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DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA

NNSA
National Nuclear Security Administration

NEVADA NATIONAL
NNSS
SECURITY SITE

September 2020

2019

Environmental Report



DOE/NV/03624--0899

NEVADA NATIONAL SECURITY SITE

NNSS

2019 Environmental Report

This report was prepared for:

U.S. Department of Energy
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Nevada Field Office

By:

Mission Support and Test Services LLC
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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 contribute 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, ecology, and cultural resources 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 wells under the Nye County Tritium Sampling and Monitoring Program.

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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.

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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.

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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

Patricia R. Hardesty
Mission Support and Test Services, LLC

Charles B. Davis
EnviroStat

1.1 Site Location

The U.S. Department of Energy (DOE), 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 at 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 lands managed by the federal government. 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 lands managed by the Bureau of Land Management. 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. NNSS terrain is typical 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). Yucca and Frenchman Flat are topographically and hydrographically closed and contain dry lake beds, or playas, at their lowest elevations. Jackass Flats is topographically and hydrographically open, and surface water from this basin flows off the NNSS to the south 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 highland areas are steep and dissected, and the slopes in the lowland areas are gentle. 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.

> Throughout this document, the definition of word(s) in ***bold italics*** may be found by referencing the Glossary, Appendix B.

The topography of the NNSS has been altered by historical DOE actions, particularly underground nuclear testing. The principal effect of testing was the creation of numerous collapse sinks (craters), the majority of which are in the Yucca Flat basin, with fewer in the 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.

1.3 Site History

The history of the NNSS and its current missions direct the focus and design of 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. In 1950, the site was established as the primary location for testing the nation's nuclear explosive devices. It was named

Figure 1-1. NNSS vicinity map

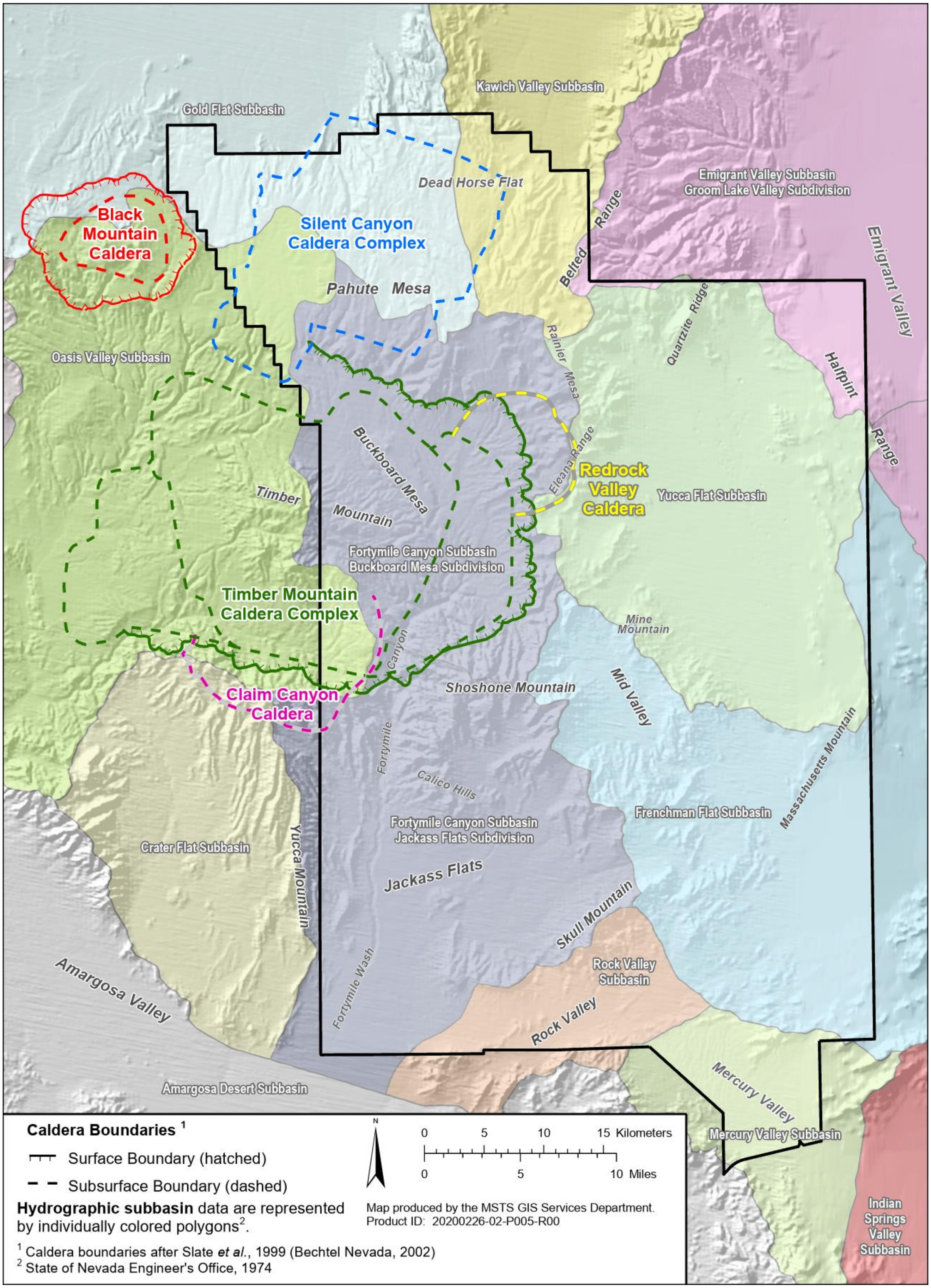

Figure 1-2. Major topographic features, calderas, and hydrographic subbasins of the NNSS

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. In 2010, the NTS was renamed the NNSS to reflect the diversity of nuclear, energy, and homeland security activities now conducted at the site. Experiments involving nuclear material are conducted at the NNSS, and are currently limited to ***subcritical experiments***.

Atmospheric Tests – The first test, an atmospheric nuclear explosive test, was conducted on the NTS in 1951. Tests conducted through the 1950s were predominantly atmospheric tests. They involved a nuclear explosive device detonated either on the ground surface, on a steel tower, suspended from tethered balloons, dropped from an aircraft, or placed on a rocket. Several tests, categorized as "safety experiments" and "storage-transportation tests," involved the destruction of a nuclear device with non-nuclear explosives. Some of these 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. The last above-ground test occurred in 1962.

Underground Tests – The first underground nuclear explosive test was a cratering test conducted in 1951. The first contained underground test was in 1957. Testing was discontinued during a bilateral moratorium that began October 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) nuclear explosive 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. The second highest yield crater test was Schooner, located on Pahute Mesa. 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, open-air nuclear reactor, nuclear engine, and nuclear furnace tests were conducted in Area 25, and tests with a nuclear ramjet engine were 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 were gaseous radioactive fission products.

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 Mission

NNSA/NFO directs facility management and program operations at the NNSS North Las Vegas Facility (NLVF) and the Remote Sensing Laboratory–Nellis (RSL-Nellis) in Nevada and as well as selected operations at five sites outside of Nevada: RSL-Andrews in Maryland, Livermore Operations in California, Los Alamos Operations and Sandia National Laboratories 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. Mission Support and Test Services, LLC, is the Management and Operating Contractor accountable for the successful execution of work and ensuring 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 following text box.

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 Program – 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 explosive 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

NNSS facilities and 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 ***Area 5 Radioactive Waste Management Complex (RWMC)*** and the Area 3 Radioactive Waste Management Site (RWMS) (Figure 1-3).

The primary NNSS activity in 2019 continued to be ensuring that the U.S. stockpile of nuclear weapons remains safe and reliable. Other 2019 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.

1.6 Scope of this Environmental Report

This report summarizes the NNSA/NFO environmental protection and monitoring programs data and the compliance status for calendar year 2019 at the NNSS and at its two support facilities, the NLVF and RSL-Nellis. This report also addresses environmental restoration projects conducted by the Environmental Management Nevada Program Office at the Tonopah Test Range (TTR).

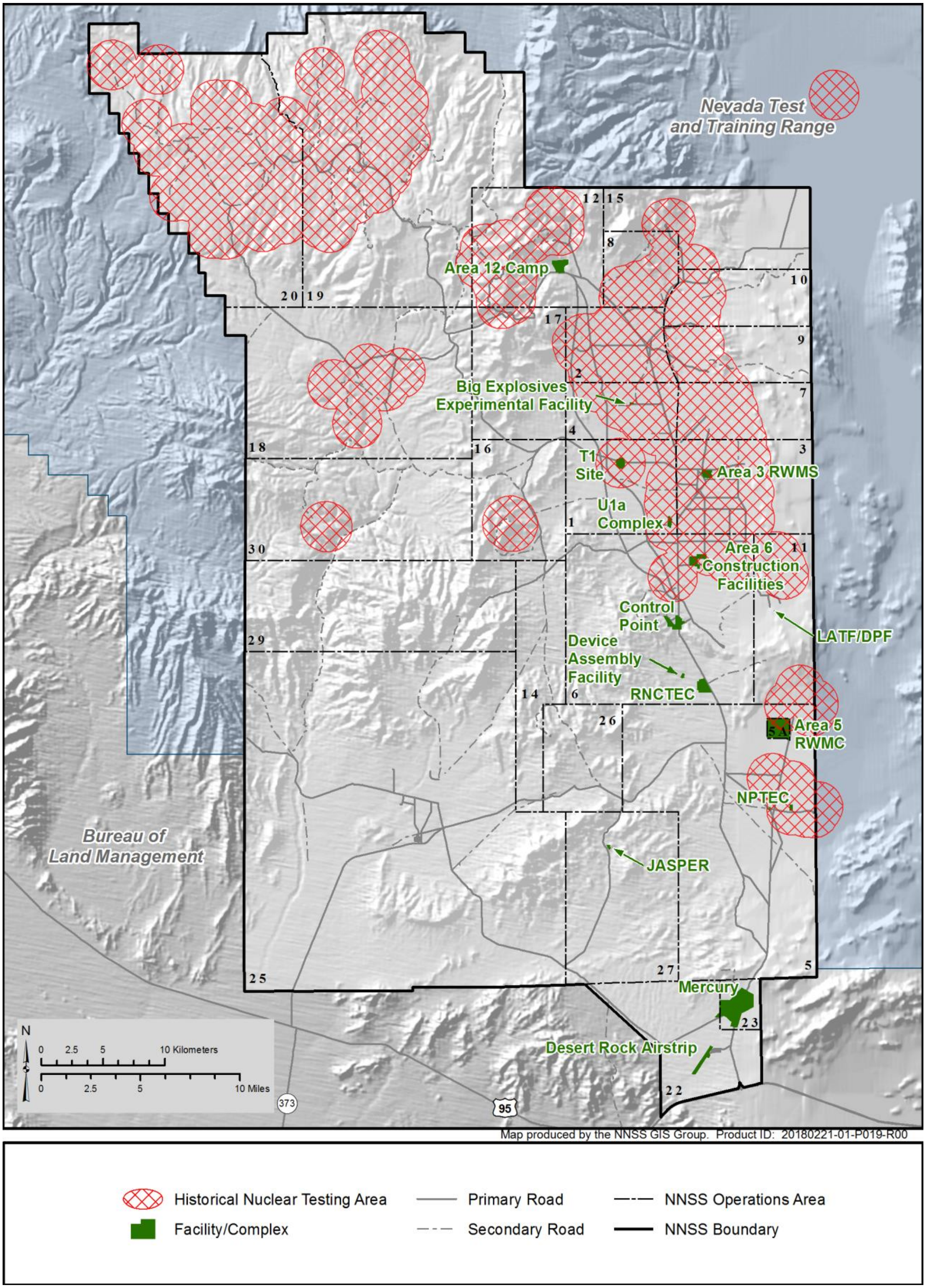

Figure 1-3. NNSS operational areas, principal facilities, and past nuclear testing areas

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 DOE, National Nuclear Security Administration Sandia Field Office 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 2019 and are provided by the Nevada State Demographer's Office (2020). The most recent population estimate for Nye County is 48,472, and the largest Nye County community is Pahrump (41,069), 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 (2,163), Amargosa (1,327), Beatty (998), Round Mountain (763), Gabbs (221), and Manhattan (138). Lincoln County to the east of the NNSS includes a few small communities, including Caliente (1,086), Pioche (798), Panaca (811), and Alamo (686), and Esmeralda County includes Goldfield (282). Clark County, southeast of the NNSS, is the major population center of Nevada and has an estimated population of 2,293,391. The total annual population estimate for all Nevada counties, cities, and towns is 3,112,937.

The Mojave Desert, 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 2018 taken from the U.S. Census Bureau (2020) 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 87,178. The next largest town, Cedar City, is located 280 km (174 mi) east-northeast of the NNSS and has an estimated population of 33,055.

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 41,193, and Kingman, 280 km (174 mi) southeast of the NNSS, with an estimated population of 31,480 (Arizona Department of Administration 2020).

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 37 billion nuclear disintegrations per second, the rate of nuclear disintegrations that occur in 1 gram of radium-226. 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 Units of Radiological Dose

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 usually 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.

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.

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 a 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 1-5. 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

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 of the numbers 1 2 3 3 4 5 5 5 6 is 4. The maximum is 6 and the minimum is 1. With an even number of numbers, the median is the average of the middle two.

1.8.12 Less Than (<) Symbol

A "less than" symbol (<) indicates 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. For some constituents the notation "ND" is 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 a reporting limit, which is often called the ***minimum detectable concentration***.

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. 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 at 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 (DOE), National Nuclear Security Administration Nevada Field Office (NNSA/NFO) conducts operations to ensure the protection of the environment and the public. In 2019, 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 current and past NNSA/NFO operations were well below the U.S. Environmental Protection Agency (EPA) ***dose***[1] limit set for the public, and the 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 and RSL-Nellis were within permit limits. In April, 2019, a Clark County Air Permit limit had been exceeded at the NLVF; the problem was resolved by early May (Table 2-7).

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 Complex (RWMC)*** continued to demonstrate that groundwater quality is not affected by disposal of low-level radioactive waste (LLW), mixed low-level radioactive waste (MLLW), and classified waste that may or may not contain hazardous and/or radioactive constituents. 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.

In 2017, the Nevada Division of Environmental Protection (NDEP) issued a Finding of Alleged Violation and Order to NNSA/NFO for the receipt and burial of 93 containers of MLLW at the Area 5 RWMC, which had been mislabeled from Nuclear Fuel Services in Tennessee. The Environmental Management (EM) Nevada Program, NDEP, and NNSA/NFO discussed a proposed Supplemental Environmental Project that would be undertaken in lieu of paying a penalty associated with the violation. In April 2019, NNSA/NFO transmitted the signed Settlement Agreement to NDEP for signature. The Settlement Agreement was signed by NDEP in May 2019 and provided a year to complete all actions.

Twenty-three hazardous substance spills occurred in 2019: 21 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.

[1] The definition of word(s) in ***bold italics*** may be found by referencing the Glossary, Appendix B.

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. In addition, the EPA offers the Enforcement and Compliance History Online 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)]	2019 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 P 451.1**	
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. Title 10 ***Code of Federal Regulations (CFR)*** Part 1021, *National Environmental Policy Act Implementing Procedures*, establishes procedures that the DOE shall use to comply with NEPA. DOE Policy DOE P 451.1, *National Environmental Policy Act Compliance Program*, establishes DOE internal requirements and responsibilities for implementing NEPA.	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 2019, 39 proposed projects/activities required analysis and documentation under NEPA compliance procedures, and 39 were exempt from any further NEPA review (Section 2.3).
Departmental Sustainability (DOE O 436.1)	
The NNSS' Management and Operating contractor, Mission Support and Test Services, LLC (MSTS), is responsible for environmental compliance. Requirements are documented in the MSTS Prime Contract, which includes Department of Energy Acquisition Regulation Clause 970.5204-2 Laws, Regulations, and DOE Directives requiring compliance with all applicable laws and regulations. DOE O 436.1, *Departmental Sustainability*, includes DOE Sustainability goals.	DOE Sustainable Environmental Stewardship goals are outlined in DOE's most current *Site Sustainability Plan Guidance Document* and incorporated into NNSA/NFO's Site Sustainability Plan. In December 2019, progress toward reaching 2019 goals was reported in the 2020 NNSA/NFO Site Sustainability Plan. NNSA/NFO met 17 of the 27 long-term DOE sustainability goals in 2019 and continues to work toward achieving the remaining eight (Chapter 3).
Air Quality	
Clean Air Act, 42 USC 7401 et seq. (1970) **• EPA: 40 CFR 50, 60, 61, 63, 80, 82, and 98 • NDEP: NAC 445B**	
The Clean Air Act and Nevada's Air Control laws regulate air pollutant release through permits and air quality limits. Radionuclide emissions are regulated via National Emission Standards for Hazardous Air Pollutants (NESHAP) authorizations. Emissions of ***criteria pollutants*** are regulated via National Ambient Air Quality Standards authorizations. Criteria and ***designated pollutants*** emitted from various industrial categories of facilities are regulated via New Source Performance Standards authorizations. The Clean Air Act also establishes production limits and a schedule for the phase-out of ***ozone depleting substances***.	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 various project-specific state-issued permits (Table 2-2). NESHAP compliance activities include radionuclide air monitoring, reporting asbestos abatement, monitoring and reporting emissions from generators and boilers, and management of gasoline/diesel storage tanks. National Ambient Air Quality Standards 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,

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

Description of Law/Regulation [(a)(b)]	2019 Compliance Status
Nevada Administrative Code (NAC) Chapter 445B, *Air Controls*, enforces Clean Air Act regulations and requires fugitive dust control and open burn authorizations.	and generators are subject to New Source Performance Standards. 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 Clean Air Act are submitted to NDEP, Clark County, and/or EPA Region 9. In 2019, all applicable requirements for monitoring, operating, and reporting for the Class II Air Quality Operating Permit (NDEP) were met. In 2019, monitored radioactive air emissions were below NESHAP limits (Section 4.1). 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	
<u>Clean Water Act, 33 USC 1251 et seq. (1972)</u> **• EPA: 40 CFR 109-140, 230, 231, 401, and 403 • NDEP: NAC 444, 445A, and 534**	
The Clean Water Act 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 an NPDES permit. NAC 444, *Sanitation (Sewage Disposal)*, and NAC 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. The 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 and the Clark County Water Reclamation District (CCWRD), respectively.	NNSA/NFO does not hold an 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, active and inactive sewage lagoons, septic tanks, septic tank pumpers, and a septic tank pumping contractor's license (Section 5.2). NNSA/NFO reports unplanned releases of hazardous substances to NDEP as required under NAC 445A. No such releases occurred in 2019 (Section 2.5). NNSA/NFO complies with NAC 534 for Underground Test Area (UGTA) activities. UGTA wells are maintained in compliance with the Clean Water Act and are regulated by the state through the *UGTA Fluid Management Plan*, an agreement between NNSA/NFO and NDEP. In 2019, UGTA well drilling fluids were monitored and managed in accordance with the plan (Section 5.1.3.7.3). The NLVF operates under a Class II Authorization to Discharge Permit issued by the City of North Las Vegas for sewer discharges, an NPDES DeMinimis permit for surface water discharge, and a No Exposure Waiver for exclusion from NPDES storm water permitting. Storm water is not contaminated by exposure to industrial activities or materials (Section A.1.2). CCWRD determined that the annual submission of a Zero Discharge Form for RSL-Nellis is sufficient to verify compliance with the Clean Water Act (Section A.2.2).

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

Description of Law/Regulation [(a)(b)]	2019 Compliance Status
	In 2019, all water chemistry parameters and contaminants that required monitoring in wastewater discharges and sewage lagoons were within permit limits, and all required inspections of wastewater systems were conducted.
<u>Safe Drinking Water Act, 42 USC 300f et seq. (1974)</u> **• EPA: 40 CFR 141-149 • NDEP: NAC 445A**	
The Safe Drinking Water Act 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 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 requires that PWSs meet both primary and secondary water quality standards. The Safe Drinking Water Act standards for radionuclides currently apply only to PWSs designated as ***community water systems.*** Although not required under the act, 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 that 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 2019, 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 City of North Las Vegas and meets or exceeds federal drinking water standards; no monitoring or reporting of water quality is required.
<u>Energy Independence and Security Act of 2007 (Pub. L. 110-140)</u>	
Section 438 of the act addresses storm water management and requires any development/redevelopment project involving a federal facility with a footprint over 5,000 gross square feet (gsf) to 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.	Storm water management strategies are addressed and incorporated into site design and building construction to meet requirements from the act for new developments.
Radiation Protection	
<u>Radiation Protection of the Public and the Environment (DOE O 458.1 Change 3)</u> **• DOE-STD-1196-2011 and DOE-STD-1153-2019**	
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***, as defined in DOE-STD-1196-2011, *Derived Concentration Technical Standard*, are used in the design and conduct of environmental radiological protection programs. The order sets a radiation dose limit of 100 millirem/year (mrem/yr) (1 millisievert/year [mSv/yr]) above ***background***	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 several chapters of this report. As in previous years, the calculated dose to the public and to the biota from NNSA/NFO operations in 2019 was below all DOE dose limits set by DOE O 458.1 and

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

Description of Law/Regulation [(a)(b)]	2019 Compliance Status
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-1153-2019, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota.*	DOE-STD-1153-2019, respectively. CAP88 and RESRAD-Biota models and Derived Concentration Standards 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 Corrective Actions	
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 (listed below) under CERCLA.
Resource Conservation Recovery Act (RCRA), 42 USC 6901 et seq. (1976) **• EPA: 40 CFR 259-282 • NDEP: NAC 444.570-7499, 444.850-8746, and 459.9921-999**	
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 waste (HW)*** to prevent contaminants from leaching into the environment from landfills, underground storage tanks, surface impoundments, and 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 HW (which includes 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 MLLW disposal cells (Section 10.3) and conducts post-closure monitoring for HW sites that were closed under RCRA prior to enactment of the Federal Facility Agreement and Consent Order (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 permit requirements were met in 2019.
Federal Facility Agreement and Consent Order (FFACO), as amended **• FFACO • NDEP**	
The FFACO was agreed to by the State of Nevada, DOE's EM Nevada Program, the U.S. Department of Defense, and DOE Legacy Management in 1996. Pursuant to Section 120(a) (4) of CERCLA and to Sections 6001 and 3004(u) of RCRA, the FFACO addresses the environmental corrective actions of historically contaminated sites for which the NNSA/NFO is responsible for cleanup and closure.	The 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 and the EM Nevada Program. In 2019, NNSA/NFO closed seven CASs and met all of the 2019 FFACO milestones for the characterization, remediation, closures, and post-closure monitoring and inspection of historically contaminated CASs. To date, 2,158 of the 3,039 CASs have been closed (Section 11.5).
Radioactive Waste Management (DOE O 435.1 Change 1) **• DOE M 435.1-1 Change 2**	
DOE O 435.1 Change 1, *Radioactive Waste Management,* 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.	The Area 3 and Area 5 Radioactive Waste Management Sites (RWMSs) operate as Category II Non-Reactor Nuclear Facilities. Both are designed and operated to manage and safely dispose of LLW, MLLW, classified non-radioactive waste, and classified non-radioactive hazardous waste

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

Description of Law/Regulation [(a)(b)]	2019 Compliance Status
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.	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*** and ***Composite Analyses*** for both RWMSs are reviewed and submitted annually to EM Nevada Program. The Disposal Authorization Statements for both RWMSs also require annual reviews to track secondary or minor unresolved issues to resolution. Waste Acceptance Criteria for wastes disposed at the RWMSs are maintained and the volumes 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 2019, all key documents and analyses were current and all required management practices were followed (Section 10.1). The radiological dose to the public in 2019 from the Area 3 and 5 RWMSs from all pathways was negligible (Section 10.1.9).
Hazardous Materials Control and Management	
Emergency Planning and Community Right-to-Know Act (EPCRA), 42 USC 11001 et seq. (1986) **• 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 (NPTEC) on the NNSS, one for NLVF, and one for RSL-Nellis. In 2019, 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 2019 included lead, mercury, nitromethane, ***polychlorinated biphenyls (PCBs)***, and polycyclic aromatic hydrocarbons (PACs) (Section 2.4.4.1). No releases at NLVF or RSL-Nellis exceeded reportable thresholds in 2019 (Sections A.1.5 and A.2.4).
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 NNSS is a registered CAPP facility. Within the NNSS, two registered chemical processes occur. An oleum release process is located at NPTEC in Area 5, and Area 1 has a temporary flammable materials storage area. The Area 1 process permit was relinquished June 27, 2019. NNSA/NFO submits an annual CAPP Registration report.

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

Description of Law/Regulation [(a)(b)]	2019 Compliance Status
	For the reporting period, 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 NNSS CAPP Program was meeting regulatory requirements (Section 2.4.4.2).
<u>Toxic Substances Control Act (TSCA), 15 USC 2601 et seq. (1976)</u> **• 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 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 record-keeping requirements for PCB activities are regulated by the state. In 2019, PCBs were managed in compliance with TSCA and state regulations (Section 2.4.2).
<u>Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), 7 USC 136 et seq. (1996)</u> **• 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. 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 2019, NNSA/NFO complied with all FIFRA requirements (Section 2.4.3).
Cultural Resources	
<u>National Historic Preservation Act (NHPA), as amended, 54 USC 300101 et seq. (1966)</u> **• 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 Program at the NNSS, which is implemented by the Desert Research Institute. The Cultural Resources Management 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 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 NSHPO, the Consolidated Group of Tribes and Organizations 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.

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

Description of Law/Regulation [(a)(b)]	2019 Compliance Status
	In 2019, field surveys and historical evaluations for 15 NNSS projects were conducted; 120 cultural resources were identified, 55 of which were determined eligible for the NRHP (Sections 12.1 and 12.2).
<u>Archaeological Resources Protection Act, as amended (16 USC 470aa–mm)</u> **• DOI: 18 CFR 1312, 36 CFR 79, and 43 CFR 7**	
The Archaeological Resources Protection Act, 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 Cultural Resources Management 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 Consolidated Group of Tribes and Organizations (Section 12.4).
<u>American Indian Religious Freedom Act, as amended (42 USC 1996)</u>	
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).
<u>Native American Graves Protection and Repatriation Act, as amended (25 USC 3001–3013)</u> **• DOI: 43 CFR 10**	
The Native American Graves Protection and Repatriation Act, 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 the act. 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	
<u>Endangered Species Act, 16 USC 1531-1544 (1973)</u> **• FWS: 50 CFR 17**	
The Endangered Species Act 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 action that causes a "***taking***" of any listed species of endangered fish or wildlife.	The threatened desert tortoise is the only species protected under the Endangered Species Act 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 Opinion issued by FWS to NNSA/NFO. NNSS activities were covered by two Opinions in 2019. The 2009 Opinion expired August 26, 2019, and FWS issued a new Opinion to cover the term of August 27, 2019 through 2029. The allowable cumulative take under the new Biological Opinion is 31 tortoises killed/injured, 440 moved, and 3,000 acres of habitat disturbed. In 2019, take totals were 2 killed

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

Description of Law/Regulation [(a)(b)]	2019 Compliance Status
	on roads, 54 moved out of harm's way, and 0.0 acres disturbed. All requirements of the Biological Opinion were met (Section 13.1).
<u>Nevada Department of Wildlife</u> **• NDOW: NAC 503 •NDOF: NAC 527**	
NDOW regulations identify protected and unprotected Nevada animal species and prohibit the harm of protected species without special permit. NAC 503, *Hunting, Fishing and Trapping; Miscellaneous Protective Measures*, also identifies game animals, which are managed by the state. NDOF regulations prohibit removal or destruction of state-protected plants without special permit.	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 2019, monitoring of raptors, wild horses, and mule deer was conducted. NNSS biologists assisted other agency biologists with desert bighorn, pronghorn antelope, western burrowing owl, and mountain lion studies on and near the NNSS (Section 13.3).
<u>Migratory Bird Treaty Act (MBTA), 16 USC 703-712 (1918)</u> **• 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 does 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 2019, 19 migratory birds were found dead; 14 of the deaths were due to human activities (e.g., electrocution on power lines) (Section 13.3).
<u>Responsibilities of Federal Agencies to Protect Migratory Birds</u> **• E.O. 13186**	
This Executive Order (E.O.) 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 power poles to reduce avian mortality. 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).
<u>The Bald and Golden Eagle Protection Act, 16 USC 668a-d, 703-712</u> **• FWS: 50 CFR 22 •NDOW: NRS 503.050**	
The Bald and Golden Eagle Protection Act prohibits any form of possession or taking of both bald and golden eagles. Eagles are also protected under Nevada wildlife laws.	Compliance with the act is documented under the EMAC Program. Eagles that are occasionally electrocuted on NNSS power lines are transferred to the FWS under an FWS special purpose possession permit. Four red-tailed hawks and 10 common ravens were electrocuted in 2019; no eagle mortalities were observed (Section 13.3).
<u>Wild Free-Roaming Horses and Burros Act (Pub. L. 92–195)</u>	
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 to protect, manage, and control wild	The NNSS is not within a ***BLM active herd management area***. A Five-Party Cooperative Agreement exists, however, between NNSA/NFO, the Nevada Test and Training Range

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

Description of Law/Regulation [(a)(b)]	2019 Compliance Status
horses and burros on lands administered by BLM and the U.S. Forest Service, in a manner that is designed to achieve and maintain a thriving natural ecological balance.	(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).
<u>**Invasive Species**</u> **• E.O. 13112**	
This E.O. directs federal agencies to act to prevent the introduction of, or to monitor and control, invasive (non-native) species; to provide for conservation 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 E.O. (Section 13.4).
Environmental Activities and Occurrence Reporting	
<u>**Environment, Safety and Health Reporting**</u> **• 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.	NNSA/NFO prepares an Annual Site Environmental Report 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.
<u>**Occurrence Reporting and Processing of Operations Information**</u> **• DOE O 232.2A**	
This order requires that 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. 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 are discussed in Section 2.5.
Quality Assurance	
<u>**Quality Assurance**</u> **• 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 the 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) 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	NNSA/NFO has quality assurance plans in place to implement quality management methodology in adherence to this DOE order. The quality assurance plans ensure that all environmental monitoring data meet ***quality assurance*** and ***quality control*** requirements. Samples are 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

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

Description of Law/Regulation [(a)(b)]	2019 Compliance Status
maximizing reliability and performance of work products. Using a graded approach, DOE/NNSA sites must develop a quality assurance plan to establish additional process-specific quality requirements and implement the approved quality assurance plan.	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 CFR title and part (e.g., 10 CFR 1021 means, "Title 10 Part 1021"). CFR references can be accessed at http://www.ecfr.gov/cgi-bin/ECFR?page=browse. If no implementing regulations have been written, then N/A (not applicable) is entered.
For Nevada State laws, either the Nevada Administrative Code (NAC) or the Nevada Revised Statute (NRS) reference is given. NACs can be accessed at http://search.leg.state.nv.us/NAC/NAC.html. NRSs can be accessed at 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 at 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 2019 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 for NNSA/NFO operations at NNSS, NLVF, and RSL-Nellis

Permit Number	Permit Name or Description	Expiration Date	Report
	Air Quality		
	NNSS		
AP9711-2557.01	NNSS Class II Air Quality Operating Permit	June 25, 2019 (permit remains in effect until NDEP issues renewal)	Annual
18-32 and 19-06	NNSS Open Burn Authorization, Fire Extinguisher Training (Various Locations)	December 31, 2019	None
18-33 and 19-07	NNSS Open Burn Authorization, Simulated Vehicle Burns, A-23, Facility #23-T00200 (NNSS Fire & Rescue Training Center)	December 31, 2019	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
AP9711-2824.01	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, 2019/2020	None
NY-4098-NC	Area 25	September 30, 2019/2020	None
NY-4099-NC	Area 12	September 30, 2019/2020	None
NY-0835-NP	NNSS Water Hauler #84846	September 30, 2019/2020	None
NY-0836-NP	NNSS Water Hauler #84847	September 30, 2019/2020	None

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

Permit Number	Permit Name or Description	Expiration Date	Report
	Septic Systems/Pumpers		
	NNSS		
NY-1054	Septic System, Area 3, Waste Management Offices – inactive	None	None
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 (Los Alamos National Laboratory)[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 (Radiological/Nuclear Countermeasures Test and Evaluation Complex)[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 Pumping Contractor (1 business/3units)	July 31, 2019/2020	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 (permit remains in effect until NDEP issues renewal)	Annual
	NLVF		
Class II ID# 036555-02	Authorization to Discharge	None	None
NV201000 Project ID DDP-42723	NPDES DeMinimis	None	Annual
	Wastewater Discharge		
Site Number: ISW-40564	Stormwater No Exposure Waiver	July 31, 2024	None
	RSL-Nellis		
Not applicable	Annual certification statement of zero discharge	None	January
	Underground Injection Control		
	NNSS		
UNEV2012203	NNSS Underground Injection Control Permit	July 6, 2022	Semi-annual

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

Permit Number	Permit Name or Description	Expiration Date	Report
	Hazardous Materials		
	NNSS		
88628	NNSS Hazardous Materials Permit	February 28, 2021	Annual
88629	Nonproliferation Test and Evaluation Complex Hazardous Materials Permit	February 28, 2021	Annual
	NLVF		
88624	NLVF Hazardous Materials Permit	February 28, 2021	Annual
	RSL-Nellis		
88647	RSL-Nellis Hazardous Materials Permit	February 28, 2021	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	Biennial 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
Not Applicable	Approval to Establish a Solid Waste Incinerator – Area 25	None	None
	RSL-Nellis		
PR0064276	RSL-Nellis Waste Management Permit-Underground Storage Tank	December 31, 2019	None
	Endangered Species/Wildlife		
File Nos. 8ENVS00-2019-F-0073 and 84320-2008-B-0015	FWS Desert Tortoise Incidental Take Authorization (Biological Opinion for Programmatic NNSS Activities)	2029	Annual
MB-008695-0/-1	FWS Migratory Bird Salvage and Collection	February 9, 2021	Annual
TE84209B-0	FWS Native Threatened Species Recovery	August 22, 2021	Annual
261454	NDOW Scientific Collection of Wildlife Samples	December 31, 2021	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

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 NNSA/NFO 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 2019.

Table 2-3. NNSS NEPA compliance activities

2019 Results of NEPA Checklist Reviews/NEPA Compliance Activities
39 NEPA Checklists were reviewed
8 projects were exempted from further NEPA analysis because they were of Categorical Exclusion[(a)] status
31 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 custodians' 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 2019, the NNSS managed 6,304 chemicals in 111,774 containers.

2.4.2 Polychlorinated Biphenyls

The storage, handling, and use of 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 contains regulated quantities of PCBs is 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).

In 2019, NNSS demolition activities generated one drum, 92 kilograms (kg) (203 pounds [lb]) of PCB light ballasts. Three drums, 258 kg (569 lb), were shipped off site from the Area 5 Hazardous Waste Storage Unit for treatment and disposal. These weights include the PCBs, the associated materials that are contaminated and/or cannot be separated from the PCBs, and the weight of the waste container. The EPA did not conduct any TSCA inspections at the NNSS in 2019.

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) and NAC 555.400-510. The NDOA has oversight functions to ensure compliance with FIFRA and the NAC. Several oversight activities are performed each year. They include the screening of all purchase requisitions for restricted-use pesticides; record keeping; 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 Nevada Pest Control Government License. This service is provided by the MSTS Waste & Water Department. The application of restricted-use pesticides was discontinued on the NNSS in 2014. Only pesticides categorized as non-restricted-use (i.e., available for purchase and application by the general public) are used. In Fiscal Year (FY) 2019, non-restricted use pesticides required the same level of record keeping as restricted use pesticides. Monthly inspections conducted in 2019 found that records were properly maintained, 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 2019.

2.4.4 Release and Inventory Reporting

2.4.4.1 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 2019.

Table 2-4. Emergency Planning and Community Right-to-Know Act reporting criteria

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	2019 Status[(a)]
Section 302	Emergency Planning Notification	Yes
Section 304	EHS Release Notification	Not required
Section 311–312	Safety Data Sheet/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 2019 chemical inventory for NNSS facilities was updated and submitted to the State of Nevada in the NCA Report on February 27, 2020. No EPCRA Section 304 reporting was required in 2019 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 2019 at the NNSS, reportable quantities of lead, mercury, nitromethane, PCBs, and PACs were released as a result of NNSS activities (Table 2-6). No accidental or intentional releases (e.g., proper waste disposal) of toxic chemicals at NLVF or RSL-Nellis exceeded the TRI reportable thresholds in 2019. On June 25, 2019, NNSA/NFO submitted the NNSS TRI Report for calendar year 2019 to the EPA and the State Emergency Response Commission. No EPCRA inspections were performed by outside regulators in 2019.

Table 2-6. Summary of reported releases at the NNSS subject to EPCRA Section 313

2019 Reported Release	Quantity[(a)] (lb) Lead	Mercury	PCB	PACs
Air Emissions[(b)]	1.982	0.28	--	4.98
Onsite Disposal[(c)(d)]	20963.01	125	25.74	111
Onsite Release[(e)]	3050	--	--	--
Offsite Recycling[(f)]	44987.11	0.018	--	--
Offsite Disposal[(g)]	7.06	0.009	0.306	--
Totals	69,009.16	125.31	26.06	115.98
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 was received and disposed in Cell 18 at the Area 5 RWMS (Section 10.1.1).

(d) PACs, which are in asphalt, were released to the ground as part of paving and resurfacing activities.

(e) 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.

(f) 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.

(g) Lead was from lead-contaminated debris and other routinely generated waste. Mercury was from lamps and test kits. PCBs were from PCB-containing ballasts.

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. NPTEC in Area 5 of the NNSS is registered as a CAPP facility because of its use of the highly hazardous chemical oleum. On October 2, 2019, NDEP conducted an annual site inspection of NPTEC and did not identify any findings.

On January 24, 2018, permits to construct and operate the Temporary Flammable Materials Storage process at the NNSS were issued by NDEP. The permits allowed for the construction and storage of flammable liquid. On June 27, 2019, NNSA/NFO relinquished the Permit to Operate the Temporary Flammable Materials Storage process.

NNSA/NFO is required to submit an annual CAPP Registration report to the State of Nevada for the NPTEC oleum release process. The CAPP reporting period is June 1 of the previous year through May 31 of the current year. The CAPP registration report for NPTEC operations for the reporting period of June 1, 2019, through May 31, 2020, was signed on June 17, 2020, and submitted to NDEP. The Registration reported that 5,000 lb of oleum was present during the reporting period.

The following information is a correction to the 2018 NNSSER, which reported that 0.0 lb of oleum and 2,088 lb of nitromethane were present. The actual reported values in the CAPP Registration dated June 17, 2019, are as follows: 5,000 lb of oleum and 133,075 lb of nitromethane were present during the reporting period of June 1, 2018, through May 31, 2019.

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

On October 1, 2017, new Occurrence Reporting Criteria were established and implemented based on DOE O 232.2A, *Occurrence Reporting and Processing of Operations Information*. DOE defines an occurrence as "a documented evaluation of a reportable occurrence that is prepared in sufficient detail to enable the reader to assess its significance, consequences, or implications and to evaluate the actions being proposed or employed to correct the condition or to avoid recurrence."

In 2019, four environmental occurrences were reportable under the requirements of the order. Twenty-three hazardous substance spills occurred in 2019, which were not reportable under DOE O 232.2A: 21 at 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 or RSL-Nellis.

