*	4	-11.83	34.45	-62.82	13.04
23	Mercury Track*	4	-2.24	13.11	-20.99	8.81
25	Gate 510*	4	1.62	8.20	-8.95	10.29
27	ABLE Site	4	1.11	14.80	-15.31	19.58
All Environmental Locations		64	-2.69	16.51	-62.82	25.37

CL = 1900 x 10^{-17} µCi/mL
* EPA-approved Critical Receptor Station

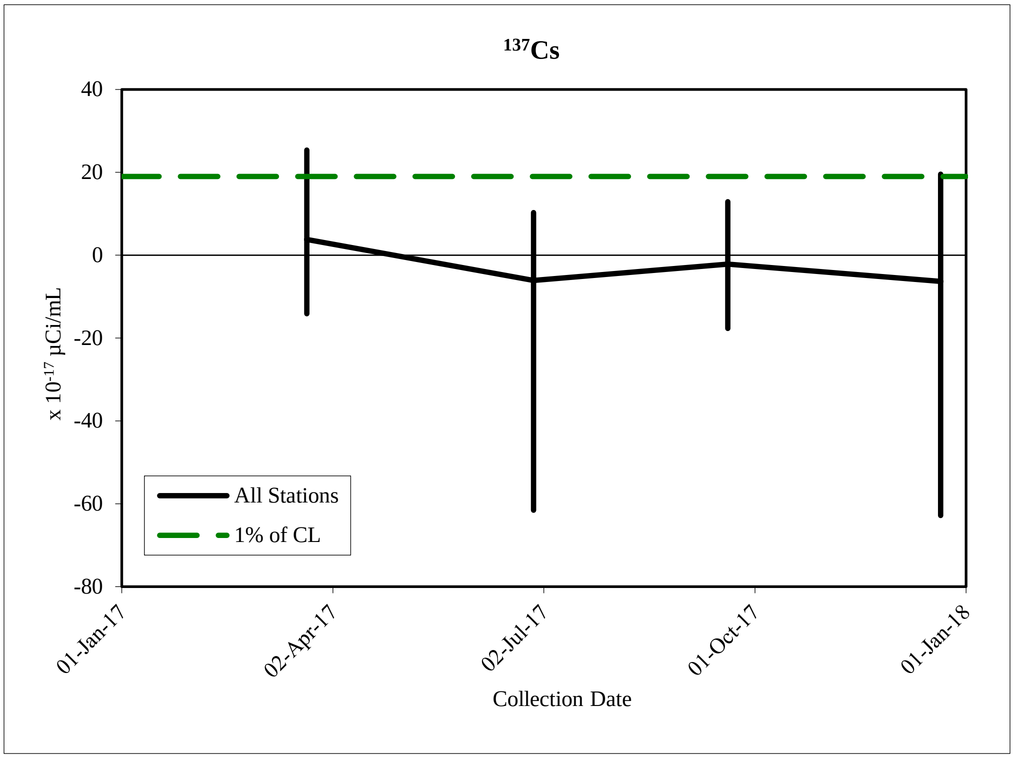

Figure 4-4. Concentrations of ^{137}Cs in air samples collected in 2017

4.1.4.4 Plutonium Isotopes

The overall mean concentration for ^{238}Pu at environmental samplers in 2017 (2.61×10^{-18} µCi/mL) (Table 4-6) is consistent with the range of values (1.15 to 3.72×10^{-18} µCi/mL) observed from 2009 through 2015, and a bit lower than that of 2016 (5.54×10^{-18} µCi/mL). The highest annual mean (13.23×10^{-18} µCi/mL) was at Bunker 9-300 in Area 9. The highest annual mean concentration is 0.6% of the CL (Figure 4-5).

The $^{239+240}$Pu isotopes are of greater abundance and hence greater interest. The overall mean of 96.46×10^{-18} µCi/mL in 2017 (Table 4-7) is somewhat above the range of values measured over the past 8 years (~33 to ~76 $\times 10^{-18}$ µCi/mL) . The location with the highest mean, as usual, is Bunker 9-300 (897×10^{-18} µCi/mL, 44.9% of the CL; Table 4-7 and Figure 4-6). The higher plutonium values at this sampler are primarily due to diffuse sources of radionuclides from historical nuclear testing in Area 9. Other samplers with relatively higher values are Sedan N and samplers in Areas 1 and 3; these are represented individually in the plots, as is Little Feller 2 N.

The concentrations of ^{241}Am, $^{239+240}$Pu, and to some extent ^{238}Pu, show similar patterns through time at Bunker 9-300 (Figures 4-3, 4-6, and 4-5, respectively). This is because ^{241}Am is the long-lived ***daughter product*** obtained when ^{241}Pu (a short-lived isotope created along with the more common Pu isotopes) decays by beta emission. Hence $^{239+240}$Pu and ^{241}Am (and also ^{238}Pu somewhat) tend to be found together in particles of Pu remaining from past nuclear tests. The half-life of ^{241}Pu is 14.4 years, whereas that of ^{241}Am is 432 years. Consequently the amount of ^{241}Am will gradually increase temporarily as ^{241}Pu decays, and then it will decrease.

Figure 4-7 shows long-term trends in $^{239+240}$Pu annual mean concentrations at locations with at least 15-year data histories since 1970. Rather than showing the time histories for all 50 such locations, Figure 4-7 shows the average (geometric mean) trend lines for Areas 1 and 3; Area 5; Areas 7, 9, 10, and 15; and other areas. Areas 1, 3, 7, 9, 10, and 15 in the northeast portion of the NNSS have a legacy of soil contamination from surface and atmospheric nuclear tests and safety shots. The average annual rates of decline for these groups range from 2.2% (Areas 1 and 3) and 2.9% (Areas 7, 9, 10, and 15) to almost 10% (the "Other Areas" group). This equates to an estimated air concentration environmental half-life for $^{239+240}$Pu in air of 31.6 years for Areas 1 and 3; 23.3 years for Areas 7, 9, 10, and 15; 6.4 years for Area 5; and 6.7 years for the "Other Areas" group. Declining rates are not attributable to ***radioactive decay***, as the physical half-lives of ^{239}Pu and ^{240}Pu are 24,110 and 6,537 years, respectively. The decreases are due primarily to immobilization and dilution of Pu particles in surface soil, resulting in reduced concentrations re-suspended in air. The half-life of the less abundant ^{238}Pu is 88 years.

Table 4-6. Concentrations of ^{238}Pu in air samples collected in 2017

			^{238}Pu (x 10^{-18} μCi/mL)			
Area	Sampling Station	Number of Samples	Mean	Standard Deviation	Minimum	Maximum
1	BJY	4	3.78	2.09	1.48	6.16
3	Bilby Crater	4	1.87	2.29	-1.42	3.60
3	Kestrel Crater N	4	2.33	1.65	0.38	4.22
3	U-3ax/bl S	4	3.09	2.25	0.00	5.32
5	DoD	4	1.36	3.11	-2.72	4.87
5	RWMS 5 Lagoons	4	1.80	2.35	0.00	5.26
6	Yucca*	4	1.28	1.42	-0.34	2.98
9	Bunker 9-300	4	13.23	9.01	3.15	22.78
10	Gate 700 S*	4	0.65	1.71	-1.60	2.51
10	Sedan N	4	2.58	5.56	-5.30	6.61
16	3545 Substation*	4	0.17	1.84	-2.48	1.76
18	Little Feller 2 N	4	3.55	5.25	0.00	11.12
20	Schooner*	4	3.38	0.62	2.46	3.79
23	Mercury Track*	4	0.64	0.45	0.35	1.31
25	Gate 510*	4	0.55	2.80	-3.64	2.20
27	ABLE Site	4	1.45	0.70	0.50	2.13
All Environmental Locations		64	2.61	4.23	-5.30	22.78

CL = 2100 x 10^{-18} μCi/mL
* EPA-approved Critical Receptor Station

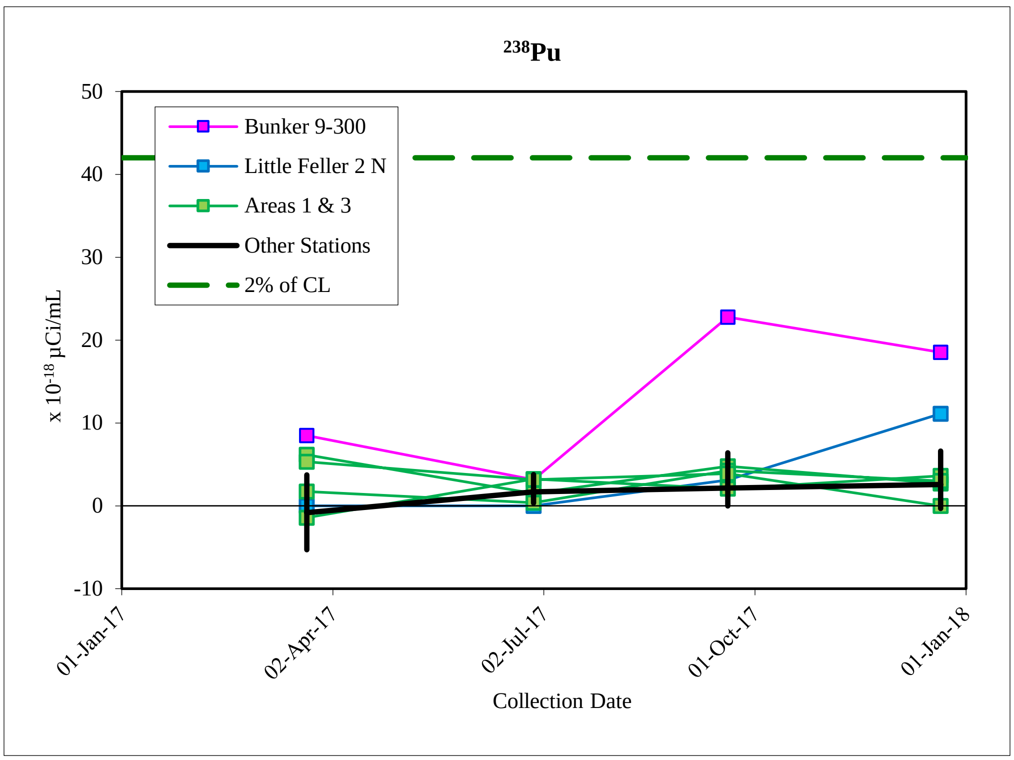

Figure 4-5. Concentrations of ^{238}Pu in air samples collected in 2017

Table 4-7. Concentrations of $^{239+240}$Pu in air samples collected in 2017

Area	Sampling Station	Number of Samples	$^{239+240}$Pu (x 10^{-18} µCi/mL) Mean	Standard Deviation	Minimum	Maximum
1	BJY	4	104.30	104.53	18.40	242.92
3	Bilby Crater	4	71.84	73.89	11.87	164.80
3	Kestrel Crater N	4	81.35	85.46	9.48	179.11
3	U-3ax/bl S	4	75.86	108.43	5.55	237.07
5	DoD	4	5.08	6.41	-0.98	14.11
5	RWMS 5 Lagoons	4	40.87	73.26	0.45	150.66
6	Yucca*	4	11.80	11.77	1.47	22.09
9	Bunker 9-300	4	896.92	731.82	160.95	1643.91
10	Gate 700 S*	4	11.54	7.95	3.19	21.24
10	Sedan N	4	44.19	46.08	9.00	111.43
16	3545 Substation*	4	1.82	1.44	0.00	3.29
18	Little Feller 2 N	4	189.28	360.06	-0.82	728.99
20	Schooner*	4	3.09	1.75	1.60	5.53
23	Mercury Track*	4	1.75	1.05	0.80	3.22
25	Gate 510*	4	0.90	1.62	-1.46	2.02
27	ABLE Site	4	2.84	1.82	0.50	4.80
All Environmental Locations		64	96.46	282.29	-1.46	1643.91

CL = 2000 x 10^{-18} µCi/mL
* EPA-approved Critical Receptor Station

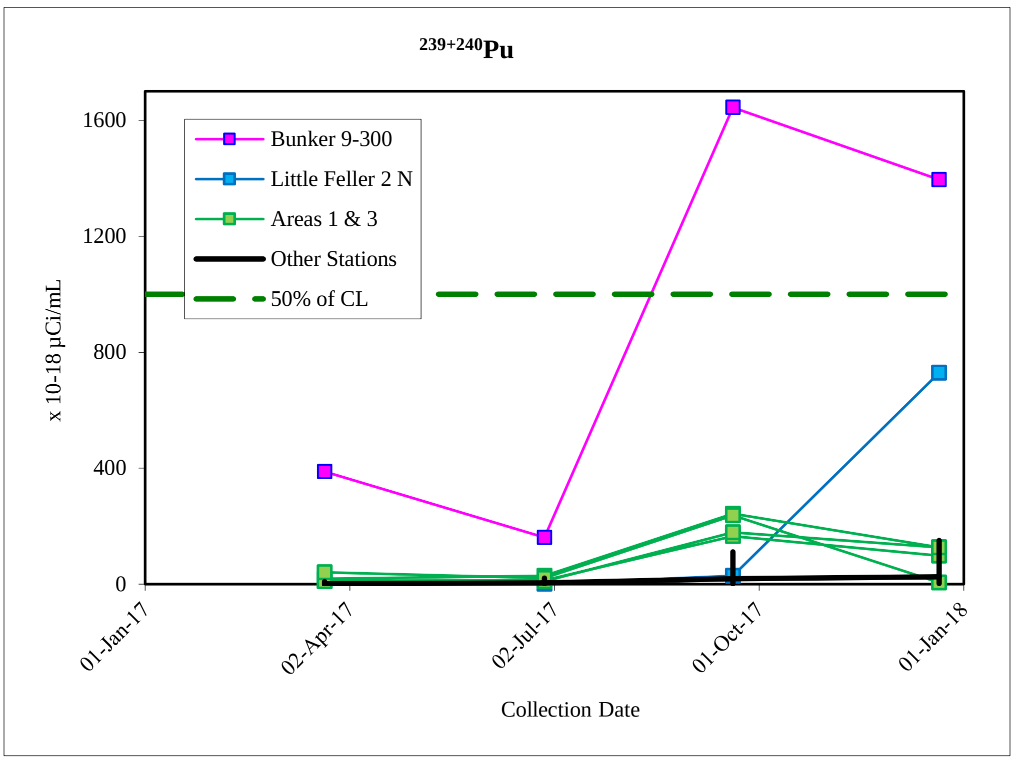

Figure 4-6. Concentrations of $^{239+240}$Pu in air samples collected in 2017

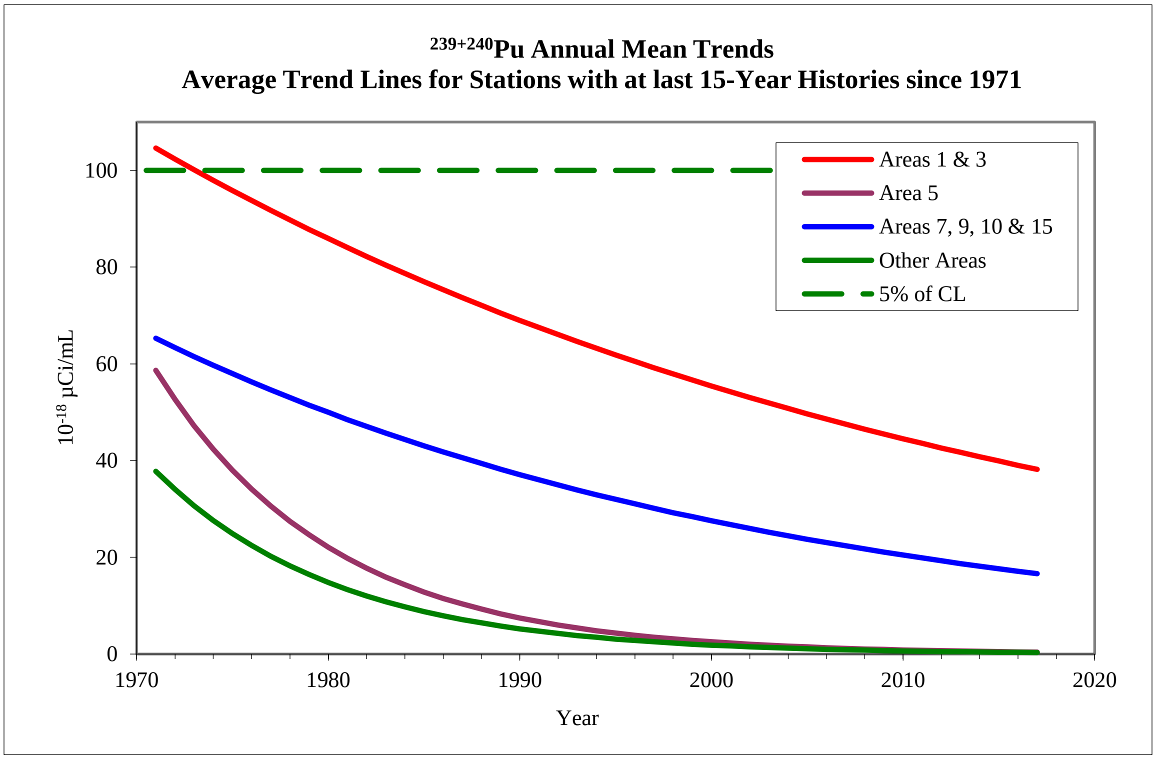

Figure 4-7. Average trends in $^{239+240}$Pu in air annual means, 1971–2017

4.1.4.5 Uranium Isotopes

Uranium analyses were performed in 2017 for samples collected near sites where exercises using uranium (predominately DU) have been conducted. Quarterly samples from nine samplers were analyzed. Ratios of the U isotopes ($^{233+234}$U / ^{238}U and $^{235+236}$U / ^{238}U) were compared among the samplers and compared with ratios found in blank filters. No evidence of elevated uranium or presence of DU in air was observed in these comparisons.

4.1.4.6 Tritium

Tritium concentrations in air vary widely across the NNSS (Table 4-8). As usual, the highest annual mean concentration was at the Schooner sampler (77.8×10^{-6} picocuries per milliliter [pCi/mL]). The next highest are 2.7×10^{-6} pCi/mL at North Schooner and 1.1×10^{-6} pCi/mL at Sedan North. Figure 4-8 shows these data with the Schooner data plotted at one-tenth of their actual values to allow the variation at other locations to be visible. The Schooner annual mean is 5.2% of the CL; mean concentrations at other locations are, at most, 0.2% of the CL.

The ^{3}H found at Schooner and Sedan N comes from past nuclear tests. Tritium associated with these tests quickly oxidizes into tritiated water, which remains in the surrounding soil and rubble until it moves to the surface and evaporates. Higher ^{3}H concentrations in air are generally observed in the summer months. Increased ^{3}H emissions are likely due to the movement of relatively deep soil moisture (> 2 m) containing relatively high concentrations of ^{3}H to the surface when temperatures are the highest and when shallow (< 2 m) soil moisture is the lowest. Rainfall can temporarily suppress these emissions by diluting ^{3}H in the atmosphere and in the shallow soil moisture. Figure 4-8 shows the relationship between ^{3}H and average daily temperature at Schooner Crater. Figure 4-9 shows the amount of precipitation occurring during monitoring periods in and around Pahute Mesa. The summer peak at Schooner Crater was slightly delayed in 2017, consistent with the spring rains; note also the dips in ^{3}H emissions following the increased precipitation in early September. The points plotted in these figures show the total ^{3}H emissions for the 2-week periods and the average temperature and total precipitation at the Schooner Crater meteorological station for those periods, all plotted against the collection date for that period.

Figure 4-10 shows average (geometric mean) long-term trends for the annual mean ^{3}H levels at locations with at least 7-year histories since 1989, by Area groups. Tritium measurements have been decreasing fairly rapidly at most locations; the overall average decline rate for samplers other than Schooner is around 16% per year. The decline rate for Schooner has been about 9.7% per year since 2002.

Table 4-8. Concentrations of ^{3}H in air samples collected in 2017

Area	Sampling Station	Number of Samples	^{3}H Concentration (x 10^{-6} pCi/mL)			
			Mean	Standard Deviation	Minimum	Maximum
1	BJY	26	0.54	1.12	-0.28	5.48
3	Bilby Crater	26	0.45	1.09	-0.27	5.56
3	Kestrel Crater N	26	0.47	1.03	-0.29	5.19
3	U-3ax/bl S	26	0.70	1.37	-0.42	6.81
5	DoD	26	0.57	0.51	-0.20	2.15
5	RWMS 5 Lagoons	26	0.45	0.53	-0.32	1.73
6	Yucca*	26	0.26	0.65	-0.47	2.90
9	Bunker 9-300	26	0.66	1.05	-0.53	5.02
10	Gate 700 S*	26	0.27	0.60	-0.40	2.87
10	Sedan N	26	1.07	1.09	-0.35	4.05
16	3545 Substation*	26	0.06	0.30	-0.48	0.68
18	Little Feller 2 N	26	0.16	0.35	-0.63	0.93
20	North Schooner	16	2.66	1.75	0.30	5.01
20	Schooner*	26	77.77	78.80	2.86	256.78
20	U-20u S	11	0.13	0.33	-0.57	0.50
23	Mercury Track*	26	0.18	0.56	-1.07	1.48
25	Gate 510*	26	0.10	0.39	-1.14	0.90
All Environmental Locations		417	5.32	26.91	-1.14	256.78

CL = 1500 x 10^{-6} pCi/mL
* EPA-approved Critical Receptor Station

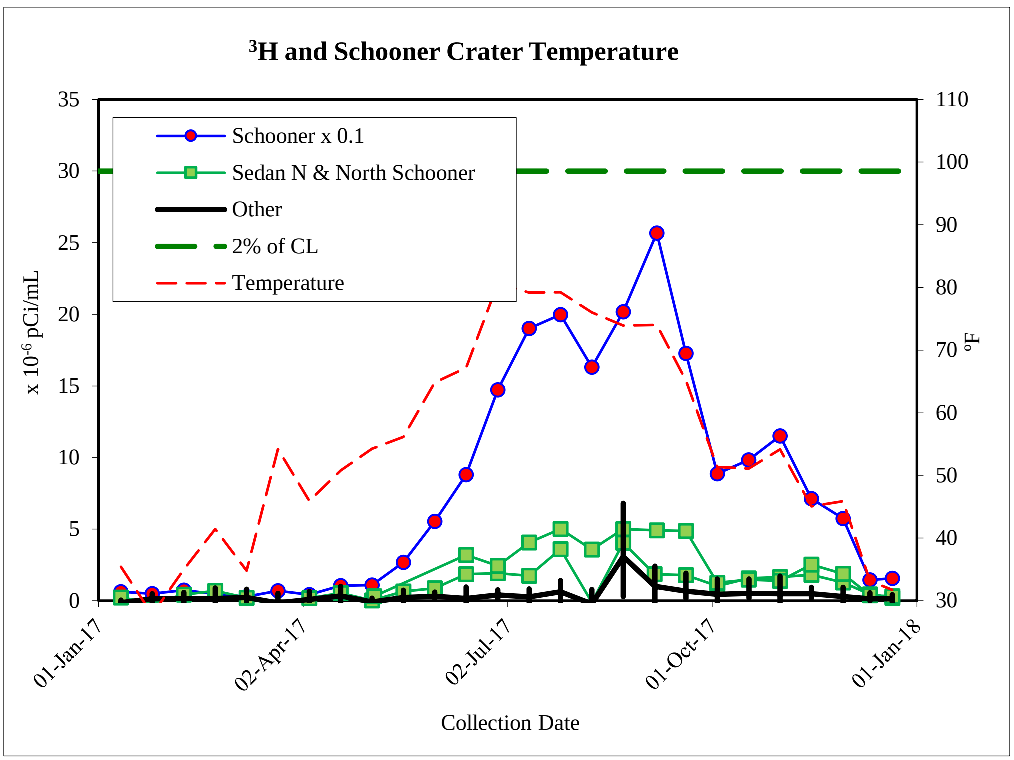

Figure 4-8. Concentrations of ^{3}H in air samples collected in 2017 with Schooner Crater average air temperature collection period

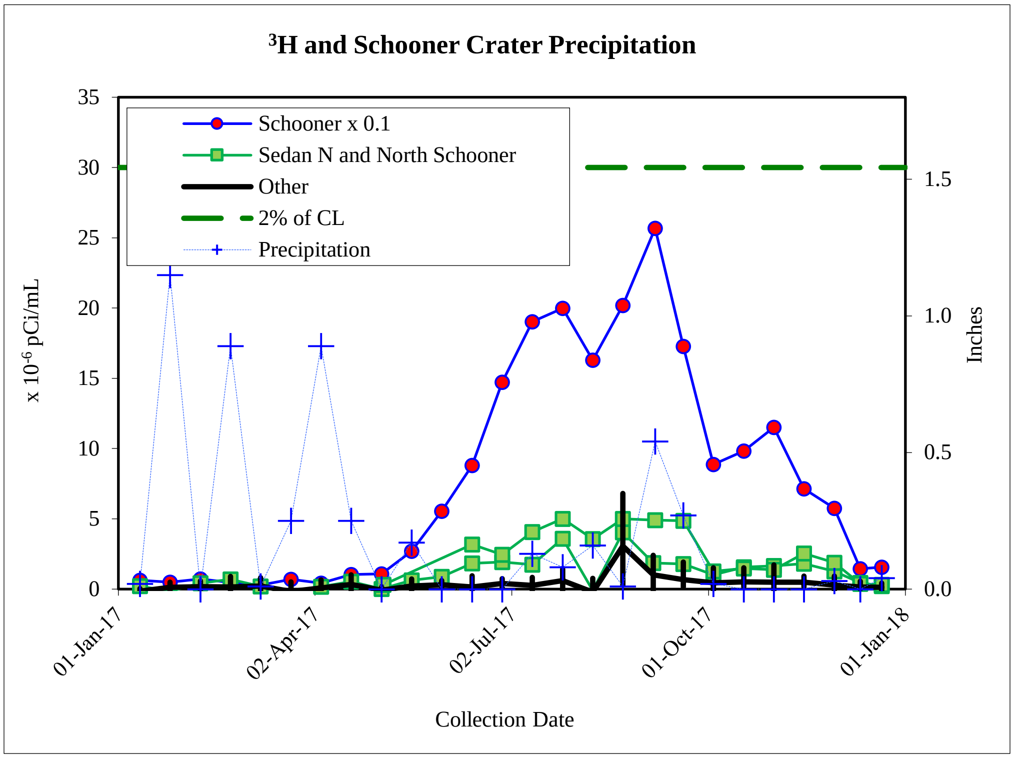

Figure 4-9. Concentrations of ^3H in air samples collected in 2017 with Schooner Crater precipitation

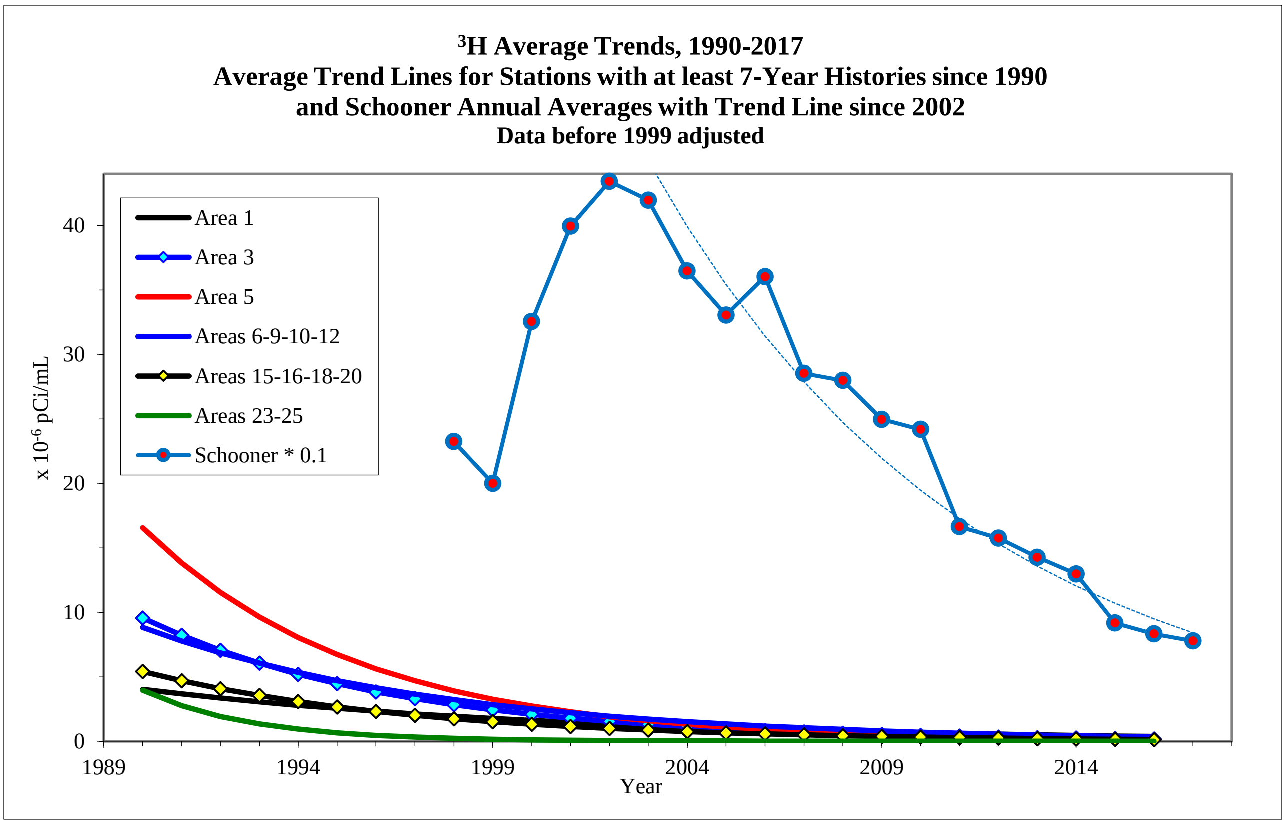

Figure 4-10. Trends in annual mean ^3H air concentrations for Area groups, 1990–2017, and Schooner Crater annual means with trend since 2002.

4.1.5 Emission Evaluations for Planned Projects

In 2017, three NESHAP evaluations for radionuclide emissions were conducted. All were for facility operations using radioactive material. These evaluations were to determine if activities had the potential to release airborne radionuclides that might expose the public to a dose equal to or greater than 0.1 mrem/yr. For any project or facility with this potential, the EPA requires monitoring of the emissions and possibly the submittal of an application for EPA approval prior to active operations. The predicted dose at the nearest offsite receptor for each activity evaluated in 2017 was much less than the 0.1 mrem/yr level specified under NESHAP regulations. Therefore, it was concluded that these activities constituted minor sources and did not require point-source operational monitoring. Detailed air emission dose evaluations for each project are reported in the NESHAP annual report for 2017 (Mission Support and Test Services, LLC [MSTS], 2018).

4.1.6 Unplanned Releases

There were no known unplanned radionuclide releases in 2017. In 2017, seven wildland fires occurred on the NNSS including one of the largest ever recorded. It burned approximately 15,000 acres in Area 30. Another fire in Area 18 burned about 10 acres before it was extinguished. The other five wildland fires were small (<0.07 acres) and were extinguished by NNSS Fire and Rescue personnel or carefully monitored until they burned out. None of these fires occurred in radiologically contaminated areas.

4.1.7 Estimate of Total NNSS Radiological Atmospheric Releases

Each year, existing operations, new construction projects, and modifications to existing facilities that have the potential for airborne emissions of radioactive materials are reviewed. Quantities of radionuclides released during these operations and from legacy contamination sites are measured or calculated to obtain the total annual quantity of radiological atmospheric releases from the NNSS. The methods are described in detail in MSTS (2018). Total emissions in 2017, by radionuclide, are shown in Table 4-9. Radionuclide emissions by source are shown in Table 4-10. Their locations in relation to critical receptor air monitoring locations are shown in Figure 4-1.

In 2017, an estimated 3,012 Ci of radionuclides were released as air emissions. Of this amount, about 55.6% (1,673.8 Ci) is from the short-lived activation and fission products ^{16}N, ^{19}O, ^{41}Ar, ^{85}Br, ^{85m}Kr, ^{106}Rh, ^{135}I, ^{135m}Xe, ^{135}Xe, and ^{144}Pr (Table 4-9 lists radionuclide name, half-life, and amount emitted). All of these decay very quickly and are essentially not available to contribute dose to the public at the 31 to 62 km (19 to 38 mi) distances over which they have to travel. Tritium makes up about 43.6% of the total emission. Other radionuclides make up only 0.8% of the total emission.

Table 4-9. Total estimated NNSS radionuclide emissions for 2017

Radionuclide	Symbol	Half-life[(a)]	Total Quantity (Ci)
		Primary Radionuclides	
Tritium	^{3}H	12.32 years (yr)	1312
Plutonium-238	^{238}Pu	87.7 yr	0.040
Plutonium-239+240	$^{239+240}Pu$	24,110 yr	0.29
Americium-241	^{241}Am	432 yr	0.069
		Noble Gases	
Argon-41	^{41}Ar	109.61 minutes (min)	0.00000026
Krypton-85	^{85}Kr	10.76 yr	0.00016
metastable Krypton-85	^{85m}Kr	4.48 hours (h)	15
metastable Xenon-131	^{131m}Xe	11.84 days (d)	0.0067
Xenon-133	^{133}Xe	5.24 d	2.73
metastable Xenon-133	^{133m}Xe	2.19 d	0.19
Xenon-135	^{135}Xe	9.14 h	38
metastable Xenon-135	^{135m}Xe	15.29 min	248
		Other	
Nitrogen-16	^{16}N	7.13 seconds (s)	0.00016
Oxygen-19	^{19}O	26.46 s	0.00000021
Bromine-85	^{85}Br	2.9 min	1322
Cobalt-60	^{60}Co	5.27 yr	0.00030

Table 4-9. Total estimated NNSS radionuclide emissions for 2017

Radionuclide	Symbol	Half-life[(a)]	Total Quantity (Ci)
		Other	
Strontium-90	^{90}Sr	28.79 yr	0.055
Rhodium-106	^{106}Rh	29.80 s	0.000020
Antimony-124	^{124}Sb	60.20 d	0.0000040
Antimony-125	^{125}Sb	2.76 yr	0.00014
Tellurium-132	^{132}Te	3.20 d	3.14
Iodine-131	^{131}I	8.02 d	0.91
Iodine-133	^{133}I	20.8 h	17
Iodine-135	^{135}I	6.57 h	51
Cesium-137	^{137}Cs	30.17 yr	0.053
Barium-140	^{140}Ba	12.75 d	1.07
Praseodymium-144	^{144}Pr	17.28 min	0.0000098
Samarium-151	^{151}Sm	90 yr	0.000028
Samarium-153	^{153}Sm	46.50 h	0.17
Europium-152	^{152}Eu	13.54 yr	0.010
Europium-154	^{154}Eu	8.59 yr	0.000099
Europium-155	^{155}Eu	4.76 yr	0.00013
Depleted Uranium	DU	>150,000 yr	0.0043

(a) Source: International Commission on Radiological Protection (2008)

Table 4-10. Radiological atmospheric releases from the NNSS for 2017

	Emission Source[(a)]	Emissions Control	Radionuclide	Quantity (Ci/y)
Legacy Contamination Sites	Sedan	None	^{3}H	14
	Schooner	None	^{3}H	14
	Grouped Area Sources – All NNSS Areas	None	^{60}Co	0.00030
			^{90}Sr	0.054
			^{137}Cs	0.052
			^{152}Eu	0.010
			^{154}Eu	0.000099
			^{155}Eu	0.000078
			^{238}Pu	0.040
			$^{239+240}Pu$	0.29
			^{241}Am	0.069
	Building A-01, basement ventilation, NLVF	None	^{3}H	0.0020
Stockpile Stewardship, Science, and Experimentation	DPF	None	^{3}H	1269
			^{16}N	0.00016
			^{19}O	0.00000021
			^{41}Ar	0.00000026
	NCERC	HEPA filter [(b)]	^{3}H	0.0000052
			^{85}Br	1322
			^{85}Kr	0.00016
			^{85m}Kr	15
			^{90}Sr	0.0012
			^{106}Rh	0.000020
			^{124}Sb	0.0000040
			^{125}Sb	0.00014
			^{132}Te	3
			^{131}I	0.91
			^{133}I	17
			^{135}I	51
			^{131m}Xe	0.0067
			^{133}Xe	3
			^{133m}Xe	0.19
			^{135}Xe	38
			^{135m}Xe	248
			^{137}Cs	0.0012
			^{140}Ba	1
			^{144}Pr	0.0000098
			^{151}Sm	0.000028
			^{153}Sm	0.17
			^{155}Eu	0.000055

Table 4-10. Radiological atmospheric releases from the NNSS for 2017

	Emission Source(a)	Emissions Control	Radionuclide	Quantity (Ci/y)
	BEEF		DU	0.0043
Nonproliferation, Counterterrorism, and Incident Response	NPTEC	None	DU	0.000020
Environmental Restoration and Waste Operations	E-Tunnel Ponds	None	^{3}H	5
	UGTA Wells	None	^{3}H	2
	Area 3 RWMS	Soil cover over waste	^{3}H	7
	Area 5 RWMC	Soil cover over waste	^{3}H	3
Support Facility Operations	Building 23-652	None	^{3}H	0.0000069

(a) All locations are on the NNSS except for Building A-01.
(b) ***High-efficiency particulate air (HEPA) filter***.

4.1.8 Radiological Emissions Compliance

The NNSS demonstrates compliance with air pathway 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 used to demonstrate compliance with the 40 CFR 61.92 dose standard since 2002. The six approved critical receptor locations are listed in Table 4-11 and displayed in Figure 4-2.

The following radionuclides from NNSS-related activities were detected at one or more of the critical receptor samplers: ^{3}H, ^{238}Pu, $^{239+240}Pu$, and ^{241}Am. Although ^{137}Cs was not detected at a critical receptor sampler, it was detected at one of the NNSS samplers (RWMS 5 Lagoons) and so is included here. All of their measured concentrations were well below their CLs. No man-made uranium was detected above levels found in blank filters (Section 4.1.4.5). The concentration of each measured man-made radionuclide at each of the six critical receptor samplers is divided by its respective CL (Table 4-1) to obtain a "fraction of CL." These are then summed for each sampler. The sum of these fractions at each critical receptor sampler is far less than 1; the highest sum was 0.057 at Schooner Crater. This demonstrates that the NESHAP dose limit of 10 mrem/yr at these critical receptor locations was not exceeded (Table 4-11).

Table 4-11. Sum of fractions of compliance levels for man-made radionuclides at critical receptor samplers in 2017

Radionuclides Included in Sum of Percents	NNSS Area	Sample Location	Sum of Fractions of Compliance Levels (CLs)
^{241}Am, ^{238}Pu, $^{239+240}Pu$, ^{137}Cs, and ^{3}H	6	Yucca	0.0092
	10	Gate 700 S	0.0086
	16	3545 Substation	0.0029
	20	Schooner	0.0565
	23	Mercury Track	0.0018
	25	Gate 510	0.0016

As a secondary measure of NNSS compliance with air pathway dose limits, the radioactive air emissions from each NNSS sample location in Table 4-11 were modeled using the ***Clean Air Package, 1988***, model (CAP88, Version 4.0; EPA 2014). Wind files containing frequency distributions of wind speed, direction, and stability class from CY 2017 meteorological stations on the NNSS were provided by the National Oceanic and Atmospheric Administration, Air Resources Laboratory, Special Operations and Research Division (ARL/SORD) (Appendix F). CAP88 predicted annual dose (mrem/year) from each emission source to each receptor were calculated. The highest value [***maximally exposed individual (MEI)***] is predicted to be 0.07 mrem/y for a person residing on the NTTR. The highest value off federal land was about the same at Springdale (Chapter 9 has a discussion of dose to the public from all pathways).

Nearly all radionuclides detected by environmental air samplers in 2017 appear to be from two sources: (1) legacy deposits of radioactivity on and in the soil from past nuclear tests, and (2) the upward flux of ^{3}H from the soil at sites of past nuclear tests and low-level radioactive waste burial. Long-term trends of $^{239+240}$Pu and ^{3}H in air continue to show a decline with time. Radionuclide concentrations in plants and animals on the NNSS and their potential impact are discussed in Chapter 8.

4.2 Nonradiological Air Quality Monitoring and Assessment

NNSS operations that are potential sources of air pollution include aggregate production, surface disturbance (e.g., construction), release of fugitive dust from driving on unpaved roads, use of fuel-burning equipment, open burning, venting from bulk fuel storage facilities, explosives detonations, and releases of various chemicals during testing. Air quality assessments are conducted to document compliance with the current State of Nevada air quality permit that regulates specific operations or facilities on the NNSS. The assessments mainly address nonradiological air pollutants. The State of Nevada has adopted the CAA standards, which include NESHAP, National Ambient Air Quality Standards (NAAQS), and New Source Performance Standards (NSPS). NESHAP compliance with radionuclide emissions monitoring and with air pathway public dose limits are presented in Section 4.1. Compliance with all other CAA air quality standards is addressed in this section. Data collection, opacity readings, recordkeeping, and reporting activities on the NNSS are conducted to meet the specific program goals in the table below.

Air Quality Assessment Program Goals
Ensure NNSS operations comply with all requirements of the current air quality permit issued by the State of Nevada.
Ensure emissions of criteria air pollutants (sulfur dioxide [SO2]), nitrogen oxides [NOX], carbon monoxide [CO], volatile organic compounds [VOCs], and particulate matter) and emissions of hazardous air pollutants do not exceed limits established under NAAQS and NESHAP, respectively.
Ensure emissions of permitted NNSS equipment comply with the opacity criteria set by NAAQS and NSPS.
Ensure NNSS operations comply with asbestos abatement reporting requirements under NESHAP.
Document usage of ***ozone-depleting substances (ODS)*** to comply with Title VI of the CAA.

4.2.1 Permitted NNSS Facilities

NNSA/NFO maintains a Class II Air Quality Operating Permit (AP9711-2557) for NNSS activities. State of Nevada Class II permits are issued for sources of air pollutants considered "minor," i.e., where annual emissions do not exceed 100 tons of any one ***criteria pollutant***, 10 tons of any one ***hazardous air pollutant (HAP)***, or 25 tons of any combination of HAPs. The NNSS facilities regulated by permit AP9711-2557 include the following:

- Approximately 14 facilities/131 pieces of equipment in Areas 1, 5, 6, 12, 23, 25, 26, 27, and 29
- Chemical releases at the Nonproliferation Test and Evaluation Complex (NPTEC) in Area 5 and in Port Gaston in Area 26
- Site-wide chemical releases (conducted throughout the NNSS)
- Big Explosives Experimental Facility (BEEF) in Area 4
- Explosives Ordnance Disposal Unit (EODU) in Area 11
- Explosives activities sites at NPTEC in Area 5; High Explosives Simulation Test (HEST) in Area 14; Test Cell C, Calico Hills, and Army Research Laboratory (ARL) in Area 25; Port Gaston in Area 26; and Baker in Area 27

4.2.2 Permit Maintenance Activities

An application to renew the NNSS air permit (AP9711-2557) was submitted to the Nevada Division of Environmental Protection (NDEP) in April 2014 prior to the permit's expiration in June 2014. By the end of 2017, the new permit had not been issued, but because the application was submitted prior to the state's deadline, subsequent operations are continued at the NNSS under a permit application "shield." Nevada Administrative Code (NAC) 445B allows for the continued operation of a stationary source until the permit is renewed or the application for renewal is denied. Also, as part of permit renewal application, the PM10 Sampling and

Meteorological Monitoring Systems Plan for particulate matter equal to or less than 10 microns in diameter was reformatted to incorporate all facilities into a single plan. New operational allowances requested in the 2014 application include:

- Elimination of the PM10 monitoring requirement for chemical releases (which do not contain particulates).
- Modification of the EODU reporting requirement to coincide with the submittal of other facility quarterly reports.
- Reduction of the site-wide HAP emissions cap for a single pollutant from 8 tons/year down to 7 tons/year. Actual emissions are typically < 1 ton/year.

Also, all operational allowances previously requested as modifications to the old permit were requested again as part of the 2014 renewal application. Because these allowances are not directly covered by the NAC but are enacted with the Director's approval, they are requested with each permit renewal. Requested allowances in the 2014 application include:

- Revision of the recordkeeping requirements for seven remotely located fuel-fired generators.
- Removal of the requirement to report the CEMP offsite air monitoring results.
- Elimination of the performance emissions test ("stack test") requirement for five diesel-fired generators and for eight baghouses associated with the aggregate plant, batch plant, and cementing services facilities.

It is expected that the majority of the requested allowances will appear in the renewed permit.

In 2017, two permit revisions were submitted to the state to add equipment to the 2014 renewal application. One revision was submitted in June to add several generators and to re-permit several pieces of construction equipment for use in a stemming operation. A second revision was submitted in November to add a new concrete batch plant. The new plant will eventually replace the existing one.

4.2.3 Emissions of Criteria Air Pollutants and Hazardous Air Pollutants

A source's regulatory status is determined by ***potential to emit (PTE)***; the maximum number of tons of criteria air pollutants and nonradiological HAPs it may emit in a 12-month period if the source were operated for the maximum number of hours and at the maximum production amounts specified in the source's air permit. The PTE is specified in an Air Emissions Inventory of all emission units. Each year, NNSA/NFO submits Actual Production/Emissions Reporting Forms to NDEP as required by the NNSS air permit. These forms report the actual annual operational information and the calculated emissions of the criteria air pollutants and HAPs for permitted emission units. The state uses the information to determine permit fees and to verify that emissions do not exceed the PTEs. Quarterly reports of HAP emission quantities were also submitted to NDEP in April, July, and October 2017, and January 2018. Quarterly reporting is required due to an NNSS-wide emissions limit or "cap" on HAPs. In February 2018, the Calendar Year 2017 Actual Production/Emissions Reporting Form was also submitted to NDEP.

All records examined in 2017 for permitted facilities and equipment indicate that operational parameters were being properly tracked and no PTEs were exceeded. An estimated 8.90 tons of criteria air pollutants were released (Table 4-12). The majority of the emissions were NO_X from diesel generators. An estimated 0.02 tons of HAPs were released in 2017 (Table 4-13). Table 4-13 also shows the calculated tons of air pollutants released on the NNSS over the past 10 years. Fluctuations in emissions over time reflect changes in project activities and facility operations.

Field measurements of particulate matter equal to or less than 10 microns in diameter (PM10) are required for all permitted explosives activities. The sampling systems must operate and record ambient PM10 concentrations at least each day a detonation or chemical release occurs. The PM10 emissions are reported to the state in reports specific to each series of detonations or chemical releases.

Unless specifically exempted, the open burning of any combustible refuse, waste, garbage, or oil is prohibited. Open burning for other purposes is allowed if approved in advance by the state issuance of an Open Burn Authorization. Open Burn Authorizations are renewed annually. At the NNSS, they are issued for fire extinguisher training and for support-vehicle live-fire training activities. In 2017, 24 fire extinguisher training sessions and 20 vehicle burns were conducted at the NNSS. Most of the fire extinguisher sessions used a new system that burns propane rather than diesel fuel, resulting in greatly reduced hydrocarbon emissions. Quantities of criteria air pollutants produced by open burns are not required to be calculated or reported.

Table 4-12. Tons of criteria air pollutant emissions released on the NNSS from permitted facilities operational in 2017

	Calculated Tons[(a)] per Year of Emissions									
	Particulate Matter (PM10)[(b)]		Carbon Monoxide (CO)		Nitrogen Oxides (NO_X)		Sulfur Dioxide (SO_2)		Volatile Organic Compounds (VOCs)	
Facility	**Actual**	**PTE[(c)]**	**Actual**	**PTE**	**Actual**	**PTE**	**Actual**	**PTE**	**Actual**	**PTE**
Construction Equipment										
Wet Aggregate Plant	0.25	2.94	NA[(d)]	NA	NA	NA	NA	NA	NA	NA
Concrete Batch Plant	0.03	2.33	NA	NA	NA	NA	NA	NA	NA	NA
Cementing Services Equipment	0.00	14.86	NA	NA	NA	NA	NA	NA	NA	NA
Fuel Burning/Storage										
Diesel Fired Generators	0.29	2.86	0.99	9.31	4.54	42.94	0.25	2.59	0.31	3.20
Gasoline Fired Generators	0.00	0.12	0.00	1.17	0.00	1.85	0.00	0.10	0.00	2.52
Propane Generators	0.00	0.02	0.01	0.95	0.01	1.44	0.000	0.001	0.00	0.20
Boilers	0.08	0.38	0.21	0.94	0.83	3.77	0.02	0.08	0.05	0.25
Bulk Gasoline Storage Tank	NA	NA	NA	NA	NA	NA	NA	NA	0.98	1.45
Bulk Diesel Fuel Storage Tank	NA	NA	NA	NA	NA	NA	NA	NA	0.01	0.02
Chemical Releases										
NPTEC	0	1.50	0	1.50	0	1.50	0	1.50	0	10.00
Detonations										
Port Gaston	0.00	0.21	0.00	1.49	0.00	0.085	0.00	0.01	0.00	0.01
NPTEC	0.00	0.21	0.00	1.485	0.00	0.085	0.00	0.01	0.00	0.01
BEEF	0.04	1.8	0.00	1.99	0.00	0.50	0.00	0.04	0.00	0.03
Total by Pollutant	0.69	27.23	1.21	18.84	5.38	52.17	0.27	4.33	1.35	17.69
Total Emissions	**Actual: 8.90 PTE: 120.26**									

(a) For metric tons (mtons), multiply tons by 0.9072
(b) Particulate matter equal to or less than 10 microns in diameter
(c) PTE's include only those facilities that were operational in 2017
(d) Not applicable: the facility does not emit the specified pollutant(s); therefore, there is no emission limit established in the air permit

Table 4-13. Criteria air pollutants and HAPs released on the NNSS over the past 10 years

	Total Emissions (tons/yr)[(a)]									
Pollutant	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Particulate Matter (PM10)[(b)]	0.22	0.49	1.09	2.40	6.51	0.45	0.43	0.52	1.10	0.54
Carbon Monoxide (CO)	0.94	0.55	1.33	3.70	2.38	1.54	1.44	1.74	1.81	0.51
Nitrogen Oxides (NO_X)	3.36	2.45	6.09	16.15	10.51	6.38	6.12	7.43	7.47	1.21
Sulfur Dioxide (SO_2)	0.06	0.10	0.36	1.20	1.14	0.23	0.19	0.39	0.31	0.01
Volatile Organic Compounds (VOCs)	0.60	0.71	0.33	1.68	1.08	1.69	1.35	1.69	1.45	1.14
Hazardous Air Pollutants (HAPs)[(c)]	0.09	0.30	0.02	0.04	0.03	0.23	0.03	0.03	0.02	0.02

(a) For mtons, multiply tons by 0.9072
(b) Particulate matter equal to or less than 10 microns in diameter
(c) The site-wide PTE for HAPs is 8 tons per individual HAP and 23.3 tons for all HAPs combined

4.2.4 Performance Emission Testing and State Inspection

The current NNSS air permit requires performance emission testing of equipment that vents emissions through stacks (called "point sources"). The tests must be conducted once during the 5-year life of the NNSS air permit for each specified source. Once a source accumulates 100 hours of operation (since issuance of the permit in June 2002), it must be tested within 90 days. Testing is conducted by inserting a probe into the stack while the equipment is operating. Visible emissions must also be read by a certified evaluator during the tests. No performance emission tests were conducted in 2017. It is anticipated that once the renewed NNSS air permit is issued (Section 4.2.2), none of the equipment will require performance testing. In addition, no state air inspections were conducted in 2017.

4.2.5 Opacity Readings

Visual opacity readings are conducted in accordance with permit and regulatory requirements. Personnel who take opacity readings are certified semiannually. In 2017, seven employees on the NNSS were certified. Readings were taken for the following NNSS facilities regulated under the NAAQS opacity limit of 20%: Area 1 Concrete Batch Plant, Area 1 Wet Aggregate Plant, and several diesel generators in various areas of the NNSS. None of the readings exceeded the 20% limit.

4.2.6 Chemical Releases and Detonations Reporting

The NNSS air permit regulates the release of chemicals at specific locations under three separate "systems": NPTEC in Area 5 (System 29), site-wide releases throughout the NNSS (System 81), and Port Gaston in Area 26 (System 95). The types and amounts of chemicals that may be released vary depending on the system. In 2017, the Spirit chemical test series was conducted at NPTEC. Fourteen small chemical releases were conducted over a 5-day period. In addition, the Vittorio II chemical test series was conducted at NPTEC. Four small chemical releases were conducted over a 4-day period. The chemicals released during both series included small amounts of HAPs. No permit limits were exceeded.

Near-surface explosives detonations can take place at nine locations on the NNSS (BEEF in Area 4; EODU in Area 11; NPTEC in Area 5; Port Gaston in Area 26; HEST in Area 14; Test Cell C, Calico Hills, and ARL in Area 25; and Baker in Area 27). BEEF is permitted to detonate large quantities of explosives (up to 41.5 tons per detonation with a limit of 50.0 tons per 12-month period), while the other locations are limited to much smaller quantities (1 ton per detonation with a limit of 10 tons per 12-month period). Permitted limits exist also for the amounts of criteria air pollutant and HAP emissions generated by the detonations. In 2017, explosives were detonated at BEEF, and no permit limits were exceeded (Table 4-12). A small detonation (less than 77 lbs of explosives) took place at EODU. Resulting criteria pollutant and HAP emissions were well within permit limits. No detonations took place at any of the other detonation facilities.

PM10 monitoring was conducted for each chemical release test and detonation at NPTEC in 2017. Monitoring was conducted in accordance with the permit and met calibration and performance audit requirements.

In addition to annual reporting, the NNSS air quality operating permit requires the submittal of test plans and final analysis reports to the state for chemical releases or release series and for detonations. For BEEF and for the detonation facilities, quarterly test plans and final reports are submitted for the types and weights of explosives and estimated emissions that may be released. Completion reports are submitted at the end of each calendar quarter for all chemical releases and detonations. In 2017, all of the required quarterly reports were submitted prior to the reporting deadline, and to streamline reporting, they were included in the quarterly HAPs reports to NDEP (Section 4.2.3).

4.2.7 Ozone-depleting Substances Recordkeeping

At the NNSS, refrigerants containing ODS are mainly in air conditioning units in vehicles, buildings, refrigerators, drinking water fountains, vending machines, and laboratory equipment. Halon 1211 and 1301, classified as ODS, have been used in the past in fire extinguishers and deluge systems, but all known occurrences of these halons have been removed from the NNSS. ODS recordkeeping requirements applicable to NNSS operations include maintaining evidence of technician certification at all times and for 3 years, recycling/recovery equipment approval, servicing records for appliances containing 22.7 kilograms (50 pounds) or more of refrigerant, and the amount and type of refrigerant sent offsite for reclamation.

4.2.8 Asbestos Abatement

A Notification of Demolition and Renovation Form is submitted to the EPA at least 10 working days prior to the start of a demolition or renovation project if the quantities of asbestos-containing material (ACM) to be removed are estimated to equal or exceed 260 linear ft, 160 square ft, or 35 ft^3. Small asbestos abatement projects are conducted during the year with the removal of lesser quantities of ACM and a Notification of Demolition and Renovation Form is not required.

Eleven Notification of Demolition and Renovation Forms were submitted in 2017. Seven notifications were for demolition of trailers and boxcars. Four notifications were for renovation activities at the NNSS. ACM was buried in the Area 10 or Area 23 ***solid waste*** disposal site as per each project's work plan. Friable materials are segregated in a defined section of the landfill.

The recordkeeping requirements for asbestos abatement activities include maintaining air and bulk sampling data records, abatement plans, and operations and maintenance activity records for up to 75 years; and maintaining location-specific records of ACM for a minimum of 75 years. Compliance is verified through periodic internal management assessments. Asbestos abatement records continue to be maintained as required.

4.2.9 Fugitive Dust Control

The NNSS Class II Air Quality Operating Permit states that the best practical methods should be used to prevent particulate matter from becoming airborne prior to the construction, repair, demolition, or use of unpaved or untreated areas. At the NNSS, the main method of dust control is the use of water sprays. In 2017, field personnel observed operations throughout the NNSS for the occurrence of excessive fugitive dust, and water sprays were used to control dust at sites where trenching and digging activities occurred in Areas 1, 12, and 23.

Off the NNSS, all NNSA/NFO surface-disturbing activities that cover 5 or more acres are regulated by stand-alone Class II Surface Area Disturbance (SAD) permits issued by the state. Current SADs exist for the operation of three Underground Test Area (UGTA) wells on the Nevada Test and Training Range: ER-EC-13, ER-EC-14, and ER-EC-15. No activities occurred at these wells in 2017, and all reporting requirements of the SADs were met.

4.2.10 Environmental Impact of Nonradiological Emissions

In 2017, NNSS activities produced a total of 8.90 tons of criteria air pollutants and 0.02 tons of HAPs. These small quantities had little, if any, impact on air quality on or around the NNSS. NNSS air pollutant emissions are very low compared to the estimated daily releases from point sources in Clark County, Nevada. For example, the average annual projected emissions of NO_X in Clark County for base year 2002 through projected year 2018 is 37,549 tons per year (Pollack 2007), whereas the estimated annual release from the NNSS in 2017 of 5.38 tons of NO_X represents 0.01% of Clark County's projected annual emissions of this criteria pollutant.

Impacts of the chemical release tests at the NNSS are minimized by controlling the amount and duration of each release. Biological monitoring at NPTEC is performed if there is a risk of significant exposure to downwind plants and animals from the planned tests. To date, chemical releases at NPTEC and other locations are such small quantities (when dispersed into the air) that downwind test-specific monitoring has not been warranted. No measurable impacts to downwind plants or animals have been observed.

4.3 References

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Chapter 5: Water Monitoring

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This chapter presents the recent results of water monitoring conducted on and near the Nevada National Security Site (NNSS) by the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) and the Environmental Management (EM) Nevada Program. NNSA/NFO and EM Nevada Program monitor groundwater to provide safe drinking water for NNSS workers and visitors, avoid NNSS groundwater contamination from current activities, and protect the public and environment from areas of known underground contamination from historical nuclear testing. Water is monitored to comply with applicable state and federal water quality and water protection regulations, U.S. Department of Energy (DOE) directives, and the Federal Facility Agreement and Consent Order (FFACO) between the DOE, the U.S. Department of Defense, and the State of Nevada. Laws and regulations applicable to water monitoring are listed in Table 2-1.

The Nevada Division of Public and Behavioral Health is allowed access to the NNSS to independently sample onsite water supply wells at its discretion. Monitoring results from the state's independent sampling and analysis are also presented in this chapter if the state performed sampling during the reporting year. The state did not sample in 2017.

The Community Environmental Monitoring Program (CEMP) and the Nye County Tritium Groundwater Monitoring Program perform annual, independent radiological monitoring of water supply systems in communities surrounding the NNSS and emphasize community involvement. The Nye County Tritium Groundwater Monitoring Program is funded through a grant from EM Nevada Program and the CEMP is established by NNSA/NFO. Sections 7.2 and 7.3 describe CEMP's and Nye County's groundwater monitoring activities in 2017.

5.1 Radiological Monitoring

Radionuclides[1] have been detected in the groundwater in some areas of the NNSS. The presence of radionuclides is a result of historical underground nuclear tests (UGTs). Between 1951 and 1992, 828 UGTs were conducted, and approximately one-third were detonated near or in the ***saturated zone*** (NNSA/NFO 2015). The FFACO (as amended) established underground test area (UGTA) corrective action units (CAUs) that geographically group the UGTAs (Figure 5-1). A complete description of the hydrogeological environment in which UGTs were conducted is in *Attachment A: Site Description.*[2]

In 2014, an integrated approach to assess both the extent of groundwater contamination from UGTs and impact of testing on water quality in communities downgradient of historical UGTs was implemented through the NNSS Integrated Groundwater Sampling Plan (NNSA/NFO 2014), referred to hereafter as the Plan. The Plan is a comprehensive approach for collecting and analyzing groundwater that combined routine radiological monitoring performed by NNSA/NFO (Bechtel Nevada 2003) with that performed by EM Nevada Program's UGTA Activity. It was designed to meet both the NNSA/NFO and EM Nevada Program's radiological water monitoring objectives not already covered by a permit (compliance wells and NNSS public water system [PWS] wells) (green text box below). NNSS public water system (PWS) wells are sampled quarterly and Compliance well sampling is consistent with the applicable permit requirements.

[1] The definition of word(s) in ***bold italics*** may be found by clicking on the word in electronic version or by referencing the Glossary, Appendix B. To return from the Glossary, right click and select Previous View.
[2] *Attachment A: Site Description* is included on the compact disc of this report and on the NNSA/NFO web site at http://www.nnss.gov/pages/resources/library/NNSSER.html.

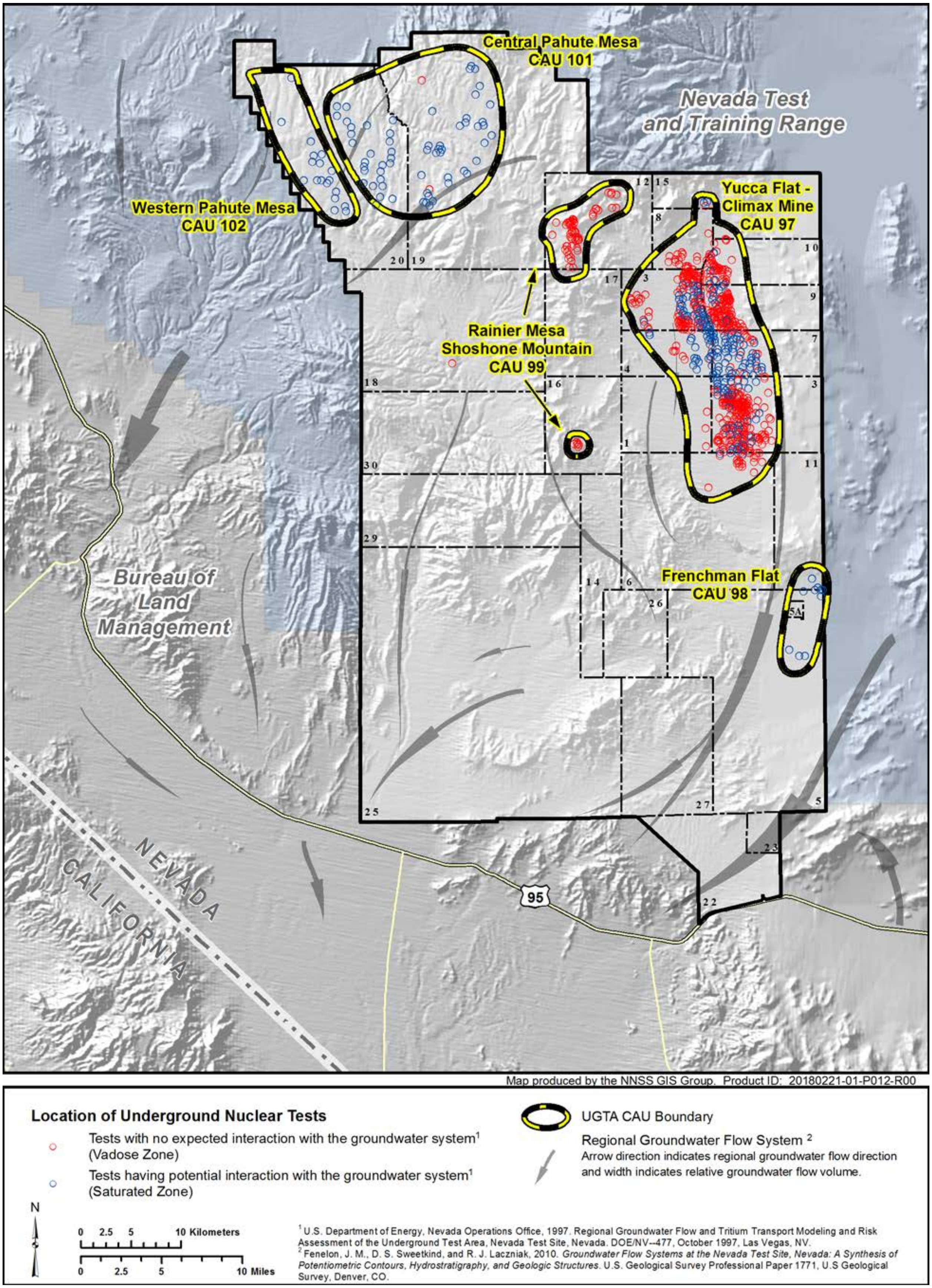

Figure 5-1. Locations of underground nuclear tests and UGTA CAUs on the NNSS

Radiological Water Monitoring Objectives
Provide data to complete corrective actions prescribed under the FFACO to protect the public from groundwater contaminated by historical underground nuclear testing.
Monitor water supply wells on the NNSS (referred to as onsite wells) to demonstrate safety of drinking water.
Determine compliance with the ***dose*** limits to the general public set by DOE O 458.1 via the water pathway (Chapter 9 for estimates of public dose).
Determine compliance with wastewater discharge permit limits for radionuclides at permitted NNSS facilities.
Monitor wells downgradient of an NNSS radioactive waste disposal unit in accordance with a Resource Conservation and Recovery Act (RCRA) permit to ensure wastes do not impact groundwater.

5.1.1 NNSA/NFO and EM Nevada Program Groundwater Sampling Design

The radiological water sampling network consists of 84 sample locations (Figure 5-2), categorized into seven different well types. Table 5-1 defines sample source type and the monitoring objectives, ***analytes***, and sample frequency associated with each. Some locations are monitored to meet multiple objectives.

The Plan focuses on evaluating the extent and movement of contaminants resulting from UGTs and describes sampling for the first five sample source types shown below (Characterization, Source/Plume, Early Detection, Distal, and Community). Baseline data are established at downgradient locations (the Regional Groundwater Flow System arrows in Figure 5-2 depicting groundwater flow direction and volume) so that the presence of ***radioisotopes*** is known with a high level of certainty well before they reach SDWA limits.[3] No NNSS springs are formally included in the sampling network; however, NNSA/NFO has monitored and reported on some springs periodically including Cane, Captain Jack, Cottonwood, Gold Meadows, John's, Tipipah, Topopah, Tub, Twin, and Whiterock springs (Figure A-4 of *Attachment A: Site Description*).The groundwater that feeds these springs is not hydrologically connected to the ***aquifers*** that may be impacted by UGTs. Detectable man-made radionuclides in onsite springs are from historical atmospheric testing activities, including global radioactive fallout (NNSA/NSO 2008).

Table 5-1. Definitions and objectives for NNSA/NFO and EM Nevada Program radiological water sample types

Sample Source Type	Definition	Objective	Analytes	Frequency
Characterization	Used for system characterization or model evaluation	• Develop and/or evaluate flow and transport models • Identify groundwater flow paths • Establish the presence or absence of groundwater contaminants of concern (COCs) and contaminants of potential concern (COPCs) • Estimate travel time of contaminants • Reclassified and sampled according to new type when above objectives are met	Specific to UGTA Strategy stage (FFACO, as amended) for each UGTA CAU (may include general chemistry, metals, gamma emitters, age and migration parameters, gross alpha, gross beta, and other radioisotopes)	2–3 years, as needed
Source/Plume	Located within the plume from an underground nuclear test (i.e., test-related contamination present)	• Develop and/or evaluate flow and transport models • Identify COCs for downgradient wells • Monitor contaminant migration • Monitor natural attenuation of radiological contaminants	Radiological COCs and CAU-specific COPCs (Table 5-2)	4 years
Early Detection	Located downgradient of an UGT and no radioisotopes detected above the minimum detection level for standard analysis	• Develop and/or evaluate flow and transport models • Detect and monitor plume edge	Tritium (^{3}H) (low-level analysis)	2–5 years

[3] NNSA/NFO and EM Nevada Program do not monitor water at locations upgradient from the UGTA CAUs.

Table 5-1. Definitions and objectives for NNSA/NFO and EM Nevada Program radiological water sample types

Sample Source Type	Definition	Objective	Analytes	Frequency
Distal	Downgradient of the Early Detection area	• Monitor COC (^{3}H) below SDWA 1,000 pCi/L detection limit • Develop and/or evaluate flow and transport models	^{3}H (standard analysis)	5 years
Community	Located on Bureau of Land Management (BLM) or private land; used as a water supply source or is near one	• Monitor COC (^{3}H) below SDWA 1,000 pCi/L detection limit	^{3}H (standard analysis)	5 years
NNSS PWS	Permitted water supply well that is part of a state-designated non-community public water system (PWS) on the NNSS	• Monitor to demonstrate safety of NNSS drinking water (radiological monitoring is not required by the state for non-community PWSs)	^{3}H (standard analysis), gross alpha, gross beta	Quarterly
Compliance	Sampled to comply with specific federal/state regulations or permits	• Determine if radiological COCs are within permit limits	As specified by permit	As specified by permit

(a) Sampling frequencies can be up to 5-year intervals because of low groundwater velocity and the resulting slow change over time in radionuclide concentrations expected within certain wells.

5.1.1.1 Analytes

An inventory of 43 radionuclides produced by NNSS UGTs is presented in Finnegan et al. (2016). Many of these radionuclides are relatively immobile because they are bound within the melt glass produced during nuclear detonation or have chemical properties that cause them to bind strongly to the aquifer rock materials. Radionuclides that are most mobile in groundwater and produced in high abundance from nuclear testing have the greatest potential for impacting groundwater quality.

A single contaminant of concern (COC) and, at some locations, additional contaminants of potential concern (COPCs) were identified based on the Finnegan et al. (2016) inventory, an understanding of the radionuclide's relative mobility, previous sampling and analysis data, and modeling results (Table 5-2). ***Tritium (^{3}H)*** is the single COC for all sample locations based on extensive groundwater characterization data from wells throughout each CAU. Subsequently, the Plan prescribes ^{3}H analysis for all sampling locations at frequencies of two to five years (Table 5-1). NNSS public water system (PWS) wells are sampled quarterly, and Compliance well sampling is consistent with the applicable permit requirements.

Tritium (^{3}H) is a radioactive form of hydrogen with a half-life of 12.3 years. The Safe Drinking Water Act (SDWA) limit for ^{3}H in drinking water is 20,000 pCi/L. If an individual drank water with this amount of ^{3}H for an entire year, it would amount to the same dose of radiation as a single commercial flight between Los Angeles and New York City.

pCi/L [picocurie per liter] is a unit used to express the amount of radioactivity in one liter of a gas or a liquid. A picocurie is one-trillionth of a ***Curie***, and 1 pCi/L is the amount of radioactive material in 1 liter of a gas or liquid that will produce 0.037 disintegrations per second. In the case of ^{3}H, a disintegration is the emission of a beta particle.

For all CAUs except Rainier Mesa/Shoshone Mountain, ^{3}H is the only radionuclide included in the inventory that is known to have exceeded its SDWA maximum contaminant level (MCL) of 20,000 picocuries per liter (pCi/L) in sampling locations away from the nuclear test cavity (NNSA/NFO 2014). Although plutonium (Pu) has been reported above its SDWA MCL of 15 pCi/L in T Tunnel, located in Rainier Mesa (Zavarin 2009), it has not been detected in downgradient wells at concentrations above 10% of its SDWA MCL. Pu has therefore been identified as a COPC for the Rainier Mesa/Shoshone Mountain CAU and is analyzed for in all Characterization and Source/ Plume well samples in that CAU. Similarly, the other CAU-specific COPCs (Table 5-2) may have exceeded their SDWA MCLs in samples collected from the test cavity, but have generally not exceeded 10% of their MCLs in downgradient locations.

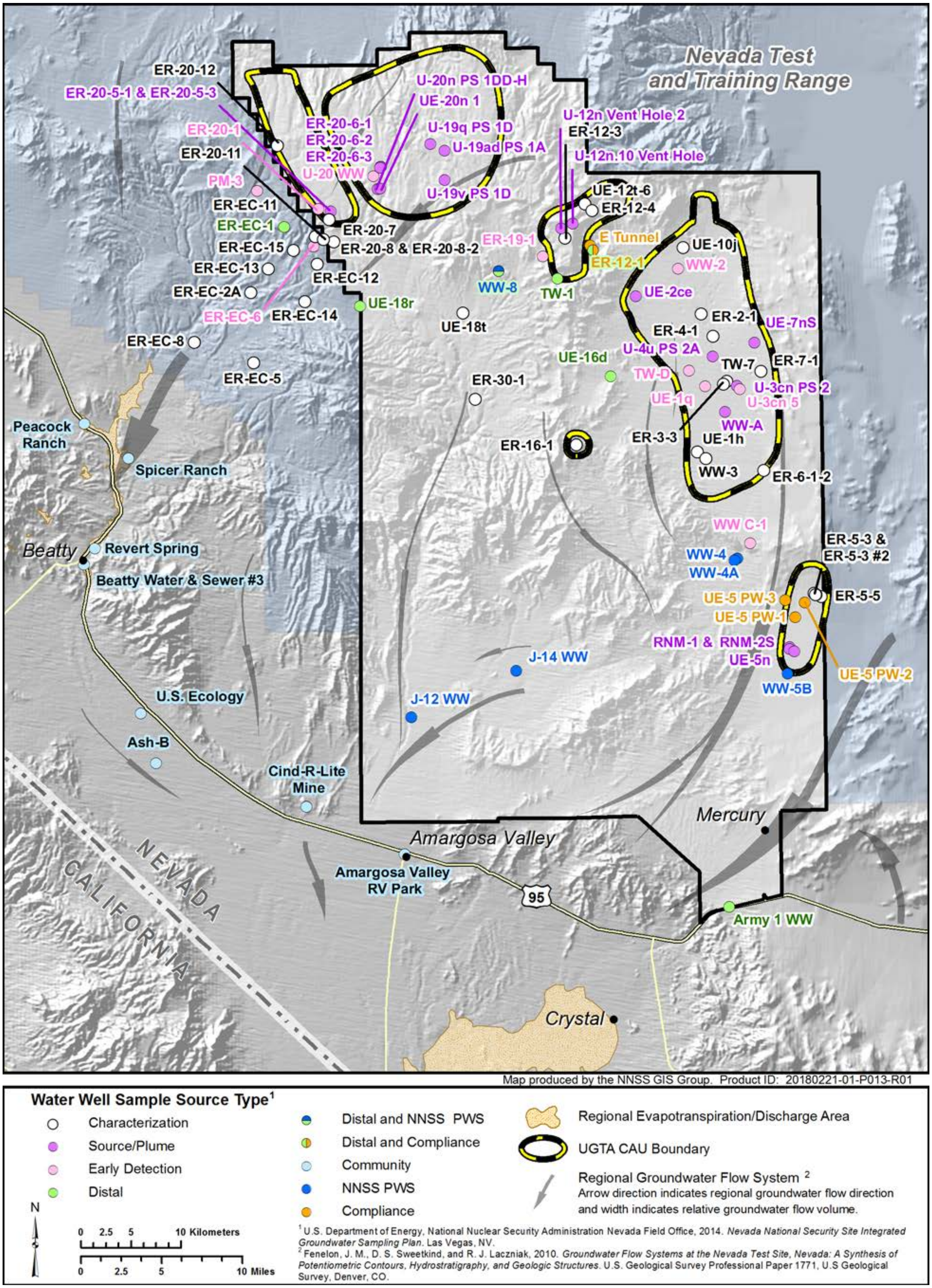

Figure 5-2. NNSA/NFO and EM Nevada Program water sampling network

Table 5-2. CAU-specific COCs and COPCs

CAU	COC(a)	COPC(b)
Frenchman Flat	^{3}H	^{14}C, ^{36}Cl, ^{99}Tc, and ^{129}I
Pahute Mesa	^{3}H	^{14}C, ^{36}Cl, ^{99}Tc, and ^{129}I
Rainier Mesa/Shoshone Mountain	^{3}H	^{14}C, ^{36}Cl, ^{90}Sr, ^{99}Tc, ^{129}I, and Pu
Yucca Flat/Climax Mine	^{3}H	^{14}C, ^{36}Cl, ^{99}Tc, and ^{129}I (and ^{90}Sr and ^{137}Cs in the lower carbonate aquifer samples)

Note: See Table 1-5 for a listing of full names and ***half-lives*** of radionuclide abbreviations listed.

(a) A radionuclide that has exceeded its SDWA MCL in sampling locations downgradient from a nuclear test cavity.

(b) A radionuclide that has the potential to become a COC based either on historical analytical data and/or on model results. COPCs may have exceeded SDWA MCLs in samples from a nuclear test cavity, but have generally not exceeded 10% of their MCLs in sampling locations downgradient from a test cavity.

Groundwater characterization data show that COPCs, if present, are at insignificant levels (i.e., < 0.1% of their MCL) unless ^{3}H is present at concentrations that greatly exceed its 20,000 pCi/L MCL. Therefore, COPCs are only analyzed in Source/Plume wells, where ^{3}H exceeds the detection limit for standard ^{3}H analysis (300 pCi/L). Instrumentation capable of detecting COPCs at levels well below their MCLs are used for their analysis in Source/Plume and Characterization well samples. This ensures that a baseline for COPC levels is established and that they will be detected early. Trends in the COPC data will be evaluated to determine whether a COPC should be reclassified as a COC and monitored in Early Detection wells. Samples collected from Characterization wells are analyzed for many of the immobile radionuclides listed in Finnegan et al. (2016). These radionuclides have not been found near their SDWA MCL in any of the samples, including those collected from underground nuclear test cavities. While not analyzed routinely as part of the Plan, the suite of radionuclides will be periodically expanded for some Source/Plume wells to confirm that they are not present near their MCLs in groundwater in, or downgradient of, the underground nuclear test cavities.

Gross alpha (α) and ***gross beta*** (β) ***radioactivity*** and gamma ***spectroscopy*** analyses are conducted for Characterization wells to establish a baseline. Gross alpha and gross beta radioactivity continue to be monitored for NNSS PWS wells and for certain Compliance water sampling locations, as required.

5.1.1.2 Sample Collection Methods

Water sampling methods are based, in part, on the characteristics and configurations of sample locations. For example, wells with dedicated pumps may be sampled from the associated plumbing (e.g., spigots) at the wellhead, while wells without pumps may be sampled using a wireline bailer or a portable pumping system. Most wells in the sample network are single-zone completion wells; samples are collected from one depth interval. Some wells, however, are multiple-completion wells and are sampled at multiple depths (e.g., wells ER-EC-11, -12, -13, -14, and -15).

Water samples are generally collected in a manner that ensures they represent ambient formation water following the sampling methods described in standard operating procedures. This may involve purging the well until the stability of certain water quality parameters (e.g., pH, temperature, and electrical conductivity) is achieved. Stabilization of these water quality parameters indicates that formation water is being sampled instead of stagnant water from within and surrounding the wellbore. In some cases, samples are collected using a depth-discrete bailer. While these samples may not be as representative of ambient formation water as samples collected using a pump, they are considered to be adequate for certain sampling objectives (e.g., sufficient to demonstrate early detection of ^{3}H at levels well below the 20,000 pCi/L MCL).

Water sampling methods also depend on the suite of analytes and the hydrogeological system being sampled. Determination of cost-effective groundwater monitoring technologies is an active area of study for UGTA. These studies include identifying mobile sampling technologies capable of sampling the deep (up to 4,100 feet) wells included in the Plan.

5.1.1.3 Detection Limits

Samples collected from all Early Detection wells and from some Characterization wells are enriched before ^{3}H analysis. These wells are expected to have ^{3}H levels less than 300 pCi/L, which is the approximate ***minimum detectable concentration (MDC)*** using a standard (or un-enriched) analysis method. The enrichment process (DOE 1997), referred to throughout this report as low-level ^{3}H analysis, concentrates ^{3}H in a sample to allow for a lower MDC, from approximately 2 to 40 pCi/L depending on the laboratory performing the enrichment process. For samples with expected levels of ^{3}H above the laboratory's standard detection capability, ^{3}H enrichment is not performed. The MDC for standard ^{3}H analyses (approximately 300 pCi/L) is well below the U.S. Environmental Protection Agency (EPA) SDWA-required detection limit of 1,000 pCi/L for ^{3}H. For COPCs (Table 5-2), standard methods for analysis are performed by State of Nevada certified commercial laboratories. The MDCs must be at or below the SDWA MCL. For gross alpha and beta radioactivity the MDCs are 2 and 4 pCi/L, respectively, and satisfy their EPA SDWA required detection limits of 3 and 4 pCi/L, respectively.

> The standard ^{3}H analysis method can detect ^{3}H at levels ≥ 300 pCi/L.
>
> The low-level ^{3}H analysis method, which concentrates ^{3}H in a sample through an enrichment process, can detect ^{3}H at levels of 2–40 pCi/L.
>
> Groundwater samples collected at all Early Detection wells are analyzed using the low-level ^{3}H analysis method.

Lawrence Livermore National Laboratory (LLNL) uses highly sensitive instrumentation to analyze ^{3}H concentrations when standard methods are not sufficient to detect ^{3}H; LLNL can detect ^{3}H at concentrations less than 1 pCi/L. Similarly, LLNL uses highly sensitive methods for COPC analyses for samples from Source/Plume and Characterization wells. These methods are capable of measuring natural levels of some COPCs (^{14}C and ^{36}Cl) in the groundwater. LLNL is not certified by the NDEP Bureau of Safe Drinking Water and therefore these results are not used for regulatory purposes.

Analysis routinely includes quality control samples such as duplicates, blanks, and spikes. Chapter 14 describes ***quality assurance*** and ***control*** procedures for groundwater samples and analyses.

5.1.2 Presentation of Water Sampling Data

NNSA/NFO and EM Nevada Program classifies each well in the sample network into one of four ^{3}H concentration levels. The four categories are based on the percent of SDWA MCL (20,000 pCi/L) each well represents at the maximum ^{3}H concentration measured in the most recent sampling event (Table 5-3 and Figure 5-3). Seventeen Source/Plume or Characterization wells and E Tunnel discharge currently exceed the SDWA MCL; all are located on the NNSS.

Table 5-3. Tritium concentration categories

^{3}H Concentration (X) in pCi/L	Percent of SDWA MCL	# of locations in each category
X < 1,000	< 5[(a)]	65
1,000 < X < 10,000	5–50	3
10,000 < X < 20,000	50–100	1
X > 20,000	> 100 (Exceeds SDWA MCL)	18

(a) includes samples in which ^{3}H is undetectable

Table 5-4 shows ^{3}H concentrations for the most recent sampling events at wells in the sampling network. For wells with multiple samples within the same year, the highest concentration is listed. Similarly, for wells sampled at multiple depths during a single sampling event, the depth with the highest concentration is listed. For example, the Plan requires that three ***piezometers*** and the main completion of Well ER-20-12 are sampled as Characterization wells; Table 5-3 and Table 5-4 only report the results of the most shallow piezometer for ER-20-12 because the greatest concentration of ^{3}H is associated with this sample location (Section 5.1.3.1). Data in Table 5-4 are grouped by CAU and then by sample location type. When ^{3}H was not detected, the value is reported as less than the sample's MDC (i.e., <1.5 or <270 when the sample's MDC is either 1.5 or 270 pCi/L, respectively). Results from the analyses for radionuclides identified as COPCs (Table 5-2) are not presented in this report but can be acquired upon request from NNSA/NFO. The ^{3}H, gross alpha, and gross beta levels for water samples in 2017 for the NNSS PWS and Compliance sampling locations are listed in Table 5-5.

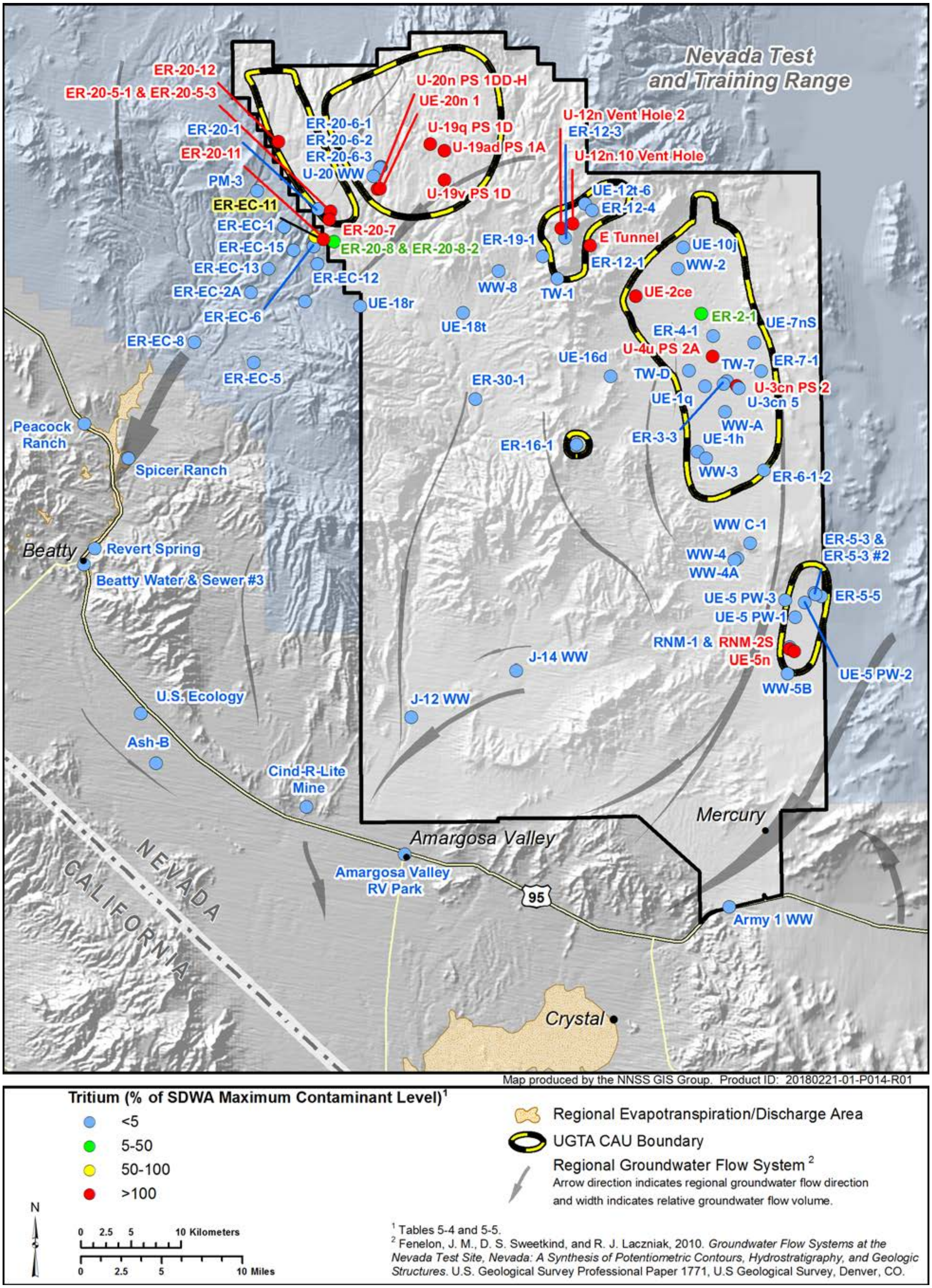

Figure 5-3. Tritium concentration categories at NNSA/NFO and EM Nevada Program sampling locations

Table 5-4. Tritium concentrations for the most recent sample at wells in the NNSA/NFO and EM Nevada Program sample network.

Sample Location	Land Management or NNSS Area	Sample Year	Maximum ^{3}H Concentration (pCi/L)[(a)(b)]
Yellow highlight indicates ^{3}H levels above the SDWA MCL of 20,000 pCi/L			
Frenchman Flat			
Characterization Wells			
ER-5-3[(c)]	Area 5	2017	<2.67
ER-5-3-2[(c)]	Area 5	2017	<2.82
ER-5-5[(c)]	Area 5	2017	<2.77[(d)]
Source/Plume Wells			
RNM-1	Area 5	2014	620
RNM-2S[(c)]	Area 5	2017	86,000
UE-5n[(c)]	Area 5	2017	132,000
Inactive Wells			
ER-11-2[(c)]	Area 5	2017	<3.03
Pahute Mesa (Central and Western)			
Characterization Wells			
ER-20-7	Area 20	2017	13,600,000
ER-20-8	Area 20	2017	6,600
ER-20-8-2	Area 20	2017	3,670
ER-20-11	Area 20	2017	202,000
ER-20-12	Area 20	2017	58,100
ER-EC-2A	NTTR[(e)]	2016	<2.90
ER-EC-5	NTTR	2003	<320
ER-EC-8	NTTR	2016	<4.52[(f)]
ER-EC-11	NTTR	2017	18,400
ER-EC-12	NTTR	2016	<2.99[(g)]
ER-EC-13	NTTR	2013	<3.0
ER-EC-14	NTTR	2014	<2.2
ER-EC-15	NTTR	2014	<2.1
Source/Plume Wells			
ER-20-5-1	Area 20	2015	24,800,000
ER-20-5-3	Area 20	2015	84,000
ER-20-6-1	Area 20	2017	<270
ER-20-6-2	Area 20	2017	390[(h)]
ER-20-6-3	Area 20	2017	<290
U-19ad PS 1A	Area 19	2008	12,900,000
U-19q PS 1D	Area 19	2003	11,000,000
U-19v PS 1D	Area 19	2009	84,900,000
U-20n PS 1DD-H	Area 20	2005	33,300,000
UE-20n 1	Area 20	2012	55,500,000
Early Detection Wells			
ER-20-1	Area 20	2017	<2.91
PM-3	NTTR	2016	194
ER-EC-6	NTTR	2017	6.66
U-20 WW	Area 20	1999	<29
Distal Wells/Locations			
ER-EC-1	NTTR	2016	<2.87
UE-18r	Area 18	2017	<188
Community Wells/Springs			
Amargosa Valley RV Park	BLM	2017	<211
Ash B, Piezometer 1	BLM	2014	<183
Ash B, Piezometer 2	BLM	2014	<177
Beatty Water & Sewer #3	Beatty	2017	<201
Cind-R-Lite Mine	BLM	2017	<205
Peacock Ranch	Private land	2017	<209
Revert Spring	Private land	2012	<22

Table 5-4. Tritium concentrations for the most recent sample at wells in the NNSA/NFO and EM Nevada Program sample network.

Sample Location	Land Management or NNSS Area	Sample Year	Maximum ^{3}H Concentration (pCi/L)[(a)(b)]
Yellow highlight indicates ^{3}H levels above the SDWA MCL of 20,000 pCi/L			
Spicer Ranch	Private land	2017	<205
U.S. Ecology	BLM	2017	<207
Inactive Wells			
U-20i PS1D	Area 20	2017	1,070,000
Rainier Mesa/Shoshone Mountain			
Characterization Wells			
ER-12-3	Area 12	2016	27.3
ER-12-4	Area 12	2016	7.62
ER-16-1	Area 16	2017	<2.33
ER-30-1	Area 30	2017	<2.64
UE-12t-6	Area 12	2017	<2.13
UE-18t	Area 18	2016	<3.07
Source/Plume Wells			
U-12n.10 Vent Hole	Area 12	2017	5,550,000
U-12n Vent Hole 2	Area 12	2017	930,000
Early Detection Wells			
ER-19-1	Area 19	2016	3.31[(i)]
Distal Wells			
ER-12-1[(j)]	Area 12	2017	<350
TW-1	Area 17	2013	<22
UE-16d	Area 16	2017	<213
WW-8[(k)]	Area 18	2017	<282
Yucca Flat/Climax Mine			
Characterization Wells			
ER-2-1	Area 2	2015	1,010
ER-3-3	Area 3	2016	<1.0
ER-4-1	Area 4	2017	<2.78
ER-6-1-2	Area 6	2004	<370
ER-7-1	Area 7	2014	<3.8
TW-7	Area 7	2015	<2.5
UE-1h	Area 1	2017	<2.53
UE-10j	Area 8	1997	<210
WW-3	Area 3	2015	6.3
Source/Plume Wells			
U-3cn PS 2	Area 3	2007	7,680,000
U-4u PS 2A	Area 4	2008	24,100,000
UE-2ce	Area 2	2016	144,000
UE-7nS	Area 7	2015	53
WW-A	Area 3	2012	355
Early Detection Wells			
TW-D	Area 4	2013	<27
U-3cn 5	Area 3	2017	12.3
UE-1q	Area 1	2013	<26
WW C-1	Area 6	2012	<27
WW-2	Area 2	2015	<2.2
Distal Wells			
Army 1 WW	Area 22	2015	<229

(a) For multiple samples within the same year, the highest value is presented.
(b) Concentrations presented as less than (<) a number, indicate that ^{3}H levels are less than its sample-specific MDC shown. When the results of multiple samples are below the MDC, the lowest MDC is reported.
(c) Well is included in the Frenchman Flat Post-Closure Monitoring Network (Section 11.1.2).
(d) A low concentration (1.92 pCi/L) was detected by LLNL in this well. This is consistent with previous results from this well. LLNL is not state certified and therefore these results are not used for regulatory purposes (Section 11.1.2).
(e) NTTR = Nevada Test and Training Range.

(f) The reported value (<4.52 pCi/L) is for the regular field sample. In the ER-EC-8 duplicate sample, ^3H was detected at 10.8 pCi/L, but was later determined to have been a false positive resulting from contamination during collection, handling, or analysis. The laboratory is reanalyzed the samples and ^3H was below the 3.8 and 3.7 pCi/L MDCs for the sample and duplicate, respectively.
(g) This 2016 result (<2.99 pCi/L) is associated with the shallow sampling interval for ER-EC-12. In 2012, samples collected from a deep interval of this well had a detectable ^3H level of 4.2 pCi/L.
(h) The reported value (390 pCi/L) is only slightly greater than the analytical detection limit (320 pCi/L) and is considered highly uncertain (measurement error is 210 pCi/L). It is likely that no ^3H is present in well ER-20-6-2.
(i) The reported value (3.31 pCi/L) is only slightly greater than the analytical detection limit (3.01 pCi/L) and is considered highly uncertain (measurement error is 1.98 pCi/L). It is likely that no ^3H is present in well ER-19-1.
(j) ER-12-1 is also a Compliance well (Table 5-5).
(k) WW-8 is also a NNSS PWS well (Table 5-5).

Table 5.5. Sample analysis results from NNSS PWS wells and Compliance wells/surface waters.

Sample Location	NNSS Area	Sample Date	Concentration (pCi/L)[(a)]		
			^3H	α[(b)]	β[(b)]
NNSS PWS Wells					
J-12 WW	Area 25	1/24/2017	<216	2.3	3.4
		1/24/17 FD[(c)]	<208	2.9	3.6
		5/9/2017	<228	2.6	4.8
		7/25/2017	<244	2.2	4.4
		10/24/2017	<165	<1.8	4.5
J-14 WW	Area 25	1/2/2017	<215	3.8	6.6
		5/22/2017	<208	2.2	8
		7/25/2017	<242	5.8	11.6
		10/24/2017	<164	3	8.4
WW-4	Area 6	1/24/2017	<217	10.1	4.2
		5/9/2017	<232	10.2	8.8
		7/25/2017	<240	8.2	5
		10/24/2017	<174	8.1	4.6
		10/24/17 FD	<176	6.5	4.9
WW-4A	Area 6	1/24/2017	<216	12.9	6.2
		5/9/2017	<227	8.5	4.4
		5/9/17 FD	<232	11.7	6.9
		7/25/2017	<246	6.6	5.3
		10/24/2017	<169	12.1	5.6
WW-5B	Area 5	1/24/2017	<210	4.7	8.8
		5/9/2017	<231	6.8	10.3
		7/25/2017	<238	4.4	10
		7/25/17 FD	<243	7.2	12
		10/24/2017	<168	4.3	9.6
WW-8	Area 18	1/24/2017	<213	<1.2	2.3
		5/9/2017	<231	3.2	4.7
		7/25/2017	<241	<1.0	4.4
		11/30/2017	<282	<1.4	4.6
Compliance Wells/Surface Waters					
UE-5 PW-1	Area 5	3/7/2017	<219	6	5.2
		3/7/17 FD	<227	NA[(d)]	NA
		3/7/17 FD	<222	NA	NA
		8/15/2017	<270	7.3	5.8
		8/15/17 FD	<278	7.2	7.9
		8/15/17 FD	<275	NA	NA
UE-5 PW-2	Area 5	3/8/2017	<218	5.9	4.6
		3/8/17 FD	<226	NA	NA
		3/8/17 FD	<225	NA	NA
		8/15/2017	<272	6.9	6.6
		8/15/17 FD	<275	NA	NA
		8/15/17 FD	<281	NA	NA
UE-5 PW-3	Area 5	3/8/2017	<216	5.9	3.3
		3/8/17 FD	<234	NA	NA
		3/8/17 FD	<222	NA	NA

Table 5.5. Sample analysis results from NNSS PWS wells and Compliance wells/surface waters.

Sample Location	NNSS Area	Sample Date	Concentration (pCi/L)[(a)]		
			^{3}H	α[(b)]	β[(b)]
Compliance Wells/Surface Waters					
UE-5 PW-3	Area 5	8/15/2017	<276	6.6	4.4
		8/15/17 FD	<265	NA	NA
		8/15/17 FD	<275	NA	NA
ER-12-1[(e)]	Area 12	4/19/2017	<350	12.3	9.3
		4/19/17 FD	<350	9.81	5
		4/19/17 1RR1	NA	5.01	1.9
		4/19/17 2RR1	NA	5.01	5
E Tunnel Waste Water Disposal System	Area 12	10/23/2017	319,000	11.4	24.1
		10/23/17 FD	307,000	7.9	26.4

(a) Concentrations given as less than (<) a number indicate ^{3}H levels are less than its sample-specific MDC shown.
(b) α = ***gross alpha*** and β = ***gross beta***.
(c) FD = field duplicate sample.
(d) NA = not applicable, analysis was not performed.
(e) α in Well ER 12-1 and E Tunnel Waste Water Disposal System is reported as adjusted α.

5.1.3 Discussion of 2017 Sample Results

The following sections discuss results for the seven well types that comprise the radiological water sampling network (Table 5-1). In addition, results are discussed for samples collected from wells of interest to UGTA, but which are not in the Plan (i.e., Inactive Wells/Sampling Locations; Section 5.1.3.8). As illustrated in Figure 5-2, all Characterization, Source/Plume, Early Detection, Distal, NNSS PWS, and Compliance wells are on government-owned property. All Community wells or springs are on BLM or private land. As reflected in Table 5-4 and discussed in the sections below, no test-related radionuclides have been detected in the Distal or Community wells. Consistent with the definition of Early Detection wells (^{3}H levels are less than 300 pCi/L), low concentrations of ^{3}H have been detected at a few locations. Sampling results from NNSS PWS wells indicate that water sources used by NNSS personnel are not affected by past UGTs. In addition, all regulatory requirements associated with Compliance well samples were satisfied.

5.1.3.1 Characterization Wells

Thirty-one Characterization wells are currently included in the sampling network including one new well in the Western Pahute Mesa CAU and two new wells in the Yucca Flat/Climax Mine CAU. Characterization wells are either new wells, or wells that require additional radionuclide data to establish a baseline and/or to ensure the current list of COCs and COPCs (Table 5-2) is accurate for the CAU. Once a baseline has been developed, each Characterization well will be reclassified and sampled according to its new type (Source/Plume, Early Detection, Distal, or Community). In 2017, EM Nevada Program sampled a total of 14 Characterization wells.

Frenchman Flat CAU - Three Characterization wells are present in this CAU and all were sampled as part of post-closure monitoring (Section 11.1.2) in 2017. Well ER-5-3 is near five UGT locations in northern Frenchman Flat. ER-5-3-2 is in the Frenchman Flat CAU but was initially selected to monitor potential radionuclide transport out of the Yucca Flat basin through the regional lower carbonate aquifer. The EM Nevada Program now uses Well ER-5-3-2 as a monitoring well for the lower carbonate aquifer in Frenchman Flat. The third Characterization well, ER-5-5, was drilled in 2012 to evaluate Phase II flow and contaminant transport models. No ^{3}H was detected using low-level ^{3}H analysis by the state certified commercial laboratory (Table 5-4). A very low concentration of ^{3}H (1.92 pCi/L) was detected in ER-5-5 by LLNL in the 2017 sample consistent with the value reported by LLNL in 2013 (1.1 pCi/L) and with the model forecasts (Navarro Nevada Environmental Services, LLC, 2010).

Pahute Mesa CAUs - Thirteen Characterization wells are associated with the Central and Western Pahute Mesa CAUs. Six Characterization wells were sampled in 2017 (ER-20-7, ER-20-8, ER-20-8-2, ER-20-11, ER-20-12, and ER-EC-11; Table 5-4). To date, ^{3}H has been detected in a total of seven Characterization wells (ER-20-7, ER-20-8, ER-20-8-2, ER-20-11, ER-20-12, ER-EC-11, and ER-EC-12). A very low reported concentration of ^{3}H was detected in the deepest interval of ER-EC-12 (4.2 pCi/L; footnote g of Table 5-4). Additional sampling and analyses are needed to confirm such a marginally measureable amount of ^3H in Well ER-EC-12. Sampling of this deep interval is planned for 2018.

Tritium in wells ER-20-7, ER-20-8, and ER-20-8-2, ER-20-11, and ER-EC-11 (Table 5-4) is believed to represent a downgradient extension of the Benham-Tybo contaminant plume (Section 11.1.1.2). The highest ^3H concentration among the Characterization wells is at Well ER-20-7, sampled in 2017 (13,600,000 pCi/L; Table 5-4). This well is 960 meters (m) (3,150 feet [ft]) and 2,100 m (6,890 ft) from the detonation points for the Tybo and Benham UGTs, respectively. The ^3H concentration in ER-20-7 has been decreasing since it was first sampled in 2010. This decrease is consistent with ^3H decay over 7 years. An increase in ^3H concentration was observed in the remaining characterization wells sampled in 2017 that are associated with the Benham-Tybo contaminant plume (ER-20-11, ER-EC-11, ER-20-8, ER-20-8-2 [Figure 5-4]).

> ^3H was detected in Well ER-EC-11, a Characterization well in the Pahute Mesa CAUs, in 2009 at 10,600 pCi/L. This was the first time that a radionuclide from NNSS UGTs had been detected in groundwater beyond NNSS boundaries. In 2017, it was detected at 18,400 pCi/L. This concentration is below the allowable drinking water limit of 20,000 pCi/L set by the EPA.

ER-20-12, in the far northwestern portion of the NNSS, is approximately 2.3 kilometers (km) (1.4 miles [mi]) south–southwest of the Handley UGT and approximately 5.1 km (3.2 mi) north–northeast of Well PM-3. It consists of the main borehole, which accesses a deep aquifer, along with four piezometers that access four additional depth intervals. Four aquifers can be accessed from this well (two piezometers access the same aquifer). In 2017, EM Nevada Program collected samples from two of the ER-20-12 piezometers using a pump and from one piezometer using a depth disrete bailer. The maximum ^3H concentration observed at ER-20-12 (58,100 pCi/L) is assocated with the bailed sample collected from the shallow piezometer at a depth of 547 m (1,795 feet). This concentration is over 30% greater than that reported in 2016 (39,200 pCi/L) from the same piezometer at a depth of 493 m (1,617 ft) bgs; however, it is important to note the depth for the 2016 sample from this piezometer was mistakenly reported in 2016 as 890 m (2,920 feet) bgs. The second greatest concentration of ^3H (41,600 pCi/L) is observed in the samples collected from the main well at a depth interval of 1,194 to 1,385 m (3,916 to 4,543 ft) bgs. The ^3H concentration is lower (25,600 pCi/L) in the piezometer just above this main completion (1,019 to 1,135 m; 3,343 to 3,725 ft bgs) and lower yet (< 320 pCi/L) in the piezometer above (765 to 898 m; 2,510 to 2,947 ft bgs). The depth of the Handley UGT detonation point was 1,209 m (3,967 ft) bgs.

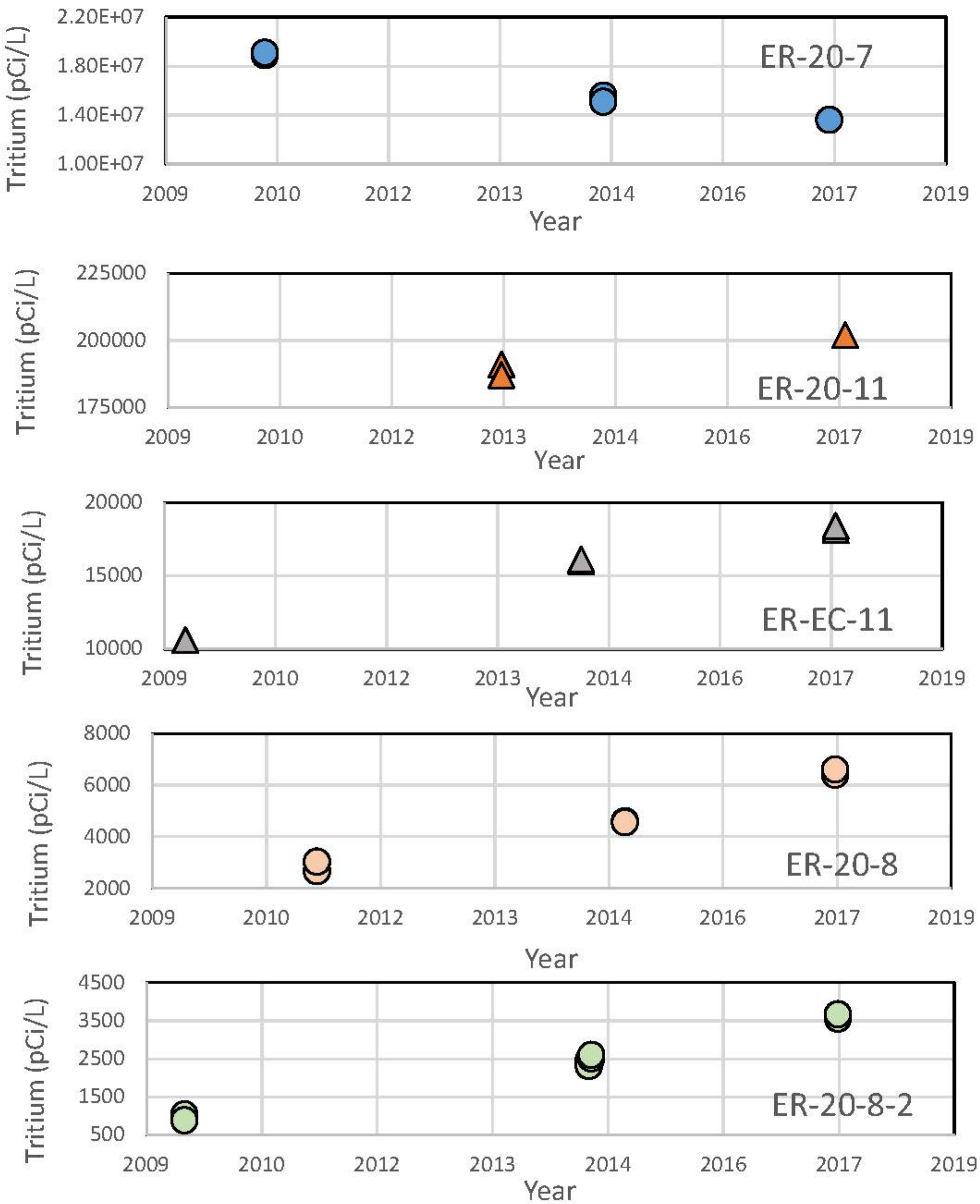

Figure 5-4. Tritium trends in wells downgradient of the Benham-Tybo contaminant plume.[4]

Rainier Mesa/Shoshone Mountain CAU - Six Characterization wells are located within this CAU (Table 5-4) and three (ER-16-1, ER-30-1, and UE-12t-6) were sampled in 2017. No ^{3}H was detected in the ER-16-1, ER-30-1, and UE-12t-6 samples (Table 5-4). While these results are consistent with previous sampling at ER-16-1 and ER-30-1, the 2017 samples were the first collected from UE-12t-6. The UE-12t-6 sample was collected with a bailer at a 253 m (830 ft). The Characterization wells may be re-categorized as Early Detection or Distal wells depending on their levels of ^{3}H and relative proximity to UGTs after characterization is complete.

Yucca Flat/Climax Mine CAU - Nine Characterization wells are located within this CAU. Two wells (ER-4-1 and UE-1h) were sampled in 2017 and no ^{3}H was observed in either location (Table 5-4). Both wells sample the lower carbonate aquifer (LCA) within Yucca Flat. This regional aquifer is considered the only groundwater pathway for radionuclides to leave the Yucca Flat basin because, although more shallow aquifers may hydraulically communicate with the LCA below them, they do not have any flow pathways directly leading

[4] Tritium scale (y-axis) varies for each well per trend range.

outside the basin (EM Nevada Program 2017). Monitoring the LCA is therefore emphasized within this CAU. Characterization wells ER-3-3, ER-6-1-2, and ER-7-1 also monitor the LCA and no ^{3}H has been detected in these wells to date (some using standard analysis and some using the low-level analysis method [Table 5-4]). The low-level ^{3}H analysis method will be used in the future for all Characterization wells in this CAU to verify the presence or absence of ^{3}H at the lower MDC. ER-6-1-2 and UE-10j are rescheduled for sampling again in fiscal year 2018.

Tritium has been detected in two Characterization wells, ER-2-1 and WW-3, that sample units overlying the LCA. The ^{3}H concentration was reported as 1,010 pCi/L at ER-2-1 in 2015, which is an increase from the reported 228 pCi/L value reported in 2003. This well is located within 1 mile of 62 nuclear tests, 19 of which are near or below the ***water table***. Five of the tests that were below the water table are within 457 m (1,500 ft) of ER-2-1 (Elliott and Fenelon 2010). The low concentration of ^{3}H (6.3 pCi/L) detected in WW-3 in 2015 is thought to result from an adjacent surface-water pond rather than from an underground nuclear test. The Characterization wells will likely be re-categorized as Source/Plume, Early Detection, or Distal wells depending on the presence/absence of ^{3}H and their relative proximity to the UGTs after characterization is complete.

5.1.3.2 Source/Plume Wells

Twenty Source/Plume wells are included in the sampling network. They have detectable radionuclides from NNSS underground nuclear testing and vary in location from within a test cavity where radionuclide concentrations are high, to downgradient of the detonation, where radionuclide concentrations can be relatively low in comparison to SDWA MCLs. With the exception of Source/Plume wells sampled in Frenchman Flat as part of post-closure monitoring, samples are collected every 4 years (three samples per one ^{3}H half-life). All Frenchman Flat post-closure monitoring wells will be sampled annually over the over the first five years of closure (NNSA/NFO 2016). All Source/Plume wells are analyzed for ^{3}H and CAU-specific COPCs (Table 5-2). Two Source/Plume wells in the Frenchman Flat CAU, three in Pahute Mesa CAUs, and two in the Rainier Mesa/Shoshone Mountain CAU were sampled in 2017.

Frenchman Flat CAU - Three Source/Plume wells are located in this CAU, and two were sampled in 2017 as part of post-closure monitoring (Section 11.1.2). Both wells exceeded the 20,000 pCi/L SDWA MCL for ^{3}H (Table 5-4; Figure 5-3). The ^{3}H concentration in the 2017 sample was greater (86,000 pCi/L) than the 2016 value of 76,000 for RNM-2S and was lower (132,000 pCi/L) than the 2016 value of 135,000 pCi/L for UE-5n. None of the COPCs were detected in the 2017 water samples. RNM-1 accesses the explosion region of the Cambric UGT (Stoller-Navarro Joint Venture [SNJV] 2005). As a result of extensive pumping of RNM-2S from 1975 to 1991, the ^{3}H in RNM-1 groundwater no longer exceeds SDWA MCLs; therefore, this well is not included in the network of Frenchman Flat post-closure monitoring wells.

Pahute Mesa CAUs - Ten Source/Plume wells, associated with six different UGTs, are located within the Central and Western Pahute Mesa CAUs and three (ER-20-6-1, ER-20-6-2, and ER-20-6-3) were sampled in 2017 (Table 5-4). Wells ER-20-6-1, ER-20-6-2, and ER-20-6-3 were used for a pumping experiment in 1997 to improve understanding of radionuclide movement away from a UGT within the Central Pahute Mesa CAU. Well ER-20-6-3, located 296 m (971 ft) from the Bullion UGT, was pumped at a rate sufficient to create an artificial gradient that was greater than the natural gradient, thereby controlling flow in the aquifer (IT Corporation 1998). Well ER-20-6-3 is the furthest from the Bullion UGT of the three wells. Samples were collected periodically from ER-20-6-1, ER-20-6-2, and ER-20-6-3 during the pumping period. The ^{3}H concentrations increased from 1,000 to 4,000 pCi/L in ER-20-6-3 and decreased from 17,000 to 3,150 pCi/L and from 70,800 to 7,000 pCi/L in ER-20-6-1 and ER-20-6-2 respectively during the pumping experiment (LLNL 1998). The reported tritum was below the MDC for ER-20-6-1 and ER-20-6-3 samples and near the analytical detection limit of 320 pCi/L in ER-20-6-2 (Table 5-4). This is a significant decrease over the 20 years since the wells were last sampled.

The groundwater in the remaining Source/Plume wells exceed the ^{3}H MCL (Table 5-4; Figure 5-3). A few radionuclides (^{90}Sr, ^{129}I, ^{137}Cs, and Pu) exceed their SDWA MCLs (8, 200, 1, and 15 pCi/L, respectively) in samples from wells drilled directly into a test cavity (U-19ad PS 1A, U-19v PS 1D, and U-20n PS 1DD-H). They have not, however, exceeded their MCLs in wells located away from the test cavity, even where the wells are within 300 m of the cavity (U-19q PS 1D and UE-20n 1) and when high levels of ^{3}H were detected.

Rainier Mesa/Shoshone Mountain CAU – The two Source/Plume locations within the Rainier Mesa/Shoshone Mountain CAU were sampled in 2017 (Table 5-4). The N Tunnel complex was sealed in 1994 and became flooded with groundwater, which is sampled through the vent holes to monitor radionuclides within the tunnel complex. The ^{3}H decreased from 6,260,000 pCi/L (2008) to 5,550,000 pCi/L (2017) in U-12n.10 Vent Hole and from 1,030,000 pCi/L (2011) to 930,000 pCi/L (2017) in U-12n Vent Hole 2. In the U-12n.10 Vent Hole, ^{129}I (3.3 pCi/L) is reported above its 1-pCi/L MCL and ^{36}Cl (99 pCi/L) is within 10% of its 700 pCi/L SDWA MCL. It is important to note that the reported result for ^{129}I at U-12n.10 Vent Hole (3.3 pCi/L) is highly uncertain. The result is quite close to the 1.5 pCi/L MDC when the analytical error (1.6 pCi/L) is considered.

Yucca Flat/Climax Mine CAU - Five Source/Plume wells are located within the Yucca Flat/Climax Mine CAU (Table 5-4) but were not sampled in 2017. Three of the five Source/Plume locations exceed the 20,000 pCi/L SDWA MCL. Two of the Source/Plume wells are drilled directly into a test cavity (U-3cn PS 2 and U-4u PS 2A). The combined presence of four radionuclides (^{14}C, ^{90}Sr, ^{129}I, and ^{137}Cs) in well U-4u PS 2A exceeds the SDWA MCL for beta- and photon-emitting radionuclides allowed in drinking water, which is the combined concentration of such emitters that would result in an ***exposure*** of 4 mrem/yr. No other radionuclides in samples from Source/Plume wells in this CAU exceed the SDWA MCL. Well WW-A is located approximately 520 m (1,705 ft) from a test cavity. Tritium was detected in WW-A in the late 1980s, peaked at ~700 pCi/L in 1999, and declined to 355 pCi/L by 2012. No radionuclides are present at levels ≥10% of their SDWA MCLs in wells located away from a test cavity within the Yucca Flat/Climax Mine CAU.

5.1.3.3 Early Detection Wells

Ten Early Detection wells are included in the sampling network: four within the Pahute Mesa CAUs, one within the Rainier Mesa/Shoshone Mountain CAU, and five within the Yucca Flat/Climax Mine CAU; there are no Early Detection wells currently associated with the Frenchman Flat CAU (Table 5-4). Early Detection Wells are the next wells downgradient of a UGT or Source/Plume well and have expected ^{3}H levels less than the MDCs for standard ^{3}H analyses (i.e., < 300 pCi/L). In the absence of ^{3}H, no other test-related radionuclides are present in historically sampled groundwater; therefore, Early Detection wells are monitored solely for low levels of ^{3}H using the low-level ^{3}H method. Early Detection wells associated with the Central and Western Pahute Mesa CAUs are sampled every 2 years to ensure that the plume front is detected in a reasonable time frame and that a time trend for ^{3}H is established early. For the other CAUs, the sampling frequency is once every 5 years because of the low groundwater velocities and the resulting slow change in radionuclide concentration with time. Two Early Detection wells in Pahute Mesa CAUs (ER-EC-6 and ER-20-1) and one in Yucca/Flat/Climax Mine CAU (U-3cn-5) were sampled in 2017.

Pahute Mesa CAUs - Wells ER-EC-6 and ER-20-1 were sampled in 2017 using depth discrete bailers. Samples were collected from the same shallow section of ER-EC-6 (451 m [1,480 ft] bgs) previously sampled using a pump. The 2017 ^{3}H concentration (6.7 pCi/L) is similar to that reported in 2015 (5.2 pCi/L). This likely represents the leading edge of the Tybo-Benham plume (Section 11.1.1.2). Well ER-20-1 was also sampled at a depth of 619 m (2,030 ft) and no ^{3}H was detected. The lack of ^{3}H in this well is consistent with the pumped sample collected in 2015.

Yucca Flat/Climax Mine CAU – Well U-3cn 5, accessing groundwater from the LCA below the Bilby UGT, was sampled in 2017. The Bilby cavity is estimated to be approximately 60 m (197 ft) from the top of the LCA (Navarro-Intera, LLC 2013). Tritium (12.3 pCi/L) was reported for the U-3cn 5 sample. This ^{3}H concentration is considered very low especially when compared to the 7,680,000 pCi/L concentration observed in U-3cn PS 2 located approximately 121 m (397 ft) away, accessing in the Bilby cavity and chimney. The lack of ^{3}H migration from the Bilby UGT to groundwater sampled by U-3cn 5 demonstrates the effectiveness of the ***confining units*** that overlie the LCA as barriers to contaminant migration (Section 11.1.1.4).

5.1.3.4 Distal Wells

Seven Distal wells are included in the sampling network: two for the Pahute Mesa CAUs, four for the Rainier Mesa/ Shoshone Mountain CAU, and one for the Yucca Flat/Climax Mine CAU; there are no Distal wells currently associated with the Frenchman Flat CAU (Table 5-4). Distal wells are analyzed for ^{3}H using the standard EPA method. Samples are collected at a 5-year frequency. The sampling objective for these wells is to demonstrate that ^{3}H is not present downgradient of UGTs at levels above the SDWA-required minimum detection limit of 1,000 pCi/L. These wells also support the development and evaluation of the groundwater flow and contaminant transport models. Three Distal wells (ER-12-1, UE-16d, and WW-8) within the Rainier Mesa/Shoshone Mountain CAU and one Distal well (UE-18r) within the Pahute Mesa CAUs were sampled in 2017. No ^{3}H was detected (Tables 5-4 and 5-5). WW-8 is also an NNSS PWS well (Section 5.1.3.6) and ER-12-1 is also a Compliance Well (Section 5.1.3.7.2).

5.1.3.5 Community Wells/Springs

Nine Community sampling locations occur within the sampling network, all associated with the Pahute Mesa CAUs (Table 5-4). Six were sampled in 2017. These wells and springs are either used as private, business, or community water supply sources or are near such sources, and they are sampled for ^{3}H every 5 years. Sampling at a 5-year frequency is sufficient because of the long flow paths to these locations, the low groundwater velocities, and the monitoring of Early Detection wells upgradient from the Community wells and springs. Early Detection well samples will detect the arrival of a contaminant plume at very low concentrations (i.e., measuring ^{3}H at 0.01% of its MCL) long before such a plume could be detected in these more distant private, business, or community water supply sources. Samples are analyzed using a standard EPA method. The objective is to demonstrate that ^{3}H is not present at levels above the SDWA-required minimum detection limit of 1,000 pCi/L. Beatty Water and Sewer #3 has replaced Well EW-4 in the network because Well EW-4 is not available for sample collection. Sampling at Beatty Water and Sewer #3 was a joint effort with the Nye County Tritium Samping Program. No ^{3}H has been detected at any of these locations (Table 5-4; Chapter 7).

5.1.3.6 NNSS Public Water System Wells

Results from the NNSS PWS water wells sampled quarterly in 2017 continue to indicate that historical underground nuclear testing has not impacted the NNSS water supply network. No ^{3}H measurements were above their MDCs using the EPA standard analysis method (Table 5-5). Gross alpha and gross beta radioactivity were found at concentrations slightly greater than their MDCs in most 2017 samples and are believed to represent the presence of naturally occurring radionuclides. However, no water supply samples had gross alpha measurements that exceeded the EPA MCL (15 pCi/L) or gross beta measurements that exceeded the EPA level of concern (50 pCi/L). Baseline sampling for uranium in 2016 yielded very low concentrations (0.38 to 6.9 µg/L), believed to be naturally occurring. Uranium levels were 1.2 to 23% of the EPA MCL of 30 µg/L in drinking water. Due to the low level results, no further uranium sampling is planned.

5.1.3.7 Compliance Wells/Groundwater Discharges

5.1.3.7.1 RCRA Permitted Wells for the Area 5 Mixed Waste Disposal Unit

Wells UE-5 PW-1, UE-5 PW-2, and UE-5 PW-3 are sampled semi-annually for ^{3}H. They are monitored for ^{3}H and nonradiological parameters (Section 10.1.7) to verify the performance of the Area 5 Mixed Waste Disposal Unit (Cell 18), which is operated under a RCRA permit. In 2017, standard ^{3}H analyses of the wells' water samples were performed; all samples had non-detectable levels of ^{3}H (Table 5-5), and their MDCs were well below the permit established investigation level (IL) of 2,000 pCi/L. Further groundwater analysis is required if the IL is exceeded. Results continue to indicate that Cell 18 radioactive wastes have not contaminated local groundwater. Table 10-3 presents the 2017 sampling results for four additional indicators of groundwater contamination, and all 2017 sample analysis results for these three wells are presented in MSTS (2018).

5.1.3.7.2 NDEP Permitted E Tunnel Waste Water Disposal System

NNSA/NFO manages and operates the NDEP Permitted E Tunnel Waste Water Disposal System (ETDS) in Area 12 under a water pollution control permit (NEV 96021) issued by the Nevada Division of Environmental Protection (NDEP) Bureau of Federal Facilities. The permit governs the management of radionuclide-contaminated wastewater that drains from the E Tunnel portal into a series of holding ponds. The permit requires Well ER-12-1 groundwater to be monitored once every 24 months and E Tunnel discharge waters (retained in the E Tunnel Ponds) to be monitored once every 12 months for ^{3}H, gross alpha, and gross beta as well as for numerous nonradiological parameters (Table 5-9).

On October 23, 2017, annual sampling for radiological analyses of ETDS discharge water was performed. The permissible limits for ^{3}H, adjusted gross alpha, and gross beta in the tunnel discharge waters are 1,000,000 pCi/L, 35.1 pCi/L, and 101 pCi/L, respectively. On April 19, 2017, biennial sampling for radiological analyses of well ER-12-1 groundwater was performed. The permissible limits for ^{3}H, adjusted gross alpha, and gross beta in the groundwater in Well ER-12-1 are identical to the EPA SDWA limits of 20,000 pCi/L, 15 pCi/L, and 50 pCi/L, respectively.

Well ER-12-1 sample results indicated no ^{3}H measurements for Well ER-12-1 were above their MDCs using an EPA-approved standard analysis method (Table 5-5) (Navarro 2018). Gross ***beta radioactivity*** and adjusted gross ***alpha radioactivity*** were found at concentrations below permit permissible limits of 50 pCi/L and 15 pCi/L, respectively. The primary and field duplicate were analyzed twice to assure adjusted gross alpha and gross beta concentrations were accurate. All 2017 samples from the E Tunnel Ponds and Well ER-12-1 were below their permit limits (Table 5-5).

5.1.3.7.3 *UGTA Well Discharged Groundwater and Fluids*

UGTA wells are regulated by the state through an agreement between NNSA/NFO and NDEP called the UGTA Fluid Management Plan (Attachment 1 of NNSA/NSO 2009). The plan prescribes the methods for disposing groundwater and fluids pumped from UGTA wells during drilling, development, and testing based on the levels of radiological contamination. Discharge water and drilling fluids with ≥400,000 pCi/L of ^{3}H are required to be diverted to lined or unlined sumps to evaporate. Samples of the discharge water from the wellhead are analyzed for gross alpha, gross beta, ^{3}H, and RCRA-regulated metals to ensure discharged water is below the established fluid management criteria for these parameters. When the ^{3}H level in discharge water and drilling fluids is ≥400,000 pCi/L, lead is monitored in the field to ensure the RCRA limit for lead of 5 milligrams per liter (mg/L) is not exceeded; exceeding this level may result in the generation of hazardous or mixed waste in a sump, which could result in the suspension of drilling operations.

In 2017, the only well sampled with ^{3}H ≥400,000 pCi/L was ER-20-7 (13,600,000 pCi/L). Groundwater purged from this well was directed to a lined sump. With the exception of UE-5n and RNM-2S, groundwater from all UGTA wells was discharged into a lined or unlined sump. Groundwater from UE-5n was discharged into an infiltration area and RNM-2S was discharged into the Cambric ditch. Samples from the Rainier Mesa vent holes were collected with a bailer. While the ^{3}H exceeded 400,000 pCi/L in the two vent holes, these samples were collected using a bailer and there is no discharge from samples collected using a bailer. Grab samples from all of the discharge water were below the fluid management criteria limits for all analyzed parameters.

5.1.3.8 Underground Test Area Inactive Wells/Sampling Locations

Sampling locations not assigned to one of the seven previously discussed water sample location types are called Inactive Wells or Inactive Sampling Locations; they are not included in the water sampling network depicted in Figures 5-2 and 5-3. Two inactive wells (ER-11-2, and U-20i PS1) were sampled in 2017.

Well ER-11-2 is included in the Frenchman Flat post-closure monitoring network, but is considered an Inactive Well with respect to the Plan. ER-11-2 was sampled in 2017, and no ^{3}H was detected.

U-20i PS1, located on Pahute Mesa, is a post-shot hole drilled in 1976 to evaluate the environment near the Boxcar UGT in support of Pahute Mesa ***source term*** characterization. The maximum ^{3}H concentration observed in U-20i PS1 samples collected in 2017 using a bailer was 1,070,000 pCi/L (Table 5-4). This high concentration is expected because the sample was collected near the Boxcar detonation point. An evaluation of these data is in progress.

5.2 Nonradiological Drinking Water and Wastewater Monitoring

The quality of drinking water and wastewater on the NNSS is regulated by federal and state laws. The design, construction, operation, and maintenance of many of the drinking water and wastewater systems are regulated under state permits. NNSA/NFO ensures systems meet applicable water quality standards and permit requirements. The NNSS nonradiological water monitoring goals are shown below. They are met by analyzing water samples, performing assessments, and maintaining documentation. This section describes the results of 2017 activities. Results from radiological monitoring of drinking water on and off the NNSS and of wastewater on the NNSS is discussed in sections 5.1.3.5, 5.1.3.6, and 5.1.3.7.

Nonradiological Water Monitoring Goals
Ensure that the operation of NNSS ***public water systems (PWSs)*** and ***private water systems*** provides high-quality drinking water to workers and visitors at the NNSS.
Determine if NNSS PWSs are operated in accordance with the requirements in Nevada Administrative Code NAC 445A, "Water Controls," under permits issued by the state.
Determine if the operation of commercial septic systems that process domestic wastewater on the NNSS meets operational standards in accordance with the requirements NAC 445A under permits issued by the state.
Determine if the operation of industrial wastewater systems on the NNSS meets operational standards of federal and state regulations as prescribed under the GNEV93001 state permit.

5.2.1 Drinking Water Monitoring

Six wells on the NNSS are permitted to supply the potable water needs of NNSS operations. These are grouped into three PWSs (Figure 5-5). The largest system (Areas 23 and 6) is classified under its permit as a non-transient non-community PWS and serves the main work areas of the NNSS. The other two systems (Area 12 and Area 25) are classified as transient non-community PWSs. The PWSs are designed, operated, and maintained in accordance with the requirements in NAC 445A under permits issued by the NDEP Bureau of Safe Drinking Water (BSDW). PWS permits are renewed annually.

The three PWSs must meet National Primary Drinking Water Standards and Secondary Standards (set by the state) for water quality. They are sampled according to a 9-year monitoring cycle, which identifies the specific classes of contaminants to monitor at each drinking water source, and the frequency (Table 5-6). At sample locations in buildings, the sampling point for coliform bacteria is a sink within the building. Samples for chemical contaminants are collected at the points of entry to the PWS. Although not required by regulation or by any permit, NNSA/NFO collects samples inside service connections for coliform bacteria to further ensure safe drinking water.

For work locations at the NNSS not connected to a PWS, NNSA/NFO hauls potable water in two water tanker trucks. Three work locations (the Device Assembly Facility [DAF] in Area 6, the Joint Actinide Shock Physics Experimental Research facility in Area 27, and the Area 5 Radioactive Waste Management Site) are designated as service connections to the Area 23 and 6 PWS. The trucks are permitted by the BSDW, and the water they carry is subject to water quality standards for coliform bacteria (Table 5-6). Normal water delivery is to remote service connections and hand-washing stations at construction sites, which are activities not subject to permitting. NNSA/NFO renews the permits for the trucks annually.

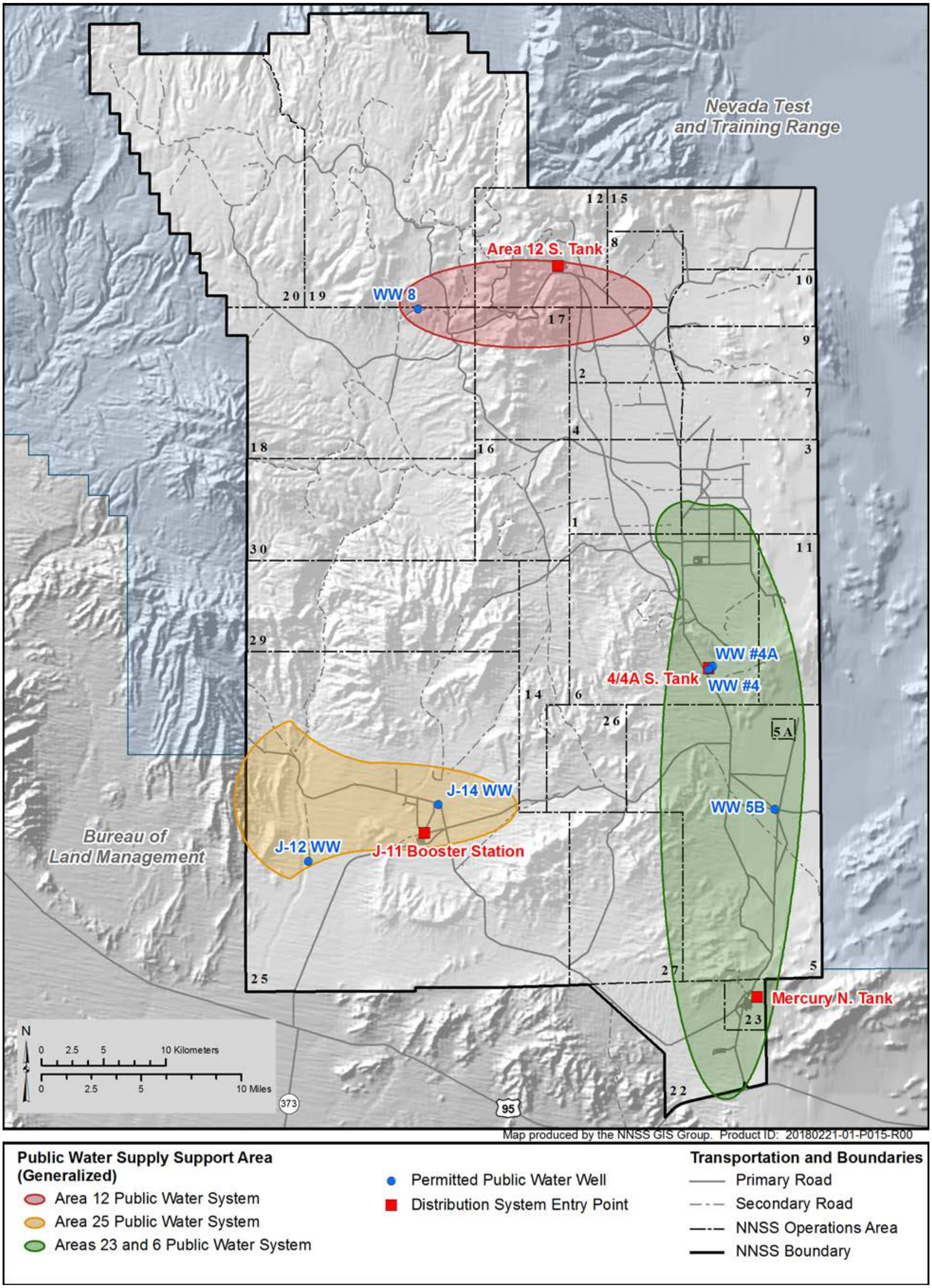

Figure 5-5. Water supply wells and drinking water systems on the NNSS

Table 5-6. Current sampling requirements for permitted NNSS PWSs and water-hauling trucks

System/ Truck	Contaminant or Contaminant Category	Sample Location	Sampling Cycle	Number of Samples
Area 23 and 6	**National Primary Standards**			
	Coliform	WDP-23/6[(a)]	monthly	2
	Disinfectant residual	WDP-23/6	monthly	2
	Asbestos	WDP-23/6	9 year	1
	Disinfection by-products	WDP-23/6	1 year	1
	Lead and copper	WDP-23/6	3 year	10
	Arsenic	POE-23/6[(b)]	3 year	1
	IOCs[(c)] - Phase 2 and 5[(d)]	POE-23/6	9 year	1
	Nitrate	POE-23/6	1 year	1
	Nitrite	POE-23/6	3 year	1
	SOCs[(e)] - Phase 2 and 5	POE-23/6	6 year	1
	VOCs[(f)] - Phase 2 and 5	POE-23/6	3 year	1
	Secondary Standards			
	Secondary IOCs	POE-23/6	3 year	1
Area 12 and Area 25	**National Primary Standards**			
	Coliform	WDP-12/25[(g)]	quarterly	1
	Nitrate	POE-12/25[(h)]	1 year	1
	Nitrite	POE-12/25	3 year	1
	Secondary Standards			
	Secondary IOCs	POE-12/25	3 year	1
Water-hauling Trucks				
Trucks 84846 and 84847	Coliform Bacteria	Truck valve	monthly	1

(a) WDP–23/6 = Water delivery points for the Area 23 and 6 PWS: taps within Buildings 5-7, 6-609, 6-900, 22-1, 23-180, 23-701, 23-777, 23-1103, and the U1H restroom
(b) POE–23/6 = Points of entry for the Area 23 and 6 PWS: Mercury N. Tank and 4/4A S. Tank (Figure 5-5)
(c) IOCs = Inorganic chemicals
(d) Refers to sets of chemical contaminants in drinking water for which the EPA established ***maximum contaminant levels (MCLs)*** through a series of rules known as the Chemical Phase Rules issued from1987 (Phase 1) through 1992 (Phase 5); http://water.epa.gov/lawsregs/rulesregs/sdwa/chemicalcontaminantrules/basicinformation.cfm.
(e) SOCs = Synthetic organic chemicals
(f) VOCs = Volatile organic compounds
(g) WDP-12/25 = Water delivery points for the Area 12 and Area 25 PWSs: Buildings 12-909 and 25-3123 or 25-4222
(h) POE-12/25 = Points of entry for the Area 12 and Area 25 PWSs: Area 12 S. Tank, J-11 Booster Station, and J-14 WW (Figure 5-5)

5.2.1.1 2017 Results of Public Water System and Water-Hauling Truck Monitoring

Water samples are collected in accordance with accepted practices, analyses are conducted by state-approved laboratories, and analytical methods are approved as listed in NAC 445A and Title 40 ***Code of Federal Regulations (CFR)*** Part 141, "National Primary Drinking Water Standards." The 2017 monitoring results indicated all of the PWSs complied with applicable National Primary Drinking Water Quality Standards (Table 5-7). In addition, water samples from the water-hauling trucks were negative for coliform bacteria.

5.2.1.2 State Inspections

Approximately every five years, NDEP conducts a sanitary survey of the permitted PWSs including an inspection of wells, tanks, and other visible portions of each PWS. The last NDEP survey was in 2014; no sanitary surveys were conducted in 2017. Water-hauling trucks are inspected annually for compliance with NAC 445A; truck inspections were in October 2017, and NDEP renewed both permits.

Table 5-7. Water quality analysis results for NNSS PWSs

Contaminant	Maximum Contaminant Level (mg/L)	2017 Results (mg/L)		
		Area 23 and 6 PWS	Area 12 PWS	Area 25 PWS
Coliform Bacteria	Absent in all samples	Absent in all samples	Absent in all samples	Absent in all samples
Synthetic Organic Chemicals - Phase II				
Alachlor	0.002	ND	NA	NA
Aldicarb	0.003	ND	NA	NA
Aldicarb sulfoxide	0.004	ND	NA	NA
Aldicarb sulfone	0.002	ND	NA	NA
Atrazine	0.003	ND	NA	NA
Carbofuran	0.04	ND	NA	NA
Chlordane	0.002	ND	NA	NA
Dibromochloropropane	0.0002	ND	NA	NA
2, 4-D	0.07	ND	NA	NA
Ethylene dibromide	0.00005	ND	NA	NA
Heptachlor	0.0004	ND	NA	NA
Heptachlor epoxide	0.0002	ND	NA	NA
Lindane	0.0002	ND	NA	NA
Methoxychlor	0.04	ND	NA	NA
Polychlorinated biphenyls	0.0005	ND	NA	NA
Pentachlorophenol	0.001	ND	NA	NA
Toxaphene	0.003	ND	NA	NA
2, 4, 5-TP	0.05	ND	NA	NA
Synthetic Organic Chemicals - Phase V				
Benzo(a)pyrene	0.0002	ND	NA	NA
Dalapon	0.2	ND	NA	NA
Di (2-ethylhexyl) adipate	0.4	ND	NA	NA
Di (2-ethylhexyl) phthalate	0.006	ND	NA	NA
Dinoseb	0.007	ND	NA	NA
Diquat	0.02	ND	NA	NA
Endothall	0.1	ND	NA	NA
Endrin	0.002	ND	NA	NA
Glyphosate	0.7	ND	NA	NA
Hexachlorobenzene	0.001	ND	NA	NA
Hexachloro-cyclopentadiene	0.05	ND	NA	NA
Oxamyl (Vydate)	0.2	ND	NA	NA
Picloram	0.5	ND	NA	NA
Simazine	0.004	ND	NA	NA
Secondary Standards				
Aluminum	0.2	NA	0.068 U	0.677
Chloride	400	NA	9.42	9.44
Color	15 color units	NA	0	2
Copper	1.3	NA	0.003 U	0.00956 B
Fluoride	2	NA	0.826	1.21
Iron	0.6	NA	0.162	2.03
Magnesium	150	NA	0.983	3.43
Manganese	0.1	NA	0.0156	0.0689
Odor	3.0 threshold odor	NA	0	1.4
pH	6.5-8.5	NA	7.52	8.04
Secondary Standards				
Silver	0.1	NA	0.001 U	0.001 U
Sulfate	500	NA	16.9	72.7
Surfactant (MBAS)	0.1	NA	<0.10	<0.10
Total Dissolved Solids (TDS)	1000	NA	120	300
Zinc	5	NA	0.0826 B	0.0193

Table 5-7. Water quality analysis results for NNSS PWSs

Contaminant	Maximum Contaminant Level (mg/L)	2017 Results (mg/L)		
		Area 23 and 6 PWS	Area 12 PWS	Area 25 PWS
Inorganic Chemicals				
Nitrate	10	2.9 and 4.2	1.2	0.68
Nitrite	0.5	NA and NA	<0.050	<0.050
Arsenic	0.01	0.00973 and 0.00674	NA	NA
Disinfection By-products				
Total Trihalomethanes	0.08	0.019	NA	NA
Haloacetic Acids	0.06	0.004	NA	NA

(a) U = Flagged by the analytical laboratory as below detection limits.
(b) NA = Not applicable, no requirement to sample in 2017.
(c) B = Flagged by the analytical laboratory as contaminant detected in blank.
(d) ND = Not detected.

5.2.2 Domestic Wastewater Monitoring

A total of 17 active and permitted domestic wastewater septic systems are being used on the NNSS (Figure 5-6). The septic systems are permitted to process/store up to 5,000 gallons of wastewater per day. They are inspected periodically for sediment loading and pumped as required. The NNSS Management and Operations contractor maintains a septic pumping contractor permit, issued by the NDEP and the Nevada Division of Public and Behavioral Health. State representatives conduct onsite inspections of septic pump trucks and contractor operations. NNSA/NFO performs management assessments and maintenance for domestic wastewater septic systems to document compliance with permit conditions. Management assessments are performed according to existing directives and procedures.

In May 2017, the state conducted an inspection of NNSS septic pump trucks and NNSS personnel conducted a management assessment for domestic wastewater septic systems; both the trucks and the septic systems were compliant with permit conditions.

A septic tank pumping contractor permit for six septic tank pump trucks (NY-17-06839) was renewed in June 2017.

5.2.3 Industrial Wastewater Monitoring

Industrial discharges on the NNSS are limited to three sewage lagoon systems: Area 6 Yucca Lake; Area 6 DAF; and, Area 23 Mercury (lagoon systems also receive domestic wastewater) (Figure 5-6). The Yucca Lake system includes two primary lagoons and two secondary lagoons. The DAF system is one primary and one secondary lagoon. Both the Yucca Lake and DAF lagoons are lined with compacted native soils and meet state requirements for transmissivity (10^{-7} centimeters per second). The Area 23 Mercury system is one primary lagoon, one secondary lagoon, and an infiltration basin. The primary and secondary lagoons are lined with geosynthetic clay and high-density polyethylene. The lining of the ponds allows these systems to operate as fully contained, evaporative, non-discharging systems. The sewage lagoons operate in compliance with Water Pollution Control General Permit, GNEV93001Rv XI.

5.2.3.1 Quarterly and Annual Influent Monitoring

Sewage systems are monitored quarterly for influent quality. Composite samples from each system are collected over a period of 8 hours and analyzed by state-approved laboratories. Methods for sample collection and analyses are in accordance with NAC 445A and 40 CFR 141. Composite samples are analyzed for three parameters: 5-day ***biological oxygen demand*** ***(BOD_5)***, total suspended solids (TSS), and pH. In 2017, sample analyses results for influent waters were within permitted limits (GNEV93001Rv XI) (Table 5-8).

Toxicity monitoring of influent waters of the lagoons was not conducted in 2017. Permit GNEV93001 Revision XI requires lagoons to be sampled and analyzed for the 29 contaminants listed in Table 4-10 of the *Nevada Test*

Site Environmental Report 2008 (NSTec 2009) only in the event of specific or accidental discharges of potential contaminants. No specific or accidental discharges occurred in 2017.

Table 5-8. Water quality and flow monitoring results for NNSS sewage lagoon influent waters in 2017

		Minimum and Maximum Values from Quarterly Samples		
Parameter	**Units**	**Area 6 Yucca Lake**	**Area 23 Mercury**	**Area 6 DAF**
BOD_5	mg/L	92–346	75.6–452	51.9–335
Permit Limit		None	None	None
BOD_5 Mean Daily Load[(a)]	kg/d	0.75–2.9	5.0–46	1.5–7.2
Permit Limit		34.43	124.31	15.29
TSS	mg/L	60–306	94–217	93–218
Permit Limit		None	None	None
pH	S.U.[(b)]	7.75–8.69	7.69–8.71	8.29–8.85
Permit Limit		6.0–9.0	6.0–9.0	6.0–9.0
Quarterly Average Flow Rate	GPD[(c)]	1,154–6,626	8,570–54,336	5,130–10,829
Permit Limit		10,850	73,407	3,080[(d)]

(a) BOD_5 Mean Daily Load in kilograms per day (kg/d) = (mg/L BOD × liters per day (L/d) average flow × 3.785)/10^6
(b) Standard units of pH
(c) Gallons per day
(d) Average flow rate exceeded reported limit; NDEP granted a waiver for flow rate at the Area 6 DAF (included in permit Revision XI). The limit was initially too low due to the use of a standard water balance calculation in lieu of a metering device.

5.2.3.2 Sewage System Inspections

NNSA/NFO personnel inspect active systems weekly and inactive lagoon systems quarterly; no notable observations were made in 2017. NDEP inspects both active and inactive NNSS lagoon systems annually; there were no findings of deficiency in 2017. Inspections evaluate all infrastructure (i.e., field maintenance programs, lagoons, sites, and access roads) for abnormal conditions, weeds, algae blooms, pond color, abnormal odors, dike erosion, burrowing animals, discharge, depth of staff gauge, crest level, excess insect population, maintenance/repairs, and general conditions.

5.2.4 E Tunnel Waste Water Disposal System Monitoring

NNSA/NFO manages and operates the ETDS in Area 12 under a separate water pollution control permit (NEV 96021) issued by the NDEP Bureau of Federal Facilities. The permit regulates the management of radionuclide-contaminated wastewater that drains from the E Tunnel portal into a series of holding ponds. The permit requires ETDS discharge waters to be monitored every 12 months for radiological parameters (Adjusted Gross Alpha, Gross Beta, ^3H) and nonradiological parameters (Table 5-9). It also requires nearby Well ER-12-1 to be sampled for the same parameters once every 24 months. ETDS discharge water is also monitored monthly for flow rate, pH, temperature, and specific conductance, and for the volume and structural integrity of the holding ponds. Monitoring data are reported to the NDEP Bureau of Federal Facilities in quarterly and annual reports.

Monitoring personnel sampled the ETDS discharge water on October 23, 2017. Well ER-12-1 was sampled on April 19, 2017. All radiological and nonradiological parameters were within the threshold limits. Nonradiological results and thresholds are provided in Table 5-9.

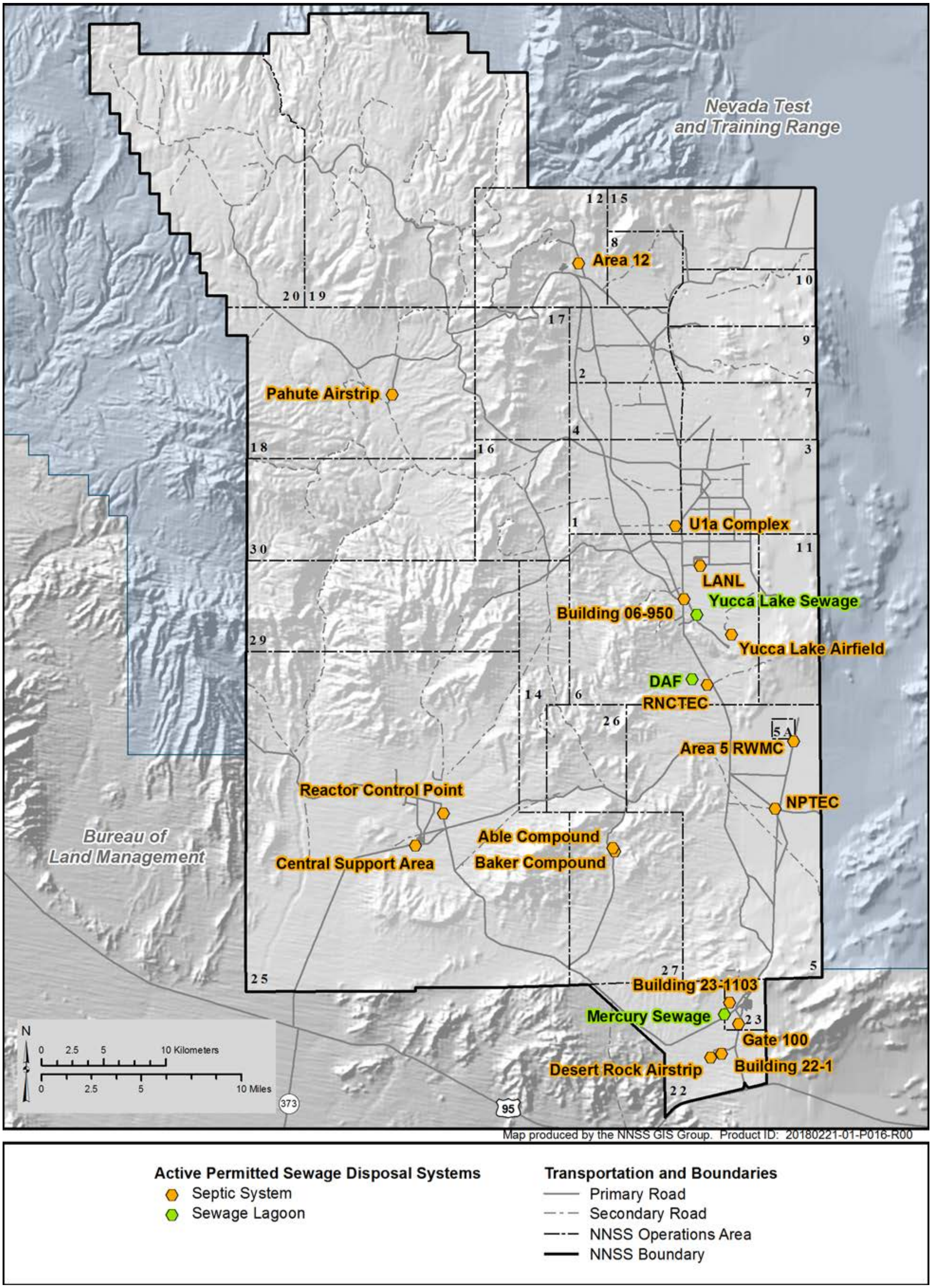

Figure 5-6. Active permitted sewage disposal systems on the NNSS

Table 5-9. Nonradiological results for Well ER-12-1 groundwater and ETDS discharge samples

	ETDS Discharge Water Sampled Every 12 Months (October 2017)		Well ER-12-1 Groundwater Sampled Every 24 Months (April 2017)	
Nonradiological Parameter	**Threshold (mg/L)**	**Averaged Value (mg/L)**	**Threshold (mg/L)**	**Averaged Value (mg/L)**
Cadmium	0.045	0.005[e]	0.005	0.005[e]
Chloride	360	8.8	250	17
Chromium	0.09	0.01[e]	0.09	0.01[e]
Copper	1.2	0.01[e]	1.2	0.01[e]
Fluoride	3.6	0.17	3.6	0.36
Iron	5.0	2.9	5.0	3.4
Lead	0.014	0.003[e]	0.014	0.003[e]
Magnesium	135	1.1	135	66
Manganese	0.25	0.034	0.25	0.15
Mercury	0.0018	0.0002[e]	0.0018	0.0002[e]
Nitrate nitrogen	9	0.32	9	0.150
Selenium	0.045	0.006[e]	0.045	0.005[e]
Sulfate	450	16	450	340
Zinc	4.5	0.03	4.5	0.023
Flow Rate (liters/minute)	MR[(a)]	28.5[(d)]	NA	NA
pH (S.U.)[(b)]	6.0–9.0	7.21[(d)]	6.5–8.5	7.15[b]
Specific conductance (µS/cm)[(c)]	<1,500	377[(d)]	<1,500	976[c]

(a) Permit requires NNSA/NFO to monitor and report; there are no threshold limits
(b) S.U. = standard unit(s) (for measuring pH)
(c) µS/cm = microsiemens per centimeter
(d) Average of 12 monthly measures
(e) Analyte undetected

5.3 Water Level and Usage Monitoring

The U.S. Geological Survey (USGS) Nevada Water Science Center collects, compiles, stores, and reports hydrologic data used in determining the local and regional hydrogeological conditions in and around the NNSS. Hydrologic data are collected quarterly or semi-annually from wells on and off the NNSS. The USGS also has developed models for the Death Valley Regional Groundwater Flow System (Belcher and Sweetkind 2010, Belcher et al. 2017), and manages other NNSS hydrologic and geologic information databases (for example, https://waterdata.usgs.gov/nv/nwis and https://pubs.usgs.gov/ds/2007/297/).