Table 2-7. Environmental occurrence in 2019 reportable under DOE O 232.2A

Description of Occurrence	Reporting Criteria[a]	Corrective Actions Taken
Report Number/Date of Occurrence: EM--NVSO-MSTS-LV-2019-001, February 28, 2019 **Occurrence Title: Notice of Violation (NOV)**		
On February 5, 2019, NNSA/NFO received an NOV from the Southern Nevada Health District (SNHD) for an Underground Storage Tank (UST) violation. The NOV requested documentation of the 3-year overfill prevention equipment inspection no later than March 31, 2019. On December 20, 2018, SNHD conducted an UST inspection at RSL-Nellis. During the inspection, it was noted that there was a violation of 40 CFR, Part 280.35(a)(2), failure to conduct inspections of overfill prevention equipment to ensure that equipment is set to activate at the correct level. The SNHD inspector asked to review the required test reports. The most recent reports of the testing (by an outside vendor) were provided, but the SNHD inspector discovered the vendor had not documented one of the required tests of the overfill protection system.	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.	On February 19, 2019, the vendor returned and performed the test on the overfill protection system of the emergency generator fuel tank. He determined the overfill protection valve worked properly, but was set to shut off at 98% capacity instead of the mandated 95%. The valve needs to be lowered, but the current configuration does not allow that, so the entire fill tube has to be replaced. This is custom work that RSL-Nellis began procurement for. SNHD was notified the repair could not be accomplished by February 27, 2019; the inspector approved a 30-day extension and repairs are complete.
Report Number/Date of Occurrence: EM--NVSO-MSTS-LV-2019-003, June 25, 2019 **Occurrence Title: Air Permit Emissions Exceedance**		
The Environmental Compliance Department, during a routine quarterly inspection, discovered that an NNSA/NFO Clark County Air Permit (Source 657) limit had been exceeded. Total Dissolved Solids (TDS) intermittently ranged up to 3,910 parts per million (ppm) during the period April 12 through May 2, 2019, with a calculated excess PM10 emissions of 1.92 lb[b]. The NNSA/NFO Clark County Air Permit for the NLVF sets a limit for TDS in the building C-1 Cooling Tower, (known as cooling tower Emission Unit C01) circulation water. TDS in cooling tower circulation water is related to PM10 emissions, and the permit limits TDS in the circulation water to 2,500 ppm. Due to a vendor going out of business in April, cooling tower maintenance, which included maintenance of the Lakewood control system, was insufficient. Cooling tower maintenance chemicals became unbalanced due to an issue with the control system. This resulted in fluctuating chemical levels from April 12, 2019, to May 2, 2019.	5A(2) – Any release (on site or off site) of a pollutant from a DOE facility that is above levels or limits specified by outside agencies in a permit, license, or equivalent authorization, when reporting is required in a format other than routine periodic reports.	An interim vendor is providing limited cooling tower maintenance until a new subcontractor is established. The cooling tower is being closely monitored by NLVF Maintenance. During this time, NLVF Maintenance added additional fresh water to dilute the TDS below the 2,500 ppm permit limit until a new vendor came on site. Also, the control system sensor was cleaned and calibrated. By early May, the problem had been resolved and the TDS levels have remained below the permit limit. On June 20, 2019, 0822 hours, the required 24-hour notification to the Clark County Department of Air Quality was made regarding the TDS exceedance from Emission Unit C01 was made. A written Deviation Report was submitted on June 20, 2019.
Report Number/Date of Occurrence: NA-NVSO-MSTS-NNSS-2019-0016, November 6, 2019 **Occurrence Title: Sewage Overflow**		
On October 24, 2019, a sewage overflow was discovered. The release was 1,000 gallons of wastewater from a manhole cover in the Area 6 Tweezer Road Lift Station. Upon investigation, it was determined the lift station float switch had malfunctioned and the pump did not operate for up to 12 hours.	5A(2) – Any release (on site or off site) of a pollutant from a DOE facility that is above levels or limits specified by outside agencies in a permit, license, or equivalent authorization, when reporting is required in a format other than routine periodic reports.	A septic pumper truck was immediately dispatched to the location, where it removed the wastewater from the manhole and lift station. A dilute liquid bleach solution was applied to the affected area for disinfection and the area was cordoned off with safety barricades. Initial notification was made to NNSA/NFO, which notified NDEP on November 4, 2019.
Report Number/Date of Occurrence: EM-NVSO-MSTS-LV-2019-0004, November 6, 2019 **Occurrence Title: Notice of Violation**		
On November 7, 2019, the NNSA/NFO received an NOV from the SNHD for UST violations from an inspection conducted at RSL-Nellis on November 5. The NOV	9(1) – Any written notification from an outside regulatory agency that a	NNSA/NFO was requested to provide documentation of a passing 3-year overfill prevention equipment inspection

Table 2-7. Environmental occurrence in 2019 reportable under DOE O 232.2A

Description of Occurrence	Reporting Criteria[a]	Corrective Actions Taken
requested documentation of the following violations no later than December 6. During the inspection, the following Title 40 CFR violations were noted: 1) Part 280.41(b)(2)(ii) failure to conduct a 3-year tightness test for suction piping. NNSA/NFO was requested to provide the most recent results of a precision line tightness test or submit documentation that the UST system has a safe suction system installed, and 2) Part 280.35 (a)(2) failure to conduct inspection of overfill prevention equipment to ensure that equipment is set to activate at the correct level.	site/facility is considered to be in noncompliance with a schedule or requirement.	for the automatic shutoff device. Sunwest Engineering is subcontracted to provide the UST inspections. MSTS Environmental Compliance and RSL-Nellis facility management are coordinating actions related to this NOV.

(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.

(b) PM10 Emission means finely divided solid or liquid material, with an aerodynamic diameter less than or equal to a nominal 10 micrometers emitted to the ambient air as measured by an applicable test method

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 activities in 2019

Regulator(s)	Report
Air Quality	
EPA Region 9	National Emission Standards for Hazardous Air Pollutants – Radionuclide Emissions, Calendar Year 2019
NDEP, EPA Region 9	Annual Asbestos Abatement Notification Form, submitted to NDEP and to EPA Region 9
NDEP	Calendar Year 2019 Actual Production/Emissions Reporting Form, submitted to NDEP
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 2019 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 2019
	NNSS Quarterly Volume Reports (for all active LLW and MLLW disposal cells), April, July, and October 2019, and January 2020
	Maintenance Plan for Performance Assessments and Composite Analyses for the Area 3 and Area 5 Radioactive Waste Management Sites at the Nevada National Security Site, Revision 3.0.
	Fourth Quarter and Annual Transportation Report FY 2019, 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 2019
	Nevada National Security Site 2019 Data Report: Groundwater Monitoring Program Area 5 Radioactive Waste Management Site.
	Nevada National Security Site 2019 Waste Management Monitoring Report, Area 3 and Area 5 Radioactive Waste Management Site

Table 2-8. List of environmental reports submitted to regulators for activities in 2019

Regulator(s)	Report
	Post-Closure Report for Closed Resource Conservation and Recovery Act Corrective Action Units, Nevada National Security Site, Nevada, for Fiscal Year 2019 (October 2018–September 2019)
	Annual Soil Moisture Monitoring Reports for the Nevada National Security Site, Nevada, Area 6 Hydrocarbon and Area 9 U10c Landfills
Waste Management	
	Area 23 Semi-Annual Solid Waste Disposal Site (SWDS) Report for the Nevada National Security Site – January 1, 2019 Through June 30, 2019
	Area 23 Semi-Annual Solid Waste Disposal Site (SWDS) Report for the Nevada National Security Site – July 1, 2019 Through December 31,2019
	The 2019 Biennial Hazardous Waste Report for the Nevada National Security Site
Environmental Corrective Actions	
NDEP	CAU 98: Frenchman Flat – Record of Technical Change (ROTC)-2 for the Final Closure Report, Revision 1
	CAU 98: Frenchman Flat – Annual Closure Monitoring Report for Calendar Year 2019
	CAU 98: Frenchman Flat – Record of Technical Change (ROTC)-1 for the Annual Closure Monitoring Report for Calendar Year 2017
	CAU 99: Rainier Mesa/Shoshone Mountain – Hydrostratigraphic Framework Model-Prime Model, Model Development Process and Model Description. Rev 0
	CAU 99: Rainier Mesa/Shoshone Mountain – Final Flow and Transport Model Report Rev 1
	CAUs 101/102 – Central and Western Pahute Mesa – Annual Sampling Report for Calendar Year 2019
	CAU 412: Clean Slate I Plutonium Dispersion (TTR) – Final Addendum to the Final Closure Report
	CAU 413: Clean Slate II Plutonium Dispersion (TTR) –Final Closure Report
	CAU 414: Clean Slate III Plutonium Dispersion (TTR) – Record of Technical Change (ROTC)-1 for the Final Corrective Action Decision Document/Closure Report (CADD/CR)
	CAU 415: Project 57 No. 1 Plutonium Dispersion (NTTR) – Record of Technical Change (ROTC)-1 for the Final Closure Report
	CAU 575: Area 15 Miscellaneous Sites – Final Closure Report
	Various CAUs – Final Post-Closure Report for the Closed Resource Conservation and Recovery Act (RCRA) Corrective Action Units for Calendar Year 2019
	Various CAUs – Final Post-Closure Inspection Report for the Tonopah Test Range (TTR) for Calendar Year 2019
	Various CAUs – Final Post-Closure Inspection Letter Report for Corrective Action Units on the Nevada National Security Site (NNSS) for Calendar Year 2019
	Nevada National Security Site (NNSS) Integrated Groundwater Sampling Plan Rev 1
Hazardous Materials Management	
State Fire Marshal	Nevada Combined Agency Hazmat Facility Report – Calendar Year (CY) 2019
EPA, NDEP	Toxic Release Inventory Report, Form Rs for CY 2019
NDEP	Chemical Accident Prevention Program 2020 Registration
Cultural and Natural Resources	
SHPO MHD PA[a]	The Historic Water, Sewer, and Steam/HTHW Systems in Mercury, Area 23, Nevada National Security Site, Nye County, Nevada. Cultural Resources Report SR010219-1
SHPO MHD PA	Proposed Grading of the Historic Men's Trailer Park Lot in Mercury, Area 23, Nevada National Security Site, Nye County, Nevada. Cultural Resources Report LR082019-1
SHPO MHD PA	Mitigation Documentation for Repurposing Building 23-753 in the Motor Pool Area, Mercury, Area 23, Nevada National Security Site, Nye County, Nevada. Cultural Resources Report LR011819-1-MIT
SHPO MHD PA	Evaluation of Buildings 23-750, -751, and -753 in the Motor Pool Area, Mercury, Area 23, Nevada National Security Site, Nye County, Nevada. Cultural Resources Report SR011819-1
SHPO MHD PA	Cultural Resources Letter Report on the Finding of Adverse Effect and Proposed Mitigation for the 1960s Dormitories and 1950s Quonset Hut Foundations, Mercury, Area 23, Nevada National Security Site, Nye County, Nevada. Cultural Resources Report LR092419-1-FOE
SHPO MHD PA	Cultural Resources Letter Report for the Submission of Mitigation Documentation Related to the 1960s Dormitories and 1950s Quonset Hut Foundations, Mercury, Area 23, Nevada National Security Site, Nye County, Nevada. Cultural Resources Report LR092419-1-MIT
SHPO	A Section 110 Evaluation of the Project 57 Rad-Safe Area Personnel Decontamination Building, Nye County, Nevada. Cultural Resources Report SR073118-1
SHPO MHD PA	Finding of Effect and Proposed Mitigation for Buildings 23-750, -751, and -753 in the Motor Pool Area, Mercury, Area 23, Nevada National Security Site, Nye County, Nevada. Cultural Resources Report SR011819-1-FOE
SHPO	A Cultural Resources Inventory for a Proposed Water Line Installation at the Control Point, Area 6, Nevada National Security Site, Nye County, Nevada. Cultural Resources Report SR121118-1

Table 2-8. List of environmental reports submitted to regulators for activities in 2019

Regulator(s)	Report
SHPO	A Cultural Resources Inventory for Proposed Geological Coring, Area 12, Nevada National Security Site, Nye County, Nevada. Cultural Resources Report SR013119-1
SHPO	An Evaluation of Cultural Resources in the Physics Experiment 1 Project Area on Aqueduct Mesa, Area 12, Nevada National Security Site, Nye County, Nevada. Cultural Resources Report SR110618-1
SHPO	A Visibility Analysis for the U1a Modernization Project, Nevada National Security Site, Nye County, Nevada. Cultural Resources Report LR020419-1A
SHPO	Proposed Undertaking to Repurpose the U12n Vent Hole #2 and the U12n.10 Vent Hole, Area 12, Nevada National Security Site, Nye County, Nevada. Cultural Resources Report SR100119-1
SHPO	A Cultural Resources Inventory for a Proposed Batch Plant, Area 6, Nevada National Security Site, Nye County, Nevada. Cultural Resources Report SR042619-1
SHPO	A Photographic Simulation for the Proposed Area 6 Batch Plant Installation, Nevada National Security Site, Nye County, Nevada. Cultural Resources Report LR042619-1
NNSA/NFO	Cultural Resources Management Program Field Procedures Manual for the Nevada National Security Site. Cultural Resources Report SR021919-1
SHPO	A Cultural Resources Inventory for the Proposed Installation of a 138 kV Transmission Line from Mercury Switching Station to Tweezer Substation, Areas 5, 6, and 23, Nevada National Security Site, Nye County, Nevada. Cultural Resources Report SR052118-1
SHPO	Supplemental Information on Identification Efforts and Determination of Effect for Historic Properties in the Area of Potential Effects for the Proposed 138 kV Transmission Line, Areas 5, 6, and 23, Nevada National Security Site, Nye County, Nevada. Cultural Resources Report LR052118-1A
SHPO	An Architectural Survey for the Proposed Removal of 10 Buildings and One Structure, Area 12, Nevada National Security Site, Nye County, Nevada. Cultural Resources Report SR100418-1
SHPO	A Cultural Resources Inventory for a Proposed Unexploded Ordnance Proficiency Training Range (UXOPTR), Area 16, Nevada National Security Site, Nye County, Nevada. Cultural Resources Report SR100219-1
SHPO MHD PA	Evaluation of Fire Station 23-425, Mercury, Area 23, Nevada National Security Site, Nye County, Nevada. Cultural Resources Report SR071118-1
SHPO MHD PA	Cultural Resources Letter Report on the Finding of Adverse Effect and Proposed Mitigation for Fire Station 23-425, Mercury, Area 23, Nevada National Security Site, Nye County, Nevada. Cultural Resources Report LR071118-1-FOE
SHPO MHD PA	Cultural Resources Letter Report for the Submission of Mitigation Documentation Related to the Demolition of the Fire Station 23-425, Mercury, Area 23, Nevada National Security Site, Nye County, Nevada. Cultural Resources Report LR071118-1-MIT
SHPO	A Revised Architectural Survey of the Nuclear Engine Maintenance Assembly and Disassembly Facility, Area 25, Nevada National Security Site, Nye County, Nevada. Cultural Resources Report TR116
SHPO	An Architectural Survey of the Test Cell C Historic District, Area 25, Nevada National Security Site, Nye County, Nevada. Cultural Resources Report TR117
SHPO MHD PA	Evaluation of the 1960s Dormitories and 1950s Quonset Hut Foundations, Mercury, Area 23, Nevada National Security Site, Nye County, Nevada. Cultural Resources Report SR092419-1
SHPO	Identification and Evaluation of Surface Resources for the U1a Modernization Project, Area 1, Nevada National Security Site, Nye County, Nevada. Cultural Resources Report SR020419-1
NNSA/NFO	Annual Report on Monitoring of Selected Historic Properties on the Nevada National Security Site. Cultural Resources Report SR101118-1
SHPO	A Cultural Resources Inventory for Proposed Removal of Surface-laid Cable, Area 2, Nevada National Security Site, Nye County, Nevada. Cultural Resources Report SR100719-1
NNSA/NFO	Curation Compliance Annual Progress Report FY 2019. Cultural Resources Report LR080119-1
SHPO MHD PA	Annual Report on Progress in the Implementation of the Mercury Programmatic Agreement Covering FY 2018 Activities. Cultural Resources Report LR010119-1
NNSA/NFO	American Indian Consultation Program Annual Report FY 2019. Cultural Resources Report LR090119-1
NNSA/NFO	Meeting Summary: Annual Tribal Update Meeting, Consolidated Group of Tribes and Organizations, Las Vegas, Nevada, April 23-25, 2019.
NNSA/NFO	FY 2019 Tribal Planning Committee and CGTO Representatives Site Visit to Ammonia Tanks (26NY5) in Area 18, Nevada National Security Site, Nye County, Nevada. Cultural Resources Report LR041019-1.
NNSA/NFO	FY 2020 Tribal Planning Committee Field Assessment of the Petroglyph and Power Rock Site (26NY10131), Mushroom Rock (26NY10132), and the Geoglyph and Arch Site (26NY6/NY5191) Area 30, Nevada National Security Site, Nye County, Nevada. Cultural Resources Report LR101519-1.
FWS	Annual Report of Actions Taken under Authorization of the Biological Opinion on NNSS Activities (File Nos. 84320-2008-F-0416, 8ENVS00-2019-F-0073 and 84320-2008-B-0015) – January 1, 2019, through December 31, 2019
FWS	Annual Report for Federal Migratory Bird Scientific Collecting Permit SCCL-008695-0

Table 2-8. List of environmental reports submitted to regulators for activities in 2019

Regulator(s)	Report
NDOW	Annual Report for Handling Permit S36422
Public Notifications/Reports	
DOE	Nevada National Security Site Environmental Report 2018
Environmental Occurrences	
	See Section 2.5 for Occurrence Reporting and Processing System Reports

(a) MHD PA: Reporting in accordance with the *Programmatic Agreement between the National Nuclear Security Administration Nevada Field Office and the Nevada State Historic Preservation Officer Regarding Modernization and Operational Maintenance of the Nevada National Security Site, at Mercury in Nye County, Nevada*.

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 (DOE), 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. The International Organization for Standardization (ISO) 14001:2004 certification of the Environmental Management System (EMS) ended in 2017 when the Management and Operating (M&O) contract transitioned to Mission Support and Test Services, LLC (MSTS). However, NNSS M&O policies and directives that were established under the prior EMS continue to promote, guide, and regulate NNSS environmental aspects in order to protect the environment and public health. MSTS established a new EMS in accordance with the ISO 14001:2015 standard during the last quarter of 2019. An EMS conformance audit is planned for 2020.

This chapter describes the 2019 progress made towards improving overall environmental performance and discusses the MSTS Sustainability Program. The Program has the specific mission to support and track DOE's 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), Remote Sensing Laboratory–Nellis (RSL-Nellis), and additional outlying sites. 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

MSTS's environmental commitments are incorporated into an Environmental Protection 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. MSTS evaluates its operations, identifies aspects that can impact the environment, qualitatively assesses the potential impacts, and manages those aspects appropriately. In addition, the MSTS policy is designed to:

- Protect environmental quality and human welfare by implementing EMS practices that conform to the ISO 14001:2015 Standard.
- Minimize environmental impacts caused by M&O activities and services by preventing pollution and protecting the natural environment.
- Use sustainable practices and purchase sustainable products to prevent degradation of resources.
- Continually improve the EMS by reviewing performance and making adjustments to achieve established objectives.
- Operate in compliance with applicable federal, state, and local regulations and contractual requirements related to environmental protection and performance.
- Rigourously review operations and correct non-compliance as discovered.

3.2 Significant Environmental Aspects

Six significant environmental aspects were identified for fiscal year (FY) 2020 (October 1–September 30) based on company processes, missions, and activities, including potential emergency situations and abnormal conditions. Since the procedure to develop environmental aspects was not finalized until October 2019, no environmental aspects were identified for FY 2019. Environmental aspects, such as energy use and sustainable acquisition, are presented in Section 3.5.1.

Significant environmental aspects for FY 2020 are as follows:

1. Hazardous, radiological, and mixed waste generation and management
2. Industrial chemical storage and use
3. Air emissions

4. Cultural resources
5. Wastewater management (generation and disposal)
6. Energy use (fuel use, electricity, propane)

3.3 Environmental Objectives and Targets

Environmental objectives and targets were developed to address significant environmental aspects over which MSTS had the ability to effect a change (Table 3-1). Energy use is addressed in Section 3.5.1. Each objective and target is an opportunity to affect a significant environmental aspect by improving compliance, reducing impacts to operations, or enacting process improvements. Measurable milestones were developed for each target.

Table 3-1. Environmental Objectives and Targets

FY 2019/2020 Target	Objective	Significant Environmental Aspect
Improve MSTS Scope of Work for cultural resources	Improve the process and reduce time between National Environmental Policy Act requests and authorizations	Cultural Resources
Improve NNSS wastewater systems	Decrease the amount of wipes flushed into NNSS septic tanks and evaluate portable toilet maintenance for regulatory compliance	Wastewater Management
Improve air quality data recordorkeeping practices at the NNSS	Improve equipment owner recordkeeping and reporting, including data quality assurrances	Air Emissions

3.4 Legal and Other Requirements

MSTS environmental compliance requirements are documented in the M&O Prime Contract. Included is DEAR [U.S. Department of Energy Acquisition Regulation] Clause 970.5204-2, “Laws, Regulations, and DOE Directives,” which requires compliance with all applicable laws and regulations (including DOE Order DOE O 436.1, “Departmental Sustainability,” which contains DOE Sustainability Goals). These baseline directives are supplemented on an activity-specific basis as needed. M&O Contractor executive management and NNSA/NFO develop, update, and approve these standards through controlled processes. The M&O Contractor must also work to applicable Air Force Directives at RSL-Andrews and RSL-Nellis.

Environmental management performance-related needs and expectations of NNSA/NFO and M&O Contractor parent companies are identified in the M&O Contract, agreements, and Board recommendations. These are considered when developing compliance obligations. The needs and expectations of interested parties include clean-up of contaminated sites, community air and groundwater monitoring, safe handling of hazardous and radioactive waste, compliance with environmental regulations, and host site environmental operating provisions.

MSTS has a process to review changes in federal, state, and local environmental regulations and to communicate those changes to affected staff and organizations.

DOE publishes updated sustainability goals and targets annually in a DOE Strategic Sustainability Performance Plan, and pursues and tracks goals under the MSTS Sustainability Program (Section 3.3.1). Implementing instructions for the new Executive Order (E.O.) listing goal targets for energy use intensity, water use intensity, and greenhouse gas (GHG) emission were completed and distributed in April 2019.

3.5 Environmental Management System Programs

NNSS 5- to 10-Year Major Initiatives

Mercury Modernization – create a modern, welcoming campus to support the goals and operations of the NNSS.

U1a Master Planning – plan for existing and future conditions of all buildings and infrastructure, personnel, space needs, and mission requirements.

DAF Master Planning – early planning for improved operations to support new capabilities and increased capacity for additional programs at the DAF [Device Assembly Facility].

Footprint Management – aggressive consolidation and modernization of facilities at the NNSS and NLVF to reduce the footprint and provide sustainable infrastructure to support mission needs.

NNSS Solar Project – early planning and viability assessment of a large solar Photo Voltaic (PV) project with storage at the NNSS to cover power usage for the majority of site power.

Sustainability Strategies

- Provide sustainable facilities and equipment that meet requirements until at least the 2080s.
- Improve energy efficiency and strive to create the first net-zero energy buildings in the NNSA complex.
- Reduce the overall size of Mercury by consolidating operations.
- Complete utility/infrastructure upgrades and consolidations across the campus.
- Dispose of 28 facilities in the next 10 years.

3.5.1 Sustainability Program

The Sustainability Program 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 facility. At the NLVF and RSL-Nellis facilities, electricity 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 predominantly surface water from Lake Mead.

Each FY, the Sustainability Program produces an NNSA/NFO Site Sustainability Plan (SSP) (MSTS 2020). The SSP identifies how NNSA/NFO will meet DOE's sustainability goals, which were first published in the 2010 Strategic Sustainability Performance Plan (SSPP) (DOE 2010). 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 meets bi-monthly to track requirements and progress and facilitate goal achievement. Table 3-2 includes a summary of the DOE goals and NNSA/NFO's FY 2019 performance.

Table 3-2. DOE sustainability goals and performance in FY 2019

DOE Goal[a]	NNSA/NFO FY 2019 Performance
Goals in green are met or exceeded	
GHG Reduction	
50% reduction in Scope 1 and 2 GHG emissions [b] by FY 2025, from the FY 2008 baseline (FY 2019 target is 28% reduction).	Emissions were 19,308 metric tons of carbon dioxide equivalent (MtCO2e), 71% below the baseline of 65,632 MtCO2e[c].
25% reduction in Scope 3 GHG emissions [b] by FY 2025, from the FY 2008 baseline (FY 2019 target is 11% reduction).	Emissions were 14,090 MtCO2e, 67% below the baseline of 43,259 MtCO2e[c].
Sustainable Buildings	
25% reduction of energy intensity (British Thermal Units per gross square feet [gsf]) in goal-subject buildings, achieving 7.5% reductions annually by FY 2025 from the FY 2015 baseline.	Continuing to work toward goal: Energy intensity increased 17.5% 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 to ensure 100% of covered facilities are assessed every 4 years.	37 energy audits/assessments were conducted, meeting this goal. They identified energy conservation measures for the facilities evaluated. Efficient Mobile Audit Technology was installed and implemented. A two-day onsite training session was conducted by the Efficient Mobile Audit Technology Program Manager where the attendees identified opportunities for improvement in how audits are conducted.
Meter all individual buildings for electricity, natural gas, water, and steam where cost-effective and appropriate.	Continuing to work toward goal: Based on a 2019 assessment of appropriate buildings, 81% are metered for electricity, 93% for natural gas, 0% for chilled water, 30% for potable water, and 0% for Chiller 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.	13 buildings or 15% of NNSA/NFO's current enduring buildings > 5,000 gsf are certified as HPSBs. No facilities completed under the HPSB certification process in 2019. Issues on one HPSB candidate were found and implemented to move the facility closer to obtaining certification.
Identify efforts to increase regional and local planning coordination and involvement.	Continued coordination with the Regional Transportation Center Park and Ride Facilities and 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.	Construction continued on the second net-zero building at the NNSS, Mercury Building 23-460.
All new buildings larger than 5,000 gsf entering the planning process designed to achieve energy net zero beginning in FY 2020.	The net zero goal is no longer a requirement, but will continue to be a path forward for the NNSS when economically feasible.
Clean and Renewable Energy	
Not less than 10% of DOE's total electric and thermal energy consumption in FY 2017–2019 shall be accounted for by renewable and alternative sources, working towards 25% by FY 2025 ("Clean Energy" requirement).	Fire Station No. l Solar PV produced 813,606 kilowatt hours. Will continue to add new onsite renewable and/or alternative energy generation projects to account for the remainder of the goal.
Not less than 10% of DOE's total electric consumption in FY 2017–2019 shall be renewable electric energy, working towards 30% by FY 2025 ("Renewable Electric Energy" requirement).	Continue to add planned onsite renewable and/or alternative energy generation projects. Renewable energy credits were purchased, resulting in 11% of the NNSS/NFO's total electric consumption being from renewable sources.
Water Use Efficiency and Management	
36% reduction in potable water intensity (gallons per square foot [gal/ft^2]) by FY 2025 from the FY 2007 baseline (FY 2019 target is 24% reduction).	Water intensity across all NNSA/NFO facilities was 41.03 gal/ft^2, a 45% reduction from the FY 2007 baseline of 70.42 gal/ft^2, exceeding the FY 2019 goal.
30% reduction in consumption of industrial, landscaping, and agricultural (ILA) water by FY 2025 from the FY 2010 baseline (FY 2019 target is 18% reduction).	ILA water production was 89,568,457 gallons (gal), a -63.1% reduction from the FY 2010 baseline of 54,913,300 gal, significantly falling short of the FY 2019 goal.

Table 3-2. DOE sustainability goals and performance in FY 2019

DOE Goal[(a)]	NNSA/NFO FY 2019 Performance
Goals in green are met or exceeded	
Fleet Management	
20% reduction in fleet annual petroleum consumption by FY 2015 from the FY 2005 baseline; maintain 20% reduction thereafter (FY 2019 target is 20%).	Petroleum consumption was 579,075 gal, a 56% reduction from the FY 2005 baseline of 1,328,957 gal, exceeding the FY 2019 goal.
10% increase in annual fleet alternative fuel consumption by FY 2015 from the FY 2005 baseline; maintain 10% increase thereafter (FY 2019 target is 10%).	Alternative fuel consumption was 507,035 gal, a 305% increase above the FY 2005 baseline of 125,090 gal, exceeding the FY 2019 goal.
75% of light duty vehicle acquisitions must consist of alternative fuel vehicles (AFVs).	94% of all light duty vehicle acquisitions (885) are AFVs, exceeding this goal.
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 2019, several hand sanitizer dispensers that utilize biobased product were installed at the NLVF.
Pollution Prevention and Waste Reduction	
Divert at least 50% of non-hazardous ***solid waste***,[1] excluding construction and demolition materials and debris, from disposal.	Continue to work toward goal: 37% of non-hazardous solid waste was diverted from disposal. The Sustainability Program worked with site subject matter experts to ensure more recycle centers were placed at several NNSS and NLVF facilities.
Divert at least 50% of construction and demolition materials and debris from disposal.	Diverted 4% of construction waste from disposal. Several construction projects occurred throughout the year, but additional education on company procedures is necessary for continuous achievement of this goal.
Energy Performance Contracts	
Identify annual targets for acquiring ***Energy Savings Performance Contracts*** and Utility Energy Service Contracts to be implemented in FY 2019 and annually thereafter.	Energy Savings Performance Contract Workshop was hosted in April 2019, with the Federal Project Executive representing the DOE Federal Energy Management Program. A draft Notice of Opportunity was completed and status of a Preliminary Assessment is pending.
Electronic Stewardship	
95% of eligible electronics acquisitions are U.S. Environmental Protection Agency (EPA) Electronic Product Environmental Assessment Tool-registered products.	Goal met; all eligible electronic acquisitions continue to be Electronic Product Environmental Assessment Tool-registered.
100% of eligible personal computers, laptops, and monitors have power management enabled.	Goal met; all eligible devices have power management enabled.
100% of eligible computers and imaging equipment have automatic duplexing enabled.	Goal met; all purchased multi-function printing devices are configured for automated duplex printing and policy is in place.
100% of used electronics are reused or recycled using environmentally sound disposition options.	Goal met; all electronic equipment that passed excess screening in 2019 was sold for reuse.
Data center efficiency: 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.	Continue to work toward goal; the data center PUE goal of less than 1.5 for existing data centers was not met.
Resilience	
Discuss overall integration of climate resilience in emergency response, workforce, and operations procedures and protocols. This is an ongoing goal.	The Nevada Site Operation Center requirements document was completed and will be used for the request for proposal process in FY 2020.

[1] The definition of word(s) in ***bold italics*** may be found by referencing the Glossary, Appendix B..

Table 3-2. DOE sustainability goals and performance in FY 2019

DOE Goal[(a)]	NNSA/NFO FY 2019 Performance
Goals in green are met or exceeded	
	The Air Resources Laboratory/Special Operations and Research Division (ARL/SORD) continues to collect meteorological data on the NNSS.[(e)] Data are distributed/displayed in near real-time and used for consequence assessment and site safety. In addition, data was summarized for use in climatological, environmental, annual compliance reports and permitting. The Sustainability Program Subject Matter Expert engaged stakeholders from Procurement, Information Technology, and Facility Management for informational and vulnerabilty/resilience process meetings in 2019.

(a) The DOE goals listed are identified in the FY 2020 DOE Site Sustainability Plan Guidance Document (DOE 2018) which is based on DOE's SSPP (DOE 2010) and E.O. 13834.
(b) The GHGs targeted for emission reductions are carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. 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 2018 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) ARL/SORD operates a network of mobile meteorological towers on the NNSS.

3.5.2 Pollution Prevention and Waste Minimization (P2/WM)

The P2/WM Program has initiatives to eliminate or reduce the generation of waste and the release of pollutants to the environment. These initiatives are pursued through source reduction, reuse, segregation, and recycling, and by procuring recycled-content materials and sustainable 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 Integrated Safety Management System requires every project/operation to identify waste minimization opportunities during the planning phase and allocate adequate funds for waste minimization activities.

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; 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.

Sustainable Acquisition – The Resource Conservation and Recovery Act, as amended, requires federal agencies to develop and implement an affirmative procurement program. NNSA/NFO's affirmative procurement program 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 designates types of materials that have a required minimum amount of bio-based chemicals. Products that meet this requirement are identified by requestors and tracked in the procurement system.

3.6 EMS Competence, Training, and Awareness

EMS awareness is included in the orientation training for all new MSTS employees. Ongoing EMS awareness is accomplished by publishing environmental articles in electronic employee newsletters. Focused environmental briefings are given at tailgate meetings in the field prior to work with high or non-routine environmental risk. Facility specific environmental aspect briefings were provided to personnel at RSL-Nellis and NLVF.

An EMS logo was developed to support employee and management awareness and recognition of the new EMS (Figure 3-1). The EMS logo was designed to be versatile, scalable, and relevant. The cogs of the wheel represent interrelated environmental and sustainability aspects and impacts of mission related activities at all NNSS locations. The logo has been successfully used in EMS presentations, email signature blocks, posters, and employee briefings.

Figure 3-1. Environmental Management System Logo

3.7 Audits and Operational Assessments

MSTS conducts internal management assessments and compliance evaluations. These assessments and evaluations determine the extent of compliance with environmental regulations, DOE sustainability goals, and identify areas for overall improvement. In FY 2019, MSTS conducted 9 internal environmental protection management assessments and 114 environmental inspections.

Prior to developing the new EMS, an Independent Assessment (IA) was performed in early 2019. The purpose of the IA was to evaluate the existing environmental program and provide recommendations to assist MSTS in meeting the updated and expanded ISO 14001:2015 standard, and to provide suggestions for updating and revising the EMS Program Description document. The IA also validated gaps identified in the May 2017 MSTS internal management assessments of the EMS. The IA results provided opportunities and approaches to prepare the EMS for eventual certification or conformance. No findings of significance were noted.

3.8 EMS Effectiveness and Reporting

The FY 2019 Facility EMS Annual Report Data for the NNSS was entered into the DOE Headquarters EMS database during January 2020. This database, which is accessed through the FedCenter.gov website, (http://www.fedcenter.gov/programs/ems/) 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 "red" in FY 2019 because the EMS was in the final stages of development and had yet to determine environmental aspects, objectives, and fully integrate the EMS and DOE O 436.1 goals into the MSTS EMS.

3.9 Awards, Recognition, and Outreach

The Solar PV Demonstration Project at the Mercury Fire Station received two awards in 2019 (Figure 3-2):

1. 2019 Department of Energy Sustainability Award for Outstanding Sustainability Program/Project – "Over the estimated 25-year life of the PV array, a savings of approximately $650,000 is expected to be realized. This project is a significant step in NNSS' long-term modernization plan that places an emphasis on sustainable buildings."
2. 2019 NNSA DOE Excellence Award, Mercury Solar Project Team – "In recognition of outstanding teamwork and collaboration… efforts to implement solar technology in support of site modernization plans and broader, national energy goals is commendable. Your dedication and drive resulted in the first NNSA net zero energy building."

Figure 3-2. Solar PV Demonstration Project at the Mercury Fire Station

Earth Day events in 2019 included the first water bottle challenge at the NNSS between Area 6 and Area 23 and a "Just say No to Styrofoam" event at our outlying sites. Along with e-waste recycling and games at the Health and Productivity Annual Spring Fair, the activities diverted a total of 1,140 pounds of e-waste from the landfill, a 42.5% increase from 2018.

Activities for Energy Action Month included two carpooling events at NLVF, free indoor water audit and Retrofit kits from the Southern Nevada Water Authority, along with another e-waste event including the Nevada State Recycle Company. Through these two annual employee outreach events, along with the site's quarterly participation with Safe Nest, site employees managed to divert a total of 3,660 pounds of clothing items and

1,890 pounds of e-waste from the landfill. Overall, at both outreach activities, our employees were educated on how to embrace and integrate sustainability into their day-to-day activities at home, as well as at work.

3.10 References

DOE, see U.S. Department of Energy.

MSTS, see Mission Support and Test Services, LLC.

Mission Support and Test Services, LLC, 2020. *NNSA/NFO Site Sustainability Plan*. Las Vegas, NV, December 2019.

U.S. Department of Energy, 2010. *2010 Strategic Sustainability Performance Plan*. Report to the White House Council on Environmental Quality. Available at: https://www.energy.gov/sites/prod/files/edg/media/DOE_Sustainability_Plan_2010.PDF as accessed on July 29, 2019.

———, 2018. *FY 2019 Site Sustainability Plan Guidance Document*, U.S. Department of Energy Sustainability Performance Office, September 2018. Available at: https://sustainabilitydashboard.doe.gov/PDF/Resources/2019%20Site%20Sustainability%20Plan%20Guidance.pdf as accessed on July 29, 2019.

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Chapter 4: Air Monitoring

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This chapter is divided into two major sections that address different categories of air monitoring. 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 (DOE), 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

Radiological Air Monitoring Goals

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 DOE Order DOE O 458.1, "Radiation Protection of the Public and the Environment."

The sources of radioactive air emissions on the NNSS include the following: (1) tritium (^{3}H) in water (tritiated water) evaporated from containment ponds; (2) tritiated water vapor diffusing 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 known radiological air emission sources in 2019 and areas of soil contamination related to historical nuclear explosive tests. 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).

Analytes Monitored
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

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 used during exercises in specific areas of

[1] The definition of word(s) in ***bold italics*** may be found by referencing the Glossary, Appendix B.

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.

4.1.1 Monitoring System Design

Air samplers operated at a total of 18 environmental monitoring locations on the NNSS in 2019 (Figure 4-2). Of these, 16 have both air particulate and atmospheric moisture samplers, one has only an air particulate sampler (Able Site), and one has only an atmospheric moisture sampler (North Schooner). Air samplers are positioned in predominantly 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) 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 atmospheric moisture are 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 atmospheric moisture samplers have been accepted 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 locations 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 location 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. Concentration limits for radionuclides in air

Radionuclide	Concentration ($\times 10^{-15}$ microcuries/milliliter [µCi/mL]) NESHAP Concentration Level for Environmental Compliance [(a)]	10% of Derived Concentration Standard [(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 Standard DOE-STD-1196-2011, "Derived Concentration Technical Standard"

[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.