In 2017, the USGS monitored water levels in 218 wells on and near the NNSS; these included 120 wells on the NNSS and 98 off the NNSS. Water levels are monitored to identify where water occurs in the subsurface, changes in the quantity of water in aquifers, the direction of groundwater movement, and groundwater velocity (derived from knowledge of groundwater movement and rock properties). Along with radiological groundwater data presented in Section 5.1, water-level data are used to develop UGTA CAU-specific models of groundwater flow and radionuclide transport (Section 11.1.2). A map showing the location of monitored wells and all water-level data are available on the USGS-U.S. Department of Energy Cooperative Studies in Nevada project website at https://nevada.usgs.gov/doe_nv/.

Groundwater-use data are collected from water supply wells on the NNSS using flow meters, and are reported monthly. The principal NNSS water supply wells monitored in 2017 included J-12 WW, J-14 WW, UE-16d WW, WW #4, WW #4A, WW 5B, and WW 8 (Figure 5-2). The USGS compiles the annual water-use data and reports annual withdrawals in millions of gallons. Discharge data from these wells for 2017 have been compiled, processed, and are available from the Water Withdrawals page on the USGS-U.S. Department of Energy Cooperative Studies in Nevada project website at https://nevada.usgs.gov/doe_nv/water_withdrawals.html. Discharge from these wells in 2017 was approximately 138 million gallons (Figure 5-7).

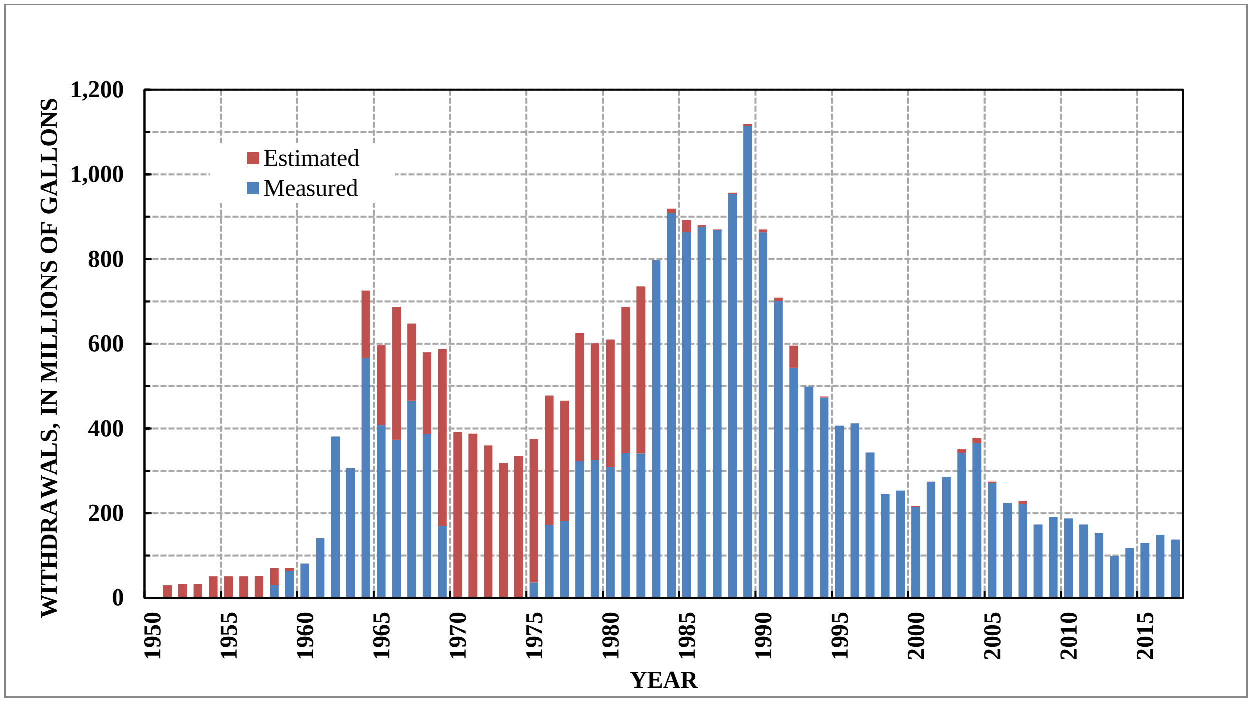

Figure 5-7. Annual withdrawals from the NNSS, 1951 to 2017

5.4 Water Monitoring Conclusions

The potential radiological impact to water resources from past activities on the NNSS is the migration of radionuclides in the groundwater downgradient from the UGTA CAUs. Currently, sampling and analysis data indicate that testing within the Pahute Mesa CAUs only has impacted groundwater off site; ^{3}H has been detected above the ^{3}H standard analysis method MDC of 300 pCi/L in one UGTA well on NTTR (ER-EC-11). Current data indicate, however, that the distance over which radionuclides have migrated from underground nuclear testing in the Pahute Mesa CAUs is not significant relative to the distance to offsite public water supply wells. Six Characterization wells within the Pahute Mesa CAUs intercept a contaminant plume of ^{3}H believed to originate from the Tybo and Benham UGTs. These six wells are within 900 ft to 17,000 ft (0.2 to 3.2 miles) of these two UGTs. Well sampling to date has not detected the presence of man-made radionuclides downgradient of Pahute Mesa in nine other UGTA wells on the NTTR. As presented in previous annual reports, samples from offsite monitoring wells in Oasis Valley, farther downgradient of Pahute Mesa, also contain no detectable man-made radionuclides. These sampling results are consistent with UGTA's Phase I Pahute Mesa flow and transport model (SNJV 2009), which forecasts migration of ^{3}H off the NNSS within 50 years of the first nuclear detonation (1965) from the Central and Western Pahute Mesa CAUs.

Currently, groundwater contaminated by historical UGTs does not impact the public or NNSS workers who drink water from wells located off or on the NNSS. However, NNSS wildlife can be exposed to ^{3}H in their drinking water or in their aquatic habitats whenever contaminated waters are retained for evaporation in state-approved ponds or sumps. Examples are the E Tunnel ponds and UGTA groundwater sumps used by wildlife as drinking water and also used by plants, insects, and amphibians as aquatic habitats. The potential dose to NNSS biota from these water sources is routinely assessed and reported annually in of this report (Section 9.2). Each year, results demonstrated that the doses to biota are below the set limits to protect plant and animal populations.

Potential nonradiological contaminants in drinking water and wastewater monitored on the NNSS in 2017 were all less than permit limits, with the following exceptions: Area 25 PWS exceeded the Nevada Secondary Standards for aluminum and iron, and the DAF sewage lagoon exceeded the daily flow limit. Area 25 exceedances were determined to be due to natural causes or the condition of the water distribution systems themselves; they have not been the result of the release of contaminants into the groundwater from site operations. The DAF sewage lagoon flow exceedance had no impact, as there was no loss of containment. If present, nonradiological contamination of groundwater from NNSS operations would likely be co-located with the radiological contamination from historical UGT within UGTA CAUs. It is expected to be minor, however, in comparison to the radiological contamination. For nuclear tests above the water table, potential nonradiological contaminants are not likely to reach groundwater because of their negligible advective and dispersive transport rates through the thick ***vadose zone***. Water samples from UGTA investigation wells, which include highly contaminated wells, have not had elevated levels of nonradiological man-made contaminants.

Well drilling, waste burial, chemical storage, and wastewater management are the only current NNSS activities that have the potential to contaminate groundwater with nonradiological contaminants. This potential is very low, however, due to engineered and operational deterrents and natural environmental factors. Current drilling operations procedures include the containment of drilling muds and well effluents in sumps (Section 5.1.3.7.3). Well effluents are monitored for nonradiological contaminants (predominantly lead) to ensure lined sumps are used when necessary. The Area 3 and Area 5 Radioactive Waste Management Sites and ***solid waste*** landfills are designed and monitored to ensure that contaminants do not reach groundwater (Chapter 10). In addition, the potential for mobilization of contaminants from all these sources to groundwater is negligible due to the arid climate, the great depth to groundwater (thickness of the vadose zone), and the proven behavior of liquid and vapor fluxes in the vadose zone (primarily upward liquid movement towards the ground surface due to evapotranspiration).

The Environmental Restoration Program for the Soils and Industrial Sites conducts cleanup and closures of historical surface and shallow subsurface contamination sites, some of which have nonradiological contaminants such as metals, petroleum hydrocarbons, hazardous organic and inorganic chemicals, and unexploded ordinance (Sections 11.2 and 11.3). The potential for mobilization of these contaminants to groundwater is negligible due to the same regional climatic, soil, and hydrogeological factors mentioned above.

Water level monitoring continues to be used to develop and refine CAU-specific models of groundwater flow and contaminant transport. Section 11.1.2 of this report describes the status of these models.

Current water usage, monitored annually, has dropped to levels that have not been seen since the early 1960s, due mainly to changes in site operations, and to some extent, recent conservation actions. Within the past several years, NNSA/NFO has taken actions to conserve groundwater by addressing DOE’s water efficiency and water management goals, which include reducing both potable and non-potable water use (Chapter 3).

5.5 References

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NNSA/NSO, see U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office.

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Chapter 6: Direct Radiation Monitoring

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U.S. Department of Energy (DOE) Orders DOE O 458.1, "Radiation Protection of the Public and the Environment," and DOE O 435.1, "Radioactive Waste Management," have requirements to protect the public and environment from radiation ***exposure***;[1] see descriptions of these orders in Table 2-1. Energy absorbed from radioactive materials outside the body results in an external ***dose***. On the Nevada National Security Site (NNSS), external dose comes from direct ***ionizing radiation*** including natural ***radioactivity*** from cosmic and terrestrial sources as well as man-made radioactive sources. This chapter presents data obtained to assess external dose for 2017. Chapters 4, 5, and 8 present monitoring results for radioactivity from NNSS activities in air, water, and biota, respectively. Those results help estimate potential internal radiation dose to the public via inhalation and ingestion. The total estimated dose, both internal and external, from NNSS activities is presented in Chapter 9.

Direct radiation monitoring is conducted to assess the external radiation environment, detect changes in that environment, respond to releases from U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) activities, and measure ***gamma radiation*** levels near potential exposure sites. In addition, DOE O 458.1 states "it is also an objective that potential exposures to members of the public be ***as low as is reasonably achievable*** (***ALARA***)."

Direct Radiation Monitoring Program Goals
Assess the proportion of external dose from ***background*** radiation versus NNSS operations.
Measure external radiation to assess the potential external dose to a member of the public from NNSA/NFO operations at the NNSS (Chapter 9 gives estimates for public dose).
Measure external radiation to assess the potential external dose to a member of the public from operations at the Area 3 and 5 Radioactive Waste Management Sites (RWMSs).
Monitor operational activities involving radioactive material, radiation-generating devices, and accidental releases of radioactive material to ensure exposure to members of the public are kept ALARA.
Measure external radiation to assess the potential external and absorbed radiation doses to NNSS plants and animals (Section 9.2 gives biota dose assessments).
Determine the patterns of exposure rates through time at various soil contamination areas to characterize releases in the environment.

An offsite monitoring program implemented by NNSA/NFO monitors direct radiation in communities adjacent to the NNSS. The Desert Research Institute (DRI) conducts this monitoring as part of its Community Environmental Monitoring Program (CEMP). DRI's 2017 direct radiation monitoring results are in Sections 7.1.4 and 7.1.5; DRI ***thermoluminescent dosimeter (TLD)*** data are compared with on-site TLD data in this chapter (Figures 6-2 and 6-3).

6.1 Measurement of Direct Radiation

Direct (or external) radiation exposure can occur when ***alpha particles***, ***beta particles***, or electromagnetic (gamma and X-ray) radiation interact with living tissue. Electromagnetic radiation can travel long distances through air and penetrate living tissue, causing ionization within the body tissues. For this reason, electromagnetic radiation is

[1] The definition of word(s) in ***bold italics*** may be found by clicking on the word in electronic version or by referencing the Glossary, Appendix B. To return from the Glossary, right click and select Previous View.

one of the greater concerns of direct radiation exposure. By contrast, alpha and beta particles do not travel far in air (a few centimeters for alpha, and about 10 meters [m] or 33 feet [ft] for beta particles). Alpha particles deposit only negligible energy to living tissue as they rarely penetrate the outer dead layer of skin and cannot penetrate thin plastic. Beta particles are generally absorbed in the layers of skin immediately below the outer layer.

Direct radiation exposure is usually reported in the unit milliroentgen (mR), which is a measure of exposure in terms of numbers of ionizations in air. The dose in human tissue resulting from an exposure from one of the most common ***radionuclides*** (cesium-137) is approximated by equating a 1-mR exposure with a 1-millirem (mrem) (or 0.01-millisievert [mSv]) dose.

6.2 Thermoluminescent Dosimetry Surveillance Network Design

A surveillance network of TLD sample locations (Figure 6-1) monitors NNSS areas with elevated radiation levels from historical nuclear weapons testing, current and past radioactive waste management activities, and/or current operations involving radioactive material or radiation-generating devices. The objectives and design of the network are described in detail in the *Routine Radiological Environmental Monitoring Plan* (RREMP) (Bechtel Nevada 2003).

TLDs have the capability to measure exposure from all sources of ionizing radiation, but with normal use, the TLD will detect only electromagnetic radiation, high-energy beta particles, and in some special cases, neutrons. This is due to the penetrative abilities of the radiation. The TLD used for environmental sampling is the Panasonic UD-814AS, which has three calcium sulfate elements housed in an air-tight, water-tight, ultra-violet light-protected case. Measurements from the three calcium sulfate elements are averaged to assess penetrating gamma radiation.

A pair of TLDs is placed at 1.0 ± 0.3 m (28 to 51 inches [in.]) above the ground at each monitoring location. TLD analysis is performed quarterly using automated TLD readers calibrated and maintained by the Radiological Control Department. Reference TLDs are exposed to a 100 mR cesium-137 source under tightly controlled conditions. These are read along with TLDs collected from the network to calibrate their responses.

There were 103 active environmental TLD locations on the NNSS in 2017 (Figure 6-1) along with six control locations. They include the following:

- Background (B) – 10 locations where radiation effects from NNSS operations are negligible.
- Environmental 1 (E1) – 41 locations where there is no measurable radioactivity from past operations, but which are locations of interest due to the presence of people in the area and/or the potential for increased radiation exposure from a current operation.
- Environmental 2 (E2) – 35 locations where there is or has been measurable added radioactivity from past operations; these locations are of interest for monitoring direct radiation trends in the area. Some locations fitting this description are grouped with the Waste Operations category below.
- Waste Operations (WO) – 17 locations in and around the Area 3 and 5 RWMSs.
- Control (C) – 5 locations in Building 652 and 1 in Building 650 (both in Area 23). Control TLDs are kept in stable environments. Those in Building 652 are shielded inside a lead cabinet, and those in Building 650 are shielded by just the building itself. These TLDs are used as a quality check on the TLDs and the analysis process.

This network of TLD stations, along with the analysis of their data, serve to monitor operational activities throughout the NNSS for changes in external radiation measures over time and any accidental releases of radioactive material. TLD data are reviewed annually to identify any patterns of exposure rates through time at various soil contamination areas.

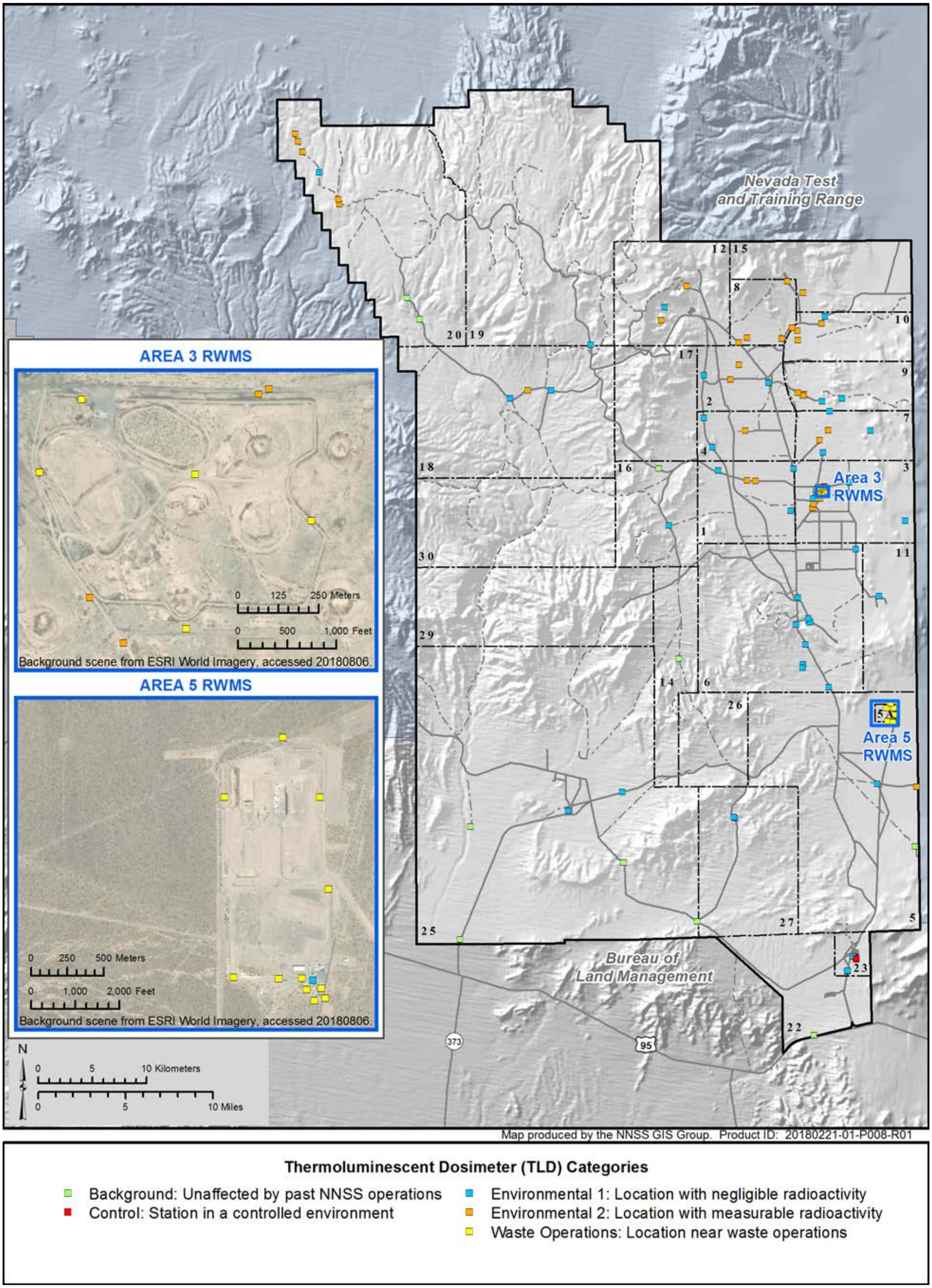

Figure 6-1. Locations of TLDs on the NNSS

6.2.1 Data Quality

Quality assurance (QA) procedures for direct radiation monitoring involve: 1) a readings comparison among the three TLD elements in individual TLDs, 2) a data comparison of the paired TLDs at each location to estimate the measurement and its precision, 3) comparison of current and past data measurements at each TLD location, and 4) review of data from the TLDs in the control locations. The TLDs in control locations allow the detection and estimation of any systematic variations that might be introduced by the measurement process itself.

As specified by the RREMP, QA and ***quality control (QC)*** protocols (including Data Quality Objectives) are maintained as essential elements of direct radiation monitoring. QA/QC requirements include the use of sample packages to thoroughly document each sampling event, rigorous management of databases, and completion of essential training (Chapter 14). The Radiological Control Department maintains certification through the DOE Laboratory Accreditation Program for ***dosimetry***.

Four steps comprise the monitoring process for each environmental TLD: the TLD is (1) annealed (i.e., heated and then cooled) to reset its original unexposed condition, then stored in a shielded location; (2) deployed to the field at the beginning of each quarter; (3) collected from the field at the end of each quarter; and (4) again stored in a shielded location until it is read. To control for variations related to holding times, an estimate of the additional dose due to holding times prior to deployment and following collection and the shielded control location is subtracted from the measured quarterly dose before computing annual exposure estimates. This adjustment has been applied retroactively to data from 2003 on. This adjustment resulted in a decrease of estimated dose between 0.2% and 8.2%; averaging 2.1% in 2017.

6.2.2 Data Reporting

Direct radiation is recorded as exposure per unit time in milliroentgens per day (mR/d), calculated by dividing the measured exposure per quarter for each TLD by the number of days the TLD was exposed at its measurement location. These are multiplied by 365.25 to obtain annualized values. The estimated annual exposure is the average of the quarterly annualized values; this is the metric used to determine compliance with federal annual dose limits.

6.3 Results

Estimated annual exposures for all TLD locations are in Table 6-1. Summary statistics for the five location types are in Table 6-2 and Figure 6-2. Data were successfully obtained from nearly all of the TLDs during all quarters in 2017; two measurements were rejected due to inadequate inter-element agreement and six pairs were found on the ground. Otherwise, agreement between the results provided by the paired TLDs was quite good, with an average relative percent difference between measurements of 4.2%. The quarter-to-quarter coefficient of variation (CV) (i.e., the relative standard deviation) ranged from 0.0% to 11.0% (median = 3.5%) over all locations excluding Gate 100 Truck Parking 1 (discussed in Section 6.3.2).

6.3.1 Background Exposure

In 2017, the average of the estimated annual exposures among the 10 background locations was 120 mR, ranging from 80 to 159 mR (Table 6-2). A 95% prediction interval (PI) for annual exposures based on the 2017 estimated mean annual exposures at the background locations (denoted "95% PI from B" in the plots) is 53.2 to 187.4 mR. This interval predicts mean annual background exposures at locations where radiation effects from NNSS operations are negligible.

For comparison, the CEMP's estimated annual exposure in Las Vegas, Nevada (at 617 m [2,025 ft] elevation), was 94 mR in 2017 (Table 7-3). Estimated mean annual exposures at CEMP locations ranged from 76 mR at the former St. George, Utah location (805 m [2,600 ft] elevation), to 139 mR at Milford, Utah (1,417 m [4,900 ft] elevation). There is a general increasing relationship between natural background exposure and elevation due to cosmic radiation (Figure 6-3). The NNSS background locations with lowest and highest exposures are at elevations 1,064 m (3,490 ft) at Old Indian Springs Road in Area 5 and 1,737 m (5,700 ft) at Stake A-112 in Area 20, respectively.

Exposure estimates at all locations include contributions from natural sources of radiation (i.e., cosmic), legacy sources (i.e., contaminated soils from NNSS historical nuclear testing), and current NNSS operational sources. It is important to note that all DOE dose limits to the public are for dose over and above background.

Table 6-1. Annual direct radiation exposures measured at TLD locations on the NNSS in 2017

			Estimated Annual Exposure (mR)[(a)]		
NNSS Area	**Station**	**Number of Quarters**	**Mean[(b)]**	**Minimum[(b)]**	**Maximum[(b)]**
		Background			
5	Old Indian Springs Road	3	80	80	81
14	Mid-Valley	3	149	143	155
16	Stake P-3	4	118	111	124
20	Stake A-112	4	159	155	162
20	Stake A-118	4	149	145	154
22	Army #1 Water Well	4	86	83	90
25	Gate 25-4-P	4	133	131	135
25	Gate 510	4	131	130	133
25	Jackass Flats & A-27 Roads	4	86	83	88
25	Skull Mtn Pass	4	110	106	116
		Control			
23	Building 650 Dosimetry	4	61	57	65
23	Lead Cabinet, 1	4	27	25	29
23	Lead Cabinet, 2	4	28	24	31
23	Lead Cabinet, 3	4	27	24	30
23	Lead Cabinet, 4	4	27	24	29
23	Lead Cabinet, 5	4	27	26	29
		Environmental 1[(c)]			
1	BJY	4	118	112	125
1	Sandbag Storage Hut	4	119	113	121
1	Stake C-2	3	119	110	125
2	Stake M-140	4	130	127	132
2	Stake TH-58	4	93	91	98
3	LANL Trailers	4	121	119	123
3	Stake OB-20	4	87	85	91
3	Well ER 3-1	4	126	120	132
4	Stake TH-41	4	113	106	118
4	Stake TH-48	4	120	116	121
5	Water Well 5B	4	115	107	119
6	CP-6	4	73	70	76
6	DAF East	4	101	98	110
6	DAF North	4	104	100	109
6	DAF South	4	139	134	143
6	DAF West	4	90	85	92
6	Decon Facility NW	4	128	122	132
6	Decon Facility SE	4	133	128	138
6	Stake OB-11.5	4	131	129	133
6	Yucca Compliance	4	93	88	98
6	Yucca Oil Storage	4	99	97	101
7	Reitmann Seep	1	130	130	130
7	Stake H-8	3	130	123	140
9	Papoose Lake Road	4	92	85	100
9	U-9CW South	2	111	104	117
9	V & G Road Junction	3	116	111	122
10	Gate 700 South	4	124	118	128
11	Stake A-21	4	131	125	136
12	Upper N Pond	4	131	129	133
16	3545 Substation	4	141	133	144
18	Stake A-83	4	146	141	152
18	Stake F-11	4	144	138	152
19	Stake P-41	4	163	156	171
20	Stake J-41	4	139	130	148

Table 6-1. Annual direct radiation exposures measured at TLD locations on the NNSS in 2017

NNSS Area	Station	Number of Quarters	Estimated Annual Exposure (mR)[(a)] Mean[(b)]	Minimum[(b)]	Maximum[(b)]
		Environmental 1[(c)]			
23	Gate 100 Truck Parking 1	4	87	68	138
23	Gate 100 Truck Parking 2	4	64	61	65
23	Mercury Fitness Track	4	59	57	61
25	HENRE	4	125	121	128
25	NRDS Warehouse	4	125	123	127
27	Cafeteria	4	117	113	121
27	JASPER-1	4	119	109	124
		Environmental 2[(c)]			
1	Bunker 1-300	4	112	108	116
1	T1	4	218	213	221
2	Stake L-9	4	159	157	162
2	Stake N-8	4	380	372	387
3	Stake A-6.5	4	136	130	146
3	T3	4	274	264	280
3	T3 West	4	264	244	274
3	T3A	4	282	268	294
3	T3B	4	389	369	410
3	U-3co North	4	166	157	173
3	U-3co South	4	138	124	148
4	Stake A-9	4	384	379	387
5	Frenchman Lake	4	243	237	249
7	Bunker 7-300	4	189	179	203
7	T7	4	117	111	127
8	BANEBERRY 1	4	317	313	323
8	Road 8-02	4	118	109	122
8	Stake K-25	4	110	106	114
8	Stake M-152	4	156	150	163
9	B9A	4	124	116	127
9	Bunker 9-300	4	124	121	128
9	T9B	4	402	396	408
10	Circle & L Roads	4	116	112	119
10	Sedan East Visitor Box	4	127	123	129
10	Sedan West	4	204	195	214
10	T10	4	218	211	231
12	T-Tunnel #2 Pond	4	227	216	234
12	Upper Haines Lake	4	105	102	108
15	EPA Farm	4	112	109	114
18	JOHNNIE BOY North	4	144	142	147
20	PALANQUIN	3	207	202	211
20	SCHOONER-1	4	478	464	499
20	SCHOONER-2	4	214	206	222
20	SCHOONER-3	3	140	139	143
20	Stake J-31	3	156	148	167
		Waste Operations[(c)]			
3	A3 RWMS Center	4	136	132	138
3	A3 RWMS East	4	130	126	133
3	A3 RWMS North	4	119	117	121
3	A3 RWMS South	4	262	239	277
3	A3 RWMS West	4	122	116	133
5	A5 RWMS East Gate	4	103	97	110
5	A5 RWMS Expansion NE	4	151	145	155
5	A5 RWMS Expansion NW	4	147	146	149
5	A5 RWMS NE Corner	4	125	121	132
5	A5 RWMS North	4	145	143	147
5	A5 RWMS South Gate	4	111	105	118
5	A5 RWMS SW Corner	4	124	118	130
5	Building 5-31	4	105	101	108

Table 6-1. Annual direct radiation exposures measured at TLD locations on the NNSS in 2017

NNSS Area	Station	Number of Quarters	Estimated Annual Exposure (mR)[(a)] Mean[(b)]	Minimum[(b)]	Maximum[(b)]
		Waste Operations[(c)]			
5	WEF East	4	126	119	131
5	WEF North	4	115	111	119
5	WEF South	4	125	122	131
5	WEF West	4	122	120	123

(a) To obtain estimated daily exposure rates, divide annual exposure estimates by 365.25

(b) Mean, minimum, and maximum values from adjusted quarterly estimates. Each quarterly estimate is the average of two TLD readings per location in all but three instances where one of the paired TLDs could not be read due to loss or damage.

(c) Location types: Environmental 1 = Environmental locations with exposure rates near background, but monitored for potential for increased exposures due to NNSS operations; Environmental 2 = Environmental locations with measurable radioactivity from past operations, excluding those designated WO; Waste Operations = Locations in or near waste operations.

Table 6-2. Summary statistics for 2017 mean annual direct radiation exposures by TLD location type

Location Type	Number of Locations	Estimated Annual Exposure (mR) Mean	Minimum	Maximum
Background (B)	10	120	80	159
Environmental 1 (E1)	41	116	59	163
Environmental 2 (E2)	35	207	105	478
Waste Operations (WO)	17	133	103	262
Control, Shielded (C)	5	27	27	28
Control, Unshielded (C)	1	61	--	--

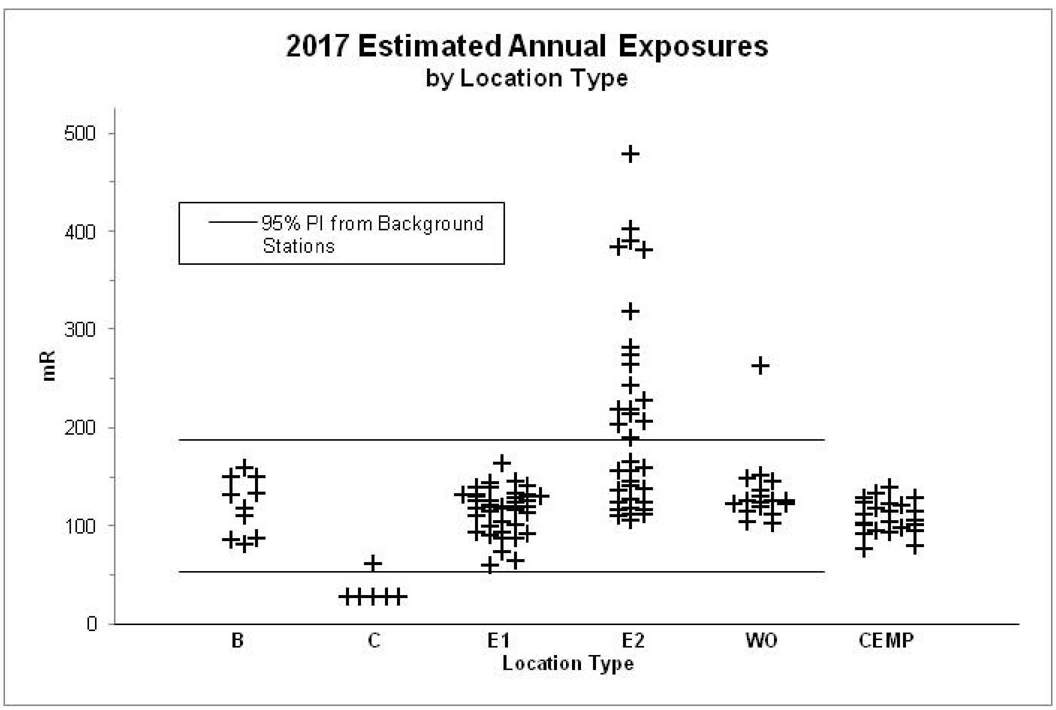

Figure 6-2. 2017 annual exposures on the NNSS, by location type, and off the NNSS at CEMP stations

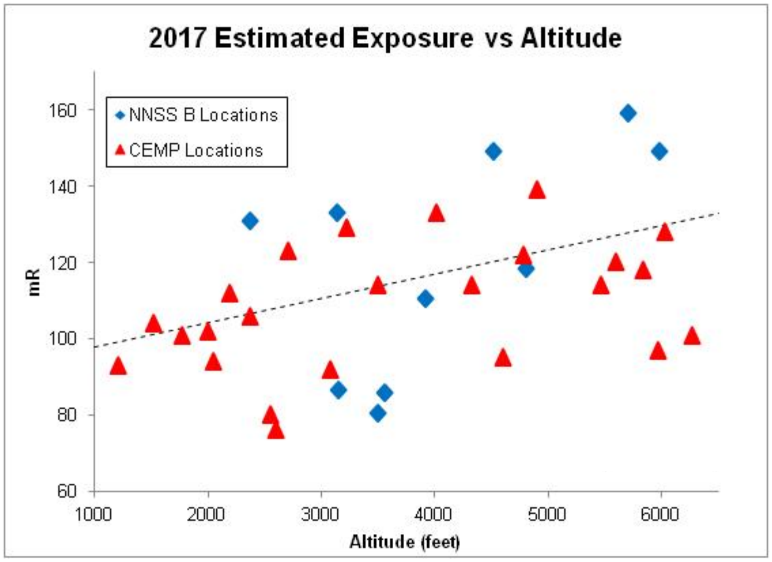

Figure 6-3. Correlation between 2017 annual exposures at NNSS Background and CEMP TLD locations and altitude

6.3.2 Potential Exposure to the Public along the NNSS Boundary

Most of the NNSS is not accessible to the public; the public has limited access only at the southern portion of the NNSS, where Gate 100 is the primary entrance point to the NNSS. The outer parking areas are accessible to the public. Trucks hauling radioactive materials, primarily ***low-level waste (LLW)*** destined for disposal in the RWMSs, often park outside Gate 100 while waiting to enter the NNSS. Two TLD locations were established in October 2003 to monitor this truck parking area.

The TLDs at the north end of the parking area (Gate 100 Truck Parking 2) had an estimated annual exposure of 64 mR in 2017, with quarterly estimates of 65, 65, 61, and 63 mR. The TLD location about 64 m (210 ft) away, on the west side of the parking area (Gate 100 Truck Parking 1), has had elevated exposure levels at various times in its history, likely from waste shipments. Its average value for 2017 was 87 mR, with quarterly estimates of 69, 138, 68, and 71 mR. All results for both locations are within the range of background variation.

While the public has limited access to the NNSS at Gate 100 along its southern border, others may have access to other boundaries of the NNSS. Most of the NNSS is bounded by the Nevada Test and Training Range (NTTR). Military or other personnel on the NTTR who are not classified as radiation workers would also be subject to the DOE public dose limit of 100 mrem/yr (1 mSv/yr). Nuclear tests on the NTTR (Double Tracks and Project 57) consisted of experiments (called safety experiments) where weapons were exploded conventionally without going critical (i.e., starting a nuclear chain reaction). These areas, therefore, have primarily alpha-emitting radionuclides that do not contribute significantly to external dose. Historical nuclear testing activities also occurred on the Tonopah Test Range (TTR) (Clean Slate I, II, and III) in the northwest portion of the NTTR. Radiation exposure rates are measured on and around the TTR, and the results are reported by Sandia National Laboratories in the TTR annual environmental report posted at https://www.sandia.gov/news/publications/.

A radioactive material area boundary extends beyond the NNSS in the Frenchman Lake region of Area 5 along the southeast boundary of the NNSS. This region was a location of atmospheric weapons testing in the 1950s and is inaccessible to the public. A TLD location was established there in July 2003 to characterize direct radiation levels from this legacy soil contaminated area and to assess the external dose to personnel not classified as radiation workers who may visit the area. The estimated annual exposure to a hypothetical person at the Frenchman Lake TLD location in 2017 was 243 mR. This has been consistently declining over time, down from 420 mR in 2003. The estimated above-background dose in 2017 would be approximately 84 to 163 mrem, depending on which background value is subtracted. This may exceed the 100 mrem dose limit to a person residing full time, year-round, at this location, but there are no living quarters or full-time non-radiation workers in this vicinity. Workers specially trained and classified as radiation workers, although they do not work in the vicinity, have a higher allowable dose limit of 5,000 mrem per year, which would not be exceeded in the vicinity of the Frenchman Lake TLD.

Based on these results, the potential external dose to a member of the public due to past or present operations at the NNSS does not exceed 100 mrem/yr (1 mSv/yr) and exposures are kept ALARA, as required by DOE O 458.1.

6.3.3 Exposures from NNSS Operational Activities

Forty-one TLDs are in locations where either workers and/or the public, have the potential to receive radiation exposure from current operations (E1 locations). E1 locations have negligible radioactivity from past operations. The mean estimated annual exposure at these locations was 116 mR in 2017, a little lower than the mean estimated annual exposure at background locations (see Table 6-2). Overall, annual exposures were not different between B and E1 locations (Figure 6-2); the estimated annual exposures at all E1 locations are well within the 95% PI of B locations. E1 location exposures were also comparable with the offsite exposures reported by the CEMP stations, as shown in Figure 6-2.

6.3.4 Exposures from Radioactive Waste Management Sites

DOE M 435.1-1, "Radioactive Waste Management Manual," states that LLW disposal facilities shall be operated, maintained, and closed so that a reasonable expectation exists that the annual dose to members of the public shall not exceed 25 mrem from all exposure pathways combined. The RWMSs are located well within the NNSS boundaries, which are patrolled by security personnel; no member of the public can access these areas for significant periods of time. TLDs placed at the RWMSs show the potential dose from external radiation to a hypothetical person residing year-round at each RWMS.

Between 1952 and 1972, 60 nuclear weapons tests were conducted in Yucca Flat within 400 m (1,312 ft) of the current Area 3 RWMS boundary. Fourteen of these tests were atmospheric tests that left radionuclide-contaminated surface soil and, therefore, elevated radiation exposures across the area. Waste pits in the Area 3 RWMS are ***subsidence craters*** from seven subsurface tests, which have been filled with LLW and then covered with clean soil. As a result, exposures inside the Area 3 RWMS are low when compared with those at or outside the fence line.

Annual exposures measured inside the Area 3 RWMS and at three of four locations at the boundary were within the range of NNSS background exposures in 2017 (Figure 6-4). The boundary location A3 RWMS South has an estimated exposure above the range of NNSS background; it is 160 m (525 ft) from the site of two atmospheric nuclear weapons tests. The three E2 TLD locations outside the RWMS that are also above the range of NNSS background (Figure 6-4) are a similar distance from the same atmospheric tests, but on the other side, farther from the RWMS boundary. Based on these measurements, it does not appear that waste buried at the Area 3 RWMS would have contributed external exposure to a hypothetical person residing at its boundary during 2017.

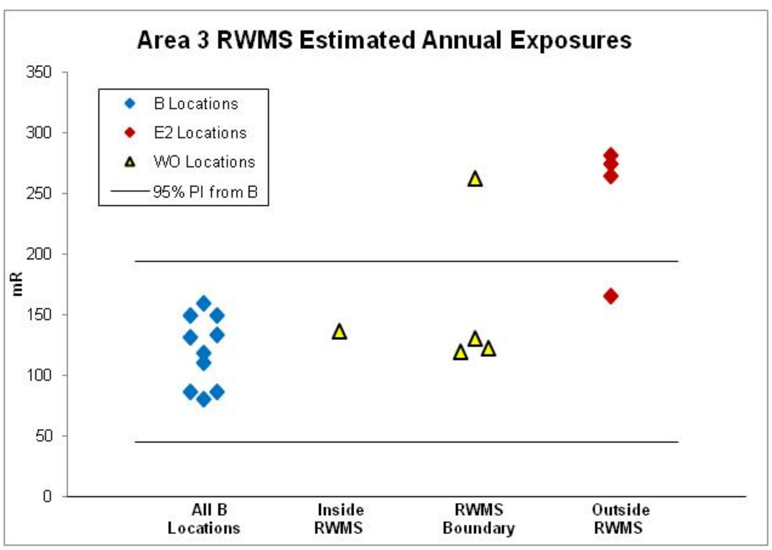

Figure 6-4. 2017 annual exposures in and around the Area 3 RWMS and at background locations

The Area 5 Radioactive Waste Management Site (RWMS) is located in the northern portion of Frenchman Flat. Between 1951 and 1971, 25 nuclear weapons tests were conducted within 6.3 kilometers (km) (3.9 miles [mi]) of the Area 5 RWMS. Fifteen of these were atmospheric tests and, of the remaining ten, nine released radioactivity to the surface, which contributes to exposures in the area. No nuclear weapons testing occurred within the boundaries of the Area 5 RWMS.

In 2017, estimated annual exposures at Area 5 RWMS TLD locations were within the range of exposures measured at NNSS ***background*** locations (Figure 6-5). The one location outside the Area 5 RWMS that has an estimated exposure above background levels (the Frenchman Lake TLD station) is within 0.5 km (0.3 mi) of six atmospheric tests in the Frenchman Lake Playa.

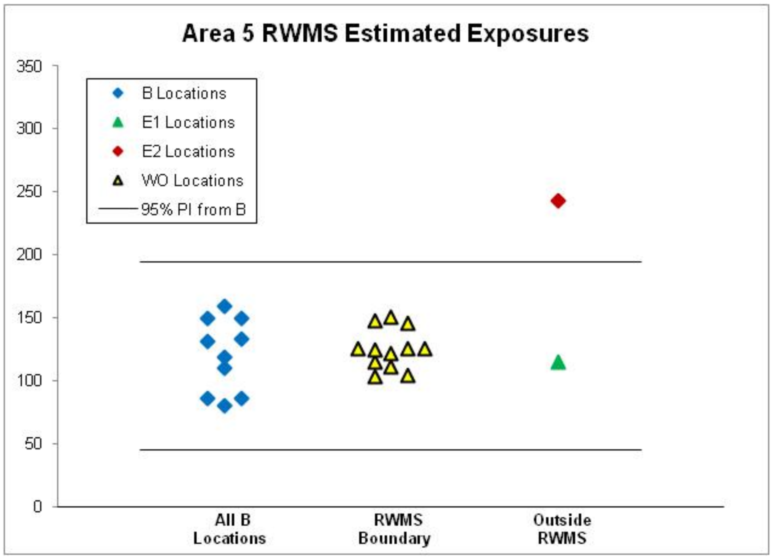

Figure 6-5. 2017 annual exposures around the Area 5 RWMS and at background locations

Based on these results, the potential external dose to a member of the public from operations at the Area 3 and Area 5 RWMSs does not exceed the 25 mrem/yr (0.25 mSv/yr) dose limit specified in DOE M 435.1-1. See Section 9.1.2 of this report for a summary of the potential dose to the public from the RWMSs from all exposure pathways.

6.3.5 Exposures to NNSS Plants and Animals

The highest exposure rate measured at any TLD location in 2017 was 499 mR/yr (1.37 mR/d) at the Schooner-1 location during the first quarter (Table 6-1). Given such a large area source, there is very little difference between the exposure measured at a height of 1 m (3.3 ft) and that measured near the ground (e.g., 3 cm [1.2 in.]) where small plants and animals reside. The daily exposure rate near the ground surface would be less than 2% of the total dose rate limit to terrestrial animals and less than 1% of the limit to terrestrial plants. Hence, doses to plants and animals from external radiation exposure at NNSS monitoring locations are much lower than the dose limits. Dose to biota from both internal and external radionuclides is presented in Section 9.2.

6.3.6 Exposure Patterns in the Environment over Time

Direct radiation monitoring is conducted to help characterize releases from NNSA/NFO activities. Continued monitoring of exposures at locations of past releases on the NNSS helps to accomplish this. Small quarter-to-quarter changes are normally seen in exposure rates from all locations. In 2017, the median CV for measurements between quarters was 3.6%. Gate 100 Truck Parking 1 showed the highest variation with a CV of 39.4%. No other environmental stations had CVs over 10%. In the past 5 years (2012-2016) the median CV has ranged from 2.8% to 4.8%; so the quarter-to-quarter variability in 2017 is consistent with those of the past 5 years.

Long-term trends are displayed in Figure 6-6 by location type for locations that have been monitored for at least 10 years. The average ***decay*** rates by location group are 0.13% (B), 0.19% (C), 0.28% (E1), 1.90% (E2), and 0.71% (WO). Annual exposures decreased 3.08% per year on average at those locations with significant added man-made radiation, those being the E2 and WO locations with 2017 estimated exposures higher than the 95% PI calculated from B locations. These average rates of decay are very similar to those measured from 2008 through 2016. The observed decreases are due to a combination of natural radioactive decay, dispersal, and dilution in the environment.

The stations with the five highest exposures in 2017 are Schooner-1 (Area 20), T9B (Area 9), T3B (Area 3), Stake A-9 (Area 4), and Stake N-8 (Area 2). Their annual exposures have been decreasing at an estimated rate of 50% every 14, 24, 37, 16, and 16 years respectively.

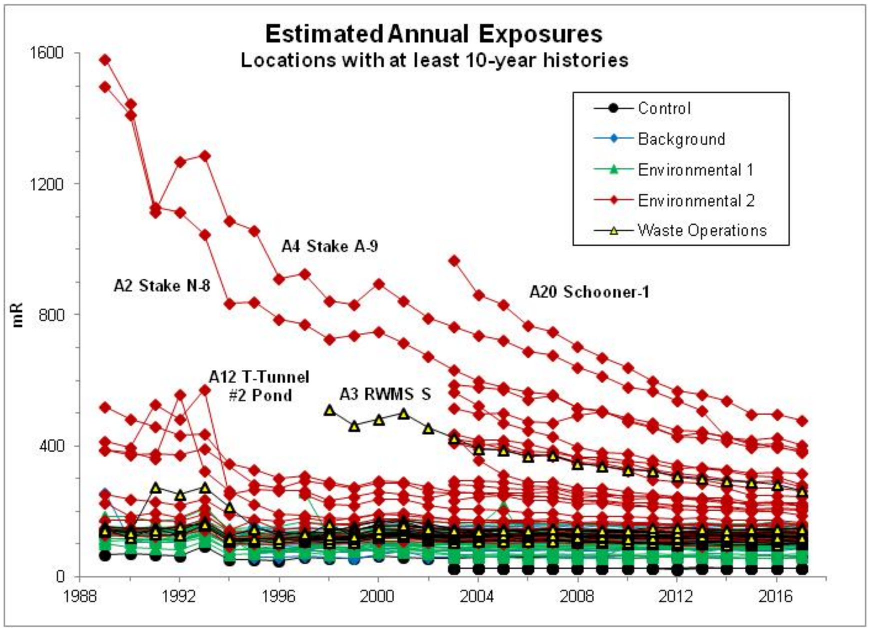

Figure 6-6. Trends in direct radiation exposure measured at TLD locations

6.4 Environmental Impact

Direct radiation exposure to the public from NNSS operations during 2017 was negligible. Radionuclides historically released to the environment on the NNSS have resulted in localized elevated exposures. The areas of elevated exposure are not open to the public, nor do personnel work in these areas full-time. Overall exposures at the RWMSs appear to be generally lower inside and at the boundary than those outside the RWMSs. This is due to the presence of radionuclides released from historical testing distributed throughout the area around the RWMSs compared with the clean soil used inside the RWMSs to cover the waste. The external dose to plants and animals at the location with the highest measured exposure was a small fraction of the dose limit to biota; hence, no detrimental effects to biota from external radiation exposure are expected at the NNSS.

6.5 References

Bechtel Nevada, 2003. *Routine Radiological Environmental Monitoring Plan*. DOE/NV/11718--804, Las Vegas, NV.

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Chapter 7: Community-Based Offsite Monitoring

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Two community-based radiological monitoring programs are conducted off the Nevada National Security Site (NNSS). They provide independent results for the presence of man-made ***radionuclides***[1] in air and groundwater samples from communities surrounding the NNSS.

The Community Environmental Monitoring Program (CEMP) was initiated in 1981 and is conducted by the Desert Research Institute (DRI) of the Nevada System of Higher Education. CEMP's mission is to provide data to the public regarding the presence of man-made radionuclides in air and groundwater off of the NNSS that could be the result of current operations or past nuclear testing on the NNSS. Initially, the CEMP network functioned as a first line of offsite detection of potential radiation releases from underground nuclear tests at the NNSS. It currently exists as a non-regulatory public informational and outreach program. Monitored and collected data include, but are not necessarily limited to, ***background*** and airborne radiation data, meteorological data, and ***tritium (^3H)*** concentrations in downgradient community drinking water. Network air monitoring stations, located in Nevada, Utah, and California, are managed by local citizens, many of them high school science teachers, whose routine tasks are to ensure equipment is operating normally and to collect air filters and route them to the DRI for analysis. These Community Environmental Monitors (CEMs) are also available to discuss the monitoring results with the public and to speak to community and school groups. DRI's responsibilities include maintaining the physical monitoring network through monthly visits by environmental radiation monitoring specialists, who also participate in training and interfacing with CEMs and interacting with local community members and organizations to provide information related to the monitoring data. DRI also provides public access to the monitoring data through maintenance of a project website at http://www.cemp.dri.edu/. A detailed informational background narrative about the CEMP can be found at http://www.cemp.dri.edu/cemp/moreinfo.html along with more detailed descriptions of the various types of sensors found at the stations and on outreach activities conducted by the CEMP.

CEMP Goals
Provide independent monitoring at offsite locations and communicate environmental data relevant to past and continuing activities at the NNSS
Engage the public through hands-on monitoring of environmental conditions in their communities as they might relate to activities at the NNSS
Communicate environmental monitoring data to the public in a transparent and accessible manner
Provide an educated, trusted, local resource for public inquiries regarding past and present activities at the NNSS

The Nye County Tritium Sampling and Monitoring Program (TSaMP) was initiated in 2015 when the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) and the Environmental Management (EM) Nevada Program issued a 5-year grant to Nye County to monitor ^3H in wells downgradient of the NNSS. The grant supports the annual sampling of 10 core wells (i.e., the same wells year to year) and 10 additional wells (selected locations change from year to year). The program also supports Nye County's involvement in technical reviews of the Underground Test Area (UGTA) corrective action program (Chapter 11). Nye County coordinates with DRI, CEMs, and Nye County citizens to determine the sample well locations. Due to CEMP's success at involving and educating local communities, the grant directs data administration and communication to the public of Nye County's program be conducted through the CEMP. DRI provides a link to Nye County's TSaMP data from the CEMP website at http://www.cemp.dri.edu/.

[1] The definition of word(s) in ***bold italics*** may be found by clicking on the word in electronic version or by referencing the Glossary, Appendix B. To return from the Glossary, right click and select Previous View.

Sections 7.1 and 7.2 of this chapter present the 2017 CEMP air and water monitoring results. Section 7.3 presents the 2017 TSaMP monitoring results. Results from radiological monitoring of air, groundwater, direct radiation, and biota conducted on the NNSS and the Nevada Test and Training Range (NTTR) by the NNSA/NFO are presented in Chapters 4, 5, 6, and 8.

7.1 CEMP Air Monitoring

In 2017, DRI managed 24 CEMP stations, which compose the Air Surveillance Network (ASN) (Figure 7-1). The ASN stations include various types of equipment to monitor airborne radiation and meteorological conditions. Descriptions of the various types of sensors at the stations can be found at http://www.cemp.dri.edu/cemp/moreinfo.html. The air monitoring equipment described in Section 7.1.1, is shown in Figure 7-2, CEMP Station in Delta, UT.

7.1.1 Air Monitoring Equipment

CEMP Low-Volume Air Sampler Network (ASN)– In 2017, the CEMP ASN included continuously operating low-volume particulate air samplers at 12 “full-time” stations that are either near to or, typically, downwind from, the NNSS. The ASN in 2017 also included low-volume air samplers at 11 “standby” stations that are either farthest from the NNSS or most frequently upwind from the NNSS; these samplers collected 2-week air samples once each quarter. Warm Springs Summit, Nevada, is the only ASN station with no low-volume air sampler. Duplicate continuously operating air samplers are co-located at two randomly selected full-time stations for three months (one calendar quarter) before being moved to a new location. Glass-fiber filters from the low-volume particulate samplers are collected by the CEMs and mailed to DRI, where they are prepared and forwarded to an independent laboratory to be analyzed for ***gross alpha*** and ***beta radioactivity***. Samples are held for a minimum of 7 days after collection to allow for the decay of naturally occurring ***radon progeny***. Upon completion of the gross alpha/beta analyses, the filters are returned to DRI to be composited quarterly for gamma ***spectroscopy*** analysis.

CEMP Thermoluminescent Dosimetry Network – Thermoluminescent ***dosimetry*** is used to measure both individual and population external ***exposure*** to ambient radiation from natural and man-made sources. In 2017, this network consisted of fixed environmental ***thermoluminescent dosimeters (TLDs)*** at 23 of the 24 CEMP stations. A TLD is not currently deployed at Warm Springs Summit due to limited access during the winter months. The TLD is a Panasonic UD-814AS. Within the TLD, a slightly shielded lithium borate element is used to check low-energy radiation levels, and three calcium sulfate elements are used to measure penetrating ***gamma radiation***. For quality assurance purposes, duplicate TLDs are deployed at three randomly selected stations. An average daily exposure rate is calculated for each quarterly exposure period. The average of the quarterly daily values is multiplied by 365.25 days to obtain the total annual exposure for each station.

CEMP Pressurized Ion Chamber (PIC) Network – The PIC detector measures gamma radiation exposure rates and, because of its sensitivity, may detect low-level exposures that go undetected by other monitoring methods. PICs are in place at all 24 stations in the CEMP ASN. The primary function of the PIC network is to detect changes in ambient gamma radiation due to human activities. In the absence of such activities, ambient gamma radiation rates vary naturally among locations, reflecting differences in altitude (cosmic radiation), ***radioactivity*** in the soil (terrestrial radiation), and slight variations at a single location due to weather patterns. Because a full suite of meteorological data is recorded at each CEMP station (see next paragraph), variations in PIC readings caused by weather events such as precipitation or changes in barometric pressure are more readily identified. Variations are easily viewed by selecting a station location on the Graph link from the CEMP home page, http://www.cemp.dri.edu/, then selecting the desired variables.

CEMP Meteorological (MET) Network – Changing weather conditions can have an effect on measurable levels of background radiation; therefore, meteorological instrumentation is in place at each of the 24 CEMP stations and at the four ranch MET stations that do not monitor airborne radiation: Stone Cabin, Twin Springs, Nyala Ranch, and Medlin’s Ranch. The MET network includes sensors that measure air temperature, humidity, wind speed and direction, solar radiation, barometric pressure, precipitation, and soil temperature and moisture. All of these data can be observed real-time at the onsite station display and archived data are available by accessing the CEMP home page at http://www.cemp.dri.edu/.

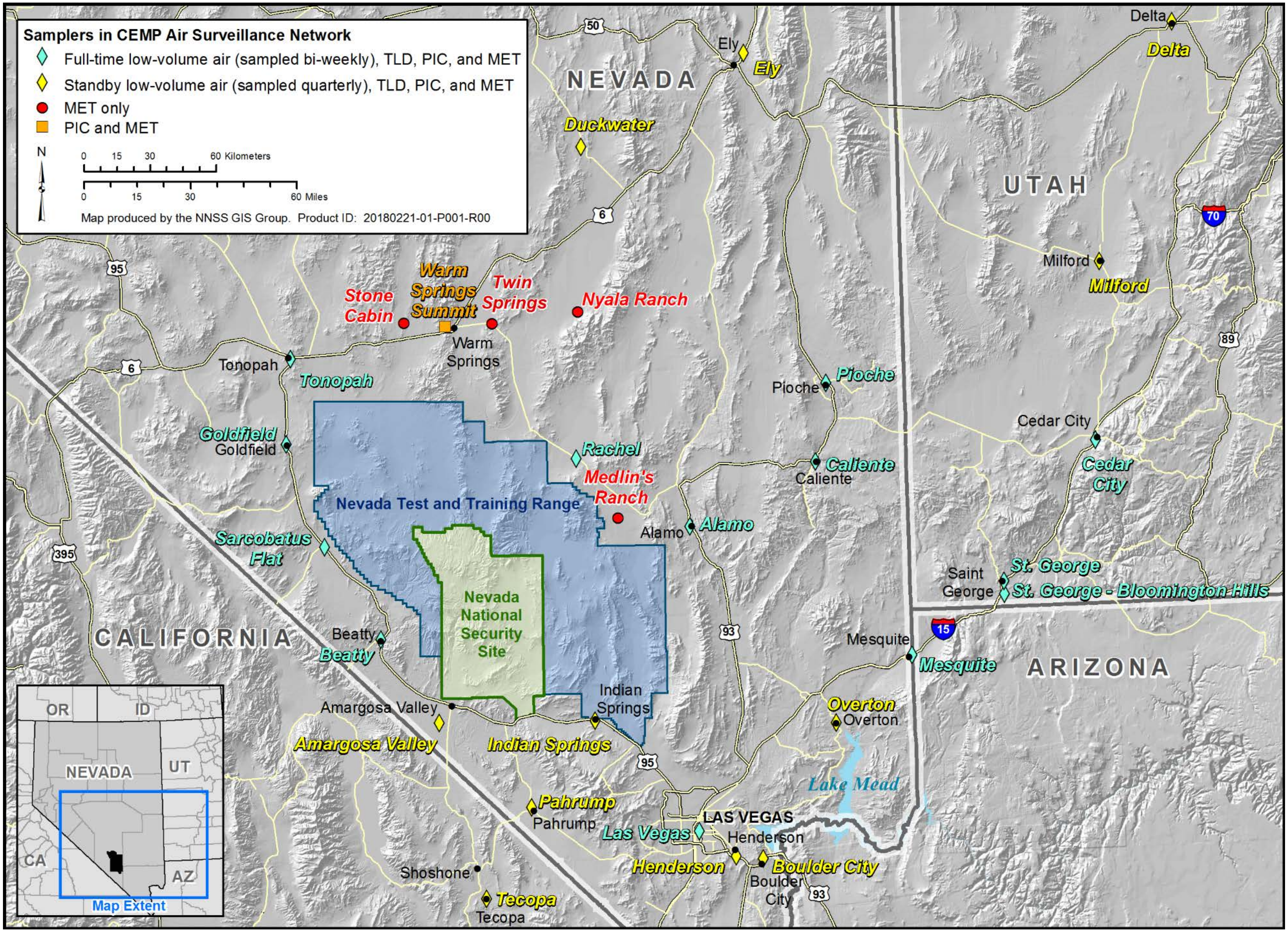

Figure 7-1. 2017 CEMP Air Surveillance Network

7.1.2 Air Sampling Methods

Samples of airborne particulates from CEMP ASN stations were collected by drawing air through a 5-centimeter (2-inch) diameter glass-fiber filter at a constant flow rate of 49.5 liters (1.75 cubic feet [ft^3]) per minute at standard temperature and pressure. The actual flow rate and total volume were measured with an in-line air-flow calibrator. The filter is mounted in a holder that faces downward at a height of approximately 1.5 meters (m) (5 feet [ft]) above the ground. The total volume of air collected ranged from approximately 1,030 to 1,290 cubic meters (m^3) (36,000 to 45,000 ft^3), depending on the elevation of the station and changes in air temperature and/or pressure.

During the first three quarters of 2017, CEMP air samples were collected on a biweekly basis from 12 “full-time” stations and one quarterly sample from the 11 ‘standby’ stations. Beginning October 1, 2017, all stations were placed in a “standby” status. Air sampling now occurs full time year around, but only one sample per quarter from each station will be selected for routine analysis. As a result of these changes, a maximum of 21 samples were collected from the full-time stations and four from the standby stations in 2017. Stations at Cedar City and St. George were relocated during the year. The relocation of the St. George station was geographically significant enough to warrant a re-naming of the station site to St. George Bloomington Hills (BH), and sampling data are segregated in the report accordingly.

Figure 7-2. CEMP Station in Delta, Utah

7.1.3 Air Sampling Results

7.1.3.1 Gross Alpha and Gross Beta

Analyses of gross alpha and beta in airborne particulate samples are used to screen for long-lived radionuclides in the air. The mean annual gross alpha activity across all sample locations was $1.33 \pm 0.26 \times 10^{-15}$ microcuries per milliliter (μCi/mL) ($4.92 \pm 0.96 \times 10^{-5}$ ***becquerels*** [Bq]/m^3) (Table 7-1). Gross alpha was detectable in all of the 2017 air samples, and overall, gross alpha levels of activity were similar to results from previous years. Figure 7-3 shows the long-term maximum, mean, and minimum alpha trend for all CEMP stations combined. Since 2009, the mean gross alpha results have been essentially unchanged following a slight decreasing trend from 2007 to 2009. This trend is also reflected by most of the stations on an individual basis.

Table 7-1. Gross alpha results for the CEMP offsite ASN in 2017

		Concentration (× 10^{-15} µCi/mL [3.7×10^{-5} Bq/m^3])			
Sampling Location	**Number of Samples**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
Alamo	21	1.68	0.99	0.74	3.85
Amargosa Valley	4	1.79	1.05	1.03	3.58
Beatty	20	1.43	0.51	0.74	2.62
Boulder City	4	1.28	0.29	0.94	1.74
Caliente	21	1.34	0.49	0.7	2.51
Cedar City	18	1.06	0.34	0.31	1.63
Delta	4	0.96	0.25	0.64	1.25
Duckwater	4	1.55	0.4	0.99	1.95
Ely	4	1.2	0.49	0.69	1.89
Goldfield	21	1.22	0.49	0.38	2.5
Henderson	4	1.25	0.52	0.89	2.15
Indian Springs	4	1.11	0.61	0.45	1.99
Las Vegas	21	1.25	0.33	0.6	2.17
Mesquite	20	1.45	0.8	0.73	3.46
Milford	4	1.13	0.26	0.79	1.5
Overton	4	2.03	1.07	0.72	3.62
Pahrump	4	1.27	0.54	0.55	2
Pioche	21	1.23	0.71	0.39	3.44
Rachel	21	1.25	0.45	0.6	2.68
Sarcobatus Flats	21	1.77	0.97	0.6	4.24
St. George (BH)	1	1.15	N/A	N/A	N/A
St. George	17	1.11	0.41	0.49	2.07
Tecopa	4	1.2	0.11	1.11	1.38
Tonopah	21	1.1	0.42	0.51	2.56

Network Mean = 1.33 ± 0.26 × 10^{-15} µCi/mL
Mean *Minimum Detectable Concentration (MDC)* = 0.31 × 10^{-15} µCi/mL
Standard Error of Mean MDC = 0.04 × 10^{-15} µCi/mL

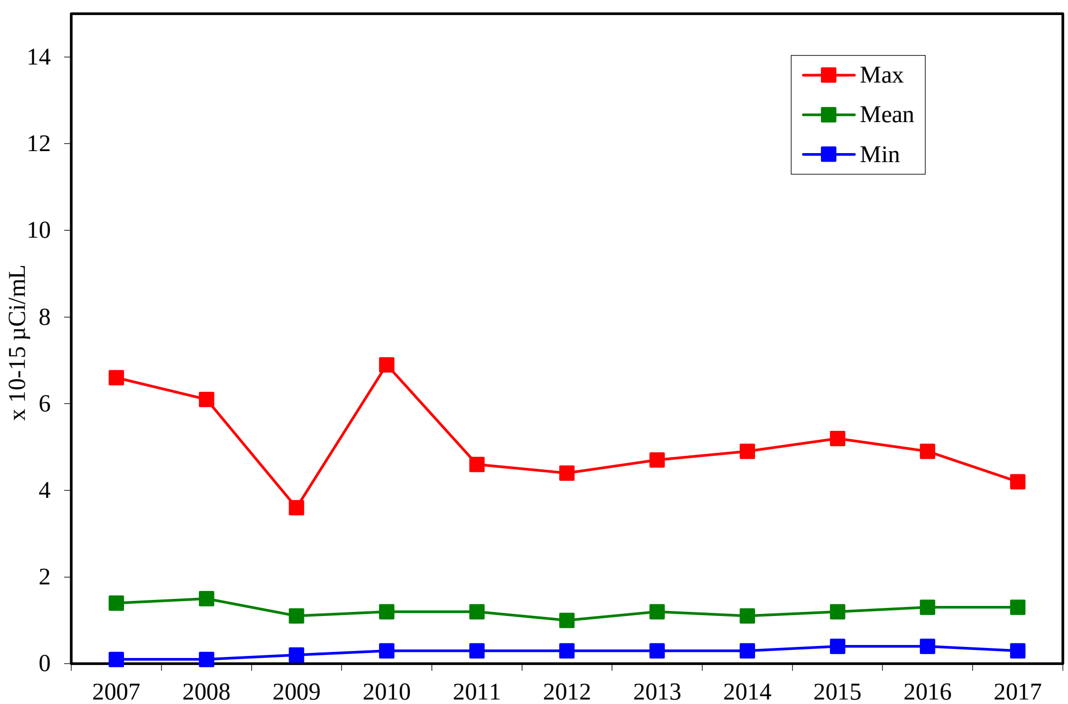

Figure 7-3. Historical trend for gross alpha analysis for all CEMP stations

The mean annual gross beta activity across all sample locations (Table 7-2) was 1.84 ± 0.19 × 10^{-14} µCi/mL (6.73 ± 0.67 × 10^{-4} Bq/m^3). Gross beta activity was detected in all air samples and, overall, was similar to previous years' levels. Figure 7-4 shows the long-term maximum, mean, and minimum beta trend for all stations combined. The 2011 peak in the maximum data, observed across all stations in the network, was due to the tsunami-damaged Fukushima Nuclear Power Plant accident in Japan. Except for 2011, mean gross beta results have been essentially level from 2007 to 2017. This trend is also reflected by most of the stations on an individual basis.

Table 7-2. Gross beta results for the CEMP offsite ASN in 2017

Sampling Location	Number of Samples	Concentration (× 10^{-14} µCi/mL [3.7 × 10^{-4} Bq/m^3])			
		Mean	Standard Deviation	Minimum	Maximum
Alamo	21	1.77	0.43	1.11	2.54
Amargosa Valley	4	2.08	0.26	1.67	2.31
Beatty	20	1.68	0.49	1.5	2.01
Boulder City	4	2.01	0.24	1.79	2.41
Caliente	21	1.87	0.42	0.98	2.37
Cedar City	18	1.59	0.39	0.89	2.12
Delta	4	2.23	0.49	1.63	2.99
Duckwater	4	2.1	0.48	1.44	2.76
Ely	4	1.69	0.28	1.37	2
Goldfield	21	1.62	0.37	1.08	2.4
Henderson	4	1.89	0.21	1.55	2.12
Indian Springs	4	1.82	0.19	1.5	2.01
Las Vegas	21	1.75	0.37	1.14	2.4
Mesquite	20	1.78	0.37	1.12	2.29
Milford	4	1.94	0.4	1.46	2.55
Overton	4	1.95	0.25	1.58	2.19
Pahrump	4	1.8	0.56	1.01	2.56
Pioche	21	1.58	0.37	0.91	2.1
Rachel	21	1.75	0.46	1.09	2.77
Sarcobatus Flats	21	1.73	0.4	1.01	2.46
St. George (BH)	1	2.21	N/A	N/A	N/A
St. George	17	1.84	0.41	1.07	2.46
Tecopa	4	2.02	0.29	1.6	2.34
Tonopah	21	1.49	0.42	0.74	2.13

Network Mean = 1.84 ± 0.19 × 10^{-14} µCi/mL **Mean MDC = 0.04 × 10^{-14} µCi/mL**
Standard Error of Mean MDC = 0.006 × 10^{-14} µCi/mL

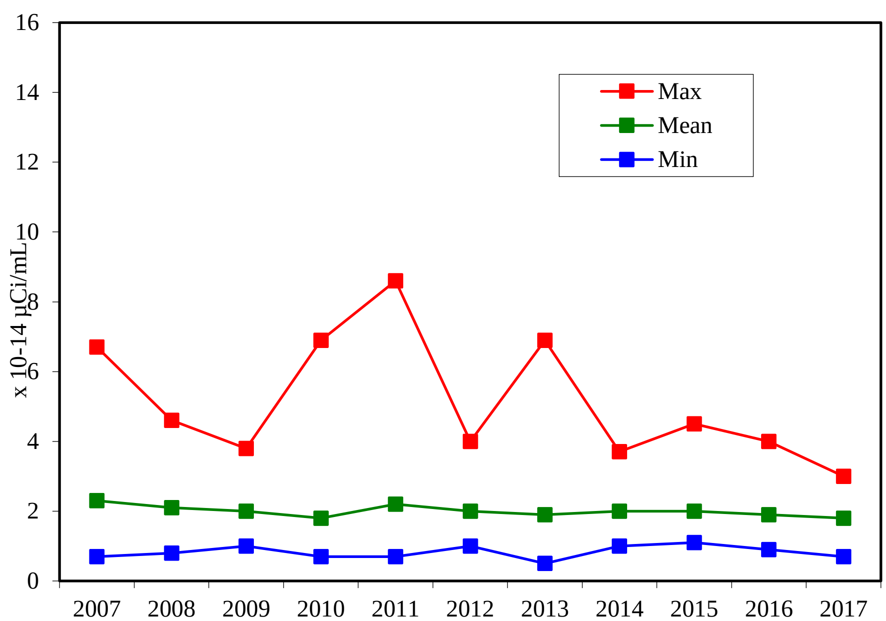

Figure 7-4. Historical trend for gross beta analysis for all CEMP stations

7.1.3.2 Gamma Spectroscopy

Gamma spectroscopy analysis was performed on all samples from the low-volume air sampling network. Generally, the filters were composited by station on a quarterly basis after gross alpha/beta analysis. As in previous years, man-made gamma-emitting radionuclides were not detected in any samples. In most of the samples, naturally occurring beryllium-7 (^{7}Be) was detectable. This radionuclide is produced by cosmic ray interaction with nitrogen in the atmosphere. The mean annual activity for ^{7}Be for the sampling network was $0.88 \pm 0.57 \times 10^{-13}$ μCi/mL.

7.1.4 Thermoluminescent Dosimetry Results

TLDs measure ***ionizing radiation*** from all sources, including natural radioactivity from cosmic or terrestrial sources and from man-made radioactive sources. The TLDs are mounted in a Plexiglas holder approximately 1 m (3.3 ft) above the ground and are exchanged quarterly. TLD results are not presented for the Warm Springs Summit station because access is limited in the winter, which does not allow for the required quarterly change of the TLD. The total annual exposure for 2017 ranged from 70 milliroentgens (mR) (0.70 millisieverts [mSv]) at St. George, Utah, to 158 mR (1.58 mSv) at Milford, Utah, with a mean annual exposure of 114 mR (1.14 mSv) for all operating locations. Results are presented in Table 7-3 and are consistent with previous years' data. Figure 7-5 shows the long-term data trend for the CEMP stations as a whole. Overall, the TLD data show a possible slight increasing trend from 2010 to 2014, followed by a slightly decreasing trend from 2014 to 2017. The 2017 results are slightly lower than 2016.

Table 7-3. TLD monitoring results for the CEMP offsite ASN in 2017

Sampling Location	Number of Quarters	Estimated Annual Exposure (mR)[(a)]		
		Mean[(b)]	Minimum[(b)]	Maximum[(b)]
Alamo	4	114	100	131
Amargosa Valley	4	102	95	120
Beatty	4	129	112	158
Boulder City	4	106	96	117
Caliente	4	114	104	127
Cedar City	4	97	88	103
Delta	4	95	86	110
Duckwater	4	114	112	116
Ely	4	101	93	111
Goldfield	4	120	108	138
Henderson	4	112	104	124
Indian Springs	4	92	85	10
Las Vegas	4	94	86	107
Mesquite	4	101	96	115
Milford	4	139	127	158
Overton	2	93	80	105
Pahrump	4	80	73	96
Pioche	4	118	108	131
Rachel	4	122	112	139
Sarcobatus Flats	4	133	116	154
St. George (BH)	1	123	N/A	N/A
St. George	3	76	70	82
Tecopa	4	104	91	120
Tonopah	4	128	116	145

(a) To obtain daily exposure rates, divide annual exposure rates by 365.25
(b) Mean, minimum, and maximum values are from quarterly estimates

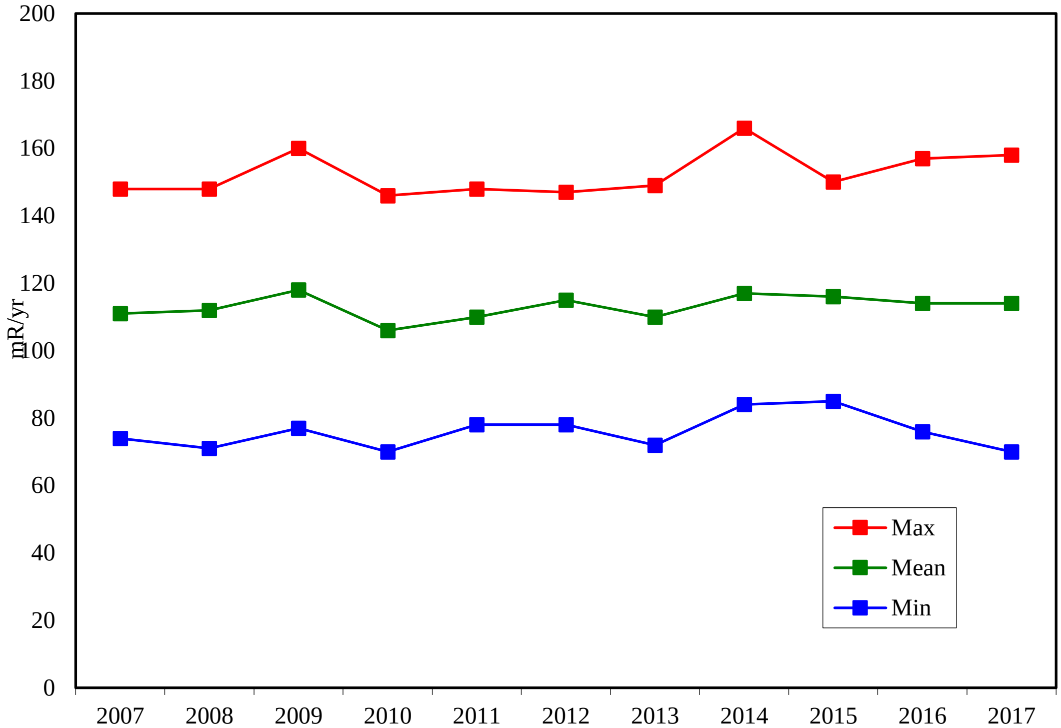

Figure 7-5. Historical trend for TLD analysis for all CEMP stations

7.1.5 Pressurized Ion Chamber Results

The PIC data presented in this section are based on daily averages of gamma exposure rates from each station. Table 7-4 lists the maximum, minimum, and standard deviation of daily averages (in microroentgens per hour [µR/hr]) for periods in 2017 when data were available. It also shows the average gamma exposure rate for each station during the year (in µR/hr) as well as the total annual exposure (in milliroentgens per year [mR/yr]). The exposure rate ranged from 73.15 mR/yr (0.73 mSv/yr) in Pahrump, Nevada, to 176.08 mR/yr (1.77 mSv/yr) at Milford, Utah. An increase from 10.45 µR/hr to 12.25 µR/hr at the Cedar City station and from 10.12 µR/hr to 13.60 µR/hr between the St. George and St. George Bloomington Hills (BH) stations correlates with the relocations of those two stations during the calendar year, which resulted in a change in background gamma rates at those locations. Background levels of environmental gamma exposure rates in the United States (from combined effects of terrestrial and cosmic sources) vary between 49 and 247 mR/yr (Committee on the Biological Effects of Ionizing Radiation III 1980). Averages for selected regions of the United States were compiled by the U.S. Environmental Protection Agency (EPA) and are shown in Table 7-5. The annual exposure levels observed at the CEMP stations in 2017 are well within these United States background levels, and are consistent with previous years' exposure rates, except as noted above.