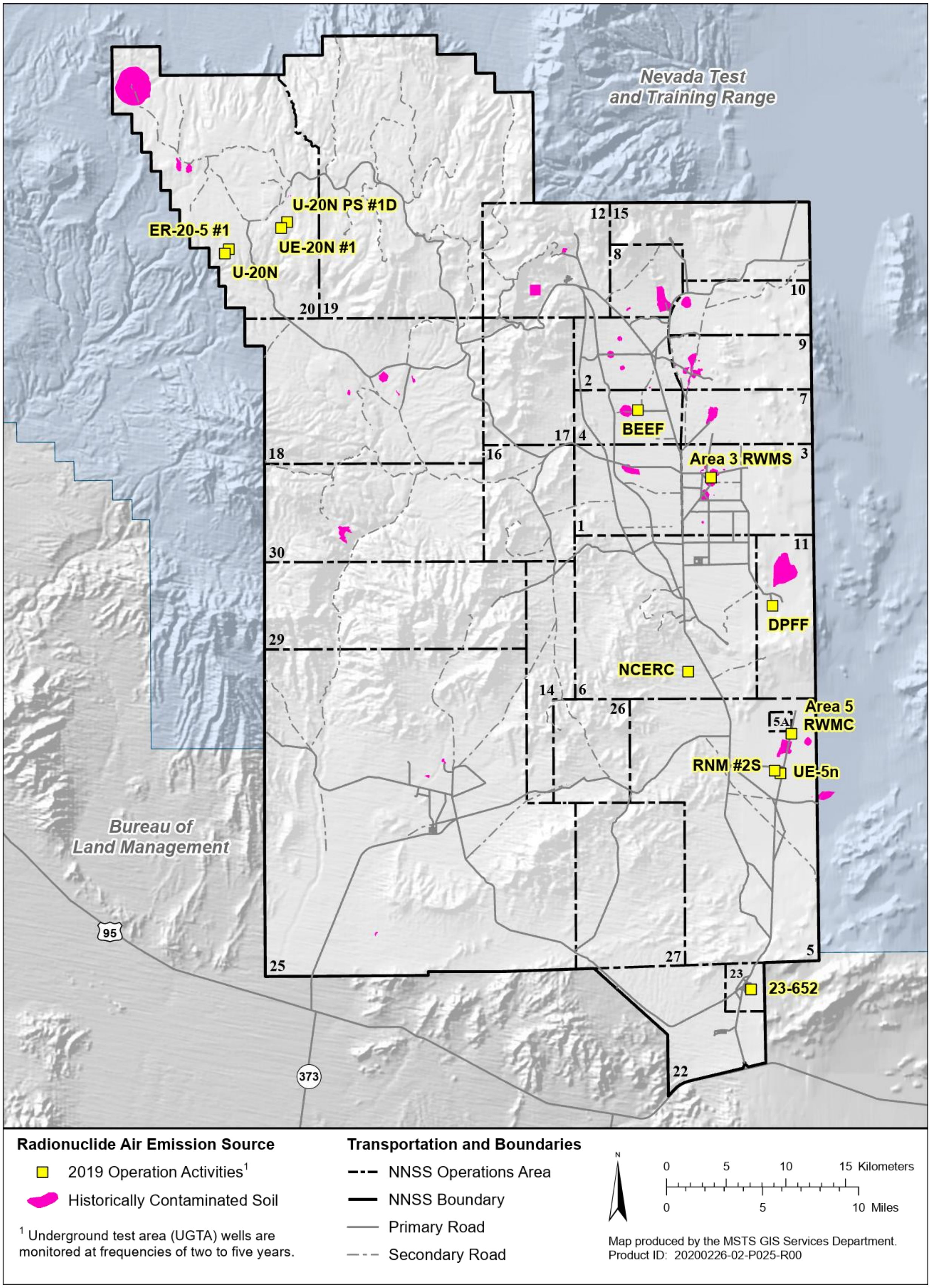

Figure 4-1. Sources of radiological air emissions on the NNSS in 2019

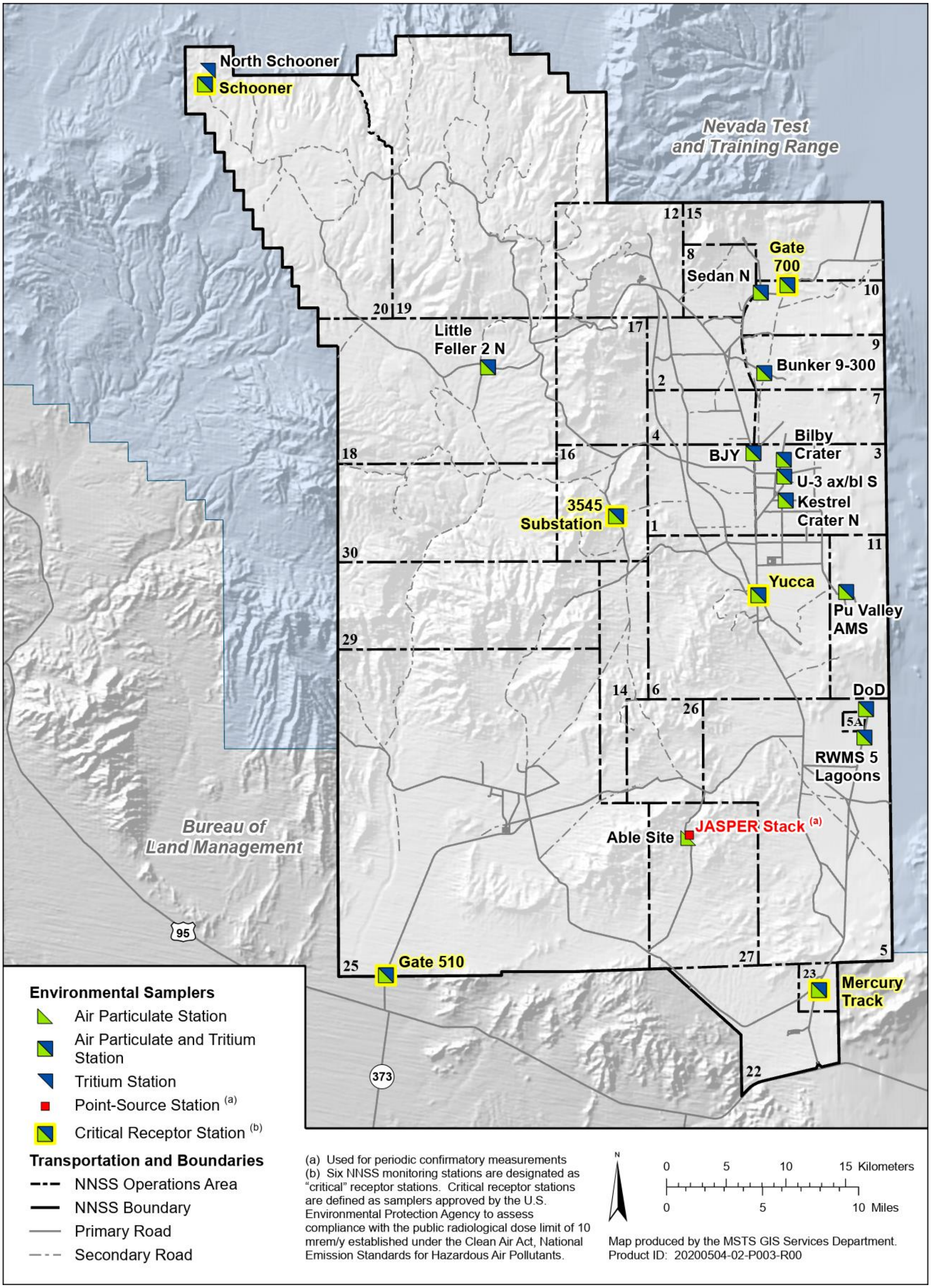

Figure 4-2. Radiological air sampling network on the NNSS in 2019

In addition to CLs, air concentrations may also be compared with ***Derived Concentration Standard (DCS)*** values. They represent the annual average air concentrations that would result in a ***total effective dose equivalent*** 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 (second column). 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.

Because of this, and the fact the CLs are regulatory values, 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 – Stack sampling is only conducted 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 offsite dose that is much less than the 0.1 mrem/yr threshold at which continuous stack monitoring is required under NESHAP. Therefore, only periodic sampling is recommended to verify low emissions. In 2019 one sample was taken from July 10–11 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 (4-inch) 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 about 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 nine locations relatively near potential sources of uranium emissions are also analyzed for uranium isotopes by alpha spectroscopy. These sampling locations are: BJY (Area 1), RWMS 5 Lagoons (Area 5), Yucca (Area 6), Bunker 9-300 (Area 9), Sedan Crater N (Area 10), Gate 700 S (Area 10), 3545 Substation (Area 16), Gate 510 (Area 25), and Able Site (Area 27).

Atmospheric moisture samples, for measuring tritium in air, are collected by continuously drawing air through molecular sieve desiccant at a flow rate of about 566 cubic centimeters per minute (1.2 ft^3 per hour). The air intake is about 1.5 m (5 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 about 11 m^3 [388 ft^3] over a 2-week sampling period. The molecular sieve desiccant is exchanged every 2 weeks. Water is extracted from the desiccant and analyzed for ^{3}H by liquid scintillation counting.

Measured radioactivity in each sample is converted to units per volume of air prior to the reporting described 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 2019 annual average radionuclide concentrations at each air sampling location are presented in the following sections. The annual average (mean) 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, or NNSS operations. Tables 4-2 through 4-7 and Figures 4-3 through 4-7 include data for all environmental locations that collect air particulate samples (i.e., the North Schooner Station is excluded from these data sets because only atmospheric moisture is sampled at that location). Table 4.8 and Figure 4-10 include data for all environmental locations that collect samples to measure ^{3}H in atmospheric moisture (Able Site is excluded from this data set because only air particulates are sampled at that location).

4.1.4.1 Gross Alpha and Gross Beta

Gross alpha and gross beta radioactivity measurements in air samples collected in 2019 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 mean gross alpha results across the network are comparable with, and somewhat lower than, those of the past few years. The gross beta measurements also resemble those of recent years.

Table 4-2. Gross Alpha radioactivity in air samples collected in 2019

			Gross Alpha (× 10^{-16} µCi/mL)			
Area	**Station**	**Number of Samples**	**Mean**	**Standard**	**Minimum**	**Maximum**
1	BJY	26	24.20	10.67	8.69	49.09
3	Bilby Crater	26	22.88	11.33	6.05	45.42
3	Kestrel Crater N	26	24.73	9.34	13.41	48.08
3	U-3ax/bl S	26	23.80	10.06	7.69	46.21
5	DoD	26	26.66	10.28	12.02	46.99
5	RWMS 5 Lagoons	26	25.00	11.13	6.70	40.32
6	Yucca*	26	23.22	9.81	8.56	39.38
9	Bunker 9-300	26	22.28	9.99	7.54	47.52
10	Gate 700 S*	26	20.74	10.28	3.88	37.72
10	Sedan N	26	24.35	9.93	12.02	57.32
11	Pu Valley AMS	25	25.92	12.72	8.95	54.84
16	3545 Substation*	26	20.17	8.06	7.46	36.05
18	Little Feller 2 N	26	21.93	11.23	0.00	47.16
20	Schooner*	26	21.19	8.20	4.45	38.01
23	Mercury Track*	26	22.77	9.12	6.18	39.72
25	Gate 510*	26	24.94	8.35	12.46	43.80
27	Able Site	26	21.41	10.15	3.12	40.03
All Environmental Locations		441	23.30	10.08	0.00	57.32

* EPA-approved Critical Receptor Station

Table 4-3. Gross Beta radioactivity in air samples collected in 2019

Area	Station	Number of Samples	Gross Beta (× 10^{-15} µCi/mL) Mean	Standard Deviation	Minimum	Maximum
1	BJY	26	21.83	5.21	12.66	32.93
3	Bilby Crater	26	21.22	5.24	13.84	33.99
3	Kestrel Crater N	26	21.88	5.38	12.82	33.65
3	U-3ax/bl S	26	21.62	5.25	12.00	30.90
5	DoD	26	23.65	6.89	13.30	43.66
5	RWMS 5 Lagoons	26	24.38	6.26	15.27	43.14
6	Yucca*	26	22.72	5.60	14.10	37.76
9	Bunker 9-300	26	21.52	6.06	10.25	38.64
10	Gate 700 S*	26	21.66	5.55	13.04	37.37
10	Sedan N	26	21.23	5.29	11.39	33.91
11	Pu Valley AMS	25	21.89	5.60	12.47	36.21
16	3545 Substation*	26	20.93	5.87	11.63	37.37
18	Little Feller 2 N	26	19.89	5.83	11.57	33.29
20	Schooner*	26	21.16	5.82	9.96	38.96
23	Mercury Track*	26	22.51	5.49	10.60	38.80
25	Gate 510*	26	23.53	5.88	13.09	37.12
27	Able Site	26	22.13	5.66	11.76	37.00
All Environmental Locations		441	21.98	5.71	9.96	43.66

* EPA-approved Critical Receptor Station

4.1.4.2 Americium-241

The mean ^{241}Am concentration for environmental sampler locations was 1.36×10^{-18} µCi/mL in 2019. This is lower than in recent years; the annual means were 15.13, 14.87, 11.67, 8.55, 10.09, 12.74, 15.99, 6.99, and 6.33×10^{-18} µCi/mL in 2018 through 2009, respectively. The 2019 average concentration is 0.07% of the CL (shown at the bottom of Table 4-4). In the plots for ^{241}Am and other actinides (^{238}Pu and $^{239+240}$Pu), values for Pu Valley AMS, Bunker 9-300, and Sedan N (Areas 11, 9, and 10 respectively) are shown individually, as these stations tend to have higher measurements. Area 1 and Area 3 stations are grouped together, with a green vertical bar extending from the lowest to highest values in the quarter and lines connecting the quarterly mean values. The other stations are grouped similarly, using black vertical bars and lines.

Table 4-4. Concentrations of ^{241}Am in air samples collected in 2019

Area	Station	Number of Samples	^{241}Am ($\times 10^{-18}$ μCi/mL) Mean	Standard Deviation	Minimum	Maximum
1	BJY	4	-3.54	9.11	-17.15	2.07
3	Bilby Crater	4	-0.27	4.59	-6.28	4.37
3	Kestrel Crater N	4	-2.25	8.03	-13.86	4.01
3	U-3ax/bl S	4	0.50	3.25	-3.11	4.77
5	DoD	4	3.90	4.63	-0.21	10.56
5	RWMS 5 Lagoons	4	2.74	3.76	-0.55	8.13
6	Yucca*	4	-1.67	4.28	-7.91	1.80
9	Bunker 9-300	4	4.28	5.89	-3.24	8.99
10	Gate 700 S*	4	-0.36	11.95	-17.46	8.37
10	Sedan N	4	3.15	14.22	-14.30	20.32
11	Pu Valley AMS	4	14.18	13.43	0.63	28.74
16	3545 Substation*	4	-0.84	3.64	-5.80	2.90
18	Little Feller 2 N	4	-0.44	3.27	-4.53	3.41
20	Schooner*	4	3.30	2.10	0.59	5.30
23	Mercury Track*	4	-4.25	9.67	-18.74	1.04
25	Gate 510*	4	3.45	3.14	0.01	7.63
27	Able Site	4	1.19	1.36	-0.29	2.79
All Environmental Locations		68	1.36	7.65	-18.74	28.74

CL = 1900 × 10^{-18} μCi/mL

* EPA-approved Critical Receptor Station

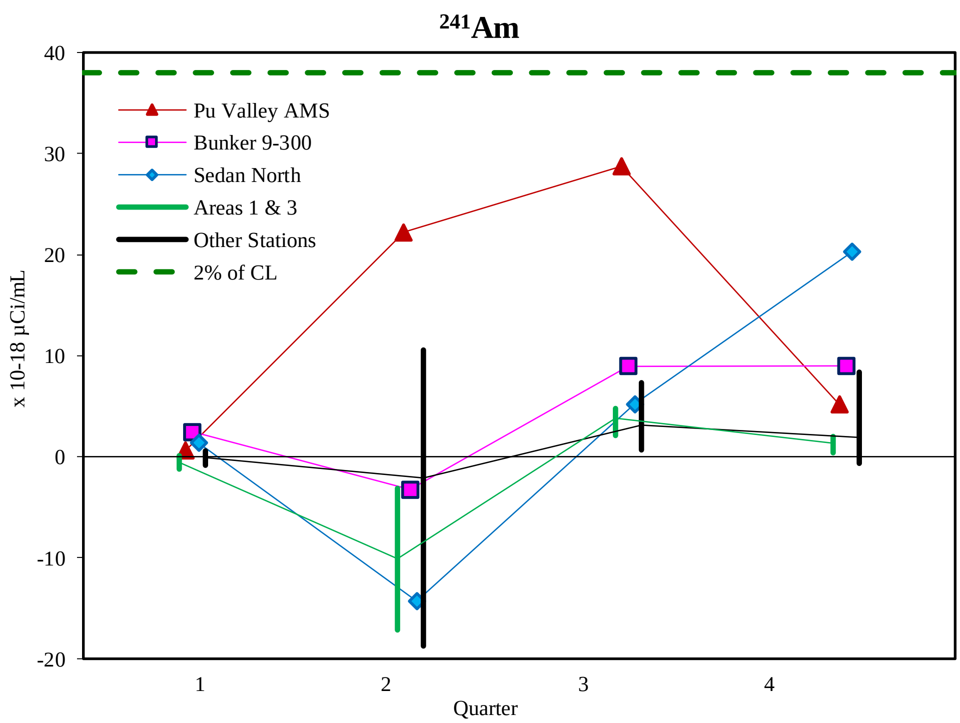

Figure 4-3. Concentrations of ^{241}Am in air samples collected in 2019

4.1.4.3 Plutonium Isotopes

The overall mean concentration for ^{238}Pu at environmental samplers in 2019 (0.98 × 10^{-18} µCi/mL) (Table 4-5) is slightly below the range of values (1.15 to 5.54 × 10^{-18} µCi/mL) observed from 2009 through 2018. The highest 2019 mean (6.30 × 10^{-18} µCi/mL) was at Schooner in Area 20; this is 0.3% of the CL (Figure 4-4).

The $^{239+240}$Pu isotopes are of greater abundance and hence greater interest. The overall mean of 14.31 × 10^{-18} µCi/mL in 2019 is somewhat below the range of values measured during 2009–2018 (33.47 to 96.46 × 10^{-18} µCi/mL). The locations with the highest means are Bunker 9-300 (54.32 × 10^{-18} µCi/mL, 2.7% of the CL), Pu Valley AMS (52.98 × 10^{-18} µCi/mL, 2.6% of the CL) and Sedan (47.00 × 10^{-18} µCi/mL, 2.4% of the CL); see Table 4-6 and Figure 4-5.

The concentrations of ^{241}Am, $^{239+240}$Pu, and to some extent ^{238}Pu, often show similar patterns through time at Bunker 9-300 and other areas of known contamination from past nuclear tests. 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) tend to be found together in particles of Pu remaining from past 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 4-6 shows long-term trends in $^{239+240}$Pu annual mean concentrations at locations with at least 15-year data histories since 1971. Rather than showing the time histories for all 50 such locations, Figure 4-6 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 2.6% (Areas 7, 9, 10, and 15) to 10.3% and 10.7% (the Area 5 and other areas groups). This equates to a reduction in $^{239+240}$Pu concentration by half every 30.9 years for Areas 1 and 3; 26.5 years for Areas 7, 9, 10, and 15; 6.4 years for Area 5; and 6.1 years for the other areas. Declining rates are not attributable to ***radioactive decay*** alone, 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 4-5. Concentrations of ^{238}Pu in air samples collected in 2019

			^{238}Pu (× 10^{-18} µCi/mL)			
Area	**Station**	**Number of Samples**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
1	BJY	4	1.73	2.02	-0.17	4.39
3	Bilby Crater	4	0.15	3.32	-4.35	3.53
3	Kestrel Crater N	4	0.70	1.41	-0.77	2.62
3	U-3ax/bl S	4	-0.65	3.81	-6.33	1.65
5	DoD	4	0.87	0.57	0.26	1.60
5	RWMS 5 Lagoons	4	-0.83	6.10	-9.18	5.48
6	Yucca*	4	1.73	3.61	-1.16	7.01
9	Bunker 9-300	4	0.32	3.58	-4.62	3.97
10	Gate 700 S*	4	0.08	2.57	-3.70	2.01
10	Sedan N	4	5.06	4.41	1.08	11.37
11	Pu Valley AMS	4	-2.37	6.76	-12.50	1.32
16	3545 Substation*	4	0.57	1.05	-0.93	1.40
18	Little Feller 2 N	4	-0.06	1.46	-2.12	1.25
20	Schooner*	4	6.30	6.63	-0.06	15.02
23	Mercury Track*	4	0.26	1.71	-2.22	1.72
25	Gate 510*	4	1.49	2.95	-1.61	5.49
27	Able Site	4	1.26	1.69	-0.55	3.43
All Environmental Locations		68	0.98	3.77	-12.50	15.02

CL = 2100 × 10^{-18} µCi/mL

* EPA-approved Critical Receptor Station

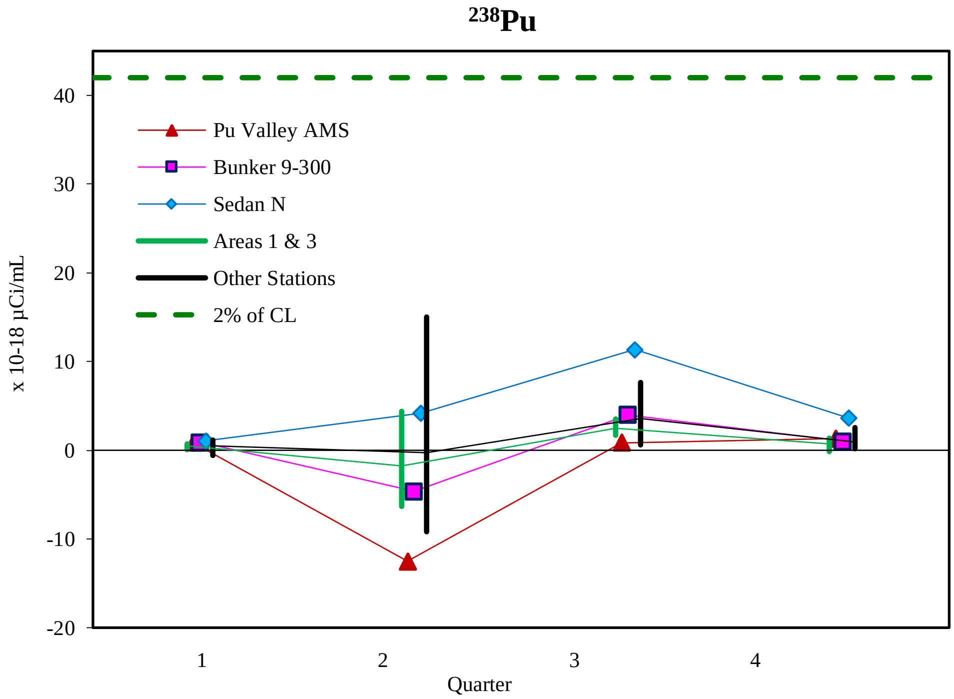

Figure 4-4. Concentrations of ^{238}Pu in air samples collected in 2019

Table 4-6. Concentrations of $^{239+240}$Pu in air samples collected in 2019

			$^{239+240}$Pu (× 10^{-18} µCi/mL)			
Area	**Station**	**Number of Samples**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
1	BJY	4	8.56	5.57	3.16	14.47
3	Bilby Crater	4	14.10	11.08	1.78	27.29
3	Kestrel Crater N	4	9.21	5.40	3.37	16.38
3	U-3ax/bl S	4	12.98	10.72	2.82	23.18
5	DoD	4	3.79	3.65	0.14	8.73
5	RWMS 5 Lagoons	4	5.69	8.27	0.27	18.02
6	Yucca*	4	5.94	4.78	0.76	11.09
9	Bunker 9-300	4	54.32	33.72	24.13	92.89
10	Gate 700 S*	4	17.24	31.03	-1.69	63.52
10	Sedan N	4	47.00	61.66	2.08	136.12
11	Pu Valley AMS	4	52.98	82.25	3.99	175.62
16	3545 Substation*	4	-1.42	6.24	-10.38	4.11
18	Little Feller 2 N	4	3.47	1.87	1.14	5.18
20	Schooner*	4	5.20	2.90	1.64	8.58
23	Mercury Track*	4	2.80	2.21	1.31	6.08
25	Gate 510*	4	-0.25	4.29	-6.53	3.05
27	Able Site	4	1.71	1.65	0.34	3.72
All Environmental Locations		68	14.31	30.22	-10.38	175.62

CL = 2000 × 10^{-18} µCi/mL

* EPA-approved Critical Receptor Station

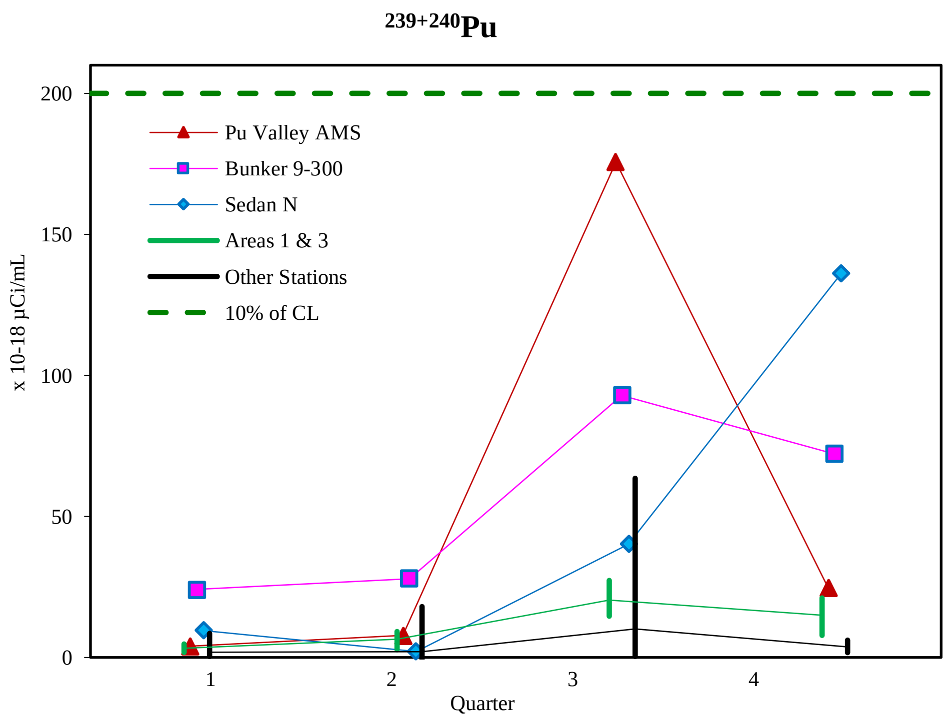

Figure 4-5. Concentrations of $^{239+240}$Pu in air samples collected in 2019

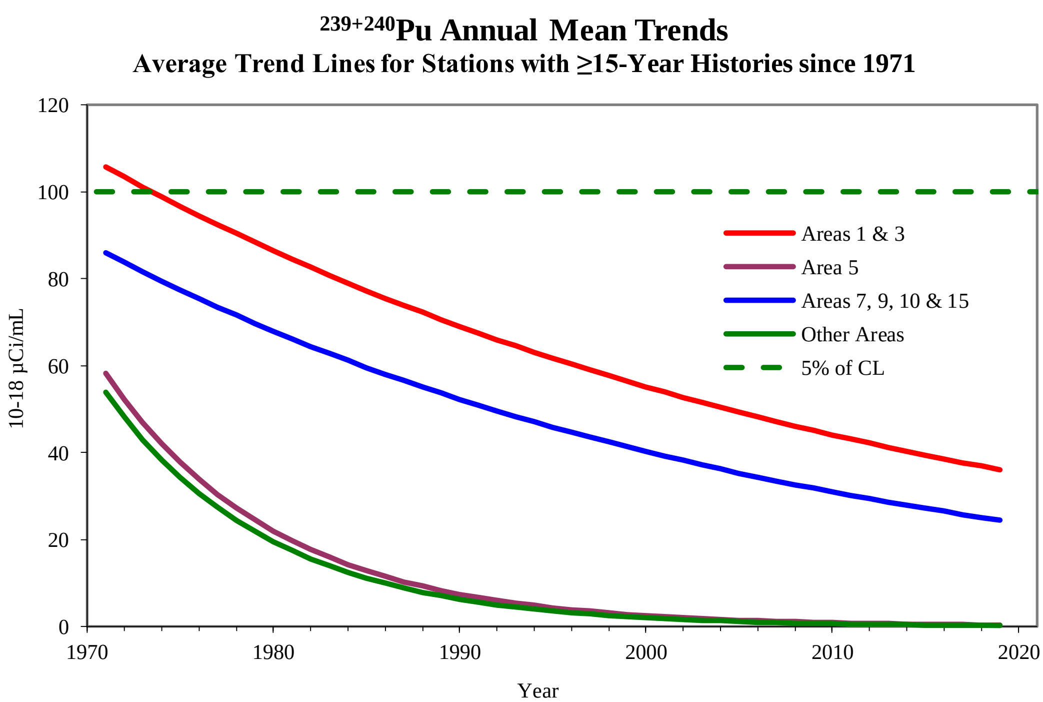

Figure 4-6. Average trends in $^{239+240}$Pu in air annual means, 1971-2019

4.1.4.4 Cesium-137

^{137}Cs was detected in only one sample during 2019 at a level slightly (1.65%) above its MDC, in the second quarter at Schooner. Results from all other samples were less than their MDCs. The mean, standard deviation, minimum, and maximum for all sample locations are listed in Table 4-7. The annual average concentration was less than 0.5% of the CL at all locations. Figure 4-7 shows all stations grouped together with a vertical bar extending from the lowest to the highest value for the quarter; the overall means are connected.

Table 4-7. Concentrations of ^{137}Cs in air samples collected in 2019

			^{137}Cs (× 10^{-17} µCi/mL)			
Area	**Station**	**Number of Samples**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
1	BJY	4	-1.96	3.11	-5.38	1.53
3	Bilby Crater	4	-5.76	5.63	-10.82	0.22
3	Kestrel Crater N	4	3.21	8.12	-4.93	13.45
3	U-3ax/bl S	4	4.71	5.51	-0.37	12.35
5	DoD	4	-11.05	15.97	-34.73	-1.01
5	RWMS 5 Lagoons	4	0.20	10.47	-12.63	9.30
6	Yucca*	4	-2.25	5.55	-7.73	4.64
9	Bunker 9-300	4	-4.90	7.24	-11.31	5.13
10	Gate 700 S*	4	-2.66	2.72	-6.54	-0.26
10	Sedan N	4	-4.96	14.27	-17.71	13.32
11	Pu Valley AMS	4	-2.35	2.76	-6.40	-0.26
16	3545 Substation*	4	2.41	11.03	-8.62	16.53
18	Little Feller 2 N	4	3.77	9.32	-8.21	12.56
20	Schooner*	4	8.55	14.13	-3.39	24.55
23	Mercury Track*	4	-8.73	8.41	-19.00	0.95
25	Gate 510*	4	-7.35	12.32	-20.38	6.73
27	Able Site	4	-1.54	9.36	-9.66	8.67
All Environmental Locations		68	-1.80	9.68	-34.73	24.55

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

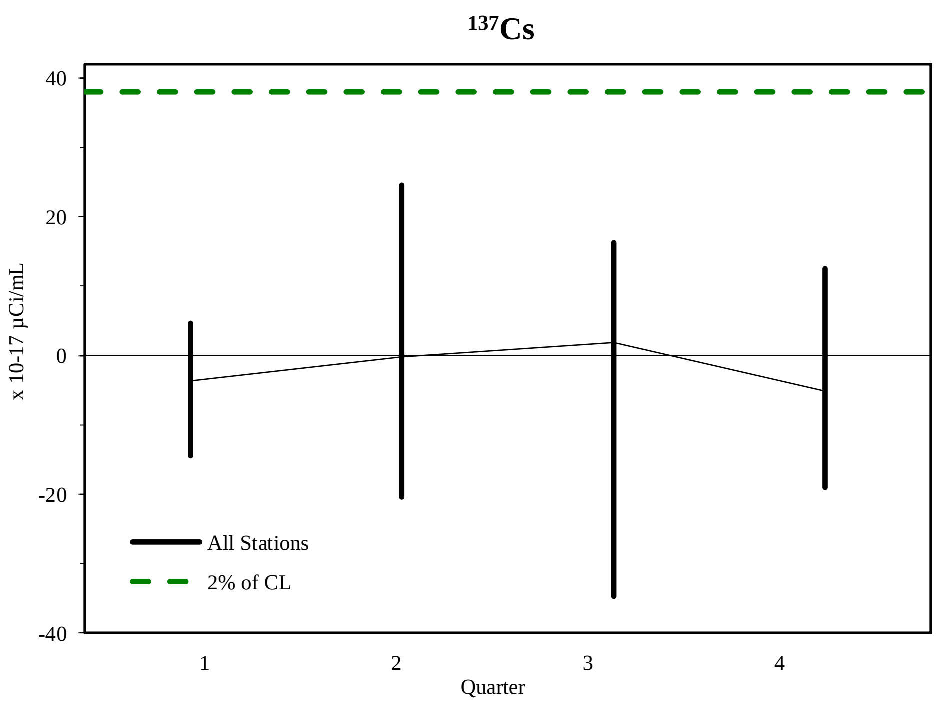

Figure 4-7. Concentrations of ^{137}Cs in air samples collected in 2019

4.1.4.5 Uranium Isotopes

Uranium analyses were performed in 2019 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 seen in previous years, the sample location with the highest annual mean concentration is at the Schooner sampler (51.6×10^{-6} picocuries per milliliter [pCi/mL]). The next highest is 8.4×10^{-6} pCi/mL at Pu Valley AMS. Figure 4-8 shows these data with Schooner results plotted at one-tenth of their actual values to allow the variation at other locations to be visible. The Schooner and Pu Valley AMS annual means are 3.4% and 0.6% of the CL, respectively; mean concentrations at other locations are less than 0.2% of the CL.

Tritium released to the environment quickly oxidizes into tritiated water. Tritium from past nuclear tests or buried waste diffuses into the surrounding soil and rubble until it moves to the surface and is emitted either through evaporation or plant transpiration. Because of this, 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. During the summer months, 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 at the Schooner sample location. In 2019, the summer rise in ^{3}H air concentrations was a bit delayed following the rains of mid-May, and the upward trajectory slowed following the precipitation in late July. The points plotted in these figures show the average ^{3}H concentrations in air for the 2-week periods. The average temperature and total precipitation are from the Schooner Crater meteorological station for those periods.

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 1999, 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 8.7% per year. The decline rate for Schooner has been about 11.8% per year since 2002. These correspond to half-lives in the environment of approximately 4.8 and 7.3 years, respectively.

Table 4-8. Concentrations of ^{3}H in air samples collected in 2019

			^{3}H Concentration (× 10^{-6} pCi/mL)			
Area	**Station**	**Number of Samples**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
1	BJY	26	0.28	0.42	-0.58	1.11
3	Bilby Crater	26	0.29	0.38	-0.22	1.34
3	Kestrel Crater N	26	0.31	0.31	-0.41	1.16
3	U-3ax/bl S	26	0.41	0.42	-0.30	1.22
5	DoD	26	0.70	0.86	-0.40	2.74
5	RWMS 5 Lagoons	26	1.53	2.18	-0.37	6.62
6	Yucca*	26	0.22	0.38	-0.40	1.47
9	Bunker 9-300	26	0.37	0.33	-0.23	1.03
10	Gate 700 S*	25	0.17	0.34	-0.51	0.91
10	Sedan N	26	1.01	0.86	-0.18	2.55
11	Pu Valley AMS	25	8.43	8.67	1.74	37.19
16	3545 Substation*	26	0.02	0.31	-0.89	0.84
18	Little Feller 2 N	26	0.09	0.28	-0.34	0.97
20	North Schooner	26	1.34	1.20	-0.03	3.99
20	Schooner*	26	51.62	53.48	2.74	175.66
23	Mercury Track*	26	0.09	0.34	-0.48	1.20
25	Gate 510*	26	0.09	0.25	-0.41	0.77
All Environmental Locations		440	3.94	17.73	-0.89	175.66

CL = 1500 × 10^{-6} pCi/mL

* EPA-approved Critical Receptor Station

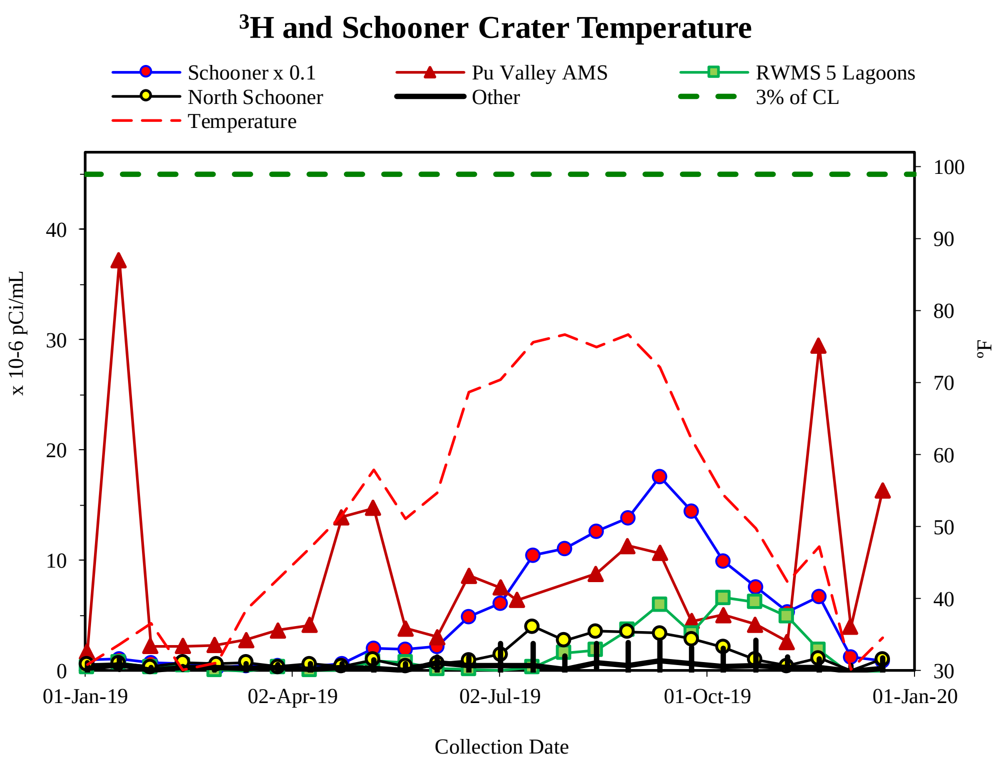

Figure 4-8. Concentrations of ^{3}H in air samples collected in 2019 with the average air temperature near the Schooner sampler during the collection period

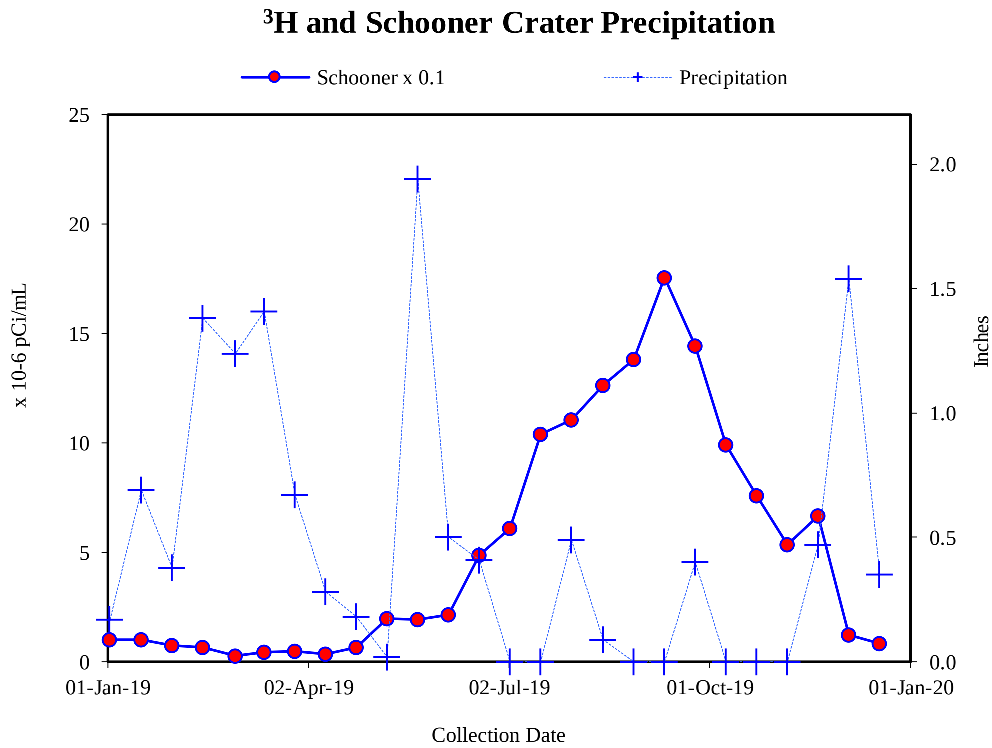

Figure 4-9. Concentrations of ^{3}H in air and precipitation during the sample collection period at Schooner

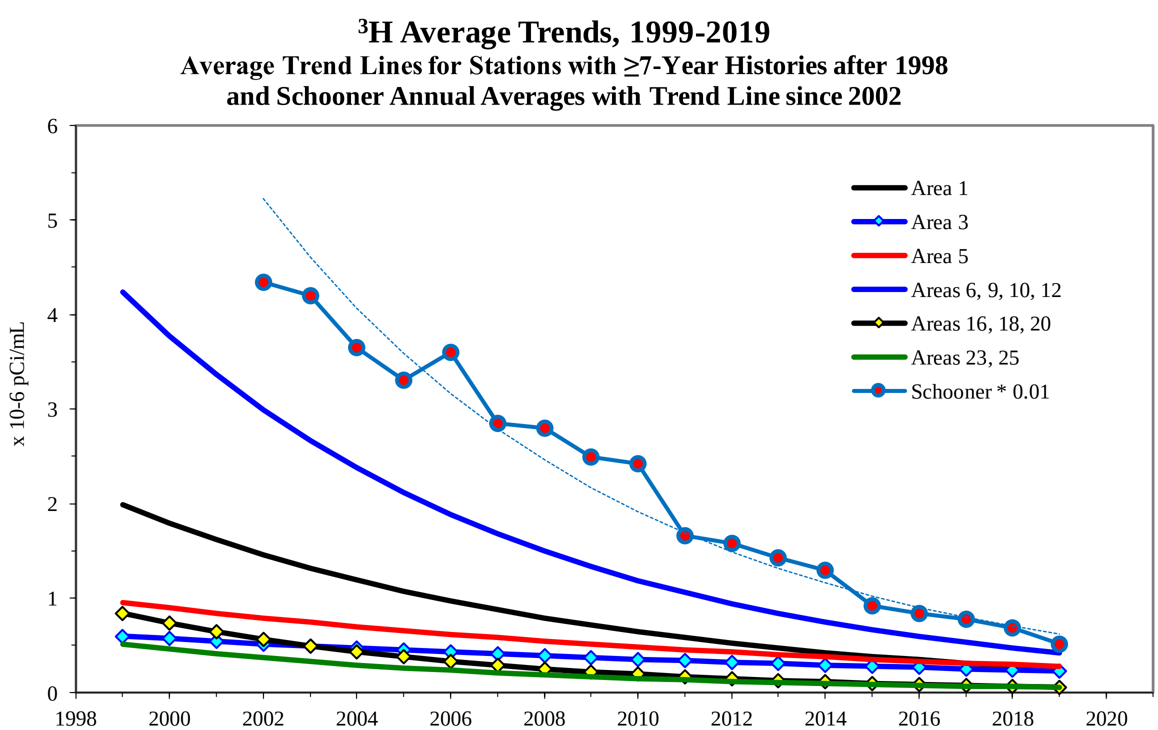

Figure 4-10. Average trend lines for annual mean ^{3}H air concentrations for Area groups, 1999-2019

4.1.5 Emission Evaluations for Planned Projects

In 2019 no NESHAP evaluations for new or modified radionuclide emissions were conducted.

4.1.6 Unplanned Releases

There were no known unplanned radionuclide releases in 2019. Two wildland fires occurred on the NNSS in 2019, both of which were very small (0.1 acres). They were extinguished by NNSS Fire and Rescue personnel or carefully monitored until they burned out.

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 the NESHAP annual report for 2019 (MSTS 2020).

Total emissions in 2019, 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 2019, an estimated 13,179 curies (Ci) of radionuclides were released as air emissions. Of this amount, about 83.6% (11,015 Ci) were from very short-lived radionuclides. These range from seven seconds for nitrogen-16 to 15.3 minutes for metastable xenon-135 (Table 4-9 lists radionuclide name, half-life, and amount emitted). All of these short-lived radionuclides decay very quickly and are essentially not available to contribute dose to the public at the 31 to 62 kilometer (19 to 38 mile) distances over which they have to travel. Tritium makes up about 9.6% of the total emission. Other radionuclides make up about 6.8% of the total emission.

Table 4-9. Total estimated NNSS radionuclide emissions for 2019

Radionuclide	Symbol	Half-life[(a)]	Total Quantity (Ci)
Primary Radionuclides			
Tritium	^{3}H	12.32 years (yr)	689
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	0.070
Noble Gases			
Argon-41	^{41}Ar	109.61 minutes (min)	0.49
Krypton-85	^{85}Kr	10.76 yr	0.000095
metastable Krypton-85	^{85m}Kr	4.48 hours (h)	9.12
metastable Xenon-131	^{131m}Xe	11.84 days (d)	0.0040
Xenon-133	^{133}Xe	5.24 d	0.11
metastable Xenon-133	^{133m}Xe	2.19 d	1.64
Xenon-135	^{135}Xe	9.14 h	22.61
metastable Xenon-135	^{135m}Xe	15.29 min	149

Other

Radionuclide	Symbol	Half-life[(a)]	Total Quantity (Ci)	Radionuclide	Symbol	Half-life[(a)]	Total Quantity (Ci)
Carbon-14	^{14}C	5,730 yr	0.0000088	Iodine-135	^{135}I	6.57 h	30.40
Nitrogen-16	^{16}N	7.1 seconds (s)	1.27	Cesium-134	^{134}Cs	2.064 yr	0.000000048
Oxygen-19	^{19}O	26.46 s	0.0023	Cesium-137	^{137}Cs	30.17 yr	0.050
Cobalt-60	^{60}Co	5.27 yr	0.00023	Barium-140	^{140}Ba	12.75 d	0.65
Bromine-85	^{85}Br	2.90 min	795	Lanthanum-140	^{140}La	1.68 d	0.000000049
Strontium-90	^{90}Sr	28.79 yr	0.052	Cerium-141	^{141}Ce	32.50 d	0.00023
Zirconium-95	^{95}Zr	64.02 d	0.0000000013	Cerium-144	^{144}Ce	285.1 d	0.000025
Niobium-95	^{95}Nb	34.99 d	0.0000000024	Praseodymium-144	^{144}Pr	17.28 min	0.0000059
metastable Niobium-95	^{95m}Nb	3.61 d	0.00000000025	Neodymium-147	^{147}Nd	10.98 d	0.0000000026
Molybdenum-99	^{99}Mo	2.75 d	0.000000029	Promethium-147	^{147}Pm	2.62 yr	0.00000000003
Ruthenium-103	^{103}Ru	39.25 d	0.0000000011	Promethium-149	^{149}Pm	53.08 h	0.0000000063

Table 4-9. Total estimated NNSS radionuclide emissions for 2019

Radionuclide	Symbol	Half-life[(a)]	Total Quantity (Ci)
Rhodium-106	^{106}Rh	29.8 s	0.000012
metastable Tin-121	^{121m}Sn	43.9 yr	0.00000000032
Antimony-124	^{124}Sb	60.2 d	0.0000024
Antimony-125	^{125}Sb	2.76 yr	0.000087
Tellurium-132	^{132}Te	3.2 d	1.89
Iodine-129	^{129}I	15,700,000 yr	0.00000000023
Iodine-131	^{131}I	8.02 d	0.55
Iodine-133	^{133}I	20.8 h	9.94
Promethium-151	^{151}Pm	28.4 h	0.0000000047
Samarium-151	^{151}Sm	90 yr	0.000017
Samarium-153	^{153}Sm	46.5 h	0.10
Europium-152	^{152}Eu	13.54 yr	0.0092
Europium-154	^{154}Eu	8.59 yr	0.000085
Europium-155	^{155}Eu	4.76 yr	0.000091
Depleted Uranium	DU	>159,000 yr	0.052

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

Table 4-10. Radiological atmospheric releases from the NNSS for 2019

Emission Source[(a)]	Emission Control	Radionuclide	Quantity (Ci/y)
Historical Contamination Sites			
Grouped Area Sources– All NNSS Areas	None	^{3}H	17.46
		^{60}Co	0.00023
		^{90}Sr	0.051
		^{137}Cs	0.050
		^{152}Eu	0.0092
		^{154}Eu	0.000085
		^{155}Eu	0.000058
		^{238}Pu	0.040
		$^{239+240}$Pu	0.29
		^{241}Am	0.070
Building A-01, basement ventilation, North Las Vegas Facility	None	^{3}H	0.0024
2019 Operations			
BEEF[(b)]	None	DU	0.052
DPF[(c)]	None	^{3}H	657
		^{16}N	0.00016
		^{19}O	0.00000021
		^{41}Ar	0.00000026
E-Tunnel Ponds	None	^{3}H	4.30
UGTA Wells[(d)]	None	^{3}H	2.91
Area 3 RWMS	Soil cover over waste	^{3}H	4.51
Area 5 RWMC	Soil cover over waste	^{3}H	2.63
Building 23-652	None	^{3}H	0.00000069

Emission Source	Emission Control	Radionuclide	Quantity (Ci/y)	Radionuclide	Quantity (Ci/y)
NCERC[(e)]	HEPA filter[(f)]	^{3}H	0.0000031	^{133}I	9.94
		^{14}C	0.0000088	^{135}I	30.4
		^{16}N	1.27	^{131m}Xe	0.0040
		^{19}O	0.0023	^{133}Xe	1.64
		^{41}Ar	0.49	^{133m}Xe	0.11
		^{85}Br	795	^{135}Xe	22.6
		^{85}Kr	0.000095	^{135m}Xe	149
		^{85m}Kr	9.12	^{134}Cs	0.000000048
		^{90}Sr	0.00071	^{137}Cs	0.00074
		^{95}Zr	0.0000000013	^{140}Ba	0.65
		^{95}Nb	0.0000000024	^{140}La	0.000000049
		^{95m}Nb	0.00000000025	^{141}Ce	0.00024
		^{99}Mo	0.000000029	^{144}Ce	0.000025
		^{103}Ru	0.0000000011	^{144}Pr	0.0000059
		^{106}Rh	0.000012	^{147}Nd	0.0000000026
		^{121m}Sn	0.00000000032	^{147}Pm	0.000000000030
		^{124}Sb	0.0000024	^{149}Pm	0.0000000063
		^{125}Sb	0.000087	^{151}Pm	0.0000000048
		^{132}Te	1.89	^{151}Sm	0.000017
		^{129}I	0.00000000023	^{153}Sm	0.10
		^{131}I	0.55	^{155}Eu	0.000033

(a) All locations are on the NNSS except for Building A-01.
(b) Big Explosives Experimental Facility.
(c) Dense Plasma Focus (Facility).
(d) Underground test area (UGTA) wells.
(e) National Criticality Experimental Research Center.
(f) ***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 accepted by EPA Region 9 for use on the NNSS in 2001 (EPA 2001) 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, ^{241}Am, and ^{137}Cs. All of the 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 annual average 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." If the average value is negative due to background measurements being higher than the low result, the negative value is set to zero to ensure the ratio to the CL is not negative. 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 0.046 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. Sums of fractions of compliance levels for man-made radionuclides at critical receptor samplers in 2019

Radionuclides Included in Sum of Fractions	NNSS Area	Sampling Location	Sum of Fractions of Compliance Levels (CLs)
^{241}Am, ^{238}Pu, $^{239+240}$Pu, ^{137}Cs, and ^{3}H	6	Yucca	0.0039
	10	Gate 700 S	0.0088
	16	3545 Substation	0.0016
	20	Schooner	0.0462
	23	Mercury Track	0.0016
	25	Gate 510	0.0026

As a secondary measure of NNSS compliance with air pathway dose limits, the radioactive air emissions from each NNSS sample location in Table 4-10 were modeled using the ***Clean Air Package, 1988***, model (CAP88-PC, Version 4.0; EPA 2014). Wind files containing frequency distributions of wind speed, direction, and stability class from Calendar Year 2019 meteorological stations on the NNSS were provided by the National Oceanic and Atmospheric Administration, Air Resources Laboratory, Special Operations and Research Division. CAP88-PC predicted annual dose (mrem/yr) from each emission source to each receptor were calculated. The highest value (***maximally exposed individual***) is predicted to be 0.057 mrem/yr for a person residing in Amargosa Valley (Chapter 9 has a discussion of dose to the public from all pathways).

Nearly all radionuclides detected by environmental air samplers in 2019 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

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 [SO_2], nitrogen oxides [NO_X], carbon monoxide [CO], volatile organic compounds [VOCs], and particulate matter) and emissions of hazardous air pollutants do not exceed limits established under National Ambient Air Quality Standards (NAAQS) and NESHAP, respectively. Ensure emissions of permitted NNSS equipment comply with the opacity criteria set by NAAQS and New Source Performance Standards (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.

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, NAAQS, and 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.

4.2.1 Permitted NNSS Facilities

NNSA/NFO maintains a Class II Air Quality Operating Permit (AP9711-2557.01) 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 AP9711-2557.01 include the following:

- Approximately 14 facilities/131 pieces of equipment in Areas 1, 2, 5, 6, 12, 18, 19, 20, 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)
- 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. The air permit was issued in January 2019. Operations at the NNSS continued under a permit application "shield" until the permit was renewed. Nevada Administrative Code Chapter 445B, "Air Controls," allows for the continued operation of a stationary source until the permit is renewed or denied. The permit issued in January 2019 expired in June 2019, and an application for permit renewal was submitted to the state in April 2019. It is anticipated that the renewal of the NNSS air permit will be issued by NDEP in 2020.

New operational allowances in the 2019 permit include:

- Modification of the EODU reporting requirement to coincide with the submittal of other facility annual reports.
- Reduction of the site-wide HAP emissions cap for a single pollutant from 8 tons/yr down to 7 tons/yr. Actual emissions are typically < 1 ton/yr.

Requested permit modifications for the next permit include:

- Addition of three aggregate hoppers and three conveyors to the Erie Strayer Batch Plant (Systems 115-122).
- Relocation of the Erie Strayer Batch Plant from NNSS Area 1 to Area 6.
- Removal of Emission Units PF1.138 and PF1.139 from System 115 to add them to Area 1 Batch Plant (Systems 16–18).
- Revsion to the List of Insignificant Activities to include two infared heaters.

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. In past years, NNSA/NFO has submitted Actual Production/Emissions Reporting Forms to NDEP, as required by the NNSS air permit. In 2019, NDEP changed annual emissions reporting to an electronic system, the State and Local Emissions Inventory System (SLEIS). Information reported electronically includes the actual annual operational information and the calculated emissions of the criteria air pollutants and HAPs for all permitted emission units used within the calendar year. The state uses the information to determine permit fees and to verify that emissions do not exceed the PTEs. Based on operational data and corresponding SLEIS calculations of emissions for calendar year 2019, PTEs for permitted facilities and equipment were not exceeded. For calendar year 2019 emissions, refer to the 2019 SLEIS annual emissions report.

In April 2019, NDEP determined that measuring meteorological data and monitoring of particulate matter equal to or less than 10 microns in diameter (PM10) were no longer applicable for permitted explosives activities at the NNSS. As such, for the applicable permitted facilities, this data and information is no longer collected nor reportable to NDEP.

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. For the NNSS, two Open Burn Authorizations are maintained and renewed annually. These authorizations are issued for fire extinguisher training and for support-vehicle live-fire training activities. In 2019, 31 fire extinguisher training sessions and 6 vehicle burns were conducted at the NNSS. The fire extinguisher training 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. Criteria air pollutants and HAPs released on the NNSS over the past 5 years

Pollutant	2015	2016	2017	2018	2019
Particulate Matter (PM10)[(b)]	0.52	1.1	0.54	0.45	0.71
Carbon Monoxide (CO)	1.74	1.81	0.51	0.61	1.48
Nitrogen Oxides (NO_X)	7.43	7.47	1.21	2.8	3.27
Sulfur Dioxide (SO_2)	0.39	0.31	0.01	0.18	0.36
Volatile Organic Compounds (VOCs)	1.69	1.45	1.14	1.83	5.25
Hazardous Air Pollutants (HAPs)[(c)]	0.03	0.02	0.02	0.01	0.01

(a) For metric tons, 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 7 tons per individual HAP and 18 tons for all

4.2.4 Performance Emission Testing and State Inspection

No performance emission testing was required or performed for any of the emission units in 2019. 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 2019. In September, 2019, NDEP conducted a partial compliance inspection consisting of a records review.

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 2019, seven employees on the NNSS were certified. Readings were taken for the following NNSS permitted systems/emission units in June and July, 2019: Systems 50, 55, 110, and 123. Results were submitted to NDEP; none of the measured opacity readings exceeded the 20% regulatory 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 2019, 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 2019, explosives were detonated at BEEF and EODU, and no permit limits were exceeded. Annual summary reports for activities at BEEF, NPTEC, and EODU were completed for activities conducted in 2019. These reports were submitted to NDEP in February 2020, as required. No detonations took place at any of the other detonation permitted explosives facilities.

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 off site 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.

Seventeen Notification of Demolition and Renovation Forms were submitted in 2019. Fifteen notifications were for demolition of facilities. Two 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 2019, 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, 2, 5, 6, 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 SAD permits exist for the operation of three 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 2019, and all reporting requirements of the SAD permits were met.

4.2.10 Environmental Impact of Nonradiological Emissions

In 2019, NNSS activities produced a total of 5.87 tons of criteria air pollutants and 0.01 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 2019 is 37,549 tons per year (Pollack 2007), whereas the estimated annual release from the NNSS in 2019 of 2.8 tons of NO_X represents less than 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 (DOE), National Nuclear Security Administration Nevada Field Office (NNSA/NFO) and the Environmental Management (EM) Nevada Program. NNSA/NFO and the 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, 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 Community Environmental Monitoring Program (CEMP) and the Nye County Tritium Sampling and Monitoring Program (TSaMP) perform annual, independent radiological monitoring of water supply systems in communities surrounding the NNSS and encourage community involvement. The TSaMP is funded through a grant from EM Nevada Program and the CEMP is funded by NNSA/NFO. Sections 7.2 and 7.3 describe CEMP's and Nye County's groundwater monitoring activities in 2019.

5.1 Radiological Monitoring

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 (see Chapter 9 for estimates of public dose). 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.

Radionuclides[1] have been detected in the groundwater in some areas of the NNSS and Nevada Test and Training Range (NTTR) that are 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 UGTs. A complete description of the hydrogeological environment in which UGTs were conducted is in *Attachment A: Site Description.*[2]

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 is implemented through the NNSS Integrated Groundwater Sampling Plan (EM Nevada Program 2018), referred to hereafter as the Plan. The Plan describes a comprehensive approach for collecting and analyzing groundwater that combines routine radiological monitoring performed by NNSA/NFO (Bechtel Nevada 2003) with that performed by EM Nevada Program's UGTA Activity. Its implementation 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) or a UGTA CAU Closure Report (closure wells).

[1] The definition of word(s) in ***bold italics*** may be found by referencing the Glossary, Appendix B.
[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.

5.1.1 NNSA/NFO and EM Nevada Program Groundwater Sampling Design

The radiological water sampling network consists of 80 sample locations (Figure 5-1), categorized into eight different well types. Table 5-1 defines sample source type, monitoring purpose, and sample frequency associated with NNSA/NFO and EM Nevada Program radiological water sample types. Some locations are monitored to meet multiple objectives. The first five sample source types lsited below (Characterization, Source/Plume, Early Detection, Distal, and Community) are described by the Plan. The remaining are either described in a permit or UGTA CAU Closure Report.

Table 5-1. Definitions and objectives for radiological water sample types

Sample Source Type	Purpose	Frequency
Characterization	Used for system characterization or model evaluation	2–3 years, as needed
Source/Plume	Located within the plume from an underground nuclear test (i.e., radionuclides from underground testing is present)	4 years
Early Detection	Located downgradient of, or near, a UGT and no radionuclides detected above the minimum detection limit for standard analysis	2–5 years
Distal	Downgradient of the Early Detection area	5 years
Community	Located on Bureau of Land Management (BLM) or private land; used as a water supply source or is near one	5 years
Closure	Monitoring location supporting closure of an UGTA CAU	As specified by Closure Report
NNSS PWS	Permitted water supply well that is part of a state-designated non-community PWS on the NNSS	Quarterly
Compliance	Sampled to comply with specific federal/state regulations or permits	As specified by permit

5.1.1.1 Analytes

Most radionuclides produced by NNSS UGTs are relatively immobile in groundwater 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. ***Tritium (^{3}H)*** is the radionuclide with the greatest potential for impacting groundwater quality because it is of the most mobile in groundwater and is produced in highest abundance during nuclear testing. In addition, ^{3}H is the only radionuclide produced by NNSS UGTs known to have exceeded its U.S. Environmental Protection Agency (EPA) Safe Drinking Water Act (SDWA) ***maximum contaminant level (MCL)*** of 20,000 picocuries per liter (pCi/L) in sampling locations away from the nuclear test location or outside of tunnels used for conducting UGTs. All sampling locations therefore require ^{3}H analysis.

> **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.

Additional radionuclides from NNSS UGTs are analyzed in samples collected at Characterization and Source Plume locations (Table 5-2). These radionuclides, if present, are at insignificant levels (i.e., < 0.1% of their MCL) unless ^{3}H is present at concentrations above its 20,000 pCi/L MCL. Therefore, these radionuclides are not required for Early Detection, Distal, and Community locations. Trends in these data will be evaluated to determine whether any additional radionuclides should be monitored in Early Detection wells in the future. ***Gross alpha*** and ***gross beta*** are analyzed along with ^{3}H for PWS and Compliance.

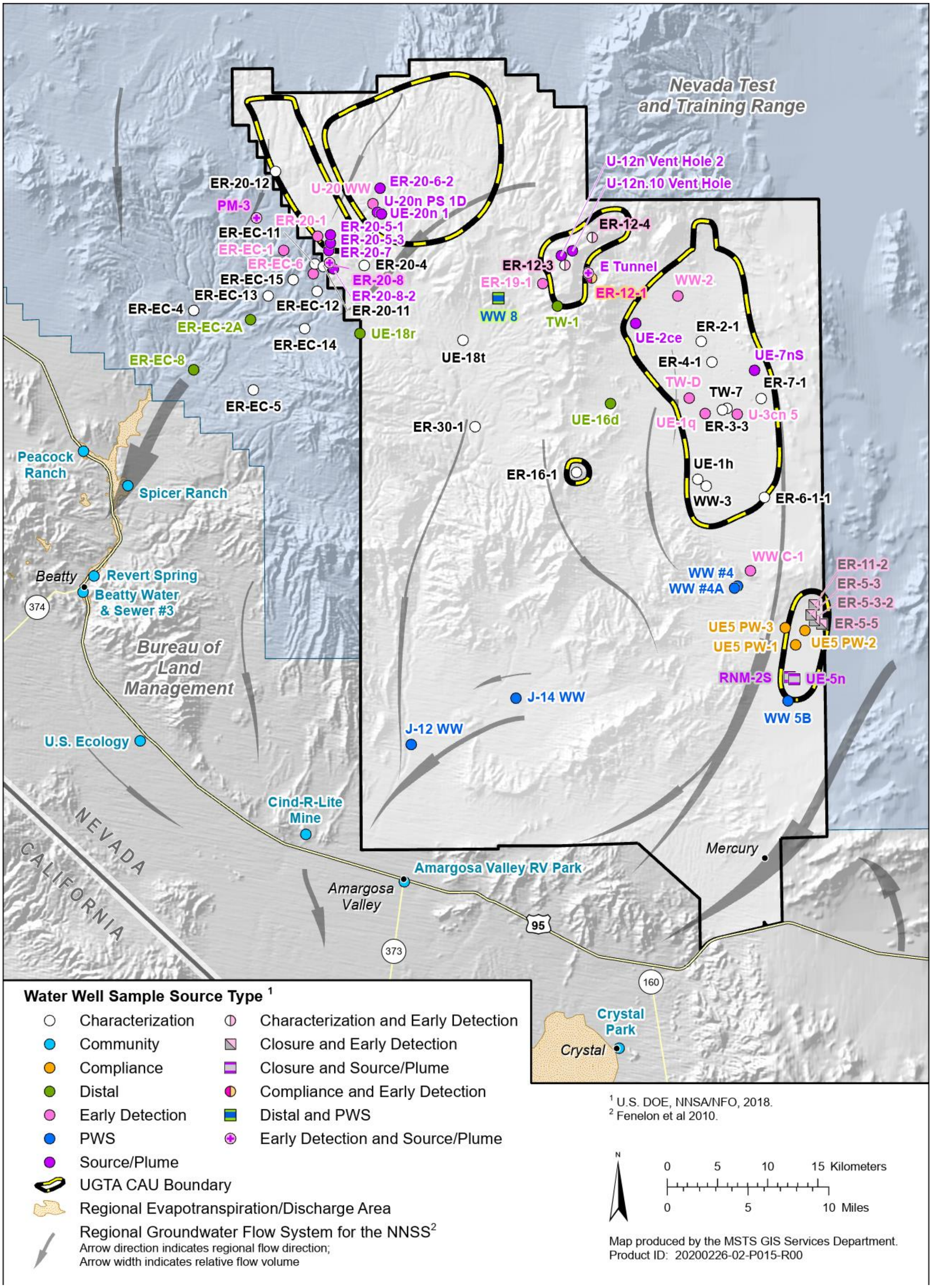

Figure 5-1. NNSA/NFO and EM Nevada Program water sampling network

Table 5-2. Radionuclides analyzed for each sample source type

CAU	Radionuclide
	Characterization
All	Gross alpha, gross beta, ^{3}H, ^{14}C, ^{36}Cl, ^{90}Sr, ^{99}Tc, ^{129}I, U, Pu Gamma emitters (^{26}Al, ^{94}Nb, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{235}U, ^{241}Am, ^{243}Am)
	Source Plume
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	^{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)
	Early Detection, Distal, and Community
All	^{3}H
	NNSS PWS and Compliance
All	Gross alpha, gross beta, and ^{3}H

Note: Closure wells are either categorized as Source Plume or Early Detection (Table 5-4).

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, and 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, -15, and ER-20-12).

Water samples are collected following the sampling methods described in standard operating procedures. To ensure samples represent ambient formation water, the well is purged 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) and to evaluate trends over time.

5.1.1.3 Detection Limits

Standard methods for radionuclide analysis are performed by commercial laboratories that are certified by the Nevada Division of Environmental Protection (NDEP) Bureau of Safe Drinking Water. The ***minimum detectable concentration (MDC)*** using these methods must be at or below the EPA SDWA MCL. The MDC for ^{3}H analyses using a standard method (approximately 300 pCi/L) is well below the EPA SDWA-required detection limit of 1,000 pCi/L and the MCL of 20,000 pCi/L. 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. Samples collected from some wells that are expected to have ^{3}H levels below 300 pCi/L (Early Detection and some Characterization wells) are enriched before ^{3}H analysis. The enrichment process (DOE 1997), referred to throughout this report as low-level ^{3}H analysis, concentrates ^{3}H in a sample to provide a lower MDC, of approximately 2 to 40 pCi/L depending on the laboratory performing the enrichment process.

> 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 and some Characterization wells are analyzed using the low-level ^{3}H analysis method.

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

5.1.2 Presentation of Water Sampling Data

NNSA/NFO and the EM Nevada Program classify each well in the sample network into one of four ^{3}H concentration levels (Table 5-3). The four categories are based on the percent of SDWA MCL (20,000 pCi/L) for ^{3}H concentrations measured in the most recent sampling event (Tables 5-4 and 5-5, and Figure 5-2). Twelve Source/Plume, Characterization, or Closure locations 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)]	64
1,000 < X < 10,000	5–50	2
10,000 < X < 20,000	50–100	1
X > 20,000	> 100 (Exceeds SDWA MCL)	13

(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 the same classification that were 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 be sampled as Characterization wells; Figure 5-2 and Table 5-4 only report the results of the shallowest 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 1.5 or 270 pCi/L, respectively). Results from the analyses for radionuclides other than ^{3}H (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 2019 for the NNSS PWS and Compliance sampling locations are listed in Table 5-5.

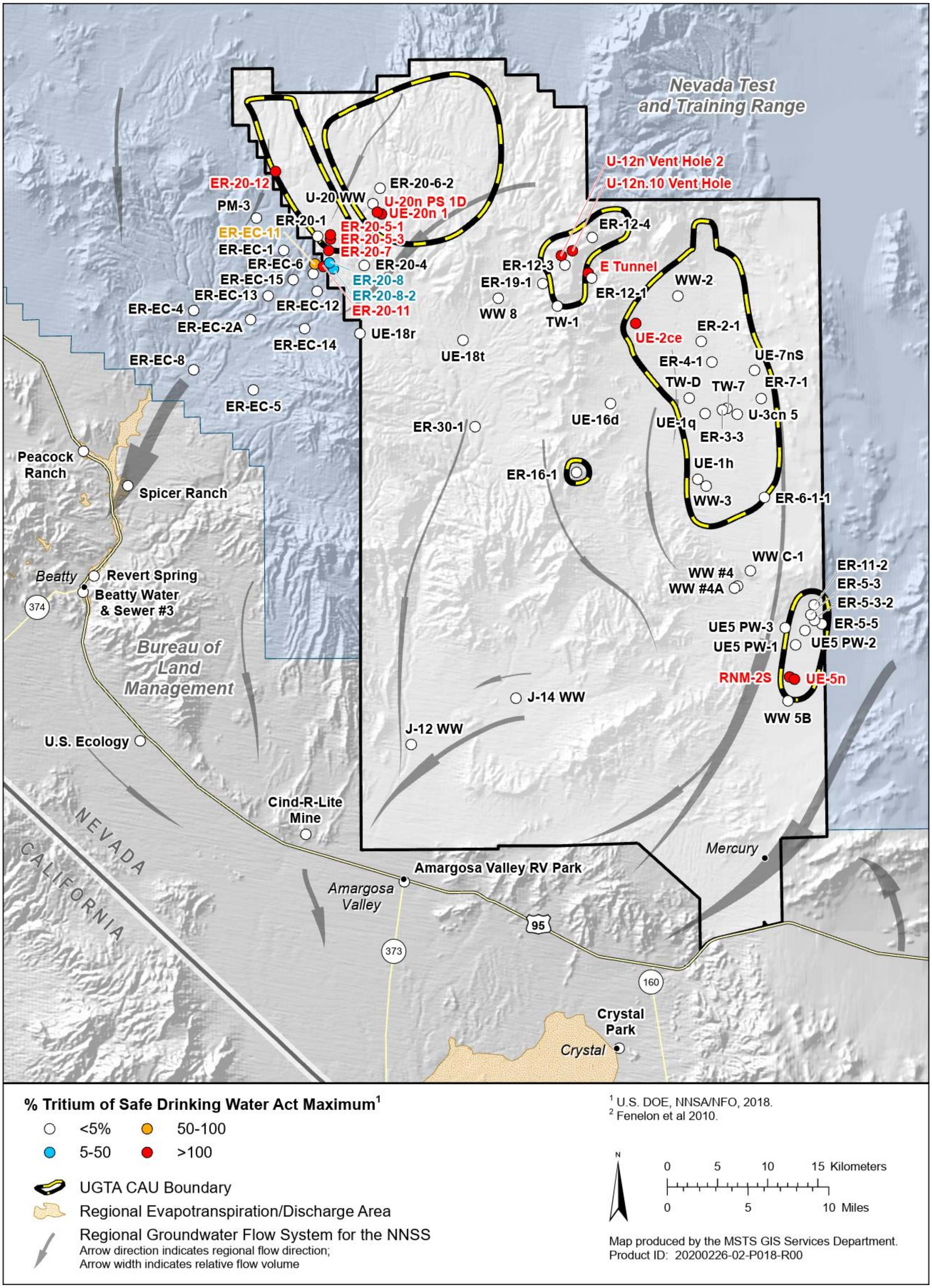

Figure 5-2. Tritium concentration categories at NNSA/NFO and EM Nevada Program sampling locations

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

Sample Location[(a)]	Land Management or NNSS Area	Sample Year	Maximum ^{3}H Concentration (pCi/L)[(b)]
Yellow highlight indicates ^{3}H levels above the SDWA MCL of 20,000 pCi/L			
Frenchman Flat			
Closure Wells			
ER-5-3[(c)]	Area 5	2019	<2.4
ER-5-3-2[(c)]	Area 5	2019	<3.1
ER-5-5[(c)]	Area 5	2019	<2.8
ER-11-2[(c)]	Area 5	2019	<2.6
RNM-2S[(d)]	Area 5	2019	65,000
UE-5n[(d)]	Area 5	2019	120,000
Pahute Mesa (Central and Western)			
Characterization Wells			
ER-20-4	Area 20	2018	<3.0
ER-20-11	Area 20	2017	202,000
ER-20-12[(e)]	Area 20	2017	58,100
ER-EC-4	NTTR	2018	<2.7
ER-EC-5	NTTR	2019	J <3.1
ER-EC-11[(e)]	NTTR	2017	18,400
ER-EC-12[(e)]	NTTR	2018	U 3.2[(f)]
ER-EC-13[(e)]	NTTR	2019	<2.7
ER-EC-14[(e)]	NTTR	2019	J <3.0
ER-EC-15[(e)]	NTTR	2019	<2.8
Source/Plume Wells			
ER-20-5-1	Area 20	2019	20,000,000
ER-20-5-3	Area 20	2019	64,900
ER-20-6-2	Area 20	2017	U 390[(f)]
ER-20-7	Area 20	2017	13,600,000
ER-20-8_m2[(g)]	Area 20	2017	6,400
ER-20-8-2	Area 20	2017	3,670
PM-3_p2[(g)]	NTTR	2018	574
U-20n PS 1D	Area 20	2019	13,100,000
UE-20n 1	Area 20	2019	32,600,000
Early Detection Wells			
ER-20-1	Area 20	2019	<3.2
ER-20-8_p1[(g)]	Area 20	2017	191
ER-EC-1	NTTR	2016	<2.9
ER-EC-6	NTTR	2018	U 4.1[(f)]
PM-3_p1[(g)]	NTTR	2018	192
U-20 WW	Area 20	2018	<3.2
Distal Wells/Locations			
ER-EC-2A	NTTR	2019	<310
ER-EC-8	NTTR	2016	<4.5
UE-18r	Area 18	2017	<188
Community Wells/Springs			
Amargosa Valley RV Park	BLM	2017	<211
Beatty Water & Sewer #3	Beatty	2017	<201
Cind-R-Lite Mine	BLM	2017	<205
Crystal Park	Private land	2012	<21
Peacock Ranch	Private land	2017	<209
Revert Spring	Private land	2019	<247
Spicer Ranch	Private land	2017	<205
U.S. Ecology	BLM	2017	<207
Rainier Mesa/Shoshone Mountain			
Characterization Wells			
ER-12-3_p1[(g)]	Area 12	2016	27.3
ER-12-4_p1[(g)]	Area 12	2016	7.6

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

Sample Location[(a)]	Land Management or NNSS Area	Sample Year	Maximum ^{3}H Concentration (pCi/L)[(b)]
Yellow highlight indicates ^{3}H levels above the SDWA MCL of 20,000 pCi/L			
ER-16-1	Area 16	2017	<2.3
ER-30-1	Area 30	2017	<2.8
UE-18t	Area 18	2016	<3.1
Source/Plume Wells			
E Tunnel[(h)]	Area 12	2019	258,000
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-12-1[(h)]	Area 12	2019	<340
ER-12-3_m1[(g)]	Area 12	2015	<2.2
ER-12-4_m1[(g)]	Area 12	2015	<1.7
ER-19-1	Area 19	2016	<3.0
Distal Wells			
TW-1	Area 17	2018	<229
UE-16d	Area 16	2019	<192
WW-8[(i)]	Area 18	2019	<286
Yucca Flat/Climax Mine			
Characterization Wells			
ER-2-1	Area 2	2019	<229
ER-3-3	Area 3	2018	<2.9
ER-4-1	Area 4	2019	<2.8
ER-6-1-1	Area 6	2018	<3.0
ER-7-1	Area 7	2018	U 3.6[(f)]
TW-7	Area 7	2015	<2.5
UE-1h	Area 1	2017	<2.5
WW-3	Area 3	2018	7.4
Source/Plume Wells			
UE-2ce	Area 2	2016	144,000
UE-7nS	Area 7	2015	53
Early Detection Wells			
TW-D	Area 4	2018	<2.9
U-3cn 5	Area 3	2017	12.3
UE-1q	Area 1	2018	<2.2
WW C-1	Area 6	2018	12.2
WW-2	Area 2	2019	<2.6

(a) Only the sample result, not the field duplicate, is reported.
(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 also an Early Detection location.
(d) Well is also a Source Plume location.
(e) The Plan requires multiple depths to be sampled at this location. The highest value is presented when multiple depths are sampled within the same year.
(f) U qualifier indicates that the reported result is less than the MDC plus measurement uncertainty and is considered a nondetect.
(g) Sampling locations access separate depth intervals. ER-12-3_p1, ER-12-4_p1, ER-20-8_m2, and PM-3_p2 access the more shallow intervals and ER-12-3_m1, ER-12-4_m1, ER-20-8_p1, and PM-3_p1 access the deeper intervals. The highest ^{3}H activities are observed in shallow versus deep intervals.
(h) ER-12-1 and E Tunnel are also Compliance locations (Table 5-5).
(i) 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 for 2019

Sample Location	NNSS Area	Sample Date	Concentration (pCi/L)[(a)] ^3H	α[(b)]	β[(b)]
NNSS PWS Wells					
J-12 WW	Area 25	1/22/2019	<188	1.5	4.9
		4/25/2019	<201	5.3	5.1
		7/23/2019	<282	<1.8	4.6
		10/29/2019	<264	<2.0	4.6
J-14 WW	Area 25	1/22/2019	<191	2.9	7.1
		4/25/2019	<200	4.9	9.3
		7/23/2019	<284	3.0	6.9
		Not Operational	--	--	--
WW-4	Area 6	1/22/2019	<187	12	6.3
		4/25/2019	<195	8.3	6.5
		4/25/2019 FD[(c)]	<198	8.1	7.5
		7/23/2019	<280	7.9	6.3
		10/29/2019	<264	6.9	4.4
WW-4A	Area 6	1/22/2019	<184	9.5	4.9
		4/25/2019	<200	8.0	5.8
		7/23/2019	<283	7.6	6.0
		10/29/2019	<265	9.7	8.1
WW-5B	Area 5	Not Operational	--	--	--
		Not Operational	--	--	--
		7/23/2019	<281	3.0	10.1
		7/23/2019 FD	<283	5.8	11.9
		10/29/2019	<267	5.8	10.1
WW-8	Area 18	1/22/2019	<189	<2.0	4.0
		4/25/2019	<197	<1.1	2.4
		7/23/2019	<286	<1.6	3.0
		10/29/2019	<268	<2.0	3.6
		10/29/2019 FD	<261	<1.9	3.0
Compliance Wells/Surface Waters					
UE-5 PW-1	Area 5	3/5/2019	<224	6.0	5.6
		3/5/2019 FD	<230	NA[(d)]	NA
		3/5/2019 FD	<226	8.3	5.8
		8/6/2019	<203	8.8	7.3
		8/6/2019 FD	<200	NA	NA
		8/6/2019 FD	<201	NA	NA
UE-5 PW-2	Area 5	3/12/2019	<209	5.8	6.6
		3/12/2019 FD	<207	NA	NA
		3/12/2019 FD	<217	NA	NA
		8/6/2019	<198	4.3	5.6
		8/6/2019 FD	<196	NA	NA
		8/6/2019 FD	<200	5.0	4.9
UE-5 PW-3	Area 5	3/5/2019	<229	4.9	3.5
		3/5/2019 FD	<223	NA	NA
		3/5/2019 FD	<217	NA	NA
		8/6/2019	<206	4.5	5.1
		8/6/2019 FD	<204	NA	NA
		8/6/2019 FD	<197	NA	NA
ER-12-1[(e)]	Area 12	4/10/2019	< 340	8.1	5.9
		4/10/2019 FD	< 350	3.8	6.0
E Tunnel Waste Water Disposal System[(e)]	Area 12	9/11/2019	258,000	10.4	21.5
		9/11/2019 FD	278,000	11.0	21.8

(a) Concentrations given as less than (<) a number indicate ^3H 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 2019 Sample Results

The following sections discuss results for the seven sample source types that comprise the radiological water-sampling network (Table 5-1). As illustrated in Figure 5-1, all Characterization, Source/Plume, Early Detection, Distal, Closure, NNSS PWS, and Compliance wells are on properties managed by the government. All Community wells or springs are on lands managed by the BLM or on 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

Results for 23 Characterization locations are presented in Table 5-4. The Plan includes a total of 33 Characterization wells, and six access multiple (2 – 4) depths at the same location; only the depth with the greatest ^{3}H concentrations is reported for each location. 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 radionuclides is accurate for monitoring the CAU. A large suite of radionuclides are analyzed in samples collected from Characterization Wells (Table 5-2). Once a baseline has been developed, each Characterization well will be reclassified and sampled according to its new type (Source/Plume, Early Detection, or Distal).