Table 7-4. PIC monitoring results for the CEMP offsite ASN in 2017

	Daily Average Gamma Exposure Rate (µR/hr)				
Sample Location	Mean	Standard Deviation	Minimum	Maximum	Annual Exposure (mR/yr)
Alamo	13.25	0.35	12.2	14.3	116.07
Amargosa Valley	11.55	0.16	11	12.1	101.18
Beatty	16.8	0.33	15.9	17.7	147.17
Boulder City	15.9	0.14	15.4	16.4	139.28
Caliente	16.15	0.27	15.3	17	141.47
Cedar City	12.25	0.34	10.4	14.1	107.31
Delta	12.45	0.27	11.4	13.5	109.06
Duckwater	14.6	0.49	13	16.2	127.9
Ely	12.05	0.3	11.2	12.9	105.56
Goldfield	15.1	0.44	13.4	16.8	132.28
Henderson	13.25	0.19	12.7	13.8	116.08
Indian Springs	11.3	0.21	10.8	11.8	98.99
Las Vegas	10.5	0.9	8.8	12.2	91.98

Table 7-4. PIC monitoring results for the CEMP offsite ASN in 2017

	Daily Average Gamma Exposure Rate (µR/hr)				
Sample Location	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Annual Exposure (mR/yr)**
Mesquite	11.8	0.2	11.2	12.4	103.37
Milford	20.1	1.65	16.8	23.4	176.08
Overton	12.5	0.55	11.4	13.6	109.5
Pahrump	8.35	0.16	7.8	8.9	73.15
Pioche	14.45	0.68	12.3	16.6	126.58
Rachel	15.25	0.34	14.2	16.3	133.59
Sarcobatus Flats	16.7	0.3	15.7	17.7	146.29
St. George (BH)	13.6	0.33	12.9	14.3	119.14
St. George	10.1	0.19	9.4	10.8	88.48
Tecopa	13.25	0.27	12.4	14.1	116.07
Tonopah	16.25	0.52	14.4	18.1	142.35
Warm Springs Summit	19.6	0.5	18.2	21	171.7

Table 7-5. Average natural background radiation (excluding radon) for selected U.S. cities

City	Annual Exposure (mR/yr)
Denver, CO	164.6
Fort Worth, TX	68.7
Las Vegas, NV	69.5
Los Angeles, CA	73.6
New Orleans, LA	63.7
Portland, OR	86.7
Richmond, VA	64.1
Rochester, NY	88.1
St. Louis, MO	87.9
Tampa, FL	63.7
Wheeling, WV	111.9

Source: http://www.wrcc.dri.edu/cemp/Radiation.html. "Radiation in Perspective," August 1990 (Access Date: 3/10/17)

7.1.6 Environmental Impact

Results of analyses conducted on data obtained from the CEMP network of low-volume particulate air samplers, TLDs, and PICs showed no measurable evidence at CEMP stations of offsite impacts from radionuclides from NNSA/NFO activities. Activity observed in gross alpha and beta analyses of low-volume air sampler filters was consistent with previous years' results, and is within the range of activity found in other communities of the United States not adjacent to man-made radiation sources. Likewise, no man-made gamma-emitting radionuclides were detected. TLD and PIC results remained consistent with previous years' background levels and are well within average background levels observed in other parts of the United States (Table 7-5).

Occasional elevated gamma readings (10%–50% above normal average background) detected by the PICs in 2017 were associated with precipitation events and/or low barometric pressure. Low barometric pressure can result in the release of naturally occurring radon and its ***daughter products*** from the surrounding soil and rock. Precipitation events can result in the "rainout" of globally distributed radionuclides occurring as airborne particulates in the upper atmosphere. Figure 7-6, generated from the CEMP website, illustrates an example of this phenomenon.

7.2 CEMP Surface and Groundwater Monitoring

The CEMP for water is a non-regulatory program; its purpose is outreach and information to the public. Water samples are collected and analyzed for the presence of man-made radionuclides that could be the result of past nuclear testing on the NNSS. The CEMP monitors four groundwater wells downgradient of the NNSS (Figure 7-7). Water samples are collected by DRI personnel and analyzed for ^{3}H. Tritium is one of the most abundant radionuclides generated by an underground nuclear test, and because it is a constituent of the water molecule itself, it is also one of the most mobile. DRI provides public access to water monitoring data through CEMP's website at http://www.cemp.dri.edu/.

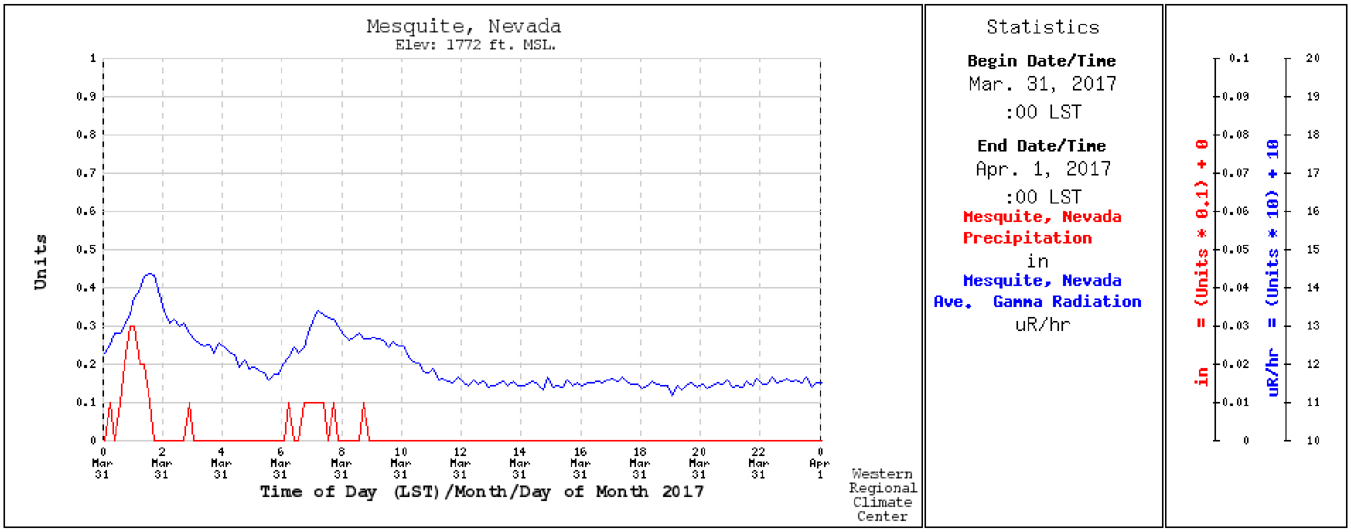

Figure 7-6. The effect of meteorological phenomena on background gamma readings at the Mesquite, Nevada CEMP station

7.2.1 Sample Locations and Methods

In September and October 2017, DRI sampled four wells. Sample locations (Figure 7-7) were selected based upon input from participating CEMs in communities downgradient of the NNSS. All wells are sampled at a water delivery point (i.e., faucet). Each sample originates from well distribution lines connected to submersible pumps that also sample the local groundwater system. Water is allowed to flow from each water delivery point for 5 to 15 minutes prior to sampling in order to purge stagnant water from distribution lines. This process ensures the resultant sample is representative of local groundwater. Table 7-6 lists sample locations, date sampled, and sampling method.

Table 7-6. CEMP water monitoring locations sampled in 2017

Monitoring Location Description	Latitude[(a)]	Longitude[(a)]	Date Sampled	Sample Collection Method
Amargosa Valley school well	36°34.16"	−116°27.66"	9/20/2017	By hand from sink in school office
Beatty Water and Sewer municipal water distribution system	36°57.09"	−116°48.26"	10/05/2017	By hand from well head
Sarcobatus Flats well	37°16.76"	−117°01.10"	9/29/2017	By hand at residential source
Tecopa residential well	35°50.86"	−116°13.63"	9/20/2017	By hand at residential source

(a) Coordinates are North American

In 2017, ARS International Laboratory in Port Allen, Louisiana analyzed samples using unenriched scintillation counting. Unenriched scintillation counting is an EPA-approved method for ^{3}H analysis. The ***decision level (L_C)*** for this counting process was less than 219 picocuries per liter (pCi/L). The L_C is based on the variability of multiple measures of samples which establish laboratory background. If a sample exceeds the L_c, it is considered distinguishable from background. The minimum detectable concentration (MDC) considers both the variability associated with multiple measures of the background and the variability associated with multiple measures of the sample itself. In 2017, the MDC for ^{3}H was approximately 445 pCi/L; this is a more rigorous threshold than the L_c, dictating that the sample be distinguishable from background at a confidence of 95%. The L_C and the MDC are approximately 1% and 2% of the EPA limit for ^{3}H in drinking water (respectively); The EPA limit is 20,000 pCi/L. ***Quality assurance*** and ***control*** procedures are described in Chapter 15.

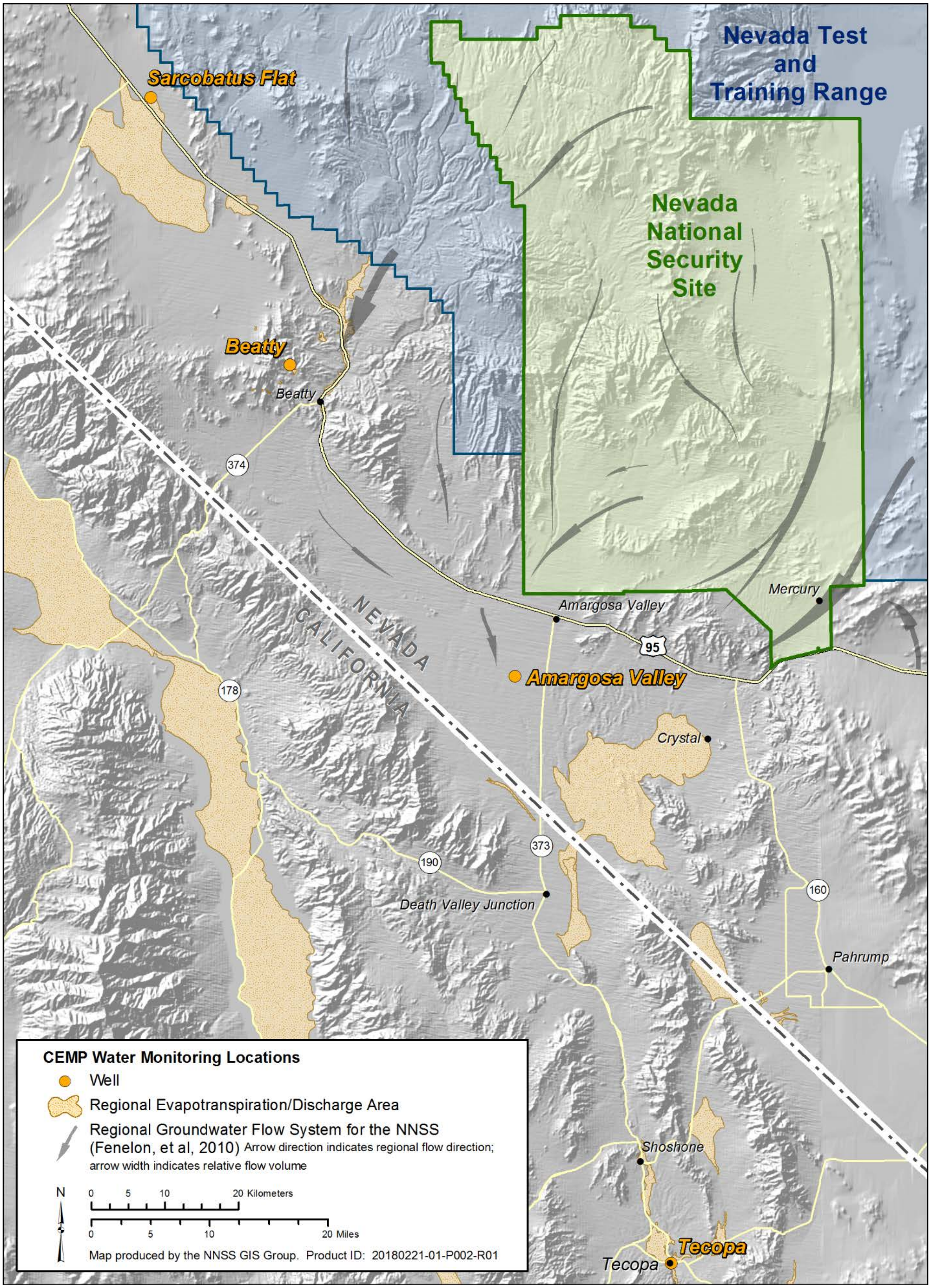

Figure 7-7. 2017 CEMP water monitoring locations

7.2.2 Results of Groundwater Monitoring

Tritium analyses from ARS International for the four groundwater samples yielded results that were all quantifiably below background (≤ the MDC of approximately 445 pCi/L). Public access to monitoring data is available on the DRI CEMP website at http://www.cemp.dri.edu/.

7.3 Nye County Tritium Sampling and Monitoring Program

The Nye County TSaMP was initiated in 2015 in response to the county's request for NNSA/NFO to expand its support of offsite community-based monitoring of wells for ^3H. A 5-year grant from the NNSA/NFO and the EM Nevada Program supports the county's annual sampling of 20 wells downgradient of the NNSS; 10 core wells (i.e., the same wells year to year) and 10 additional wells (selected locations change from year to year). The grant also supports Nye County's involvement in technical reviews of the UGTA corrective action program (Chapter 11). To help determine sample well locations, Nye County coordinates with DRI, who conducts the CEMP, with the CEMP's CEMs, and Nye County citizens. Nye County communicates their TSaMP activities and results to the public through poster presentations at annual DOE EM-funded Groundwater Open House meetings (Section 11.6), presentations at annual CEMP meetings, articles published in the Pahrump Valley Times, and this annually published report.

In 2017, in addition to the 10 core wells (9 wells and 1 spring), Nye County sampled 8 wells and 2 springs. (Table 7-7 and Figure 7-8). Selected locations for 2017 were in the same general areas as 2015 and 2016, and were chosen for their position within the projected groundwater flow path from the NNSS, proximity to downgradient communities, and recommendations provided by CEMs or Nye County citizens. Wells managed by Nye County and being sampled for ^3H under the TSaMP were initially drilled as part of the Early Warning Drill Program ("EWDP" labelled wells) or as Nye County Groundwater Evaluation Wells ("NC-GWE" labelled wells). Nye County also takes water levels in these wells on a quarterly basis through funding from the Nye County Water District's Water Level Measurement Program. Some locations selected for sampling under the TSaMP may include NNSA/NFO wells or locations that are also sampled under the NNSS Integrated Groundwater Sampling Plan (Section 5.1) or under the CEMP. All wells were sampled using either an air-powered submersible positive-was pumped from each displacement pump or a 3-inch submersible electric pump. A minimum of three well volumes (16 to 1,158 gallons) was pumped from each well prior to sampling in order to purge water from the pump tubing and well annulus and ensure samples are representative of local groundwater conditions. Community wells, which include domestic or municipal wells, were sampled from the dedicated pump discharge. The three springs sampled in 2017 are on private land and were sampled directly from the spring discharge.

All samples were analyzed for ^3H by Radiation Safety Engineering, Inc., in Chandler, Arizona using an EPA-approved, unenriched scintillation counting method. The sample MDCs for this method was 291 pCi/L, which is less than 2% of the EPA limit for ^3H in drinking water (20,000 pCi/L). Analytical methods included the use of quality control samples such as duplicates, blanks, and spikes. Nye County's quality assurance procedures for ^3H sampling are documented in Test Plan TPN-11.8, "Groundwater Sampling and Analysis for the Nye County Tritium Sampling and Monitoring Program" and Work Plan WP-11, "Groundwater Chemistry Sampling and Analysis" (available on the Nye County website at http://www.co.nye.nv.us/index.aspx?NID=901).

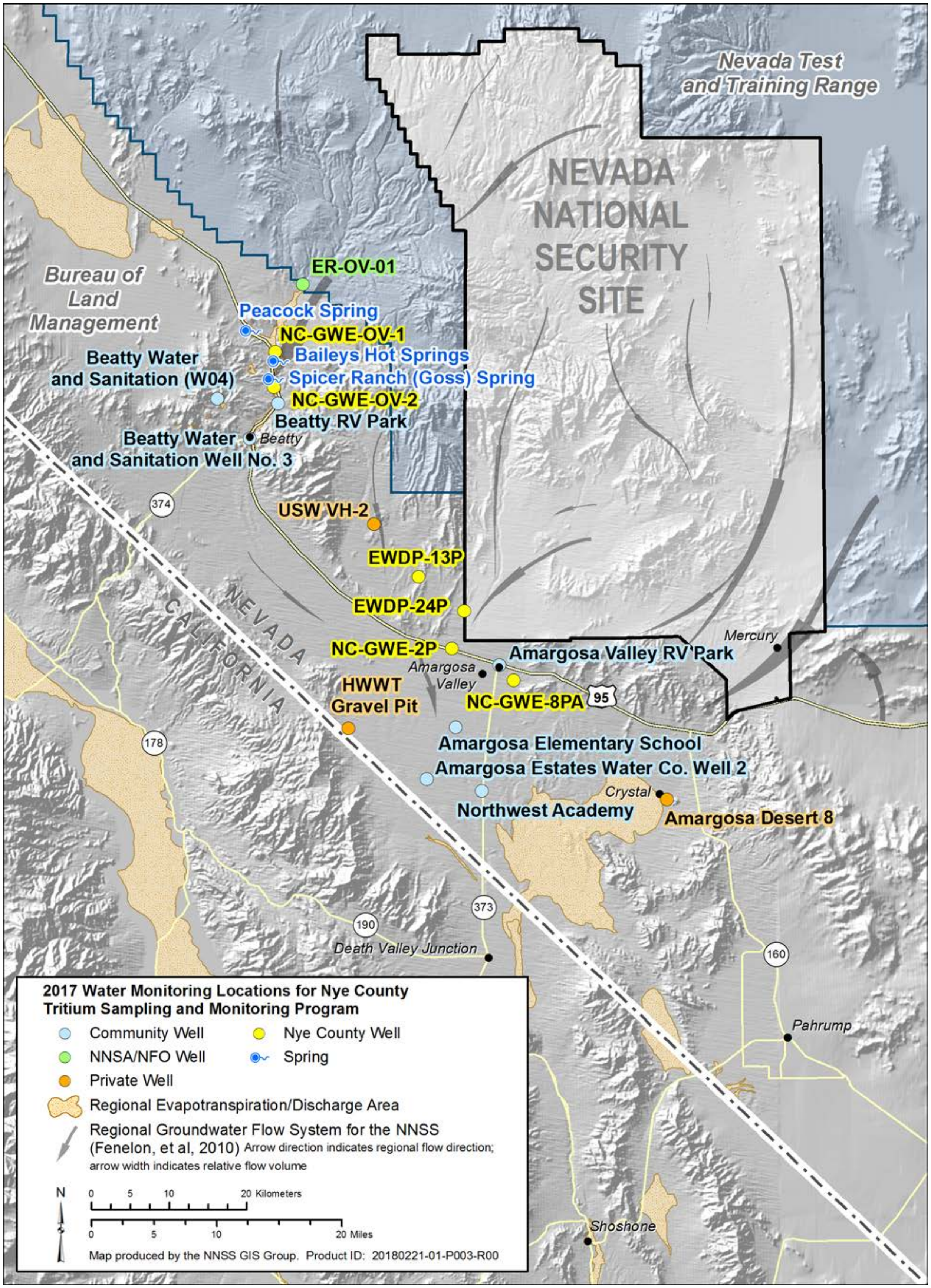

Figure 7-8. 2017 Nye County TSaMP water monitoring locations

Table 7-7. 2017 Nye County TSaMP water monitoring locations, results, and dates sampled

Sample Locations	Latitude(a)	Longitude(a)	Date Sampled
	^{3}H Concentration in all samples is <291 pCi/L		
	Nye County Wells		
EWDP-13P*	36° 44' 40"	-116° 30' 50"	10/26/2017 (10/26/2017 FB(b))
EWDP-24P*	36° 42' 17"	-116° 26' 53"	10/23/2017
NC-GWE-8PA*	36° 37' 28"	-116° 22' 38"	10/19/2017
NC-GWE-2P	36° 39' 40"	-116° 27' 57"	10/25/2017 (10/25/2017 FD(c))
NC-GWE-OV-1*	37° 0' 22"	-116° 43' 15"	11/1/2017
NC-GWE-OV-2*	36° 57' 52"	-116° 43' 23"	11/2/2017 (11/2/2017 FD)
	NNSA/NFO Wells		
ER-OV-01	36° 5' 4"	-116° 40' 52"	11/14/2017
	Community Wells		
Amargosa Elementary School*	36° 34' 11"	-116° 27' 39"	11/28/2017 (11/28/2017 FB)
Amargosa Valley RV Park*	36° 38' 31"	-116° 23' 51"	11/15/2017 (11/15/2017 FB)
Beatty RV Park	36° 56’ 45”	-116° 42’ 59”	11/14/2017 (11/14/2017 FD)
Beatty Water and Sanitation, Indian	36° 57' 6"	-116° 48' 16"	11/16/2017
Beatty Water and Sanitation, Well (W03)	36° 54' 18"	-116° 45' 28"	11/29/2017 (11/29/2017 FD)
Armargosa Estates Water Co. Well 2	36° 30' 35"	-116° 30' 9"	11/16/2017
Northwest Academy*	36° 29' 46"	-116° 25' 25"	11/28/2017
	Private Wells		
Amargosa Desert 8	36° 29' 6"	-116° 9' 27"	11/15/2017
HWWT Gravel Pit	36° 34' 9"	-116° 36' 54"	11/16/2017
USW VH-2	37° 48' 21"	-116° 34' 40"	11/15/2017
	Springs		
Baileys Hot Springs*(d)	36° 58' 29"	-116° 43' 21"	11/28/2017
Peacock Spring	37° 1’ 51"	-116° 45' 20"	11/29/2017
Spicer Ranch (Goss) Spring	37° 59' 44"	-116° 42' 57"	11/28/2017

*Core wells are sampled in the same location annually

(a) Coordinates are North American Datum 1983 (b) Field blank (c) Field duplicate

(d) In 2015 and 2016, Baileys Hot Springs was listed as a private well. Due to the temporary closure of the resort, the location is listed as a spring in 2017.

All ^{3}H analysis results were below background, i.e., ≤ the MDC. Similar to the CEMP water sampling results (Section 7.2) and those of the Community wells within NNSA/NFO’s water sampling network (Section 5.1.3.5), Nye County’s monitoring confirms that ^{3}H from past underground nuclear testing on the NNSS is not present in these wells.

On April 18th 2018, the Pahrump Valley Times printed TSaMP’s 2017 monitoring results (https://pvtimes.com/news/three-years-of-sampling-show-tritium-remains-undetectable-in-nye-water/). The article provided sample locations, described methods, and highlighted sampling results.

7.4 Environmental Impact

The wells and water supply systems within the CEMP and Nye County monitored network downgradient of the NNSS continue to show no evidence of ^{3}H contamination from past underground nuclear testing on the NNSS. To date, the maximum concentration of ^{3}H observed offsite is at ER-EC-11 on the NTTR. Tritium at ER-EC-11 was reported as 18,400 pCi/L in 2017 (Table 5-4). Well ER-EC-11 is approximately 0.72 kilometers (km) (0.45 mile [mi]) west of the NNSS boundary (Figure 5-2). Additional sampling and analyses will continue as part of the Phase II investigation for the Central and Western Pahute Mesa and groundwater characterization and modeling activities are ongoing to forecast the extent of offsite contamination over the next 1,000 years (Section 11.1.1.2). The nearest CEMP water monitoring locations downgradient of the NNSS are Amargosa Valley and Beatty, approximately 70 km (43 mi) and 40 km (25 mi), respectively, southwest of Well ER-EC-11.

7.5 References

Committee on the Biological Effects of Ionizing Radiation III, 1980. *The Effects on Populations of Exposure to Low Levels of Ionizing Radiation: 1980*. National Academy Press, Washington, D.C.

Chapter 8: Radiological Biota Monitoring

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Historical atmospheric nuclear weapons testing, outfalls from underground nuclear tests, and radioactive waste disposal sites provide potential sources of radiation contamination and ***exposure***[1] to Nevada National Security Site (NNSS) plants and animals (biota). U.S. Department of Energy (DOE) Order DOE O 458.1, "Radiation Protection of the Public and the Environment," requires DOE sites to monitor ***radioactivity*** in the environment to ensure the public does not receive a radiological ***dose*** greater than 100 millirems per year (mrem/yr) from all pathways of exposure, including the ingestion of contaminated plants and animals. DOE O 458.1 also requires monitoring to ensure aquatic and terrestrial plant and animal populations are protected from excessive radiological dose.

The U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) land use practices on the NNSS discourage the harvest of plants or plant parts (e.g., pine nuts and wolfberries) for direct consumption by humans. Some edible plant material might be taken off site and consumed, but this is generally not allowed and, if it does occur, is very limited. Game animals on the NNSS might travel off the site and become available through hunting for consumption by the public, which makes the ingestion of game animals the primary potential biotic pathway for dose to the public.

Plants and game animals are monitored under the Routine Radiological Environmental Monitoring Plan (RREMP) (Bechtel Nevada [BN] 2003). They are sampled annually from contaminated NNSS sites to estimate doses to persons hypothetically consuming them, to measure the potential for ***radionuclide*** transfer through the food chain, and to determine if NNSS biota are exposed to radiation levels harmful to their own populations. Biota and soil samples from the Radioactive Waste Management Sites (RWMSs) are also periodically collected to assess the integrity of waste disposal cells. This chapter describes the biota monitoring program designed to meet public and environmental radiation protection regulations (Section 2.4) and presents the field sampling and analysis results from 2017. The estimated dose to humans potentially consuming NNSS plants and animals and the dose to biota from these radionuclides are presented in Chapter 9.

Radiological Biota Monitoring Goals
Collect and analyze biota samples for radionuclides to estimate the potential dose to humans who may consume plants or game animals from the NNSS (see Chapter 9 for the estimates of dose to humans).
Collect and analyze biota samples for radionuclides to estimate the ***absorbed radiation dose*** to NNSS biota (see Chapter 9 for the estimates of dose to NNSS plants and animals).
Collect and analyze soil samples at the Area 3 and Area 5 RWMSs to provide evidence that the burrowing activities of fossorial animals have or have not compromised the integrity of the soil covered waste disposal units.

8.1 Species Selection

The goal for vegetation monitoring is to sample the plants most likely to have the highest contamination within the NNSS environment. They are generally found inside demarcated radiological areas near the "ground zero" locations of historical aboveground or near-surface nuclear tests. The species selected for sampling represent the most dominant life forms (e.g., trees, shrubs, herbs, or grasses) at these sites. Woody vegetation (i.e., shrubs versus forbs or grasses) is sampled because it is reported to have deeper penetrating roots and potentially higher concentrations of ***tritium*** (**^3H**) (Hunter and Kinnison 1998). Woody vegetation also is a major source of browse for game animals that might potentially migrate off site. Grasses and forbs are sampled when present because they are also a source of food for wildlife. Plant parts collected for analysis represent new growth over the past year. Pine nuts from singleleaf pinyon pine trees, which may be consumed by humans, are also sampled periodically.

[1] The definition of word(s) in ***bold italics*** may be found by clicking on the word in electronic version or by referencing the Glossary, Appendix B. To return from the Glossary, right click and select Previous View.

When determining the potential dose to animals, the goal of sampling is to select species that are most exposed and most sensitive to the effects of radiation. In general, mammals and birds are more sensitive to radiation than fish, amphibians, or invertebrates (DOE Standard DOE-STD-1153-2002, "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota"). The list of species used to assess the potential dose to animals in Table 8-1 reflects this graded approach and the fact that no native fish or amphibian are found on the NNSS.

The game animals monitored to assess the potential dose to the public meet three criteria: (1) they are a species consumed by humans; (2) they have a home range that overlaps a contaminated site and, as a result, have the potential for relatively high radionuclide body burdens from exposure to contaminated soil, air, water, or plants at the contaminated site; and (3) they are sufficiently abundant at a site that an adequate tissue sample can be acquired for laboratory analysis. These criteria limit the candidate game animals to those listed in Table 8-1. Mule deer, pronghorn antelope, bighorn sheep, and predatory game animals such as mountain lions are only collected as the opportunity arises, that is, if they are found dead on the NNSS (e.g., killed by a predator or accidentally hit by a vehicle). Tissues from species analogous to big game, such as feral horses, may be collected opportunistically as well. If game animals are not sufficiently abundant at a particular site or at a particular time, non-game small mammals may be used as an analog (Table 8-1).

The sampling strategy to assess the integrity of radioactive waste containment includes sampling plants, animals, and soil excavated by ants or small mammals on top of waste covers. Plants are generally selected by size with preference for larger shrubs, under the assumption that they have deeper roots and therefore would be more likely to penetrate buried waste. Small mammals selected for sampling meet three criteria: (1) they are fossorial (i.e., they burrow and live predominantly underground), (2) they have a home range small enough to ensure that they reside a majority of the time on the waste disposal site, and (3) they are sufficiently abundant at a site to acquire an adequate tissue sample for laboratory analysis. These criteria limit the animals to those listed in Table 8-1. Soils excavated by ants or small mammals are also selected for sampling on the basis of size, with preference for larger ant mounds and animal burrow sites under the assumption that these burrows are deeper and have a higher potential for penetrating waste.

Table 8-1. NNSS animals monitored for radionuclides

Small Mammals	Large Mammals	Birds
	Game Animals Monitored for Dose Assessments	
Cottontail rabbit *(Sylvilagus audubonii)* Jackrabbit *(Lepus californicus)*	Mule deer *(Odocoileus hemionus)* Pronghorn antelope *(Antilocapra americana)* Mountain lion *(Puma concolor)* Desert bighorn sheep *(Ovis canadensis nelsoni)* Bobcat *(Lynx rufus)*	Mourning dove *(Zenaida macroura)* Chukar *(Alectoris chukar)* Gambel's quail *(Callipepla gambelii)*
	Animals Monitored for Integrity of Radioactive Waste Containment or as Game Animal Analogs	
Kangaroo rats *(Dipodomys spp.)* Mice *(Peromyscus spp.)* Antelope ground squirrel *(Ammospermophilus leucurus)* Desert woodrat *(Neotoma lepida)*		

8.2 Site Selection

The monitoring program design focuses on sampling sites with the highest concentrations of radionuclides in other media (e.g., soil and surface water) and have relatively high densities of candidate animals. The RREMP identifies five contaminated sites and their associated control sites. Each year, biota from one or two of these sites is sampled, and each of the sites is sampled once every 5 years. They are E Tunnel Ponds, Palanquin/Schooner Crater, Sedan Crater, T2, and Plutonium Valley (Figure 8-1), and each is associated with one type of a legacy contamination area (see list below). The control site selected for each contaminated site has similar biological and physical features. Control sites are sampled to document the radionuclide levels representative of ***background***.

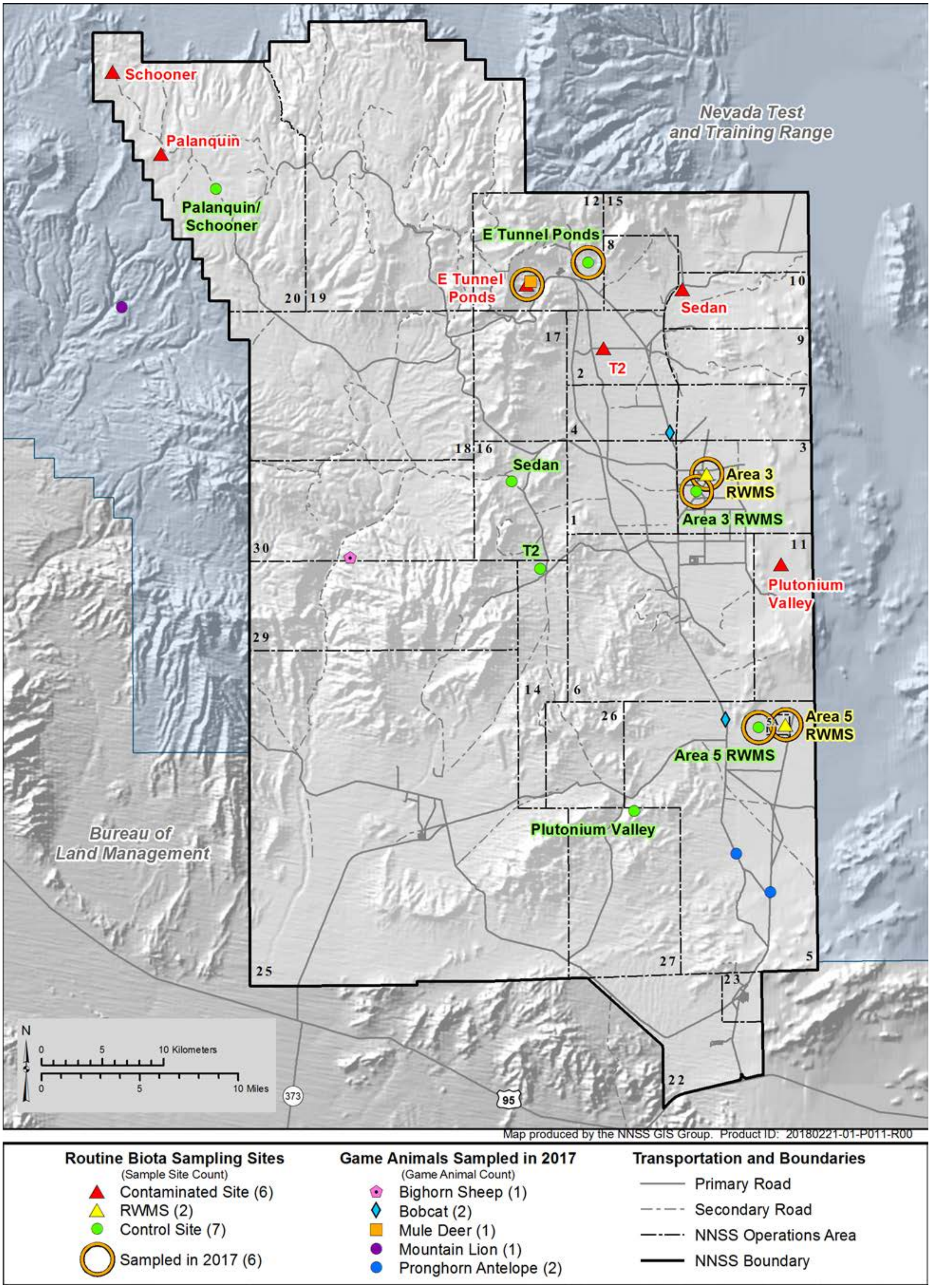

Figure 8-1. Radiological biota monitoring sites on the NNSS

- **Runoff areas or containment ponds associated with underground or tunnel test areas.** Contaminated water draining from test areas can form surface water sources that are important given the limited availability of surface water on the NNSS. Therefore, they have a high potential for transferring radionuclides to plants and wildlife seeking surface water. The associated monitoring site is E Tunnel Ponds below Rainier Mesa. This contaminated site, along with its control site, was sampled in 2017.
- **Plowshare sites in alluvial fill at lower elevations with high surface contamination.** The historical ***Plowshare Program***, conducted throughout the NNSS, explored the potential use of nuclear weapons for peaceful purposes. Surface and shallow subsurface nuclear detonations at these alluvial, low elevation sites have distributed contaminants over a wide area, usually in the lowest precipitation areas of the NNSS. The associated monitoring site is Sedan Crater in Yucca Flat. It was last sampled in 2015.
- **Plowshare sites in bedrock or rocky fill at higher elevations with high surface contamination.** Surface and shallow subsurface nuclear detonations at these Plowshare Program sites distributed contaminants over a wide area, usually in the highest precipitation areas of the NNSS. Two monitored sites are in this category: Palanquin Crater and Schooner Crater. Both sites were last sampled in 2013.
- **Atmospheric test areas.** These sites have highly disturbed soils due to the removal of topsoil during historical cleanup efforts and due to the sterilization of soils from heat and radiation during testing. The same areas were often used for multiple nuclear tests. The associated monitoring site is T2 in Yucca Flat. It was last sampled in 2016.
- **Aboveground safety experiment sites.** These areas are typified by current radioactive soil contamination, primarily in the form of plutonium and uranium. The associated monitoring site is Plutonium Valley in Area 11. It was last sampled in 2014.

Soil sampling is also conducted periodically at radioactive waste disposal locations on the NNSS to assess whether fossorial small mammals are being exposed to buried wastes and, therefore, whether the integrity of waste containment is compromised. Two radioactive waste disposal facilities are sampled:

- **Area 3 RWMS.** Waste disposal cells within the Area 3 RWMS are subsidence craters resulting from underground nuclear testing. Two closed cells containing bulk ***low-level radioactive waste*** are craters U-3ax and U-3bl, which were combined to form the U-3ax/bl disposal unit (Corrective Action Unit 110). U-3ax/bl is covered with a vegetated, native alluvium closure cover that is at least 2.4 meters (m) (8 feet [ft]) thick. It was sampled in 2017.
- **Area 5 RWMS.** Waste disposal has occurred at the Area 5 RWMS since the early 1960s. There are 11 closed disposal cells containing bulk low-level radioactive waste. The cells are unlined pits and trenches that range in depth from 4.6 to 15 m (15 to 48 ft). Efforts are currently being made to establish native vegetation on the cover cap of the 92-Acre Area, which caps multiple waste cells. The cover cap is approximately 2.4 m (8 ft) thick. Plants and animals from three different portions of the 92-Acre Area cover were sampled in 2017.

8.3 2017 Sampling and Analysis

In 2017, the E Tunnel Ponds and the E Tunnel Ponds Control sites were sampled for plants. The E Tunnel Ponds are just southeast of Rainier Mesa in Area 12 in the northern part of the NNSS (Figure 8-1). Radionuclide-contaminated water and soils occur at this site. The ponds were constructed to collect and hold contaminated water (mainly from ^{3}H), which drains out of E Tunnel where nuclear testing was conducted. The water is perched groundwater that has percolated through fractures in the tunnel system. Eight basins make up the E Tunnel Ponds site (Figure 8-2). Ponds 1 – 5 received water from 1970 – 2013, with various ponds receiving water at various times. Ponds 6a – 6c received water from 2009 – present. The E Tunnel Ponds Control site is an uncontaminated natural spring (Whiterock Spring) 5.2 km west-northwest of the E Tunnel Ponds. Attempts were made to collect game birds from these locations but after a total of 69 trap-nights at the E Tunnel Ponds site and 55 trap-nights at the E Tunnel Ponds Control site, no game birds were captured and no game animal samples are from these locations in 2017.

The Area 3 and Area 5 RWMSs, and their associated control sites were also sampled in 2017 (Figure 8-1). The Area 3 RWMS is in Yucca Flat at an elevation of 1,223 m (4,012 ft). Yucca Flat was one of several primary nuclear test areas. Between 1952 and 1972, 60 nuclear weapons tests were conducted within 400 m (1,312 ft) of the Area 3 RWMS boundary (NNSA/NFO 2015). Fourteen of these tests were atmospheric, which left primarily ^{3}H, ^{90}Sr, ^{137}Cs, ^{152}Eu, $^{239+240}$Pu, and ^{241}Am in the surface soil across the area. Sampling in 2017 was conducted on the U-3ax/bl cover. The Area 3 RWMS Control site is located about 1.7 km southwest of the U-3 ax/bl cover.

The Area 5 RWMS is in northern Frenchman Flat at an elevation of 962 m (3,156 ft) and consists of numerous landfill cells. Buried radioactive materials at the Area 5 RWMS consist primarily of ^{3}H, ^{90}Sr, ^{137}Cs, uranium (various ***isotopes***), plutonium (various isotopes), and ^{241}Am. No nuclear weapons testing occurred within the boundaries of the Area 5 RWMS, but there were 10 underground tests within 4.3 km (2.7 mi) and 14 atmospheric tests within 7 km (4.3 mi). Sampling was conducted on the 92-Acre Area cover, specifically the South, South-North, and West portions of the 92-Acre Area cover (Figure 8-3). The Area 5 RWMS Control site is located about 1.7 km west of the 92-Acre Area cover.

Figure 8-2. E Tunnel Pond basins

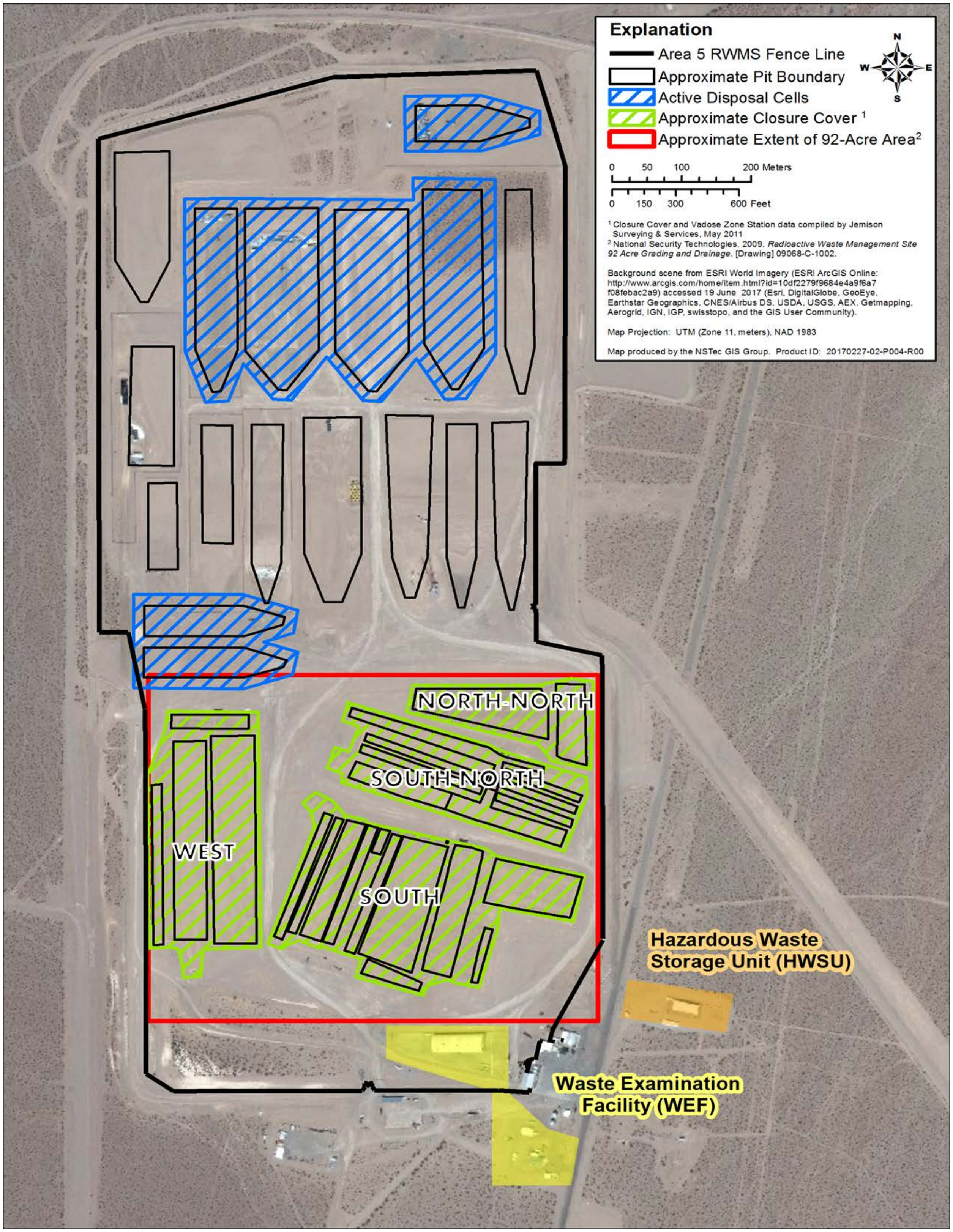

Figure 8-3. Area 5 RWMS 92 Acre Covers (green hatch areas within red outlined area)

8.3.1 Plants

Plants were sampled in the dry basins of ponds 4 and 5 and around ponds 6a and 6b of the E Tunnel Ponds site on August 31, 2017 and from the E Tunnel Ponds Control site on September 5, 2017. Two composite samples were collected from each of these three locations (ponds 4 and 5, ponds 6a and 6b, and the control site) (Table 8-2). One composite plant sample was collected from the 92-Acre Area covers and the Area 5 RWMS control site on August 31, 2017. One composite plant sample was collected from the Area 3 RWMS U-3ax/bl cover and the Area 3 control site on September 5, 2017.

All samples consisted of about 150 to 500 grams (g) (5.3 to 17.6 ounces [oz]) of fresh-weight plant material and were composites of material from 2 to 23 plants of the same species. The species sampled (Table 8-2) represent the dominant vegetation at each site.

Plant leaves and stems were hand-picked and stored in airtight bags. Rubber gloves were used by samplers and changed between each composite sample collection. Samples were labeled and stored in an ice chest and delivered to the laboratory within 4 hours after collection. Water was separated from the samples by distillation. Plant water and dried plant tissues were submitted to a commercial laboratory for analysis; plant water was analyzed for ^{3}H and dried plant tissue was analyzed for ^{241}Am, ^{90}Sr, ^{238}Pu, $^{239+240}Pu$, and gamma emitting radionuclides (e.g. ^{137}Cs).

Table 8-2. Plant samples collected in 2017

Common Name	Scientific Name	Name Code	E Tunnel Ponds (4 & 5)	E Tunnel Ponds (6a & 6b)	E Tunnel Ponds Control	Area 3 RWMS	Area 3 RWMS Control	Area 5 RWMS	Area 5 RWMS Control
Indian ricegrass	*Achnatherum hymenoides*	ACHY			X				
Shadscale saltbush	*Atriplex confertifolia*	ATCO				X			
Cheatgrass	*Bromus tectorum*	BRTE	X						
Rubber rabbitbrush	*Ericameria nauseosus*	ERNA	X	X	X				
Creosote bush	*Larrea tridentata*	LATR							X
Mixed grasses	*various unknown*	Mixed Grass		X					
Russian thistle	*Salsola sp.*	Salsola sp.					X	X	

Results of radiological analyses are shown in Table 8-3. No man-made radionuclides were detected in plants from the E Tunnel Ponds Control site. The man-made radionuclides, ^{3}H, ^{90}Sr, ^{137}Cs, ^{238}Pu, $^{239+240}Pu$, and ^{241}Am were detected in plants from the E Tunnel Ponds Site with ^{137}Cs and ^{241}Am not detected at other locations. $^{239+240}Pu$ was detected in plants from all sampled locations except the E Tunnel Ponds Control site. ^{3}H was detected at all locations except the Area 5 RWMS Control site and the E Tunnel Ponds Control site. In general there were no changes in radionuclide concentrations in plants compared with those sampled in the recent past (Figures 8-4 and 8-5). Slightly higher ^{137}Cs, $^{239+240}Pu$, and ^{241}Am in the E Tunnel Ponds vegetation is likely due to the plants being sampled inside the pond basins instead of around the edge as in years past.

Table 8-3. Concentrations of man-made radionuclides in plants sampled in 2017

	Radionuclide Concentrations ± Uncertainty[(a)]					
Sample	**^{3}H (pCi/L)[(b)]**	**^{90}Sr (pCi/g)[(c)]**	**^{137}Cs (pCi/g)[(c)]**	**^{238}Pu (pCi/g)[(c)]**	**$^{239+240}$Pu (pCi/g)[(c)]**	**^{241}Am (pCi/g)[(c)]**
E Tunnel Ponds						
Ponds 4 and 5						
BTRE	NM[(d)]	0.117 ± 0.039	0.361 ± 0.556	0.0082 ± 0.0062	0.1950 ± 0.0430	0.0322 ± 0.0085
ERNA	117,000 ± 10,400	0.050 ± 0.028	0.520 ± 0.482	0.0039 ± 0.0039	0.1140 ± 0.0257	0.0190 ± 0.0057
Ponds 6a and 6b						
Mixed Grasses	180,000 ± 16,000	0.125 ± 0.045	7.840 ± 1.500	0.0211 ± 0.0092	0.1890 ± 0.0399	0.0078 ± 0.0044
ERNA	154,000 ± 13,700	0.006 ± 0.028	1.810 ± 0.787	0.0028 ± 0.0036	0.0051 ± 0.0043	-0.0023 ± 0.0024
Average Concentration	150,333	0.075	2.633	0.0090	0.1258	0.0142
Average MDC[(e)]	316	0.050	0.863	0.0059	0.0029	0.0054
E Tunnel Ponds Control						
ACHY	NM[(d)]	0.013 ± 0.028	-0.051 ± 0.507	0.0038 ± 0.0050	0.0041 ± 0.0049	-0.0006 ± 0.0027
ERNA	96 ± 158	-0.003 ± 0.025	0.156 ± 0.476	0.0034 ± 0.0037	0.0055 ± 0.0047	-0.0008 ± 0.0024
Average Concentration	96	0.005	0.053	0.0036	0.0048	-0.0007
Average MDC[(e)]	264	0.050	0.927	0.0070	0.0070	0.0051

Table 8-3. Concentrations of man-made radionuclides in plants sampled in 2017

	Radionuclide Concentrations ± Uncertainty[(a)]					
Sample	**^{3}H (pCi/L)[(b)]**	**^{90}Sr (pCi/g)[(c)]**	**^{137}Cs (pCi/g)[(c)]**	**^{238}Pu (pCi/g)[(c)]**	**$^{239+240}$Pu (pCi/g)[(c)]**	**^{241}Am (pCi/g)[(c)]**
Area 3 RWMS ax/bl Cover						
ATCO	15,500 ± 1,490	0.077 ± 0.031	0.057 ± 0.255	0.0031 ± 0.0035	0.0418 ± 0.0138	0.0050 ± 0.0041
MDC[(e)]	274	0.044	0.474	0.0047	0.0023	0.0062
Area 3 RWMS Control						
Salsola sp.	1340 ± 258	-0.001 ± 0.026	0.080 ± 0.242	0.0008 ± 0.0029	0.0092 ± 0.0057	-0.0007 ± 0.0025
MDC[(e)]	273	0.048	0.432	0.0021	0.0044	0.0051
Area 5 RWMS 92 Acre Cover						
South						
Salsola sp.	38,000,000 ± 3,380,000	0.005 ± 0.025	-0.049 ± 0.199	0.0041 ± 0.0038	0.0047 ± 0.0042	-0.0028 ± 0.0026
South-North						
Salsola sp.	8,530 ± 876	0.023 ± 0.028	-0.072 ± 0.231	0.0008 ± 0.0033	0.0059 ± 0.0053	0.0006 ± 0.0031
West						
Salsola sp.	423,000 ± 37,800	0.012 ± 0.023	-0.040 ± 0.183	0.0030 ± 0.0032	0.0039 ± 0.0035	0.0001 ± 0.0032
Average Concentration	12,810,510	0.013	-0.054	0.0027	0.0048	-0.0007
Average MDC[(e)]	2855	0.046	0.424	0.0045	0.0053	0.0059
Area 5 RWMS Control						
LATR	22.7 ± 155	0.029 ± 0.024	-0.045 ± 0.232	0.0013 ± 0.0032	0.0066 ± 0.0050	-0.0021 ± 0.0022
MDC[(e)]	267	0.042	0.462	0.0071	0.0047	0.0050

(a) ***Uncertainty*** is ± 2 standard deviations
(b) Picocuries per liter water from sample
(c) Picocuries per gram dry weight of sample
(d) Not measured. There was not enough moisture in the sample to obtain a sample for analysis of ^{3}H
(e) Average sample specific MDC

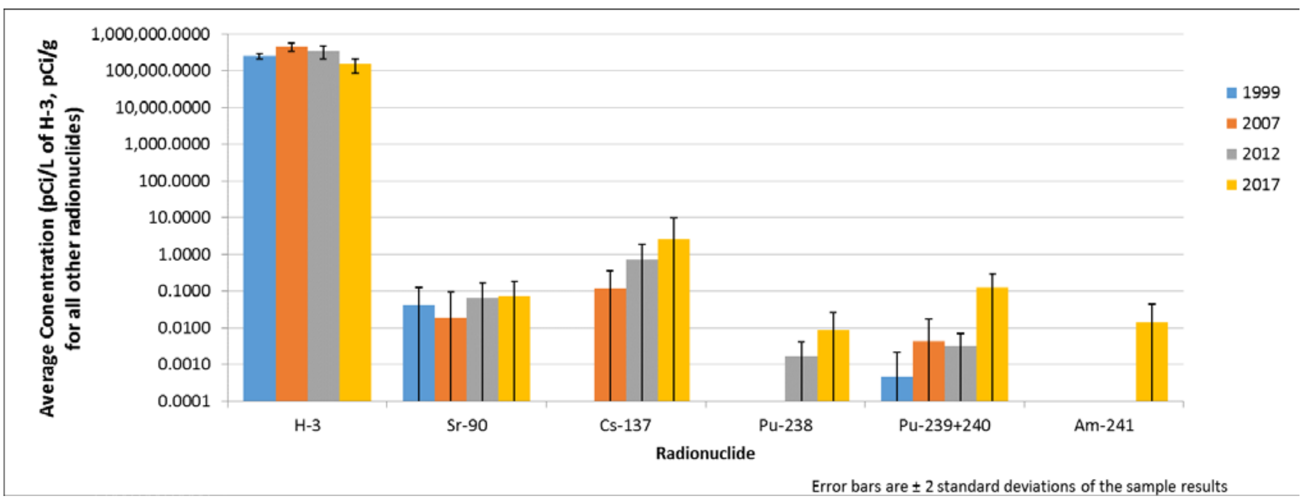

Figure 8-4. Concentrations of man-made radionuclides in plants from E Tunnel Ponds, 1999 – 2017

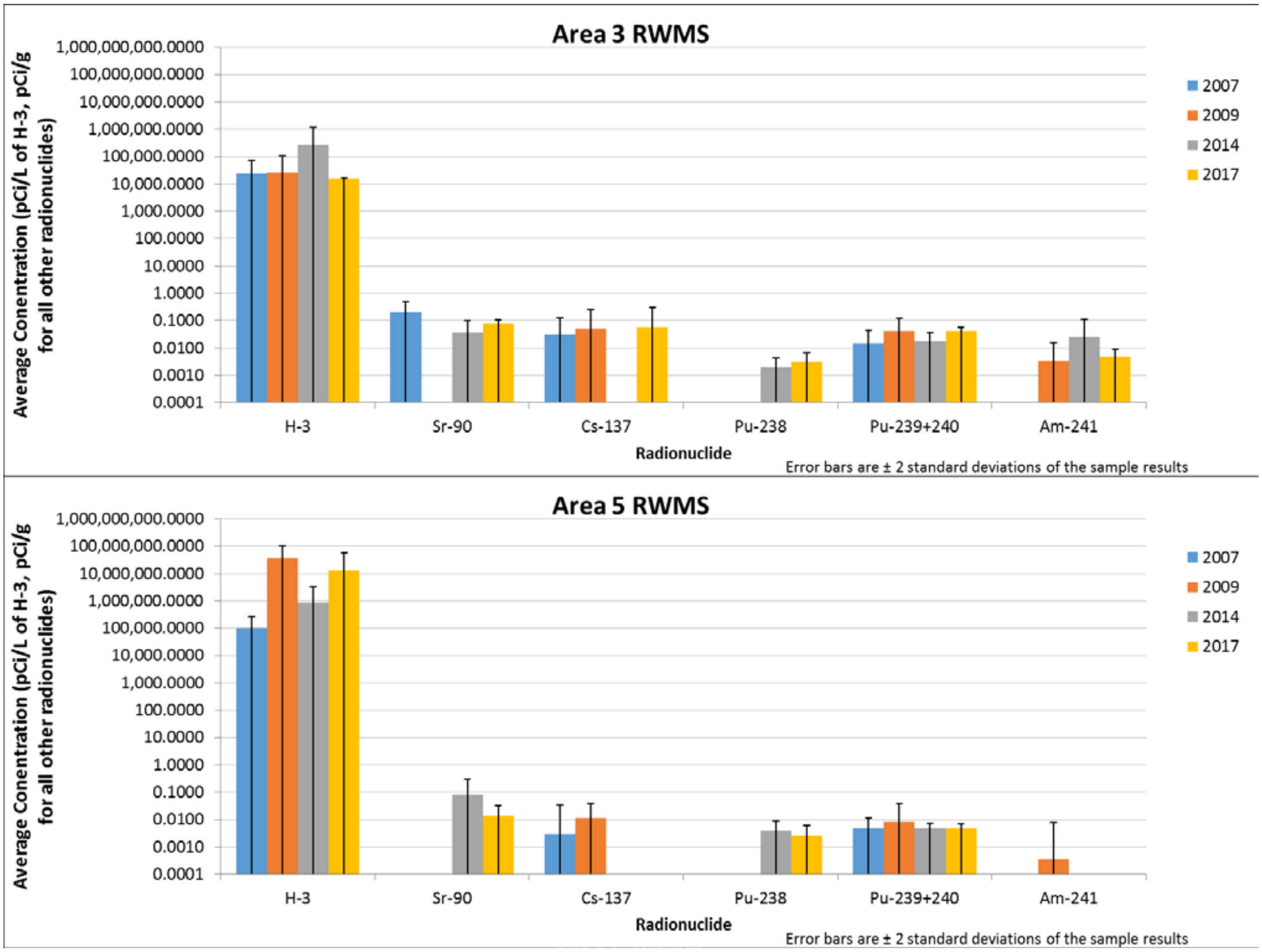

Figure 8-5. Concentrations of man-made radionuclides in plants from the Area 3 and 5 RWMS, 2007 – 2017

8.3.2 Animals

State and federal permits were secured to trap specific small mammals and birds in 2017 and to opportunistically sample large mammal mortalities on the NNSS. Animal trapping was unsuccessful at the E Tunnel Ponds and its Control site in 2017, but small mammals were collected from the Area 3 and Area 5 RWMSs, and their control sites, on November 29, 2017. All animal samples are described in Table 8-4. The mule deer from Area 12 is considered an E Tunnel Ponds site sample because it was collected adjacent to the E Tunnel Ponds. Composite samples of small mammals were collected from the Area 3 and Area 5 RWMSs sites and control sites. The entire bodies of the small mammals were homogenized and analyzed. Muscle from two bobcats, two pronghorn antelope, one bighorn sheep, one mountain lion, and one mule deer which either died from natural causes or by being hit by a vehicle, were sampled during 2017. Water was distilled from the samples and submitted to a laboratory for ^{3}H analysis, and the remaining tissue samples were submitted for ^{90}Sr, ^{238}Pu, $^{239+240}$Pu, ^{241}Am, and gamma ***spectroscopy*** analysis. Only ^{3}H was analyzed in the mountain lion sample due to problems with the solid tissue portion of the sample.

Table 8-4. Animal samples collected in 2017

Location	Sample	Collection Date	Sample Description
Routine Monitoring Samples			
Area 3 RWMS ax/bl Cover			
	Small Mammal Composite	11/29/2017	3 kangaroo rats (2 *Dipodomys microps* and 1 *Dipodomys merriami)*
Area 3 RWMS Control			
	Small Mammal Composite	11/29/2017	3 kangaroo rats (*Dipodomys merriami)*

Table 8-4. Animal samples collected in 2017

Routine Monitoring Samples			
Location	**Sample**	**Collection Date**	**Sample Description**
Area 5 RWMS 92 Acre Cover			
South	Small Mammal Composite	11/29/2017	4 kangaroo rats (*Dipodomys merriami)*
South-North	Small Mammal Composite	11/29/2017	6 kangaroo rats (*Dipodomys merriami)*
West	Small Mammal Composite	11/29/2017	3 kangaroo rats (*Dipodomys merriami)*
Area 5 RWMS Control			
	Small Mammal Composite	11/29/2017	2 kangaroo rats (*Dipodomys merriami)* and 1 antelope ground squirrel (*Ammospermophilus leucurus*)
Opportunistic Samples			
Location	**Sample**	**Collection Date**	**Sample Description**
Area 30	Bighorn Sheep	4/19/2017	Muscle from front leg of male bighorn sheep; died of natural causes
Area 4	Bobcat	5/1/2017	Muscle from back leg of an adult bobcat (unknown sex); killed by vehicle
Area 5	Bobcat	6/18/2017	Muscle from hind legs of an adult female bobcat; killed by vehicle
NTTR	Mountain Lion	3/1/2017	Muscle from hind leg of 4 year old male mountain lion; died of natural causes
Area 12: E Tunnel Ponds	Mule Deer	11/2/2017	Muscle from hind leg of 4 year old male mule deer; died of natural causes
Area 5	Pronghorn #1	1/18/2017	Muscle from hind leg of 2-3 year old male pronghorn; killed by vehicle
Area 5	Pronghorn #2	8/29/2017	Muscle from < 1 year old female pronghorn; killed by vehicle

Man-made radionuclides were detected in at least one sample from each location (Table 8-5). Tritium was the only radionuclide detected at significantly higher concentrations than the control locations. All animals from the Area 3 and Area 5 RWMS locations contained detectable ^{3}H. The mule deer from Area 12 had the highest levels of ^{3}H. All ^{3}H detections are expected because ^{3}H is a mobile radionuclide and these animals were sampled at locations of known ^{3}H sources (waste at the Area 3 and 5 RWMS and the E Tunnel ponds). No other radionuclide was significantly different from the control site samples.

Table 8-5. Concentrations of man-made radionuclides in animals sampled during routine monitoring in 2017

	Radionuclide Concentrations ± Uncertainty[(a)]				
Sample	^{3}H (pCi/L)[(b)]	^{90}Sr (pCi/g)[(c)]	^{238}Pu (pCi/g)[(c)]	$^{239+240}$Pu (pCi/g)[(c)]	^{241}Am (pCi/g)[(c)]
Area 3 RWMS ax/bl Cover					
Small Mammal Composite	5,160 ± 835	-0.027 ± 0.029	0.0000 ± 0.0147	0.0078 ± 0.0138	0.0013 ± 0.0030
MDC[(d)]	303	0.066	0.0313	0.0241	0.0052
Area 3 RWMS Control					
Small Mammal Composite	464 ± 210	0.033 ± 0.034	0.0000 ± 0.0015	0.0338 ± 0.0082	-0.0012 ± 0.0028
MDC[(d)]	312	0.070	0.0022	0.0008	0.0057
Area 5 RWMS 92 Acre Cover					
South: Small Mammal Composite	3,420 ± 582	0.014 ± 0.034	0.0023 ± 0.0025	0.0060 ± 0.0038	-0.0009 ± 0.0026
South-North Small Mammal Composite	14,700 ± 2,270	-0.004 ± 0.029	0.0000 ± 0.0069	0.9180 ± 0.1700	0.0287 ± 0.0074
West Small Mammal Composite	84,800 ± 12,900	-0.002 ± 0.030	0.0021 ± 0.0027	0.0063 ± 0.0039	-0.0012 ± 0.0026
Average Concentration	34,307	0.003	0.0015	0.3101	0.0089
Average MDC[(d)]	379	0.068	0.0075	0.0059	0.0052
Area 5 RWMS Control					
Small Mammal Composite	-93.8 ± 185	0.025 ± 0.033	0.0014 ± 0.0015	0.129 ± 0.0232	0.0150 ± 0.0053
MDC[(d)]	314	0.069	0.00209	0.00209	0.00515
Opportunistic Sampling					
Bighorn Sheep (Area 30)	-67 ± 134	-0.008 ± 0.015	0.0008 ± 0.0009	0.0013 ± 0.0012	0.0004 ± 0.0018
Bobcat (Area 4)	-54 ± 131	0.027 ± 0.025	0.0062 ± 0.0051	0.0021 ± 0.0041	0.0000 ± 0.0088
Bobcat (Area 5)	89 ± 140	-0.024 ± 0.047	0.0063 ± 0.0061	0.0081 ± 0.0086	-0.0012 ± 0.0032
Mountain Lion (NTTR)	2,000 ± 423	NM[(e)]	NM[(e)]	NM[(e)]	NM[(e)]

Table 8-5. Concentrations of man-made radionuclides in animals sampled during routine monitoring in 2017

	Radionuclide Concentrations ± Uncertainty[a]				
Sample	**^{3}H (pCi/L)[b]**	**^{90}Sr (pCi/g)[c]**	**^{238}Pu (pCi/g)[c]**	**$^{239+240}$Pu (pCi/g)[c]**	**^{241}Am (pCi/g)[c]**
Opportunistic Sampling					
Mule Deer (Area 12 -)	146,000 ± 22,300	0.043 ± 0.028	0.0047 ± 0.0039	0.0008 ± 0.0016	0.0017 ± 0.0034
Pronghorn #1 (Area 5)	-6 ± 132	0.103 ± 0.075	0.0000 ± 0.0072	0.0000 ± 0.0058	0.0019 ± 0.0052
Pronghorn #2 (Area 5)	236 ± 188	0.056 ± 0.031	0.0092 ± 0.0074	0.0058 ± 0.0061	0.0048 ± 0.0043
Average Concentration	21,171	0.033	0.0045	0.0030	0.0013
Average MDC[d]	336	0.063	0.0062	0.0075	0.0080

(a) ± 2 standard deviations.
(b) Picocuries per liter water from sample.
(c) Picocuries per gram wet weight of sample.
(d) Average sample specific MDC.
(e) Not measured. Tissue sample was not analyzed for all radionuclides.

8.3.3 Soil

Sampling of soil at the Area 3 and Area 5 RWMSs took place on November 28, 2017. Composite samples of soil brought to the surface from either small mammal or ant burrowing activity were collected from each of the RWMSs and their control sites (Table 8-6). Each sample consisted of about 500 g (17.6 oz) of dry soil, which was submitted to a commercial laboratory for analysis of ^{90}Sr, ^{238}Pu, $^{239+240}$Pu, ^{241}Am, and gamma-emitting radionuclides (which includes ^{137}Cs).

Man-made radionuclides were detected in all soil samples except those from the Area 5 RWMS 92 Acre Cover (Table 8-7). The soil sample from the Area 3 RWMS Control site had relatively higher concentrations of all detected man-made radionuclides (^{152}Eu, ^{238}Pu, $^{239+240}$Pu, and ^{241}Am). This is due to fallout from nearby atmospheric nuclear weapons tests. If small mammals and/or ants were in contact with the waste at the RWMSs, then it would be expected that radionuclide concentrations would be significantly elevated at these locations. Because this was not the case, it does not appear that small mammals and ants are in contact with, or are bringing to the surface, buried waste.

Table 8-6. Animal excavated soil samples collected in 2017

Location	Sample Description
Area 3 RWMS ax/bl Cover	Composite from 2 small mammal burrows
Area 3 RWMS Control	Composite from 2 ant nests and 2 small mammal burrows
Area 5 RWMS 92 Acre Cover	
South	Composite from 2 small mammal burrows
South-North	Composite from 2 small mammal burrows
West	Composite from 3 small mammal burrows
Area 5 RWMS Control	Composite from 4 small mammal burrows

Table 8-7. Man-made radionuclides detected in animal excavated soil samples collected in 2017

	Radionuclide Concentrations ± Uncertainty[a] (pCi/g)[b]			
Sample	**^{152}Eu**	**^{238}Pu**	**$^{239+240}$Pu**	**^{241}Am**
Area 3 RWMS ax/bl Cover	0.209 ± 0.781	0.0000 ± 0.0052	0.0514 ± 0.0175	-0.0025 ± 0.0120
MDC[c]	1.470	0.0098	0.0113	0.0240
Area 3 RWMS Control	0.834 ± 0.300	0.0237 ± 0.0114	0.2580 ± 0.0511	0.0681 ± 0.0222
MDC[c]	0.384	0.0106	0.0073	0.0189
Area 5 RWMS 92 Acre Cover				
South	0.213 ± 0.377	0.0011 ± 0.0054	0.0022 ± 0.0054	-0.0074 ± 0.0102
South-North	-0.154 ± 0.435	-0.0021 ± 0.0053	0.0021 ± 0.0052	-0.0037 ± 0.0095
West	0.103 ± 0.634	0.0018 ± 0.0045	0.0036 ± 0.0045	-0.0021 ± 0.0092
Average Concentration	0.054	0.0003	0.0027	-0.0044
Average MDC[c]	0.937	0.0088	0.0058	0.0197
Area 5 RWMS Control	-0.284 ± 0.467	-0.0010 ± 0.0050	0.0390 ± 0.0140	0.0024 ± 0.0108
MDC[c]	1.140	0.0096	0.0028	0.0200

(a) ± 2 standard deviations.
(b) Picocuries per gram wet weight of sample.
(c) Average sample specific MDC.

8.4 Data Assessment

Plant and animal sample results confirm that man-made radionuclide concentrations, specifically ^3H, are higher at monitored locations (Area 3 and Area 5 RWMSs and E Tunnel Ponds) compared with their control locations. Elevated concentrations of ^3H in vegetation at both RWMSs indicate that ^3H in soil moisture at the root zone is elevated at both sites. This does not necessarily indicate that the roots of these plants have penetrated the waste zone, but more likely indicates that ^3H is highly mobile and is moving away from the waste as water vapor moving upward through the soil profile. This is supported by the lack of other radionuclides which would also be highly elevated if the plant's roots had invaded the buried waste. Also, soil samples do not suggest burrowing animals have come into contact with buried waste. It is likely that elevated ^3H concentrations in animals come from their consuming plants on the covers and from inhalation of ^3H evaporating from the soil. Though NNSS-related radionuclides are detected in some plants and animals, the levels pose negligible risk to humans and biota. The potential dose to a person hunting and consuming these animals is well below dose limits to members of the public (Section 9.1.1.2). Also, radionuclide concentrations were below levels considered harmful to the health of the plants or animals; the dose resulting from observed concentrations were less than 6% of dose limits set to protect populations of plants and animals (Section 9.2).

8.5 References

Bechtel Nevada, 2003. *Routine Radiological Environmental Monitoring Plan*. DOE/NV/11718--804, Las Vegas, NV.

Hunter, R. B., and R. R. Kinnison, 1998. *Tritium in Vegetation on the Nevada Test Site, U.S. Department of Energy, December 1998, In: Nevada Test Site Routine Radiological Environmental Monitoring Plan*, Appendices. DOE/NV/11718--244. Bechtel Nevada, Las Vegas, NV.

NNSA/NFO, see U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office

U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office, 2015. *United States Nuclear Tests, July 1945 through September 1992*. DOE/NV--209, Rev. 16, Las Vegas, NV. Available at http://www.nnss.gov/docs/docs_LibraryPublications/DOE_NV-209_Rev16.pdf, as accessed on May 23, 2016.

Chapter 9: Radiological Dose Assessment

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The U.S. Department of Energy (DOE) requires DOE facilities to estimate the radiological ***dose***[1] to the general public and to plants and animals in the environment caused by past or present facility operations. These requirements are specified in DOE Orders DOE O 458.1, "Radiation Protection of the Public and the Environment," and DOE O 435.1, "Radioactive Waste Management" (Table 2-1). To estimate these radiological doses, ***radionuclide*** concentration data gathered on the Nevada National Security Site (NNSS) are used along with dose conversion factors published in DOE Technical Standard DOE-STD-1196-2011, "***Derived Concentration Technical Standard***." The dose conversion factors take into account the different population fractions of age and sex to give representative dose coefficients for a reference person within the U.S. population. The 2017 data are presented in Chapters 4, 5, 6, and 8 of this report, and include the results for onsite monitoring of air, water, direct radiation, and biota, and for offsite monitoring of groundwater. The independent offsite air and groundwater data presented in Chapter 7, *Community-Based Offsite Monitoring*, provide extra assurance to the public that estimated doses do not underestimate potential offsite ***exposures*** to NNSS-related radiation. The specific goals for the dose assessment component of radiological monitoring are shown below.

Radiological Dose Assessment Goals
Determine if the maximum radiation dose to a member of the general public from airborne radionuclide emissions at the NNSS complies with the Clean Air Act, National Emission Standards for Hazardous Air Pollutants (NESHAP) limit of 10 millirems per year (mrem/yr) (0.1 millisieverts per year [mSv/yr]).
Determine if radiation levels from the Radioactive Waste Management Sites (RWMSs) comply with the 25 mrem/yr (0.25 mSv/yr) dose limit to members of the public as specified in DOE Manual DOE M 435.1-1, "Radioactive Waste Management Manual."
Determine if the total radiation dose (***total effective dose equivalent [TEDE]***) to a member of the general public from all possible pathways (direct exposure, inhalation, ingestion of water and food) as a result of NNSS operations complies with the limit of 100 mrem/yr (1 mSv/yr) established by DOE O 458.1.
Determine if the radiation dose (in a unit of measure called a ***rad***) to NNSS biota complies with the following limits set by DOE-STD-1153-2002, "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota." < 1 rad per day (rad/d) for terrestrial plants and aquatic animals < 0.1 rad/d for terrestrial animals

9.1 Dose to the Public

This section identifies the possible pathways by which the public could be exposed to radionuclides present in the environment due to past or current NNSS activities. It describes how field monitoring data are used with other NNSS data sources (e.g., radionuclide inventory data) to provide input to the dose estimates, and presents the estimated 2017 public dose attributable to U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) activities from each pathway and from all pathways combined. The public dose due to radioactive waste operations on the NNSS is also assessed, and a description of the program that controls the release of NNSS materials having residual ***radioactivity*** into the public domain is provided.

[1] The definition of word(s) in ***bold italics*** may be found by clicking on the word in electronic version or by referencing the Glossary, Appendix B. To return from the Glossary, right click and select Previous View.

9.1.1 Dose from Possible Exposure Pathways

As prescribed in the *Routine Radiological Environmental Monitoring Plan* (Bechtel Nevada [BN] 2003), air, groundwater, and biota are routinely sampled to document the amount of radioactivity in these media and to provide data to assess the radiation dose received by the general public from several pathways.

The potential pathways by which a member of the general public residing off site might receive a radiation dose resulting from past or present NNSS operations include the following:

- Inhalation of, ingestion of, or direct external exposure to airborne radionuclide emissions transported off site by wind.
- Ingestion of wild game animals that drink from surface waters and/or eat vegetation containing NNSS-related radioactivity.
- Ingestion of plants containing radioactivity from NNSS-related activities
- Drinking water from underground ***aquifers*** containing radionuclides that have migrated from the sites of past underground nuclear tests or waste management sites.
- Exposure to direct radiation along the borders of the NNSS.

The subsections below address all of the potential pathways and their contribution to public dose estimated for 2017.

9.1.1.1 Dose from NNSS Air Emissions

Six air particulate and ***tritium (^3H)*** sampling stations located near the boundaries and the center of the NNSS are approved by the U.S. Environmental Protection Agency (EPA) Region 9 as ***critical receptor samplers*** to demonstrate compliance with the NESHAP public dose limit of 10 mrem/yr (0.1 mSv/yr) from air emissions. The annual average concentration of an airborne radionuclide must be less than its NESHAP Concentration Level for Environmental Compliance (abbreviated as ***compliance level [CL]***) (Table 4-1). The CL for each radionuclide represents the annual average concentration of that radionuclide in air that would result in a TEDE of 10 mrem/yr. If multiple radionuclides are detected at a station, then 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 critical receptor sampling stations can be thought of as worst case for an offsite receptor because these samplers are close to emissions sources (Figure 4-2). Table 9-1 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 (Figure 4-1) is also listed.

Table 9-1. 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			
	Residence	Business/Office	School	NNSS Emission Source
Area 6, Yucca	47 km SW Amargosa Valley	38 km SSE American Silica(c)	54 km SE Indian Springs	6.3 km SSE Area 6, National Criticality Experiments Research Center
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, Substation 3545	46 km SSW Amargosa Valley	46 km SSW Amargosa Valley	58 km SSW Amargosa Valley	14 km ENE Area 3, RWMS
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 Grouped Area Sources

(a) Distance is shown in kilometers (km). For miles, multiply by 0.62.
(b) N=north, S=south, E=east, W=west in all direction combinations shown.
(c) The American Silica mine was not active in 2017 but is the closest business to the NNSS.

In 2017, the man-made radionuclides detected in samples from at least one air monitoring station included ^{3}H, cesium-137 (^{137}Cs), americium-241 (^{241}Am), plutonium-238 (^{238}Pu), and plutonium-239+240 ($^{239+240}$Pu) (Section 4.1.4). The annual average concentrations of these radionuclides were well below their CLs, and the sum of fractions for each location were all less than 1.0 (Table 4-11). As in previous years, 2017 data from the six critical receptor stations show that the NESHAP public dose limit of 10 mrem/yr (0.1 mSv/yr) was not exceeded.

The radioactive air emissions from each 2017 NNSS source were modeled using the ***Clean Air Package, 1988***, model (CAP88, Version 4.0; EPA 2014). The highest value is predicted to be a person residing on the U.S. Air Force, Nevada Test and Training Range (NTTR), or in the Springdale area west of the NNSS. Both locations received a predicted dose of 0.07 mrem/yr (0.007 mSv/yr). More detailed information regarding the estimation of the dose to the public from airborne radioactivity in 2017 from all activities conducted by NNSA/NFO on the NNSS and its Nevada support facilities is reported in Mission Support and Test Services, LLC (MSTS) (2018).

9.1.1.2 Dose from Ingestion of Game Animals from the NNSS

Three game species, mule deer, bighorn sheep, and mourning doves, have been shown to travel off the NNSS and be available to hunters (Giles and Cooper 1985; Hall and Perry 2018; National Security Technologies, LLC [NSTec] 2009). Because of this, game animals on the NNSS are sampled annually near known radiologically contaminated areas to give conservative (worst-case) estimates of the level of radionuclides that hunters may consume if these animals are harvested off of the NNSS. In 2017, the following animals were sampled (Figure 8-1 and Tables 8-4, and 8-5):

- One mule deer that died from natural causes (Area 12, E Tunnel Ponds)
- One bighorn sheep from that died from natural causes (Area 30)
- Two bobcats killed by vehicles (one in Area 4 and one in Area 5)
- One mountain lion that died from natural causes on the NTTR
- Two pronghorn antelope killed by vehicles (Area 5)
- One composite small mammal sample from the Area 3 RWMS ax/bl Cover
- Three composite small mammal samples from the ***Area 5 Radioactive Waste Management Complex (RWMC)*** 92 Acre Cover.

The potential ***committed effective dose equivalent (CEDE)*** to an individual from consuming game animals was calculated for each animal sampled in 2017. The following assumption/parameters were used to estimate dose:

- Analysis results from all samples were included in calculating dose from consuming a particular species as long as the radionuclide was detected, i.e., the analysis result was above the ***minimum detectable concentration (MDC),*** in at least one sample of that species at a particular location. The opportunistic samples are grouped as all being from the same location (NNSS) for this assessment.
- If the analytical result for a radionuclide concentration in the sample was a negative value (resulting from a ***background*** measurement higher than what was observed in the sample), then the concentration for that sample was set to zero.
- An individual consumes all meat from one of each species of animal sampled during 2017 (small mammal composite samples were assessed as one cottontail rabbit): one mule deer (35.4 kilograms [kg]), one bighorn sheep (35.4 kg), one bobcat (9.6 kg), one mountain lion (21.3 kg), one pronghorn antelope (20.0 kg), and one cottontail rabbit (167 g) during the year.
- The moisture content of the muscle tissue samples of all species is 73%.
- Dose coefficients for a reference person as defined by DOE-STD-1196-2011 are used; they are for a hypothetical person representing an aggregate of individuals in the U.S. population.
- The entire committed dose is considered to be received during the calendar year.

Dose coefficients (mrem per picocurie [pCi] ingested), based on values listed in DOE-STD-1196-2011, were multiplied by the amount of radioactivity (pCi) potentially ingested to obtain the potential dose (CEDE) (Table 9-2). The average and maximum CEDEs for each monitored location and for each animal species are presented in Table 9-2. When more than one sample of a particular species was sampled, the maximum concentration of each radionuclide was used for that species. Based on the 2017 samples, an individual who consumes one animal of each sampled species from each location (where opportunistic large game samples were considered to be from one location, i.e., the entire NNSS) may receive an estimated dose of 1.44 mrem (0.0144 mSv) based on the averages. To put this dose in perspective, the dose from naturally occurring cosmic radiation received during a 2-hour airplane flight at 39,000 feet is about 1 mrem (0.01 mSv). From consuming just one animal, the maximum would come from the mule deer sampled at the Area 12 E Tunnel Ponds (Table 8-5), and would result in a dose of 0.74 mrem (0.0074 mSv).

Table 9-2. Hypothetical CEDE from ingesting game animals sampled in 2017

		Committed Effective Dose Equivalent (mrem)[a]							
Samples	**Sample Location**	**^{3}H [b]**	**^{90}Sr**	**^{238}Pu**	**$^{239+240}$Pu**	**^{241}Am**	**Total**	**Location Average**	**Max**
Small Mammal Composite[c]	Area 3 RWMS ax/bl Cover	0.0000	0.0000	0.0000	0.0014	0.0002	0.0016	0.0016	0.0016
Small Mammal Composite[c]	Area 5 RWMS 92 Acre Cover South	0.0000	0.0003	0.0004	0.0011	0.0000	0.0018	0.0573	0.1677
Small Mammal Composite[c]	South-North	0.0001	0.0000	0.0000	0.1634	0.0042	0.1677		
Small Mammal Composite[c]	West	0.0008	0.0000	0.0003	0.0011	0.0000	0.0023		
	Opportunistic samples from natural mortality or accidental road kills:								
Samples	**Sample Location**	**^{3}H [b]**	**^{90}Sr**	**^{238}Pu**	**$^{239+240}$Pu**	**^{241}Am**	**Total**	**Species Average**	**Max**
Bighorn Sheep	Area 30	0.0000	0.0000	0.0277	0.0506	0.0127	0.0910	0.0910	0.0910
Bobcat	Area 4	0.0000	0.0349	0.0577	0.0211	0.0000	0.1137	0.1277	0.1417
Bobcat	Area 5	0.0000	0.0000	0.0585	0.0832	0.0000	0.1417		
Mountain Lion	NTTR	0.0024	NM[d]	NM[d]	NM[d]	NM[d]	0.0024	0.0024	0.0024
Mule Deer	Area 12 (E Tunnel Ponds)	0.2929	0.2021	0.1621	0.0296	0.0530	0.7397	0.7397	0.7397
Pronghorn #1	Area 5	0.0000	0.2750	0.0000	0.0000	0.0328	0.3078	0.4236	0.5393
Pronghorn #2	Area 5	0.0003	0.1506	0.1802	0.1235	0.0847	0.5393		
CEDE from consuming one animal of each species and location = 1.44 mrem (using averages) and 1.68 mrem (using maximums)									

(a) Based on dose coefficients in Appendix A of DOE-STD-1196-2011 for a Reference Person.
(b) Based on assumption that the water content of all muscle tissue samples is 73%.
(c) Assumed analog of cottontail rabbit (167 g muscle tissue).
(d) Not measured. Tissue sample was not analyzed for all radionuclides.

A person may consume animals from locations on the NNSS other than where samples were collected in 2017; therefore, Table 9-3 presents the maximum CEDE for humans consuming various species of wildlife from all animals sampled from 2001–2017. While it is possible that someone could consume an animal from the NNSS, the probability is low. Table 9-3 gives a worst-case scenario based on radionuclide analyses of NNSS game animal samples over the past 17 years.

The highest CEDE from consuming just one animal (3.23 mrem or 0.0323 mSv) would be from the mule deer sampled in 2014 from Area 19 (Table 9-3). This represents 3.23% of the annual dose limit for members of the public and is about three times the dose one would receive from naturally occurring cosmic radiation during a 2-hour airplane flight at 39,000 feet.

Table 9-3. Maximum CEDEs to a person hypothetically ingesting NNSS game animals sampled from 2001–2017

Game Animal	Sample Location	Year Sampled	Amount Consumed	CEDE for Consumption of One Animal (mrem)
Bighorn Sheep	Area 25 (captured study animal)	2015	all muscle	0.170
Bobcat	Area 25 (roadkill)	2012	all muscle	0.032
Chuckar	Area 12 (E-Tunnel)	2001	breast muscle	0.006
Cottontail Rabbit	Area 20 (Schooner Crater)	2013	whole body	0.032
Gambel's Quail	Area 2 (T2)	2002	all muscle	0.004
Jackrabbit	Area 10 (Sedan)	2015	all muscle	1.298
Mountain Lion	NTTR (natural mortality of study lion NNSS4)	2013	all muscle	0.095
Mourning Dove	Area 20 (Palanquin control but likely from sump of Well U-20n)	2003	breast muscle	0.032
Mule Deer	Area 19 (killed by a mountain lion)	2014	all muscle	3.228
Pronghorn	Area 10 (roadkill)	2015	all muscle	2.869

9.1.1.3 Dose from Ingestion of Plants from the NNSS

Current NNSS land use practices discourage the harvest of plants or plant parts for direct consumption by humans. However, it is possible that individuals with access might collect and consume edible plant material. One species in particular, the pinyon pine tree, produces pine nuts that are harvested and consumed across the western United States. Pinyon pine trees grow throughout regions of higher elevation on the NNSS. In 2013, pine nuts were sampled from three locations on the NNSS (Area 15, Area 17, and in Area 12 near the E Tunnel Ponds). The estimated dose from consuming them was shown to be extremely low (0.00056 mrem or 0.0000056 mSv) and a negligible contribution to the total potential dose to a member of the public (NSTec 2014). No other edible plant materials have been collected for analysis on the NNSS in recent history, and no edible plants were sampled in 2017.

9.1.1.4 Dose from Drinking Contaminated Groundwater

The 2017 groundwater monitoring data indicate that groundwater from offsite private and community wells and springs has not been impacted by past NNSS nuclear testing operations (Sections 5.1.3.5, 7.2, and 7.3). No man-made radionuclides have been detected in any sampled wells accessible to the offsite public or in sampled private wells or springs. These field monitoring data also agree with the forecasts of current groundwater flow and contaminant transport models discussed in Chapter 11 (Section 11.1). Therefore, drinking water from underground aquifers containing radionuclides is not a possible pathway of exposure to the public residing off site.

9.1.1.5 Dose from Direct Radiation Exposure along NNSS Borders

The direct exposure pathway from ***gamma radiation*** to the public is monitored routinely (Chapter 6). In 2017, the only place where the public had the potential to be exposed to direct radiation from NNSS operations was at Gate 100, the primary entrance to the site on the southern NNSS border. Trucks hauling radioactive materials, primarily ***low-level waste (LLW)*** being shipped for disposal at the Area 5 RWMS, park outside Gate 100 while waiting for entry approval. Only during these times is there a potential for exposure to the public due to NNSS activities. However, no member of the public resides or remains full-time at the Gate 100 truck parking area. Therefore, dose from direct radiation is not included as a current pathway of exposure to the public residing off site.

9.1.2 Dose from Waste Operations

DOE M 435.1-1 states that LLW disposal facilities shall be operated, maintained, and closed so that a reasonable expectation exists that annual dose to members of the public shall not exceed 10 mrem through the air pathway and 25 mrem through all pathways for a 1,000-year compliance period after closure of the disposal units. Given that the RWMSs are located well within the NNSS boundaries and public access is limited (e.g., tours), members of the public have access for only brief periods of time. However, for purposes of documenting potential impacts, the pathways for radionuclide movement from waste disposal facilities are monitored.

In 2017, external radiation from waste operations measured near the boundaries of the Area 3 and Area 5 RWMSs could not be distinguished from background levels at those locations (Section 6.3.4). Area 3 and Area 5 RWMS operations would have contributed negligible external exposure to a hypothetical person residing near the boundaries of these sites and would have resulted in no dose to the offsite public.

The dose from the air pathway can be estimated from air monitoring results from stations near the RWMSs (Figure 4-2 and Table 10-4). Mean concentrations of radionuclides in air at the Area 3 and Area 5 environmental sampler locations were, at the most, only 5% of their CLs (Table 10-4). Scaling this to the 10-mrem dose that the CL represents would be 0.5 mrem (0.005 mSv) to a hypothetical person residing near the boundaries of the RWMS, and the dose would be much lower to the offsite public.

There is no exposure, and therefore no dose, to the public from groundwater beneath waste disposal sites on the NNSS. Groundwater monitoring indicates that man-made radionuclides have not been detected in wells accessible to the offsite public or in private wells or springs (Sections 5.1.3.5, 7.2, and 7.3). Also, groundwater and ***vadose zone*** monitoring at the Area 3 and Area 5 RWMSs, conducted to verify the performance of waste disposal facilities, have not detected the migration of radiological wastes into groundwater (Sections 10.1.7 and 10.1.8).

Based on these results, potential doses to members of the public from LLW disposal facilities on the NNSS from all pathways are negligible.

9.1.3 Total Offsite Dose to the Public from all Pathways

The DOE-established radiation dose limit to a member of the general public from all possible pathways as a result of NNSA/NFO facility operations is 100 mrem/yr (1 mSv/yr) excluding background radiation, while considering air transport, ingestion, and direct exposure pathways. For 2017, the only plausible pathways of public exposure to man-made radionuclides from current or past NNSS activities included the air transport pathway and the ingestion of game animals and plants. The doses from these pathways are combined in Table 9-4 to present an estimate of the total 2017 dose to the ***maximally exposed individual (MEI)*** residing off site.

The MEI for the air pathway was considered to be a person residing in the Springdale area west of the NNSS (Section 9.1.1.1). If the offsite MEI is assumed to also eat wildlife from the NNSS, additional dose would be received. The additional dose may be 0.0016 mrem (0.000016 mSv) from eating a cottontail rabbit having radionuclide concentrations similar to the 2017 small mammal composite sample from Area 3 RWMS (Table 9-2) and could range up to 3.23 mrem (0.0323 mSv) if a person ate a mule deer having elevated radionuclide concentrations like the mule deer sampled in 2014 in Area 19 (Table 9-3). The maximum dose someone would receive from eating a single animal sampled in 2017 would be 0.74 mrem (0.0074 mSv) from the mule deer sampled at the Area 12 E Tunnel Ponds (Table 9-2). Since this is a 2017 result, it will be used for the game ingestion pathway dose for 2017. When the 0.07 mrem (0.0007 mSv) dose from the air pathway is added, the TEDE to this hypothetical MEI from all exposure pathways combined due to NNSA/NFO activities would be 0.81 mrem/yr (0.0081 mSv/yr) (Table 9-4).

Table 9-4. Estimated radiological dose to a hypothetical MEI of the general public from 2017 NNSS activities

Pathway	Dose to MEI (mrem/yr)	Dose to MEI (mSv/yr)	Percent of DOE 100 mrem/yr Limit
Air[(a)]	0.070	0.00070	0.07
Water[(b)]	0	0	0
Wildlife[(c)]	0.74	0.00745	0.74
Direct[(d)]	0	0	0
All Pathways	**0.81**	**0.0081**	**0.81**

(a) Based on highest offsite dose predicted from modeled 2017 air emissions (Section 9.1.1.1).
(b) Based on all offsite groundwater sampling conducted by NNSA/NFO to date (Section 5.1).
(c) Based on consuming one animal sampled in 2017 which would result in the highest dose (Table 9-2).
(d) Based on 2017 gamma radiation monitoring data at the NNSS entrance (Section 6.3.1).

The total dose of 0.81 mrem/yr to the hypothetical MEI is 0.81% of the DOE limit of 100 mrem/yr and about 0.2% of the total dose that the MEI receives from natural background radiation (360 mrem/yr [3.6 mSv/yr]) (Figure 9-1). Natural background radiation consists of cosmic radiation, terrestrial radiation, radiation from radionuclides within the composition of the human body (primarily potassium-40), and radiation from the inhalation of naturally occurring radon and ***radon progeny***. The cosmic and terrestrial components of background radiation shown in Figure 9-1 were estimated from the annual mean radiation exposure rate measured with a pressurized ion chamber (PIC) at Indian Springs by the CEMP (98.99 milliroentgens per year [mR/yr], rounded to 99 mR/yr; Table 7-4). The radiation exposure in air, measured by the PIC in units of mR/yr, is conservatively approximated to be equivalent to the unit of mrem/yr for tissue. The portion of the background dose from the internally deposited, naturally occurring radionuclides and from the inhalation of radon and its ***daughters*** were estimated at 31 mrem/yr (0.31 mSv/yr) and 229 mrem/yr (2.29 mSv/yr), respectively (Figure 9-1), using the approximations by the National Council on Radiation Protection and Measurements (2006).

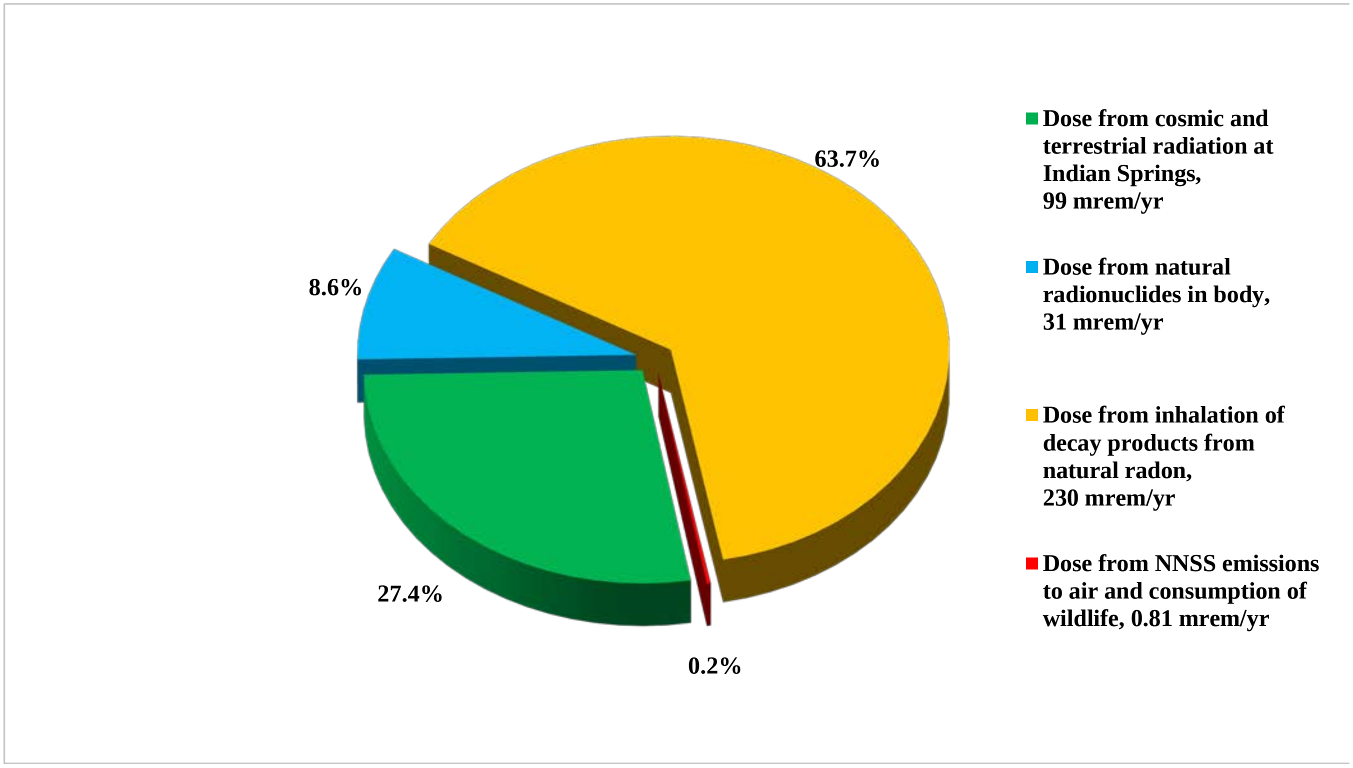

Figure 9-1. Comparison of radiation dose to the MEI from the NNSS and natural background (% of total)

9.1.4 Collective Population Dose

The ***collective population dose*** to residents within 80 km (50 mi) is the product of the predicted individual doses multiplied by the population potentially receiving those doses. The CAP88 modeled doses from 2017 air emissions for the estimated 493,700 people living within 80 km (50 mi) of NNSS resulted in a collective dose of 0.25 person-rem/yr. This is down from 0.47 person-rem/yr predicted for 2004, the last year this value was calculated. DOE approved the discontinuance of reporting collective population dose from NNSS operations after 2004 because it is so low. This 2017 calculation verifies this particular dose value remains low for the NNSS.

9.1.5 Release of Property Containing Residual Radioactive Material

In addition to discharges to the environment, the release of DOE property containing residual radioactive material is a potential contributor to the dose received by the public. The release of property off the NNSS is controlled. No vehicles, equipment, structures, or other materials can be released from the NNSS for unrestricted public use unless the amount of residual radioactivity on such items is less than the authorized limits. The default authorized limits are specified in the *Nevada Test Site Radiological Control Manual* (Radiological Control Manager's Council 2012) and are consistent with the limits set by DOE O 458.1. These limits are shown in Table 9-5.

All NNSA/NFO contractors use a graded approach for release of material and equipment for unrestricted public use. Items are either surveyed prior to release to the public, or a process knowledge evaluation is conducted to verify that the material has not been exposed to radioactive material or beams of radiation capable of generating radioactive material. In some cases, both a radiological survey and a process knowledge evaluation are performed (e.g., a radiological survey is conducted on the outside of the item, and a process knowledge form is signed by the custodian to address inaccessible surfaces). Items are evaluated/surveyed prior to shipment to the NNSA/NFO property/excess warehouse. All contractors also complete material surveys prior to release and transport to the Area 23 landfill. The only exception is for items that could be internally contaminated; these items are submitted to Waste Generator Services for disposal using one of the facilities that can accept LLW. Excess items that can be free-released are either donated to interested state agencies, federal agencies, or universities; redeployed to other onsite users; or sold on an auction website. No released items had residual radioactivity in excess of the limits specified in Table 9-5.

Independent verification of radiological surveys and process knowledge evaluations performed by NSTec and MSTS (the former and current Management and Operating contractor in 2017, respectively) is achieved through NNSA/NFO program oversight and through assessments. DOE O 458.1, which includes the process of releasing property to the public, has been incorporated into the site's Radiological Control Manager's Council Internal Assessment Schedule, and DOE O 458.1 assessments are scheduled to occur once every 3 years. An assessment was conducted in 2016, and NNSS property release activities were found to be in compliance with the order. The next assessment is scheduled for 2019.

Table 9-5. Allowable total residual surface contamination for property released off the NNSS

	Residual Surface Contamination (dpm/100 cm^2)(a)		
Radionuclide	**Removable**	**Average(b) (Fixed & Removable)**	**Maximum Allowable(c) (Fixed & Removable)**
Transuranics, ^{125}I, ^{129}I, ^{226}Ra, ^{227}Ac, ^{228}Ra, ^{228}Th, ^{230}Th, ^{231}Pa	20	100	300
Th-natural, ^{90}Sr, ^{126}I, ^{131}I, ^{133}I, ^{223}Ra, ^{224}Ra, ^{232}U, ^{232}Th	200	1,000	3,000
U-natural, ^{235}U, ^{238}U, and associated ***decay*** products, alpha emitters (α)	1,000 α	5,000 α	15,000 α
Beta (β)-gamma (γ) emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except ^{90}Sr and others noted above	1,000 β+γ	5,000 β+γ	15,000 β+γ
^{3}H and tritiated compounds	10,000	N/A	N/A

(a) Disintegrations per minute per 100 square centimeters (cm^2).

(b) Averaged over an area of not more than 100 cm^2.

(c) Applicable to an area of not more than 100 cm^2.

Source: Radiological Control Manager's Council (2012)

9.2 Dose to Aquatic and Terrestrial Biota

DOE requires their facilities to evaluate the potential impacts of radiation exposure to biota in the vicinity of DOE activities. To assist in such an evaluation, DOE's Biota Dose Assessment Committee developed DOE-STD-1153-2002. This standard established the following radiological dose limits for plants and animals. Dose rates equal to or less than these are expected to have no direct, observable effect on plant or animal reproduction:

- 1 rad/d (0.01 grays per day [Gy/d]) for aquatic animals
- 1 rad/d (0.01 Gy/d) for terrestrial plants
- 0.1 rad/d (1 milligray per day) for terrestrial animals

DOE-STD-1153-2002 also provides concentration values for radionuclides in soil, water, and sediment to use as a guide to determine if biota are potentially receiving radiation doses above the limits. These concentrations are called the Biota Concentration Guide (BCG) values. They are defined as the minimum concentration of a radionuclide that would cause dose limits to be exceeded using very conservative uptake and exposure assumptions.

NNSS biologists use the graded approach described in DOE-STD-1153-2002. The approach is a three-step process consisting of a data assembly step, a general screening step, and an analysis step. The analysis step consists of site-specific screening, site-specific analysis, and site-specific biota dose assessment. The following information is required by the graded approach:

- Identification of terrestrial and aquatic habitats on the NNSS with radionuclides in soil, water, or sediment.
- Identification of terrestrial and aquatic biota on the NNSS in contaminated habitats and at risk of exposure.
- Measured or calculated radionuclide concentrations in soil, water, and sediment in contaminated habitats on the NNSS that can be compared to BCG values to determine the potential for exceeding biota dose limits.
- Measured radionuclide concentrations in NNSS biota, soil, water, and sediment in contaminated habitats on the NNSS to estimate site-specific dose to biota.

A comprehensive biota dose assessment for the NNSS using the graded approach was reported in the *Nevada Test Site Environmental Report 2003* (BN 2004). The assessment demonstrated that the potential radiological dose to biota on the NNSS was not likely to exceed dose limits. Data from monitoring air, water, and biota across the NNSS suggest no significant change to NNSS surface conditions; therefore, the biota dose evaluation conclusion remains the same for 2017.

9.2.1 2017 Site-Specific Biota Dose Assessment

The site-specific biota dose assessment phase of the graded approach centers on the actual collection and analysis of biota. To obtain a predicted internal dose to biota sampled in 2017, the RESRAD-BIOTA, Version 1.5, computer model (DOE 2004) was used. Maximum concentrations of man-made radionuclides detected in plant and animal tissue (Table 8-3 and 8-5) were entered into the model. External dose was based on the measured annual exposure rate using the maximum quarterly ***thermoluminescent dosimeter (TLD)*** measurement made close to each biota sampling site (Table 6-1), minus average background exposure rate (Table 6-2). If the average background exposure rate was higher than the monitored location, then man-made external dose was set to zero.

The 2017 site-specific estimated dose rates to biota were all below the DOE limits for both plants and animals (Table 9-6). The highest dose was predicted for plants on the 92 Acre Cover of the Area 5 RWMC followed by animals at that same location.

Table 9-6. Site-specific dose assessment for terrestrial plants and animals sampled in 2017

	Estimated Radiological Dose (rad/d)		
Location [(a)]	**Internal [(b)]**	**External [(c)] (TLD Location)**	**Total**
Terrestrial Plants			
E Tunnel Ponds (Area 12) (4 samples, max. concentrations)	0.0014275	0.00010	0.00153
E Tunnel Ponds Control (Area 12) (1 sample)	0.0000469	0.00024	0.00028
Area 3 RWMS (1 sample)	0.0001597	0.00018	0.00034
Area 3 RWMS Control (1 sample)	0.0000239	0.00017	0.00019
Area 5 RWMS (3 samples, max. concentrations)	0.0064738	0.00022	0.00669
Area 5 RWMS Control (1 sample)	0.0000328	0.00019	0.00022
		DOE Dose Limit:	**1**
Terrestrial Animals			
E Tunnel Ponds (Area 12) (1 sample)	0.0000740	0.00010	0.00018
Area 3 RWMS (1 sample)	0.0000502	0.00018	0.00023
Area 3 RWMS Control (1 sample)	0.0001826	0.00017	0.00035
Area 5 RWMS (3 samples, max. concentrations)	0.0050998	0.00022	0.00532
Area 5 RWMS Control (1 sample)	0.0007841	0.00019	0.00097
Bighorn Sheep (Area 30) (1 sample)	0.0000141	0.00018	0.00019
Bobcat (Areas 4 & 5) (2 samples, max. concentrations)	0.0000805	0.00010	0.00018
Mountain Lion (NTTR) (1 sample)	0.0000004	0.00022	0.00022
Pronghorn (Area 5) (2 samples, max. concentrations)	0.0001166	0.00010	0.00022
		DOE Dose Limit:	**0.1**

(a) For information on plants and animals sampled, see Chapter 8.
(b) Based on maximum concentrations of each man-made radionuclide detected in plant or animal sampled at that location.
(c) Based on TLD measured exposure rates at or near the sample location. See Chapter 6 for information on direct radiation.

9.3 Dose Assessment Summary

Radionuclides in the environment as a result of past or present NNSS activities result in a potential dose to the public or biota much lower than the dose limits set to protect health and the environment. The estimated dose to the MEI for 2017 was 0.81 rem/yr (0.0081 mSv/yr), which is 0.81% of the dose limit set to protect human health. Dose to biota at the NNSS sites sampled in 2017 were less than 6% of dose limits set to protect plant and animal populations. Based on the low potential doses from NNSS radionuclides, impacts from those radionuclides are expected to be negligible.

9.4 References

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Chapter 10: Waste Management

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Several federal and state regulations govern the safe management, storage, and disposal of radioactive, hazardous, and solid wastes generated or received on the Nevada National Security Site (NNSS) (Tables 2-1 and 2-3). This chapter describes the waste management operations conducted on the NNSS in 2017, which comply with all applicable environmental/public safety regulations and which meet the major goals shown below. The Environmental Management (EM) Nevada Program is responsible for the Area 3 and Area 5 radioactive waste facilities described in Section 10.1 and operates them in conjunction with the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO). NNSA/NFO is responsible for and operates all other waste disposal facilities on the NNSS, as described in Sections 10.2, 10.3, and 10.4.

This chapter describes several waste streams including: ***low-level waste (LLW)***[1], ***mixed low-level waste (MLLW)***, and non-radioactive classified waste/matter generated by NNSA/NFO, other U.S. Department of Energy (DOE) approved generators, or selected U.S. Department of Defense (DoD) operations; ***transuranic (TRU)*** and mixed transuranic (MTRU) wastes generated on the NNSS; ***hazardous waste (HW)*** generated on the NNSS; explosive ordnance wastes generated on the NNSS; and, solid/sanitary wastes generated by NNSA/NFO operations. In addition, details are included for the management of underground storage tanks (USTs); the process to evaluate, design, construct, maintain, and monitor closure covers for radioactive waste disposal units at the Area 3 and Area 5 Radioactive Waste Management Sites (RWMSs); and, monitoring radiation ***doses*** from the Area 3 RWMS and the ***Area 5 Radioactive Waste Management Complex (RWMC)*** to the levels specified in DOE Manual DOE M 435.1-1, "Radioactive Waste Management Manual."

10.1 Radioactive Waste Management

The NNSS Radioactive Waste Management facilities include the Area 5 RWMC and the Area 3 RWMS. They operate as Category II non-reactor nuclear facilities. The Area 5 RWMC (Figure 10-1) is composed of the Area 5 RWMS, the Hazardous Waste Storage Unit (HWSU), and the Waste Examination Facility (WEF). This section describes the facilities and processes that comprise the safe receipt, storage, disposal, and disposal unit monitoring of radioactive wastes at the NNSS.

Waste Management Goals
Ensure disposal systems meet performance objectives.
Manage and safely dispose of all types of wastes generated on the NNSS or received from other approved generators.
Ensure wastes received for disposal meet NNSS waste acceptance criteria.
Manage and monitor wastes and waste sites for the protection of the public and environment.

10.1.1 Area 5 Radioactive Waste Management Site

The Area 5 RWMS is a DOE-owned radioactive waste disposal facility. It encompasses approximately 740 acres (ac) including 200 ac of historical and active disposal cells used for burial of LLW, MLLW, Non-Radiological Classified (NRC) waste, and Non-Radiological Classified Hazardous (NRCH) waste, and 540 ac of land available for future radioactive disposal cells. Waste disposal at the Area 5 RWMS occurred in a 92-acre portion of the site starting in the early 1960s. This "92-Acre Area" consists of 31 disposal cells and 13 Greater Confinement Disposal boreholes, and was used for disposal of waste in drums, soft-sided containers, large cargo containers, and boxes. The 92-Acre Area was filled and permanently closed in 2011. Closure covers for the 92-Acre Area were seeded in the fall of 2011. They have been monitored and reseeded in several failed attempts to produce covers supporting sustainable native plant populations.

[1] The definition of word(s) in ***bold italics*** may be found by clicking on the word in electronic version or by referencing the *Glossary*, Appendix B. To return from the Glossary, right click and select Previous View.

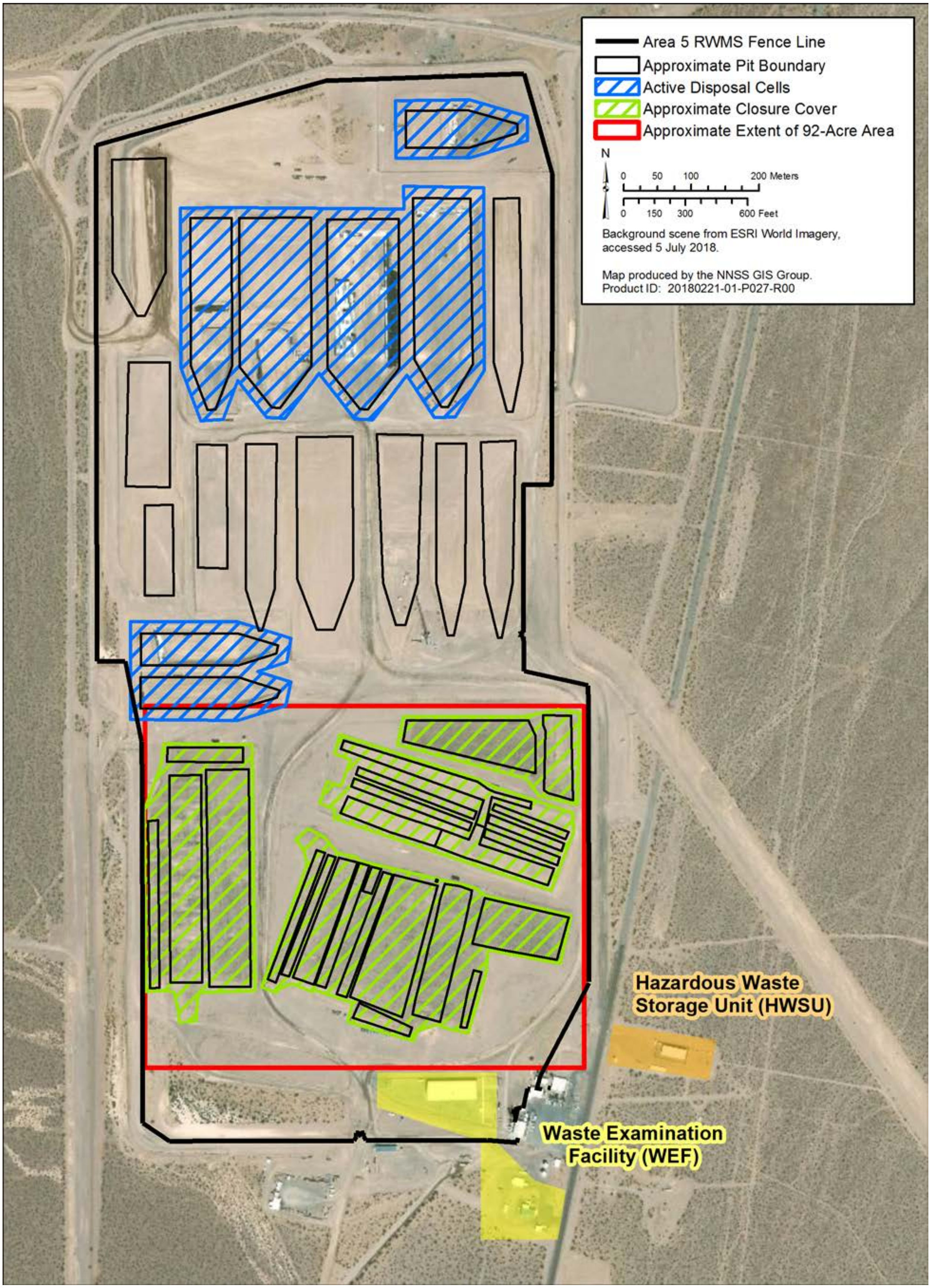

Figure 10-1. The Area 5 RWMC

In 2017, the EM Nevada Program investigated other strategies for revegetating these closure covers and teamed with Numic-speaking people, who have cultural ties to lands on the NNSS. The goal was to help ensure success by integrating traditional ecological knowledge with scientific ecological methods (http://www.nnss.gov/pages/News/news_JanMar2018.html).

Seven cells, developed immediately north and west of the 92-Acre Area, have been receiving wastes since 2010. They include six LLW cells (Cells 19, 20, 21, 22, 27, and 28) and a MLLW cell (Cell 18). All active Area 5 RWMS cells can accept radioactive waste contaminated with non-regulated ***polychlorinated biphenyl (PCB) bulk product waste***, but only Cell 18 can accept waste contaminated with regulated PCB remediation waste as well as asbestos-contaminated MLLW. Cells 18, 19, 20, 22, 27, and 28 can accept asbestos-contaminated LLW. Table 10-1 lists disposal cells active in 2017. MLLW disposal services are expected to continue at the Area 5 RWMS until the remaining needs of the DOE complex are met.

Disposal Cell 18 is operated under a Resource Conservation and Recovery Act (RCRA) Part B Permit (NEV HW0101), which authorizes the disposal of up to 25,485 cubic meters (m^3) (899,994 cubic feet [ft^3]) of MLLW and NRCH. The volume and weight of wastes received at Cell 18 in 2017 is shown in Table 10-1. A cumulative total of 17,678 m^3 (624,301 ft^3) of MLLW/NRCH has been disposed in Cell 18 through the end of 2017. Quarterly reports are submitted to the State of Nevada to document the weight in tons of MLLW/NRCH disposed.

In 2017, the Area 5 RWMS received shipments containing a total of 32,417 m^3 (1,144,806 ft^3) of radioactive waste for disposal (Table 10-1), which included both NRC and NRCH waste. The majority of waste disposed was received from offsite generators. The total number of waste shipments in fiscal year (FY) 2017 are reported annually (Mission Support and Test Services, LLC [MSTS] 2018a). Offsite waste generators delivering MLLW with regulated quantities of PCBs are issued Certificates of Disposal, as required under the Toxic Substances Control Act.

Table 10-1. Total waste volumes received and disposed at the Area 5 RWMS in calendar year 2017

Waste Type	Disposal Cell(s)	Volume Received and Disposed in m^3 (ft^3)
LLW and NRC	Cells 19, 20, 21, 22, 27, and 28	29,332 (1,035,845)
MLLW and NRCH (includes regulated PCB-contaminated LLW)	Cell 18	3,085 (108,961) [1,609 tons][(a)]
Total		**32,417 (1,144,806)**

(a) Fees paid to the state for HW generated at the NNSS and MLLW wastes received for disposal are based on weight

10.1.2 Waste Examination Facility

Operational units of the WEF include the TRU Pad, TRU Pad Cover Building (TPCB), TRU Loading Operations Area, WEF Yard, WEF Drum Holding Pad, Sprung Instant Structure (SIS), and the Visual Examination and Repackaging Building (VERB). Until 2009, the WEF was used for the staging, characterization, repackaging, and offsite shipment of legacy TRU wastes that had been stored for many years at the NNSS.

At present, the SIS, VERB, TRU Pad, and TPCB are authorized for the safe storage of radioactive mixed waste under the current RCRA Permit. The TPCB also accepts TRU/MTRU waste from NNSS generators. The TPCB stores the waste until it is characterized for disposal at the Waste Isolation Pilot Plant in Carlsbad, New Mexico. In 2017, the TRU waste remaining in storage at the TPCB consisted of two experimental spheres from Lawrence Livermore National Laboratory and 33 standard waste boxes from the Joint Actinide Shock Physics Experimental Research facility. The VERB is no longer a Category III Nuclear Facility; it was downgraded in 2016 to a radiological facility.

10.1.3 Area 3 Radioactive Waste Management Site

Disposal operations at the Area 3 RWMS began in the late 1960s. The Area 3 RWMS consists of seven ***subsidence craters*** configured into five disposal cells. Each subsidence crater was created by an underground nuclear explosives test. Until 2006, the site was used for disposal of bulk LLW, such as soils or debris, and waste in large cargo containers.

The Area 3 RWMS site consists of seven craters (Figure 10-2):

2 Disposal Cells (Inactive Status):	1 Closed Cell:	2 Undeveloped Cells:
U-3ah/at	U-3ax/bl	U-3az
U-3bh	(Corrective Action Unit 110)	U-3bg

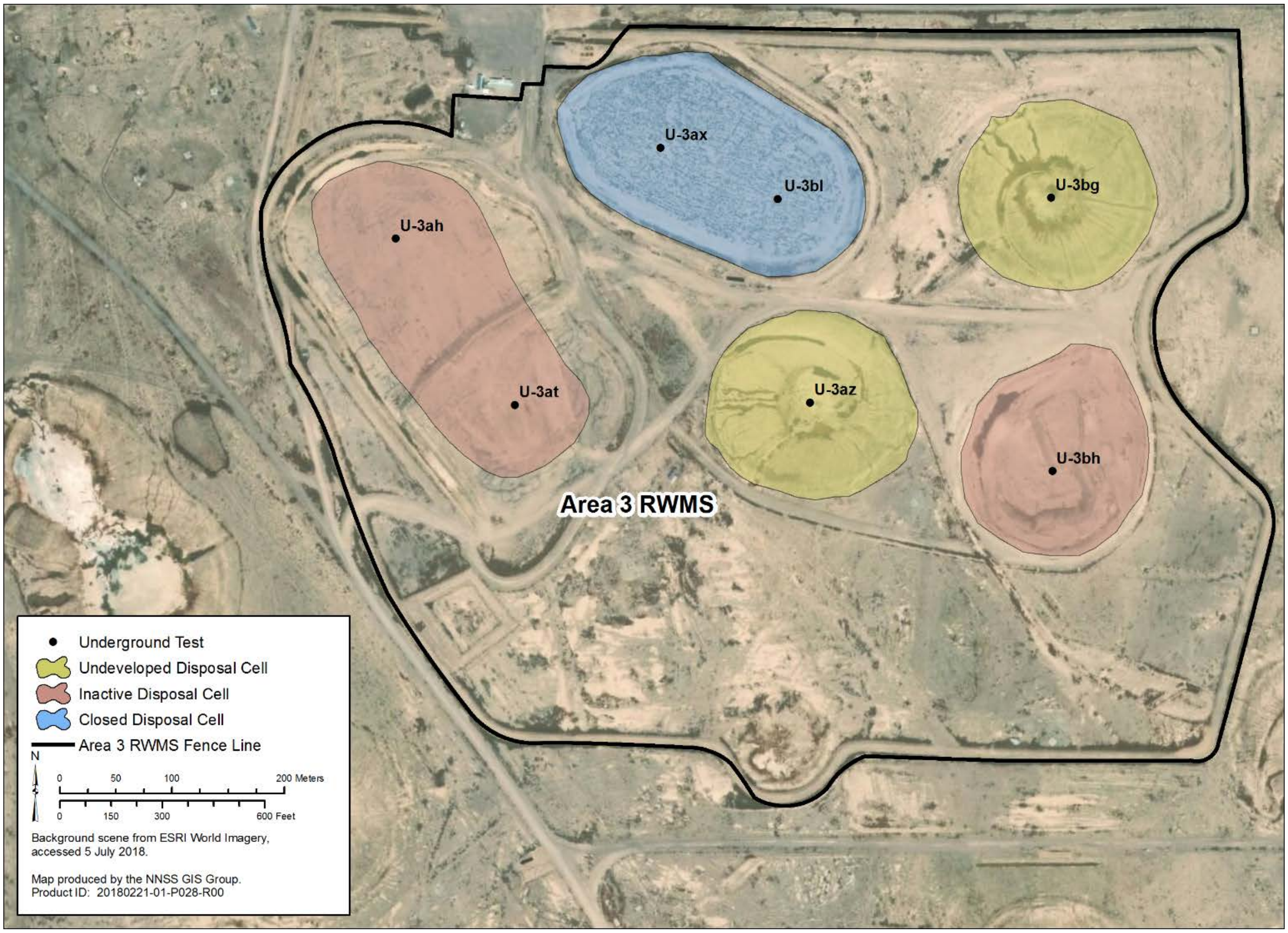

Figure 10-2. The Area 3 RWMS

10.1.4 Waste Characterization

All generators of waste must demonstrate eligibility for waste to be disposed at the NNSS, submit profiles characterizing specific waste streams, meet the NNSS Waste Acceptance Criteria (WAC), and receive programmatic approval from the EM Nevada Program for their site waste certification programs.

Characterization is performed by approved EM Nevada Program waste generators using knowledge of the generating process, sampling and analysis, or non-destructive analysis. Following the characterization of a waste stream, the approved EM Nevada Program waste generator develops a waste profile. The waste profile delineates the pedigree of the waste including, but not limited to, a description of the waste generating process, physical and chemical characteristics, radioactive ***isotope*** activity and quantity, and packaging information. The waste profile is reviewed by the Waste Acceptance Review Panel for eventual approval or disapproval by the EM Nevada

Program. The approved waste generator packages and ships approved waste streams in accordance with U.S. Department of Transportation requirements to the Area 5 RWMC or to an offsite facility for treatment, if necessary, prior to its shipment for disposal at the Area 5 RWMC.

In 2017, LLW, MLLW, and classified waste/matter were characterized by approved waste generators for the following general waste stream categories:

- Lead Solids
- Sealed Sources
- Miscellaneous Debris/Solids
- Contaminated PCB Waste
- Compactable Trash
- Radioactive Hazardous Classified Matter/Waste
- Amalgamated Mercury
- Contaminated Demolition Debris
- Contaminated Soil
- ***Depleted Uranium*** Waste
- Contaminated Asbestos Waste
- Non-radioactive Classified Matter/Waste
- ***High-efficiency particulate air (HEPA)*** Exhaust and Filter Media

An incident in 2016 necessitated the removal of a waste container from Cell 21 that had been mischaracterized and not permitted for disposal in Cell 21. During the Nuclear Fuel Services (NFS) extent-of-condition evaluation, questions arose regarding the characterization of additional containers that have been received at the NNSS. A resolution is being developed and both the states of Tennessee and Nevada are involved; the final path forward has not been determined.

10.1.5 Mixed Waste and Classified Non-Radioactive Hazardous Matter Verification

Waste verification is an inspection process that confirms the waste stream data supplied by approved waste generators before MLLW or non-radioactive classified HW is accepted for disposal at the NNSS. Verification may involve visual inspection, Real-Time Radiography (RTR), and/or chemical screening on a designated percentage of MLLW or non-radioactive classified hazardous matter. The objectives of waste verification include verifying that HW treatment objectives are met, confirming that waste containers do not contain free liquids, and ensuring that waste containers are at least 90% full, per RCRA and State of Nevada requirements. Offsite-generated waste is verified either when the waste is received at the NNSS or when it is still at a generator facility or a designated treatment, storage, or disposal facility. The first choice for the method of verification is visual inspection at the site of generation.

In 2017, offsite visual inspections were completed on 29 MLLW packages from eight separate waste streams and on two radioactive classified hazardous matter packages from one matter stream. Chemical screening was conducted on one waste stream. No RTR was required. In addition, onsite visual inspections were conducted on 20 MLLW packages from one offsite waste stream. The wastes were packaged at the generator site, and the packaging activities were digitally recorded on video. The videos were reviewed and the packages accepted by NNSS verification personnel at the North Las Vegas Facility (NLVF). No MLLW or non-radioactive classified hazardous matter packages were rejected.

10.1.6 Performance Assessments, Analyses, and Annual Reviews

To assess and forecast the long-term performance of NNSS disposal sites, the EM Nevada Program conducts a ***Performance Assessment (PA)*** and a ***Composite Analysis (CA)***. A PA is a systematic analysis of the potential risks posed to the public and environment by a waste disposal facility for LLW disposed after 1988. A CA is an assessment of the risks posed by all wastes disposed in a LLW disposal facility and by all other sources of residual contamination that may interact with the disposal site. The EM Nevada Program maintains current PAs and CAs for the Area 3 and Area 5 RWMSs (Table 10-2). The *Maintenance Plan for the Performance Assessments and Composite Analyses for the Area 3 and Area 5 Radioactive Waste Management Sites at the NNSS* (National Security Technologies, LLC [NSTec], 2007) requires an annual review of the PAs and CAs, and results are submitted annually to the DOE Office of Environmental Management. The Disposal Authorization Statements for the Area 3 and Area 5 RWMSs also require annual reviews and that secondary or minor unresolved issues be tracked and addressed as part of the Maintenance Plan.

In 2017, the EM Nevada Program performed an annual review of the Area 3 and Area 5 RWMS PAs and CAs. Operational factors (e.g., waste forms and containers, facility design), closure plans, monitoring results, and research and development activities in or near the facilities were also reviewed. The FY 2017 summary report to DOE (MSTS 2018b) presented data and conclusions that verified the adequacy of both the Area 3 and Area 5 PAs and CAs. Table 10-2 lists the necessary documents required and maintained for RWMS disposal operations.

Table 10-2. Key documents required for Area 3 RWMS and Area 5 RWMS disposal operations

Disposal Authorization Statement
Disposal Authorization Statement for Area 5 RWMS, December 2000
Disposal Authorization Statement for Area 3 RWMS, October 1999
Performance Assessment
Addendum 2 to Performance Assessment for Area 5 RWMS, June 2006
Performance Assessment/Composite Analysis for Area 3 RWMS, Revision 2.1, October 2000
Annual Summary Report for the Area 3 and 5 Radioactive Waste Management Sites at the Nevada National Security Site (Review of Performance Assessments and Composite Analyses), March 2018
Composite Analysis
Composite Analysis for Area 5 RWMS, September 2001
Performance Assessment/Composite Analysis for Area 3 RWMS, Revision 2.1, October 2000
NNSS Waste Acceptance Criteria
NNSS Waste Acceptance Criteria, Revision 10a, February 2015
Integrated Closure and Monitoring Plan
Closure Plan for the Area 3 RWMS at the NNSS, September 2007
Closure Plan for the Area 5 RWMS at the NNSS, September 2008
Documented Safety Analysis
Documented Safety Analysis (DSA) for the NNSS Areas 3 and 5 Radioactive Waste Facilities, Revision 5, Change Notice 4, May 2012
Safety Evaluation Report (SER) Addendum C, Revision 0, for the Visual Examination and Repackaging Building Addendum to the Area 5 RWMC DSA and Technical Safety Requirements (TSR) for the Area 5 RWMC TRU Waste Activities, November 2008
Visual Examination and Repackaging Building Addendum to the Area 5 RWMC DSA, Revision 0, Change Notice 3, November 2008
SER Addendum C, Revision 0, for the NNSS Areas 3 and 5 Radioactive Waste Facility DSA, Revision 5, Change Notice 3, and TSR Revision 7, Change Notice 3, January 2012
TSR for the Area 5 RWMC TRU Waste Activities, Revision 10, Change Notice 4, May 2012
TSR for the Areas 3 and 5 RWMS LLW Activities, Revision 7, Change Notice 4, May 2012

10.1.7 Groundwater Monitoring

Disposal Cell 18 is operated following RCRA standards for the disposal of MLLW. Title 40 ***Code of Federal Regulations (CFR)*** Part 264, Subpart F (40 CFR 264.92) requires groundwater monitoring to verify the performance of Cell 18 to protect groundwater from buried waste. Specifically, groundwater monitoring at the Area 5 RWMS is conducted in accordance with 40 CFR 264.97, General Ground-Water Monitoring Requirements, and 40 CFR 264.98, Detection Monitoring Program. Groundwater samples are analyzed for indicators of contamination (pH, specific conductance, total organic carbon, total organic halides, and ***tritium***) and, beginning in 2017, toxicity characteristic metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver). Limits for each parameter were established by the NDEP RCRA Permit NEV HW0101. Groundwater samples are collected and analyzed semiannually at wells UE5 PW-1, UE5 PW-2, and UE5 PW-3 to meet groundwater monitoring requirements. All grab samples collected semiannually in 2017 from the wells had contaminant levels below their Investigation Levels (ILs) (Table 10-3). Static water levels and general water chemistry parameters are also monitored. All sample analysis results are presented in MSTS (2018c). The tritium results were all below their sample-specific ***minimum detectable concentration (MDC)*** of between 133 and 103 pCi/L. (Table 5-5 presents the sample-specific MDCs for each water sample collected from these wells in 2017). No groundwater contamination from Cell 18 is indicated by the 2017 results.

Table 10-3. Results of groundwater monitoring of UE5 PW-1, UE5 PW-2, and UE5 PW-3 in 2017

Parameter	Investigation Level (IL)	Sample Levels[(a)]
pH	< 7.6 or > 9.2 S.U.[(b)]	8.25 to 8.48 S.U.
Specific conductance (SC)	0.440 mmhos/cm[(c)]	0.357 to 0.378 mmhos/cm
Total organic carbon (TOC)	2 mg/L[(d)]	ND[(e)]
Total organic halides (TOX)	50 µg/L[(f)]	<0.01 µg/L
Tritium (^{3}H)	2,000 pCi/L[(g)]	ND[(e)]
Arsenic (As)	0.05 mg/l	ND[(e)] to < 0.03
Barium (Ba)	1 mg/l	ND[(e)] to <0.05
Cadmium (Cd)	0.01 mg/l	ND[(e)]
Chromium (Cr)	0.05 mg/l	ND[(e)] to 0.007
Lead (Pb)	0.05 mg/l	ND[(e)]
Mercury (Hg)	0.002 mg/l	ND[(e)]
Selenium (Se)	0.01 mg/l	ND[(e)]
Silver (Ag)	0.05 mg/l	ND[(e)]

(a) Levels shown are the lowest and highest values for each well for each sample date. Source: MSTS (2018c)
(b) S.U. = standard unit(s) (for measuring pH)
(c) mmhos/cm = millimhos per centimeter
(d) mg/L = milligrams per liter
(e) ND = not detected; levels were below sample-specific MDCs
(f) µg/L = microgram(s) per liter
(g) pCi/L = picocuries per liter

10.1.8 Vadose Zone Monitoring

Monitoring of the ***vadose zone*** (***unsaturated zone*** above the ***water table***) is conducted at the RWMC to demonstrate (1) the PA assumptions at the RWMSs are valid regarding the hydrologic conceptual models used, including soil water contents, and upward and downward flux rates; and (2) there is negligible infiltration and percolation of precipitation into zones of buried waste at the RWMSs. Vadose zone monitoring (VZM) offers many advantages over groundwater monitoring, including detecting potential problems long before groundwater resources would be impacted, allowing corrective actions to be made early, and being less expensive than groundwater monitoring. The components of the VZM program include the Drainage Lysimeter Facility northwest of U-3ax/bl, the Area 5 Weighing Lysimeter Facility southwest of the Area 5 RWMS, two meteorology towers, and instruments at eight depth levels at six locations in four waste disposal cell covers that measure water content and water potential profiles. Data from all of these components are used to monitor the natural water balance at the RWMSs. Descriptions of the VZM components and the results of monitoring in 2017 are reported in MSTS (2018d). All VZM continued to demonstrate negligible infiltration of precipitation into zones of buried waste at the RWMC, and performance criteria to prevent contamination of groundwater and the environment are being met.

10.1.9 Assessment of Radiological Dose to the Public

DOE M 435.1-1 states that LLW disposal facilities shall be operated, maintained, and closed so that a reasonable expectation exists that annual dose to members of the public shall not exceed 10 millirem (mrem) through the air pathway and 25 mrem through all pathways for a 1,000-year compliance period after closure of the disposal units. Given that the RWMSs are well within the NNSS boundaries, no members of the public can currently access the areas for significant enough periods of time to acquire a dose exceeding the annual limit. To document compliance with DOE M 435.1-1, however, the possible pathways for ***radionuclide*** movement from waste disposal facilities are monitored. Long-term compliance with the DOE M 435.1-1 dose limits is evaluated by performance assessment modeling. As discussed below, waste operations would contribute negligible ***exposure*** to a hypothetical person residing near the boundaries of the RWMSs and would contribute no dose to the offsite public.

10.1.9.1 Dose from Air and Direct Radiation

Air samplers operate continuously to collect air particulates and atmospheric moisture near each RWMS. These samples are analyzed for radionuclides, and results are used to assess potential dose. Details of the air sampling and a summary of the analysis results are given in Chapter 4. In 2017, three environmental sampling stations operated in/near the Area 3 RWMS (U-3ax/bl S, Bilby Crater, and Kestrel Crater N), and two air monitoring stations operated near the Area 5 RWMS (DoD and RWMS 5 Lagoons). The dose from the air pathway was estimated based on the highest annual mean concentration results for each measured radionuclide from among these five stations in order to estimate a worst-case dose for a member of the public at either of the RWMSs.

The highest annual mean concentration of each measured radionuclide among the five stations, and the station at which the highest concentration occurred, are shown in Table 10-4. The highest concentration of any radionuclide was 6,810 x 10^{-15} microcuries per milliliter (µCi/mL) for ^{3}H at U-3ax/bl S. In fact, all four of the highest mean concentrations were from the same location (Table 10-4) and all were far below their established National Emission Standards for Hazardous Air Pollutants (NESHAP) Concentration Levels for Environmental Compliance (CLs) (Table 10-4, fourth column). The highest mean concentration of each measured radionuclide is divided by its respective CL to obtain a "fraction of CL" (Table 10-4, right-most column). The fractions are then summed, and if the sum is less than 1, it demonstrates that the NESHAP dose limit of 10 mrem/yr was not exceeded at a location having all those radionuclides at those concentrations. Summing the fractions of CLs gives 0.14, which is only 14% of the limit in this worst-case scenario. Scaling this to the 10 mrem dose that the CLs represent would mean that a hypothetical person residing near the RWMS would receive an annual dose of about 1.4 mrem/yr from the air pathway.

Table 10-4. Highest annual mean concentrations of radionuclides detected in 2017 at Area 3 and Area 5 RWMS

Radionuclide	RWMS Sampler with Highest Concentration	Highest Annual Mean Concentration (× 10^{-15} µCi/mL)	NESHAP CL[(a)] (× 10^{-15} µCi/mL)	Fraction of CL
^{3}H	U-3ax/bl S	6,810	1,500,000	0.0045
^{238}Pu	U-3ax/bl S	0.00532	2.1	0.0025
^{239}Pu	U-3ax/bl S	0.237 ($^{239+240}Pu$)	2	0.1185
^{241}Am	U-3ax/bl S	0.0302	1.9	0.0159
			Sum of Fractions:	**0.1415**

(a) CL values represent an annual average concentration that would result in a ***total effective dose equivalent*** of 10 mrem/yr, the federal dose limit to the public from all radioactive air emissions (from Table 2, Appendix E of 40 CFR 61, "National Emission Standards for Hazardous Air Pollutants," 1999).

Thermoluminescent dosimeters (TLDs) are used to measure ***ionizing radiation*** exposure at five locations in and around the Area 3 RWMS and 12 locations in and around the Area 5 RWMS. The TLDs have three calcium sulfate elements used to measure the total exposure rate from penetrating ***gamma radiation***, including ***background*** radiation. The penetrating gamma radiation makes up the deep dose, which is compared to the 25 mrem/yr limit when background exposure is subtracted. Details of the direct radiation monitoring are given in Chapter 6. During 2017, the external radiation measured near the boundaries of the Area 3 and Area 5 RWMSs could not be distinguished from background levels (Section 6.3.4). Area 3 and Area 5 RWMS operations would have contributed negligible external exposure to a hypothetical person residing near the boundaries of these sites, and no dose to the offsite public.

10.1.9.2 Dose from Groundwater

Groundwater and vadose zone monitoring at the RWMSs is conducted to verify the performance of waste disposal facilities. Such monitoring has not detected the migration of radiological wastes into groundwater (Sections 10.1.7 and 10.1.8). Also, the results of monitoring offsite public and private wells and springs indicate that man-made radionuclides have not been detected in any public or private water supplies (Table 5-4, and Sections 7.2 and 7.3). Based on these results, potential doses to members of the public from LLW disposal facilities on the NNSS from groundwater, and from all pathways combined, are negligible.

10.2 Hazardous Waste Management

HW regulated under RCRA is generated at the NNSS from a broad range of activities including onsite laboratories, site and vehicle maintenance, communications operations, and environmental restoration of historical contaminated sites. The RCRA Part B Permit regulates operation of the Area 5 Mixed Waste Disposal Unit (MWDU), consisting of a Subtitle C landfill (Cell 18) and 3,000-gallon leachate collection tank, the Area 5 HWSU, and the Area 11 Explosive Ordnance Disposal Unit (EODU) facilities. Included in the RCRA Part B permit is authorization for MLLW storage at the Mixed Waste Storage Unit (MWSU), which comprises the TRU Pad/TPCB, the SIS Building, the VERB, and the Drum Holding Pad.

The HWSU (Figure 10-1) is a prefabricated, rigid-steel-framed, roofed shelter and is permitted to store a maximum of 61,600 liters (16,300 gallons) of approved waste at a time. HW generated at NNSA/NFO environmental restoration sites off the NNSS (e.g., Tonopah Test Range) or generated at the NLVF are direct-shipped to approved disposal facilities. HW generated on the NNSS is also direct-shipped from sites on the NNSS (i.e., not from the HWSU) if the sites generate bulk, non-packaged HW not accepted for storage at the HWSU. HW would also be direct-shipped from NNSS sites in the unlikely case the waste volume capacity of the HWSU is approaching permitted limits. Satellite Accumulation Areas (SAAs) and 90-day Hazardous Waste Accumulation Areas (HWAAs) are temporary storage at the NNSS for HW prior to direct shipment off site or to the HWSU.

The EODU is permitted to treat explosive ordnance wastes by open detonation of not more than 45.4 kilograms (100 pounds) of approved waste at a time, not to exceed one detonation event per hour. Conventional explosive wastes are generated at the NNSS from explosive operations at construction and experiment sites, the NNSS firing range, the resident national laboratories, and other activities.

10.2.1 2017 Hazardous Waste Activities

The RCRA permit requires preparation of a U.S. Environmental Protection Agency Biennial Hazardous Waste Report of all HW volumes generated and disposed or stored at the NNSS. This report is prepared for odd-numbered years only. It was most recently prepared for 2017 and electronically submitted to the State of Nevada on March 1, 2018. The next biennial report will be prepared for 2019 and submitted to the state in 2020. An annual waste volume report was prepared in 2017 and submitted to the State of Nevada in February 2018 (MSTS 2018e). It includes the amount of wastes received in calendar year 2017 at the Area 5 MWDU, MWSU, HWSU; and Area 11 EODU.

Table 10-5 lists the quantities of HW generated either on or off site that were managed (received, stored, shipped, or disposed) at the various NNSS waste units during calendar year 2017. It includes the tons of MLLW received and disposed on site in MWDU Cell 18; the tons of MLLW received at the MWSU; the tons of MLLW shipped off site from the MWSU for disposal; the tons of HW with and without PCBs received, stored, and shipped off site from the HWSU; and the tons of HW stored and then shipped off site from one or more HWAAs. Quarterly 2017 HW volume reports were submitted on schedule to NDEP.

Table 10-5. Hazardous waste managed at the NNSS in 2017

Unit	Amount Received (tons)[(a)]	Amount Shipped (tons)	Amount Disposed (tons)
MWDU Cell 18	1,609	0	1,609
MWSU	0	0	--
HWSU	1.37	2.014	--
HWSU – PCB Waste	0.197	0.197	--
HWAA	NA[(b)]	2.61	--
EODU	0.0383	0	0.0383[(c)]

(a) Fees paid to the state for HW generated at the NNSS and MLLW wastes received for disposal are based on weight (tons).
(b) Not applicable; amounts of HW received at HWAAs are not tracked, only the length of time they are stored and the amounts shipped off from all HWAAs combined are tracked.
(c) 0.0383 tons (76.6 lbs) is the weight of explosive ordnance detonated at the EODU.

Each year NDEP performs a Compliance Evaluation Inspection (CEI) of the RCRA permitted HW units at the NNSS. On April 12, 19, 24 and 25, 2017, NDEP conducted its CEI of the waste units listed in Table 10-5, selected SAAs, Universal Waste Collection Centers and closed historic RCRA waste management units at the NNSS (Section 11.4). The 2017 CEI documented that NNSA/NFO was compliant with the NNSS Part B Permit.

10.3 Underground Storage Tank (UST) Management

RCRA regulates the storage, transportation, treatment, and disposal of HW to prevent contaminants from leaching into the environment from USTs. Nevada Administrative Code NAC 459.9921–459.999, “Storage Tanks,” enforces the federal regulations under RCRA pertaining to the maintenance and operation of USTs and the regulated substances contained in them so as to prevent environmental contamination. NNSA/NFO operates one deferred UST and three excluded USTs at the Device Assembly Facility; one fully regulated UST at the Area 6 Helicopter pad, which is not in service; and three fully regulated USTs, one deferred UST, and three excluded USTs at the Remote Sensing Laboratory–Nellis (RSL-Nellis). NDEP has oversight authority of the NNSS USTs, and the Southern Nevada Health District has oversight authority of USTs in Clark County (Section A.2.3 of Appendix A regarding UST management at RSL-Nellis). NDEP usually conducts inspections of NNSS USTs once every three years. NDEP's most recent inspection of the USTs at the NNSS was in 2016 and no issues were identified. No NNSS USTs were upgraded or removed in 2017.

10.4 Solid and Sanitary Waste Management

Three landfills for ***solid waste*** disposal were operated at the NNSS in 2017. The landfills are regulated and permitted by the State of Nevada (Table 2-3 for list of permits). No liquids, HW, or radioactive waste are accepted in these landfills. They include:

- Area 6 Hydrocarbon Landfill – accepts hydrocarbon-contaminated wastes, such as soil and absorbents.
- Area 9 U10c Solid Waste Landfill – designated for industrial waste such as construction and demolition debris and asbestos waste under certain circumstances.
- Area 23 Solid Waste Landfill – accepts municipal-type wastes such as food waste and office waste. Regulated asbestos-containing material is also permitted in a special section. The permit allows disposal of no more than an average of 20 tons/day at this site.

These landfills are designed, constructed, operated, maintained, and monitored in adherence to the requirements of their state permits. NDEP visually inspects the landfills annually for compliance. No non-compliance items were noted during the July 2017 NDEP inspection. The amount of waste disposed in each landfill is shown in Table 10-6. Biannual reports for the Area 23 Solid Waste Landfill were submitted in July 2017 and January 2018 to NDEP (NSTec 2017; MSTS 2018f).

The vadose zone is monitored at the Area 6 Hydrocarbon Landfill and the Area 9 U10c Solid Waste Landfill. VZM is performed once annually in lieu of groundwater monitoring to demonstrate that contaminants from the landfills are not leaching into the groundwater. VZM in 2017 indicated no soil moisture migration and, therefore, no waste leachate migration to the water table. Annual 2017 soil moisture monitoring reports for the Area 6 and Area 9 sites were submitted in February 2018 to NDEP (MSTS 2018g, 2018h).

Table 10-6. Quantity of solid wastes disposed in NNSS landfills in 2017

Waste Disposed in Landfills in Metric Tons (Tons)		
Area 6	**Area 9**	**Area 23**
28.35 (31.25)	564.43 (622.17)	321.11 (353.97)

10.5 References

Mission Support and Test Services, LLC, 2018a. *4th Quarter/Annual Transportation Report FY2017, Waste Shipments to and from the Nevada National Security Site (NNSS), Radioactive Waste Management Complex*. DOE/NV/25946--3397, Las Vegas, Nevada, January 2018.

———, 2018b. *2017 Annual Summary Report for the Area 3 and 5 Radioactive Waste Management Sites at the Nevada National Security Site (Review of Performance Assessments and Composite Analyses)*. DOE/NV/03624--0081, Las Vegas, Nevada, March 2018.

———, 2018c. *Nevada National Security Site 2017 Data Report: Groundwater Monitoring Program Area 5 Radioactive Waste Management Site*. DOE/NV/03624--0061, Las Vegas, Nevada.

———, 2018d. *Nevada National Security Site 2017 Waste Management Monitoring Report, Area 3 and Area 5 Radioactive Waste Management Site (in review)*. Las Vegas, Nevada.

———, 2018e. *RCRA Permit for a Hazardous Waste Management Facility Permit Number NEV HW0101, Annual Summary/Waste Minimization Report, Calendar Year 2017, Nevada National Security Site, Nevada*. DOE/NV/25946--3131, Las Vegas, Nevada, February 2018.

———, 2018f. *July–December 2017 Biannual Solid Waste Disposal Site Report for the Nevada National Security Site Area 23 Sanitary Landfill*, Las Vegas, Nevada, January 2018.

———, 2018g. *Annual Soil Moisture Monitoring Report for the Area 9 U10c Landfill, Nevada National Security Site, Nevada, for the Period March 2017 – February 2018,* Las Vegas, Nevada.

———, 2018h. *Annual Soil Moisture Monitoring Report for the Area 6 Hydrocarbon Landfill, Nevada National Security Site, Nevada, for the Period March 2017–February 2018*, Las Vegas, Nevada.

MSTS, see Mission Support and Test Services, LLC.

National Security Technologies, LLC, 2007. *Maintenance Plan for Performance Assessments and Composite Analyses of the Area 3 and Area 5 Radioactive Waste Management Sites at the Nevada Test Site*. DOE/NV/25946--091, Las Vegas, Nevada. OSTI ID: 914419

———, 2017. *January–June 2017 Biannual Solid Waste Disposal Site Report for the Nevada National Security Site Area 23 Sanitary Landfill*, Las Vegas, Nevada, July 2017.

NSTec, see National Security and Technologies, LLC.

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Chapter 11: Environmental Restoration

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The Environmental Management (EM) Nevada Program is responsible for evaluating and implementing corrective actions on areas of the Nevada National Security Site (NNSS), the Nevada Test and Training Range (NTTR), and the Tonopah Test Range (TTR) impacted by atmospheric and underground nuclear tests conducted from 1951 to 1992. These areas are referred to as corrective action sites (CASs). Environmental restoration (ER) strategies and corrective actions are developed based on the nature and extent of contamination, the risks posed by contamination, and future land use. EM Nevada Program is responsible for approximately 3,000 CASs in Nevada.

CASs are broadly organized into four categories based on the source of contamination: Underground Test Area (UGTA) sites, Industrial sites, Soils sites, and Nevada Offsites. Multiple CASs are grouped into larger, geographic corrective action units (CAUs) according to location, physical and geological characteristics, and/or contaminants. UGTA is the largest component of the EM Nevada Program and includes 878 CASs in 5 CAUs that are directly related to groundwater in the geographical areas of past underground nuclear testing. Industrial sites are facilities and land that may have become contaminated due to activities conducted in support of nuclear testing, and include disposal wells, inactive tanks, contaminated waste sites, inactive ponds, muck piles, spill sites, drains and sumps, and ordnance sites. Soils sites include areas where nuclear tests have resulted in extensive surface and/or shallow subsurface contamination from radioactive materials and potentially from oils, solvents, heavy metals, and contaminated instruments and test structures used during testing activities. Nevada Offsites are associated with underground nuclear testing at the Project Shoal Area and the Central Nevada Test Area, located in northern and central Nevada, respectively. Nevada Offsites are managed by the U.S. Department of Energy (DOE) Office of Legacy Management.

In April 1996, the DOE, the U.S. Department of Defense, and the State of Nevada entered into a Federal Facility Agreement and Consent Order (FFACO) to address the environmental restoration of CASs. Appendix VI of the FFACO (as amended), describes the strategy to plan, implement, and complete environmental corrective actions (i.e., to "close" the CASs). ER activities follow a formal work process described in the FFACO. The State of Nevada is a participant throughout the closure process, and the Nevada Site Specific Advisory Board (NSSAB)[1] is kept informed of progress. The NSSAB is a formal volunteer group of interested citizens and representatives who provide informed recommendations to the EM Nevada Program. The NSSAB's comments are strongly considered throughout the corrective action process. This chapter summarizes actions taken by the EM Nevada Program towards the closure of UGTA, Industrial, and Soils sites in 2017.

Environmental Restoration Objectives for All Sites
Characterize sites contaminated by DOE nuclear testing activities.
Remediate contaminated sites in accordance with FFACO-approved planning documents.
Conduct post-closure monitoring of sites in accordance with FFACO closure documents.