In 2019, a total of six Characterization wells were sampled; four locations are associated with the Pahute Mesa CAUs (ER-EC-5, ER-EC-13, ER-EC-14, and ER-EC-15) and two locations are associated with the Yucca Flat/Climax Mine CAU (ER-2-1 and ER-4-1). No ^{3}H was detected in samples collected from these locations (Table 5-4).

The four wells associated with the Pahute Mesa CAUs are located on the NTTR. Wells ER-EC-13, ER-EC-14, and ER-EC-15 are located downgradient of the BENHAM and TYBO UGTs (Section 11.2.1.2). These wells are also downgradient of Well ER-EC-11, which is the first location that a radionuclide from NNSS UGTs had been detected in groundwater beyond NNSS boundaries. In 2017, ^{3}H was detected at 18,400 pCi/L at ER-EC-11 (Table 5-4).

> ^{3}H 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.

Wells ER-2-1 and ER-4-1 are located near several UGTs within the Yucca Flat/Climax Mine CAU. ER-4-1 accesses the lower carbonate aquifer (LCA) near the STRAIT UGT and ER-2-1 accesses a ***confining unit*** located within 1,500 feet (ft) of five UGTs detonated below the water table (Elliott and Fenelon 2010). No ^{3}H was detected at these locations. The ^{3}H concentration in ER-2-1 groundwater decreased from 1,010 pCi/L concentration previously reported (2015).

5.1.3.2 Source/Plume Wells

Sixteen Source/Plume wells are included in the sampling network (Table 5-4). They have detectable radionuclides from NNSS UGTs and vary in location from within a nuclear test cavity where radionuclide concentrations are high (e.g., U-20n PS 1D), to downgradient of a nuclear test cavity (e.g., PM-3), where radionuclide concentrations can be relatively low. Source/Plume wells are analyzed for ^{3}H and additional CAU-specific radionuclides (Table 5-2). In 2019, a total of seven Source/Plume wells were sampled; four locations are associated with the Pahute Mesa CAUs (ER-20-5-1, ER-20-5-3, U-20n PS 1D, and UE-20n 1), two locations are associated with the Frenchman Flat CAU (RNM-2S and UE-5n), and one location is associated with the Rainier Mesa/Shoshone Mountain CAU (E Tunnel).

Two Source/Plume wells sampled in 2019 are associated with the CHESHIRE UGT in Central Pahute Mesa (Section 11.1.2); one well (U-20n PS 1D) accesses groundwater near the CHESHIRE cavity and the other

(UE-20n 1) accesses groundwater 0.3 kilometers (km) (0.2 miles) downgradient of the CHESHIRE cavity. The CHESHIRE UGT took place in 1976, and has one of the larger announced yields (200–500 kiloton) within this CAU (NNSA/NFO 2015). Although ^{3}H exceeded the 20,000 pCi/L MCL in both sampling locations, only one other radionuclide (^{137}Cs) exceeded its MCL in U-20n PS 1D samples and no other radionuclides exceeded their MCL in UE-20n 1 samples. The low concentration of ^{137}Cs in UE-20n 1 (<8.0 pCi/L) compared to U-20n PS 1D (745 pCi/L) shows that this radionuclide adsorbs to the aquifer materials and does not freely migrate away from the cavity environment. The ^{3}H decreased from 33,300,000 pCi/L (2005) to 13,100,000 pCi/L (2019) in U-20n PS 1D samples and from 55,500,000 pCi/L (2012) to 32,600,000 pCi/L (2019).

Two Source/Plume wells sampled in 2019 (ER-20-5-1 and ER-20-5-3) are associated with the BENHAM and TYBO UGTs in Central Pahute Mesa (Section 11.1.2). In the 2019 samples, ^{3}H decreased by over 20 percent from the 24,800,000 pCi/L (ER-20-5-1) and 84,000 pCi/L (ER-20-5-3) concentrations reported in 2015. No other radionuclides exceeded their MCL in the 2019 samples. Additional wells monitor contamination downgradient from these UGTs, including the three characterization wells (ER-EC-13, ER-EC-14, and ER-EC-15) sampled in 2019 in which no ^{3}H was detected, and ER-EC-11, where ^{3}H was reported as 18,400 pCi/L in 2017 (Section 5.1.3.1).

The remaining Source/Plume wells sampled in 2019 are also Closure (RNM-2S and UE-5n) or Compliance (E Tunnel) wells and are described in Sections 5.1.3.6 and 5.1.3.8, respectively.

5.1.3.3 Early Detection Wells

Nineteen Early Detection wells are included in the sampling network (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.

The sampling frequency for Early Detection wells is once every 5 years because of the low groundwater velocities and the resulting slow change in radionuclide concentration with time. Four Early Detection wells in Frenchman Flat (wells ER-11-2, ER-5-3, ER-5-3-2, and ER-5-5), one in Pahute Mesa CAU (ER-20-1), one in Rainier Mesa/Shoshone Mountain CAU (ER-12-1), and one in Yucca/Flat/Climax Mine CAU (WW-2) were sampled in 2019. No ^{3}H was detected in the 2019 samples. One Early Detection well, ER-12-1, is also a compliance well and is further discussed in Section 5.1.3.8. Consistent with the requirement for compliance sampling, only standard ^{3}H analysis was performed on the ER-12-1 samples resulting in a higher MDC (340 pCi/L) when compared to the other Early Detection samples (2.4 - 3.2 pCi/L) analyzed in 2019. The two Frenchman Flat Early Detection wells are also Closure wells and are described further in Section 5.1.3.6.

5.1.3.4 Distal Wells

Six Distal wells are included in the sampling network (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. Data from these wells also support the development and evaluation of the groundwater flow and contaminant transport models. Three Distal wells were sampled in 2019; one location is associated with the Pahute Mesa CAUs (ER-EC-2a) and two are associated with the Rainier Mesa/Shoshone Mountain CAU (UE-16d and WW-8). No ^{3}H was detected at these locations. Well WW-8 is also an NNSS PWS well (Section 5.1.3.6).

5.1.3.5 Community Wells/Springs

The community sampling network comprises nine locations that are associated with the Pahute Mesa CAUs (Table 5-4). Revert Spring was sampled in 2019. These wells and springs are 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. No ^{3}H has been detected at any community location (Table 5-4 and Chapter 7).

5.1.3.6 Closure Wells

Six Closure wells are included in the sampling network (Table 5-4). In 2019, a single UGTA CAU, Frenchman Flat, was in the Closure stage and sampling for this CAU is described in its Closure Report (NNSA/NFO 2016). Although not included in the Plan, the Closure wells are also categorized as Source/Plume wells (RNM-2S and UE-5n) and analyzed for the radionuclides presented in Table 5-2. Early Detection wells (ER-5-3, ER-5-5, ER-5-3-2, and ER-11-2) are analyzed for low-level ^{3}H. No ^{3}H was detected in the four Early Detection wells (Table 5-4). In 2019, the ^{3}H concentration decreased from 82,000 to 65,000 pCi/L and from 123,000 to 120,000 pCi/L for RNM-2s and UE-5n, respectively. No other radionuclides were detected in these samples. Post-closure monitoring is further discussed in Section 11.2.2.

5.1.3.7 NNSS Public Water System Wells

Results from the NNSS PWS water wells sampled quarterly in 2019 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 2019 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).

5.1.3.8 Compliance Wells/Groundwater Discharges

5.1.3.8.1 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 2019, standard ^{3}H analyses of water samples from these wells 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 10-4 presents the 2019 sampling results for four additional indicators of groundwater contamination, and all 2019 sample analysis results for these three wells are presented by the NNSS Management and Operating Contractor, Mission Support and Test Services, LLC (MSTS), in MSTS (2020).

5.1.3.8.2 NDEP Permitted E Tunnel Waste Water Disposal System

NNSA/NFO manages and operates the NNSS Area 12 E Tunnel Waste Water Disposal System (ETDS) in accordance with the NDEP Bureau of Federal Facilities water pollution control permit (NEV 96021), Revision 1. The permit governs the management of radionuclide-contaminated wastewater that discharges from the E Tunnel portal into a series of conveyance pipes and earthen holding/infiltration ponds.

The permit requires chemical and radiological constituents monitoring of the ETDS effluent and groundwater associated with nearby Well ER-12-1. Tritium, adjusted gross alpha, and gross beta activities are measured in ETDS effluent annually. Groundwater ^{3}H, adjusted gross alpha, and gross beta activities are measured biennially at Well ER-12-1. The permissible limits of ^{3}H, adjusted gross alpha, and gross beta in the ETDS effluent are 1,000,000 pCi/L, 35.1 pCi/L, and 101 pCi/L, respectively. The permissible limits for ^{3}H, adjusted gross alpha, and gross beta in groundwater of Well ER-12-1 are 20,000 pCi/L, 15 pCi/L, and 50 pCi/L, respectively.

Monitoring personnel sampled the ETDS effluent on September 11, 2019, and sampled Well ER-12-1 on April 10, 2019 (Table 5.5). All radiological and non-radiological parameters were within their permissible and threshold limits. Non-radiological results and associated threshold limits are provided in Section 5.2.4.

5.1.3.8.3 UGTA Well Discharged Groundwater and Fluids

UGTA wells are regulated through an agreement between DOE and NDEP called the Fluid Management Plan for the UGTA Project (Attachment 1 of NNSA/NFO 2009). The Fluid Management Plan is used in lieu of an NDEP-approved water pollution control permit for management of fluids produced during the drilling, construction, development, testing, experimentation, and/or sampling of wells by the UGTA Activity. The plan provides criteria by which fluids may be discharged on site. Groundwater ^3H concentrations are monitored daily during sampling activities. Groundwater with $^3H \geq 400,000$ pCi/L is discharged to lined sumps to evaporate. Groundwater with ^3H activity <400,000 pCi/L may be discharged to either lined/unlined sumps or infiltration areas. Fluid Management Plan samples are collected to analyze for metals, gross alpha, gross beta, and ^3H, unless previously demonstrated that these analyses have satisfied criteria established by the plan.

All requirements of the UGTA Fluid Management Plan were satisfied in 2019. Three wells (ER-20-5-1, U-20n PS 1D, and UE-20n 1) were sampled and found to have $^3H \geq 400,000$ pCi/L; this groundwater was discharged to lined sumps. Groundwater from pumped wells with ^3H <400,000 pCi/L was discharged to either lined/unlined sumps or infiltration areas. Criteria for all Fluid Management Plan samples were below threshold levels established in the plan.

5.2 Nonradiological Drinking Water and Wastewater Monitoring

Nonradiological Water Monitoring Goals

Ensure that the operation of NNSS 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 of 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.

Federal and state laws regulate the quality of drinking water and wastewater on the NNSS. 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 2019 activities. Results from radiological monitoring of drinking water on and off the NNSS and of wastewater on the NNSS are discussed in Sections 5.1.3.5, 5.1.3.7, and 5.1.3.8.

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 5-3). The largest system (NNSS Main) 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 (NNSS 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. 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.

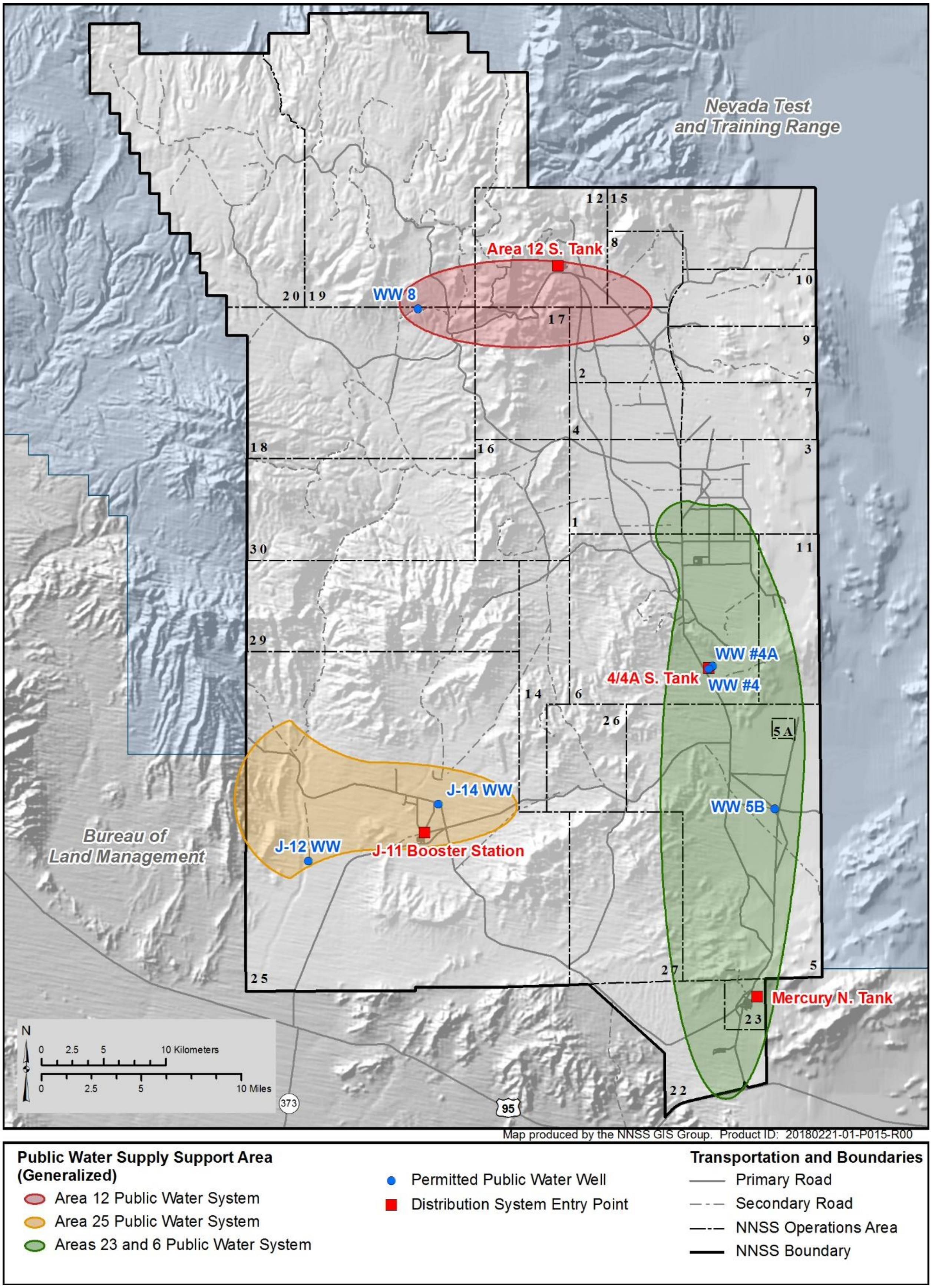

Figure 5-3. Water supply wells and drinking water systems on the NNSS

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
NNSS Main	**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 NNSS Main 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 5-3).
(c) IOCs = Inorganic chemicals.
(d) Refers to sets of chemical contaminants in drinking water for which the EPA established 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 5-3).

5.2.1.1 2019 Results of Public Water System and Water-Hauling Truck Monitoring

Water samples are collected in accordance with accepted practices, analyses are conducted by state-certified 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 2019 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 three years, NDEP conducts a sanitary survey of the permitted PWSs that includes an inspection of wells, tanks, and other visible portions of each PWS. The last NDEP survey was in 2017; no sanitary surveys were conducted in 2019. Water-hauling trucks are inspected annually for compliance with NAC 445A; truck inspections were in June 2019, and NDEP renewed both permits.

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

Contaminant	Maximum Contaminant Level (mg/L)[a]	2019 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
Secondary Standards				
Aluminum	0.2	0.068 U[b] and 0.068 U	NA[c]	0.068 U
Chloride	400.0	12 and 11.7	NA	8.81
Color	15 color units	0 and 0	NA	0
Copper	1.3	0.003 U and 0.003 U	NA	0.003 U
Fluoride	2.0	0.875 and 0.901	NA	2.09
Iron	0.6	0.030 U and 0.041 B[d]	NA	0.003 U
Magnesium	150.0	7.89 and 7.31	NA	1.47
Manganese	0.1	0.002 U and 0.002 U	NA	0.002 U
Odor	3.0 threshold odor number	1.0 and 0	NA	0
pH	6.5-8.5	8.05 and 7.75	NA	8.09
Secondary Standards				
Silver	0.1	0.001 U and 0.001 U	NA	0.001 U
Sulfate	500.0	42.2 and 41.8	NA	22.6
Surfactant (MBAS)	0.10	<0.10	NA	<0.10
Total Dissolved Solids	1000.00	240 and 260	NA	130
Zinc	5.0	0.0036 B and 0.003 U	NA	0.033 U
Inorganic Chemicals				
Nitrate	10 (as nitrogen)	3.9 and 4.0	1.1	1.9
Disinfection By-products				
Total Trihalomethanes	0.005	0.014	NA	NA
Haloacetic Acids	0.005	0.004	NA	NA

(a) mg/L = milligrams per liter.
(b) U = Flagged by the analytical laboratory as below detection limits.
(c) NA = Not applicable, no requirement to sample in 2019.
(d) B = Flagged by the analytical laboratory as contaminant detected in blank.

5.2.2 Domestic Wastewater Monitoring

A total of 17 active and permitted domestic wastewater septic systems are being used on the NNSS (Figure 5-4). 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 Operating 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 March 2019, 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 three septic tank pump trucks (NY-17-06839) was renewed in June 2019.

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 [Device Assembly Facility], and Area 23 Mercury (lagoon systems also receive domestic wastewater) (Figure 5-4). The Yucca Lake system includes two primary lagoons and two secondary lagoons. The DAF system comprises 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).

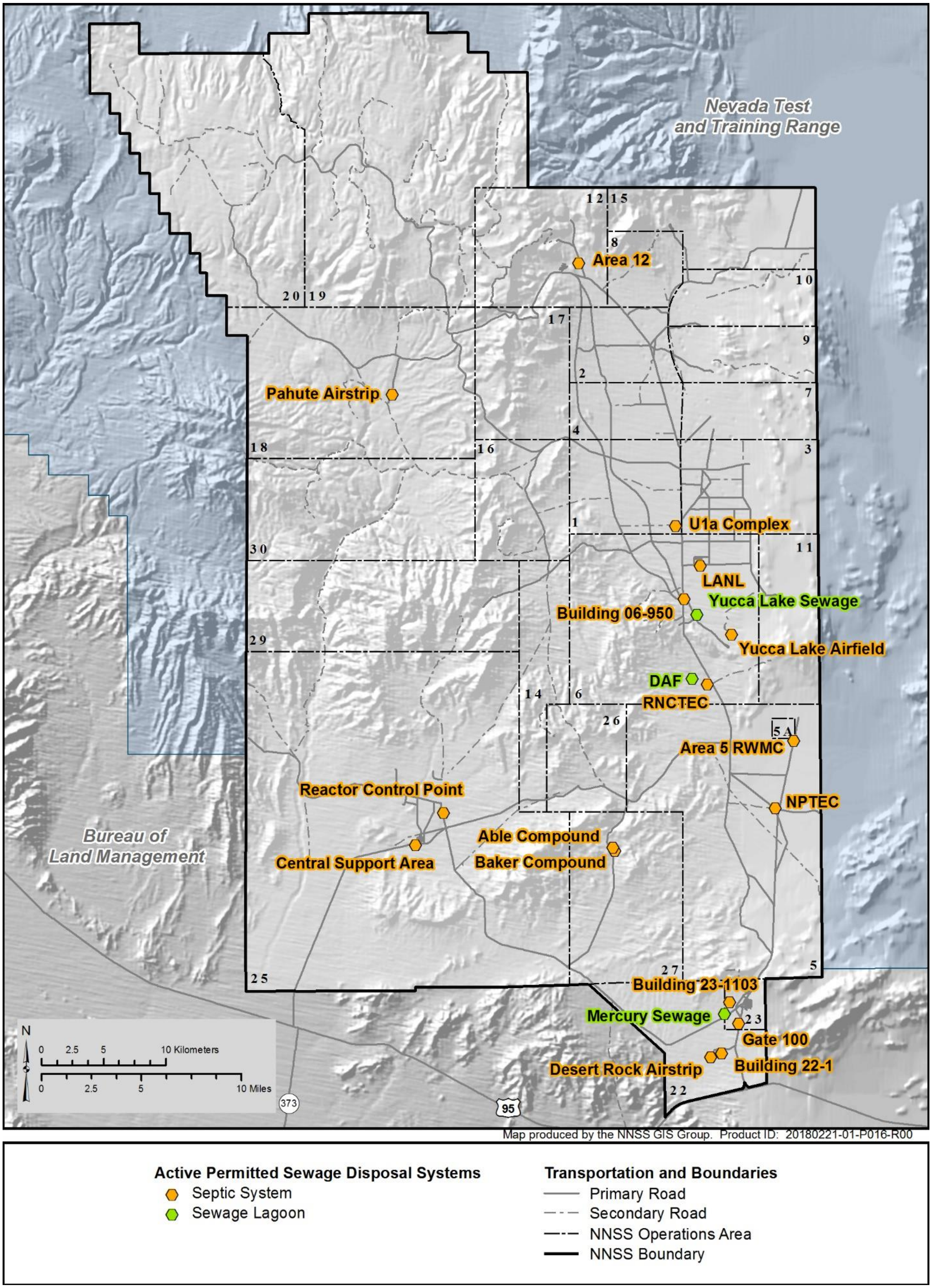

Figure 5-4. Active permitted sewage disposal systems on the NNSS

The Area 23 Mercury system includes 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-certified 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 2019, 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 2019. 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 2019.

Table 5-8. Water quality and flow monitoring results for NNSS sewage lagoon influent waters in 2019

		Minimum and Maximum Values from Quarterly Samples		
Parameter	**Units**	**Area 6 Yucca Lake**	**Area 23 Mercury**	**Area 6 DAF**
BOD_5	mg/L	81-403	108-340	45.0-105
Permit Limit		None	None	None
BOD_5 Mean Daily Load[(a)]	kg/d	1.14-7.93	6.74-24.48	1.2-3.5
Permit Limit		34.43	124.31	15.29
TSS	mg/L	170-450	220-386	70-147
Permit Limit		None	None	None
pH	S.U.[(b)]	8.31-8.82	7.92-8.86	8.40-8.70
Permit Limit		6.0–9.0	6.0–9.0	6.0–9.0
Quarterly Average Flow Rate	GPD[(c)]	761-9,344	11,352-24,638	6,358-16,447
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 bi-weekly and inactive lagoon systems quarterly; no notable observations were made in 2019. NDEP inspects both active and inactive NNSS lagoon systems annually; there were no findings of deficiency in 2019. 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 effluent on September 11, 2019, and sampled well ER-12-1 on April 10, 2019. All radiological and nonradiological parameters were within the threshold limits. Nonradiological results and thresholds are provided in Table 5-9.

Table 5-9. Nonradiological results for Well ER-12-1 groundwater and E Tunnel Waste Water Disposal System discharge samples

	ETDS Discharge Water Sampled Every 12 Months (October 2019)		Well ER-12-1 Groundwater Sampled Every 24 Months (April 2019)	
Nonradiological Parameter	**Threshold (mg/L)**	**Averaged Value (mg/L)**	**Threshold (mg/L)**	**Averaged Value (mg/L)**
Cadmium	0.045	0.005[(a)]	0.005	0.005[(a)]
Chloride	360	8.7	250	15
Chromium	0.09	0.01[(a)]	0.09	0.01[(a)]
Copper	1.2	0.001[(b)]	1.2	0.001[(b)]
Fluoride	3.6	0.19	3.6	0.22
Iron	5.0	0.76	5.0	3.1
Lead	0.014	0.003[(a)]	0.014	0.003[(a)]
Magnesium	135	0.76[(b)]	135	65
Manganese	0.25	0.01	0.25	0.09
Mercury	0.0018	0.0002[(a)]	0.0018	0.0002[(a)]
Nitrate Nitrogen	9	0.20[(a)]	9	0.2
Selenium	0.045	0.005[(a)]	0.045	0.005[(a)]
Sulfate	450	16	450	370
Zinc	4.5	0.014[(b)]	4.5	0.011[(b)]
Flow Rate (liters/minute)	MR[(c)]	30.0[(d)]	NA	NA
pH (S.U.)[(e)]	6.0–9.0	7.2 [(d)]	6.0–9.0	7.26
Specific conductance (µS/cm)[(f)]	<1,500	373[(d)]	<1,500	1,046

(a) Analyte not detected.
(b) Reported result is an estimate.
(c) Permit requires NNSA/NFO to monitor and report (MR); there are no threshold limits.
(d) Average of 12 monthly measures.
(e) S.U. = standard unit(s) (for measuring pH).
(f) µS/cm = microsiemens per centimeter.

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 2019, the USGS monitored water levels in 221 wells on and near the NNSS; these included 121 wells on the NNSS and 100 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 contribute to the development of UGTA CAU-specific models of groundwater flow and radionuclide transport (Section 11.1.2). A map showing the locations 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 included wells J-12 WW, J-14 WW, UE-16d WW, WW #4, WW #4A, WW 5B, and WW 8 (Figure 5-1). The USGS and MSTS compile water-use data and report annual withdrawals in millions of gallons. Withdrawal data from these wells for 2019 have been compiled and processed, with the January through June data 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. The July through November data are maintained by MSTS. The December 2019 data were not available. Total groundwater withdrawals from these wells in 2019 was about 150 million gallons (Figure 5-5).

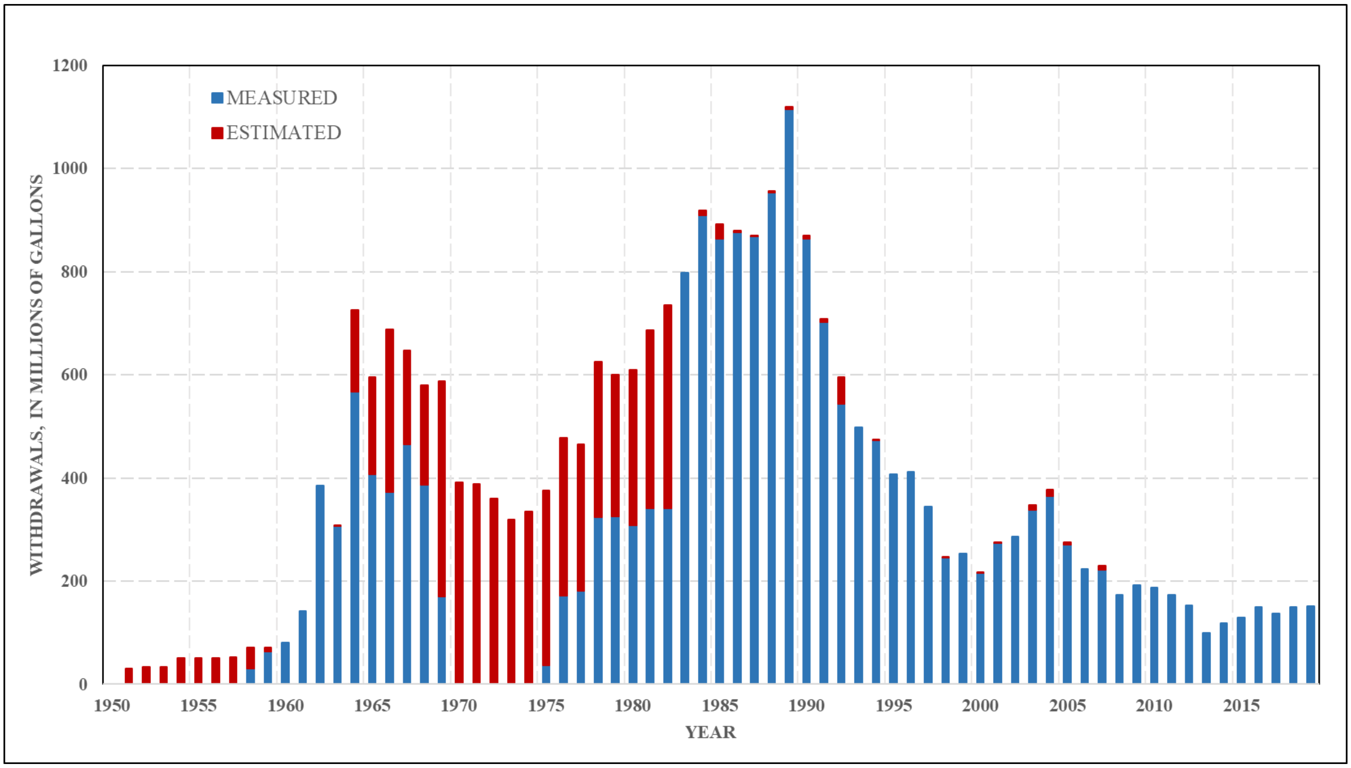

Figure 5-5. Annual withdrawals from the NNSS, 1951 to 2019

5.4 Water Monitoring Conclusions

Groundwater contaminated by historical UGTs does not impact the public or NNSS workers who drink water from wells located off or on the NNSS. Although 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, only testing within the Pahute Mesa CAUs has impacted groundwater off site. Furthermore, the detection of ^{3}H above its standard analysis method MDC of 300 pCi/L has only been observed in two wells on the NTTR (ER-EC-11 and PM-3). Seven wells (including ER-EC-11) monitor a contaminant plume of ^{3}H believed to originate from the TYBO and BENHAM UGTs. These seven wells are within 900 ft to 17,000 ft (0.2 to 3.2 miles) of these two UGTs. Similarly, two wells (including PM-3) monitor a contaminant plume of ^{3}H believed to originate from the HANDLEY UGT. Eight other UGTA wells on the NTTR Well have not shown the presence of man-made radionuclides downgradient of Pahute Mesa. Current data indicate that the distance over which radionuclides have migrated from underground nuclear testing is not significant relative to the distance to offsite public water supply wells. Samples from community wells, including samples collected by CEMP and TSaMP (Sections 7.2 and 7.3), farther downgradient of Pahute Mesa, also contain no detectable man-made radionuclides.

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 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 this report (Section 9.2). Each year, results have demonstrated that the doses to biota are below the limits established to protect plant and animal populations.

Potential nonradiological contaminants in drinking water and wastewater monitored on the NNSS in 2019 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 UGTs 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 5.1.3.8.3). 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 EM Nevada Program is responsible for completing environmental corrective actions at sites where surface and shallow subsurface contamination historically occurred. Some of these sites also 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).

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Chapter 6: Direct Radiation Monitoring

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Direct Radiation Monitoring Program Goals

Assess the proportion of external dose from background radiation versus that from operations at the Nevada National Security Site (NNSS). Measure external radiation to assess the potential external dose to a member of the public from 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 as low as is reasonably achievable (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.

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 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 2019. 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 that "it is also an objective that potential exposures to members of the public be ***as low as is reasonably achievable (ALARA)***."

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 2019 direct radiation monitoring results are in Sections 7.1.4 and 7.1.5; DRI ***thermoluminescent dosimeter (TLD)*** data are compared with onsite 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 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.

[1] The definition of word(s) in ***bold italics*** may be found by referencing the Glossary, Appendix B.

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 dose of 1 millirem (mrem) (or 0.01 millisievert [mSv]).

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) 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 105 active environmental TLD locations on the NNSS in 2019 (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) – 19 locations in and around the Area 3 and 5 RWMSs. Four WO stations (Building 5-31, RWMS Expansion NW, RWMS South Gate, and WEF East) were removed after 2018. Six stations (CAU-111, Lysimeter, Pilot Well 3, Powerline Rd, Vefa, and Waterline Rd) were added in Area 5.
- Control (C) – Five locations in Building 652 and one 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.

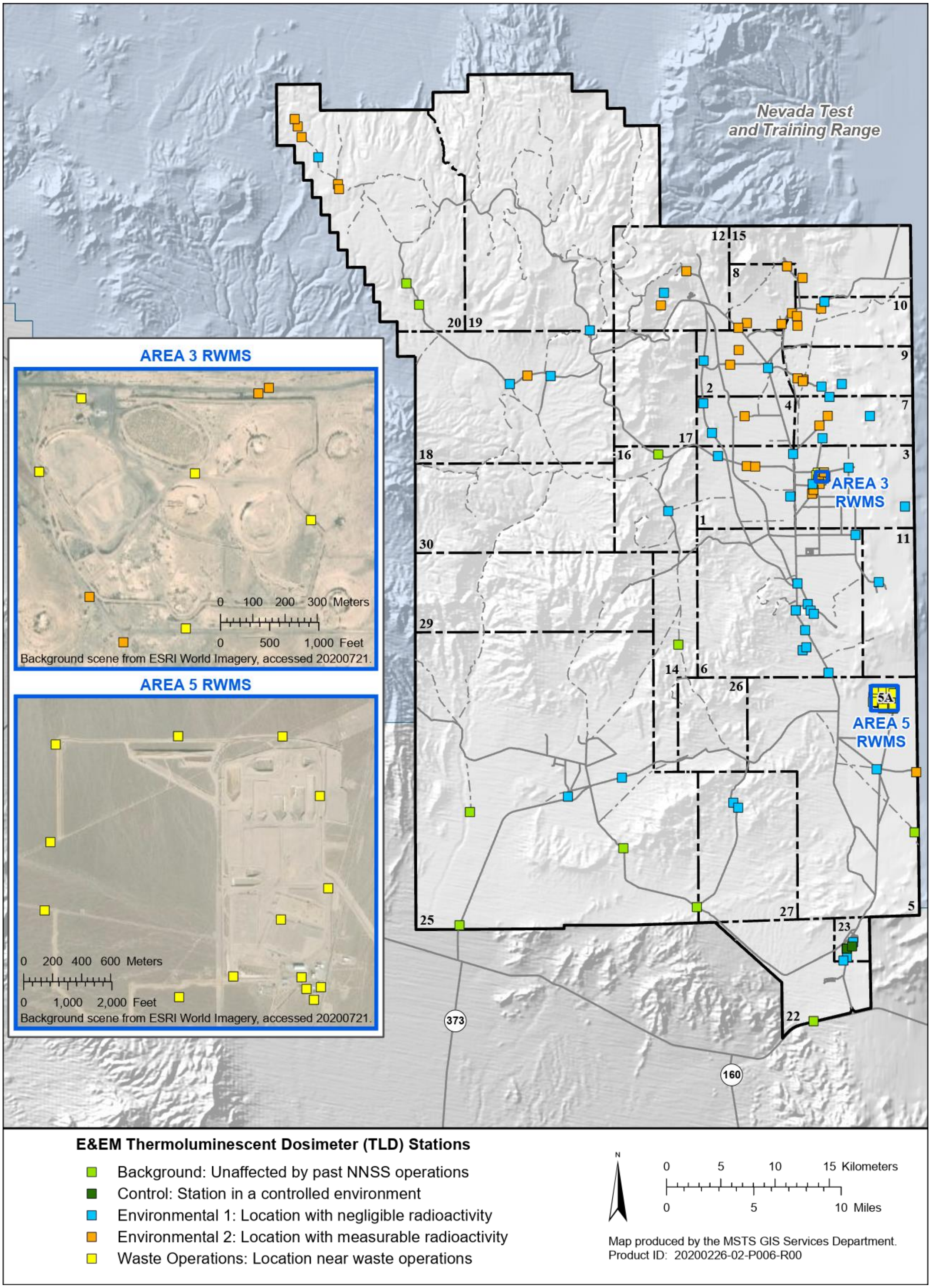

Figure 6-1. Locations of TLDs on the NNSS

6.2.1 Data Quality

Quality assurance (QA) procedures for direct radiation monitoring involve: (1) comparison of readings among the three TLD elements in individual TLDs, (2) comparison of data from 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 prior to deployment and following collection in the shielded 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 0.17% and 4.61%; averaging 1.68% for stations that were in the field at the beginning of 2019. The adjustment was a bit higher (7.91% to 9.23%) in the first quarter of 2019 for the new stations deployed during that quarter.

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 listed in Table 6-1. Summary statistics for the five location types are in listed Table 6-2. Data were successfully obtained from nearly all of the TLDs during all quarters in 2019; one pair was damaged during construction and was unusable. Otherwise, agreement between the results provided by the paired TLDs was quite good, with an average relative percent difference between measurements of 2.9%. The quarter-to-quarter coefficient of variation (CV) (i.e., the relative standard deviation) ranged from 0.5% to 6.8% (mean = 3.1%) over all locations, excluding Gate 100 Truck Parking 1 (discussed in Section 6.3.2).

6.3.1 Background Exposure

In 2019, the average of the estimated annual exposures among the 10 background locations was 117 mR, ranging from 79 to 156 mR (Table 6-2). A 95% prediction interval (PI) for annual exposures based on the 2019 estimated annual exposures at the background locations (denoted "95% PI from B" in the plots, Figures 6-2, 6-4, and 6-5) is 47.8 to 185.6 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 622 m [2,040 ft] elevation), was 107 mR in 2019 (Table 7-3). Estimated mean annual exposures at CEMP locations ranged from 93 mR at Pahrump, Nevada (777 m [2,550 ft] elevation), to 154 mR at Milford, Utah (1,494 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, terrestrial), 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. In order to study whether the NNSS TLD system is able to measure very small dose changes in environment above the background radiation, statistical analyses of historical data from the 10 current background locations was performed, and is summarized in Table 6.3. The estimated annual exposure was consistent over time at each background location from 2003 to 2018. The average annual exposures of the background locations varied from 79 mR to 162 mR, and the year-to-year CVs ranged from 0.9% to 2.4% (mean = 1.8%). The relative differences between the 2019 mean exposures and their corresponding average annual exposures of the background locations are very small, ranging from -4.5% to 0.9%, averaging -1.7%. These results showed that the TLDs are sensitive enough to measure a very low radiation level above background, and no man-made radiation from NNSS operations was detected at the background locations in 2019. These data are shown in Figure 6-7.