11.1 Underground Test Area Sites

From 1951 to 1992, more than 800 underground nuclear tests (UGTs), some involving multiple detonations, were conducted at the NNSS (NNSA/NFO 2015a). Most were conducted hundreds of feet above groundwater;

[1] NSSAB activities can be accessed at http://www.nnss.gov/NSSAB/.

however, over 200 were within or near the ***water table***[2]. The test locations (i.e., CASs) are grouped into five CAUs based primarily on geographically distinct areas of underground testing (Figure 11-1). ***Closure-in-place*** with institutional controls (e.g., restricting land and groundwater access) and monitoring is considered to be the only feasible corrective action for these sites because cost-effective groundwater technologies have not been developed to effectively remove or stabilize deep subsurface radiological contaminants.

Corrective actions for each CAU begin with characterization studies (i.e., data collection and analysis). In addition, water levels and groundwater chemistry in wells in and near the NNSS are evaluated to determine groundwater flow directions (e.g., Fenelon et al. 2010) (Figure 11-2). Characterization studies, water-level and groundwater chemistry data, and regional three-dimensional groundwater flow models (International Technology Corporation 1996; Belcher and Sweetkind 2010) provide the basis for developing models of the hydrogeologic setting, the radiological ***source term***, and flow and contaminant transport for each CAU. The numerous surface and subsurface investigations and computer modeling for UGTA CAUs are conducted by various participating organizations including Navarro Research and Engineering, Inc. (Navarro); Los Alamos National Laboratory (LANL); Lawrence Livermore National Laboratory (LLNL); the U.S. Geological Survey (USGS); the Desert Research Institute (DRI); and Mission Support and Test Services, LLC (MSTS).

The groundwater flow and contaminant transport models will ultimately be used to design monitoring well networks and land-use restrictions that protect the public. For four of the five UGTA CAUs, these models will be used to identify ***contaminant boundaries*** that forecast areas with the potential to exceed the Safe Drinking Water Act (SDWA) ***maximum contaminant levels*** for ***radionuclides*** over the next 1,000 years. Such contaminant boundary forecasts are not required by the FFACO for the Rainier Mesa/Shoshone Mountain CAU; field data are insufficient and the area is too geologically complex to develop reliable models for a contaminant boundary (NNSA/NFO 2013). For this CAU, the models must instead forecast the maximum extent of contamination and demonstrate institutional controls will not be challenged by radionuclides originating from UGTs conducted in the CAU within the 1,000-year compliance period.

As required under the FFACO, after characterization activities and model development are complete, the following items will be sequentially identified/defined for each CAU in agreement between DOE and the Nevada Division of Environmental Protection (NDEP): a ***regulatory boundary*** objective, regulatory boundary (ies), and ***use-restriction boundaries***. UGTA corrective actions for all CAUs are expected to be complete by fiscal year (FY) 2030 (October 1, 2029–September 30, 2030).

Environmental Restoration Objectives for UGTA Sites
Collect data (e.g., groundwater samples, water-levels, hydrologic testing, field and laboratory studies) to characterize the hydrogeological setting and nature and extent of contamination.
Develop CAU-specific models of groundwater flow and contaminant transport that geographically include the five former NNSS UGTAs.
Identify boundaries within which contaminants are forecasted to exceed the SDWA limits at any time within a 1,000-year compliance period.
Negotiate and implement regulatory objectives and regulatory boundaries to protect the public and environment from the effects of radioactive contaminant migration.
Negotiate and implement use-restriction boundaries to restrict access to contaminated groundwater.
Develop and implement a long-term closure monitoring network to verify consistency with the flow and transport models, compliance to the regulatory boundary, and protection of human health and the environment.

[2] The definition of word(s) in ***bold italics*** may be found by clicking on the word in electronic version or by referencing the Glossary, Appendix B. To return from the Glossary, right click and select Previous View.

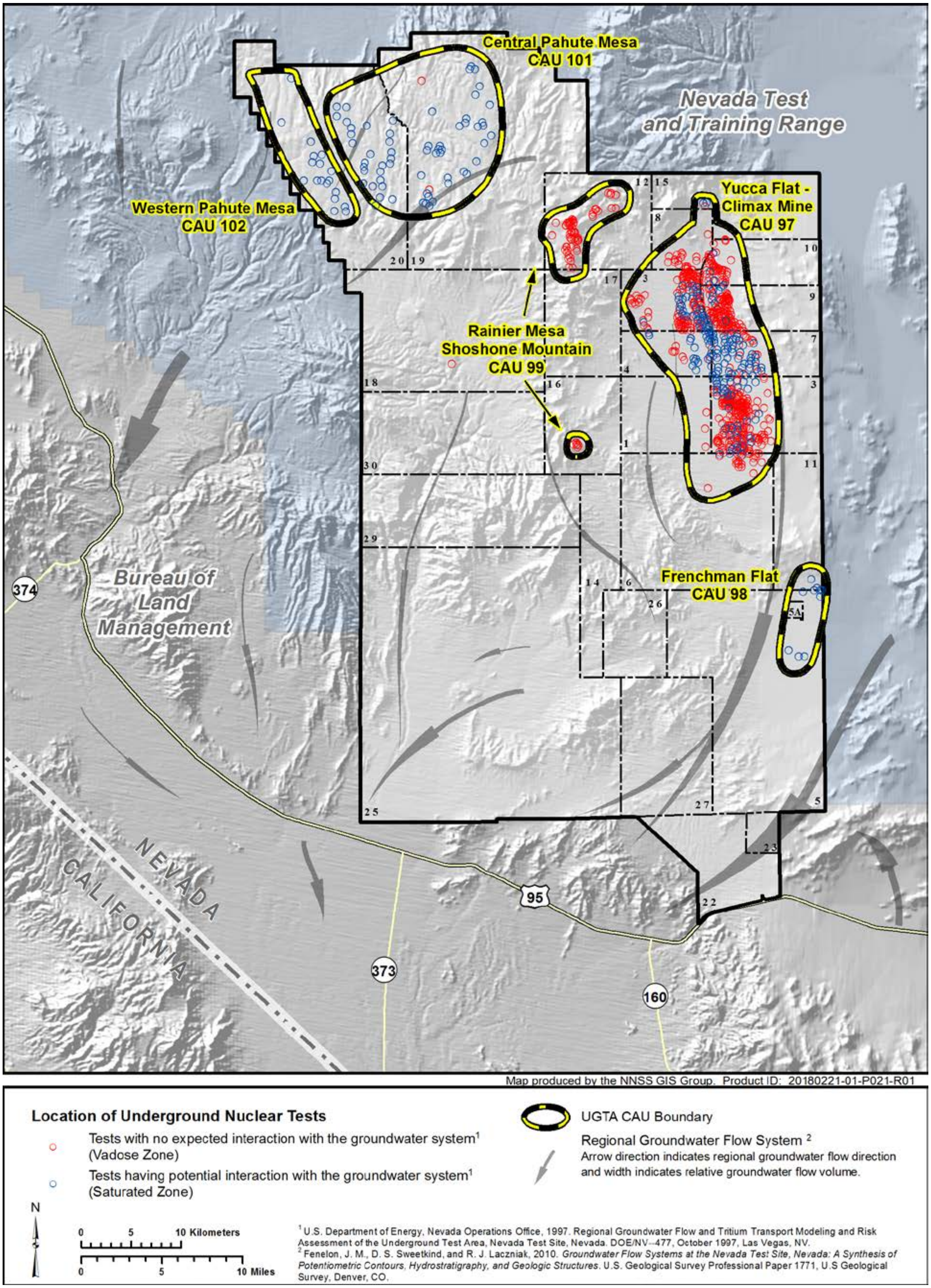

Figure 11-1. UGTA CAUs on the NNSS

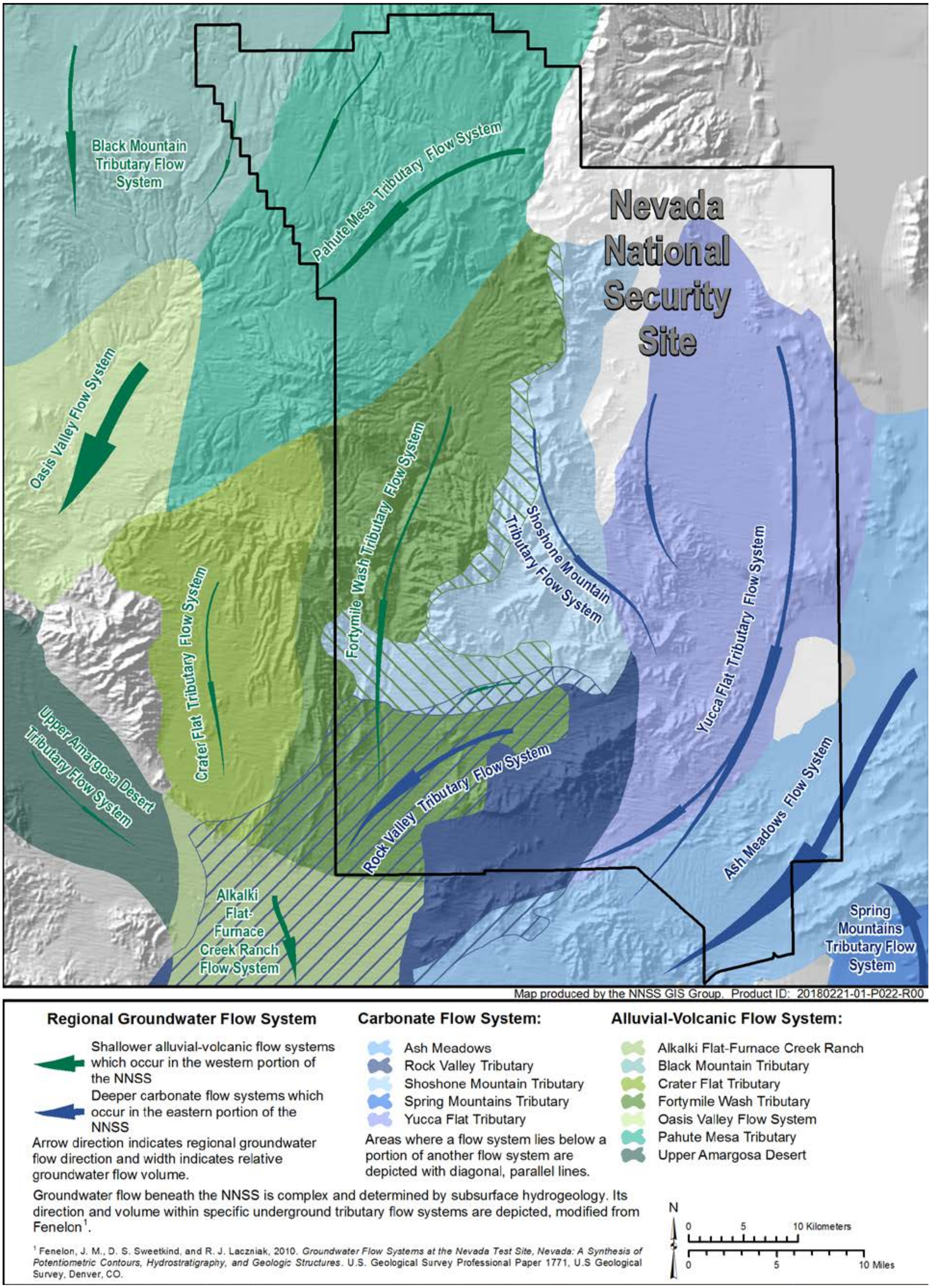

Figure 11-2. Groundwater flow systems of the NNSS

11.1.1 Underground Test Area Corrective Action Unit Corrective Action Activities

The UGTA CAU closure strategy involves characterization and modeling studies during an *investigation stage* to support 1,000-year contaminant boundary forecasts. Sufficient confidence in flow and transport models and supporting data must be demonstrated to earn NDEP's approval to advance from the investigation stage to the *model evaluation stage* and then to the *closure stage* for each CAU. The long-term monitoring program and CAU-specific institutional controls to protect the public from consuming potentially contaminated groundwater are initiated in the closure stage. The five UGTA CAUs are in various stages of this process. The following subsections provide the status to date toward the closure-in-place of each CAU. The results of annual groundwater sampling, conducted for the purposes of characterizing groundwater within the CAUs and monitoring groundwater downgradient of them, are presented and discussed in Sections 5.1.2 and 5.1.3.

11.1.1.1 Frenchman Flat Corrective Action Unit 98

The Frenchman Flat CAU is the first of the five UGTA CAUs at the NNSS to reach closure. The Closure Report was approved by the NDEP in July 2016 and is the culmination of 20 years of characterization, modeling, and model evaluation. The Closure Report describes the final contaminant, use restriction, and regulatory boundaries agreed upon by NNSA/NFO and NDEP for the Frenchman Flat CAU. It also specifies the monitoring program prescribed for the first five years. Three types of monitoring are performed for the Frenchman Flat CAU: water quality monitoring, water level monitoring, and institutional control monitoring. The results are used to determine if the use-restriction boundaries remain protective of human health and the environment, and to evaluate consistency with the groundwater flow and contaminant transport models supporting use restrictions. Though the Frenchman Flat CAU is closed, the UGTA closure strategy calls for continued monitoring and periodic evaluations to assess if the process specified in the corrective action decision is effective.

A summary of monitoring activities and results is in Section 11.1.2. The first long-term monitoring report for Frenchman Flat, presenting results from 2016, was published in 2017 (EM Nevada Program 2017a).

11.1.1.2 Central and Western Pahute Mesa Corrective Action Units 101 and 102

In 2009, Phase II of the Central and Western Pahute Mesa investigation stage was initiated as outlined in the Phase II Central and Western Pahute Mesa Corrective Action Investigation Plan (CAIP) (NNSA/NSO 2009). By 2016, eleven new wells were drilled, developed, tested, and sampled as part of the Phase II investigations. Other Phase II investigations continued through 2017 including groundwater sampling, measuring water levels, and a variety of analysis tasks to evaluate the Phase II geologic, hydrologic, and chemistry data. Analysis of faults and fracture characteristics and hydraulic properties of selected hydrostratigraphic units is used to enhance conceptual models for the Phase II hydrostratigraphic framework model by providing attributes for specific ***aquifers*** on and immediately downgradient of Pahute Mesa.

To date, the maximum concentration of ***tritium*** observed offsite is at the Phase II well ER-EC-11 on the NTTR, approximately 0.72 km (0.45 mi) west of the NNSS boundary (Figure 5-2). Tritium at ER-EC-11 was reported as 18,400 pCi/L in 2017 (Table 5-4). Well ER-EC-11 is approximately 3.2 km (2 mi) from the nearest underground nuclear tests, Benham and Tybo, which were conducted in 1968 and 1975, respectively. Much information regarding the extent and nature of the Benham and Tybo plume, first encountered at ER-20-5 (DOE/NV 1997), was gained through the Phase II wells. The conceptual model assumes that thermally driven vertical flow transports contaminants upward through the rubble of the UGT collapse chimney to the relatively permeable aquifers above the detonation point. Horizontal transport occurs through these aquifers along the regional hydraulic gradient. This is demonstrated by the decrease of tritium concentrations in a southward direction, with 24,800,000 pCi/L measured at Well ER-20-5-1, 13,600,000 pCi/L at ER-20-7, 202,000 pCi/L at ER-20-11, 18,400 pCi/L at ER-EC-11, 6,600 pCi/L at ER-20-8, 3,600 pCi/L at ER-20-8-2, and 6.66 pCi/L at ER-EC-6 (Table 5-4 and Figure 5-2). LANL is currently applying their advanced computing capabilities to develop a model of this area to better understand migration from the Benham-Tybo UGTs, and to forecast the potential extent of the contaminant plume over the next 1,000 years.

The most recent Phase II well, ER-20-12, is located in the far northwestern portion of the NNSS, approximately 2.3 km (1.4 mi) south-southwest of the Handley UGT and approximately 5.1 km (3.2 mi) north-northeast of

PM-3. The objective for Well ER-20-12 is to evaluate tritium migration from the Handley UGT to PM-3. Well ER-20-12 was specifically designed to determine the deepest contaminated aquifer; the vertical distribution of tritium in the well; the lithology, stratigraphy, and hydraulic characteristics of units intersected by the borehole; and to monitor the most productive, laterally extensive aquifers that contain tritium. The borehole penetrated several aquifers and ***confining units*** and the main casing is located in the unit considered most likely to be responsible for tritium migration. The tritium within this unit was reported as 34,000 pCi/L. Interestingly, the highest concentration of tritium observed at Well ER-20-12 (58,100 pCi/L) is assocated with the shallow at a depth of 547 meters (m) (1,795 feet [ft]) (Table 5-4). The tritium concentration at depths between this shallow piezometer and the main completion are lower. The tritium concentration in the piezometer just above this main completion zone (1,019 to 1,135 m; 3,343 to 3,725 ft below ground surface [bgs]) is 25,600 pCi/L; the concentration is lower yet (< 320 pCi/L) in the piezometer above (765 to 898 m; 2,510 to 2,947 ft bgs). This suggests that the Handley plume is stratified. Phase II flow and transport modeling will include the new data from the Phase II drilling initiative, and will reflect the recent tritium measurements (Table 5-4).

11.1.1.3 Rainier Mesa/Shoshone Mountain Corrective Action Unit 99

The Rainier Mesa/Shoshone Mountain CAU is near the end of the investigation stage of the closure process. An alternative modeling strategy to close the Rainier Mesa/Shoshone Mountain CAU, unique from the other UGTA CAUs, was accepted by NDEP in 2013. Instead of a requirement to develop sophisticated models to forecast potential contaminated volumes (i.e., contaminant boundaries), the new strategy has a requirement to develop simple models to investigate potential directions and distances of contaminated groundwater away from the UGTs. The alternative modeling strategy allows advancement from the investigation stage directly to the closure stage following a successful peer review. The new closure process is expected to save several years and several million dollars over the original process, while continuing to protect human health and the environment over the 1,000-year compliance period required by the FFACO.

Implementation of the revised strategy continued in 2017. Simplified models of radionuclide transport along potential transport pathways from source locations in Rainier Mesa were developed. The potential flow paths are identified based on the hydrogeological conceptual model and regional groundwater flow information. Tritium observations in wells in the vicinity of the flow paths (ER-19-1, ER-12-3, and TW-1 [Figure 5-4]) are being compared to the simulation results. Forty-seven potential pathways for transport of radionuclides away from Rainier Mesa make up the range of possible scenarios. The contamination is forecast to remain within the boundaries of the NNSS, where institutional controls will prevent inadvertent access to contaminated groundwater. The very deep water table at Shoshone Mountain, overlain by a thick ***unsaturated zone***, resulted in no simulations for which radionuclides exceeded the SDWA limits at the water table. Therefore, there were no simulations with transport away from Shoshone Mountain within 1,000 years.

The draft report describing the extensive modeling and associated results was completed and internally reviewed in 2017. The final report, Rainier Mesa/Shoshone Mountain Flow and Transport Model Report Nevada National Security Site, Nevada (EM Nevada Program 2018a) was completed in early 2018, in prepration for an external peer review. The NDEP will use the results and recommendations of the external Peer Review Panel to determine if the CAU 99 Flow and Transport Model meets the requirements for advancement to the closure stage.

11.1.1.4 Yucca Flat/Climax Mine Corrective Action Unit 97

The Yucca Flat/Climax Mine CAU entered into the model evaluation stage of the FFACO closure process in 2017. A Corrective Action Decision Document/Corrective Action Plan describing the model evaluation plan, initial use-restrition boundaries, and regulatory boundary objective was approved by NDEP in 2017 (EM Nevada Program 2017b). The regulatory boundary objective for the Yucca Flat/Climax Mine CAU is to verify that radionuclide contamination from the Yucca Flat/Climax Mine CAU is contained within the Yucca Flat basin, thus not impacting the Frenchman Flat lower carbonate aquifer or downgradient receptors. The focus of model evaluation is to reduce uncertainty in the contaminant boundary extent and build confidence in the final models to support regulatory decisions, including finalizing use-restriction boundaries and regulatory boundaries; and siting monitoring wells during closure.

Testing and sampling of two model evaluation wells in Yucca Flat (ER-3-3 and ER-4-1) were completed in 2017 (Navarro 2018a). These wells are located near detonations identified as the most likely to have impacted the regional carbonate aquifer within the Yucca Flat basin. Understanding radionuclide transport to the regional carbonate aquifer was identified as the highest priority for siting the wells because it is the only pathway for radionuclides to migrate out of the basin. No tritium was detected in the carbonate aquifer at wells ER-3-3 and ER-4-1 (designated as Characterization Wells; Table 5-4). The lack of tritium migration from the shallow volcanic rock units to the deeper carbonate aquifer demonstrates the effectiveness of the confining units that overlie the carbonate aquifer as barriers to contaminant migration. The lack of tritium at Well ER-3-3 also indicates that contaminant migration within the Yucca Fault is limited. Both of these observations verify the conceptual model that UGTs not intersecting the carbonate aquifer have a negligible impact on migration within the regional carbonate aquifer and outside of the basin.

In 2017, EM Nevada Program continued to evaluate the Yucca Flat/Climax Mine flow and contaminant transport model. The results of model evaluation activities will be used to refine the model to to be more realistic assumptions than in the present model, which is considered overly conservative (EM Nevada Program 2017b).

11.1.2 Post-Closure Monitoring of Frenchman Flat

The Closure Report for the Frenchman Flat CAU, approved by NDEP in 2016, specifies a monitoring program for the first five years post-closure (NNSA/NFO 2016). Three types of monitoring are performed under this program: water quality, water level, and institutional control monitoring. The monitoring objective is to determine if the use-restriction boundaries identified for the Frenchman Flat CAU remain protective of human health and the environment. Additionally, water quality and water level monitoring is used to evaluate consistency with the groundwater flow and contaminant transport conceptual and numerical models. Such consistency is important because the models are the primary basis for use-restriction boundaries. The Frenchman Flat CAU use-restriction, contaminant, and regulatory boundaries are identified in Figure 11-3.

The Frenchman Flat Post-Closure Monitoring Network includes the following 17 wells (Figure 11-3), 5 of which are sampled for water quality and water levels (Q/L), 1 for only water quality (Q), and 11 for only water levels (L):

- ER-5-3 Deep Piezometer (L)
- ER-5-3 Main (Upper Zone) (L)
- ER-5-3 Shallow Piezometer (Q)
- ER-5-3-2 (Q/L)
- ER-5-3-3 (L)
- ER-5-4 Main (L)
- ER-5-4 Piezometer (L)
- ER-5-4-2 (L)
- ER-5-5 (Q/L)
- RNM-1 (L)
- RNM-2S (Q/L)
- UE-5n (Q/L)
- WW-5A (L)
- WW-5B (L)
- WW-4 (L)
- WW-4A (L)
- ER-11-2 (Q/L)

The six wells sampled for water quality include three Characterization, two Source/Plume, and one UGTA inactive well within the CAU. The contaminants for which each of the six wells were sampled, based on the well type, is described in Section 5.1.1, and the 2017 analytical results for tritium are presented in Table 5-4. Tritium at a concentration above the regulatory approved minimum detection limit is present in only the two Source/Plume wells previously identified as containing contamination as a result of a radionuclide migration experiment (wells RNM-2S and UE-5n). The tritium concentration in Well RNM-2S is about 12% higher than in 2016, but remains over an order of magnitude less than the peak value measured in 1980. The concentration in Well UE-5n continues to slowly decrease. A very low concentration of tritium (1.92 pCi/L) was detected in one of the characterization wells, Well ER-5-5, using an ultra-low detection technique not certified by the NDEP. This technique is used to improve the understanding of flow and transport of radionuclides in groundwater, not for regulatory purposes.

Depth to water measured in 2017 in the 16 water level monitoring wells is generally consistent with measurements taken in recent years. A declining water level trend exists in most of the wells completed in the alluvium and is primarily attributed to drawdown from basin-scale pumping. Groundwater has been pumped from wells in the central and southern part of the Frenchman Flat basin since the 1950s. Water-level declines differing from long-term trends were observed in four wells. Three of these are water-supply wells that experienced increases in pumping during the year (WW-4, WW-4A, and WW-5B). No definitive cause for the sharp decline in the fourth well, ER-5-3-2 is known as yet, though temperature changes in the water column during pumping of this deep well may be a factor.

The objective of the Frenchman Flat CAU regulatory boundary is to protect receptors downgradient of the Rock Valley fault system from radionuclide contamination. Although contaminants resulting from UGTs are not forecast to migrate out of the basin within the next 1,000 years, the Rock Valley fault system is the expected groundwater migration pathway. The negotiated regulatory boundary is established at the interface of the Alluvial/Volcanic aquifer and the Rock Valley fault (Figure 11-3). If radionuclides reach this boundary, NNSA/NFO is required to submit a plan to NDEP which will meet the CAU's regulatory boundary objectives. All monitoring results indicate that the regulatory boundary objective has been met.

Institutional control monitoring confirmed as of the end of January 2017, use restrictions are recorded in NNSA/NFO and USAF land management systems and no activities within Frenchman Flat basin are occurring that could potentially affect the contaminant boundaries. A survey of groundwater resources in basins surrounding Frenchman Flat similarly identified no current or pending development that would indicate the need to increase monitoring activities or otherwise cause concern for the closure decision. Use restrictions continue to prevent ***exposure*** to the public, workers, and the environment from contaminants of concern by preventing the use of potentially contaminated groundwater.

11.1.3 Quality Assurance

The UGTA Quality Assurance Plan (QAP) (NNSA/NFO 2015b) provides the overall quality assurance requirements and general quality practices applied to UGTA drilling, laboratory analyses, and modeling. The UGTA QAP complies with DOE Order DOE O 414.1D, "Quality Assurance;" Guidance for Quality Assurance Project Plans for Modeling (U.S. Environmental Protection Agency [EPA] 2002); and Guidance on the Development, Evaluation, and Application of Environmental Models (EPA 2009). UGTA work is conducted under the UGTA QAP in conjunction with other UGTA participants' quality assurance programs. In 2017, quality assurance included conducting oversight assessments, identifying findings and completing corrective actions, and evaluating laboratory performance. These activities are described in an annual quality assurance report completed in April 2018 (EM Nevada Program 2018b). Future calendar year reports will be issued in April. In addition, UGTA documents and models undergo thorough preemptive reviews throughout the investigation and model evaluation stages of the CAU closure process as well an independent formal peer review at the end of the investigation stage. Chapter 14 discusses the quality assurance and quality control procedures used for collecting and analyzing groundwater samples.

11.1.4 Other Activities and Studies

Compiling, evaluating, and updating various databases (e.g., chemistry, water level, hydraulic properties, hydro-stratigraphy) is an ongoing effort. In 2017, The USGS continued their water-level monitoring program and also continued work on revising their regional model of groundwater flow within the Death Valley regional flow system. Water levels and other pertinent NNSS information and data sets can be accessed through the USGS/U.S. Department of Energy Cooperative Studies in Nevada website at http://nevada.usgs.gov/doe_nv/.

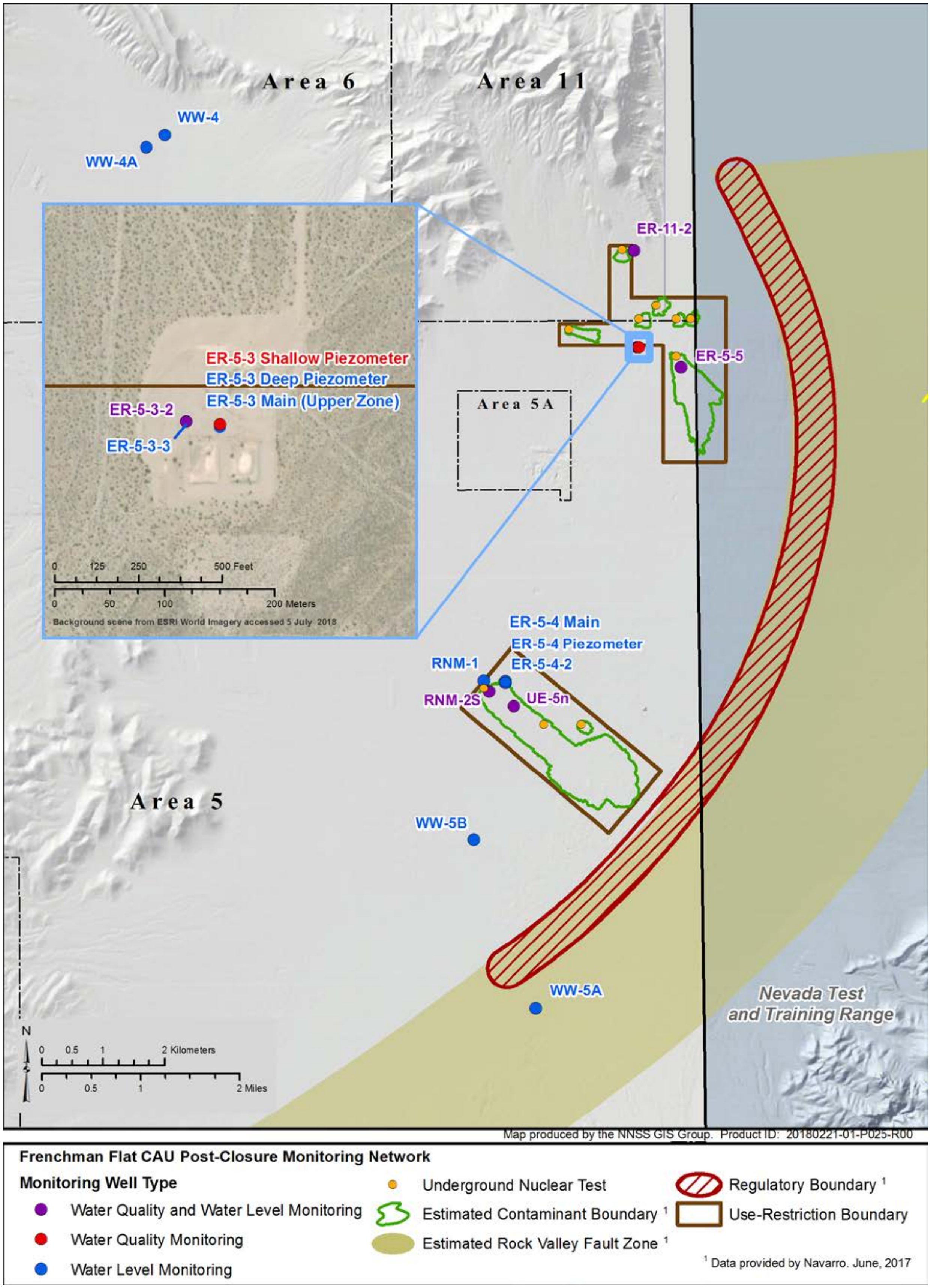

Figure 11-3. Frenchman Flat CAU post-closure monitoring network

11.1.5 Underground Test Area Publications

All UGTA-related reports and publications completed and published in 2017 are listed in Table 11-1. Some of the published technical reports can be obtained from DOE's Office of Scientific and Technical Information (OSTI) at http://www.osti.gov/bridge.

Table 11-1. UGTA publications published in 2017 or prior to June 2018

Report	Reference
2016 Annual Report Timber Mountain Environmental Monitoring Station	Lyles et al., 2018
Ambient Chemistry Logging, TFM Logging, and Discrete-interval Fluid Sampling of ER-20-12	Healey et al. 2017
The Analysis of Sulfur-35 as a Young Groundwater Tracer at E-Tunnel, Rainier Mesa, Nevada National Security Site	Deinhart et al., 2017
An Update of the Death Valley Regional Groundwater Flow System Transient Model, Nevada and California	Belcher et al., 2017
Applications of the Advanced Simulation Capability for Environmental Management (ASCEM)	Freshley et al., 2017
Completion Report for Well ER-2-2 Corrective Action Unit 97: Yucca Flat/Climax Mine	EM Nevada Program, 2017c
Completion Report for Well ER-4-1 Corrective Action Unit 97: Yucca Flat/Climax Mine	EM Nevada Program, 2017d
Corrective Action Decision Document/Corrective Action Plan for Corrective Action Unit 97: Yucca Flat/Climax Mine, Nevada National Security Site, Nevada	EM Nevada Program, 2017b
Hydraulic Characterization of Volcanic Rocks in Pahute Mesa Using an Integrated Analysis of 16 Multiple-Well Aquifer Tests, Nevada National Security Site	Garcia et al., 2017
Hydrogeologic applications for historical records and images from rock samples collected at the Nevada National Security Site and vicinity, Nye County, Nevada	Wood, 2018
Hydrophysical Evaluation of Wells TW-B, TW-7, UE-6d, U-2gg PSE 3A, U-10L 1, and UE-6e in Yucca Flat	Pohlmann et al., 2017
Hydrologic Source Term Processes and Models for the Clearwater and Wineskin Tests, Rainier Mesa, Nevada National Security Site (2011)	Carle, 2018a
Investigating the Influence of Regional Stress on Fault and Fracture Permeability at Pahute Mesa, Nevada National Security Site	Reeves et al., 2017
Lawrence Livermore National Laboratory participation in the IAEA 2017 Nuclear Material Round Robin Exercise	Treinen and Williams, 2017
Letter Report: Ambient Chemtool Logging of ER-3-3_p1	Heintz et al., 2018a
Letter Report: Ambient Chemtool Logging of ER-4-1_m1	Heintz et al., 2017
Letter Report: Pilot Test of Distributed Thermal Perturbation Sensing to Assess Hydrogeologic Heterogeneities at ER-EC-11_p1.	Hausner and Heintz, 2018
Post-Closure Monitoring Report for Corrective Action Unit 98, Frenchman Flat, Underground Test Area, Nevada National Security Site, Nevada for Calendar Year 2016 (January–December 2016)	EM Nevada Program, 2017a
Letter Report: Well Evaluations for U-20aa PS 1D, U-20i PS 1D, U-19g PS 1D, and U-19c PS 2D at Pahute Mesa, Nevada National Security Site	Heintz et al., 2018b
Rainier Mesa/Shoshone Mountain Flow and Transport Model Report	EM Nevada Program, 2018a
Rainier Mesa/Shoshone Mountain Hydrostratigraphic Framework Model-Prime Model Model Development Process and Model Description	Navarro, 2018b
Trend Analysis of Groundwater Levels through 2015, Pahute Mesa—Oasis Valley Groundwater Basin, Nye County, Nevada	Jackson and Fenelon, 2018
Underground Test Area Calendar Year 2015 Annual Sampling Analysis Report, Nevada National Security Site, Nevada	EM Nevada Program, 2017e
Underground Test Area Calendar Year 2016 Annual Sampling Analysis Report, Nevada National Security Site, Nevada	EM Nevada Program, 2018c
Underground Test Area October 1, 2015,to December 31, 2016 Quality Assurance Report, Nevada National Security Site, Nevada	EM Nevada Program, 2018d

Table 11-1. UGTA publications published in 2017 or prior to June 2018

Report	Reference
Updated Kd Estimates for Modeling Sorption of Cs, Sr, and Pu Isotopes in Hydrostratigraphic Units of Rainier Mesa and Shoshone Mountain	Carle, 2018b
Yucca Flat Well Development and Testing Analysis for ER-3-3 and ER-4-1, Nevada National Security Site, Nevada	Navarro, 2018a

11.2 Industrial Sites

The EM Nevada Program identified 1,865 Industrial Sites CASs on and off the NNSS for which they are responsible for characterization and closure under the FFACO. Closure strategies include removal of debris, excavation of soil, decontamination and decommissioning of facilities, and closure-in-place with subsequent monitoring. The contaminants of concern include hazardous chemicals/materials, unexploded ordnance, and low-level radiological materials. Clean closures are those where pollutants, ***hazardous wastes***, and ***solid wastes*** have been removed and properly disposed, and where removal of all contaminants is verified in accordance with corrective action plans approved under the FFACO. Closure-in-place entails the stabilization or isolation of pollutants, hazardous wastes, and solid wastes, with or without partial treatment, removal activities, and/or post-closure monitoring in accordance with corrective actions plans approved under the FFACO. Radioactive materials removed from sites are either disposed as ***low-level waste (LLW)*** or ***mixed low-level waste (MLLW)*** at the Area 5 Radioactive Waste Management Site (Section 10.1). Solid waste (e.g., demolition debris) containing asbestos is disposed of onsite at the Area 9 U10c Solid Waste Landfill. Hazardous waste removed from the CASs is shipped to approved offsite treatment and disposal facilities or recycled. Beyond remediation, Industrial Sites long-term monitoring programs protect the safety of the public and the environment.

Since the mid-1990s, a total of 1,853 Industrial Sites CASs have been evaluated, characterized, and closed. Over 950 of these sites were clean closures and 80 were closures-in-place; the remainder are a combination of state approved closures involving simple “housekeeping” cleanup, no further actions, or no further actions except administrative controls to restrict access. A major focus of Industrial Sites closures has included the decontamination and decommissioning (D&D) of facilities with no active mission and in which contamination exists. To date, seven of the eight facilities identified as D&D sites are closed under the FFACO with state approval. They include the Pluto Disassembly; Reactor Maintenance, Assembly, and Disassembly,Test Cell A; Test Cell C; Super Kukla; Junior Hot Cell; and the EPA Farm. Major Industrial Sites efforts have also involved the safe removal, treatment, and disposal of unexploded ordnance at sites on the TTR. Large volumes of remediation wastes have been disposed on the NNSS since the mid-1990s, while cleanups conducted on the TTR have utilized the TTR landfill for approved disposal.

Only 12 Industrial Sites CASs from three CAUs remain to be closed. The three CAUs are CAU 114, Area 25 Engine Maintenance, Assembly, and Disassembly Facility (the eighth remaining D&D facility); CAU 572, Test Cell C Ancillary Buildings and Structures; and CAU 575, Area 15 Miscellaneous sites. Their closures will occur prior to the end of the EM Nevada Program Activity, which is currently planned for 2030. In 2017, no field work was conducted toward their closure.

11.3 Soils

The EM Nevada Program has identified a total of 148 Soils CASs on and off the NNSS for which they are/were responsible for characterization and closure under the FFACO. Corrective actions range from removal of soil to closure-in-place with restricted access controls. Historical research and the preparation of summary reports have been completed for all 148 CASs. In 2017, 16 Soils CASs from two CAUs were closed (Table 11-2), and work was conducted towards closure at 19 CASs in 5 CAUs (Table 11-3).

The total number of Soils CASs closed and approved by the state by the end of 2017 was 139; 9 Soils CASs remain to be formally closed. Closure of CASs on the TTR and NTTR require negotiation with the State of Nevada and coordination with the U.S. Department of Defense. The anticipated date for Soils closure is FY 2027.

Table 11-2. Soils Sites closed in 2017

CAU	CAU Description	Number of CASs	Corrective Actions	Wastes Generated
568	Area 3 Plutonium Dispersion Sites	14	Clean closure[a]/Closure- in-place[b]	LLW, Sanitary
572	Alpha Contaminated Sites	2	Clean closure/Closure-in-place	LLW, Sanitary

(a) Clean closure is the removal of pollutants, contaminants, and waste at a CAS in accordance with Corrective Action Plans.
(b) Closure-in-place is the stabilization or isolation of pollutants, and hazardous and solid waste with or without partial treatment, removal activities, and/or post-closure monitoring.

Table 11-3. Other Soils Sites where work was conducted in 2017

CAU	CAU Description	Number of CASs	Activity	Wastes Generated
413	Clean Slate II Plutonium Dispersion (TTR)	1	Implementing corrective actions	LLW, Sanitary
414	Clean Slate III Plutonium Dispersion (TTR)	1	Corrective action investigations	LLW, Sanitary
415	Project 57 No. 1 Plutonium Dispersion (NTTR)	1	Implementing corrective actions	LLW, PCB
568	Area 3 Plutonium Dispersion Sites	14	Implementing corrective actions	LLW, MLLW, Hazardous, Sanitary
573	Alpha Contaminated Sites	2	Implementing corrective actions	LLW

11.3.1 Monitoring Activities at Soils Corrective Action Units

The monitoring efforts described in this section are intended to assess potential airborne (wind, dust) transport of man-made radionuclides during closure activities at Clean Slate 2 and 3, and to develop long-term post-closure monitoring requirements for these sites. Since 2008, the EM Nevada Program has monitored airborne radiation and meteorological parameters at selected locations on the TTR to determine if there is wind transport of man-made radionuclides from Clean Slate 1, 2, and 3 Plutonium Dispersion CAUs (CAUs 412, 413, and 414, respectively). Air monitoring stations were originally placed at Clean Slate 3 and the Range Operations Center; a third monitoring station was placed at Clean Slate 1 in 2011. In 2017, monitoring at Clean Slate 1 was discontinued and the equipment was moved to Clean Slate 3. In addition, two new stations were established at Clean Slate 2 to provide air monitoring capability during clean-up activities. There are a total of five monitoring stations. Monitoring stations at Clean Slate 2 and 3 are located downwind of the contamination areas when winds are from either of the two dominant directions (north and south). Design of the air monitoring stations is similar to that used in the Community Environmental Monitoring Program (CEMP) (Section 7.1). Additional information on the TTR monitoring effort is available in the 2017 TTR ASER.

In 2017, no man-made radionuclides were detected by gamma ***spectroscopy*** in any of the airborne particulate matter samples collected at TTR. Alpha spectroscopy did not detect Pu-238 or Pu-239/240 in the analyzed sub-set of airborne particulate matter samples collected from the Range Operation Center, but these man-made radionuclides were detected in the analyzed sub-set of airborne particulate matter samples collected from air monitoring stations at Clean Slate 2 and 3. Sandia National Laboratories reports this monitoring in the TTR annual environmental report, which is posted at http://www.sandia.gov/news/publications/environmental/index.html.

The EM Nevada Program also monitors meteorological and surface runoff data from two Soils CAUs on the NNSS: Smoky Contamination Area (CAU 550) in Area 8 and the Area 11 Plutonium Valley Dispersion Sites (CAU 366). In 2011, one meteorological station and a flume to measure channelized runoff were installed at CAU 550, and two meteorological stations and an instrument station to collect surface water runoff and transported suspended and bedload sediments were installed at CAU 366. The meteorological stations are similar in design and function to those used in the CEMP (see Chapter 7) except the NNSS stations do not include air particulate matter sample collection or pressurized ion chambers. The equipment at both NNSS sites collect data to develop an understanding of meteorological conditions that may contribute to potential radionuclide-contaminated soil transport. These monitoring efforts are conducted to aid in developing post-closure monitoring requirements.

During FY 2017 (October 1, 2016 – September 30, 2017), data from the CAU 550 meteorological station, the flume, and visual observations of sediment transport were summarized, evaluated, and reported (Mizell et al. 2018). No surface water flow was measured at the flume in the monitored channel during any precipitation events at CAU 550; therefore, no measurable water-borne transport of radionuclide-contaminated soils occurred. In FY 2017, air monitoring data collected at CAU 366 identified wind speed conditions that resulted in increased dust transport and, thus, the potential re-suspension of contaminated soils. Several precipitation events were recorded within Plutonium Valley but none produced significant runoff. Therefore, no suspended sediment or bedload transport sediment samples at CAU 366 were collected (Nikolich et al. 2018).

11.4 Post-Closure Monitoring and Inspections

All nine of the historical waste management units on the NNSS identified for closure under the Resource Conservation and Recovery Act (RCRA) have been closed (Table 11-4). The NNSS RCRA Part B Permit prescribes post-closure monitoring requirements for six of these sites. CAUs 110 and 111 require ***vadose zone*** monitoring (VZM) of the engineered covers over the craters/waste pits. The covers were designed to limit infiltration into the disposal units and are monitored with time-domain reflectometry soil water content sensors buried at various depths in the waste covers to provide water content profile data. The data are used to demonstrate whether the covers are performing as expected. The covers were vegetated with native plants and are monitored routinely for revegetation success. Various revegetation techniques have been studied and implemented on the covers in attempts to produce sustainable native plant communities.

Table 11-4. Historical RCRA closure sites and their post-closure monitoring requirements

CAU	Remediation Site	Closure Date	2017 Post-closure Requirements
90	Area 2 Bitcutter Containment	2/27/1997	Annual site inspection
91	Area 3 U-3fi Injection Well	2/27/1997	Annual site inspection
92	Area 6 Decon Pond Facility	5/11/1999	Semi-annual site inspection Inspection if precipitation >1.0 inch/24-hour period
93	Area 6 Steam Cleaning Effluent Ponds	2/20/1998	None
94	Area 23 Building 650 Leachfield	11/3/1998	None
109	Area 2 U-2bu Crater	1/25/2000	None
110	Area 3 Waste Management Division (WMD) U-3ax/bl Crater	8/30/2001	Semi-annual site inspection VZM of the engineered cover caps Biennial subsidence survey Annual vegetation survey
111	Area 5 WMD Retired Mixed Waste Pits	2/21/2012	Quarterly site inspection Inspection if precipitation >0.5 inches/24-hour period Annual subsidence survey Annual vegetation survey Quarterly TLD readings Tritium air analyses Gamma-emitting and isotopic radionuclide air analyses Annual measurements of radon flux Groundwater monitoring of Wells UE5 PW-1, -2, and -3 VZM of the engineered cover caps
112	Area 23 Hazardous Waste Trenches	11/14/1994	Quarterly[(a)] site inspection

In 2017, VZM results for CAUs 110 and 111 indicated that surface water is not migrating into buried wastes and that the covers are functioning as designed (EM Nevada Program 2018e). For CAU 111, external radiation measurements from ***thermoluminescent dosimeters (TLDs)***, air and groundwater sample analyses for radionuclides, and radon flux measurements indicate that the closure covers are performing within expectations and parameter assumptions of performance assessment models, and there is no impact on the surrounding environment (EM Nevada Program 2018e, 2018f). One report for all RCRA closure sites monitored in 2017 was submitted to NDEP in May 2018 (EM Nevada Program 2018e).

Post-closure inspections are also required for many of the closed remediation sites managed under the FFACO that are not included in the RCRA Part B Permit (non-RCRA CASs). In 2017, the EM Nevada Program conducted visual inspections at 166 closed non-RCRA CASs managed under the FFACO. Several CASs that do not require inspections were inspected as a best-management practice to ensure that the signs are intact. A 2017 annual inspection letter report for non-RCRA post-closure sites on the NNSS was prepared and submitted to NDEP in May 2018 (EM Nevada Program 2018f). A 2017 annual inspection report for post-closure sites on the TTR was prepared and submitted to NDEP in May 2018 (EM Nevada Program 2018g).

11.5 Restoration Progress under the Federal Facility Agreement and Consent Order

In 2017, the EM Nevada Program met all of the 2017 FFACO milestones (Table 11-5), and closed 16 CASs. Figure 11-4 depicts the progress made since 1996 in the remediation of all historically contaminated sites managed under the FFACO. A total of 2,145 of the 3,039 CASs have been closed; they include 142 sites that have been closed by the DOE Office of Legacy Management, the Defense Threat Reduction Agency, or other owners. Of the remaining 894 CASs yet to be closed under the FFACO (889 of which are the responsibility of the EM Nevada Program), 868 (97%) of them are UGTA CASs, which will be closed in place with monitoring in perpetuity. The public can view an interactive map that shows all CASs on the NNSS, NTTR, and TTR at the following NNSS Remediation Sites website: http://nnssremediation.dri.edu/. The website identifies all CASs that have been closed and those still open.

Table 11-5. FFACO milestones for 2017 (sorted by due date, in ascending order)

CAU	CAU Name	# of CASs	Milestone	Due Date	Date Submitted	Date NDEP Approved
DOE Soil Sites						
573	Alpha Contaminated Sites	2	Closure Report	4/6/2017	4/4/2017	4/13/2017
413	Clean Slate II Plutonium Dispersion (TTR)	1	CADD/CAP	5/30/2017	5/24/2017	6/15/2017
568	Area 3 Plutonium Dispersion Sites	14	Closure Report	6/30/2017	6/27/2017	7/24/2017
414	Clean Slate III Plutonium Dispersion (TTR)	1	CADD/CAP	12/6/2017	11/29/2017	1/3/2018
415	Project 57 No. 1 Plutonium Dispersion (NTTR)	1	Closure Report	12/29/2017	12/13/2017	4/11/2018
DOE UGTA Sites						
98	Frenchman Flat	10	Post-Closure Presentation #1	5/4/2017	1/25/2017	5/11/2017*
97	Yucca Flat/Climax Mine	720	CADD/CAP	5/30/2017	5/25/2017	8/21/2017
101	Central Pahute Mesa	64	Phase II Data Completion Presentation #3	9/14/2017	9/12/2017	9/27/2017*
102	Western Pahute Mesa	18	Phase II Data Completion Presentation #3	9/14/2017	9/12/2017	9/27/2017*
99	Rainier Mesa/Shoshone Mountain	66	Complete Peer Review Panel Selection	9/29/2017	9/7/2017	10/5/2017*
97	Yucca Flat/Climax Mine	720	Model Evaluation Pump Test Decision Point Presentation	10/2/2017	6/7/2017	8/2/2017*
99	Rainier Mesa/Shoshone Mountain	66	Phase I Data Completion Presentation #2	10/31/2017	10/30/2017	11/1/2017*
97	Yucca Flat/Climax Mine	720	Model Evaluation New Data Presentation #1	12/14/2017	12/7/2017	12/20/2017*

*Date NDEP issued a Notice of Completion for the milestone.

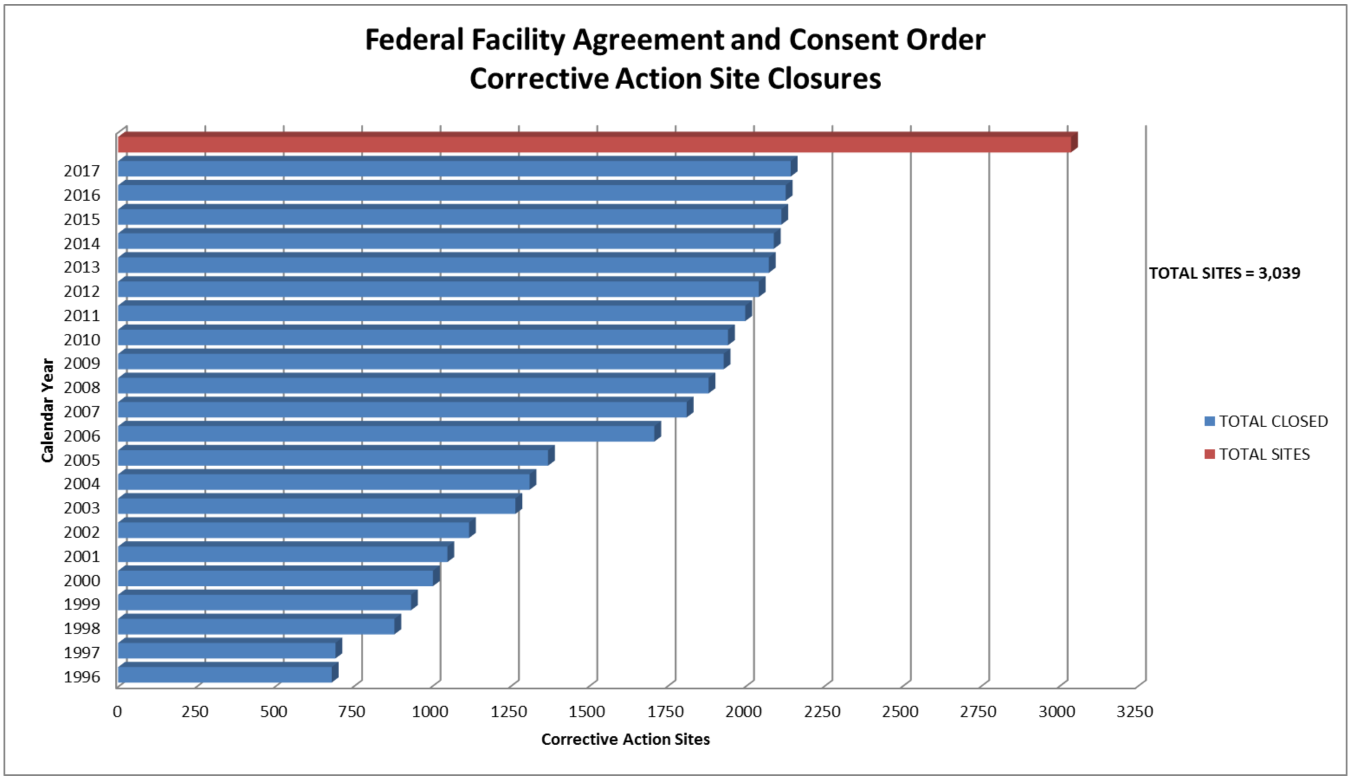

Figure 11-4. Annual cumulative totals of FFACO CAS closures

11.6 Environmental Management Nevada Program Public Outreach

Throughout calendar year 2017, eight NSSAB meetings were held, which were all open to the public and announced by NNSA/NFO on their NSSAB web page. The NSSAB is a part of the Environmental Management Site-Specific Advisory Board, a stakeholder board that provides the Assistant Secretary for Environmental Management and designees with independent advice, information, and recommendations on issues affecting the EM program at various DOE/NNSA sites. Among those issues are clean-up standards and environmental restoration, waste management and disposition, and clean-up science and technology activities.

The 2017 NSSAB public meetings covered a wide range of topics, which included the status of and, as applicable, NSSAB recommendations for the following items:

- Corrective Action Alternatives for Corrective Action Unit 576, Misc. Radiological Sites and Debris
- Radioactive Waste Acceptance Program Assessment Improvement Opportunities
- Internal Peer Review Process Improvement
- Proposed Changes to Long-term Monitoring at Closed Industrial and Soils Sites at the NNSS
- NSSAB Recommendation and DOE Response to Groundwater Sampling Techniques
- NSSAB Recommendation and DOE Response to Internal Peer Review Process (Rainier Mesa/Shoshone Mountain GoldSim Model)
- NSSAB Recommendation and DOE Response to Internal Peer Review Process Improvement for Yucca Flat CADD/CAP
- RWAP Assessment Process Improvement Opportunities

Educational briefings included Emergency Management at the NNSS; Compliance with the National Historic Preservation Act at the NNSS; Roles and Responsibilities of the Nevada Division of Environmental Protection at DOE Sites; ER-20-12: A Case Study of Corrective Action Investigation in a Challenging Environment; and Subsurface Microbial Worlds of the NNSS and the Death Valley Flow System; The meeting agendas, handouts, and minutes for all of the 2016 NSSAB meetings can be found under the Meetings/Minutes tab of the NSSAB web page.

NSSAB hosts a program for children to aid in their learning about the NNSS. Operation Clean Desert offers a set of activities geared toward teaching children about ongoing efforts to address environmental challenges, such as contaminated groundwater and radioactive waste disposal. Information for Operation Clean Desert is at http://www.nnss.gov/pages/PublicAffairsOutreach/KidsZone/OpCleanDesert.html, where parents, educators, and community groups can access a complete lesson plan, an activity book, a teacher's guide, an interactive computer game, and several videos.

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Chapter 12: Historic Preservation and Cultural Resources Management

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The cultural landscape of the Nevada National Security Site (NNSS) contains prehistoric and historic archaeological sites; buildings and structures that are part of the built environment; and places of religious and cultural importance to American Indians and other people interested in our history. The U.S. Department of Energy (DOE) Order DOE O 436.1, "Departmental Sustainability," requires the DOE to develop policies and directives for the conservation and preservation of these cultural resources. The Cultural Resources Management Program (CRMP) at the NNSS was established by the DOE National Nuclear Security Administration Nevada Field Office (NNSA/NFO). The mandates of this program are implemented by the Desert Research Institute (DRI) to aid in conserving and preserving cultural resources that may be impacted by NNSA/NFO activities. The NNSA/NFO must comply with applicable federal and state regulations to protect and manage cultural resources eligible for listing in the National Register of Historic Places (NRHP). These eligible resources are technically known as *historic properties* regardless of the age of the resource.

Cultural Resources Management Program Goals
Ensure compliance with all regulations pertaining to cultural resources on the NNSS.
Identify and manage cultural resources on the NNSS.
Evaluate the potential impacts of proposed projects to cultural resources on the NNSS and, when necessary, mitigate adverse effects.
Curate archaeological collections in accordance with Title 36 ***Code of Federal Regulations (CFR)***[1] Part 79, "Curation of Federally-Owned and Administered Archeological Collections."
Consult with American Indians regarding places and items of importance to the Consolidated Groups of Tribes and Organizations.

In order to achieve CRMP goals and meet federal and state requirements, the NNSA/NFO program is multifaceted and contains the following major components: (1) archival research, field surveys, and historical evaluations; (2) the curation of archaeological collections; and (3) the American Indian Consultation Program (AICP). Guidance for CRMP work is provided in the Cultural Resources Management Plan for the Nevada Test Site (Drollinger and Beck 2010). DRI historic preservation personnel and archaeologists, who meet the professional qualification standards set by the Secretary of the Interior, carry out these activities. Archaeological efforts are permitted pursuant to the Archaeological Resources Protection Act (ARPA).

A brief description of CRMP components and 2017 accomplishments is provided below. Methods used to conduct cultural resources inventories and historical evaluations are summarized in the Nevada Test Site Environmental Report 2003 (Bechtel Nevada 2004). Additional information is available in Attachment A[2]. Attachment A, Section A.5 provides a summary of the known human occupation and uses of the NNSS from the Paleoamerican period, about 13,000 to 10,000 years ago, through the Cold War era and nuclear testing from 1951 to 1992.

[1] The definition of word(s) in ***bold italics*** may be found by clicking on the word in electronic version or by referencing the Glossary, Appendix B. To return from the Glossary, right click and select Previous View.
[2] Attachment A, *Site Description*, is a separate file on the compact disc version of this report and is also accessible on the NNSA/NFO web page at http://www.nnss.gov/pages/resources/library/NNSSER.html.

12.1 Cultural Resources Inventories and Historical Evaluations

Cultural resources inventories are field surveys conducted to meet the requirements of the National Historic Preservation Act (NHPA) and the ARPA. Inventories are completed prior to proposed projects or activities that may adversely affect cultural resources eligible to the NRHP. Architectural assessments evaluate historic buildings and structures for eligibility to the NRHP. The information resulting from these inventories and historical evaluations includes the following:

- Numbers and types of cultural resources identified at each proposed project location on the NNSS
- Cultural resources determined eligible to the NRHP
- Recommendations for mitigating adverse effects to cultural resources
- Reports detailing the results of inventories and evaluations

In 2017, DRI conducted cultural resources inventories and historical evaluations for 18 projects in 14 areas of the NNSS (Table 12-1). A total of 252.7 acres was inventoried, 118 cultural resources identified and recorded, and, of these, 103 were recommended eligible to the NRHP. Cultural resources documented include prehistoric and historic sites, buildings, structures, and isolated features. In accordance with the NHPA, the DOE consults with the Nevada State Historic Preservation Office (SHPO) prior to initiating an undertaking that has the potential to affect historic properties.

Table 12-1. 2017 Cultural Resources Inventories and Historical Evaluations

Project	NNSS Area	Project Size (acres)	Cultural Resource	NRHP Eligible	Reference
Mercury Power & Communications Upgrade	23	0.57	1	1	Collins and King 2017
Underground Utilities in Mercury	23	—	3	3	Collins 2017
DOE Point Roundabout	12	0.38	0	—	Drollinger 2017a
Dry Alluvium Geology (DAG) Test Pad	2	23.1	2	0	Drollinger 2017b
Turnaround on Shoshone Mtn.	29	0.13	0	—	Drollinger 2017c
Echo Peak Road Turnaround	19	0.5	0	—	Drollinger 2017d
Synopsis for Rover and Pluto Programs	25, 26	—	13	13	Drollinger 2017e
Dense Plasma Rocus Facility R&D	11	68	1	0	Keach 2017a
Performant Optimized Data Center (update)	6	17.9	0	—	Keach 2017b
Millstone Pad Construction Project	26	2	0	—	Keach 2017c
Kennebec Rad-Chem Assembly	2	1.5	1	1	Keach and King 2017
Mercury Historic Buildings	23	—	73	—	King 2017a
Pole Replacement on BDK Powerline	29	3.66	2	1	Menocal 2017a
Vegetation Abatement 138kV Powerline	22, 25, 27	7.86	3	1	Menocal 2017c
Power System Replacement (Mercury to Tweezer)	5, 6, 23	—	—	—	Menocal 2017d
UNESE Drill Hole Project	12	30.3	11	4	Menocal et al. 2017a
Frey 2 Project	3, 7	96.8	8	6	Menocal et al. 2017b
Atlas Pulsed Power Machine Evaluation	6	—	0	—	Rowe and King 2017
Total		**252.7**	**118**	**30**	

12.2 Evaluations of Historic Buildings and Structures

In 2017, a ***Section 106*** evaluation of the architecture in the Mercury Historic District (MHD) was initiated to comply with the NHPA in preparation for the Mercury Modernization Project, an undertaking which will update and upgrade existing facilities. Also proposed for Mercury is the construction of a contemporary industrial campus to meet future research and development needs.

Figure 12-1. Aerial photograph of the Mercury Historic District.

The MHD (Figure 12-1) is located in the Mercury Valley in Area 23 of the NNSS and encompasses almost 900 acres. There are 93 buildings, 25 structures, and 36 landscape-level features that contribute to the historic importance of the MHD. The MHD qualifies for listing in the NRHP due to its national significance in the context of the Cold War and the development of nuclear testing.

One important but sometimes overlooked part of the MHD are its water and sewage lines. This infrastructure is critical, and pipelines were installed early in the development of the NNSS. Historic engineering drawings are available and have been crucial in assisting DRI in documenting the extent of the potable water distribution system, the sewage system, and the steam/high temperature hot water system (Figure 12-2), all of which are primarily composed of underground components (Collins 2017).

Figure 12-2. Steam system pipes being replaced on the north side of Ranger Avenue in late 1970.

Upgrades to the water and sewer lines, while necessary, destroy the historic significance of this infrastructure and compromise the characteristics that qualify it for listing in the NRHP. In consultation with the Nevada SHPO, the DOE developed a Memorandum of Agreement (MOA) which states how the lines will be treated such that their historic values will be preserved as part of the archival record.

In 2017, DRI documented the Kennebec radiochemical (rad-chem) assembly in Area 2 of the NNSS. Kennebec was a low yield weapons-related underground test conducted in 1963 (NNSA/NFO 2015). A notable feature of the Kennebec test setup was the rad-chem assembly designed to meet the challenges of capturing small samples of gas from an underground cloud generated by a nuclear detonation. These samples were used to perform test diagnostics (Keach and King 2017) and provided reliable information on many aspects of the nuclear reaction. The Kennebec rad-chem assembly represents the apex of rad-chem sampling design.

During a pre-activity survey for the proposed Frey 2 Project, DRI documented three structures and five sites associated with nuclear testing activities. Of particular note were a series of blast and thermal towers used during early 1950s atmospheric tests in Yucca Flat. These towers were designed to measure air pressure and ground shock with blast gauges, pressure gauges, and accelerometers (Figure 12-3).

Figure 12-3. Blast and thermal towers used during several atmospheric tests in the early 1950s.

12.3 Other Cultural Resources Projects

Prior to every proposed project, cultural resources records at DRI and the Nevada Cultural Resource Information System (NVCRIS) database are consulted to identify previous cultural resource inventories and NRHP-eligible cultural resources within or near the project area. This helps determine whether an inventory is required and the potential of a proposed project to affect cultural resources. In addition to the projects in Table 12-1, which required cultural resources inventories and historical evaluations, reviews also included proposed projects that were in areas previously inventoried for cultural resources; therefore, additional inventories or evaluations were not required and no reports were prepared for these projects.

Further projects and activities carried out by DRI resulting in reports are listed below and referenced in Table 12-2.

- AICP progress report that details tribal participation and involvement in NNSA/NFO activities and meetings in 2017.
- Preserve America activities overview the document progress over the past three years: inventory of more than 2,500 acres and the recordation of a series of Cold War resources.
- Assessment of vertical shaft tests within Corrective Action Unit 568 in Area 3.
- Cultural resources historic preservation and management contributions to this NNSS Environmental Report in 2017.
- Annual report for tasks completed in support of the NNSS artifact collection and records in the NNSA/NFO curation facility at the DRI Southern Nevada Sciences Center
- Cultural resources monitoring, which entailed revisiting a sample of historic properties, reporting their current conditions, and determining if they maintain integrity and are still eligible. Ten cultural resources were monitored in 2017.

Table 12-2. Other 2017 Cultural Resources Projects

Project	Reference
AICP Annual Progress Report	Arnold 2017
Preserve America Activities Assessment	King 2017b
CAU 568, Assessment of the Unstemmed Tests	King and Keach 2017
NNSSER 2016 Contributions	Drollinger and Arnold 2017
NNSA/NFO Annual Curation Compliance Report	Menocal 2017b
NNSS Cultural Resources Monitoring	Drollinger et al. 2017

12.4 Curation

The NHPA requires that archaeological collections and associated records be maintained at professional standards. The specific requirements are delineated in 36 CFR 79. The NNSS Archaeological Collection currently contains approximately 467,000 artifacts and is curated in accordance with 36 CFR 79. Curation requirements include:

- Maintaining an inventory catalog of the items in the NNSS collection.
- Packaging the NNSS collection in materials that meet archival standards (e.g., acid-free boxes).
- Maintaining the NNSS collection and records in a secure facility with environmental controls.
- Following established procedures for the NNSS collection and curation facility.
- Complying with the Native American Graves Protection and Repatriation Act (NAGPRA).

In ***Fiscal Year*** (FY) 2017, catalog records were maintained through spot-check inventories. Erroneous and absent artifact entries related to seven archaeological sites were discovered and corrected. Additionally, the artifact catalog database was improved through the standardization of entry field codes and the correction of line entry errors. Standardization of entry field codes is an ongoing process. A catalog reference document is updated as changes are made.

Copies of Section 106 compliance cultural resources reports and associated site forms completed in FY16 and FY17 were archived. Photographs from various projects conducted in the early 2000s were organized, labeled, and stored. Hard copies of six documents related to the AICP were filed and copies of these records were backed up on an external hard drive.

The loan of the McGuffin artifact collection was renewed for another year. The collection consists of 39 prehistoric artifacts from the NNSS. The artifacts are arranged in a glass picture frame and are on display in the Atomic Testing Museum in Las Vegas, Nevada. Prior to FY17, six boxes of prehistoric and historic artifacts and associated records were stored containing artifacts collected from lands outside of the NNSS. These artifacts and records were transferred into the possession of the Department of the Air Force, Tonopah Test Range Operations.

During the 1990s, the NNSA/NFO completed the required inventory and summary of NNSS cultural materials accessioned into the NNSS Archaeological Collection, and completed NAGPRA consultations and repatriations to the tribes by 2002. The DOE now upholds a “no collection of artifacts” policy on the NNSS; however, consultations will occur if any cultural items covered by the provisions of NAGPRA are recovered during archaeological investigations or as unanticipated discoveries.

12.5 American Indian Consultation Program

The NNSA/NFO AICP was developed in 1991 and involves sixteen Southern Paiute, Western Shoshone, and Owens Valley Paiute-Shoshone tribes with cultural and historic ties to the NNSS. The AICP operates in accordance with DOE Order 144.1, “Department of Energy American Indian Tribal Government Interactions and Policy,” which provides a foundation for engaging tribal leadership and their designated representatives in activities that occur on the NNSS.

In 1994, the tribes aligned together to form the Consolidated Group of Tribes and Organizations (CGTO), which serves as a conduit for speaking through one collective voice while retaining each tribe’s individual ability to interact independently with NNSA/NFO, if desired. The CGTO selects a Spokesperson who is responsible for representing the group and interfacing with NNSA/NFO on an interim basis between regularly scheduled meetings. The CGTO and its Spokesperson share tribal perspectives and identify topics of mutual interest to both the tribes and NNSA/NFO.

The 16 tribes are listed in NNSS environmental reports (e.g., National Security Technologies, LLC, 2008) and in *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* (NNSA/NSO 2013). A history of this program is contained in *American Indians and the Nevada Test Site, A Model of Research and Consultation* (Stoffle et al. 2001). The goals of the program are to:

- Provide a government-to-government forum for the CGTO to interface directly with NNSA/NFO management on activities associated with NNSA/NFO undertakings.
- Provide the CGTO with opportunities to actively participate and help guide decisions that involve culturally significant places, resources, and locations on the NNSS.
- Involve the CGTO in the management, curation, display, and protection of American Indian artifacts originating from the NNSS.
- Enable tribal representatives of the CGTO to engage in religious and traditional activities within the boundaries of the NNSS.
- Provide opportunities for CGTO subgroups to participate in the review and evaluation of program documents on an interim basis between regularly scheduled meetings.
- Include the CGTO in the development of tribal text in the agency's National Environmental Policy Act (NEPA) documents.
- Work in collaboration with the CGTO Spokesperson to develop approaches for expanding tribal involvement in NNSA/NFO activities on the NNSS.

Throughout 2017, NNSA/NFO interacted with the CGTO Spokesperson to develop activities that support expanded tribal involvement, including sharing project information with the CGTO and exchanging ideas that can be further discussed during the annual CGTO Tribal Update Meetings or used to expand tribal involvement. Tribal representatives consider these ongoing interactions and regular project updates as integral parts of the AICP.

In April, the NNSA/NFO held its annual CGTO Tribal Update Meeting in Las Vegas, Nevada, in tandem with a field visit to the NNSS. The meeting involved attendees from Environmental Management (EM) Nevada Program and NNSA/NFO, including the NNSA/NFO Site Manager and Assistant Manager for Site Operations, the NNSA/NFO AICP Manager, and the NNSA/NFO Director of Public Affairs. Tribal leadership and other CGTO representatives participated in a three-day meeting and received project updates followed by discussions about NNSS activities. On Day 2, meeting attendees visited Area 18 on the NNSS to examine an archaeological site of interest and to evaluate its condition (Figure 12-4).

On the final day of the meeting, the CGTO developed recommendations to help refine the AICP through expanded tribal involvement. A primary outcome from the recommendations included the appointment of a six-member Tribal Planning Committee (TPC) comprising Southern Paiute; Western Shoshone and Owens Valley Paiute; and Shoshone ethnic groups. The TPC interacts with NNSA/NFO on a quarterly basis and is responsible for shaping future activities and expanding tribal participation. One goal of the TPC will be to promote interactive discussions at Tribal Update Meetings through collaborative presentations. An ongoing activity planned for the future is periodic field visits to the NNSS to allow the TPC to access more remote locations to evaluate the cultural integrity of selected sites.

Figure 12-4. Consolidated Group of Tribes and Organizations representatives on a 2017 NNSS site visit.

Another recommendation identified the importance of developing an American Indian Cultural Awareness presentation for the NNSA/NFO and contractor staff. The TPC is actively planning this presentation for FY18; it will include contributions from tribal representatives from each of the three ethnic groups to broaden understanding of American Indian culture and its unique ties to the NNSS.

Lastly, the CGTO highlighted the importance of expanding opportunities for tribal youth and integrating them into science, technology, engineering, and math (STEM) activities. The CGTO recommends expanding tribal involvement at varying levels among NNSA/NFO and contractor staff. The NNSA/NFO and the CGTO are exploring methods to create opportunities for tribal representatives to participate in NNSA/NFO internships and employment opportunities that support NNSS activities.

In 2017, DRI, with involvement from the CGTO Spokesperson, arranged a CGTO field visit to the NNSS for the purpose of examining a proposed turnaround location in Area 19 and relocating a nearby previously recorded archaeological site. Both locations provided useful information, which was shared with the NNSA/NFO and the CGTO. Tribal involvement in these activities is consistent with CGTO recommendations and in alignment with DOE O 144.1.

In 2017, NNSA/NFO and the EM Nevada Program continued to support the Tribal Revegetation Project at the 92-acre Site located at the Radioactive Waste Management Complex (RWMC) in Area 5. This project integrates traditional ecological knowledge derived from selected tribal representatives with scientific ecological methods provided with assistance from a restoration contractor and ecologists from DRI and Portland State University. The multi-year project incorporates innovative cultural approaches for restoration activities to sustain revegetation efforts at the RWMC. The program reaffirms the ongoing relationship between the CGTO and NNSA/NFO.

In accordance with DOE O 144.1, DOE Headquarters periodically convenes a complex-wide Tribal Energy Summit (TES) in Washington, D.C. The meeting provided opportunities for different DOE Site Offices to share information about tribal involvement at their respective locations. In 2017, NNSA/NFO personnel, the CGTO

Spokesperson, and a CGTO tribal representative attended the TES. The CGTO Spokesperson had the opportunity to provide updates about the AICP and share insight about the Tribal Revegetation Project.

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Chapter 13: Ecological Monitoring

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The Ecological Monitoring and Compliance (EMAC) Program provides ecological monitoring and biological compliance support for activities and programs conducted at the Nevada National Security Site (NNSS). The major sub-programs and tasks within EMAC include (1) the Desert Tortoise Compliance Program, (2) biological surveys at proposed project/activity sites, (3) important species and ecosystem monitoring, (4) the Habitat Restoration Program, and (5) wildland fire hazard assessment. Brief descriptions of these sub-programs and their 2017 accomplishments are provided in this chapter. Detailed information may be found in the most recent annual EMAC report (Hall and Perry 2018). EMAC annual reports are available at http://www.nnss.gov/pages/resources/library/EMAC.html. The reader is also directed to *Attachment A: Site Description*, a separate file on the compact disc of this report, where the ecology of the NNSS is described.

Ecological Monitoring and Compliance Program Goals
Ensure compliance with all state and federal regulations and stakeholder commitments pertaining to NNSS flora, fauna, wetlands, and sensitive vegetation and wildlife habitats.
Ecosystem monitoring to identify impacts of climate and other environmental changes on the NNSS.
Provide ecological information that can be used to evaluate the potential impacts of proposed projects and programs on NNSS ecosystems and important plant and animal species.
Provide fuels assesments to examine fire risk and monitor for the success of restoration programs.

13.1 Desert Tortoise Compliance Program

The Mojave Desert tortoise (*Gopherus agassizii*), which inhabits the southern one-third (514 square miles) of the NNSS (Figure 13-1), is listed as threatened under the federal Endangered Species Act. Activities conducted in desert tortoise habitat on the NNSS must comply with the terms and conditions of a Biological Opinion (Opinion) issued to the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) by the U.S. Fish and Wildlife Service (FWS) (FWS 2009); the term of the Opinion is through February 2019. The Opinion is effectively a permit to conduct activities in desert tortoise habitat in a specific manner. It authorizes the ***incidental***[1] ***take*** of tortoises that may occur during the activities, which, without the Opinion, would be illegal and subject to civil or criminal penalties.

The Opinion states that proposed NNSS activities are not likely to jeopardize the continued existence of the Mojave population. It sets limits for the acres of tortoise habitat that can be disturbed; the number of accidentally injured and killed tortoises; and, the number of captured, displaced, and relocated tortoises (Table 13-1). It also establishes mitigation requirements for habitat loss. The focus of the Desert Tortoise Compliance Program is to implement the Opinion's terms and conditions, document compliance actions, and assist NNSA/NFO in continuing FWS consultations.

[1] The definition of word(s) in ***bold italics*** may be found by clicking on the word in electronic version or by referencing the Glossary, Appendix B. To return from the Glossary, right click and select Previous View.