Table 6-1. Annual direct radiation exposures measured at TLD locations on the NNSS in 2019

NNSS Area	Station	Number of Quarters	Estimated Annual Exposure (mR)[a] Mean[b]	Minimum[b]	Maximum[b]
		Background			
5	Old Indian Springs Road	4	79	77	81
14	Mid-Valley	4	141	137	143
16	Stake P-3	4	112	109	118
20	Stake A-112	4	156	148	163
20	Stake A-118	4	151	144	162
22	Army #1 Water Well	4	83	81	85
25	Gate 25-4-P	4	132	127	139
25	Gate 510	4	126	124	128
25	Jackass Flats & A-27 Roads	4	81	78	83
25	Skull Mtn Pass	4	106	105	110
		Control			
23	Building 650 Dosimetry	4	58	56	59
23	Lead Cabinet, 1	4	26	25	27
23	Lead Cabinet, 2	4	27	25	29
23	Lead Cabinet, 3	4	26	24	27
23	Lead Cabinet, 4	4	26	25	27
23	Lead Cabinet, 5	4	26	24	27
		Environmental 1[c]			
1	BJY	4	115	113	118
1	Sandbag Storage Hut	4	112	108	115
1	Stake C-2	4	115	112	119
2	Stake M-140	4	131	128	134
2	Stake TH-58	4	92	88	97
3	LANL Trailers	4	121	115	126
3	Stake OB-20	4	88	84	92
3	Well ER 3-1	4	124	119	129
4	Stake TH-41	4	109	104	114
4	Stake TH-48	4	116	113	118
5	Water Well 5b	4	111	107	114
6	CP-6	4	69	67	72
6	DAF East	4	97	94	102
6	DAF North	4	101	100	102
6	DAF South	4	136	129	141
6	DAF West	4	85	81	87
6	Decon Facility NW	4	125	120	129
6	Decon Facility SE	4	135	134	136
6	Stake OB-11.5	4	129	126	132
6	Yucca Compliance	4	91	88	94
6	Yucca Oil Storage	4	97	94	101
7	Reitmann Seep	4	126	123	130

Table 6-1. Annual direct radiation exposures measured at TLD locations on the NNSS in 2019

NNSS Area	Station	Number of Quarters	Estimated Annual Exposure (mR)[a] Mean[b]	Minimum[b]	Maximum[b]
		Environmental 1[c]			
7	Stake H-8	4	125	121	130
9	Papoose Lake Road	4	89	84	93
9	U-9cw South	4	104	98	110
9	V & G Road Junction	4	113	109	118
10	Gate 700 South	4	124	118	129
11	Stake A-21	4	131	124	135
12	Upper N Pond	4	129	126	133
16	3545 Substation	4	136	131	140
18	Stake A-83	4	142	136	152
18	Stake F-11	4	141	137	145
19	Stake P-41	4	158	153	164
20	Stake J-41	4	137	134	139
23	Gate 100 Truck Parking 1	4	101	66	136
23	Gate 100 Truck Parking 2	4	64	59	69
23	Mercury Fitness Track	3	57	54	59
25	HENRE	4	124	122	127
25	NRDS Warehouse	4	122	118	126
27	Cafeteria	4	113	109	115
27	JASPER-1	4	114	113	116
		Environmental 2[c]			
1	Bunker 1-300	4	107	104	111
1	T1	4	200	191	206
2	Stake L-9	4	156	151	163
2	Stake N-8	4	348	342	360
3	Stake A-6.5	4	133	132	135
3	T3	4	263	244	275
3	T3 West	4	254	247	265
3	T3a	4	267	251	274
3	T3b	4	362	347	371
3	U-3co North	4	162	153	167
3	U-3co South	4	140	135	145
4	Stake A-9	4	357	354	360
5	Frenchman Lake	4	223	212	233
7	Bunker 7-300	4	180	173	193
7	T7	4	115	111	118
8	Baneberry 1	4	301	296	309
8	Road 8-02	4	120	116	124
8	Stake K-25	4	110	108	112
8	Stake M-152	4	155	152	157
9	B9a	4	124	121	125
9	Bunker 9-300	4	120	118	122
9	T9b	4	381	370	393
10	Circle & L Roads	4	116	113	119
10	Sedan East Visitor Box	4	126	123	128
10	Sedan West	4	198	192	202
10	T10	4	211	207	218
12	T-Tunnel #2 Pond	4	220	215	226
12	Upper Haines Lake	4	103	98	106
15	EPA Farm	4	110	108	113
18	Johnnie Boy North	4	143	139	150
20	Palanquin	4	197	191	208
20	Schooner-1	4	424	409	443
20	Schooner-2	4	206	196	214
20	Schooner-3	4	140	134	149
20	Stake J-31	4	156	151	163

Table 6-1. Annual direct radiation exposures measured at TLD locations on the NNSS in 2019

NNSS Area	Station	Number of Quarters	Estimated Annual Exposure (mR)[a] Mean[b]	Minimum[b]	Maximum[b]
		Waste Operations[c]			
3	RWMS Center	4	134	130	139
3	RWMS East	4	133	126	146
3	RWMS North	4	123	117	128
3	RWMS South	4	255	250	260
3	RWMS West	4	123	116	127
5	CAU-111	4	119	117	122
5	Lysimeter	4	128	125	130
5	Pilot Well 3	4	143	139	146
5	Powerline Rd	4	137	136	138
5	RWMS East Gate	4	98	96	100
5	RWMS Expansion NE	4	144	141	148
5	RWMS NE Corner	4	121	116	125
5	RWMS North	4	136	129	141
5	RWMS SW Corner	4	121	117	124
5	Vefa	4	139	131	144
5	Waterline Rd	4	131	130	132
5	WEF North	4	114	111	118
5	WEF South	4	120	118	122
5	WEF West	4	118	112	122

(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 2019 mean annual direct radiation exposure by TLD location type

Location Type	Number of Locations	Estimated Annual Exposure (mR) Mean	Minimum	Maximum
Background (B)	10	117	79	156
Environmental 1 (E1)	41	113	57	158
Environmental 2 (E2)	35	198	103	424
Waste Operations (WO)	19	133	98	255
Control, Shielded (C)	5	26	26	27
Control, Unshielded (C)	1	58	58	58

Table 6-3. Summary statistics for exposure history of background TLD stations

Area	Station	Average Annual Exposure(mR)[(a)]	CV(%)[(b)]	Exposure in 2019(mR)[(c)]	Difference(%)[(d)]
5	Old Indian Springs Road	79	0.9	79	-0.5
14	Mid-Valley	145	2.2	141	-3.0
16	Stake P-3	118	1.8	112	-4.5
20	Stake A-118	154	2.4	151	-2.2
20	Stake A-112	162	1.8	156	-3.8
22	Army #1 Water Well	84	2.0	83	-1.2
25	Gate 25-4-P	131	1.9	132	0.9
25	Gate 510	127	1.7	126	-0.9
25	Jackass Flats & A-27 Roads	81	2.4	81	-0.5
25	Skull Mtn Pass	108	1.4	106	-1.4

(a) Average annual exposure was calculated from all available TLD data from 2003 to 2018.
(b) Coefficient of variation = the relative standard deviation.
(c) Estimated exposure during 2019.
(d) Relative difference between the 2019 exposure and the average of 2003-2018 estimates (includes decimal places not shown).

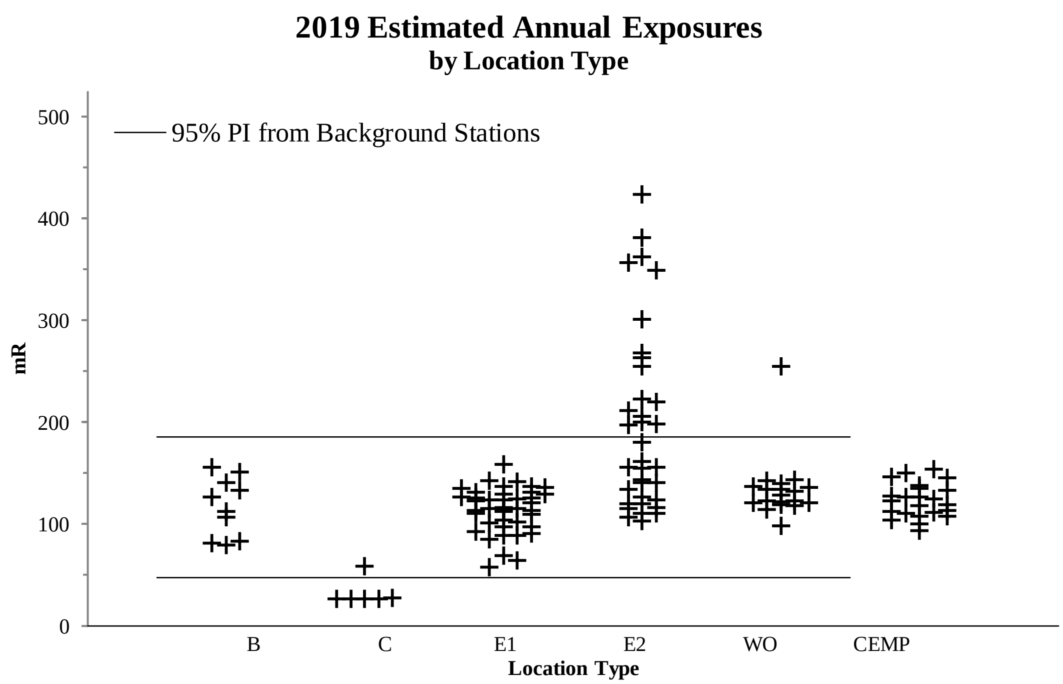

Figure 6-2. 2019 annual exposures on the NNSS, by location type, and off the NNSS at CEMP stations

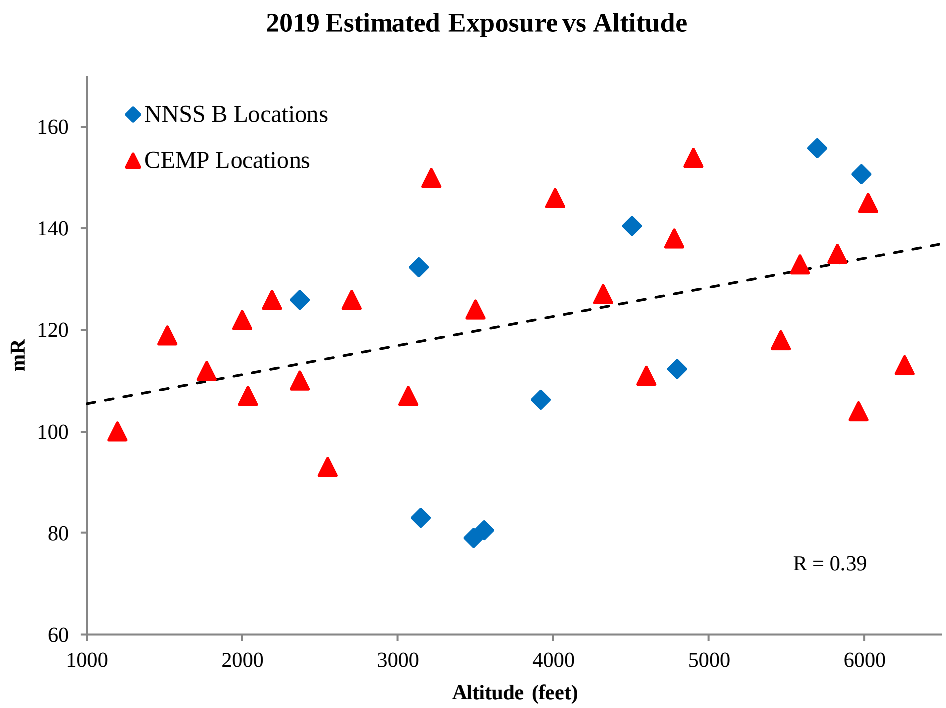

Figure 6-3. Correlation between 2019 annual exposures at NNSS Background and CEMP TLD locations and altitude

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 2019, with quarterly estimates of 64, 62, 69, and 59 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 2019 was 101 mR, with quarterly estimates of 77, 127, 66, and 136 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 millirem per year (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 contaminated-soil 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 2019 was 223 mR. This has been consistently declining over time, down from 420 mR in 2003. The estimated above-background dose in 2019 would be approximately 61 to 144 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/yr, 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 placed 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 113 mR in 2019, 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 calculated from 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 Manual 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 2019 (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 2019.

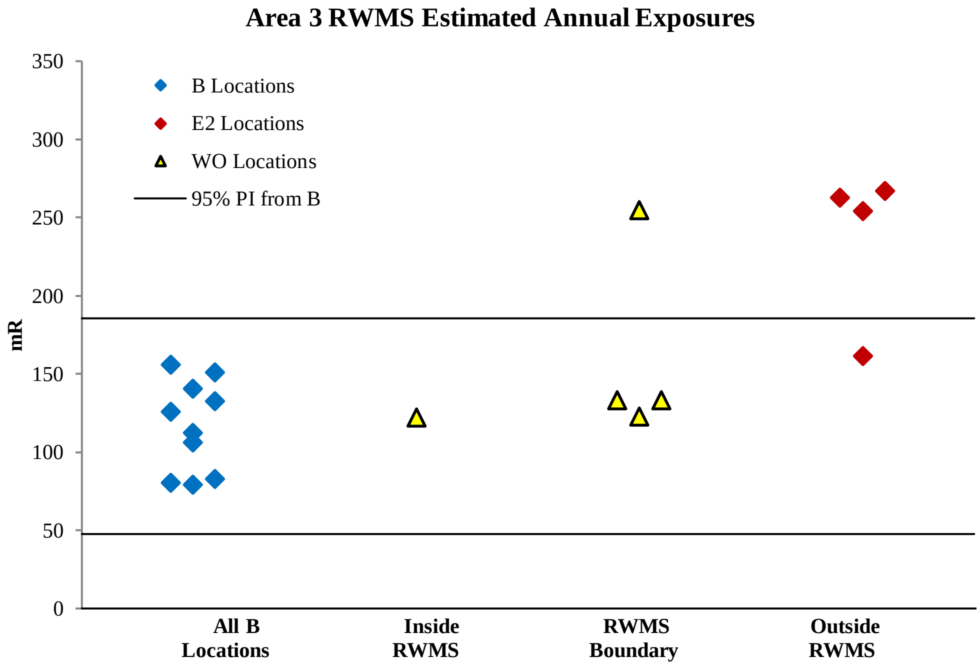

Figure 6-4. 2019 annual exposures in and around the Area 3 RWMS and at background locations

The Area 5 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 2019, 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.

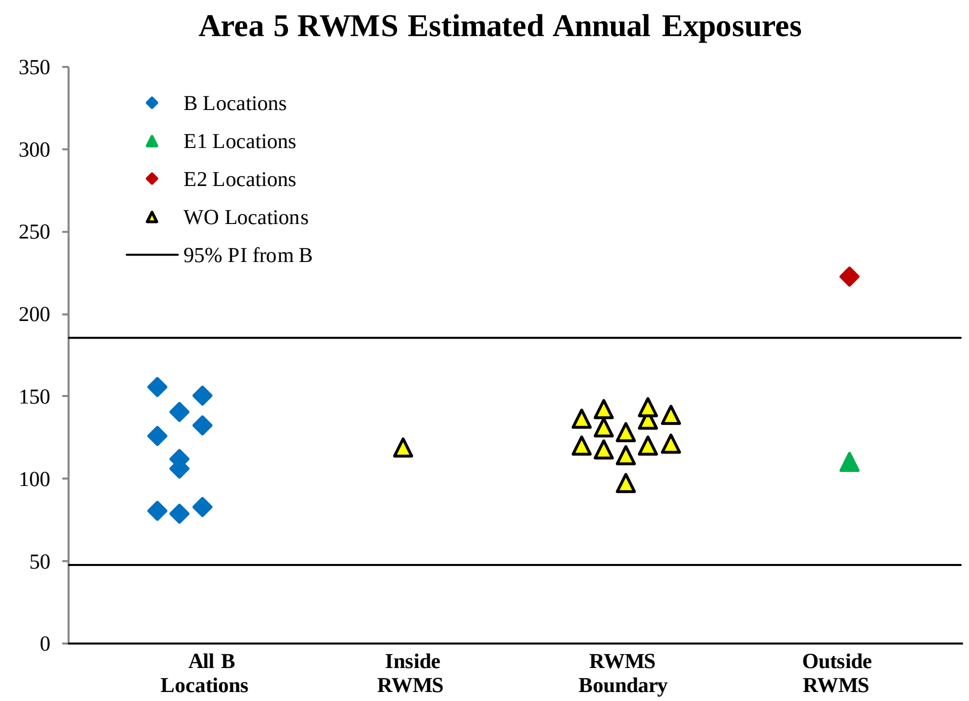

Figure 6-5. 2019 annual exposures around the Area 5 RWMS and at background locations

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 2019 was 424 mR/yr (1.37 mR/d) at the Schooner-1 location during the second 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 centimeters, or 1.2 inches) 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. Doses 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 2019, the median CV for measurements between quarters was 3.0%. Gate 100 Truck Parking 1 showed the highest variation with a CV of 34.06%. No other environmental stations had CVs over 10%. In the past 7 years (2012–2018) the median CV has ranged from 2.8% to 4.8%, so the quarter-to-quarter variability in 2019 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 annual ***decay*** rates by location group are 0.15% (B), 0.09% (C), 0.21% (E1), 1.81% (E2), and 0.66% (WO). Annual exposures decreased 3.01% per year on average at those locations with significant added man-made radiation, those being the E2 and WO locations with 2019 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 2018. The observed decreases are due to a combination of natural radioactive decay, dispersal, and dilution in the environment.

The stations with the six highest estimated annual exposures in 2019 are Schooner-1 (Area 20), T9B (Area 9), T3B (Area 3), Stake A-9 (Area 4), Stake N-8 (Area 2), and Baneberry 1 (Area 8). Their annual exposures have been decreasing at an estimated rate of 50% every 15, 25, 34, 16, 16, and 31 years respectively.

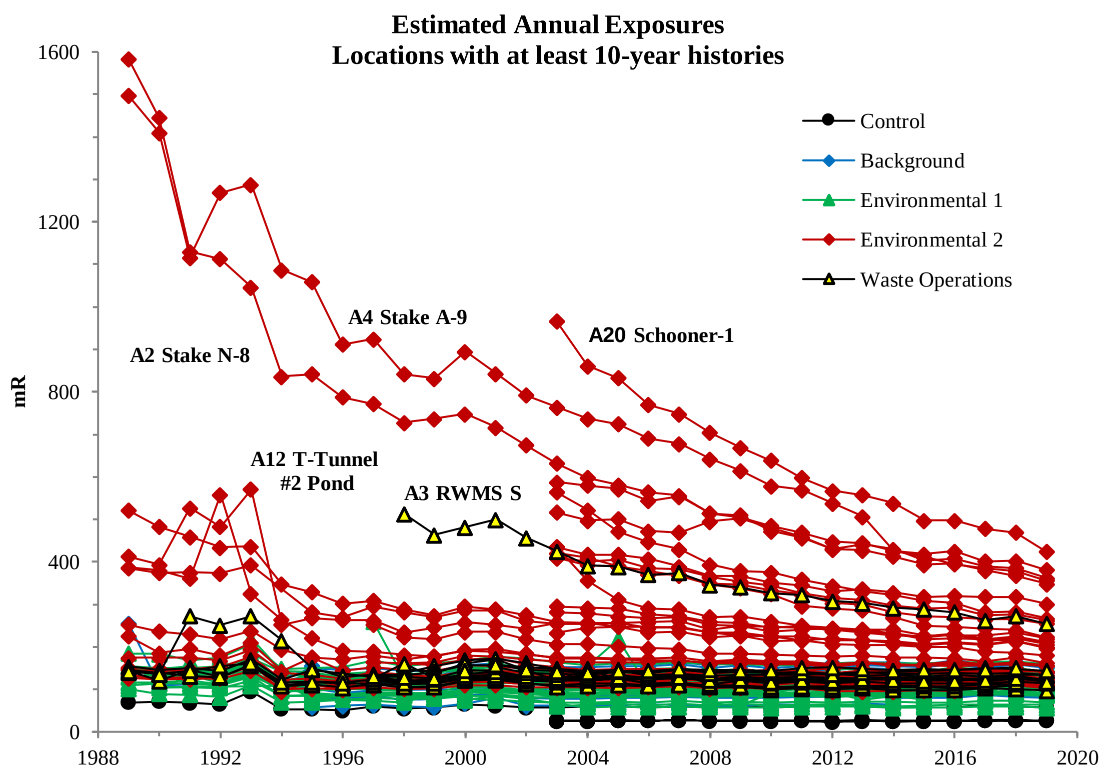

Figure 6-6. Trends in direct radiation exposure measured at TLD locations

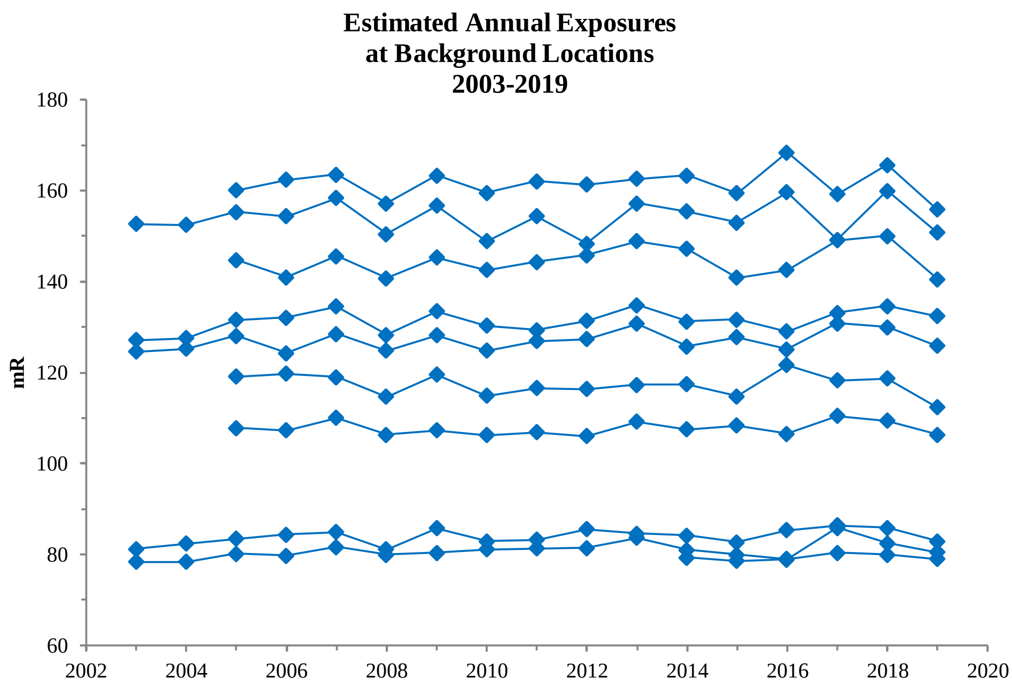

Figure 6-7. Trends in direct radiation exposure at 2019 background locations

6.4 Environmental Impact

Direct radiation exposure to the public from NNSS operations during 2019 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.

Chapter 7: Community-Based Offsite Monitoring

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Community Environmental Monitoring Program Goals

Provide independent monitoring at offsite locations and communicate environmental data relevant to past and continuing activities at the Nevada National Security Site (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.

Two community-based radiological monitoring programs are conducted off the 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 (^{3}H)*** 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 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.

The Nye County Tritium Sampling and Monitoring Program (TSaMP) was initiated in 2015 when the U.S. Department of Energy (DOE), 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 ^{3}H 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 that 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/.

Sections 7.1 and 7.2 of this chapter present the 2019 CEMP air and water monitoring results. Section 7.3 presents the 2019 TSaMP monitoring results. Results from radiological monitoring of air, groundwater, direct radiation,

[1] The definition of word(s) in ***bold italics*** may be found by referencing the Glossary, Appendix B.

and biota conducted on the NNSS and the Nevada Test and Training Range (NTTR) by NNSA/NFO are presented in Chapters 4, 5, 6, and 8.

7.1 CEMP Air Monitoring

In 2019, 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 2019, the CEMP ASN included 23 continuously operating low-volume particulate air samplers. 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 3 months (one calendar quarter) before being moved to a new location. Glass-fiber filters from the low-volume particulate samplers are collected every 2 weeks by the CEMs and mailed to DRI. Each quarter, one complete set of filters are selected, prepared, and forwarded to an independent laboratory to be analyzed for ***gross alpha*** and ***beta radioactivity***, as well as gamma ***spectroscopy***. Samples are held for a minimum of 7 days after collection to allow for the decay of naturally occurring ***radon progeny***. Filters not selected for laboratory analysis are archived at DRI.

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 2019, 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 utilized for the CEMP 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/.

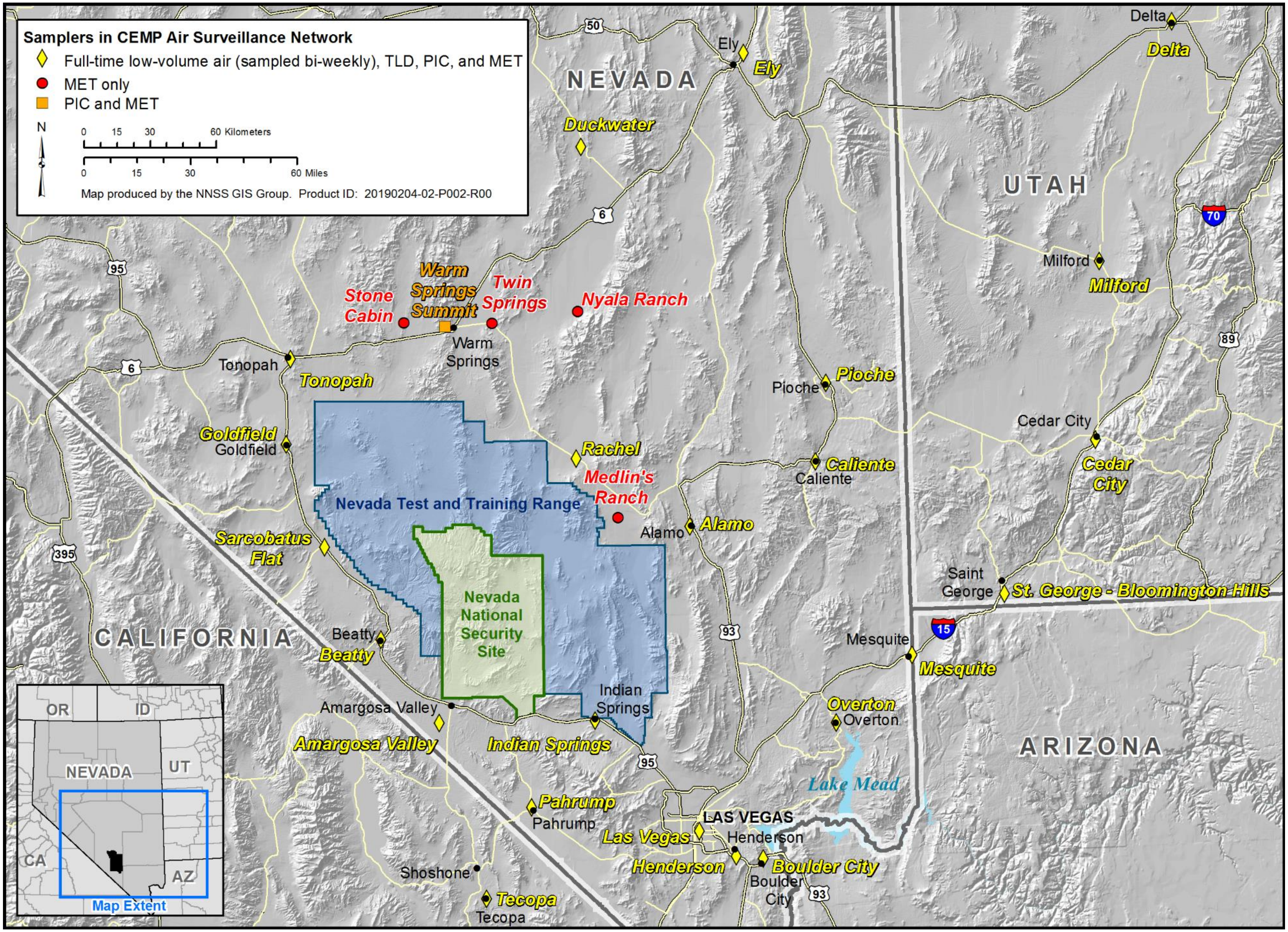

Figure 7-1. 2019 CEMP Air Surveillance Network

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.

Air sampling occurs full time year around at all stations, but only one sample per quarter from each station is selected for routine analysis.

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 $1.59 \pm 0.68 \times 10^{-15}$ microcuries per milliliter (μCi/mL) ($5.88 \pm 2.52 \times 10^{-5}$ ***becquerels*** [Bq/m^3]) (Table 7-1). Gross alpha was detectable in all of the 2019 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 2019

Sampling Location	Number of Samples	Concentration ($\times 10^{-15}$ µCi/mL [3.7×10^{-5} Bq/m^3])			
		Mean	Standard Deviation	Minimum	Maximum
Alamo	4	1.52	0.36	1.00	1.75
Amargosa Valley	4	1.40	0.57	0.87	2.15
Beatty	4	1.33	0.44	0.68	1.62
Boulder City	5	1.54	0.85	0.62	2.65
Caliente	5	1.87	0.73	0.61	2.46
Cedar City	5	1.12	0.67	0.59	2.25
Delta	4	1.96	1.23	0.70	3.52
Duckwater	4	1.03	0.22	0.74	1.27
Ely	5	1.67	0.59	0.80	2.54
Goldfield	4	1.51	0.81	0.45	2.37
Henderson	4	1.91	0.75	0.83	2.55
Indian Springs	4	1.51	0.65	0.76	2.10
Las Vegas	4	1.70	0.76	0.82	2.54
Mesquite	5	2.18	0.65	1.06	2.67
Milford	4	1.39	0.54	0.96	2.17
Overton	5	1.50	0.58	0.95	2.35
Pahrump	4	2.11	1.24	0.61	3.64
Pioche	5	1.18	0.51	0.53	1.61
Rachel	4	1.58	0.76	0.37	2.40
Sarcobatus Flats	4	1.71	0.72	0.59	2.39
St. George, Bloomington Hills (BH)	5	1.71	0.51	0.88	2.26
Tecopa	4	1.60	0.51	0.86	1.97
Tonopah	4	1.69	0.93	0.48	2.63

Network Mean = 1.59 ± 0.68 × 10^{-15} µCi/mL
Mean *Minimum Detectable Concentration (MDC)* = 0.29 × 10^{-15} µCi/mL
Standard Error of Mean MDC = 0.01 × 10^{-15} µCi/mL

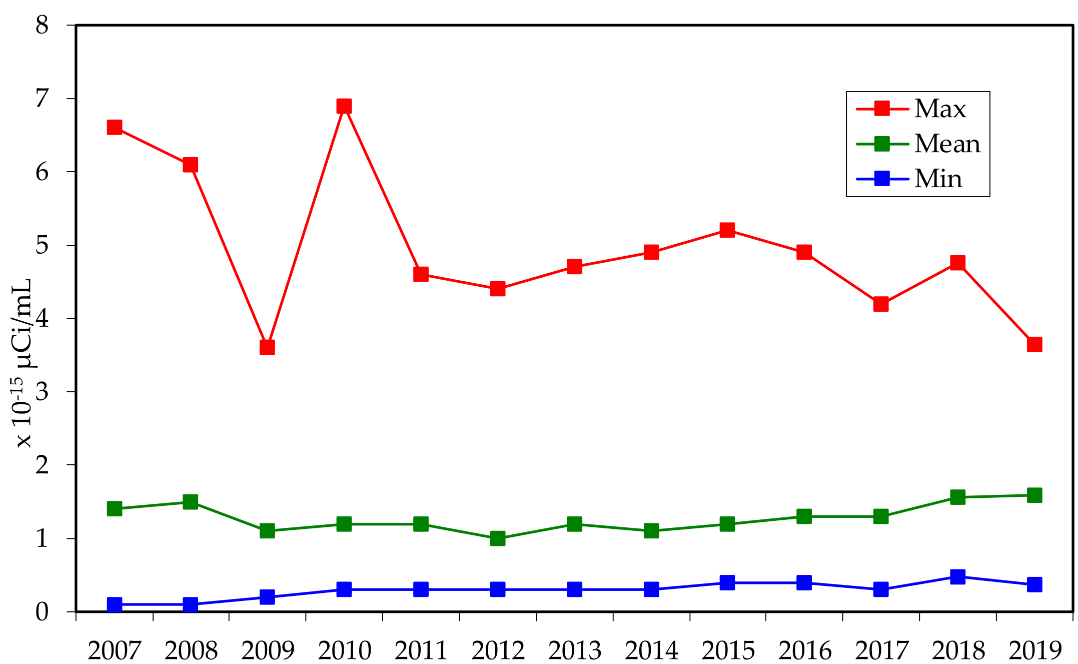

Figure 7-3. Historical trend for gross alpha analysis for all CEMP stations

The mean annual gross beta activity across all sample locations (Table 7-2) was 2.24± 0.77× 10^{-14} µCi/mL (8.29 ± 2.85 × 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 2019. 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 2019

Sampling Location	Number of Samples	Concentration ($\times 10^{-14}$ µCi/mL [3.7×10^{-4} Bq/m^3])			
		Mean	Standard Deviation	Minimum	Maximum
Alamo	4	2.35	7.47	1.36	3.17
Amargosa Valley	4	2.03	0.48	1.45	2.62
Beatty	4	2.46	0.92	1.29	3.53
Boulder City	5	2.35	0.99	1.28	3.77
Caliente	5	2.41	0.66	1.41	3.09
Cedar City	5	1.80	0.55	1.12	2.44
Delta	4	2.28	0.71	1.57	3.18
Duckwater	4	1.72	0.82	0.85	2.82
Ely	5	1.87	0.37	1.21	2.22
Goldfield	4	2.15	1.34	0.84	4.02
Henderson	4	2.38	0.85	1.48	3.51
Indian Springs	4	2.29	0.70	1.52	3.06
Las Vegas	4	2.53	0.66	1.75	3.22
Mesquite	5	2.70	0.96	1.49	3.75
Milford	4	2.26	0.89	1.47	3.52
Overton	5	2.50	0.90	1.40	3.93
Pahrump	4	2.25	0.77	1.26	2.97
Pioche	5	1.93	0.80	0.98	2.83
Rachel	4	2.15	0.86	1.03	2.99
Sarcobatus Flats	4	2.30	0.87	1.40	3.68
St. George (BH)	5	2.28	0.77	1.19	3.35
Tecopa	4	2.64	1.02	1.33	3.79
Tonopah	4	2.15	0.84	1.11	3.17

Network Mean = 2.24± 0.77 × 10^{-14} µCi/mL
Mean MDC = 0.05 × 10^{-14} µCi/mL
Standard Error of Mean MDC = 0.001 × 10^{-14} µCi/mL

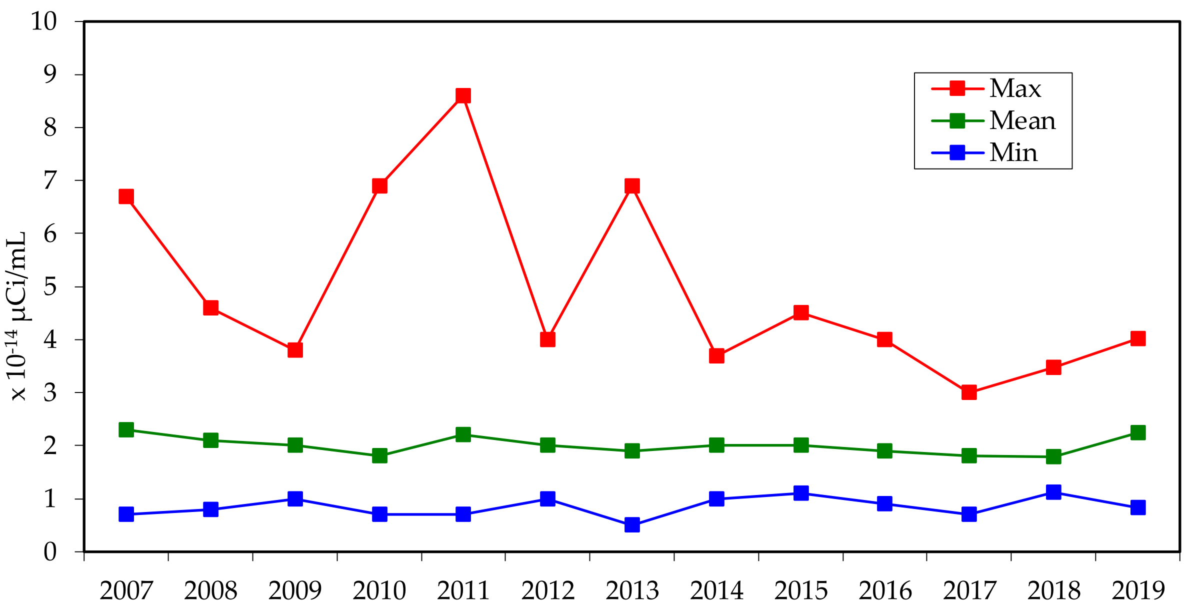

Figure 7-4. Historical trend for gross beta analysis for all CEMP stations

7.1.3.2 Gamma Spectroscopy

As with gross alpha and beta, gamma spectroscopy analysis was performed on one set of samples from the low-volume air sampling network each quarter. 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 $1.42 \pm 0.35 \times 10^{-13}$ 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 mean annual exposure for 2019 ranged from 84 milliroentgens (mR) (0.84 millisieverts [mSv]) at Pahrump, Nevada, and Overton, Nevada, to 173 mR (1.73 mSv) at Milford, Utah, with a mean annual exposure of 123 mR (1.23 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.