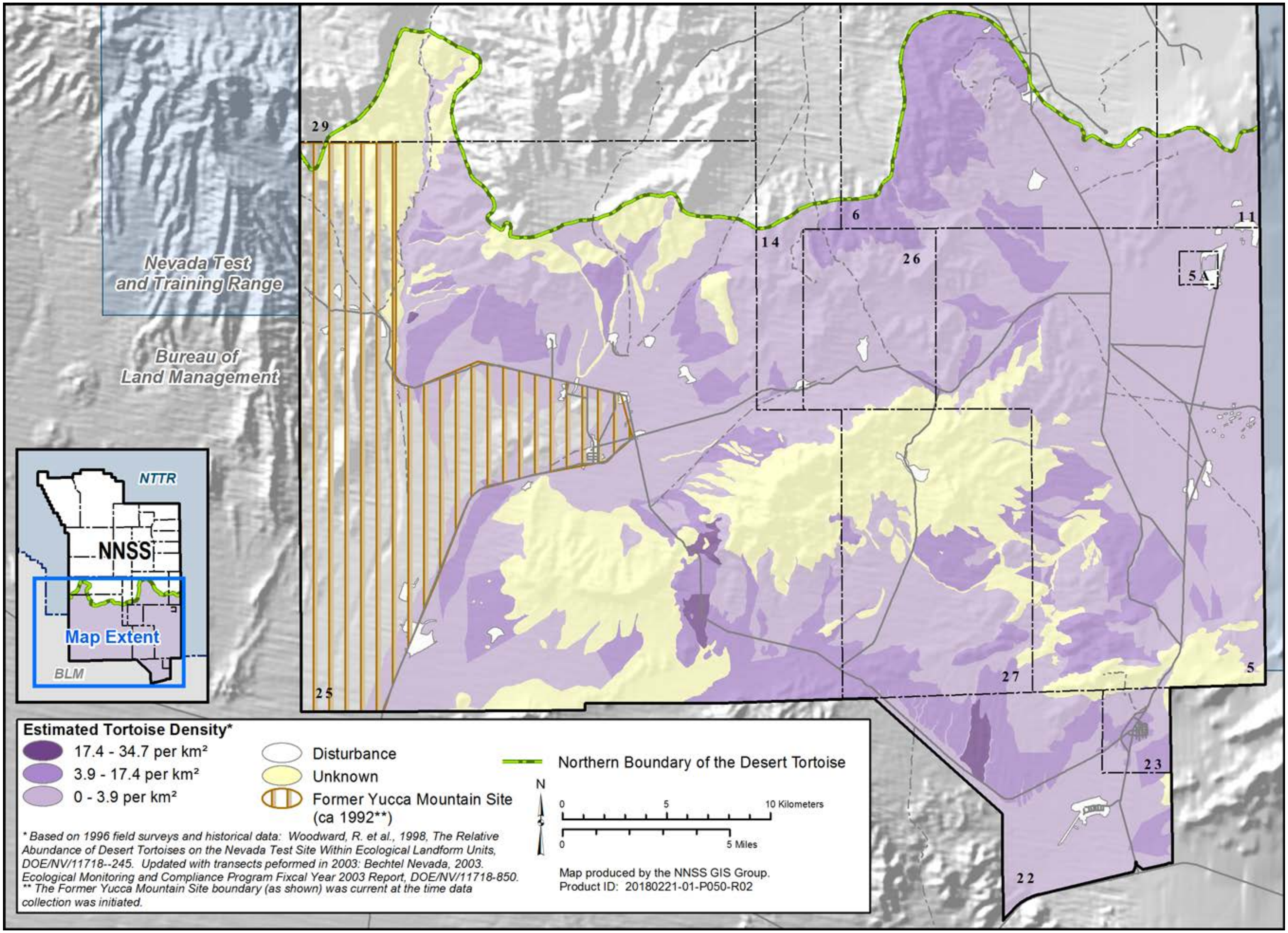

Figure 13-1. Desert tortoise distribution and abundance

13.1.1 Surveys and Compliance

In 2017, biologists reviewed 21 proposed projects occurring in or near desert tortoise habitat, and conducted surveys for nine of the projects, as required. No desert tortoises were reported injured or killed due to project activities. At one project site, a desert tortoise was found and relocated outside of the project area. Most projects occurred in previously disturbed areas or in areas where surveys are not required according to the Opinion. One project caused direct disturbance to tortoise habitat (1.3 acres). No compliance limits have been exceeded except the cumulative number of tortoises that can be moved off roads (*Other Incidental Take*, Table 13-1). FWS authorized the continued moving of tortoises off roads when in harm's way. In 2017, two desert tortoises were reported accidentally killed by vehicles on NNSS roads, and 41 were reported moved off roads and out of harm's way.

In January 2018, NNSA/NFO submitted an annual report to the FWS Southern Nevada Field Office that summarizes tortoise compliance activities on the NNSS during the 2017 CY.

Table 13-1. 2017 and cumulative totals (2009–2017), and permit limits for take of desert tortoise and habitat

	Acres Impacted			Tortoises Killed or Injured			Other Incidental Take[(a)]		
Program/Activity	**Annual Total**	**Cumulative Total**	**Permit Limit**	**Annual Total**	**Cumulative Total**	**Permit Limit**	**Annual Total**	**Cumulative Total**	**Permit Limit**
Defense	0	5.6	500	0	0	1	0	0	10
Waste Management	0	0	100	0	0	1	0	0	2
Environmental Restoration	0	0	10	0	0	1	0	0	2
Nondefense Research and Development	0	0	1,500	0	0	2	0	0	35
Work for Others	0	35.8[(b)]	500	0	0	1	0	0	10
Infrastructure Development	1.3	9.9[(c)]	100	0	0	1	1	1	10
Vehicle Traffic on Roads	-	-	-	2	12	15[(d)]	41	153[(e)]	125
Totals	1.3	51.4	2,710	2	12	22	42	154	194

(a) The number of desert tortoises that a qualified biologist can move if desert tortoises are found in harm's way within a project area and that NNSS personnel can move off roads.

(b) This cumulative total was reported as 32.8 acres for 2016. Project record reviews conducted in 2017 discovered that the actual cumulative total in 2016 was 35.8 acres.

(c) This cumulative total was reported as 8.4 acres for 2016. Project record reviews conducted in 2017 discovered that the actual cumulative total in 2016 was 8.6 acres.

(d) No more than 4 desert tortoises killed in any calendar year and 15 during the term of the Opinion (2009–2019).

(e) NNSA/NFO received concurrence from the FWS to continue moving tortoises off roads when in harm's way even though the 2009–2019 cumulative limit in the Opinion is 125.

13.1.2 Desert Tortoise Conservation Projects

Two desert tortoise projects on the NNSS, approved by the FWS, are being conducted by NNSS biologists. The roadside movements study tracks tortoise movement patterns for resident adult tortoises found along paved NNSS roads. The goals of the study are to determine patterns of habitat use near roads on the NNSS and assess the risk of road mortality. The juvenile tortoise translocation study monitors 60 juvenile tortoises to evaluate the survival of juveniles released from captivity to the wild. Prior to their release, the tortoises were in the care of the San Diego Zoo Institute for Conservation Research at the Desert Tortoise Conservation Center located near Las Vegas, Nevada. For both projects, NNSS biologists use radiotelemetry to track the location of study tortoises, record habitat characteristics and use, and collect other ecological data. Since 2013, NNSS biologists have conducted/supported these projects in lieu of the NNSS paying mitigation fees to FWS for habitat loss that may result from NNSS projects (i.e., all projects except for the Work for Others Program).

Since 2012, the roadside movements study has monitored a total of 30 tortoises (the maximum allowed by the FWS) for a minimum of three active seasons (March through October) per individual. Each tortoise is affixed with a Global Positioning Unit; an analysis of the data logged in these units will help NNSS and FWS understand tortoise use of roads and adjacent habitats and the risk of mortality or injury associated with that use. In 2017, 13 tortoises were actively monitored as part of the ongoing study; of the 13, data collected for seven was complete and their transmitters were removed. The remaining six tortoises will continue to be monitored through 2018.

Of the 60 juvenile tortoises released in 2012, 27 continued to be monitored in 2017. Monitoring includes location tracking and annual health assessments. This study will continue for the next several years and will provide valuable data for future juvenile desert tortoise translocations that help augment wild populations.

13.2 Biological Surveys at Proposed Project Sites

Biological surveys are performed at proposed project sites where project activities may have significant impacts to plants, animals, associated habitat, and other biological resources (e.g., the demolition of structures that may contain bird nests). The goal is to minimize the adverse effects to important biological resources (Section 13.3). Important biological resources include such things as cover sites, nest/burrow sites, roost sites, wetlands, or water sources that are vital to important species.

In 2017, biologists surveyed a total of 504 acres for 19 proposed projects in or near the NNSS. Eleven of the projects were within previously disturbed habitat (e.g., road shoulders, utility corridors), and 8 were in previously disturbed habitat that extended into pristine habitat (habitat having few human-made disturbances). The projects disturbed 152 acres of pristine habitat. Important animal species and other biological resources observed included one live desert tortoise, five tortoise burrows, one burrowing owl burrow, 17 predator burrows, five bird nests (unknown species), three dead ravens, an abundance of raptors, one cottontail rabbit, and western red-tailed skink habitat. Important plant species observed were yucca, cacti, and pine trees. In addition, pronghorn antelope, mule deer, burro, and horse scat was observered at several project sites. Biologists communicated to ground crews and provided written reports of survey findings and mitigation recommendations. Important biological resources within project sites were flagged, avoided, or removed.

13.3 Important Species and Ecosystem Monitoring

NNSA/NFO strives to protect and conserve sensitive plant and animal species found on the NNSS and to minimize cumulative impacts to those species as a result of NNSA/NFO activities. Important species known to occur on the NNSS include one mollusk, two reptiles, 240 birds, 23 mammals, 19 sensitive plants, and 23 plants protected from unauthorized collection. They are identified in Tables A-10 and A-11 of *Attachment A: Site Description*, included on the compact disc of this document. They are classified as important due to their sensitive, protected, and/or regulatory status with state or federal agencies, and they are evaluated for inclusion in long-term monitoring activities on the NNSS. NNSA/NFO has produced numerous documents reporting the occurrence, distribution, and susceptibility to threats for predominately sensitive species on the NNSS (Wills and Ostler 2001).

Field monitoring activities in 2017 related to important NNSS plants and animals and to ecosystem monitoring are listed in Table 13-2. A description of the methods and a more detailed presentation of the results of these activities are reported in Hall and Perry (2018).

In 2017, biologists in cooperation with state and federal agencies, revised the Nevada Natural Heritage Program (NNHP) status of some bat species as found in the Revised Nevada Bat Conservation Plan (Bradley et al., 2006). As a result, five bats are no longer considered NNHP sensitive, including California myotis (*Myotis californicus*), small-footed myotis (*M. ciliolabrum*), long-eared myotis (*M. evotis*), Yuma myotis (*M. yumanensis*), and canyon bat (*Parastrellus hesperus*). Silver-haired and hoary bats are now considered NNHP sensitive species.

Table 13-2. Activities conducted in 2017 for important species and ecosystem monitoring on the NNSS

Sensitive Plants (Table A-10 of *Attachment A: Site Description*)
The list of known sensitive plants on the NNSS was reviewed and determined to be up-to-date with the current NNHP's "At-Risk Plant and Animal Tracking List". No sensitive plant populations were observed during compliance surveys and no field surveys were conducted in 2017 for sensitive plants.
Reptiles
No trapping or roadkill surveys were conducted in 2017. Opportunistic observations were documented.

Table 13-2. Activities conducted in 2017 for important species and ecosystem monitoring on the NNSS

Migratory Birds (protected under the Migratory Bird Treaty Act)

Biologists rescued and released four grounded birds: one eared grebe (Podiceps nigricollis), two barn owls (Tyto alba), and one cactus wren (Campylorhynchus brunneicapillus).

A record number of 45 bird mortalities were documented. Thirty were electrocuted, including 14 golden eagles, 7 red-tailed hawks, 5 common ravens, 1 turkey vulture, 1 barn owl, and 2 unknown hawks. A western burrowing owl (Athene cunicularia), red-tailed hawk, and red-breasted merganser (Mergus serrator) were killed by vehicles; a barn owl was killed when it became entangled in razor wire; and 10 birds were found dead of unknown causes including 6 barn owls, and 1 each of Cooper's hawk (Accipiter cooperi), greater roadrunner (Geococcyx californianus), California gull (Larus californicus), and slate-colored race dark-eyed junco (Junco hyemalis). A golden eagle with severe wing tissue damage was found alive in north Yucca Flat (Area 2) and taken to the North Las Vegas Animal Hospital. It died within a day or two. It appeared to have been attacked by another bird but the specific cause of death is unknown.

The Power Group installed bird guards, protective covers, and other retrofits on 64 power poles to reduce avian mortality with additional poles planned to retrofit in 2018. A variety of retrofits were made including installing insulator covers and extenders, perch deterrents, conductor wire covers, and fuse covers. In addition, the power group submitted an application to FWS for a Special Purpose Utility permit and reported dead/injured birds to FWS.

Biologists finalized a NNSA/NFO Avian Protection Plan in cooperation with the FWS. The focus of the plan is to reduce operational and avian risks from avian interactions with electric transmission and distribution lines on the NNSS as well as other non-electric sources of mortality (e.g., vehicle collisions, habitat disturbance).

Two winter raptor survey routes were sampled in January and February; 44 raptors representing 6 species were observed. Data were shared with the U.S. Army Corps of Engineers for their nationwide mid-winter bald eagle survey and with the Nevada Department of Wildlife (NDOW) for their statewide monitoring effort.

Wild Horses (*Equus caballus*) (protected under the Wild Free Roaming Horses and Burros Act)

Horse monitoring has been conducted since 1989 to determine abundance, foal survival, and population distribution on the NNSS. Horse surveys were conducted during the summer in 2017 to determine abundance and band distribution. Survey locations included Camp 17 Pond, Airport Road, and Pahute Mesa Road. A total of 24 individuals were observed in 4 different bands, and at least 3 foals were observed.

Opportunistic sightings were also noted and motion-activated cameras at water sources were used. Camp 17 Pond and Gold Meadows Spring continue to be important summer water sources for NNSS horses.

Mule Deer (*Odocoileus hemionus*) (managed as a game mammal by NDOW)

Mule deer surveys were conducted on Pahute and Rainier mesas, and the average number of deer counted was 25 deer/night. The observed buck/doe ratio was 74 bucks/100 does, which is the third highest recorded since 2006. The observed fawn/doe ratio was 26 fawns/100 does, the third highest measured on the NNSS.

Desert Bighorn Sheep (*Ovis canadensis nelsoni*) (managed as a game mammal by NDOW)

Five sheep (two ewes and three rams) were captured, radio-collared, and marked with ear tags on the NNSS on November 17, 2015. A sixth sheep (ram too young to be collared) was captured and marked with ear tags on November 18. Radio-collared sheep were tracked until their collars prematurely dropped off on May 1, 2016. On November 28–29, 2016, 15 desert bighorn sheep (7 ewes and 8 rams) were captured on or near the NNSS on Yucca Mountain, Shoshone Mountain and in Fortymile Canyon. Thirteen of these (6 ewes and 7 rams) were radio-collared with satellite transmitters to track their movements over the next 1.5 years. Collars were programmed to record locations four times a day (1800, 0000, 0600, and 1200), except for the first five days of each month when hourly locations were recorded. This was done to better understand ***diel*** movement patterns. A total of 35,301 GPS locations were successfully recorded for the 13 radio-collared animals from November 30, 2016 through December 31, 2017.

Sensitive Bats (see Table A-11 of *Attachment A: Site Description*)

Bat monitoring in 2017 was restricted to documenting roost sites in buildings.

NNSS biologists continued to respond to reports of bats in NNSS buildings. Two bats were found roosting in buildings in Mercury and were released away from populated areas, and three were found dead.

Mountain Lions (*Puma concolor*) (managed as a game mammal by NDOW)

A collaborative effort with U.S. Geological Survey (USGS) scientists Dr. Erin Boydston and Dr. Kathy Longshore continued in 2017 to investigate mountain lion distribution and abundance on the NNSS using remote, motion-activated cameras. Cameras collected a total of 72 photographs/video clips of mountain lions from 5 of 29 camera sites, and 4 visual sightings by workers/biologists were recorded (Figure 13-3). A minimum of 4 lions (3 adult males and 1 adult female) inhabited the NNSS in 2017 based on photographic data.

A collaborative effort with Kathy Longshore and Brian Jansen of the USGS continued in 2017 to investigate the movements, habitat use, and food habits of mountain lions on the NNSS using radio-collared individuals. In July and August 2016, two adult males were

Table 13-2. Activities conducted in 2017 for important species and ecosystem monitoring on the NNSS

trapped on the NNSS, radio-collared, and tracked. Both collared individuals died in 2017. While collared, their movements were tracked and kill sites were visited and all observed prey were mule deer with the exception of one bighorn sheep. Preferred lion habitat on the NNSS is rugged, mountainous, typically forested areas in the northern and western portions of the NNSS (Figure 13-2).

The USGS produced and released a video titled "Wildlife on the Nevada National Security Site," which highlights the cooperative efforts of the USGS, NDOW, and NNSS biologists to study mountain lions and bighorn sheep on the NNSS (Longshore and Wessells, 2017). The video is available at: https://www.usgs.gov/media/videos/wildlife-nevada-national-security-site.

Natural and Man-made Water Sources

Nine natural water sources, 1 well pond, 5 wildlife water troughs, and 4 well sumps that periodically retain tritium contaminated groundwater discharged from monitoring wells (Chapter 5, Section 5.1.3.7.3) were monitored with motion-activated cameras to document wildlife use. Tritium contaminated well sumps are monitored to identify which species are being exposed and which may provide an exposure pathway to offsite hunters who may consume them. Mule deer and desert bighorn sheep were photographed at the monitored well sumps.

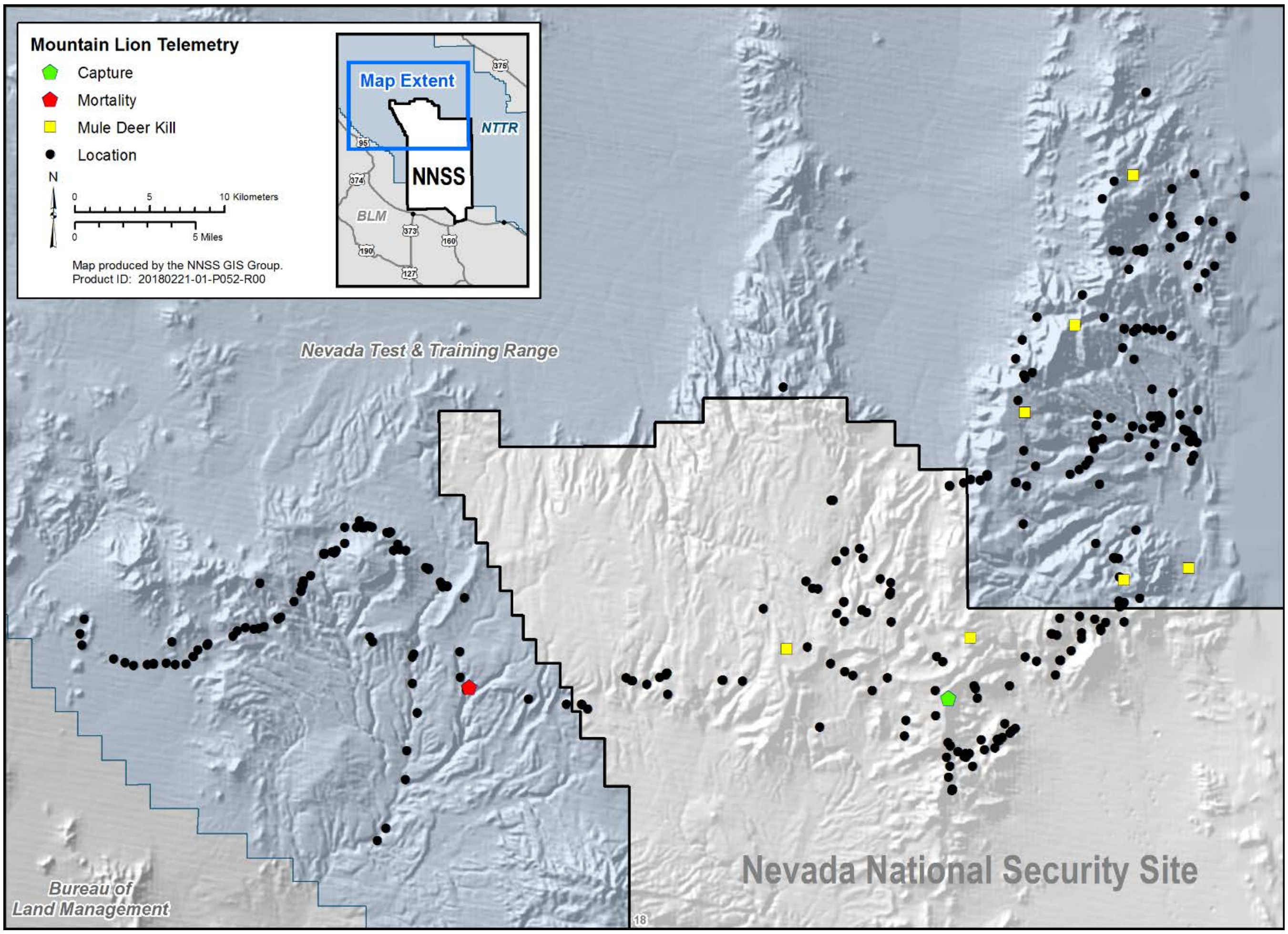

Figure 13-2. Locations of one radio-collared male mountain lion and mule deer kills (purple dots are radio-collared male mountain lion from July 30, 2016 to May 11, 2017, pink dot is the capture site, pink asterisk is the mortality site, and yellow dots are recorded mule deer kill locations)

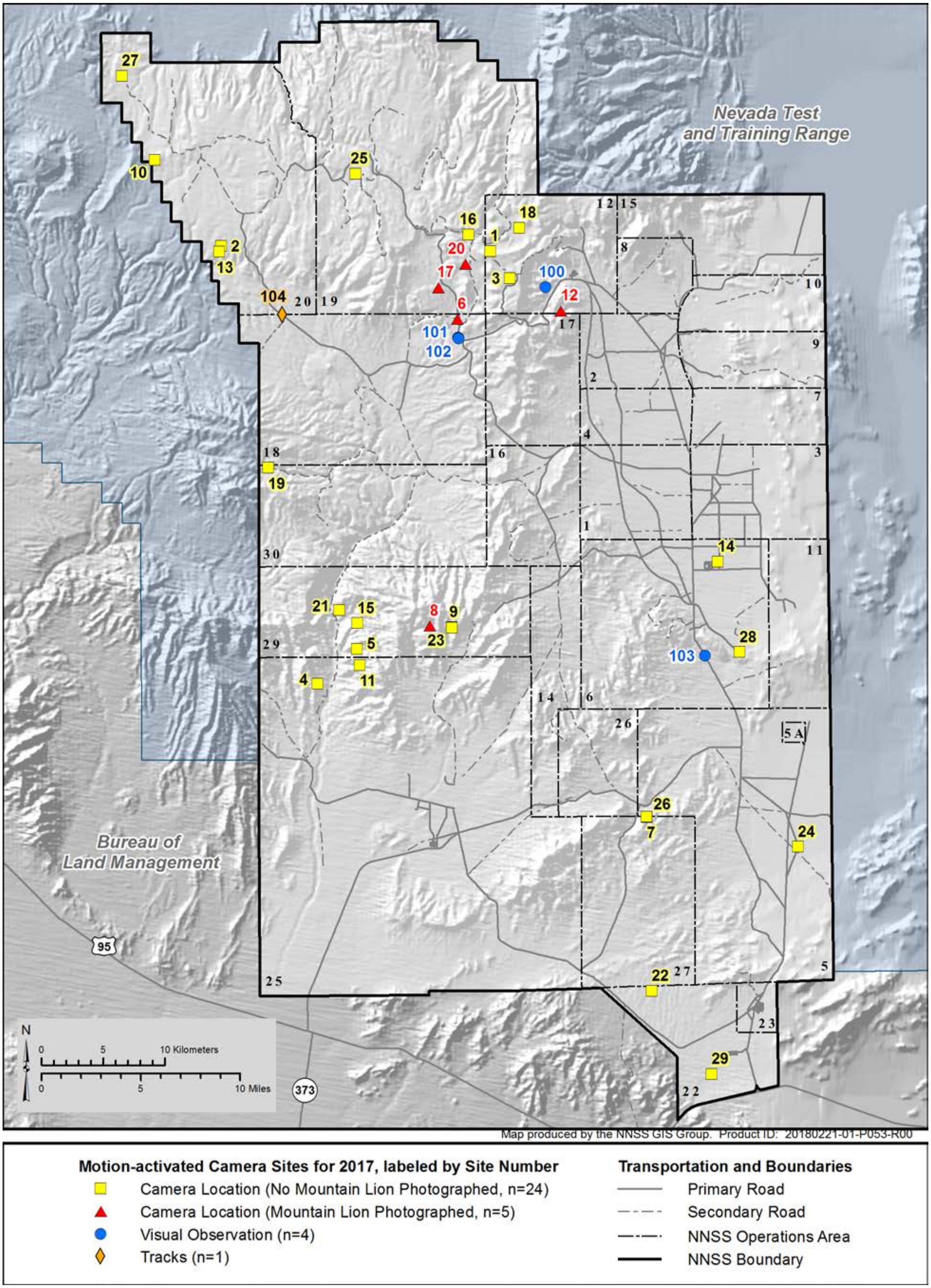

Figure 13-3. Locations of mountain lion photo detections, camera traps, and visual observations in 2017

13.4 Habitat Restoration Program

The Habitat Restoration Program revegetates disturbances and evaluates previous revegetation efforts. Sites that have been revegetated are periodically monitored or sampled, and the information obtained is used to develop site-specific revegetation plans for future restoration efforts on the NNSS. Revegetation supports the intent of Executive Order EO 13112, "Invasive Species," to prevent the introduction and spread of non-native species and restore native species to disturbed sites. Revegetation also may qualify as mitigation for the loss of desert tortoise habitat under the current Opinion. NNSA/NFO revegetation projects include lands disturbed in desert tortoise habitat; wildland fire sites; abandoned industrial or nuclear test support sites classified into Corrective Action Units (CAUs) that are remediated by Environmental Management (EM) Operations; and EM soil closure covers (or cover caps) over closed waste disposal pits. Sites that have been revegetated are periodically sampled as needed to monitor success or identify further needed actions. Sites at which revegetation has occurred in past years are listed below (the year each was revegetated is shown in parentheses).

- Double Tracks (CAU 411), Tonopah Test Range (TTR) (1996)
- Bomblet Pit and Five Points Landfill (CAU 400), TTR (1997)
- Cactus Spring Waste Trenches (CAU 426), TTR (1997)
- Roller Coaster Lagoons and Trench (CAU 404), TTR (1997)
- U3ax/bl Closure Cover (CAU 110), Area 3, NNSS (2000)
- Egg Point Fire, Area 12, NNSS (2002)
- Roller Coaster RadSafe Area (CAU 407), TTR (2004)
- NTS Waterline Replacement, Area 6, NNSS (2005)
- CP Hill Waterline, Area 6, NNSS (2009)
- 92 Acre Site, Area 5 RWMC (CAU 111), NNSS (2011)

Activities conducted in 2017 included visually assessing the vegetation at the U-3ax/bl closure cover and the "92-Acre Site."

13.4.1 CAU 110, U-3ax/bl, Closure Cover

No quantitative sampling occurred at the U-3ax/bl closure cover in 2017. A visual assessment in July indicated that the vegetative cover continues to show signs of a stable plant community capable of removing water from the soil profile through evapotranspiration. The dominant plant species is shadscale (*Atriplex confertifolia*) with lesser amounts of Nevada jointfir and winterfat. Relatively low annual plant cover was observed despite the above-average precipitation received the prior winter and spring. A few ant mounds and some rodent burrows were observed but did not appear to negatively influence the integrity of the waste cover cap.

13.5 Wildland Fire Hazard Assessment

A Wildland Fire Management Plan is maintained, which requires protection of site resources from wildland and operational fires. An annual vegetation survey to determine wildland fire hazards is conducted on the NNSS each spring. Survey findings are submitted to the NNSS Fire Marshal and summarized in the annual Ecological Monitoring and Compliance (EMAC) report (Hall and Perry 2018). In April and May 2017, NNSS biologists visited 104 roadside sampling stations to assess a fuel index that can range from 0 to 10 (lowest to highest risk of wildfires). The mean combined fuels index (which includes both fine [non-woody] and woody fuels) for all sampling stations was 4.87, which was an average value in comparison to previous years, suggesting normal fuel levels (the highest since 2004 was 5.64 in 2005). Average precipitation during December 2016–April, 2017, when it most influences plant growth and thus the availability of fine fuels for wildland fires, was 5.9 inches, above the average of 4.12 inches for this period over the last 30 years.

In 2017, seven wildland fires occurred on the NNSS including one of the largest ever recorded. It burned approximately 15,000 acres in Area 30 and took NNSS Fire and Rescue personnel nearly a week to extinguish it. Another fire in Area 18 burned about 10 acres before it was extinguished. The other five wildland fires were small (<0.07 acre) and were extinguished by NNSS Fire and Rescue personnel or carefully monitored until they burned out.

13.5.1 CAU 111, "92-Acre Site," Closure Covers

No quantitative sampling occurred at the "92-Acre Site" in 2017. A visual assessment in July found very few perennial plants on any of the cover caps. An abundance of annual plants, mostly saltlover (*Halogeton glomeratus*), prickly Russian thistle (*Salsola tragus*), Arabian schismus, and buckwheat species (*Eriogonum* spp.) were found on each cover cap. Some evidence of rabbit use and ant and rodent burrowing was detected. Burrowing activity was light and did not appear to negatively influence the integrity of the cover caps.

Seed production of creosotebush and white bursage in 2017 was the best in several years, so seed from both species was harvested for use in future revegetation efforts. Seed was sent to Comstock Seed for cleaning. A total of 10 bulk kg of cleaned white bursage and 8.4 bulk kg of creosotebush seed was harvested in Frenchman Flat within 5 miles of the Area 5 Radioactive Waste Management Complex.

13.6 References

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Chapter 14: Quality Assurance Program

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Required Criteria of a Quality Program
• Quality assurance program • Personnel training and qualification • Quality improvement process • Documents and records • Established work processes • Established standards for design and verification • Established procurement requirements • Inspection and acceptance testing • Management assessment • Independent assessment

The environmental monitoring work conducted for the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) is performed in accordance with the Quality Assurance Program (QAP) established by the current Management and Operations (M&O) contractor, Mission Support and Test Services, LLC (MSTS), and with the Underground Test Area (UGTA) QAP implemented by Navarro Research and Engineering, Inc. (Navarro). The QAPs describe the methods used to ensure quality is integrated into monitoring work, and to comply with Title 10 ***Code of Federal Regulations (CFR)***[1] Part 830, Subpart A, "Quality Assurance Requirements," and with U.S. Department of Energy (DOE) Order DOE O 414.1D, "Quality Assurance." The 10 criteria of a quality program specified by these regulations are shown in the box above. The QAPs require a graded approach to quality for determining the level of rigor that effectively provides assurance of performance and conformance to requirements.

The Data Quality Objective (DQO) process developed by the U.S. Environmental Protection Agency (EPA) provides the ***quality assurance (QA)*** structure for designing, implementing, and improving upon environmental monitoring efforts when environmental sampling and analysis are involved. Sampling and Analysis Plans are developed prior to performing an activity to ensure complete understanding of the data-use objectives. Personnel are trained and qualified in accordance with company- and task-specific requirements. Access to sampling locations is coordinated with organizations conducting work at or having authority over those locations in order to avoid conflicts in activities and to communicate hazards to better ensure successful execution of the work and protection of the safety and health of sampling personnel. Sample collection activities adhere to organization instructions and/or procedures designed to ensure that samples are representative and data are reliable and defensible. Sample shipments on site and to offsite laboratories are conducted in accordance with U.S. Department of Transportation and International Air Transport Association regulations, as applicable. ***Quality control (QC)*** in the analytical laboratories is maintained through adherence to standard operating procedures based on methodologies developed by nationally recognized organizations such as the EPA, DOE, and ASTM International. Key quality-affecting procedural areas cover sample collection, preparation, instrument calibration, instrument performance checking, testing for precision and accuracy, obtaining a measurement, and laboratory data review. Data users perform reviews as required by the project-specific objectives before the data are used to support decision making.

The key elements of the environmental monitoring process work flow are listed below. Each element is designed to ensure that applicable QA requirements are implemented. A discussion of these elements follows.

- A **Sampling and Analysis Plan** (SAP) is developed using the EPA DQO process to ensure clear goals and objectives are established for the environmental monitoring activity. The SAP is implemented in accordance with EPA, DOE, and other requirements addressing environmental, safety, and health.
- **Environmental Sampling** is performed in accordance with the SAP and site work controls to ensure defensibility of the resulting data products and worker and environment protection.

[1] The definition of word(s) in ***bold italics*** may be found by clicking on the word in electronic version or by referencing the Glossary, Appendix B. To return from the Glossary, right click and select Previous View.

- **Laboratory Analyses** are performed to ensure the resultant data meet DOE, MSTS (as the current M&O contractor), and UGTA regulation-defined requirements.
- **Data Review** ensures the SAP DQOs have been met, and determines whether the data are suitable for their intended purpose.
- **Assessments** ensure monitoring operations are conducted according to procedure and analytical data quality requirements are met in order to identify nonconforming items, investigate causal factors, implement corrective actions, and monitor for corrective action effectiveness.

14.1 Sampling and Analysis Plan

Sampling is specifically mandated to demonstrate compliance with a variety of requirements, including federal and state regulations and DOE orders and standards. Developing the SAP using the DQO approach ensures those requirements are considered in the planning stage. The following statistical concepts and controls are vital in designing and evaluating the system design and implementation.

14.1.1 Precision

Precision is the degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to themselves. Precision is a data quality indicator and is usually expressed as standard deviation, variance, or range, in either absolute or relative terms (DOE 2013).

In practice, precision is determined by comparing the results obtained from performing analyses on split or duplicate samples taken at the same time from the same location or locations very close to one another, maintaining sampling and analytical conditions as nearly identical as possible.

14.1.2 Accuracy

Accuracy refers to the degree of agreement between an observed value and an accepted reference value. Accuracy includes a combination of random error (precision) and systematic error (bias) components that are due to sampling and analytical operations. Accuracy is a data quality indicator (DOE 2013) and is monitored by performing measurements and evaluating results of control samples containing known quantities of the ***analytes*** of interest.

14.1.3 Representativeness

Representativeness is the degree to which measured analytical concentrations represent concentrations in the medium being sampled (Stanley and Verner 1985).

At each point in the sampling and analysis process, samples of the medium of interest are obtained. The challenge is to ensure each sample maintains the character of the larger population being sampled. From a field sample collection standpoint, representativeness is managed through sampling plan design and execution. Sampling locations are/have been determined historically by consensus and/or agreement with authorities, in many cases, or are determined based on the properties of the operation being monitored (such as environmental remediation).

Representativeness related to laboratory operations addresses the ability to appropriately subsample and characterize for analytes of interest. For example, to ensure representative characterization of a heterogeneous matrix (soil, sludge, solids, etc.), the sampling and/or analysis process should evaluate whether homogenization or segregation should be employed prior to sampling or analysis. Water samples are generally considered homogeneous unless observation suggests otherwise. Each air monitoring station’s continuous operation at a fixed location results in representatively sampling the ambient atmosphere. Field sample duplicate analyses are additional controls allowing evaluation of representativeness and heterogeneity; these are employed for air monitoring and direct radiation monitoring measurements. Generally, monitoring measurements are compared with historical measurements at the same location.

14.1.4 Comparability

Comparability refers to "the confidence with which one data set can be compared to another" (Stanley and Verner 1985). Comparability from an overall monitoring perspective is ensured by consistent execution of the sampling design for sample collection and handling, laboratory analyses, and data review and through adherence to established procedures and standardized methodologies. Ongoing data evaluation compares data collected at the same locations from sampling events conducted over multiple years and produced by numerous laboratories to detect any anomalies that might occur.

14.2 Environmental Sampling

Environmental samples are collected in support of various environmental programs. Each program executes field sampling activities in accordance with the SAP to ensure usability and defensibility of the resulting data. The key elements supporting the quality and defensibility of the sampling process and products include the following:

- Training and qualification
- Procedures and methods
- Field documentation
- Inspection and acceptance testing

14.2.1 Training and Qualification

The environmental programs ensure that personnel are properly trained and qualified prior to doing the work. In addition to procedure-specific and task-specific qualifications for performing work, training addresses environment, safety, and health aspects for protection of workers, the public, and the environment. Recurrent training is also conducted as appropriate to maintain proficiency.

14.2.2 Procedures and Methods

Sampling is conducted in accordance with established procedures to ensure consistent execution and continuous comparability of the environmental data. Descriptions of the analytical methods to be used are also consulted to ensure that, as methods are revised, sample collection is performed appropriately and viable samples are obtained.

14.2.3 Field Documentation

Field documentation is generated for each sample collection activity. This may include chain of custody documentation, sampling procedures, analytical methods, equipment and data logs, maps, Safety Data Sheets, and other materials needed to support the safe and successful execution and defense of the sampling effort. Chain-of-custody practices are employed from point of generation through disposal (cradle-to-grave); these are critical to the defensibility of the decisions made as a result of the sampling and analysis. Sampling data and documentation are stored and archived so they are readily retrievable for use at a later date. In many cases the data are managed in electronic data management systems. Routine assessments or surveillances are performed to ensure that sampling activities are performed in accordance with applicable requirements. Deficiencies are noted, causal factors are determined, corrective actions are implemented, and follow-up assessments are performed to ensure effective resolution. This data management approach ensures the quality and defensibility of the decisions made using analytical environmental data.

14.2.4 Inspection and Acceptance Testing

Sample collection data are reviewed for appropriateness, accuracy, and fit with historical measurements. In the case of groundwater sampling, water quality parameters are monitored during purging. Stabilization of these parameters generally indicates that the water is representative of the ***aquifer***, at which time sample collection may begin. After a sampling activity is complete, data are reviewed to ensure the samples were collected in accordance with the SAP. Samples are further inspected to ensure their integrity has not been compromised, either physically (leaks, tears, breakage, custody seals) or administratively (labeled incorrectly) and they are valid for supporting the intended analyses. If concerns are raised at any point during collection, the data user, in consideration of data usability, is consulted for direction on proceeding with or canceling the subsequent analyses.

14.3 Laboratory Analyses

Samples are transported to a laboratory for analysis. Several DOE contractor organizations maintain measurement capabilities that may be used to support planning or decision-making activities. However, unless specifically authorized by NNSA/NFO or the regulator, data used for demonstrating regulatory compliance are generated by a DOE- and MSTS-qualified laboratory whose services have been obtained through subcontracts. Ensuring the quality of procured laboratory services is accomplished through focus on three specific areas: (1) procurement, (2) initial and continuing assessment, and (3) data evaluation.

14.3.1 Procurement

Laboratory services are procured through subcontracts in accordance with the Competition in Contracting Act, the Federal Acquisition Regulations, the DOE Acquisition Regulations, contractor terms and conditions for subcontracting, and other relevant policies and procedures. The analytical services technical basis is codified in the Department of Energy (DOE) Consolidated Quality Systems Manual (QSM) for Environmental Laboratories (DOE 2013). The QSM is based on the National Environmental Laboratory Accreditation Conference Chapter 5, “Quality Systems,” as implemented in 2005, based on International Organization for Standardization Standard ISO 17025, “General Requirements for the Competence of Testing and Calibration Laboratories,” and the NELAC Institute (TNI) Standards Volume 1 2009. Subcontracted laboratories are assessed to be in compliance with the QSM and are routinely audited under the DOE Consolidated Audit Program (DOECAP).

A request for proposal (RFP) is posted to the government website, laboratory responses are evaluated, and subcontracts awarded. The RFP cites the QSM and DOECAP participation as base requirements and addresses site-specific conditions. Multiple laboratories may receive a subcontract through one RFP.

The laboratories are primarily those providing a wide range of analytical services to DOE. Other services can be subcontracted by the laboratory (i.e., lower-tier subcontractor) or contracted directly from a vendor. In either case, requirements are established for the specific services provided.

The subcontract places numerous requirements on the laboratory, including the following:

- Maintaining the following documents:
  - A Quality Assurance Plan and/or Manual describing the laboratory’s policies and approach to the implementation of QA requirements
  - An Environment, Safety, and Health Plan
  - A Waste Management Plan
  - Procedures pertinent to subcontract scope
- The ability to generate data deliverables, both hard copy reports and electronic files
- Responding to all data quality questions in a timely manner
- Mandatory participation in proficiency testing programs
- Maintaining specific licenses, accreditations, and certifications
- Conducting internal audits of laboratory operations as well as audits of vendors
- Allowing external audits by DOECAP and NNSA/NFO contractors and providing copies of other audits considered to be comparable and applicable

14.3.2 Initial and Continuing Assessment

An initial assessment is made during the RFP process, including a pre-award audit. If an acceptable audit has not been performed within the past year, MSTS or Navarro will consider performing an audit (or participating in a

DOECAP audit) of those laboratories awarded the contract. Neither contractor will initiate work with a laboratory without authorized approval from those personnel responsible for ensuring vendor acceptability.

A continuing assessment consists of the ongoing monitoring of a laboratory's performance against contract terms and conditions, of which the technical specifications are a part. Tasks supporting continuing assessment are listed below:

- Conducting regular audits or participating in evaluation of DOECAP audit products
- Monitoring for continued successful participation in proficiency testing programs such as:
  - National Institute of Standards and Technology Radiochemistry Intercomparison Program
  - Studies that support certification by the State of Nevada or appropriate regulatory authority for analyses performed in support of routine monitoring
- Routine ongoing monitoring of the laboratory's adherence to the quality requirements

14.3.3 Data Evaluation

Data products are routinely evaluated for compliance with contract terms and specifications. This primarily involves review of the data against the specified analytical method to determine the laboratory's ability to adhere to the QA/QC requirements, as well as an evaluation of the data against the DQOs. This activity is discussed in further detail in Section 14.4. Any discrepancies are documented and resolved with the laboratory, and ongoing assessment tracks the recurrence and efficacy of corrective actions.

14.4 Data Review

A systematic approach to thoroughly evaluating the data products generated from an environmental monitoring effort is essential for understanding and sustaining the quality of data collected under the program. This allows the programs to determine whether the DQOs established in the planning phase were achieved and whether the monitoring design performed as intended or requires review.

Because decisions are based on environmental data, and the effectiveness of operations is measured at least in part by environmental data, reliable, accurate, and defensible records are essential. Detailed records that must be kept include temporal, spatial, numerical, geotechnical, chemical, and radiological data as well as all sampling, analytical, and data review procedures used. Failure to maintain these records in a secure but accessible form may result in exposure to legal challenges and the inability to respond to demands or requests from regulators and other interested organizations.

An electronic data management system is a key tool used by many programs for achieving standardization and integrity in managing environmental data. The primary objective is to store and manage in an easily and efficiently retrievable form unclassified environmental data that are directly or indirectly tied to monitoring events. This may include information on monitoring system construction (groundwater wells, ambient air monitoring), and analytical, geotechnical, and field parameters at the Nevada National Security Site. Database integrity and security are enforced through the assignment of varying database access privileges commensurate with an employee's database responsibilities.

14.4.1 Data Verification

Data verification is defined as a subcontract compliance and completeness review to ensure that all laboratory data and sample documentation are present and complete. Additional critical sampling and analysis process information is also reviewed at this stage, which may include, but is not limited to, sample preservation and temperature, defensible chain-of-custody documentation and integrity, and analytical hold-time compliance. Data verification also ensures that electronic data products correctly represent the sampling and/or analyses performed, and includes evaluation of QC sample results.

14.4.2 Data Validation

Data validation supplements verification and is a more thorough process of analytical data review to better determine if the data meet the analytical and project requirements. Data validation ensures that the reported results correctly represent the sampling and analyses performed, determines the validity of the reported results, and assigns data qualifiers (or "flags"), if required.

14.4.3 Data Quality Assessment (DQA)

DQA is a scientific and statistical evaluation to determine if the data obtained from environmental operations are of the right type, quality, and quantity to support their intended use. The DQA includes reviewing data for accuracy, representativeness, and fit with historical measurements to ensure that the data will support their intended uses.

14.5 Assessments

The overall effectiveness of the environmental program is determined through routine surveillance and assessments of work execution as well as review of program requirements. Deficiencies are identified, causal factors are investigated, corrective actions are developed and implemented, and follow-on monitoring is performed to ensure effective resolution. The assessments discussed below are broken down into general programmatic and focused measurement data areas.

14.5.1 Programmatic

Assessments and audits under this category include evaluations of work planning, execution, and performance activities. Personnel independent of the work activity perform the assessments to evaluate compliance with established requirements and report on deficiencies identified. Organizations responsible for the activity are required to develop and implement corrective actions, with the concurrence of the deficiency originator or recognized subject matter expert. NNSA/NFO contractors maintain companywide issues tracking systems to manage assessments, findings, and corrective actions.

14.5.2 Measurement Data

This type of assessment includes routine evaluation of data generated from analyses of QC and other samples. QC sample data are used to monitor the analytical control on a given batch of samples and are indicators over time of potential biases in laboratory performance. Discussions of the 2017 results for field duplicates, laboratory control samples, blank analyses, matrix spikes, and proficiency testing programs are provided, and summary tables are included below.

14.5.2.1 Field Duplicates

Samples obtained at nearly the same locations and times as initial samples are termed field duplicates. These are used to evaluate the overall precision of the measurement process, including small-scale heterogeneity in the medium (air, water, or direct radiation) being sampled as well as analytical and sample preparation variation. The absolute relative percent difference (RPD) compares the absolute difference of initial and field duplicate measurements with the average of the two measurements (Table 14-1, footnote c); it is computed only from pairs for which both values are above their respective ***minimum detectable concentrations (MDCs)***. The relative error ratio (RER) compares the absolute difference of initial and field duplicate measurements to the laboratory's reported analytical uncertainty (Table 14-1, footnote d).

The average absolute RPD and average RER values for all 2017 radiological air and water duplicate pairs are shown in Table 14-1. They are similar to those seen in prior years. The higher average absolute RPDs (those greater than 25) are associated with two types of phenomena. RPDs for ***actinides*** in air, in particular, and consequently for gross alpha in air, can be elevated when one sampler of a pair intercepts a particle with high americium (Am) or plutonium (Pu), while the other sampler in the pair had a typical ***background*** value. For example, average absolute RPDs for ^{241}Am and $^{239+240}$Pu were 20.3 and 55.9 respectively. Also, higher average absolute RPDs are often associated with relatively few pairs having both values above their MDCs, as low level measurements are typically relatively "noisier" than higher-level measurements ($^{235+236}$U in 2017, with only two pairs above MDCs).

Table 14-1. Summary of field duplicate samples for 2017

Analyte	Medium	Number of Duplicate Pairs[(a)]	Number of Pairs > MDC[(b)]	Average Absolute RPD[(c)]	Average Absolute RER[(d)]
Environmental Monitoring Samples					
Gross Alpha	Air	51	33	19.3	0.71
Gross Beta	Air	51	51	8.3	1.17
Tritium	Air	52	9	6.1	0.67
^{241}Am	Air	8	1	20.3	0.81
^{238}Pu	Air	8	1	3.0	0.80
$^{239+240}$Pu	Air	8	4	55.9	1.87
$^{233+234}$U	Air	6	6	13.1	0.67
$^{235+236}$U	Air	6	2	27.8	1.06
^{238}U	Air	6	6	20.7	0.94
^{7}Be[(e)]	Air	8	8	10.3	1.28
^{137}Cs	Air	8	0	–	0.94
^{40}K[(e)]	Air	8	6	22.5	0.66
Gross Alpha	Water	5	5	24.9	1.02
Gross Beta	Water	5	5	20.9	1.37
Tritium (standard)	Water	17	0	–	0.70
TLD	Ambient Radiation	422	NA	4.2	0.38
Underground Test Area (UGTA) Samples					
Gross Alpha	Water	22	17	33.9	1.21
Gross Beta	Water	22	16	21.4	0.90
Tritium (standard)	Water	32	17	5.1	0.53
Tritium (low-level)	Water	9	6	20.1[(f)]	0.91

(a) Represents the number of field duplicates reported for evaluating precision.

(b) Represents the number of field duplicate–field sample pairs with both values above their MDCs. If either the field sample or duplicate was below the MDC, the RPD was not determined. This does not apply to ***thermoluminescent dosimeter (TLD)*** measurements; because TLDs virtually always detect ambient background radiation, MDCs are not computed.

(c) Represents the average absolute RPD calculated as follows:

$$Absolute\ RPD = \frac{|S - D|}{(D + S)/2}\ X\ \ 100$$

Where: S = Sample result
D = Duplicate result

(d) Represents the absolute RER, determined by the following equation, which is used to determine whether a sample result and the associated field duplicate result differ significantly when compared to their respective 1 sigma uncertainties (i.e., measurement standard deviation). The RER is calculated for all sample and field duplicate pairs reported without regard to the MDC.

$$Absolute\ RER = \frac{|S - D|}{\sqrt{(SD_S)^2 + (SD_D)^2}}$$

Where: S = Sample result
D = Duplicate result
SD_S Standard deviation of the sample result as reported
SD_D = Standard deviation of the duplicate result as reported

(e) ^{7}Be and ^{40}K are naturally occurring analytes included for quality assessment of the gamma ***spectroscopy*** analyses.

(f) Two pairs of results had RPDs greater than 80; those RPDs were considered outliers and therefore, were not included in calculation of the average. One of the results was rejected and replaced with two separate reanalyses.

14.5.2.2 Laboratory Control Samples (LCSs)

An LCS is prepared from a sample matrix verified to be free from the analytes of interest, and then spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes. The LCS is generally used to establish intra-laboratory or analyst-specific precision and bias or to assess the performance of all or a portion of the measurement system (DOE 2013).

The results are calculated as a percentage of the true value (i.e., percent recovery), and must fall within established control limits to be considered acceptable. If the LCS recovery falls outside control limits, evaluation for potential sample data bias is necessary. The numbers of the 2017 LCSs analyzed and within control limits are summarized in Table 14-2. There were no systemic issues identified in 2017 by LCS recovery data, and no failures that invalidated the associated sample data.

Table 14-2. Summary of laboratory control samples for 2017

Analyte	Matrix	Number of LCS Results Reported	Number Within Control Limits	Control Limits (%)
Environmental Monitoring Samples				
Tritium	Air	65	65	75–125
^{60}Co	Air	5	5	75–125
^{137}Cs	Air	5	5	75–125
$^{239+240}$Pu	Air	14	14	75–125
^{241}Am	Air	23	23	75–125
Gross alpha	Water	15	14	75–125
Gross beta	Water	15	15	75–125
Tritium (standard)	Water	22	22	75–125
^{60}Co	Water	0	0	75–125
^{90}Sr	Water	0	0	75–125
^{137}Cs	Water	0	0	75–125
$^{239+240}$Pu	Water	0	0	75–125
^{241}Am	Water	0	0	75–125
Tritium	Soil	0	0	75–125
^{60}Co	Soil	7	7	75–125
^{90}Sr	Soil	10	10	75–125
^{137}Cs	Soil	7	7	75–125
$^{239+240}$Pu	Soil	10	10	75–125
^{241}Am	Soil	16	16	75–125
^{60}Co	Vegetation	1	1	75–125
^{90}Sr	Vegetation	1	1	75–125
^{137}Cs	Vegetation	1	1	75–125
$^{239+240}$Pu	Vegetation	1	1	75–125
^{241}Am	Vegetation	2	2	75–125
Metals	Water	118	117	80–120
Volatiles	Water	444	442	70–130
Semi volatiles	Water	781	781	Laboratory specific
Miscellaneous	Water	61	59	80–120
Metals	Soil	0	0	80–120
Volatiles	Soil	0	0	70–130
Semi volatiles	Soil	0	0	Laboratory specific
Miscellaneous	Soil	0	0	80–120
UGTA Samples				
Gross alpha	Water	22	22	80-120
Gross beta	Water	22	22	80-120
Tritium (standard)	Water	26	26	80-120
Tritium (low-level)	Water	10	10	80-120

14.5.2.3 Blank Analysis

In general, a blank is a sample that has not been exposed to the targeted environment and is analyzed in order to monitor "no exposure" analyte levels and contamination that might be introduced during sampling, transport, storage, or analysis. The blank is subjected to the usual analytical and measurement process to establish a baseline or background value, and is sometimes used to adjust or correct routine analytical results (DOE 2013). Blanks are processed simultaneously with and under the same conditions as samples through all steps of the analytical procedures. The following list identifies the blanks routinely used during environmental monitoring activities.

- A trip blank is a sample of analyte-free media taken from the laboratory to the sampling site and returned to the laboratory unopened. A trip blank is used to document contamination attributable to shipping and field handling procedures. This type of blank is useful in documenting contamination of volatile organics samples (DOE 2013).
- An equipment blank is a sample of analyte-free media that has been used to rinse common sampling equipment to check effectiveness of decontamination procedures (DOE 2013).
- A field blank is prepared in the field by filling a clean container with purified water (appropriate for the target analytes) and appropriate preservative, if any, for the specific sampling activity being undertaken. The field blank is used to indicate the presence of contamination due to sample collection and handling (DOE 2013).
- A method blank is a sample of a matrix similar to the associated sample batch in which no target analytes or interferences are present at concentrations that would impact the sample analyses results (DOE 2013). Method blank data are summarized in Table 14-3.

There were no systemic issues and no failures that required invalidating the associated sample data identified in 2017 by the blank data.

Table 14-3. Summary of laboratory method blank samples for 2017

Analyte	Matrix	Number of Blank Results Reported	Number of Results < MDC
Environmental Monitoring Samples			
Tritium	Air	70	69
^{7}Be	Air	5	5
^{60}Co	Air	2	2
^{137}Cs	Air	5	5
^{238}Pu	Air	8	6
$^{239+240}$Pu	Air	8	7
^{241}Am	Air	12	10
Gross alpha	Water	15	15
Gross beta	Water	15	14
Tritium (standard)	Water	21	21
^{60}Co	Water	0	0
^{90}Sr	Water	0	0
^{137}Cs	Water	0	0
^{238}Pu	Water	0	0
$^{239+240}$Pu	Water	0	0
^{241}Am	Water	0	0
Tritium	Soil	0	0
^{60}Co	Soil	5	5
^{90}Sr	Soil	7	5
^{137}Cs	Soil	7	7
^{238}Pu	Soil	7	7
$^{239+240}$Pu	Soil	7	7
^{241}Am	Soil	11	11
^{60}Co	Vegetation	1	1
^{90}Sr	Vegetation	1	1
^{137}Cs	Vegetation	1	1
^{238}Pu	Vegetation	1	1
$^{239+240}$Pu	Vegetation	1	1
^{241}Am	Vegetation	2	2
Metals	Water	135	125
Volatiles	Water	361	361
Semi volatiles	Water	414	414
Miscellaneous	Water	163	158
Metals	Soil	0	0

Analyte	Matrix	Number of Blank Results Reported	Number of Results < MDC
Volatiles	Soil	0	0
Semi volatiles	Soil	0	0
Miscellaneous	Soil	0	0
UGTA Samples			
Gross alpha	Water	21	20
Gross beta	Water	21	21
Tritium (standard)	Water	21	21
Tritium (low-level)	Water	8	7

14.5.2.4 Matrix Spike Analysis

A matrix spike is a sample spiked with a known concentration of analyte. This spiked sample is subjected to the same sample preparation and analysis as the original environmental sample. The matrix spike is used to indicate if the matrix (e.g., soil, water with sediment) interferes with the analytical results. Matrix spike analyses were conducted for samples in 2017, and there were no issues identified by the analysis data (Table 14-4).

Table 14-4. Summary of matrix spike samples for 2017

Analyte	Matrix	Number of Matrix Spikes Reported	Number Within Control Limits	Control Limits (%)
Environmental Monitoring Samples				
Tritium	Air	20	20	60–140
Gross alpha	Water	8	8	60–140
Gross beta	Water	8	8	60–140
Tritium	Water	8	8	60–140
UGTA Samples				
Gross alpha	Water	30	30	60-140
Gross beta	Water	30	30	60-140
Tritium (standard)	Water	29	29	60-140
Tritium (low-level)	Water	6	6	60-140

14.5.2.5 Proficiency Testing Program Participation

All contracted laboratories are required to participate in proficiency testing programs. Laboratory performance supports decisions on work distribution and may also be a basis for state certifications. Table 14-5 presents the 2017 results for the laboratory performance in the March and August studies of the Mixed Analyte Performance Evaluation Program (MAPEP) (http://www.id.energy.gov/resl/mapep/mapepreports.html) administered by the Radiological and Environmental Sciences Laboratory of the Idaho National Laboratory. The MAPEP discontinued several studies during calendar year 2016, including gross alpha/beta in air filters and water and organics (volatiles and semi-volatiles) in water and soil. Proficiency testing programs are not available for the low-level tritium analytical method. Low-level tritium proficiency was assessed by comparing commercial laboratory results to LLNL data for the same wells. The relative percent difference (RPD) was within established acceptance criteria.

Table 14-5. Summary of 2017 Mixed Analyte Performance Evaluation Program reports

Analyte	Matrix	Number of Results Reported	Number within Control Limits[(a)]
Environmental Monitoring Samples			
^{60}Co	Filter	6	6
^{137}Cs	Filter	6	6
^{238}Pu	Filter	6	5
$^{239+240}$Pu	Filter	6	6
^{241}Am	Filter	6	6
Tritium (standard)	Water	6	5
^{60}Co	Water	6	6
^{90}Sr	Water	6	6
^{137}Cs	Water	6	6
^{238}Pu	Water	6	6
$^{239+240}$Pu	Water	6	6
^{241}Am	Water	6	6
^{60}Co	Vegetation	6	6
^{90}Sr	Vegetation	56	6
^{137}Cs	Vegetation	6	6
^{238}Pu	Vegetation	6	6
$^{239+240}$Pu	Vegetation	6	6
^{60}Co	Soil	6	6
^{90}Sr	Soil	6	6
^{137}Cs	Soil	6	6
^{238}Pu	Soil	6	6
$^{239+240}$Pu	Soil	6	6
^{241}Am	Soil	6	6
Metals	Water	111	109
Metals	Soil	116	112

(a) Based upon MAPEP criteria

Table 14-6 shows the summary of inter-laboratory comparison sample results for the NSTec Radiological Health Dosimetry Group. The DOE Standard DOE-STD-1095-2011, "Department of Energy Laboratory Accreditation for External Dosimetry," establishes the methodology for determining acceptable performance testing of dosimeter systems. It also establishes the technical basis for performance testing and the testing categories and performance criteria, which are outlined in the American National Standards Institute/Health Physics Society (ANSI/HPS) N13.11-2009, "American National Standard for Dosimetry–Personnel Dosimetry Performance–Criteria for Testing," and in ANSI/HPS N13.32-2008, "An American National Standard, Performance Testing of Extremity Dosimeters." The Dosimetry Group participated in the Battelle Pacific Northwest National Laboratory proficiency testing program during the course of the year.

Table 14-6. Summary of inter-laboratory comparison TLD samples (UD-802 dosimeters) for 2017

Analysis	Matrix	Number of Results Reported	Number within Control Limits[(a)]
TLD	Gamma Radiation	85	85

(a) Based upon ANSI/HPS N13.11-2009 criteria

American National Standard ANSI/HSP N13.37-2014, "Environmental Dosimetry – Criteria for System Design and Implementation," contains guidance on conducting "blind spike" quality assurance testing. This process was followed in 2017 by having 24 Panasonic UD-814AS environmental TLDs exposed to a known radiation level (200 milliroentgens) and placing them with routine monitoring TLDs for analysis. A performance quotient for each ***dosimeter*** was calculated as follows: P = (reported exposure – true value) / true value. According to the standard, the absolute value of the mean performance quotient should not exceed 0.15. The value for 2017-tested environmental TLDs was 0.01, demonstrating good agreement between the results and the controlled exposure using the blind spike.

14.6 References

DOE, see U.S. Department of Energy.

Stanley, T. W., and S. S. Verner, 1985. The U.S. Environmental Protection Agency's Quality Assurance Program. In: Taylor, J. K., and T. W. Stanley (eds.), *Quality Assurance for Environmental Measurements*, ASTM STP-867, Philadelphia, PA.

U.S. Department of Energy, 2013. *Department of Energy (DOE) Consolidated Quality Systems Manual (QSM) for Environmental Laboratories*, July 2013.

Chapter 15: Quality Assurance Program for the Community Environmental Monitoring Program

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Desert Research Institute

The Community Environmental Monitoring Program (CEMP) Quality Assurance Management and Assessment Plan (QAMAP) (Desert Research Institute [DRI] 2009) is followed for the collection and analysis of radiological air and water data presented in Chapter 7 of this report. The CEMP QAMAP ensures compliance with U.S. Department of Energy (DOE) Order DOE O 414.1D, "Quality Assurance," which implements a quality management system, ensuring the generation and use of quality data. This QAMAP addresses the following items previously defined in Chapter 14:

- Data Quality Objectives (DQOs)
- Sampling plan development to satisfy the DQOs
- Environmental health and safety
- Sampling plan execution
- Sample analyses
- Data review
- Continuous improvement

15.1 Data Quality Objectives (DQOs)

The DQO process is a strategic planning approach used to plan data collection activities. It provides a systematic process for defining the criteria that a data collection design should satisfy. These criteria include when and where samples should be collected, how many samples to collect, and the tolerable level of decision errors for the study. DQOs are unique to the specific data collection or monitoring activity, and follow similar guidelines for onsite activities where applicable (Chapter 14).

15.2 Measurement Quality Objectives (MQOs)

The MQOs are basically equivalent to DQOs for analytical processes. The MQOs provide direction to the laboratory concerning performance objectives or requirements for specific method performance characteristics. Default MQOs are established in the subcontract with the laboratory, but may be altered in order to satisfy changes in the DQOs. The MQOs for the CEMP project are described in terms of precision, accuracy, representativeness, completeness, and comparability requirements. These terms are defined and discussed in Section 14.1 for onsite activities.

15.3 Sampling Quality Assurance Program

Quality Assurance (QA)[1] in CEMP field operations includes sampling assessment, surveillance, and oversight of the following supporting elements:

- The sampling plan, DQOs, and field data sheets accompanying the sample package
- Database support for field and laboratory results, including systems for long-term storage and retrieval
- A training program to ensure that qualified personnel are available to perform required tasks

Sample packages include:

- Station manager checklist confirming all observable information pertinent to sample collection
- An Air Surveillance Network Sample Data Form documenting air sampler parameters, collection dates and times, and total sample volumes collected
- Chain-of-custody forms

This managed approach ensures the sampling is traceable and enhances the value of the final data. The sample package also ensures the Community Environmental Monitor (CEM) station manager (Chapter 7 describes CEMs) followed proper procedures for sample collection. The CEMP Project Manager or QA Officer routinely

[1] The definition of word(s) in ***bold italics*** may be found by clicking on the word in electronic version or by referencing the *Glossary*, Appendix B. To return from the Glossary, right click and select Previous View.

performs assessments of the station managers and field monitors to ensure standard operating procedures and sampling protocols are followed properly.

Data obtained in the course of executing field operations are entered in the documentation accompanying the sample package during sample collection and in the CEMP database along with analytical results upon their receipt and evaluation.

Completed sample packages are kept as hard copy in file archives. Analytical reports are kept as hard copy in file archives as well as on read-only compact discs by calendar year. Analytical reports and databases are protected and maintained in accordance with the DRI's Computer Protection Program.

15.4 Laboratory QA Oversight

The CEMP QA Officer ensures that DOE O 414.1D requirements are met with respect to laboratory services through review of the vendor laboratory policies formalized in a Laboratory Quality Assurance Plan (LQAP) (Testamerica, Inc., 2017). The CEMP is assured of obtaining quality data from laboratory services through a multifaceted approach involving specific procurement protocols, the conduct of quality assessments, and requirements for selected laboratories to have an acceptable QA program. These elements are discussed below.

15.4.1 Procurement

Laboratory services are procured through subcontracts. The subcontract establishes the technical specifications required of the laboratory and provides the basis for determining compliance with those requirements and evaluating overall performance. The subcontract is awarded on a "best value" basis as determined by pre-award audits. The prospective vendor is required to provide a review package to the CEMP QA Officer that includes:

- All procedures pertinent to subcontract scope
- Environment, Safety, and Health Plan
- LQAP
- Example deliverables (hard copy and/or electronic)
- Proficiency testing (PT) results from the previous year from recognized PT programs
- Résumés
- All procedures pertinent to subcontract scope
- Facility design/description
- Accreditations and certifications
- Licenses
- Pricing
- Audits performed by an acceptable DOE program covering comparable scope
- Past performance surveys

The CEMP QA Officer evaluates the review package in terms of technical capability. Vendor selection is based solely on these capabilities and not biased by pricing.

15.4.2 Initial and Continuing Assessment

An initial assessment of a laboratory is managed through the procurement process above, including a pre-award audit. Pre-award audits are conducted by the CEMP (usually by the CEMP QA Officer). The CEMP does not initiate work with a laboratory without approval from CEMP Program Manager.

A continuing assessment of a selected laboratory involves ongoing monitoring of a laboratory's performance against the contract terms and conditions, of which technical specifications are a part. The following tasks support continuing assessment:

- Tracking schedule compliance
- Reviewing analytical data deliverables
- Monitoring the laboratory's adherence to the LQAP
- Conducting regular audits
- Monitoring for continued successful participation in approved PT programs

15.4.3 Laboratory QA Program

The laboratory policy and approach to implement DOE O 414.1D is verified in a LQAP prepared by the laboratory. The required elements of a CEMP LQAP are similar to those required by Mission Support and Test Services, LLC, for onsite monitoring (Section 14.3).

15.5 Data Review

Essential components of process-based QA are data checks, verification, validation, and data quality assessment to evaluate data quality and usability.

Data Checks – Data checks are conducted to ensure accuracy and consistency of field data collection operations prior to and upon data entry into CEMP databases and data management systems.

Data Verification – Data verification is defined as a subcontract compliance and completeness review to ensure that all laboratory data and sample documentation are present and complete. Sample preservation, chain-of-custody, and other field sampling documentation is reviewed during the verification process. Data verification ensures the reported results entered in CEMP databases correctly represent the sampling and/or analyses performed and includes evaluation of ***quality control (QC)*** sample results.

Data Validation – Data validation is the process of reviewing a body of analytical data to determine if it meets the data quality criteria defined in operating instructions. Data validation ensures the reported results correctly represent the sampling and/or analyses performed, determines the validity of reported results, and assigns data qualifiers (or "flags"), if required. The process of data validation consists of the following:

- Evaluating the quality of data to ensure all project requirements are met
- Determining the impact on data quality of those requirements if they are not met
- Verifying compliance with QA requirements
- Checking QC values against defined limits
- Applying qualifiers to analytical results in CEMP databases to define the limitations in the use of the reviewed data

Operating instructions, procedures, applicable project-specific work plans, field sampling plans, QA plans, analytical method references, and laboratory statements of work may all be used in the process of data validation. Documentation of data validation includes checklists, qualifier assignments, and summary forms.

Data Quality Assessment (DQA) – DQA is the scientific evaluation of data to determine if the data obtained from environmental data operations are of the right type, quality, and quantity to support their intended use. DQA review is a systematic review against pre-established criteria to verify the data are valid for their intended use.

15.6 QA Program Assessments

The overall effectiveness of the QA Program is determined through management and independent assessments as defined in the CEMP QAMAP. These assessments evaluate the plan execution workflow (sampling plan development and execution, chain-of-custody, sample receiving, shipping, subcontract laboratory analytical activities, and data review) as well as program requirements as they pertains to the organization.

15.7 2017 Sample QA Results

QA assessments were performed by the CEMP, including the laboratories responsible for sample analyses. These assessments ensure sample collection procedures, analytical techniques, and data provided by the subcontracted laboratories comply with CEMP requirements. Data were provided by Testamerica Laboratories and the University of Nevada, Las Vegas, Radiation Services Laboratory (***gross alpha/beta*** and gamma ***spectroscopy*** data); Mirion Technologies (***thermoluminescent dosimeter [TLD]*** data); and, the American Radiation Services Laboratory in Port Allen, Louisiana (tritium [^{3}H] data). A brief discussion of the 2017 results for field duplicates, laboratory control samples, blank analyses, and inter-laboratory comparison studies is provided along with summary tables within this section. The 2017 CEMP radiological air and water monitoring data are presented in Chapter 7.

15.7.1 Field Duplicates (Precision)

A field duplicate is a sample collected, handled, and analyzed by the same procedures as the primary sample. The relative percent difference (RPD) between the field duplicate result and the corresponding field sample result is a measure of the variability in the process caused by the sampling uncertainty (matrix heterogeneity, collection variables, etc.) and measurement uncertainty (field and laboratory) used to arrive at a final result. The average absolute RPD, expressed as a percentage, was determined for the calendar year 2017 samples and is listed in Table 15-1. An RPD of zero indicates a perfect duplication of results of the duplicate pair, whereas an RPD greater than 100% generally indicates that a duplicate pair falls beyond QA requirements and is not considered valid for use in data interpretation. These samples are further evaluated to determine the reason for QA failure and if any corrective actions are required. Overall, the RPD values for all analyses indicate very good results, with only two gross alpha duplicates exceeding an RPD of 100%.

Table 15-1. Summary of field duplicate samples for CEMP monitoring in 2017

Analysis	Matrix	Number of Samples Reported[(a)]	Number of Samples Reported above MDC[(b)]	Average Absolute RPD of those above MDC (%)[(c)]
Gross Alpha	Air	39	39	58.0
Gross Beta	Air	39	39	34.6
Gamma – Beryllium-7	Air	8	6	32.6
^{3}H	Water	1	0	NA[(d)]
TLDs	Ambient Radiation	12	NA	2.1

(a) Represents the number of field duplicates reported for the purpose of monitoring precision. If an associated field sample was not processed, the field duplicate was not included in this table.
(b) Represents the number of field duplicate–field sample result sets reported above the minimum detectable concentration (MDC) (MDC is not applicable for TLDs). If either the field sample or its duplicate was reported below the detection limit, the precision was not determined.
(c) Reflects the average absolute RPD calculated for those field duplicates reported above the MDC.
(d) Not applicable.

The absolute RPD calculation is as follows:

$$Absolute\ RPD = \frac{|FD - FS|}{(FD + FS)/2}\ X\ 100\%$$

Where: FD = Field duplicate result
FS = Field sample result

15.7.2 Laboratory Control Samples (Accuracy)

Laboratory control samples (LCSs) (also known as matrix spikes) are performed by the subcontract laboratory to evaluate analytical accuracy, which is the degree of agreement of a measured value with the true or expected value. Samples of known concentration are analyzed using the same methods as employed for the project samples. The results are determined as the measured value divided by the true value, expressed as a percentage. To be considered valid, the results must fall within established control limits (or percentage ranges) for further analyses to be performed. The LCS results obtained for 2017 are summarized in Table 15-2. The LCS results were satisfactory, with all samples falling within control parameters for the air sample matrix.

Table 15-2. Summary of laboratory control samples (LCSs) for CEMP monitoring in 2017

Analysis	Matrix	Number of LCS Results Reported	Number Within Control Limits	Control Limits
Gross Alpha	Air	31	31	75-125%
Gross Beta	Air	31	31	75-125%
Gamma (^{137}Cs, ^{60}Co, ^{241}Am)	Air	11	11	87-120%
^{3}H	Water	1	1	75-125%

15.7.3 Blank Analysis

Laboratory blank analyses are essentially the opposite of LCSs. These samples do not contain any of the ***analyte*** of interest. Results of these analyses are expected to be "zero," or, more accurately, below the MDC of a specific procedure. Blank analysis and control samples are used to evaluate overall laboratory procedures, including sample preparation and instrument performance. The laboratory blank sample results obtained for 2017 are summarized in Table 15-3. The laboratory blank results were satisfactory with only one alpha, one gamma, and two beta blank samples outside of control parameters for the air sample matrix.

Table 15-3. Summary of laboratory blank samples for CEMP monitoring in 2017

Analysis	Matrix	Number of Blank Results Reported	Number within Control Limits[(a)]
Gross Alpha	Air	31	30
Gross Beta	Air	31	29
Gamma	Air	11	10
^{3}H	Water	1	1

(a) Control limit is less than the MDC.

15.7.4 Inter-laboratory Comparison Studies

Inter-laboratory comparison studies are conducted by the subcontracted laboratories to evaluate their performance relative to other laboratories providing the same service. These types of samples are commonly known as “blind” samples, in which the expected values are known only to the program conducting the study. The analyses are evaluated and, if found satisfactory, the laboratory is certified that its procedures produce reliable results. The inter-laboratory comparison sample results obtained for 2017 are summarized in Tables 15-4 and 15-5.

Table 15-4 shows the summary of inter-laboratory comparison sample results for the subcontract radiochemistry laboratories. The laboratories participated in either the QA Program administered by Environmental Research Associates (ERA) and/or the Mixed Analyte Performance Evaluation Program (MAPEP) for gross alpha, gross beta, and gamma analyses. The subcontract ^{3}H laboratory also participated in the MAPEP program. Overall, all of the subcontractors performed very well during the year by passing all of the parameters analyzed.

Table 15-4. Summary of inter-laboratory comparison samples of the subcontract radiochemistry and tritium laboratories for CEMP monitoring in 2017

		MAPEP and ERA Results	
Analysis	Matrix	Number of Results Reported	Number Within Control Limits[(a)]
Gross Alpha	Air	2	2
Gross Beta	Air	2	1
Gamma	Air	4	4
^{3}H	Water	2	2

(a) Control limits are determined by the individual inter-laboratory comparison study.

Table 15-5 shows the summary of the in-house performance evaluation results conducted by the subcontract dosimetry group. This internal evaluation was based on National Voluntary Laboratory Accreditation Program (NVLAP) criteria and is performed biannually. The dosimetry group performed very well during the year, passing 12 out of 12 TLDs analyzed.

Table 15-5. Summary of inter-laboratory comparison TLD samples of the subcontract dosimetry group for CEMP monitoring in 2017

Analysis	Matrix	Number of Results Reported	Number Within Control Limits[(a)]
TLDs	Ambient Radiation	12	12

(a) Based upon NVLAP criteria; absolute value of the bias plus one standard deviation < 0.3.

15.8 References

Desert Research Institute, 2009. *DOE NNSA/NSO Community Environmental Monitoring Program Quality Assurance Management and Assessment Plan*, July 2009.

Testamerica, Inc., 2017. *Quality Assurance Manual*. Version 8.0, February 2017.

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Appendix A
Las Vegas Area Support Facilities

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Appendix A: Las Vegas Area Support Facilities

Troy S. Belka, Delane P. Fitzpatrick-Maul, Jennifer M. Larotonda, Nikolas J. Taranik, and Ronald W. Warren
Mission Support and Test Services, LLC

The U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) manages two facilities in Clark County, Nevada, that support NNSA/NFO missions on and off the Nevada National Security Site (NNSS). These are the North Las Vegas Facility (NLVF) and the Remote Sensing Laboratory–Nellis (RSL-Nellis) (Figure A-1). This appendix describes environmental monitoring and compliance activities in 2017 at these facilities.