Table 7-3. TLD monitoring results for the CEMP offsite ASN in 2019

		Estimated Annual Exposure (mR)[(a)]		
Sampling Location	**Number of Quarters**	**Mean[(b)]**	**Minimum[(b)]**	**Maximum[(b)]**
Alamo	4	124	120	133
Amargosa Valley	4	122	112	133
Beatty	4	150	133	161
Boulder City	4	110	96	119
Caliente	4	127	114	157
Cedar City	4	104	87	116
Delta	4	111	100	123
Duckwater	4	118	106	133
Ely	4	113	96	137
Goldfield	4	133	128	137
Henderson	4	126	110	136
Indian Springs	4	107	96	124
Las Vegas	3	107	90	116
Mesquite	4	112	100	122
Milford	4	154	142	173
Overton	4	100	84	124
Pahrump	4	93	84	104
Pioche	4	135	120	162
Rachel	4	138	133	145
Sarcobatus Flats	4	146	137	153
St. George (BH)	4	126	116	138
Tecopa	4	119	108	132
Tonopah	4	145	133	154

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

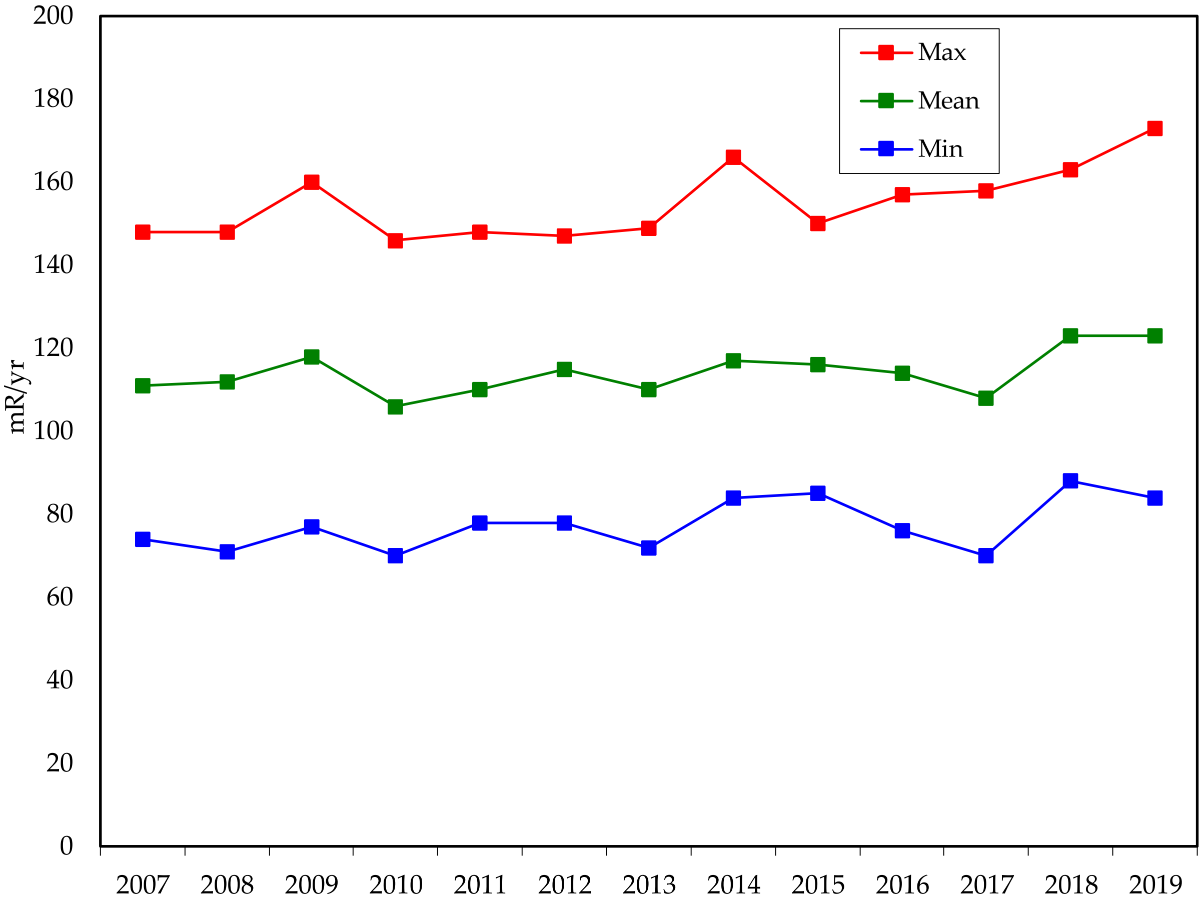

Figure 7-5. Historical trend for TLD analysis for all CEMP stations

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 2019 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 73.58 mR/yr (0.74 mSv/yr) in Pahrump, Nevada, to 176.95 mR/yr (1.77 mSv/yr) at Warm Springs Summit, Nevada. 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 2019 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 2019

	Daily Average Gamma Exposure Rate (µR/hr)				
Sample Location	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	**Annual Exposure (mR/yr)**
Alamo	13.10	0.34	12.2	14.0	114.76
Amargosa Valley	11.55	0.17	11.0	12.1	101.18
Beatty	16.45	0.31	15.4	17.5	144.10
Boulder City	15.35	0.18	14.7	16.0	134.47
Caliente	16.10	0.25	15.3	16.9	141.04
Cedar City	13.00	0.41	11.9	14.1	113.88
Delta	12.75	0.42	11.6	13.9	111.69
Duckwater	15.80	0.37	14.3	17.3	138.41
Ely	12.250	0.35	11.2	13.3	107.31
Goldfield	15.10	0.44	12.1	18.1	132.28
Henderson	13.80	0.32	12.9	14.7	120.89
Indian Springs	11.45	0.21	10.8	12.1	100.30
Las Vegas	11.10	0.84	9.1	13.1	97.24
Mesquite	11.90	0.19	11.1	12.7	104.24
Milford	17.80	0.38	16.4	19.2	155.93
Overton	11.40	0.24	10.4	12.4	99.86
Pahrump	8.40	0.24	7.7	9.1	73.58
Pioche	15.50	0.48	13.7	17.3	135.78
Rachel	15.30	0.33	14.3	16.3	134.03
Sarcobatus Flats	16.95	0.31	16.1	17.8	148.48
St. George (BH)	14.35	0.21	13.5	15.2	125.71
Tecopa	13.25	0.25	12.5	14.0	116.07
Tonopah	17.15	0.40	15.0	19.3	150.23
Warm Springs Summit	20.20	0.48	18.0	22.4	176.95

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 2019 were associated with precipitation events and/or low barometric pressure. Low barometric pressure can result in the release of naturally occurring radon and its progeny 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.

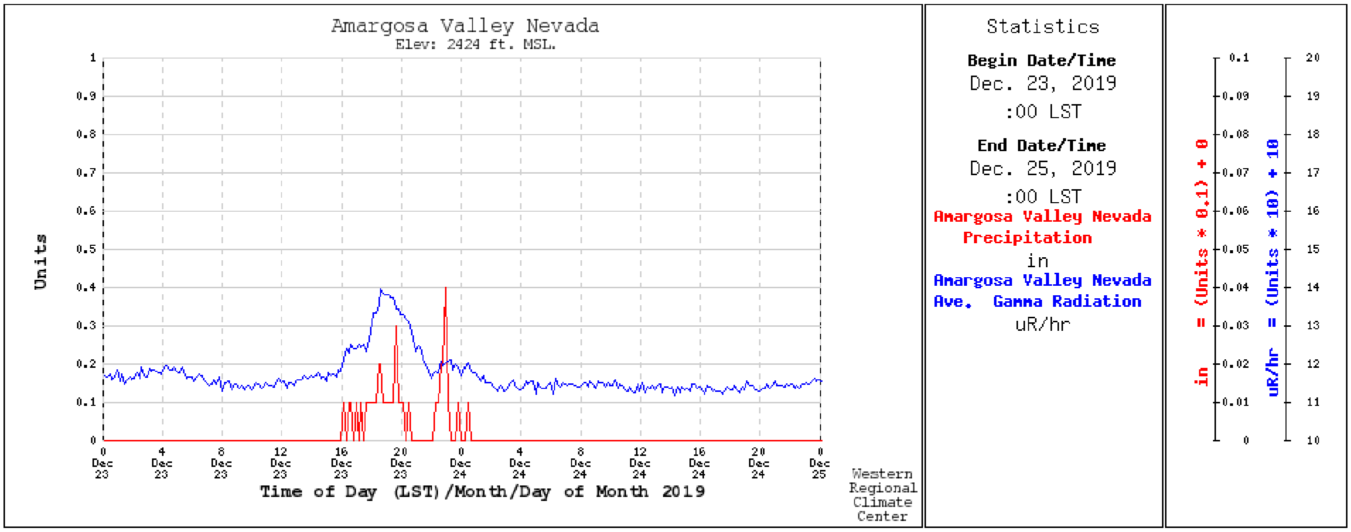

Figure 7-6. An example of the effect of meteorological phenomena on background gamma readings at the Amargosa Valley, Nevada, CEMP station

7.2 CEMP 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/.

7.2.1 Sample Locations and Methods

In September 2019, 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 were 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 2019

Monitoring Location Description	Latitude[(a)]	Longitude[(a)]	Date Sampled	Sample Collection Method
Amargosa Valley school well	36°34.16'	−116°27.66'	9/5/2019	By hand from sink in school
Beatty Water and Sewer municipal water distribution system	36°57.09'	−116°48.26'	9/17/2019	By hand from well head
Sarcobatus Flats well	37°16.76'	−117°01.10'	9/05/2019	By hand at residential source
Tecopa residential well	35°50.90'	−116°13.58'	9/12/2019	By hand at residential source

(a) Coordinates are North American Datum 1983

In 2019, ARS International Laboratory in Port Allen, Louisiana, analyzed the 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 205 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 MDC considers both the variability associated with multiple measures of the background and the variability associated with multiple measures of the sample itself. In 2019, the MDC for ^3H was approximately 410 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 ^3H in drinking water (respectively); the EPA limit is 20,000 pCi/L. ***Quality assurance*** and ***quality control*** procedures are described in Chapter 15.

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 410 pCi/L). Public access to monitoring data is available on the DRI CEMP website at http://www.cemp.dri.edu/.

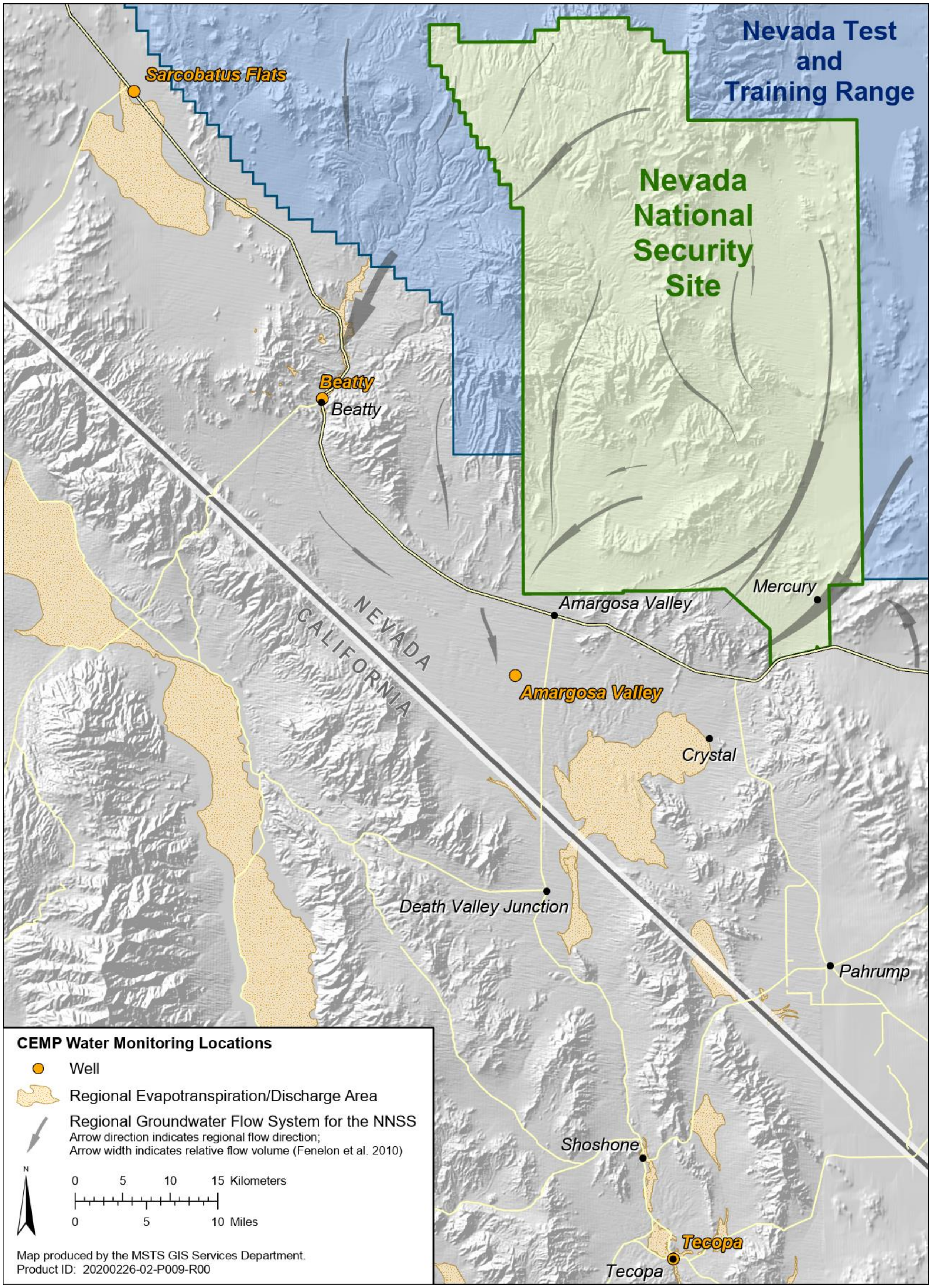

Figure 7-7. 2019 CEMP water monitoring locations

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 ^{3}H. 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 2019, 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 2019 were in the same general areas as 2015–2017, 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 ^{3}H under the TSaMP were initially drilled as part of the Early Warning Drill Program ("EWDP" labeled wells) or as Nye County Groundwater Evaluation Wells ("NC-GWE" labeled 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 without integrated pumps were sampled using either an air-powered submersible positive displacement pump or a 3-inch submersible electric pump. A minimum of three well volumes 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. Three private wells were sampled in 2019, with the samples also being collected from the dedicated pump discharge. New to 2018 was the addition of private domestic wells, also sampled from the dedicated pump discharge. The private well sampling initiative was approved by CEMs at the 2018 CEMP annual workshop (July 23rd–25th), and was incorporated into the program in order to expand the spatial distribution of sampling sites and to provide a means to increase community involvement. Three springs were sampled in 2019, with samples being collected directly from the spring discharge.

All samples were analyzed for ^{3}H 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 ^{3}H 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 ^{3}H sampling are documented in Test Plan TPN-11.8 (2016), "Groundwater Sampling and Analysis for the Nye County Tritium Sampling and Monitoring Program," and Work Plan WP-11, "Groundwater Chemistry Sampling and Analysis" (2016) (available on the Nye County website at http://www.co.nye.nv.us/index.aspx?NID=901).

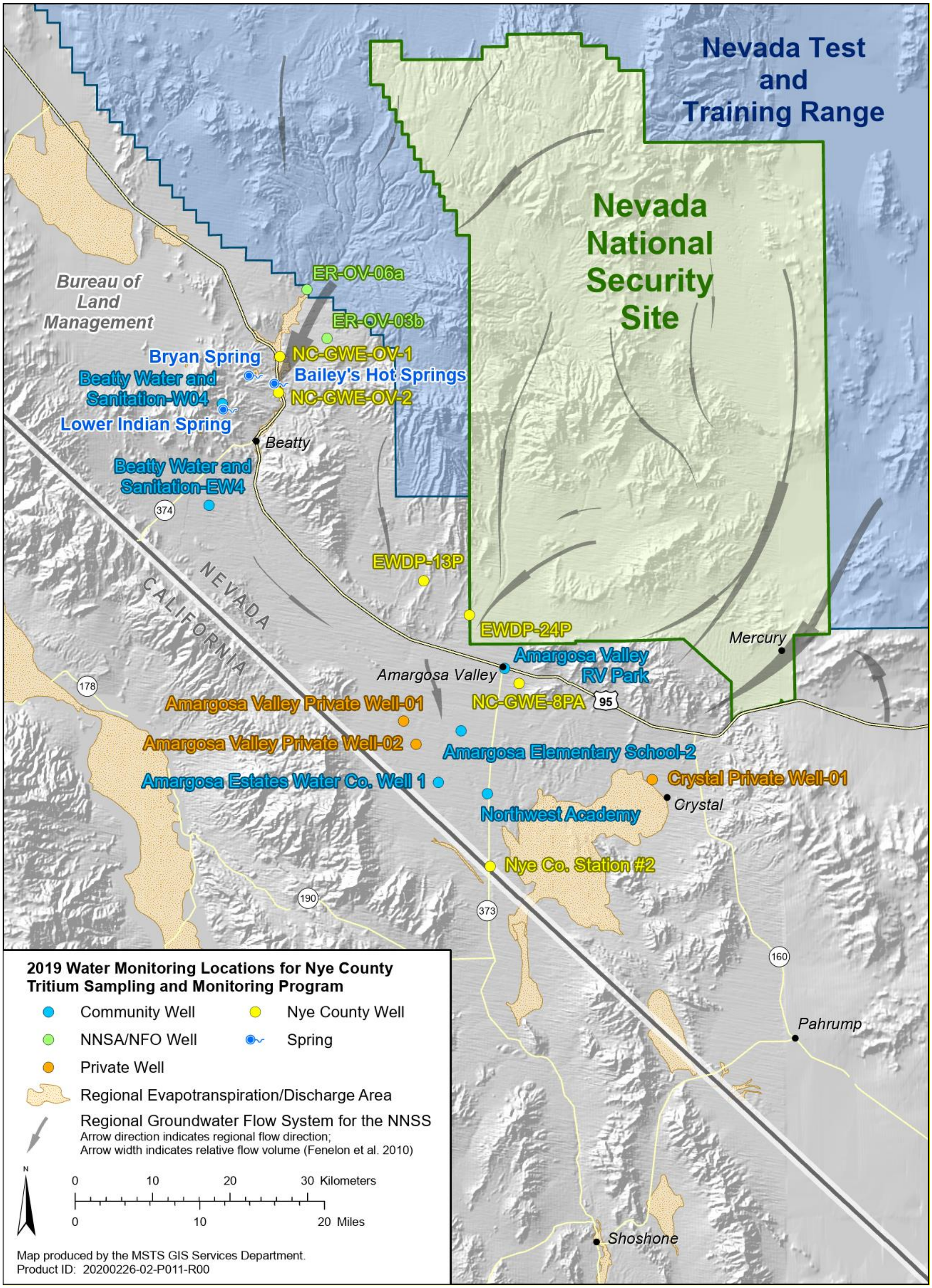

Figure 7-8. 2019 Nye County TSaMP water monitoring locations

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

Sample Locations	Latitude[(a)]	Longitude[(a)]	Date Sampled	H^3 Activity Method Detection Limit (pCi/L)
		Nye County Wells		
EWDP-7S	36.72556	-116.55700	10/29/2019	<291
EWDP-13P*	36.74441	−116.51395	10/29/2019	<291
EWDP-24P*	36.70466	−116.44799	10/16/2019	<291
NC-GWE-8PA*	36.62442	−116.37708	10/15/2019	<291
NC-GWE-Felderhoff-25-1PA	36.61773	-116.40937	10/21/2019	<291
NC-GWE-OV-1*	37.00618	−116.72076	10/30/2019	<291
NC-GWE-OV-2*	36.96455	−116.72298	10/30/2019	<291
		NNSA/NFO Wells		
ER-OV-02	37.03606	−116.70506	12/4/2019	<291
ER-OV-03a3	36.99883	−116.70534	12/4/2019	<291
		Community Wells		
Amargosa Elementary School-2*	36.56988	−116.46063	11/7/2019	<291
Amargosa Valley RV Park*	36.64205	−116.39751	10/31/2019	<291
Beatty Water and Sanitation Well 1	36.91537	-11676070	11/5/2019	<291
Beatty Water and Sanitation W04*	36.95155	−116.80433	11/7/2019	<291
Never Give Up*[(b)]	36.49617	−116.42356	11/7/2019	<291
		Private Wells		
Amargosa Valley Private Well-03	36.53909	-116.48317	12/5/2019	<291
Amargosa Valley Private Well-04	36.50276	-116.50305	12/16/2019	<291
Amargosa Valley U.S. Post Office	36.52601	-116.42043	12/18/2019	<291
		Springs		
Baileys Hot Springs*	36.97472	−116.72250	10/30/2019	<291
Cave Spring	36.94530	-116.79472	11/6/2019	<291
Revert Springs	36.91840	-116.74464	11/6/2019	<291

*Core wells are sampled in the same location annually

(a) Coordinates are North American Datum 1983

(b) Formerly Northwest Academy

All ^3H 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 ^3H from past underground nuclear testing on the NNSS is not present in these wells.

The wells and water supply systems within the CEMP and Nye County monitored network downgradient of the NNSS continue to show no evidence of ^3H contamination from past underground nuclear testing on the NNSS. To date, the maximum concentration of ^3H observed off site is at ER-EC-11 on the NTTR. Tritium at ER-EC-11 was reported as 18,400 pCi/L in 2017 (NNSS Environmental Report 2017, Table 5-4 [MSTS 2018]). 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.

7.4 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.

Mission Support and Test Services LLC, 2018. Nevada National Security Site Environmental Report 2017. DOE/NV/03624--0270, Las Vegas, Nevada.

MSTS, see Mission Support and Test Services, LLC.

TPN-11.8.2016. *Groundwater Sampling and Analysis for the Nye County Tritium Sampling and Monitoring Program*. Test Plan: Nye County Nuclear Waste Repository Project Office, Pahrump, Nevada.

WP-11, 2016. *Groundwater Chemistry Sampling and Analysis for the Nye County Tritium Sampling and Monitoring Program*. Work Plan: Nye County Nuclear Waste Repository Project Office, Pahrump, Nevada.

Chapter 8: Radiological Biota Monitoring

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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 Nevada National Security Site (NNSS) (see Chapter 9 for the estimates of dose to humans). Collect and analyze biota samples for radionuclides to estimate the ***absorbed radiation dose***[1] *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 Radioactive Waste Management Sites (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.*

Historical atmospheric nuclear explosive testing, releases from underground nuclear tests, and radioactive waste disposal sites provide potential sources of radiation contamination and ***exposure*** to 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 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 land-use practices on the NNSS discourage the harvesting 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 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 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 2019. The estimated dose to humans potentially consuming NNSS plants and animals and the dose to biota from these radionuclides are presented in Chapter 9.

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 referencing the Glossary, Appendix B.

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, reptiles, or invertebrates (DOE Standard DOE-STD-1153-2019, "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 amphibians 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 or bobcat 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 or burros, 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).

A habitat-use study of mule deer and pronghorn antelope was initiated in 2019. A total of 23 mule deer and 20 pronghorn antelope were captured in November. GPS [global positioning system] collars were put on all of the 23 mule deer and on 18 of the pronghorn antelope. Part of this study is to learn of how these animals use the NNSS, how much time they may spend in radiologically contaminated areas, and what the potential dose is to the animals and to someone who may consume them.

During 2019, the U.S. Fish and Wildlife Service requested a study of the radionuclide exposure desert tortoises may experience on the NNSS. To better understand this, concentrations of radionuclides will be determined in desert tortoises found dead on NNSS.

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	Reptiles
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)*	Desert tortoise (*Gopherus agassizii*)
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 natural media (e.g., soil and surface water) and 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 craters, Sedan Crater, T2, and Plutonium Valley (Figure 8-1), and each is associated with one type of 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***.

- **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 to wildlife seeking surface water. The associated monitoring site is E Tunnel Ponds below Rainier Mesa. This contaminated site, along with its control site, was last 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 explosives 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 2018.
- **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 sampled in 2019.

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 were created within 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 last 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. It was last sampled in 2017.

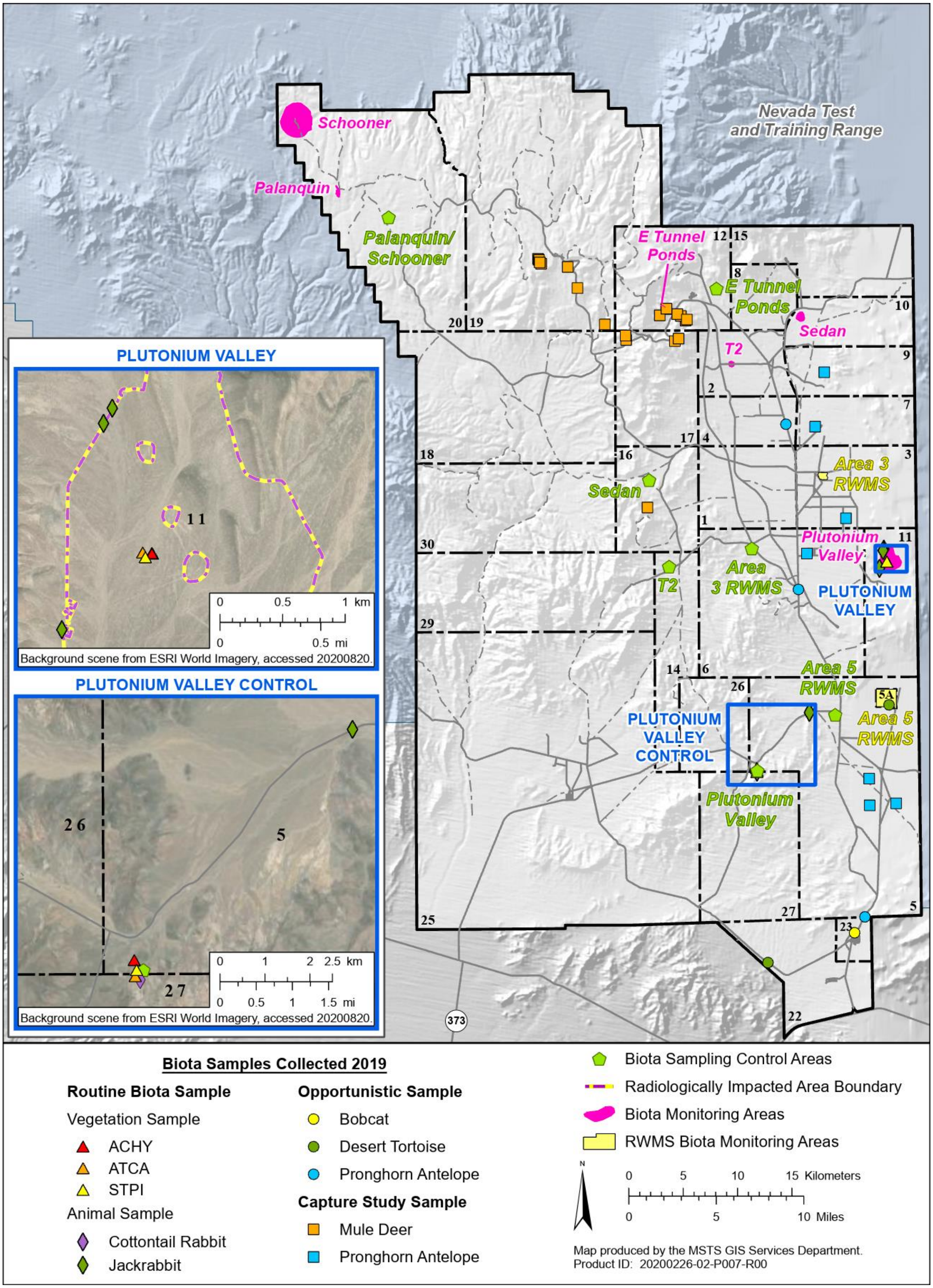

Figure 8-1. Radiological biota monitoring sites on the NNSS

8.3 2019 Sampling and Analysis

Plutonium Valley, located in Area 11 on the eastern edge of the NNSS at an elevation of 1,250 m (4,100 ft), was sampled in 2019 (Figure 8-1). Four safety experiments were conducted in Plutonium Valley from November 1, 1955, through January 18, 1956. These tests were designed to confirm that a nuclear explosion would not occur in case of accidental detonation of the chemical explosive associated with the nuclear device. In one of these tests there was a slight nuclear yield that resulted in the production of fission products (e.g., ^{137}Cs and ^{90}Sr), but the primary contaminant produced and dispersed in the area was plutonium. A control area for Plutonium Valley is located about 24 kilometers (km) (14.9 miles) southwest of the sample site (Figure 8-1). Any of the candidate game species could be present in Plutonium Valley or at the control site.

In 2019, no biota or soil sampling was conducted at the Area 3 or Area 5 RWMSs. The last sampling of the RWMSs in 2017 did not suggest that burrowing animals had come into contact with buried waste (MSTS 2018).

8.3.1 Plants

On June 12, 2019, three composite plant samples were collected from each of the Plutonium Valley and control locations (Figure 8-1). Sampled species represented common vegetation at each site (Table 8-2). All samples consisted of about 150 to 500 grams (5.3 to 17.6 ounces) of fresh-weight plant material collected from many plants of the same species found along meandering transects about 100 to 250 m long.

Plant leaves and stems from plants at the Plutonium Valley control sites were handpicked and stored in airtight Mylar bags. Rubber gloves were used by samplers and changed between each composite sample. Samples were labeled and stored in an ice chest. Within 4 hours of collection, the samples were delivered to the laboratory for processing. Water was separated from the samples by distillation and the dry plant material homogenized. The water and dried plant tissues were submitted for analysis of americium-241 (^{241}Am), strontium-90 (^{90}Sr), plutonium-238 (^{238}Pu), plutonium-239+240 ($^{239+240}$Pu), and gamma emitting radionuclides (including cobalt-60 [^{60}Co] and cesium-137 [^{137}Ce]).

Table 8-2. Plant samples collected in 2019

Common Name	Scientific Name	Name Code	Plutonium Valley	Control
Indian ricegrass	*Achnatherum hymenoides*	ACHY	X	X
Fourwing saltbush	*Atriplex canescens*	ATCA	X	X
Desert princeplume	*Stanleya pinnata*	STPI	X	X

Results of radiological analyses are shown in Table 8-3. No manmade radionuclides were detected in plants from the control site. The manmade radionuclides ^{3}H (tritium), ^{90}Sr, $^{239+240}$Pu, and ^{241}Am were detected in plants from Plutonium Valley. ^{3}H was detected at the highest concentrations. This nuclide has not been detected in Plutonium Valley in the recent past. It is believed to be from known tritium emissions from a facility just south of Plutonium Valley. Concentrations of other radionuclide are consistent with past measurements. In general, there were no changes in radionuclide concentrations in plants compared with those sampled in the recent past.

Table 8-3. Concentrations of manmade radionuclides in plants sampled in 2019

Sample	Radionuclide Concentrations ± Uncertainty(a)			
	^{3}H (pCi/L)(b)	^{90}Sr (pCi/g)(c)	$^{239+240}$Pu (pCi/g)(c)	^{241}Am (pCi/g)(c)
Plutonium Valley				
ACHY	513 ± 171	-0.003 ± 0.038	0.0086 ± 0.0056	-0.0006 ± 0.0019
ATCA	946 ± 239	0.086 ± 0.046	0.0946 ± 0.0251	0.0248 ± 0.0096
STPI	833 ± 222	0.056 ± 0.042	0.012 ± 0.0064	0.0013 ± 0.0027
Average Concentration	764	0.046	0.0384	0.0085
Average MDC(d)	151	0.081	0.004	0.0058
Plutonium Valley Control				
ACHY	-65 ± 64.8	0.005 ± 0.033	0.0014 ± 0.0033	-0.0004 ± 0.0022
ATCA	-45 ± 68.6	0.049 ± 0.039	-0.0003 ± 0.003	-0.0007 ± 0.0023
STPI	13 ± 81.5	-0.014 ± 0.044	0 ± 0.0028	0.0002 ± 0.0025
Average Concentration	-32	0.013	0.0003	-0.0003
Average MDC(d)	151	0.081	0.0038	0.0059

(a) ***Uncertainty*** is ± 2 standard deviations.

(b) Picocuries per liter water from sample.

(c) Picocuries per gram dry weight of sample.

(d) Average sample-specific ***minimum detectable concentration (MDC)***.

8.3.2 Animals

State and federal permits were secured to trap specific small mammals and birds in 2019 and opportunistically sample large mammal mortalities on the NNSS. Small mammal trapping occurred July 8 through August 19, 2019. Three jackrabbits were captured from the Plutonium Valley site and one cottontail rabbit and one jackrabbit were sampled from the control site (Table 8-4). Three pronghorn antelope and two desert tortoise killed by vehicles on the NNSS and one bobcat found dead, likely from starvation, were also sampled during 2019 (Table 8-4). Though muscle is usually the only portion consumed by humans, the whole body of the rabbits were homogenized to give a more conservative (higher) estimate of potential dose to someone consuming them (Section 9.1.1.2). The whole body of desert tortoises sampled were also homogenized to get a measure of the body burden of radionuclide. Only muscle tissue was sampled from the pronghorn and bobcat. Water was distilled from the samples and submitted to a laboratory for ^{3}H analysis. The remaining tissue samples were submitted for ^{90}Sr, ^{238}Pu, $^{239+240}$Pu, ^{241}Am, and gamma spectroscopy analysis. Uranium was also analyzed for in the desert tortoises.

Blood samples were collected from most animals captured as part of the habitat use study before they were released. One pronghorn antelope died from injuries sustained during the capture and two died within two days after the capture. Blood and tissue samples were collected from the animal that died during the capture and muscle tissue was sampled from one animal that died shortly after capture (no tissue was available from the second due to scavengers). Water was distilled from all samples and submitted to a laboratory for ^{3}H analysis. The remaining tissue samples and a subset of blood samples were submitted for ^{90}Sr, ^{238}Pu, $^{239+240}$Pu, ^{241}Am, and gamma spectroscopy analysis. Not all blood samples were analyzed for ^{90}Sr, ^{238}Pu, $^{239+240}$Pu and ^{241}Am due to cost constraints.

Table 8-4. Animal samples collected in 2019

Location	Sample	Collection Date	Sample Description
			Routine Monitoring Samples
Plutonium Valley			
	Jackrabbit #1	8/14/2019	Whole body (1907.3 g)
	Jackrabbit #2	8/15/2019	Whole body (1611.0 g)
	Jackrabbit #3	8/15/2019	Whole body (1248.5 g)
Control			
	Cottontail rabbit	7/23/2019	Whole body (611.7 g)
	Jackrabbit	7/24/2019	Whole body (1541.1 g)
			Opportunistic Samples
Area 23	Bobcat	3/5/2019	Muscle from hindquarter of an adult female bobcat found dead (3/4/2019) by Building 23-129 (Mercury). Animal in very poor condition (emaciated), likely starved
Area 5	Desert tortoise	6/21/2019	Whole body of desert tortoise (unknown sex, sub-adult [6-inch]) killed by a vehicle at Area 5 RWMS
Area 22	Desert tortoise	6/21/2019	Whole body of and adult (8-inch) female desert tortoise killed by a vehicle on Jackass Flats Road
Area 4	Pronghorn	10/24/2019	Muscle tissue from hindquarter of an adult female killed by a vehicle on Mercury Highway
Area 5	Pronghorn	1/31/2019	Muscle tissue from hindquarter of a 2-year-old male killed by a vehicle on Mercury Highway
Area 6	Pronghorn	9/24/2019	Muscle tissue from hindquarter of an adult male killed by a vehicle on Mercury Highway
			Mule Deer and Pronghorn Study
Area 12	Mule Deer 705922	11/15/2019	Blood from female captured in Eleana Range, north of Captain Jack Spring
Area 12	Mule Deer 705923	11/15/2019	Blood from male captured in Eleana Range, north of Captain Jack Spring
Area 19	Mule Deer 705924	11/16/2019	Blood from female captured on Echo Peak
Area 12	Mule Deer 705925	11/15/2019	Blood from female captured in Eleana Range
Area 19	Mule Deer 705929	11/16/2019	Blood from male captured on Echo Peak
Area 12	Mule Deer 705931	11/15/2019	Blood from female captured near ER 12-1 sump
Area 17	Mule Deer 705932	11/15/2019	Blood from female captured in Eleana Range, southwest of Captain Jack Spring
Area 17	Mule Deer 705933	11/15/2019	Blood from female captured on southwest slope of Rainier Mesa
Area 19	Mule Deer 705934	11/16/2019	Blood from female captured on Echo Peak
Area 17	Mule Deer 705935	11/15/2019	Blood from female captured on southwest slope of Rainier Mesa
Area 19	Mule Deer 705936	11/16/2019	Blood from female captured in northern Big Burn Valley
Area 19	Mule Deer 705937	11/16/2019	Blood from female captured on Echo Peak
Area 12	Mule Deer 705938	11/15/2019	Blood from female captured above V Tunnel
Area 19	Mule Deer 705939	11/16/2019	Blood from female captured east of Rattlesnake Ridge
Area 16	Mule Deer 705945	11/17/2019	Blood from female captured on Shoshone Mountain
Area 19	Mule Deer 705954	11/16/2019	Blood from male captured on Echo Peak
Area 12	Mule Deer 705955	11/15/2019	Blood from male captured near ER 12-1 sump
Area 17	Mule Deer 705956	11/15/2019	Blood from male captured in Eleana Range, south of Captain Jack Spring
Area 19	Mule Deer 705958	11/16/2019	Blood from male captured north of Camp 17 Pond
Area 19	Mule Deer 705959	11/16/2019	Blood from male captured on Echo Peak
Area 12	Mule Deer 705960	11/15/2019	Blood from male captured in Eleana Range, north of Captain Jack Spring
Area 9	Pronghorn 12062	11/17/2019	Blood from female captured in northeast Yucca Flat
Area 7	Pronghorn 694710	11/17/2019	Blood from female captured east of Ice Cap
Area 9	Pronghorn 705927	11/17/2019	Blood from female captured in northeast Yucca Flat
Area 7	Pronghorn 705941	11/17/2019	Blood from female captured east of Ice Cap
Area 3	Pronghorn 705942	11/15/2019	Blood from female captured west of Orange Blossom Road
Area 5	Pronghorn 705943	11/15/2019	Blood from female captured east of FACE Facility
Area 3, 6, and 7	Pronghorn 705944	11/15, 11/17, and 11/20/2019	Female captured twice (11/15 and 11/17) and released but died on 11/20 (all on Yucca Flat). Blood samples taken during both captures; muscle from head and neck sampled after death
Area 3	Pronghorn 705946	11/15/2019	Blood from female captured west of Orange Blossom Road
Area 5	Pronghorn 705947	11/15/2019	Blood from female captured southwest of Well 5B
Area 7	Pronghorn 705948	11/17/2019	Blood from female captured east of Ice Cap

Table 8-4. Animal samples collected in 2019

Location	Sample	Collection Date	Sample Description
Area 5	Pronghorn 705949	11/15/2019	Blood from female captured southwest of Well 5B
Area 3	Pronghorn 705953	11/15/2019	Blood from female captured west of Orange Blossom Road
Area 9	Pronghorn 705962	11/17/2019	Blood from male captured in northeast Yucca Flat
Area 5	Pronghorn 705963	11/15/2019	Blood from male captured east of FACE Facility
Area 7	Pronghorn 705964	11/17/2019	Blood from male captured east of Ice Cap
Area 5	Pronghorn 705965	11/15/2019	Blood from male captured east of FACE Facility
Area 3	Pronghorn 705967	11/15/2019	Blood from male captured west of Orange Blossom Road
Area 3	Pronghorn 705970	11/15/2019	Blood from female captured west of Orange Blossom Road
Area 3	Pronghorn705961	11/15/2019	Blood from male captured west of Orange Blossom Road
Area 5	Pronghorn 11/15/2019	11/15/2019	Muscle, liver, and blood from female that died from injuries during capture

Radionuclide concentration results from routine samples are listed in Table 8-5. Elevated concentrations of ^{3}H, $^{239+240}$Pu, and ^{241}Am were measured in rabbits from Plutonium Valley. The $^{239+240}$Pu and ^{241}Am results are within the range of values measured in the past. Tritium has not been recently measured in biota from Plutonium Valley but, just as in vegetation samples discussed previously, it is believed to be from known tritium emissions from a facility just south of Plutonium Valley. No manmade radionuclides were measured in samples from the Plutonium Valley control site. Very low concentrations of manmade ^{90}Sr were measured in both desert tortoises and ^{241}Am in the pronghorn from Area 4. Because there is a relatively high amount of bone per whole body mass in tortoises, it is not surprising to see more ^{90}Sr, as it acts like calcium chemically and so accumulates in bone.