A.1 North Las Vegas Facility

The NLVF is a fenced complex composed of 31 buildings that house much of the NNSS project management, diagnostic development and testing, design, engineering, and procurement personnel. The 32-hectare (80-acre) facility is located along Losee Road, a short distance west of Interstate 15 (Figure A-1). The facility is buffered on the north, south, and east by general industrial zoning. The western border separates the property from fully developed, single-family residential-zoned property. The NLVF is a controlled-access facility. Environmental compliance and monitoring activities associated with this facility in 2017 included the maintenance of one air quality operating permit; one wastewater permit; one National Pollutant Discharge Elimination System (NPDES) permit; one Spill Prevention, Control, and Countermeasure (SPCC) Plan; and one hazardous materials permit (Table 2-3 lists NNSA/NFO permits). NNSA/NFO also monitors ***tritium (^{3}H)***[1] in air and ambient gamma emissions to comply with federal radiation protection regulations.

A.1.1 Air Quality and Protection

Sources of air pollutants at the NLVF are regulated by the Source 657 Minor Source Permit issued by the Clark County Department of Air Quality (DAQ) for the emission of ***criteria pollutants***. These pollutants include particulate matter (PM), nitrogen oxide (NO_X), carbon monoxide (CO), sulfur oxides (SO_x), and volatile organic compounds (VOCs). Because the NLVF is considered a true minor source, there is no requirement to report ***hazardous air pollutants (HAPs)***. The regulated sources of emissions at the NLVF include diesel generators, a fire pump, cooling towers, and boilers. The DAQ requires an annual emissions inventory of criteria air pollutants; the 2017 inventory reported the estimated quantities (Table A-1) on March 6, 2018.

Table A-1. Summary of air emissions for the NLVF in 2017

	Criteria Pollutant (tons/yr)[(a)]					
Parameter	**PM10[(b)]**	**PM2.5[(c)]**	**NO_x**	**CO**	**SO_x**	**VOC**
PTE[(d)]	1.49	0.87	20.40	4.54	0.09	0.93
Actual[(e)]	0.26	0.07	1.59	0.41	0.01	0.07
Total Emissions = 2.41 Actual, 28.32 PTE						

(a) 1 ton equals 0.91 metric tons
(b) Particulate matter equal to or less than 10 microns in diameter
(c) Particulate matter equal to or less than 2.5 microns in diameter
(d) Potential to emit (PTE) is the quantity of criteria air pollutant facilities/pieces of equipment would emit annually if they were operated for the maximum number of hours at the maximum production rate specified in the air permit
(e) Emissions based on calculations using actual hours of operation for each piece of equipment

Clark County air regulations specify that the opacity from any emission unit may not exceed the Clean Air Act National Ambient Air Quality Standards (NAAQS) opacity limit of 20% for more than six consecutive minutes. The NLVF air permit requires that at least one visual emissions observation be performed each month of operating equipment, i.e., boilers, generators, emergency fire pump, emergency generator, and cooling towers. If emissions are observed, then U.S. Environmental Protection Agency (EPA) Method 9 opacity readings are recorded by a

[1] The definition of word(s) in ***bold italics*** may be found by clicking on the word in electronic version or by referencing the Glossary, Appendix B. To return from the Glossary, right click and select Previous View.

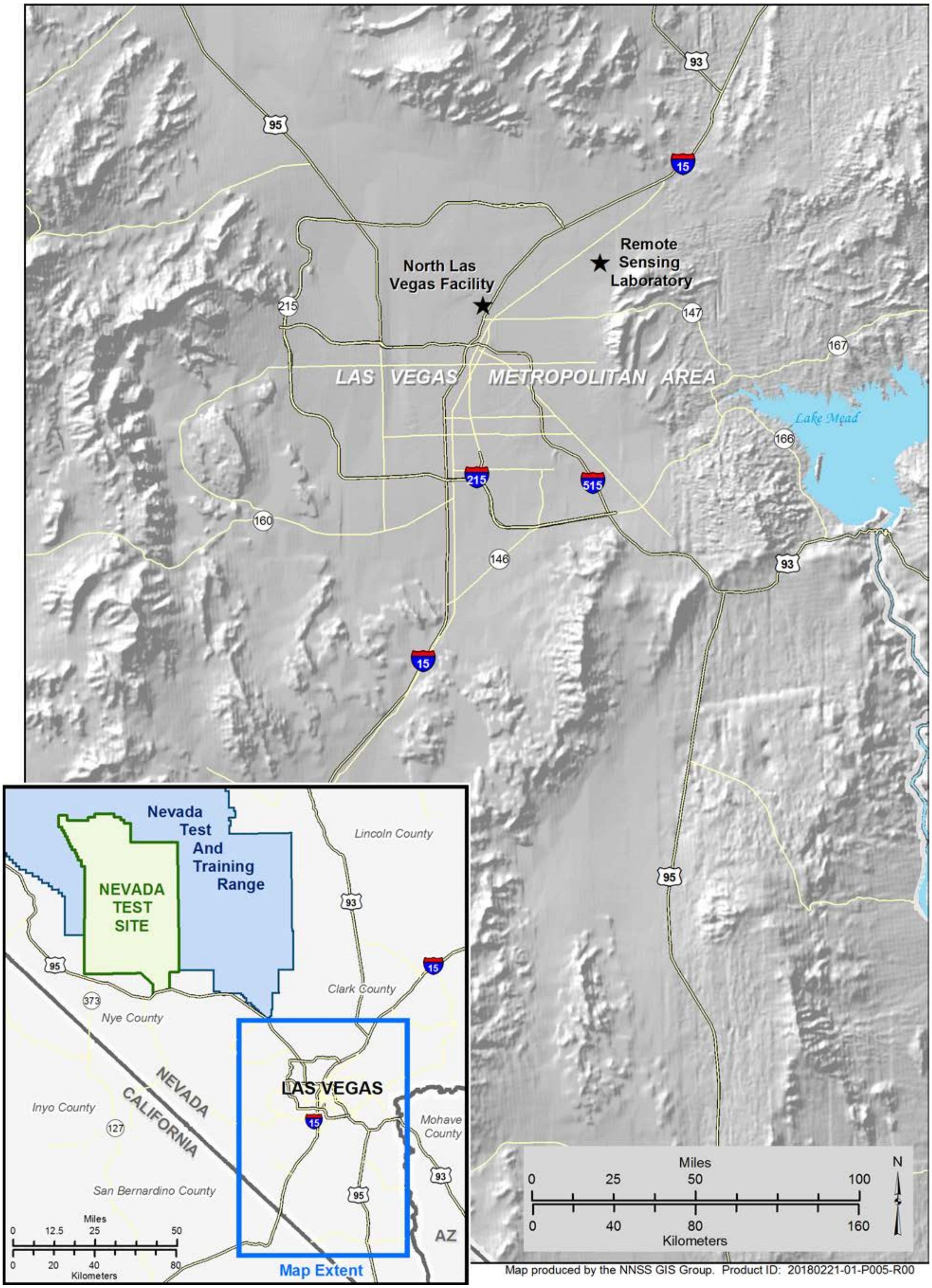

Figure A-1. Location of NNSS offsite facilities in Las Vegas and North Las Vegas

certified visible emissions evaluator. If visible emissions appear to exceed the limit, corrective actions must be taken to minimize emissions. In 2017, two NLVF Maintenance Engineers were recertified and two new employees were certified to conduct opacity readings. In 2017, observations were taken for the boilers, generators, the fire pump, and cooling towers; emissions were below the NAAQS opacity limit of 20%.

At NLVF, a verbal notification to the City of North Las Vegas (CNLV) Fire Department is required before each fire extinguisher training session. In 2017, one hot work live fire extinguisher training session was conducted at the NLVF. Quantities of criteria air pollutants produced by the open burns during training are not required to be calculated or reported.

A.1.2 Water Quality and Protection

Water used at the NLVF is supplied by the CNLV and meets or exceeds federal drinking water standards. Water quality permits issued to NNSA/NFO include a Class II Wastewater Control Permit (036555-02) from the CNLV for NLVF sewer discharges and an NPDES DeMinimus (NV201000) permit from the Nevada Division of Environmental Protection (NDEP) for dewatering operations to control rising groundwater levels at the facility. Discharges of sewage and industrial wastewater from the NLVF must meet permit limits set by the CNLV. These limits support the permit limits for the Publicly Owned Treatment Works operated by the CNLV. The Class II Permit specifies substances prohibited from being discharged at NLVF and requires CNLV be notified of changes in discharge flow rates, spills, or other abnormal events. In 2017, no changes, spills, or abnormal events occurred.

A.1.2.1 Storm Water No Exposure Waiver ISW-40565

This waiver was approved on July 16, 2015 and it provides a conditional exemption from the NPDES Storm Water Program and the State of Nevada Stormwater General Permit. The conditions specify that storm water discharges from the NLVF will not be exposed to industrial activities or materials. In 2017, no storm water exposures to such activities or materials occurred.

A.1.2.2 National Pollutant Discharge Elimination System DeMinimus General Permit

An NPDES DeMinimus general permit covers the dewatering operation at the NLVF (Section A.1.2.3). Dewatering wells (NLVF-13s, -15, -16, -17) and the A-01 Basement Sump Well pump groundwater into a 37,854-liter (L) (10,000-gallon [gal]) storage tank (Figure A-2). The DeMinimus general permit replaced the previous permit on January 1, 2017. The permit type was changed because NNSA/NFO received approval to discharge the water from the A-01 Basement Sump Well along with the discharge from the other four dewatering wells. Prior to the change, water from the A-01 Basement Sump Well was stored in tanker trucks and taken to the NNSS for disposal due to residual ^{3}H. Because the level of ^{3}H has remained under the average analytical ***minimum detection limit (MDL)*** for several years, approval was given to discharge the water from the storage tank into the Las Vegas Wash via direct discharge (Outfall 002) into the CNLV storm water drainage system along with the discharge from the dewatering wells. On May 5, 2017, maintenance personnel finished the changes required to re-route the discharge from the A-01 Sump Well to the storage tank. Chemistry analyses are performed annually for water samples collected from the storage tank. Results of the 2017 analyses are in Table A-2. The total quantities of groundwater produced and discharged and the results of chemistry analyses are reported annually to NDEP’s Bureau of Water Pollution Control.

In 2017, the four dewatering wells produced a total of about 9,464 L (2,500 gal) per day that were directed into the storage tank (Figure A-2). The average pumping rates varied from 2.8 liters per minute (Lpm) (0.73 gallons per minute [gpm]) at Well NLVF-13s to 0.68 Lpm (0.18 gpm) at Well NLVF-16. The average combined discharge from all four wells was about 285,799 L (75,500 gal) per month.

Figure A-2. Location of dewatering and monitoring wells around Building A-1

Table A-2. NLVF NPDES permit 2017 monitoring requirements and analysis results of storage tank water samples

	Monitoring Requirements		Permit Discharge Limits	Sample Results			
Parameter	**Sample Frequency**	**Sample Type**	**Daily Maximum**	**1st Quarter**	**2nd Quarter**	**3rd Quarter**	**4th Quarter**
Daily Maximum Flow (MGD)[(a)]	Continuous	Flow Meter	0.36	0.0025	0.0038	0.0034	0.0039
Total Petroleum Hydrocarbons[(b)] (mg/L)	Annually (4th Qtr)	Discrete	1	NS[(c)]	NS	NS	ND[(d)]
Total Suspended Solids (mg/L)	Annually	Discrete	135	NS	NS	NS	5
Total Dissolved Solids (mg/L)	Annually	Discrete	1900	NS	NS	NS	1330
Total Inorganic Nitrogen as N (mg/L)	Annually	Discrete	10	NS	NS	NS	1.15
pH (Standard Units)	Annually	Discrete	6.5–9.0	NS	NS	NS	7.82

(a) MGD = million gallons per day

(b) This parameter includes three analytes: diesel range organics, gasoline range organics, and oil range organics

(c) NS = not required to be sampled that quarter

(d) ND = not detected; values were less than the laboratory detection limits

Annual water sampling for the presence of 23 ***analytes*** (listed in Section A.10.3.4 of the permit) was performed on October 31, 2017. All analytes were below permit limits (Table A-2) and discharge rates (i.e., daily maximum flows) did not exceed the NPDES DeMinimus general permit limits (Table A-2).

A.1.2.3 Groundwater Control and Dewatering Operation

In 2017, the groundwater control and dewatering project at the NLVF continued efforts to reduce the intrusion of groundwater below Building A-01. The project has transitioned from initial groundwater investigations and characterization to a long-term/permanent dewatering operation project. A review of the rising groundwater situation and past efforts to understand and remediate is presented in previous reports (Bechtel Nevada [BN] 2003, 2004; National Security Technologies, LLC [NSTec] 2006). Monitoring for this operation includes periodic measurements for water level at 24 of the 27 NLVF monitoring wells, continuous water level measurements at the A-01 Basement Sump Well, measuring the total volume of discharged groundwater, and conducting groundwater chemistry analyses in accordance with the NPDES DeMinimus general permit. Groundwater data are assessed quarterly or as new data become available. This information is used to help characterize groundwater conditions, validate the conceptual hydrologic model, and evaluate the dewatering operation.

In 2017, about 127,568 L (33,700 gal) per month were pumped from the A-01 Basement Sump Well. When the pump is active, the water level directly beneath Building A-01 averages 51.1 centimeters (cm) (20.1 inches [in.]) below the basement floor, as measured in a monitoring tube installed in a nearby elevator shaft. This average water level is based on daily measurements taken in 2017 and reflects a drop of about 72.6 cm (28.6 in.) in the local ***water table*** beneath Building A-01 since full-scale dewatering operations began in 2006. The general trend for the NLVF site-wide monitoring network shows an average rise in the water level of 1.2 meters (3.8 feet) since 2003. Although recently the water levels in many of the wells appear to be stabilizing or decreasing, dewatering efforts continue to counter this rising groundwater trend.

A.1.2.4 Discharge of Groundwater from Building A-01 Sump Well

In 2001, the sump well was installed in the basement of Building A-01 to remediate ^{3}H contamination detected between 1994 and 1995 (BN 2000). The discharge water, which contained ^{3}H, was disposed of at the NNSS. The sump well was turned off after remedial operations were complete. However, beginning in early 2003, the sump has been used to help control the encroaching water below Building A-01. The amount of ^{3}H in the sump well water has decreased from about 1,970 pCi/L in 2003 to less than the average analytical MDL of 282 pCi/L (well below the Safe Drinking Water Act limit of 20,000 pCi/L). Since the residual ^{3}H levels continued to remain under the MDL, a new permit was obtained that allowed the sump well water to be discharged into the storm drain. In 2017, a total of 1,529,810 L (404,133 gal) of water were pumped from the sump well. Of that total, 380,040 L (100,396 gal) were transported to the NNSS for disposal prior to May 5, 2017 when the sump well discharge was re-routed.

A.1.2.5 Oil Pollution Prevention

The NLVF has an SPCC Plan that was prepared in accordance with the Clean Water Act to minimize the potential discharge of petroleum products, animal fats and vegetable oils, and other non-petroleum oils and greases into waters of the U.S. (i.e., the Las Vegas Wash). The EPA requires SPCC Plans for non-transportation–related facilities having the potential to pollute waters of the U.S. and having an aggregate aboveground oil storage capacity of more than 4,997 L (1,320 gal). Oil storage facilities at the NLVF include 9 aboveground tanks, 18 transformers, 14 pieces of oil-filled machining equipment (e.g., lathes, elevators), and numerous 55-gal drums that are used to store new and used oils. These facilities/pieces of equipment are located within approved spill and storm water runoff containment structures. The SPCC specifies procedures for removing storm water from containment structures and identifies discharge countermeasures, disposal methods for recovered materials, and discharge reporting requirements.

In 2017, quarterly inspections of tanks, transformers, oil-filled equipment, and drums were conducted in March, May, September, and November. Throughout 2017, all NLVF employees who handle oil received their required annual spill prevention and management training. Two oil spills were documented during 2017. A small quantity (< 1 gallon) of hydraulic fluid leaked from shredder truck (subcontractor). A small quantity (< 1 gallon) of diesel fuel leaked from a fuel tank due to the fuel expanding in the heat . Both spills were contained, cleaned up, and the residues properly disposed. No spills occurred in 2017 that met regulatory agency reporting criteria..

A.1.3 Radiation Protection

A.1.3.1 National Emission Standards for Hazardous Air Pollutants

In compliance with the National Emission Standards for Hazardous Air Pollutants (NESHAP) of the Clean Air Act, the ***radionuclide*** air emissions from the NLVF and the resultant radiological ***dose*** to the public surrounding the facility were assessed. NESHAP establishes a dose limit for the general public to be no greater than 10 millirems per year (mrem/yr) from all radioactive air emissions. The basement of Building A-01 was contaminated with ^{3}H in 1995 when a container of ^{3}H foils was opened, emitting about 1 curie of ^{3}H (U.S. Department of Energy, Nevada Operations Office 1996). Complete cleanup of the ^{3}H was unsuccessful due to the ^{3}H being absorbed into the building materials. This has resulted in a continuous but decreasing release of ^{3}H into the basement air space, which is ventilated to the outdoors. Since 1995, a dose assessment has been performed every year for this building.

In 2017, no ^{3}H was detected above its analytical MDL in groundwater pumped from the sump well in the basement of Building A-01 during dewatering operations. However, there is still an emission from ^{3}H emanating from building materials in the building's basement. This ^{3}H emission was determined by taking two air samples from the basement (on April 10–17 and September 13–20, 2017) in order to compute average ^{3}H emissions. A calculated annual total of 2.14 millicuries were released from the basement air that was vented to the outside. Based on this emission rate, the 2017 calculated radiation dose to the nearest member of the general public from the NLVF was very low: 0.0000098 mrem/yr (MSTS 2018). The nearest public place is 100 meters (328 feet) northwest of Building A-01. This annual public dose is well below the regulatory limit of 10 mrem/yr and continues to decrease at a rate of about one-half every 4.75 years (MSTS 2018).

A.1.3.2 U.S. Department of Energy Order 458.1

U.S. Department of Energy (DOE) Order 458.1, "Radiation Protection of the Public and the Environment," specifies that the radiological dose to a member of the public from radiation from all pathways must not exceed 100 mrem/yr as a result of DOE activities. This dose limit does not include the dose contribution from natural ***background*** radiation. The Atlas A-1 Source Range Laboratory and the Building C-3 High Intensity Source Building are two NLVF facilities that use radioactive sources or where radiation-producing operations are conducted that have the potential to expose the general population or non-project personnel to direct radiation. Direct radiation monitoring is conducted using ***thermoluminescent dosimeters (TLDs)*** to monitor external ***gamma radiation exposure*** near the boundaries of these facilities. The methods of TLD use and data analyses are described in Chapter 6 of this report.

In 2017, radiation exposure was measured at two locations along perimeter fences for Buildings A-01 and C-3 and at one control location along the west fence of Building C-1 (Figure A-2). Annual exposure rates estimated from measurements at those locations are summarized in Table A-3. The radiation exposure in air measured by the TLDs is in the unit of milliroentgens per year (mR/yr), which is considered equivalent to the unit of mrem/yr for tissue. These exposures include contributions from background radiation and are similar to the TLD measurement of 100 mR/yr for total annual exposure reported by the Desert Research Institute from their Las Vegas air monitoring station (Section 7.1.4, Table 7-3). The NLVF TLD results indicate that facility activities do not contribute a radiological dose to the surrounding public that can be distinguished from the dose due to background radiation.

Table A-3. Results of 2016 direct radiation exposure monitoring at the NLVF

Location	Number of Samples	Gamma Exposure (mR/yr)			
		Mean	Median	Minimum	Maximum
West Fence of Building C-1 (Control)	4	96	96	94	98
North Fence of Building A-01	4	67	66	62	69
North Fence of Building C-3	4	65	64	63	68

A.1.4 Hazardous Waste Management

Hazardous wastes (HWs) generated at the NLVF include such items as non-empty aerosol cans, lead debris, and oily rags. HWs are stored temporarily in satellite accumulation areas until they are direct-shipped to approved disposal facilities. The NLVF is normally a Conditionally Exempt Small Quantity Generator; therefore, no HW permit is required by the State of Nevada. However, the Southern Nevada Health District (SNHD) issues the facility an annual permit for restricted waste management. The SNHD normally conducts an annual audit to validate proper handling and storage of restricted wastes; in 2017, SNHD did not conduct the audit.

A.1.5 Hazardous Materials Control and Management

The 2017 NLVF chemical inventory was submitted to the state in the Nevada Combined Agency (NCA) Report on February 22, 2018. The inventory data were submitted in accordance with the requirements of the Hazardous Materials Permit 74195. For a description of the content, purpose, and federal regulatory driver behind the NCA Report, Section 2.4.4.1, Emergency Planning and Community Right-to-Know Act. No accidental or unplanned release of an extremely hazardous substance (EHS) occurred at the NLVF. Also, the quantities of toxic chemicals kept at the NLVF that are used annually did not exceed the specified reporting thresholds (Chapter 2, Table 2-5 concerning Toxic Chemical Release Inventory, Form R).

A.2 Remote Sensing Laboratory–Nellis

RSL-Nellis is approximately 13.7 kilometers (km) (8.5 miles [mi]) northeast of the Las Vegas city center and approximately 11.3 km (7 mi) northeast of the NLVF. It occupies six facilities on approximately 14 secured hectares (35 acres) at the Nellis Air Force Base. A Memorandum of Agreement between the U.S. Air Force (USAF) and NNSA/NFO acknowledges the land belongs to the USAF and is leased to the NNSA/NFO, while the RSL facilities are owned by NNSA/NFO. RSL-Nellis provides emergency response resources for weapons-of-mass-destruction incidents. The laboratory also designs and conducts field tests of counterterrorism/intelligence technologies, and has the capability to assess environmental and facility conditions using complex radiation measurements and multi-spectral imaging technologies.

Environmental compliance and monitoring activities at RSL-Nellis in 2017 included maintenance of an air quality permit, a waste management permit for underground storage tanks (USTs), and a hazardous materials permit (Table 2-3 lists NNSA/NFO permits). Sealed radiation sources are used for calibration at RSL-Nellis, but the public has no access to any area that may have elevated gamma radiation emitted by the sources. Therefore, no environmental TLD monitoring is conducted. However, dosimetry monitoring is performed to ensure worker protection.

A.2.1 Air Quality and Protection

Sources of air pollutants at RSL-Nellis are regulated by the Minor Source Permit 348 issued by the Clark County DAQ for the emission of criteria pollutants. The permit was renewed June 29, 2017 and expires June 28, 2022. Regulated sources of emissions at RSL-Nellis include an aluminum sander, an abrasive blaster, spray paint booth, generators, a fire pump, cooling towers, and boilers. The 2017 emissions inventory of criteria air pollutants was submitted to the DAQ on March 22, 2018, and is shown in Table A-4.

Clark County Air Quality Regulations specify that the opacity from any emission unit may not exceed the Clean Air Act NAAQS opacity limit of 20% for more than 6 consecutive minutes. The RSL-Nellis air permit requires that equipment be observed each day it is operated. If visible emissions are observed, then EPA Method 9 opacity readings are recorded by a certified visible emissions evaluator. If visible emissions appear to exceed the limit, corrective actions are taken to minimize emissions. In 2017, two RSL-Nellis Maintenance Engineers were recertified and two more were certified to conduct opacity readings. Observations were taken for the permitted emission units. Emissions for all equipment were well below the Clean Air Act NAAQS limit.

Table A-4. Summary of air emissions for RSL-Nellis in 2017

	Criteria Pollutant (tons/yr)[(a)]					
Parameter	**PM10[(b)]**	**PM2.5[(c)]**	**NO_x**	**CO**	**SO_x**	**VOC**
PTE[(d)]	0.83	0.45	6.86	2.12	0.12	1.11
Actual[(e)]	0.19	.10	1.84	0.45	0.2	0.16
Total Emissions = 4.02 Actual, 23.36 PTE						

(a) 1 ton equals 0.91 metric tons

(b) Particulate matter equal to or less than 10 microns in diameter

(c) Particulate matter equal to or less than 2.5 microns in diameter

(d) ***Potential to emit***: The quantity of criteria pollutant facilities/pieces of equipment would emit annually if they were operated for the maximum number of hours at the maximum production rate specified in the air permit

(e) Emissions based on calculations using actual hours of operation for each piece of equipment

A.2.2 Water Quality and Protection

Water used at RSL-Nellis is supplied by the CNLV and meets or exceeds federal drinking water standards. The Clark County Water Reclamation District (CCWRD) determined that a discharge permit is not necessary for RSL-Nellis since no industrial wastewaters are discharged. Instead, an annual submission of a Zero Discharge Form verifying that no industrial wastewater was discharged to the sanitary sewer system is required. A Zero Discharge Certification for 2017 was submitted to CCWRD on January 20, 2018. There were no regulatory inspections of RSL-Nellis by the CCWRD and no findings or corrective actions were identified by internal assessments.

A.2.2.1 Oil Pollution Prevention

An SPCC Plan is in place for RSL-Nellis. Similar to the NLVF (Section A.1.3), the SPCC Plan is required because the facility has an aggregate aboveground oil storage capacity of more than 4,997 L (1,320 gal), and spills could potentially enter the Las Vegas Wash. Oil storage facilities at RSL-Nellis include nine aboveground tanks, four transformers, and two pieces of oil-filled machining equipment (e.g., elevators). These facilities and pieces of equipment are within approved spill and storm water runoff containment structures. The SPCC specifies procedures for removing storm water from containment structures and identifies discharge countermeasures, disposal methods for recovered materials, and discharge reporting requirements.

In 2017, quarterly inspections of tanks, transformers, and oil-filled equipment were conducted in March, May, July, and November. All RSL Nellis employees who handle oil received their required annual spill prevention and management training. No spills occurred in 2017 that met regulatory agency reporting criteria.

A.2.3 Underground Storage Tank Management

The SNHD has oversight authority of USTs in Clark County. The UST program at RSL-Nellis consists of three fully regulated tanks (one for unleaded gasoline, one for diesel fuel, and one for used oil), one deferred tank (in accordance with Title 40 ***Code of Federal Regulations*** Part 280.10[d]) for emergency power generation, and three excluded tanks. They are managed under the RSL-Nellis Waste Management Permit PR0064276 issued by SNHD. The active tanks are inspected annually by SNHD. In November, 2017, SNHD inspected the fully regulated and deferred USTs at RSL-Nellis. One deficiency was noted.

A.2.4 Hazardous Materials Control and Management

The 2017 chemical inventory at RSL-Nellis was submitted to the state in the NCA Report on February 22, 2018 in accordance with the requirements of the Hazardous Materials Permit 74199 (Section 2.4.4.1 describes the content, purpose, and federal regulatory driver behind the NCA Report). No accidental or unplanned release of an EHS occurred at RSL-Nellis in 2017. Also, no annual usage quantities of toxic chemicals kept at RSL-Nellis exceeded specified thresholds (Chapter 2, Table 2-5 concerning Toxic Chemical Release Inventory, Form R).

A.3 References

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Appendix B: Glossary of Terms

A **Absorbed dose:** the amount of energy absorbed by an object or person per unit mass. It reflects the amount of energy that ionizing radiation sources deposit in materials through which they pass, and is measured in units of radiation-absorbed dose (rad). The related international system unit is the gray (Gy), where 1 Gy is equivalent to 100 rad.

Actinide: any of the series of 15 metallic elements from actinium (atomic number 89) to lawrencium (atomic number 103) in the periodic table. They are all radioactive, the heavier members being extremely unstable and not of natural occurrence. The actinides mentioned in this document include uranium, plutonium, and americium.

Alpha particle: a positively charged particle emitted from the nucleus of an atom having mass and charge equal to those of a helium nucleus (two protons and two neutrons), usually emitted by transuranic elements (elements with atomic numbers greater than 92 [the atomic number of uranium], all of which are unstable and decay radioactively into other elements).

Alpha radioactivity: ionizing radiation consisting of alpha particles, emitted by some substances undergoing radioactive decay.

Analyte: the specific component measured in a chemical analysis.

Aquifer: a saturated layer of rock or soil below the ground surface that can supply usable quantities of groundwater to wells and springs and be a source of water for domestic, agricultural, and industrial uses.

Area 5 Radioactive Waste Management Complex (RWMC): the complex in Area 5 of the Nevada National Security Site at which low-level waste (LLW) and mixed low-level waste (MLLW) may be received, examined, packaged, stored, or disposed. Limited quantities of onsite-generated transuranic waste (TRU) are also stored temporarily at the RWMC. The RWMC is composed of the Area 5 Radioactive Waste Management Site (RWMS) and the Waste Examination Facility (WEF) and supporting administrative buildings, parking areas, and utilities. The operational units of the Area 5 RWMS include active, inactive, and closed LLW and MLLW cells and a Real Time Radiography Building. The operational units of the WEF include the TRU Pad, TRU Pad Cover Building, TRU Loading Operations Area, WEF Yard, WEF Drum Holding Pad, Sprung Instant Structure, and the Visual Examination and Repackaging Building.

As low as reasonably achievable (ALARA): an approach to radiation safety that strives to manage and control doses to the work force and general public.

Atom: the smallest particle of an element capable of entering into a chemical reaction.

Atomic number: the number of protons in the nucleus of an atom, which determines the chemical properties of an element and its place in the periodic table.

B **Background:** as used in this report, background is the term for the amounts of chemical constituents or radioactivity in the environment that are not caused by Nevada National Security Site operations. In the broader context outside this report, background radiation refers to radiation arising from natural sources always present in the environment, including solar and cosmic radiation from outer space and naturally radioactive elements in the atmosphere, the ground, building materials, and the human body.

Becquerel (Bq): the International System of Units unit of activity of a radionuclide, equal to the activity of a radionuclide having one spontaneous nuclear transition per second.

Beta particle: a negatively charged particle emitted from the nucleus of an atom, having charge, mass, and other properties of an electron, emitted from fission products such as cesium-137.

Beta radioactivity: ionizing radiation consisting of beta particles emitted in the radioactive decay of an atomic nucleus.

Biological oxygen demand (BOD): a measure of the amount of dissolved oxygen that microorganisms need to break down organic matter in water; used as an indicator of water quality.

Bureau of Land Management (BLM) herd management areas (HMA): the BLM manages wild horses and burros in 177 herd management areas across 10 western states. Each HMA is unique in its terrain features, local climate and natural resources, just as each herd is unique in its history, genetic heritage, coloring and size distribution (source: https://www.blm.gov/programs/wild-horse-and-burro/herd-management/herd-management-areas).

C **Clean Air Package, 1988, (CAP88-PC): a** computer model with a set of computer programs, databases and associated utility programs for estimating dose and risk from radionuclideemissions to air. CAP-88 is a regulatory compliance tool under the National Emissions Standard for Hazardous Air Pollutants (NESHAP) (source: https://www.epa.gov/radiation/cap-88-pc).

Closure-in-place: the stabilization or isolation of pollutants, hazardous wastes, and solid wastes, with or without partial treatment, removal activities, and/or post-closure monitoring. Closures-in-place of legacy contamination sites on and off the Nevada National Security Site, which are managed by the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office, are attained in accordance with approved corrective action plans outlined in the 1996 Federal Facility Agreement and Consent Order (as amended) between the U.S. Department of Energy, the U.S. Department of Defense, and the State of Nevada.

Code of Federal Regulations (CFR): a codification of all regulations promulgated by federal government agencies.

Collective population dose: the sum of the total effective dose equivalents of all individuals within a defined population. The unit of collective population dose is person-rem or person-sievert. Collective population dose may also be referred to as "collective effective dose equivalent" or simply "population dose."

Committed dose equivalent: the dose equivalent to a tissue or organ over a 50-year period after an intake of a radionuclide into the body. Committed dose equivalent is expressed in units of rem or sievert.

Committed effective dose equivalent (CEDE): the sum of the committed dose equivalents to various tissues in the body, each multiplied by an appropriate weighting factor representing the relative vulnerability of different parts of the body to radiation. Committed effective dose equivalent is expressed in units of rem or sievert.

Community water system: as defined in Nevada Revised Statute 445A.808, a public water system that has at least 15 service connections used by year-round residents of the area served by the system; or regularly serves at least 25 year-round residents of the area served by the system.

Compliance Level (CL): the Clean Air Act National Emission Standards for Hazardous Air Pollutants Concentration Level for Environmental Compliance. The CL value represents the annual average concentration that would result in a dose of 10 millirem per year, which is the federal dose limit to the public from all radioactive air emissions.

Composite analysis (CA): an analysis of the risks posed by all wastes disposed in a low-level radioactive waste disposal facility and by all other sources of residual contamination that may interact with the disposal site. CAs, along with performance assessments (PAs), are conducted for the Area 3 and Area 5 Radioactive Waste Management Sites on the Nevada National Security Site to assess and predict their long-term performance.

Confining unit: a geologic unit of relatively low permeability that impedes the vertical movement of groundwater.

Contaminant Boundary: a type of boundary developed for an Underground Test Area (UGTA) corrective action unit (CAU). It is a forecast perimeter and a lower hydrostratigraphic unit boundary that delineates the potential extent of radionuclide-contaminated groundwater from underground testing for 1,000 years. Contaminated groundwater is defined as water exceeding the radiological standards of the Safe Drinking Water Act (SDWA). The forecasted contamination is a volume, which is projected upward to the ground surface to define a two-dimensional contaminant boundary perimeter. Simulation modeling of the transport of radiological contaminants in groundwater is usually used to forecast the locations of the contaminant boundaries within the next 1,000 years. CAU-specific contaminant boundaries are approved by the Nevada Division of Environmental Protection.

Continuous release: defined by the U.S Environmental Protection Agency as a release that occurs without interruption or abatement, or that is routine, anticipated, intermittent, and incidental to normal operation or treatment process.

Criteria pollutants: those air pollutants designated by the U.S. Environmental Protection Agency as potentially harmful and for which National Ambient Air Quality Standards under the Clean Air Act have been established to protect the public health and welfare. These pollutants include sulfur dioxide (SO_2), nitrogen oxides (NO_X), carbon monoxide (CO), ozone, lead, and particulate matter equal to or less than 10 microns in diameter (PM10). The State of Nevada, through an air quality permit, establishes emission limits on the Nevada National Security Site for SO_2, NO_X, CO, PM10, and volatile organic compounds (VOCs). Ozone is not regulated by the permit as an emission, as it is formed in part from NO_X and VOCs. Lead is considered a hazardous air pollutant (HAP) as well as a criteria pollutant, and lead emissions on the Nevada National Security Site are reported as part of the total HAP emissions. Lead emissions above a specified threshold are also reported under Section 313 of the Emergency Planning and Community Right-to-Know Act.

Critical Level (L_C) (also known as decision level): the counts of radioactivity (or concentration level of a radionuclide) in a sample that must be exceeded before there is a specified level of confidence (typically 95 or 99 percent) that the sample contains radioactive material above the background.

Critical receptor sampler: a type of radiological air monitoring station on the NNSS that samples air particulates and water vapor for the purpose of assessing dose to the public from airborne radionuclides originating from past or current NNSS activities and documenting if the assessed dose exceeds the DOE public dose limit of 10 millirems per year from inhalation. The U.S. Environmental Protection Agency has approved a sampling network of six such stations on the NNSS. The critical receptor is assumed to be an individual who resides at the station location. Air sample analysis results for each station identify whether this hypothetical individual would be exposed to airborne radionuclides that would exceed the DOE public dose limit. It is assumed that if air sampling results at these six locations on the NNSS indicate doses below the public limit, then the public who reside off the NNSS at greater distances from the NNSS sources of airborne radionuclides, then the offsite public dose is even less.

Curie (Ci): a unit of measurement of radioactivity, defined as the amount of radioactive material in which the decay rate is 3.7×10^{10} (37 billion) disintegrations per second; one Ci is approximately equal to the decay rate of one gram of pure radium.

D **Daughter nuclide (also known as isotope or product):** a nuclide formed by the radioactive decay of another nuclide, which is called the parent.

Decision level (also known as critical level): the counts of radioactivity (or concentration level of a radionuclide) in a sample that must be exceeded before there is a specified level of confidence (typically 95 or 99 percent) that the sample contains radioactive material above the background...

Depleted uranium: uranium having a lower proportion of the isotope ^{235}U than is found in naturally occurring uranium. The masses of the three uranium isotopes with atomic weights 238, 235, and 234 occur in depleted uranium in the weight-percentages 99.8, 0.2, and 5×10^{-4}, respectively.

Derived Concentration Standard (DCS): concentration of a given radionuclide in either water or air that results in a member of the public receiving 100 millirem (1 millisievert) effective dose following continuous exposure for one year via each of the following pathways: ingestion of water, submersion in air, and inhalation. They replace the Derived Concentration Guides previously published by the U.S. Department of Energy (DOE) in 1993 in DOE Order DOE O 5400.5. Since 1993, the radiation protection framework on which DCSs are based has evolved with more sophisticated biokinetic and dosimetric information provided by the International Commission on Radiological Protection (ICRP), thus enabling consideration of age and gender. DOE-STD-1196-2011 establishes DCS values that reflect the current state of knowledge and practice in radiation protection. These DCSs are based on age-specific effective dose coefficients, revised gender specific physiological parameters for the Reference Man (ICRP 2002), and the latest information on the energies and intensities of radiation emitted by radionuclides (ICRP 2008).

Designated pollutant: any pollutant regulated by the Clean Air Act's New Source Performance Standards that is not a criteria pollutant. Examples of these are acid mist, fluorides, hydrogen sulfide in acid gas, and total reduced sulfur.

Diel: of or relating to a 24-hour period, especially a regular daily cycle, as of the physiology or behavior of an organism.

Diffuse source: an area source from which radioactive air emissions are continuously distributed over a given area or emanate from a number of points randomly distributed over the area (generally, all sources other than point sources). Diffuse sources are not actively ventilated or exhausted. Diffuse sources include: emissions from large areas of contaminated soil, resuspension of dust deposited on open fields, ponds and uncontrolled releases from openings in a structure.

Dose: the energy imparted to matter by ionizing radiation; the unit of absorbed dose is the rad, equal to 0.01 joules per kilogram for irradiated material in any medium.

Dose equivalent: a measure of the biological damage to living tissue as a result of radiation exposure. Also known as the "biological dose," the dose equivalent is calculated as the product of absorbed dose in tissue multiplied by a quality factor and then sometimes multiplied by other necessary modifying factors at the location of interest. The dose equivalent is expressed numerically in rems or sieverts (Sv).

Dosimeter: a portable detection device for measuring the total accumulated exposure to ionizing radiation.

Dosimetry: the theory and application of the principles and techniques of measuring and recording radiation doses.

E

Effective dose equivalent (EDE): an estimate of the total risk of potential effects from radiation exposure; it is the summation of the products of the dose equivalent and weighting factor for each tissue. The weighting factor is the decimal fraction of the risk arising from irradiation of a selected tissue to the total risk when the whole body is irradiated uniformly to the same dose equivalent. These factors permit dose equivalents from non-uniform exposure of the body to be expressed in terms of an EDE that is numerically equal to the dose from a uniform exposure of the whole body that entails the same risk as the internal exposure. The EDE includes the committed effective dose equivalent from internal deposition of radionuclides and the EDE caused by penetrating radiation from sources external to the body, and is expressed in units of rem or sievert.

Energy Savings Performance Contract (ESPC): a type of Energy Performance Contract (EPC). EPCs are alternative financing mechanisms authorized by the U.S. Congress designed to accelerate investment in cost effective energy conservation measures in existing federal buildings. Another type of EPC is a Utility Energy Service Contract. ESPCs allow federal agencies to accomplish energy savings projects without up-front capital costs and without special Congressional appropriations. The contract is a partnership between a federal agency and an energy service company (ESCO). The ESCO conducts a comprehensive energy audit for the federal facility and identifies improvements to save energy. In consultation with the federal agency, the ESCO designs and constructs a project that meets the agency's needs and arranges the necessary financing. The ESCO guarantees that the improvements will generate energy cost savings sufficient to pay for the project over the term of the contract. After the contract ends, all additional cost savings accrue to the agency. The savings must be guaranteed and the federal agencies may enter into a multiyear contract for a period not to exceed 25 years.

Exposure: the absorption of ionizing radiation or ingestion of a radioisotope. Acute exposure is a large exposure received over a short period. Chronic exposure is exposure received over a long period, such as during a lifetime.

F **Federal citation:** a reference to a federal law identified by its Public Law (Pub. L) or United States Code (USC) abbreviation, or a reference to the implementing regulation of a federal law identified by its Code of Federal Regulations (CFR) abbreviation. CFR citations are used in this report unless none have been written, in which case, USC citations are used. If a public law has yet to be incorporated into the USC, then its public law (Pub. L) citation is used.

When a bill is signed by the President and becomes a new public law, it is assigned a law number, legal statutory citation, and prepared for publication as a slip law. Citations for public laws include the abbreviation, Pub. L., the Congress number, and the number of the law. At the end of each session of Congress, the slip laws are compiled into bound volumes called the Statutes at Large, which present a chronological arrangement of the laws in the order that they have been enacted.

Every 6 years, public laws are incorporated into the USC, which is a codification of all general and permanent laws of the United States. They are assigned a USC number which reflects their relationship to similar laws or laws that govern similar programs. A supplement to the USC is published during each interim year until the next comprehensive volume is published. The USC is arranged by subject matter, and it shows the present status of laws with amendments already incorporated in the text that have been amended on one or more occasions.

Implementing regulations for federal laws are written by the government agencies responsible for the subject matter of the laws and explain in detail how the laws are to be carried out. For example, the United States Environmental Protection Agency writes the regulations concerning water pollution control which are found in Title 40 of the CFR, while the U. S. Fish and Wildlife Service writes the regulations concerning endangered species protection found in Title 50 of the CFR.

G **Gamma radiation:** high-energy, short-wavelength, ionizing, electromagnetic radiation emitted from the nucleus of an atom, frequently accompanying the emission of alpha or beta particles. It consists of photons in the highest observed range of photon energy. Gamma radiation (or gamma rays) easily pass through the human body but can be almost completely blocked by about 40 inches of concrete, 40 feet of water, or a few inches of lead.

Gray (Gy): the International System of Units unit of measure for absorbed dose; the quantity of energy imparted by ionizing radiation to a unit mass of matter, such as tissue. One gray equals 100 rads, or 1 joule per kilogram.

Gross alpha: the measure of radioactivity caused by all radionuclides present in a sample that emit alpha particles. Gross alpha measurements reflect alpha activity from all sources, including those that occur naturally. Gross measurements are used as a method to screen samples for relative levels of radioactivity.

Gross beta: the measure of radioactivity caused by all radionuclides present in a sample that emit beta particles. Gross beta measurements reflect beta activity from all sources, including those that occur naturally. Gross measurements are used as a method to screen samples for relative levels of radioactivity.

H **Half-life:** the time required for one-half of the radioactive atoms in a given amount of material to decay; for example, after one half-life, half of the atoms will have decayed; after two half-lives, three-fourths; after three half-lives, seven-eighths; and so on, exponentially.

Hazardous air pollutant (HAP): a toxic air pollutant that is known or suspected to cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental effects. The U.S.

Environmental Protection Agency has set emission standards for 22 of the 187 designated HAPs. Examples of toxic air pollutants include benzene, which is found in gasoline; perchloroethylene, which is emitted from some dry cleaning facilities; and methylene chloride, which is used as a solvent and paint stripper by a number of industries. Examples of other listed HAPs include dioxin, asbestos, toluene, and metals such as cadmium, mercury, chromium, and lead compounds.

Hazardous waste (HW): hazardous wastes exhibit any of the following characteristics: ignitability, corrosivity, reactivity, or Extraction Procedure toxicity (yielding excessive levels of toxic constituents in a leaching test), but other wastes that do not necessarily exhibit these characteristics have been determined to be hazardous by the U.S. Environmental Protection Agency (EPA). Although the legal definition of hazardous waste is complex, according to the EPA, the term generally refers to any waste that, if managed improperly, could pose a threat to human health and the environment.

High-efficiency particulate air (HEPA) filter: a disposable, extended-media, dry-type filter used to capture particulates in an air stream; HEPA collection efficiencies are at least 99.97 percent for 0.3-micrometer diameter particles.

I **Incidental take:** as per the Endangered Species Act (ESA), 'take' means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct of a listed species under the ESA. An incidental take is a take that results from activities that are otherwise lawful.

International System of Units (SI): an international system of physical units that includes meter (length), kilogram (mass), kelvin (temperature), becquerel (radioactivity), gray (radioactive dose), and sievert (dose equivalent). The abbreviation, SI, comes from the French term Système International d'Unités.

Ion: (1) an atom that has too many or too few electrons, causing it to have an electrical charge, and therefore, be chemically active. (2) An electron that is not associated (in orbit) with a nucleus.

Ionizing radiation: a form of radiation, which includes alpha particles, beta particles, gamma rays, x-rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions. Compared to non-ionizing radiation, such as radio- or microwaves, or visible, infrared, or ultraviolet light, ionizing radiation is considerably more energetic. When ionizing radiation passes through material such as air, water, or living tissue, it deposits enough energy to produce ions by breaking molecular bonds and displace (or remove) electrons from atoms or molecules. This electron displacement may lead to changes in living cells. Given this ability, ionizing radiation has a number of beneficial uses, including treating cancer or sterilizing medical equipment. However, ionizing radiation is potentially harmful if not used correctly, and high doses may result in severe skin or tissue damage.

Isotope (also known as daughter nuclide or product): each of two or more forms of the same element that contain equal numbers of protons but different numbers of neutrons in their nuclei, and hence differ in relative atomic mass but not in chemical properties; in particular, a radioactive form of an element. For example, carbon-12 (^{12}C), the most common form of carbon, has six protons and six neutrons, whereas carbon-14 (^{14}C), the radioactive isotope of carbon, has six protons and eight neutrons.

L **L_C:** see Critical Level (L_C).

Low-level waste (LLW): defined by U.S. Department of Energy Manual DOE M 435.1-1, "Radioactive Waste Management Manual," as radioactive waste that is not high-level radioactive waste, spent nuclear fuel, transuranic waste, byproduct material (as defined in section 11e.(2) of the Atomic Energy Act of 1954, as amended), or naturally occurring radioactive material.

Lysimeter: an instrument for measuring the water percolating through soils and determining the dissolved materials.

M **Maximally exposed individual (MEI):** a hypothetical member of the public at a fixed location who, over an entire year, receives the maximum effective dose equivalent (summed over all pathways) from a given source of radionuclide releases to air. Generally, the MEI is different for each source at a site.

Maximum contaminant level (MCL): the highest level of a contaminant in drinking water that is allowed by U.S. Environmental Protection Agency regulation.

Minimum detectable concentration (MDC): also known as the lower limit of detection, the smallest amount of radioactive material in a sample that can be quantitatively distinguished from background radiation in the sample with 95 percent confidence.

Mixed low-level waste (MLLW): waste containing both radioactive and hazardous components. It is defined by U.S. Department of Energy Manual DOE M 435.1-1, "Radioactive Waste Management Manual," as low-level waste determined to contain both source, special nuclear, or byproduct material subject to the Atomic Energy Act of 1954, as amended, and a hazardous component subject to the Resource Conservation and Recovery Act (RCRA), as amended.

N **Non-community water system:** as defined in Nevada Revised Statute 445A.828, it is a public water system that is not a community water system.

Nuclide: any species of atom that exists for a measurable length of time. A nuclide can be distinguished by its atomic mass, atomic number, and energy state.

O **Ozone Depleting Substances (ODS):** substances regulated by the EPA in the U.S. as Class I or Class II controlled substances. Class I substances have a higher ozone depletion potential (0.2 or higher) and have been completely phased out in the U.S. With a few exceptions, this means no one can produce or import Class I substances. Class I ODS include halons, chlorofluorocarbons (CFCs), methyl chloroform, carbon tetrachloride, and methyl bromide. Class II substances have an ozone depletion potential less than 0.2 and are all hydrochlorofluorocarbons (HCFCs). HCFCs were developed as transitional substitutes for many Class I substances. New production and import of most HCFCs will be phased out by 2020. The most common HCFC in use today is HCFC-22 or R-22, a refrigerant still used in existing air conditioners and refrigeration equipment.

P **Performance assessment (PA):** a systematic analysis of the potential risks posed by a waste disposal facility to the public and to the environment from disposed low-level radioactive waste. PAs are conducted, along with composite analyses (CAs), for the Area 3 and Area 5 Radioactive Waste Management Sites on the Nevada National Security Site to assess and predict their long-term performance.

Piezometer: an instrument for measuring the pressure of a liquid or gas, or something related to pressure (such as the compressibility of liquid). Piezometers are often placed in boreholes to monitor the pressure or depth of groundwater.

Plowshare Program: the program established by the United States Atomic Energy Commission (AEC), now the Department of Energy (DOE), as a research and development activity to explore the technical and economic feasibility of using nuclear explosives for industrial applications. The reasoning was that the relatively inexpensive energy available from nuclear explosions could prove useful for a wide variety of peaceful purposes. The Plowshare Program began in 1958 and continued through 1975. Between December 1961 and May 1973, the U.S. conducted 27 Plowshare nuclear explosive tests comprising 35 individual detonations. (source: https://www.osti.gov/opennet/reports/plowshar.pdf)

Point-source: a single well-defined point (origin) of an airborne release, such as a stack or vent or other functionally equivalent structure. Point sources are actively ventilated or exhausted. Point source monitoring is monitoring emissions from a stack or vent.

Polychlorinated biphenyls (PCBs): a chemical belonging to the broad family of man-made organic chemicals known as chlorinated hydrocarbons. PCBs were domestically manufactured from 1929 until their manufacture was banned by the U.S. Congress in 1979. They have a range of toxicity and vary in consistency from thin, light-colored liquids to yellow or black waxy solids. Due to their non-flammability, chemical stability, high boiling point, and electrical insulating properties, PCBs were used in hundreds of industrial and commercial applications including electrical, heat transfer, and hydraulic equipment; as plasticizers in paints, plastics, and rubber products; in pigments, dyes, and carbonless copy paper; and many other industrial applications. PCBs can persist in the environment and accumulate in the food chain. PCBs' are classified as persistent organic pollutants. Their production was banned by the Stockholm Convention on Persistent Organic Pollutants in 2001. The International Research Agency on Cancer (IRAC) rendered PCBs as definite carcinogens in humans. According to the U.S. Environmental Protection Agency, PCBs cause cancer in animals and are probable human carcinogens.

Polychlorinated biphenyl (PCB) bulk waste: building material (i.e., substrate) "coated or serviced" with PCB bulk product waste (e.g., caulk, paint, mastics, sealants) at the time of disposal are managed as a PCB bulk product waste, even if the PCBs have migrated from the overlying bulk product waste into the substrate (source: https://www.epa.gov/pcbs/polychlorinated-biphenyl-pcb-guidance-reinterpretation).

Potential to emit (PTE): the quantity of a criteria air pollutant that each facility/piece of equipment would emit annually if it were operated for the maximum number of hours at the maximum production rate specified under its applicable air permit.

Private water system: a water system that is not a public water system, as defined in Nevada Revised Statute 445A.235, and is not regulated under State of Nevada permits.

Product (also known as daughter nuclide or isotope): each of two or more forms of the same element that contain equal numbers of protons but different numbers of neutrons in their nuclei, and hence differ in relative atomic mass but not in chemical properties; in particular, a radioactive form of an element. For example, carbon-12 (^{12}C), the most common form of carbon, has six protons and six neutrons, whereas carbon-14 (^{14}C), the radioactive isotope of carbon, has six protons and eight neutrons.

Public water system (PWS): as defined in Nevada Revised Statute 445A.235, it is a system, regardless of ownership, that provides the public with water for human consumption through pipes or other constructed conveyances, if the system has 15 or more service connections, as defined in NRS 445A.843, or regularly serves 25 or more persons. The three PWSs on the NNSS are permitted by the State of Nevada as non-community water systems.

Q **Quality assurance (QA):** a system of activities whose purpose is to provide the assurance that standards of quality are attained with a stated level of confidence.

Quality control (QC): procedures used to verify that prescribed standards of performance are attained.

Quality factor: the factor by which the absorbed dose (rad) is multiplied to obtain a quantity that expresses (on a common scale for all ionizing radiation) the biological damage to exposed persons, usually used because some types of radiation, such as alpha particles, are biologically more damaging than others. Quality factors for alpha, beta, and gamma radiation are in the ratio 20:1:1.

R **Rad:** one of the two units used to measure the amount of radiation absorbed by an object or person, known as the "absorbed dose," which reflects the amount of energy that radioactive sources deposit in materials through which they pass. The radiation-absorbed dose (rad) is the amount of energy (from any type of ionizing radiation) deposited in any medium (e.g., water, tissue, air). An absorbed dose of 1 rad means that 1 gram of material absorbed 100 ergs of energy (a small but measurable amount) as a result of exposure to radiation. The related international system unit is the gray (Gy), where 1 Gy is equivalent to 100 rad.

Radioactive decay: the spontaneous transformation of one radionuclide into a different nuclide (which may or may not be radioactive), or de-excitation to a lower energy state of the nucleus by emission of nuclear radiation, primarily alpha or beta particles, or gamma rays (photons).

Radioactivity: the spontaneous emission of nuclear radiation, generally alpha or beta particles, or gamma rays, from the nucleus of an unstable isotope.

Radioisotope: same as radionuclide.

Radionuclide: may also be called a radioactive nuclide, radioisotope, or radioactive isotope. It is an atom that has excess nuclear energy, making it unstable. This excess energy can either create and emit from the nucleus new radiation (gamma radiation) or a new particle (alpha particle or beta particle), or transfer this excess energy to one of its electrons, causing it to be ejected (conversion electron). During this process, the radionuclide is said to undergo radioactive decay.

Radon progeny: When radon in air decays, it forms a number of short-lived radioactive decay products (radon progeny), which include polonium-218, lead-214, bismuth-214 and polonium-214. All are radioactive isotopes of heavy metal elements and all have half-lives that are much less than that of radon.

Regulatory Boundary: a type of boundary developed for an Underground Test Area (UGTA) corrective action unit (CAU). It is established by negotiation between the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) and the Nevada Division of Environmental Protection (NDEP) during the CAU closure process based upon negotiated CAU-specific objectives to provide protection for the public and the environment from the effects of migration of radioactive contaminants. If radionuclides above the agreed-upon levels reach this boundary, NNSA/NFO is required to submit a plan for NDEP approval that will identify how the CAU-specific regulatory boundary objectives will be met.

Rem: one of the two standard units used to measure the dose equivalent (or effective dose), which combines the amount of energy (from any type of ionizing radiation that is deposited in human tissue), along with the medical effects of the given type of radiation. For beta and gamma radiation, the dose equivalent is the same as the absorbed dose. By contrast, the dose equivalent is larger than the absorbed dose for alpha and neutron radiation, because these types of radiation are more damaging to the human body. Thus, the dose equivalent (in rems) is equal to the absorbed dose (in rads) multiplied by the quality factor of the type of radiation [see Title 10, Section 20.1004, of the *Code of Federal Regulations* (10 CFR 20.1004), "Units of Radiation Dose"]. The related international system unit is the sievert (Sv), where 100 rem is equivalent to 1 Sv.

Roentgen (R): a unit of measurement used to express radiation exposure in terms of the amount of ionization produced in a volume of air. It is the amount of gamma or x-rays required to produce ions resulting in a charge of 0.000258 coulombs/kilogram of air under standard conditions. Named after Wilhelm Roentgen, the German scientist who discovered x-rays in 1895.

S **Saturated zone:** a zone below the earth's surface below which all pore spaces between rocks or soil are completely filled with water.

Section 106: Section 106 of the National Historic Preservation Act requires federal agencies to take into account the effects of their undertakings on historic properties and afford the Council a reasonable opportunity to comment on such undertakings (source: https://www.achp.gov/protecting-historic-properties).

Sievert (Sv): the International System of Units unit of radiation dose equivalent and effective dose equivalent, that is the product of the absorbed dose (gray), quality factor, distribution factor, and other necessary modifying factors; 1 Sv equals 100 rem.

Solid waste: most simply, waste generated by routine operations that is not regulated as hazardous or radioactive by state or federal agencies.

Source term: the amount of a specific pollutant emitted or discharged to a particular medium, such as the air or water, from a particular source.

Spectroscopy: the study of the interaction between matter and electromagnetic radiation.

Subcritical experiment: an experiment using high explosives and nuclear weapon materials (including special nuclear materials like plutonium) to gain data used to maintain the nuclear stockpile without conducting nuclear explosions banned by the Comprehensive Nuclear Test Ban Treaty.

Subsidence crater: a hole or depression left on the surface of an area which has had an underground (usually nuclear) explosion.

T **Thermoluminescent dosimeter (TLD):** a device used to measure external beta or gamma radiation levels, and which contains a material that, after exposure to beta or gamma radiation, emits light when processed and heated.

Total effective dose equivalent (TEDE): The sum of the external exposures and the committed effective dose equivalent (CEDE) for internal exposures.

Transuranic (TRU) waste: material contaminated with alpha-emitting transuranium nuclides, which have an atomic number greater than 92 (e.g., ^{239}Pu), half-lives longer than 20 years, and are present in concentrations greater than 100 nanocuries per gram of waste. Mixed TRU waste contains hazardous waste also.

Tritium (^3H): a radioactive form of hydrogen that is produced naturally in the upper atmosphere when cosmic rays strike nitrogen molecules in the air. Although tritium can be a gas, its most common form is in water, because, like non-radioactive hydrogen, tritium reacts with oxygen to form water. Tritium replaces one of the stable hydrogens in the water molecule, H_2O, and is called tritiated water (HTO). Like H_2O, tritiated water is colorless and odorless. Naturally-occurring tritium is found in very small or trace amounts in the environment as HTO, which easily disperses in the atmosphere, water bodies, soil, and rock. Tritium is also produced during nuclear weapons explosions, as a by-product in nuclear reactors producing electricity, and in special production reactors, where the isotope lithium-6 is bombarded to produce tritium. In the mid-1950s and early 1960s, tritium was widely dispersed during the above-ground testing of nuclear weapons. The quantity of tritium in the atmosphere from weapons testing peaked in 1963 and has been decreasing ever since. Tritium is a contaminant of groundwater in select areas of the NNSS as a result of historical underground nuclear testing and is the contaminant of concern being monitored in NNSS groundwater samples. Tritium decays at a half-life of 12.3 years by emitting a low-energy beta particle. In 1976, EPA established a dose-based drinking water standard of 4 mrem per year and set a maximum contaminant level for drinking water of 20,000 picocuries per liter (pCi/L) for tritium, the level assumed to yield a dose of 4 mrem per year. One year of drinking water with this amount of contamination would produce approximately the same dose of radiation you would get during a single commercial flight between Los Angeles and New York City.

U **Uncertainty:** the parameter associated with a sample measurement that characterizes the range of the measurement that could reasonably be attributed to the sample. Used in this report, the uncertainty value is established at ± 2 standard deviations.

United States Code (USC): a codification of all general and permanent laws of the United States. Laws in the USC are grouped into various Titles, Chapters, and Sections by topic. For example, the citation 16 USC 1531-1544 is for Title 16 (Conservation), Sections 1531-1544 (in Chapter 35) which comprise the law called the Endangered Species Act.

Unsaturated zone: that portion of the subsurface in which the pores are only partially filled with water and the direction of water flow is vertical; also referred to as the vadose zone.

Use-Restriction (UR) Boundary: a type of boundary developed for an Underground Test Area (UGTA) corrective action unit (CAU). It delineates an area expected to require institutional controls to restrict access to potentially contaminated groundwater. A UR boundary is established by negotiation between the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) and the Nevada Division of Environmental Protection. It is based primarily on ***contaminant boundary*** (see Glossary definition) forecasts. A UR boundary is established to protect site workers from inadvertently contacting, or site activities from affecting, the flow paths of contaminated groundwater. NNSA/NFO, and any future land manager, must maintain all official CAU-specific UR boundary records.

V **Vadose zone:** the partially saturated or unsaturated region above the water table that does not yield water to wells; also referred to as the unsaturated zone.

W **Water table:** the underground boundary between saturated and unsaturated soils or rock. It is the point beneath the surface of the ground at which natural groundwater is found. It is the upper surface of a saturation zone where the body of groundwater (i.e., aquifer) is not confined by an overlying impermeable formation. In the situation where an aquifer does have an overlying confining formation, the aquifer has no water table.

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Appendix C: Acronyms and Abbreviations

ac	acre(s)
Ac	actinium
ACHP	Advisory Council on Historic Preservation
ACM	asbestos-containing material
AEA	Atomic Energy Act
AEC	Atomic Energy Commission
AFV	alternative fuel vehicle
AICP	American Indian Consultation Program
ALARA	as low as reasonably achievable
Am	americium
ANSI/HPS	American National Standards Institute/Health Physics Society
APP	affirmative procurement program
ARL	Army Research Laboratory
ARL/SORD	Air Resources Laboratory, Special Operations and Research Division
ARPA	Archaeological Resources Protection Act
ASCEM	Advanced Simulation Capability for Environmental Management
ASER	Annual Site Environmental Report
ASN	Air Surveillance Network
B	Background
BCG	Biota Concentration Guide
Be	beryllium
BEEF	Big Explosives Experimental Facility
BFF	Bureau of Federal Facilities
BGEPA	Bald and Golden Eagle Protection Act
bgs	below ground surface
BH	Bloomington Hills
BLM	Bureau of Land Management
BN	Bechtel Nevada
BO	Biological Opinion
BOD_5	5-day biological oxygen demand
Bq	becquerel
BREN	Bare Reactor Experiment–Nevada
BSDW	Bureau of Safe Drinking Water
BTU	British thermal unit
C	carbon (except in Chapter 6, where it denotes “control”)
CA	Composite Analysis
CAA	Clean Air Act
CADD	Corrective Action Decision Document
CAI	Corrective Action Investigation
CAIP	Corrective Action Investigation Plan
CAP	Corrective Action Plan
CAPP	Chemical Accident Prevention Program
CAS	Corrective Action Site
CAU	Corrective Action Unit
CCDAQ	Clark County Department of Air Quality
CCWRD	Clark County Water Reclamation District
CEDE	committed effective dose equivalent
CEI	Compliance Evaluation Inspection
CEM	Community Environmental Monitor
CEMP	Community Environmental Monitoring Program
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFC	chlorofluorocarbon
CFR	Code of Federal Regulations
CGTO	Consolidated Group of Tribes and Organizations
Ci	curie(s)
CL	compliance level (used in text for the Clean Air Act National Emission Standards for Hazardous Pollutants Concentration Level for Environmental Compliance)
cm	centimeter(s)
cm^2	square centimeter(s)
CNLV	City of North Las Vegas
Co	cobalt
CO	carbon monoxide
COC	contaminant of concern
COPC	contaminant of potential concern
CR	Closure Report
CRM	Cultural Resources Management
CRMP	Cultural Resources Management Program
Cs	cesium
CV	coefficient of variation

CWA	Clean Water Act
CX	Categorical Exclusion
CY	calendar year
DAF	Device Assembly Facility
DAG	Dry Alluvium Geology
DAQ	Department of Air Quality (Clark County)
DCS	Derived Concentration Standard
D&D	decontamination and decommissioning
DNWR	Desert National Wildlife Refuge
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOECOE	Department of Energy Common Operating Environment
DOECAP	U.S. Department of Energy Consolidated Audit Program
DOE/NV	U.S. Department of Energy, Nevada Operations Office
DOI	U.S. Department of Interior
DPF	Dense Plasma Focus
dpm	disintegrations per minute
DQA	Data Quality Assessment
DQO	Data Quality Objective
DRI	Desert Research Institute
DTCC	Desert Tortoise Conservation Center
DSA	Documented Safety Analysis
DU	depleted uranium
E1	Environmental 1
E2	Environmental 2
EA	Environmental Assessment
E&EM	Ecological and Environmental Monitoring
ECM	energy conservation measure
EDE	effective dose equivalent
EHS	extremely hazardous substance
EIS	Environmental Impact Statement
EISA	Energy Independence and Security Act of 2007
ELU	ecological landform units
EM	Environmental Management
EMAC	Ecological Monitoring and Compliance
EMAD	Engine Maintenance, Assembly, and Disassembly
EMC	Energy Management Council
EMP	Energy Management Program
EMS	Environmental Management System
EO	Executive Order
EODU	Explosive Ordnance Disposal Unit
EP	Environmental Programs
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
EPEAT	Electronic Product Environmental Assessment Tool
EPP	Environmentally Preferable Product
ER	Environmental Restoration
ERA	Environmental Research Associates
ESA	Endangered Species Act
ESCO	energy service company
ESPC	Energy Savings Performance Contract
ETDS	E-Tunnel Waste Water Disposal System
Eu	europium
EWDP	Early Warning Drill Program
EWG	Environmental Working Group
EWO	Environmental Waste Operations
F&I	Facility and Infrastructure
FD	field duplicate
FEMP	Federal Energy Management Program
FFACO	Federal Facility Agreement and Consent Order
FFCA	Federal Facility Compliance Act
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
ft	foot or feet
ft^2	square feet
ft^3	cubic feet
FS	U.S. Forest Service
FWS	U.S. Fish and Wildlife Service
FY	fiscal year
g	gram(s)
gal	gallon(s)
gal/ft^2	gallons used per square foot
GCD	Greater Confinement Disposal
$gCO_2e/mile$	grams of carbon dioxide equivalents per mile
GHG	greenhouse gas
GIS	Geographic Information System
gpm	gallon(s) per minute
GP	Guiding Principle
GSA	General Services Administration

gsf	gross square feet
Gy	gray(s)
Gy/d	gray(s) per day
^{3}H	tritium
ha	hectare(s)
HAP	hazardous air pollutant
HCFC	hydrochlorofluorocarbon
HENRE	High-Energy Neutron Reactions Experiment
HEPA	high-efficiency particulate air
HEST	High Explosives Simulation Test
HMA	Herd Management Area
HPSB	High Performance Sustainable Building
HQ	Headquarters
HTO	tritiated water
HVAC	heating, ventilation, and air conditioning
HW	hazardous waste
HWAA	Hazardous Waste Accumulation Area
HWSU	Hazardous Waste Storage Unit
I	iodine
IAEA	International Atomic Energy Agency
ICR	San Diego Zoo Institute for Conservation Research
ICRP	International Comission on Radiological Protection
ID	identification number
IL	investigation level
ILA	industrial, landscaping, and agricultural
in.	inch(es)
IOC	inorganic chemical
ISMS	Integrated Safety Management System
ISO	International Organization for Standardization
ISWG	Interagency Sustainability Working Group
IT	International Technology Corporation
JASPER	Joint Actinide Shock Physics Experimental Research
JIT	Just-In-Time
K	potassium
kg	kilogram(s)
kg/d	kilogram(s) per day
km	kilometer(s)
km^2	square kilometer(s)
L	liter(s)
LANL	Los Alamos National Laboratory
LATF	Los Alamos Technical Facility
lb	pound(s)
L_C	Critical Level (synonymous with Decision Level)
LCA	lower carbonate aquifer
LCS	laboratory control sample
L/d	liter(s) per day
LED	light emitting diode
LEED	Leadership in Energy and Environmental Design
LEPC	Local Emergency Planning Commission
LLNL	Lawrence Livermore National Laboratory
LLW	low-level waste
Lpm	liter(s) per minute
LoC	Level of Concern
log	logarithmic
LQAP	Laboratory Quality Assurance Plan
LRQA	Lloyd's Register Quality Assurance
m	meter(s)
m^2	square meter(s)
m^3	cubic meter(s)
M&O	Management and Operating
MAPEP	Mixed Analyte Performance Evaluation Program
MBTA	Migratory Bird Treaty Act
mCi	millicurie(s)
MCL	maximum contaminant level
MDC	minimum detectable concentration
MEI	maximally exposed individual
MET	meteorological
MGD	million gallons per day
mg/L	milligram(s) per liter
mGy/d	milligray(s) per day
MHD	Mercury Historic District
mi	mile(s)
mi^2	square mile(s)
mL	milliliter
MLLW	mixed low-level waste
mm	millimeter(s)
mmhos/cm	millimhos per centimeter
MOA	Memorandum of Agreement
Mod.	Modification

MQO	Measurement Quality Objectives
MR	monitor and report
mR	milliroentgen(s)
mR/d	milliroentgen(s) per day
mR/yr	milliroentgen(s) per year
mrad	millirad(s)
mrem	millirem(s)
mrem/yr	millirem(s) per year
MSDS	Material Safety Data Sheet
MSTS	Mission Support and Test Services, LLC
mSv	millisievert(s)
mSv/yr	millisievert(s) per year
$mTCO_2e$	metric ton(s) of carbon dioxide equivalent
mton	metric ton(s)
MTRU	mixed transuranic
MWDU	Mixed Waste Disposal Unit
MWSU	Mixed Waste Storage Unit
µCi/mL	microcurie(s) per milliliter
µg/L	microgram(s) per liter
µR/hr	microroentgen(s) per hour
µS/cm	microseimen(s) per centimeter
N	nitrogen
NAAQS	National Ambient Air Quality Standards
NAC	Nevada Administrative Code
NAGPRA	Native American Graves Protection and Repatriation Act
NATM	National Atomic Testing Museum
NCA	Nevada Combined Agency
NC-GWE	Nye County Groundwater Evaluation
NCRP	National Council on Radiation Protection
ND	not detected
NDEP	Nevada Division of Environmental Protection
NDOA	Nevada Department of Agriculture
NDOF	Nevada Department of Forestry
NDOW	Nevada Department of Wildlife
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NELAC	National Environmental Laboratory Accreditation Conference
NFS	Nuclear Fuel Services
NHPA	National Historic Preservation Act
N-I	Navarro-Intera, LLC
NLVF	North Las Vegas Facility
NNES	Navarro Nevada Environmental Services, LLC
NNHP	Nevada Natural Heritage Program
NNSA	U.S. Department of Energy, National Nuclear Security Administration
NNSA/NFO	U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office
NNSA/NSO	U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office
NNSA/SFO	U.S. Department of Energy, National Nuclear Security Administration Sandia Field Office
NNSS	Nevada National Security Site
NNSSER	Nevada National Security Site Environmental Report
NO_x	nitrogen oxides
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPTEC	Nonproliferation Test and Evaluation Complex
NRC	Non-Radiological Classified
NRCH	Non-Radiological Classified Hazardous
NREL	National Renewable Energy Laboratory
NRHP	National Register of Historic Places
NRS	Nevada Revised Statutes
NSHPO	Nevada State Historic Preservation Office
NSPS	New Source Performance Standards
NSSAB	Nevada Site Specific Advisory Board
NSSER	Nevada National Security Site Environmental Report
NSTec	National Security Technologies, LLC
NTS	Nevada Test Site
NTSER	Nevada Test Site Environmental Report
NTSF	National Transportation Stakeholders Forum
NTTR	Nevada Test and Training Range
NV	Nevada

NVCRIS	Nevada Cultural Resource Information System
NVLAP	National Voluntary Laboratory Accreditation Program
ODS	ozone-depleting substance
ORPS	Occurrence Reporting and Processing System
OSHA	Occupational Safety and Health Administration
OSTI	Office of Scientific and Technical Information
oz	ounce(s)
P2/WM	pollution prevention/waste minimization
PA	Performance Assessment
PAAA	Price-Anderson Amendments Act
Pb	lead
PCB	polychlorinated biphenyl
pCi	picocurie(s)
pCi/g	picocurie(s) per gram
pCi/L	picocurie(s) per liter
pCi/mL	picocurie(s) per milliliter
PEV	plug-in electric vehicle
PI	prediction interval
PIC	pressurized ion chamber
PLall	prediction limit for all enriched tritium measurements
PM	particulate matter
PM10	particulate matter equal to or less than 10 microns in diameter
PMOV	Pahute Mesa-Oasis Valley
POE	point of entry
PT	proficiency testing
PTE	potential to emit
Pu	plutonium
PUE	Power Utilization Effectiveness
PV	photovoltaic
PWS	public water system
QA	quality assurance
QAP	Quality Assurance Program
QAMAP	Quality Assurance Management and Assessment Plan
QAPP	Quality Assurance Program Plan
QC	quality control
QPID	Quality and Performance Improvement Division
QSAS	Quality Systems for Analytical Services
R	roentgen(s)
Ra	radium
rad	radiation absorbed dose (a unit of measure)
rad/d	rad(s) per day
RC	Radiological Control
RCRA	Resource Conservation and Recovery Act
RCT	Radiological Control Technician
REC	Renewable Energy Credit
rem	roentgen equivalent man
RER	relative error ratio
RFP	request for proposal
RIDP	Radionuclide Inventory and Distribution Program
RMAD	Reactor Maintenance, Assembly, and Disassembly
RNCTEC	Radiological/Nuclear Countermeasures Test and Evaluation Complex
ROTC	Record of Technical Change
RPD	relative percent difference
RREMP	Routine Radiological Environmental Monitoring Plan
RSL	Remote Sensing Laboratory
RTR	Real-Time Radiography
RW	Radioactive Waste
RWAP	Radioactive Waste Acceptance Program
RWMC	Radioactive Waste Management Complex
RWMS	Radioactive Waste Management Site
SA	Supplement Analysis
SAA	Satellite Accumulation Area
SAD	surface area disturbance
SAFER	Streamlined Approach for Environmental Restoration
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SC	specific conductance
SD	standard deviation
SDWA	Safe Drinking Water Act
SE	standard error of the mean
SER	Safety Evaluation Report

SERC	State Emergency Response Commissioner
SF_6	Sulfur hexafluoride
SHPO	State Historic Preservation Office
SI	International System of Units
SIS	Sprung Instant Structure
SMCL	Secondary maximum Contaminant Level
SNHD	Southern Nevada Health District
SNJV	Stoller-Navarro Joint Venture
SNL	Sandia National Laboratories
SOC	synthetic organic chemical
SORD	Special Operations and Research Division
SO_2	sulfur dioxide
SPCC	Spill Prevention, Control, and Countermeasure
SPO	Sustainability Performance Office
Sr	strontium
SSC	structures, systems, and components
SSP	Site Sustainability Plan
SSPP	Strategic Sustainability Performance Plan
STEM	science, technology, engineering, and math
STGWG	State Tribal Government Working Group
S.U.	standard unit(s) (for measuring pH)
Sv	sievert(s)
SWEIS	Site-Wide Environmental Impact Statement
SWO	Solid Waste Operations
T½	half-life
Tc	technetium
TDS	total dissolved solids
TEDE	total effective dose equivalent
TEK	traditional ecological knowledge
TES	Tribal Energy Summit
Th	thorium
TLD	thermoluminescent dosimeter
TNI	The NELAC Institute
TOC	total organic carbon
TOX	total organic halides
TPC	Tribal Planning Committee
TPCB	Transuranic Pad Cover Building
TPH	total petroleum hydrocarbons
TRI	Toxic Release Inventory
TRU	transuranic
TSaMP	Tritium Sampling and Monitoring Program
TSCA	Toxic Substances Control Act
TSR	Technical Safety Requirements
TSS	total suspended solids
TTR	Tonopah Test Range
U	uranium
UESC	Utility Energy Service Contract
UGT	underground test
UGTA	Underground Test Area
UIC	underground injection control
UNESE	Underground Nuclear Event Signatures Experiment Forensics
UR	use restriction
U.S.	United States
USACE	U.S. Army Corps of Engineers
USAF	U.S. Air Force
USC	United States Code
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
UST	underground storage tank
VERB	Visual Examination and Repackaging Building
VOC	volatile organic compound
VZM	vadose zone monitoring
WAC	Waste Acceptance Criteria
WDP	water delivery point
WEF	Waste Examination Facility
WIPP	Waste Isolation Pilot Plant
WMD	Waste Management Division
WO	Waste Operations
WW	water well
yr	year(s)

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Front cover photo:

Great Basin gopher snake *(Pituophis catenifer deserticola)* in Mercury, Area 23 (photo taken by Ron Warren)

Back cover photo:

Wild horses *(Equus caballus)* near Camp 17, Area 18 (photo taken by Patricia Hardesty)

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