Table 8-5. Concentrations of manmade radionuclides in animals sampled during routine monitoring in 2019

	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)$^{(c)}$**
Plutonium Valley					
Jackrabbit #1	237 ± 113	0.006 ± 0.032	-0.0001 ± 0.0040	0.0014 ± 0.0040	0.0006 ± 0.0047
Jackrabbit #2	441 ± 132	-0.003 ± 0.033	0.0035 ± 0.0044	0.0091 ± 0.0061	0.0006 ± 0.0047
Jackrabbit #3	160 ± 112	0.004 ± 0.034	0.0126 ± 0.0073	0.4970 ± 0.0925	0.0871 ± 0.0211
Average Concentration	279	0.002	0.0053	0.1692	0.0294
Average MDC$^{(d)}$	173	0.071	0.0069	0.0053	0.0107
Plutonium Valley					
Cottontail	38 ± 104	-0.008 ± 0.032	0.0002 ± 0.0029	0.0021 ± 0.0029	-0.0026 ± 0.0028
Jackrabbit	26 ± 102	0.017 ± 0.032	0.0013 ± 0.0037	0.0006 ± 0.0037	-0.0023 ± 0.0037
Average Concentration	32	0.004	0.0008	0.0014	-0.0024
Average MDC$^{(d)}$	175	0.069	0.0060	0.0049	0.0108
Opportunistic Sampling					
Area 23 Bobcat	-61 ± 180	0.006 ± 0.028	0.0045 ± 0.0127	0.0034 ± 0.0050	0.0062 ± 0.0101
Area 5 Desert Tortoise	16 ± 175	0.121 ± 0.053	-0.0007 ± 0.0069	-0.0007 ± 0.0069	-0.0001 ± 0.0068
Area 22 Desert Tortoise	-133 ± 171	0.124 ± 0.053	0.0006 ± 0.0049	0.0015 ± 0.0049	-0.0018 ± 0.0068
Area 4 Pronghorn	-27 ± 112	-0.001 ± 0.025	0.0020 ± 0.0069	-0.0020 ± 0.0040	0.0022 ± 0.0053
Area 5 Pronghorn	143 ± 170	-0.011 ± 0.057	-0.0031 ± 0.0053	-0.0091 ± 0.0095	0.0018 ± 0.0052
Area 6 Pronghorn	-98 ± 168	-0.015 ± 0.027	0.0145 ± 0.0122	0.0042 ± 0.0042	0.0000 ± 0.0106
Average Concentration	-27	0.037	0.0030	-0.0005	0.0014
Average MDC$^{(d)}$	287	0.071	0.0153	0.0115	0.0153

(a) Uncertainty is ± 2 standard deviations.
(b) Picocuries per liter water from sample.
(c) Picocuries per gram wet weight of sample.
(d) Average sample-specific MDC.

Radionuclide concentration results from samples collected from mule deer and pronghorn captured as part of the habitat use study are listed in Table 8-6. No manmade gamma-emitting radionuclides were detected in any of the samples. Tritium was detected in 85.7% of mule deer samples and in 65% of the pronghorn antelope samples. The highest concentrations of tritium were in mule deer within 4 km of the E Tunnel Ponds (a known source of tritium). Concentrations dropped with distance from the ponds (Figure 8-2) at a rate of about half every 1 km. Concentrations of ^{90}Sr exceeded the MDC in two samples from Pronghorn 705944 (11/15/2019 and 11/17/2019) and one mule deer (Mule Deer 705937). Concentrations of $^{239+240}$Pu exceeded the MDC only slightly in two mule deer (Mule Deer 705922 and Mule Deer 705929) and one pronghorn (Pronghorn 705944 11/20/2019). All of these concentrations are very low and well within the range previously measured on the NNSS.

Table 8-6. Concentrations of manmade radionuclides in animals sampled during routine monitoring in 2019

		Radionuclide Concentrations ± Uncertainty[(a)]		
Location	**Sample**	**^{3}H (pCi/L)[(b)]**	**^{90}Sr (pCi/g)[(c)]**	**$^{239+240}$Pu (pCi/g)[(c)]**
Area 12	Mule Deer 705922	100,511 ± 407	0.004 ± 0.011	0.0010 ± 0.0009
Area 12	Mule Deer 705923	81,209 ± 357	-0.006 ± 0.013	0.0003 ± 0.0018
Area 19	Mule Deer 705924	9,258 ± 167	NM[(d)]	NM[(d)]
Area 12	Mule Deer 705925	89,856 ± 388	NM[(d)]	NM[(d)]
Area 19	Mule Deer 705929	5,466 ± 147	0.000 ± 0.012	0.0012 ± 0.0012
Area 12	Mule Deer 705931	89,067 ± 375	-0.001 ± 0.012	0.0010 ± 0.0019
Area 17	Mule Deer 705932	108,649 ± 419	-0.004 ± 0.013	0.0009 ± 0.0015
Area 17	Mule Deer 705933	2,730 ± 121	NM[(d)]	NM[(d)]
Area 19	Mule Deer 705934	1,131 ± 112	NM[(d)]	NM[(d)]
Area 17	Mule Deer 705935	1,321 ± 112	NM[(d)]	NM[(d)]
Area 19	Mule Deer 705936	-311 ± 102	NM[(d)]	NM[(d)]
Area 19	Mule Deer 705937	4,315 ± 140	0.039 ± 0.019	0.0006 ± 0.0011
Area 12	Mule Deer 705938	69,204 ± 327	-0.006 ± 0.014	0.0015 ± 0.0014
Area 19	Mule Deer 705939	8,794 ± 165	-0.006 ± 0.014	-0.0004 ± 0.0037
Area 16	Mule Deer 705945	-312 ± 103	NM[(d)]	NM[(d)]
Area 19	Mule Deer 705954	1,006 ± 120	-0.003 ± 0.011	-0.0003 ± 0.0025
Area 12	Mule Deer 705955	171,439 ± 544	NM[(d)]	NM[(d)]
Area 17	Mule Deer 705956	65,890 ± 334	-0.009 ± 0.013	0.0012 ± 0.0018
Area 19	Mule Deer 705958	-335 ± 110	NM[(d)]	NM[(d)]
Area 19	Mule Deer 705959	6,307 ± 151	NM[(d)]	NM[(d)]
Area 12	Mule Deer 705960	91,086 ± 391	NM[(d)]	NM[(d)]
	Average Concentration	43,156	0.001	0.0007
	Average MDC[(e)]	404	0.021	0.0024
Area 5	Pronghorn 11/15/2019 blood	-53 ± 37	0.009 ± 0.013	0.0000 ± 0.0009
Area 5	Pronghorn 11/15/2019 liver	NM[(d)]	0.001 ± 0.001	0.0000 ± 0.0001
Area 5	Pronghorn 11/15/2019 muscle	1,990 ± 263	-0.001 ± 0.002	0.0000 ± 0.0001
Area 9	Pronghorn 12062	112 ± 114	NM[(d)]	NM[(d)]
Area 7	Pronghorn 694710	1,967 ± 118	NM[(d)]	NM[(d)]
Area 9	Pronghorn 705927	1,363 ± 116	NM[(d)]	NM[(d)]
Area 7	Pronghorn 705941	100 ± 102	0.005 ± 0.011	0.0008 ± 0.0015
Area 3	Pronghorn 705942	4,149 ± 135	0.003 ± 0.011	0.0000 ± 0.0016
Area 5	Pronghorn 705943	-319 ± 105	NM[(d)]	NM[(d)]
Area 3	Pronghorn 705944 11/15/2019	655 ± 99	0.154 ± 0.044	0.0006 ± 0.0033
Area 7	Pronghorn 705944 11/17/2019	1,090 ± 108	0.035 ± 0.016	0.0007 ± 0.0016
Area 6	Pronghorn 705944 11/20/2019	516 ± 147	0.001 ± 0.002	0.0002 ± 0.0002
Area 3	Pronghorn 705946	1,809 ± 120	-0.007 ± 0.010	0.0002 ± 0.0014
Area 5	Pronghorn 705947	-511 ± 100	NM[(d)]	NM[(d)]
Area 7	Pronghorn 705948	1,646 ± 109	-0.006 ± 0.012	0.0014 ± 0.0018
Area 5	Pronghorn 705949	-304 ± 100	0.006 ± 0.010	-0.0003 ± 0.0015
Area 3	Pronghorn 705953	1,536 ± 114	NM[(d)]	NM[(d)]
Area 3	Pronghorn 705961	2,533 ± 120	-0.013 ± 0.013	0.0001 ± 0.0015
Area 9	Pronghorn 705962	334 ± 115	NM[(d)]	NM[(d)]
Area 5	Pronghorn 705963	967 ± 147	NM[(d)]	NM[(d)]
Area 7	Pronghorn 705964	-99 ± 100	-0.010 ± 0.012	0.0017 ± 0.0020
Area 5	Pronghorn 705965	309 ± 106	0.017 ± 0.013	0.0004 ± 0.0016
Area 3	Pronghorn 705967	11,630 ± 161	-0.009 ± 0.008	-0.0001 ± 0.0018
Area 3	Pronghorn 705970	315 ± 108	NM[(d)]	NM[(d)]

Table 8-6. Concentrations of manmade radionuclides in animals sampled during routine monitoring in 2019

Location	Sample	Radionuclide Concentrations ± Uncertainty[(a)] ^{3}H (pCi/L)[(b)]	^{90}Sr (pCi/g)[(c)]	$^{239+240}$Pu (pCi/g)[(c)]
	Average Concentration	1,380	0.012	0.0004
	Average MDC[(e)]	393	0.017	0.0020

(a) Uncertainty is ± 2 standard deviations.
(b) Picocuries per liter water from sample.
(c) Picocuries per gram wet weight of sample.
(d) Not measured.
(e) Average sample-specific MDC.

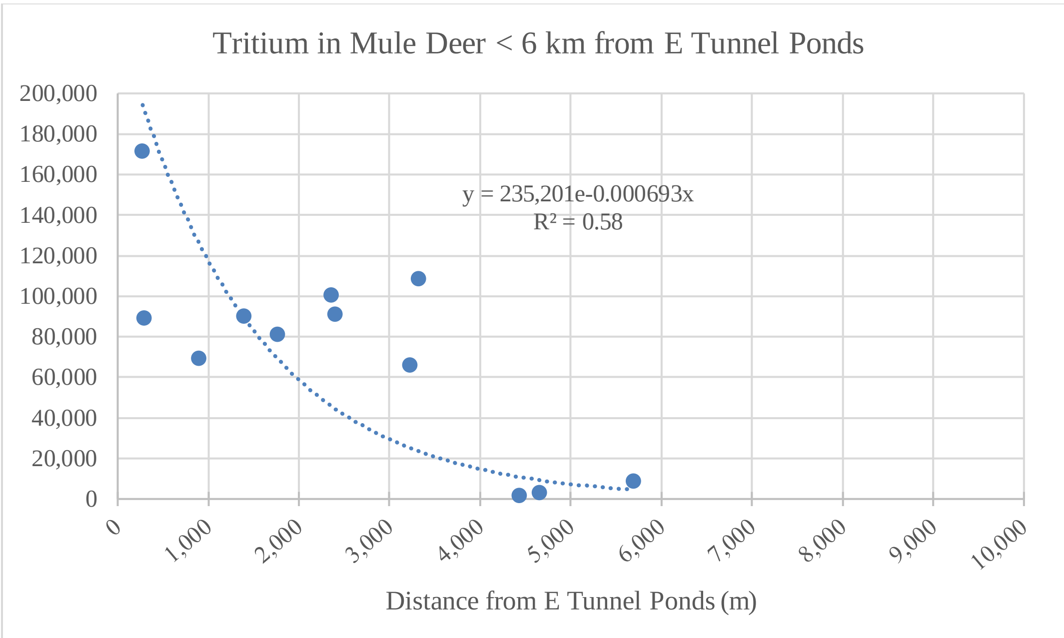

Figure 8-2. Tritium concentrations in mule deer with distance from the E Tunnel Ponds

8.4 Data Assessment

Biota sampling results confirm that manmade radionuclide concentrations are generally higher at locations near surface contamination than at more remote or control locations. Though certain radionuclides are elevated, the levels detected pose negligible risk to humans and biota. The potential dose to a person consuming these animals is well below dose limits to members of the public (see 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 was less than 4% of dose limits set to protect populations of plants and animals (see 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.

Mission Support and Test Services, LLC, 2018. *Nevada National Security Site Environmental Report 2017*. DOE/NV/03624--0270, Las Vegas, NV.

MSTS, see Mission Support and Test Services, LLC.

Chapter 9: Radiological Dose Assessment

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Radiological Dose Assessment Goals

Determine if the maximum radiation dose to a member of the general public from airborne radionuclide emissions at the Nevada National Security Site (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 U.S. Department of Energy (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 Order DOE O 458.1, "Radiation Protection of the Public and the Environment." Determine if the radiation dose (in a unit of measure called a rad) to NNSS biota complies with the following limits set by DOE Standard DOE-STD-1153-2019, "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota."

The U.S. Department of Energy 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 O 458.1 and in DOE O 435.1, "Radioactive Waste Management" (Table 2-1). To estimate these radiological doses, ***radionuclide*** concentration data gathered on the NNSS are used along with dose conversion factors published in 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 2019 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 described below.

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 2019 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.

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.

[1] The definition of word(s) in ***bold italics*** may be found by referencing the Glossary, Appendix B.

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 2019.

9.1.1.1 Dose from NNSS Air Emissions

Six air particulate and ***tritium (^{3}H)*** 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	2.4 km NE Area 6, nearest portion of Grouped Area Sources
Area 10, Gate 700	49 km ENE Medlin's Ranch	56 km NNE Rachel	75 km SSE Indian Springs	2.4 km SW Area 10, Sedan Crater
Area 16, Substation 3545	46 km SSW Amargosa Valley	46 km SSW Amargosa Valley	58 km SSW Amargosa Valley	1.6 km NW Area 3, RWMS
Area 20, Schooner	36 km WSW Sarcobatus Flat	20 km WSW Tolicha Peak	56 km SSW Beatty	0.3 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 2019 but is the closest business to the NNSS.

In 2019, 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, 2019 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 2019 NNSS source were modeled using the ***Clean Air Package, 1988***, model (CAP88, Version 4.0; EPA 2014). The highest value (0.06 mrem/yr [0.0006 mSv/yr]) is predicted to be a person residing in Amargosa Valley. More detailed information regarding the estimation of the dose to the public from airborne radioactivity in 2019 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) (2020).

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 2019; 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 the NNSS. In 2019, the following animals were sampled (Figure 8-1 and Tables 8-4, 8-5, and 8-6):

- Three jackrabbits from Plutonium Valley, Area 11
- One cottontail rabbit and one jackrabbit sampled from the control location for Plutonium Valley Area 27
- One bobcat that died of natural causes in Area 23
- Two desert tortoises killed by vehicles, one in Area 5 and one in Area 22
- Three pronghorn, each killed by a vehicle, one each in Area 4, Area 5, and Area 6
- 21 mule deer captured and released as part of a habitat-use study (23 mule deer were captured but samples were only collected from 21)
- 20 pronghorn antelope captured as part of a habitat-use study

The potential ***committed effective dose equivalent (CEDE)*** to an individual consuming game animals was calculated for each animal sampled in 2019 unless no man-made radionuclides were detected in animals from a particular location. 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***, 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.
- Some samples from animals captured as part of the habitat-use study were not analyzed for all radionuclides (Table 8-6). The average concentration from analyzed samples was used in those cases.
- An individual consumes one of each species of animal sampled during the year: one jackrabbit (513 grams [g]), one cottontail rabbit (167 g), one bobcat (9.6 kilograms [kg]), one mule deer (35.4 kg), and one pronghorn antelope (20.0 kg).
- Dose is calculated for someone consuming a desert tortoise, but this is not likely.
- 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. Based on the 2019 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 0.45 mrem (0.0045 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 Pronghorn 705944 sampled on November 15, 2019, in Area 3 (Table 8-6) and would result in a dose of 0.43 mrem (0.0043 mSv) (Table 9-3).

Table 9-2. Hypothetical CEDE from ingesting game animals sampled in 2019

	Committed Effective Dose Equivalent (mrem)[(a)]							
Location and Sample	**^{3}H[(b)]**	**^{90}Sr**	**^{238}Pu**	**$^{239+240}$Pu**	**^{241}Am**	**Total**	**Location Average**	**Max**
Plutonium Valley								
Jackrabbit #1	0.0000	0.0004	0.0000	0.0008	0.0003	0.0014	0.1087	0.3176
Jackrabbit #2	0.0000	0.0000	0.0018	0.0050	0.0003	0.0070	--	--
Jackrabbit #3	0.0000	0.0003	0.0063	0.2717	0.0393	0.3176	--	--
Plutonium Valley Control								
Cottontail	No man-made radionuclides detected in Plutonium Valley Control samples							
Jackrabbit								

Opportunistic samples from natural mortality or accidental road kills

Location and Sample	^{3}H[(b)]	^{90}Sr	^{238}Pu	$^{239+240}$Pu	^{241}Am	Total	Species Average	Max
Area 23 Bobcat	0.0000	0.0072	0.0420	0.0346	0.0522	0.1360	0.1360	0.1360
Area 5 Desert Tortoise	0.0000	0.0029	0.0000	0.0000	0.0000	0.0029	0.0060	0.0090
Area 22 Desert Tortoise	0.0000	0.0080	0.0003	0.0008	0.0000	0.0090	--	--
Area 4 Pronghorn	0.0000	0.0000	0.0388	0.0000	0.0383	0.0771	0.1599	0.3715
Area 5 Pronghorn	0.0002	0.0000	0.0000	0.0000	0.0311	0.0312	--	--
Area 6 Pronghorn	0.0000	0.0000	0.2828	0.0886	0.0000	0.3715	--	--

Animals captured as part of habitat-use study

Location and Sample	^{3}H[(b)]	^{90}Sr	$^{239+240}$Pu	Total	Location Average	Max
Area 12 Mule Deer 705922	0.2017	0.0177	0.0359	0.2553	0.1355	0.3928
Area 12 Mule Deer 705923	0.1629	0.0000	0.0107	0.1736	--	--
Area 19 Mule Deer 705924	0.0186	0.0202[(c)]	0.0286[(c)]	0.0674	--	--
Area 12 Mule Deer 705925	0.1803	0.0202[(c)]	0.0286	0.2291	--	--
Area 19 Mule Deer 705929	0.0110	0.0000	0.0445	0.0554	--	--
Area 12 Mule Deer 705931	0.1787	0.0000	0.0375	0.2162	--	--
Area 17 Mule Deer 705932	0.2180	0.0000	0.0327	0.2507	--	--
Area 17 Mule Deer 705933	0.0055	0.0202[(c)]	0.0286[(c)]	0.0543	--	--
Area 19 Mule Deer 705934	0.0023	0.0202[(c)]	0.0286[(c)]	0.0511	--	--
Area 17 Mule Deer 705935	0.0027	0.0202[(c)]	0.0286[(c)]	0.0515	--	--
Area 19 Mule Deer 705936	0.0000	0.0202[(c)]	0.0286[(c)]	0.0488	--	--
Area 19 Mule Deer 705937	0.0087	0.1847	0.0230	0.2164	--	--
Area 12 Mule Deer 705938	0.1389	0.0000	0.0554	0.1943	--	--
Area 19 Mule Deer 705939	0.0176	0.0000	0.0000	0.0176	--	--
Area 16 Mule Deer 705945	0.0000	0.0202[(c)]	0.0286[(c)]	0.0488	--	--
Area 19 Mule Deer 705954	0.0020	0.0000	0.0000	0.0020	--	--
Area 12 Mule Deer 705955	0.3440	0.0202[(c)]	0.0286[(c)]	0.3928	--	--
Area 17 Mule Deer 705956	0.1322	0.0000	0.0460	0.1782	--	--
Area 19 Mule Deer 705958	0.0000	0.0202[(c)]	0.0286[(c)]	0.0488	--	--
Area 19 Mule Deer 705959	0.0127	0.0202[(c)]	0.0286[(c)]	0.0615	--	--
Area 12 Mule Deer 705960	0.1828	0.0202[(c)]	0.0286[(c)]	0.2316	--	--
Area 5 Pronghorn 11/15/2019 blood	0.0000	0.0239	0.0000	0.0239	0.0511	0.4257
Area 5 Pronghorn 11/15/2019 liver	0.0000	0.0015	0.0000	0.0015	--	--
Area 5 Pronghorn 11/15/2019 muscle	0.0023	0.0000	0.0003	0.0025	--	--
Area 9 Pronghorn 12062	0.0001	0.0408[(c)]	0.0088[(c)]	0.0497	--	--
Area 7 Pronghorn 694710	0.0022	0.0408[(c)]	0.0088[(c)]	0.0518	--	--
Area 9 Pronghorn 705927	0.0015	0.0408[(c)]	0.0088[(c)]	0.0511	--	--
Area 7 Pronghorn 705941	0.0001	0.0124	0.0168	0.0294	--	--
Area 3 Pronghorn 705942	0.0047	0.0067	0.0000	0.0114	--	--
Area 5 Pronghorn 705943	0.0000	0.0408[(c)]	0.0088[(c)]	0.0496	--	--
Area 3 Pronghorn 705944 11/15/2019	0.0007	0.4112	0.0137	0.4257	--	--

Table 9-2. Hypothetical CEDE from ingesting game animals sampled in 2019

	Committed Effective Dose Equivalent (mrem)[(a)]					
Location and Sample	**^{3}H[(b)]**	**^{90}Sr**	**$^{239+240}Pu$**	**Total**	**Location Average**	**Max**
Area 7 Pronghorn 705944 11/17/2019	0.0012	0.0926	0.0143	0.1082	--	--
Area 6 Pronghorn 705944 11/20/2019	0.0006	0.0017	0.0047	0.0069	--	--
Area 3 Pronghorn 705946	0.0021	0.0000	0.0044	0.0065	--	--
Area 5 Pronghorn 705947	0.0000	0.0408[(c)]	0.0088[(c)]	0.0496	--	--
Area 7 Pronghorn 705948	0.0019	0.0000	0.0301	0.0320	--	--
Area 5 Pronghorn 705949	0.0000	0.0159	0.0000	0.0159	--	--
Area 3 Pronghorn 705953	0.0017	0.0408[(c)]	0.0088[(c)]	0.0513	--	--
Area 3 Pronghorn 705961	0.0029	0.0000	0.0014	0.0043	--	--
Area 9 Pronghorn 705962	0.0004	0.0408[(c)]	0.0088[(c)]	0.0499	--	--
Area 5 Pronghorn 705963	0.0011	0.0408[(c)]	0.0088[(c)]	0.0507	--	--
Area 7 Pronghorn 705964	0.0000	0.0000	0.0365	0.0365	--	--
Area 5 Pronghorn 705965	0.0004	0.0462	0.0092	0.0557	--	--
Area 3 Pronghorn 705967	0.0132	0.0000	0.0000	0.0132	--	--
Area 3 Pronghorn 705970	0.0004	0.0408[(c)]	0.0088[(c)]	0.0499	--	--
CEDE from consuming one animal of each species = 0.45 mrem (using averages) and 1.28 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) Average concentration measured in analyzed samples.

A person may consume animals from locations on the NNSS other than where samples were collected in 2019; therefore, Table 9-3 presents the maximum CEDE for humans consuming various species of wildlife from all animals sampled from 2001–2019. 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 19 years.

The highest CEDE from consuming just one animal (12.9 mrem or 0.129 mSv) would be from the pronghorn sampled in 2018 from Area 9 (Table 9-3). This represents 12.9% of the annual dose limit for members of the public.

Table 9-3. Maximum CEDEs to a person hypothetically ingesting NNSS game animals sampled from 2001–2019

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
Desert Tortoise	Area 22 roadkill (Jackass Flats Road)	2020	whole body	0.009
Gambel's Quail	Area 2 (T2)	2002	all muscle	0.004
Jackrabbit	Area 10 (Sedan)	2015	all muscle	1.298
Mountain Lion	Nevada Test and Training Range (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 9 (likely killed by coyotes)	2018	all muscle	12.869

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 will 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 2019.

9.1.1.4 Dose from Drinking Contaminated Groundwater

The 2019 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 2019, 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 only for brief periods. However, for purposes of documenting potential impacts, the pathways for radionuclide movement from waste disposal facilities are monitored.

In 2019, 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 0.71% of their CLs (Table 10-4). Scaling this to the 10-mrem dose that the CL represents would be 0.07 mrem (0.0007 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 2019, 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 2019 dose to the ***maximally exposed individual (MEI)*** residing off site.

The MEI for the air pathway was considered to be a person residing in Amargosa Valley south of the NNSS (Section 9.1.1.1). If the offsite MEI were assumed to also eat wildlife from the NNSS, additional dose would be received. Based on 2019 samples, the additional dose may range up to 0.43 mrem (0.0043 mSv) if a person ate a pronghorn having elevated radionuclide concentrations like the one sampled in Area 3 (Pronghorn 705944 sample on November 15, 2019) (Table 9-2). When the 0.06 mrem (0.0006 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 0.49 mrem/yr (0.0049 mSv/yr) (Table 9-4).

Table 9-4. Estimated radiological dose to hypothetical MEI of the general public from 2019 NNSS activities

	Dose to MEI		
Pathway	**(mrem/yr)**	**(mSv/yr)**	**Percent of DOE 100 mrem/yr Limit**
Air[(a)]	0.060	0.00060	0.06
Water[(b)]	0	0	0
Wildlife[(c)]	0.43	0.0043	0.43
Direct[(d)]	0	0	0
All Pathways	**0.49**	**0.0049**	**0.49**

(a) Based on highest offsite dose predicted from modeled 2019 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 2019, which would result in the highest dose (Table 9-2).
(d) Based on 2019 gamma radiation monitoring data at the NNSS entrance (Section 6.3.1).

The total dose of 0.49 mrem/yr to the hypothetical MEI is 0.49% of the DOE limit of 100 mrem/yr and about 0.14% 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 its ***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 Community Environmental Monitoring Program (100.30 milliroentgens per year [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).

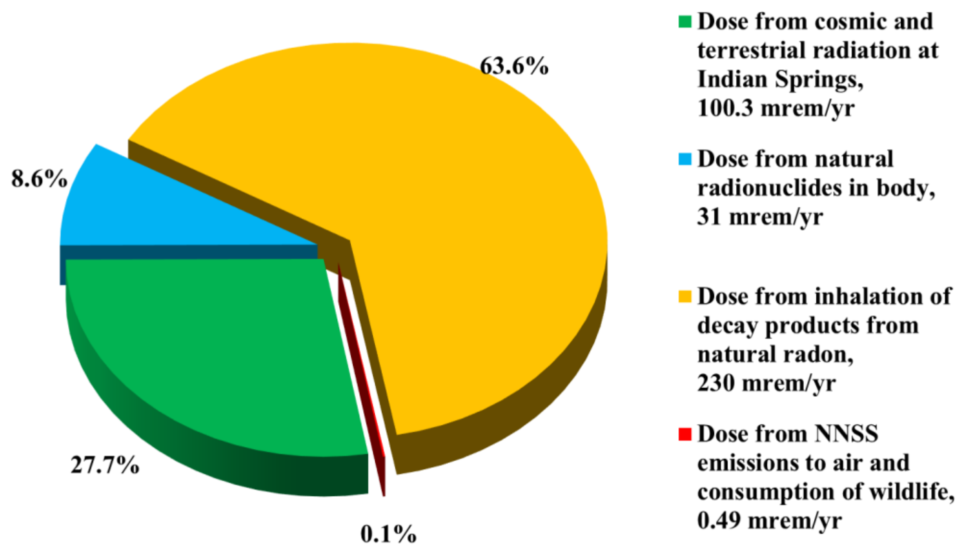

Figure 9-1. Comparison of radiation dose to the MEI from the NNSS and natural background (% of total) in 2019

9.1.4 Collective Population Dose

The ***collective population dose*** to residents within 80 km (50 miles [mi]) is the product of the predicted individual doses multiplied by the population potentially receiving those doses. The CAP88 modeled doses from 2019 air emissions for the estimated 499,500 people who lived within 80 km (50 mi) of NNSS emission sources resulted in a collective dose of 0.29 person-rem/yr. This 2019 calculation verifies the relatively low dose risk from 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. Either items are 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 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 2019, and NNSS property release activities were found to comply with the order.

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 and Removable)**	**Maximum Allowable[(c)] (Fixed and 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-1153-2019. 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 radiation absorbed dose per day (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-1153-2019 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-1153-2019. 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 2019.

9.2.1 2019 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 2019, 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 2019 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 jackrabbits in Plutonium Valley, followed by pronghorn.

Table 9-6. Site-specific dose assessment for terrestrial plants and animals sampled in 2019

Location [(a)]	Estimated Radiological Dose (rad/d) Internal [(b)]	External [(c)]	Total
Terrestrial Plants			
Plutonium Valley	0.000344	0.000074	0.000418
Plutonium Valley Control	No man-made radionuclides detected	0.000000	0.000000
		DOE Dose	**1**
Terrestrial Animals			
Plutonium Valley Jackrabbit (Area 11)	0.003223	0.000074	0.003297
Bobcat (Area 23)	No man-made radionuclides detected	0.000000	0.000000
Desert Tortoise (Areas 5 and 22)	0.000007	0.000101	0.000109
Mule Deer (Areas 12, 16, and 19)	0.000046	0.000126	0.000172
Pronghorn (Areas 3, 4, 5, 6, 7, and 9)	0.000021	0.000797	0.000818
		DOE Dose	**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 2019 was 0.49 mrem/yr (0.0049 mSv/yr), which is 0.49% of the dose limit set to protect human health. Dose to biota at the NNSS sites sampled in 2019 were less than 4% 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

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

———, 2004. *Nevada Test Site Environmental Report 2003*. DOE/NV/11718--971, Las Vegas, NV.

BN, see Bechtel Nevada.

DOE, see U.S. Department of Energy.

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Chapter 10: Waste Management

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Waste Management Goals

Ensure disposal systems meet performance objectives. Manage and safely dispose of all types of wastes. Ensure wastes received for disposal at the Nevada National Security Site (NNSS) meet NNSS acceptance criteria. Manage and monitor wastes and waste sites for the protection of the worker, the public, and the environment.

Several federal and state regulations govern the safe management, storage, and disposal of radioactive, hazardous, and solid wastes generated or received on the NNSS (Tables 2-1 and 2-3). This chapter describes waste management operations and compliance with all applicable environmental/public safety regulations. The U.S. Department of Energy (DOE) Environmental Management (EM) Nevada Program, in coordination with the National Nuclear Security Administration Nevada Field Office (NNSA/NFO), is responsible for the Area 3 and Area 5 radioactive waste facilities described in Section 10.1. NNSA/NFO is responsible for and operates all other waste disposal facilities on the NNSS (Figure 10-1).

This chapter describes several waste streams, including the following:

- ***low-level waste (LLW)***[1]
- ***mixed LLW (MLLW)***
- classified non-radioactive waste/matter
- ***hazardous waste (HW)***
- ***transuranic*** and mixed transuranic (TRU/MTRU)
- explosive ordnance wastes
- solid/sanitary waste

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 10-2) is composed of the Area 5 RWMS, the Mixed Waste Storage Unit (MWSU), Mixed Waste Disposal Unit (MWDU), and the Waste Examination Facility (WEF). The Hazardous Waste Storage Unit (HWSU) is adjacent to the Area 5 RWMC. The waste disposed at these facilities must be generated at DOE facility or defense-affiliated site or have a clear nexus to a DOE-sponsored program. This section describes the facilities and processes that comprise the safe receipt, storage, disposal, and disposal unit monitoring of radioactive and mixed wastes at the NNSS.

[1] The definition of word(s) in ***bold italics*** may be found by referencing the Glossary, Appendix B.

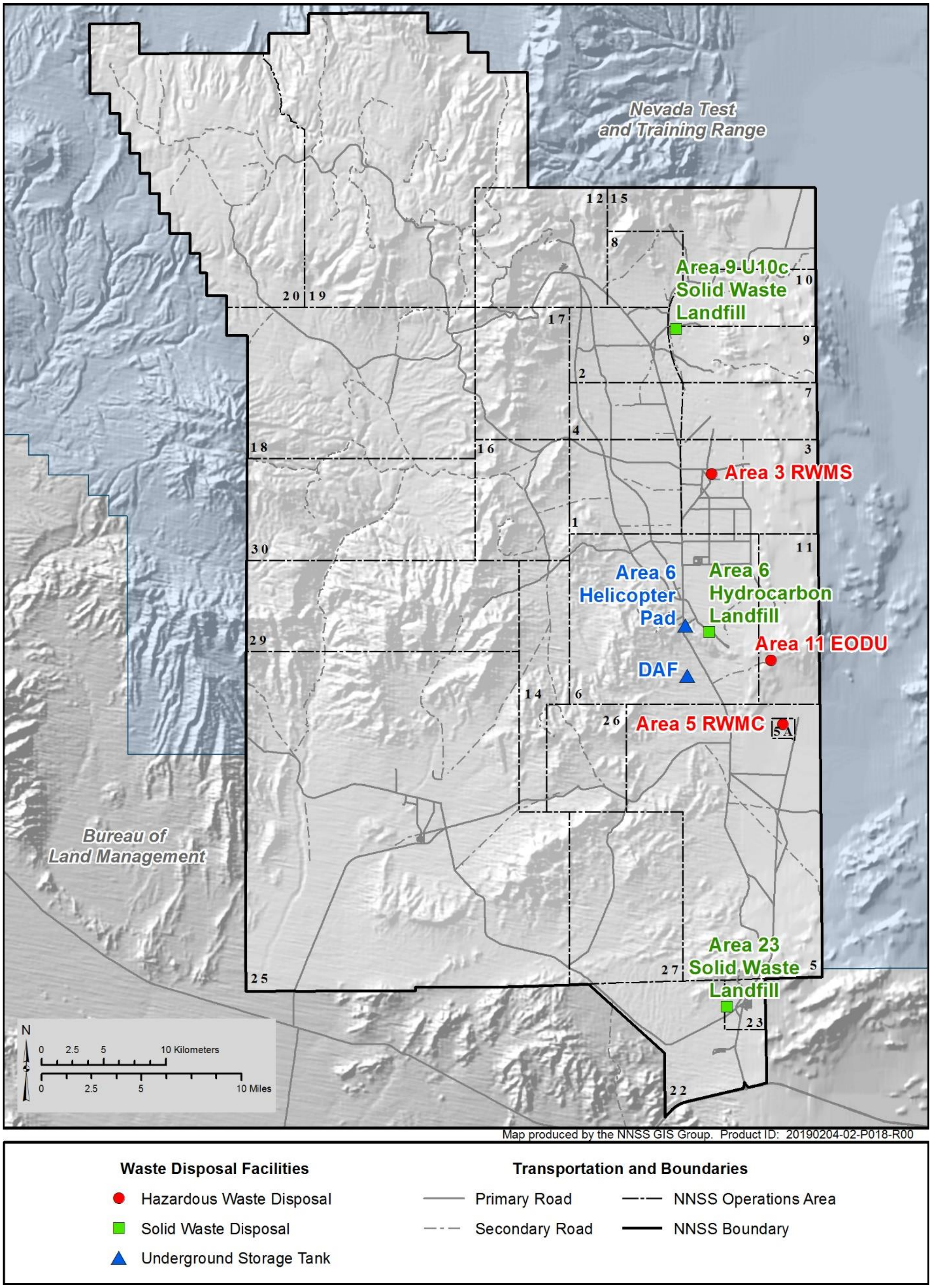

Figure 10-1. Waste Disposal Facilities on the NNSS

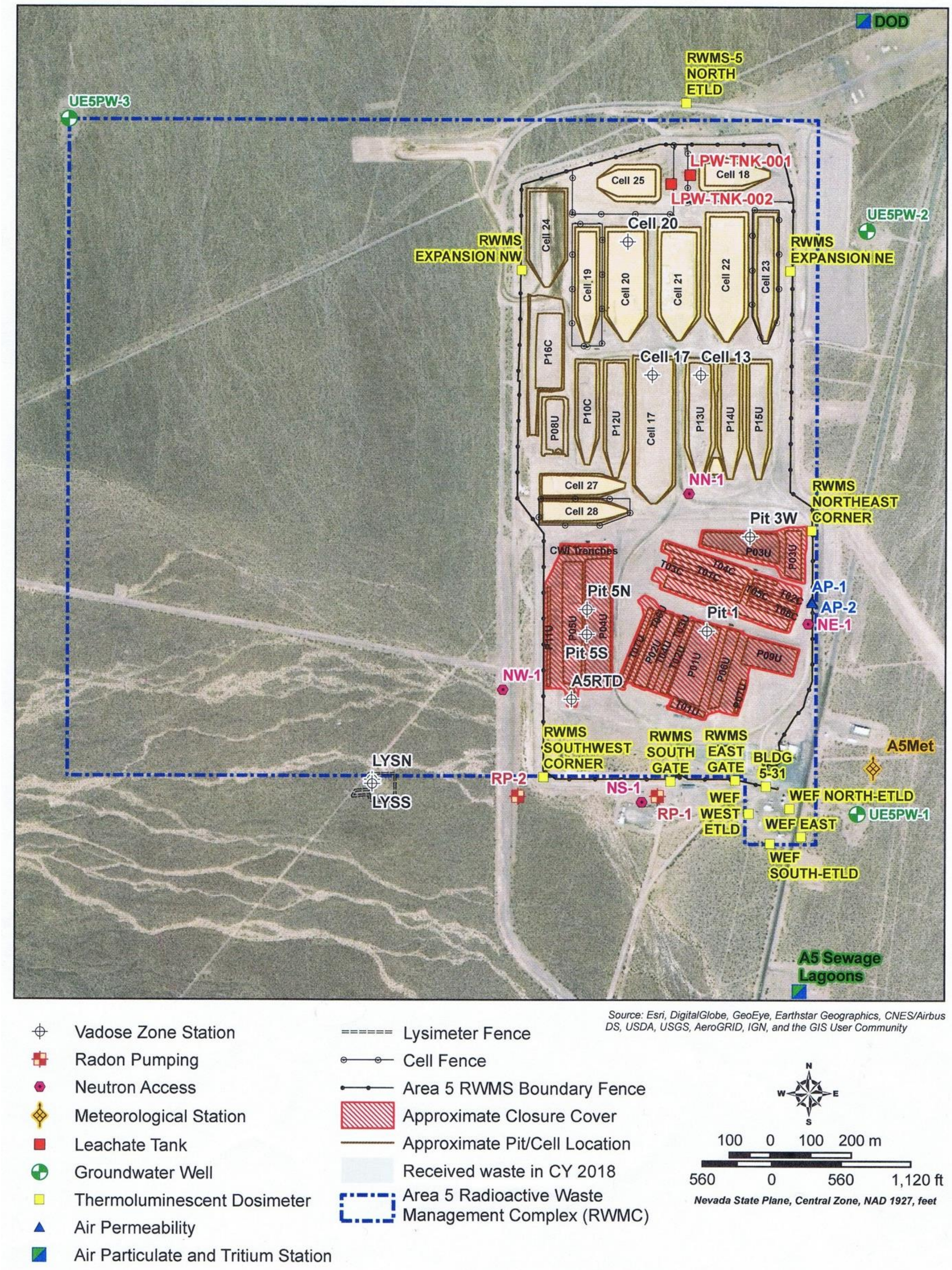

Figure 10-2. Area 5 RWMC facilities

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, Classified Non-Radiological (CNR) waste, and Classified Non-Radiological Hazardous (CNRH) 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 attempts to produce covers supporting sustainable native plant populations.

In an effort to successfully establish an evapotranspitation landfill cover over the 92-acres, it was decided by the EM Nevada Program that a test plot would be planted as the first step to establish vegetation on the cover. In early 2017, the Tribal Revegetation Project commenced, and a Fieldwork Plan was soon developed. The Tribal Revegetation Project is an amalgamation of complex tribal perspectives based on tribal ecological knowledge and blended with Western scientific ecological methods. The project required a unique collaboration among NNSA/NFO, the EM Nevada Program, a select group of tribal representatives (the Tribal Revegetation Committee [TRC], who have cultural ties to lands on the NNSS), an environmental anthropologist from Portland State University, and an ecologist from the Desert Research Institute.

The purpose of the experimental design, based on both traditional knowledge and natural science, was to test the efficacy of four different revegetation treatments during two planting seasons, along with four transplant treatments during two planting seasons with three replicates each for a total of 38 plots. Nineteen plots were planted in the fall of 2017 and nineteen plots were planted in the spring of 2018. Navarro personnel worked together with Mission Support and Test Services, LLC (MSTS), the NNSS Management and Operating contractor, to safely plant and irrigate the seeds and transplants according to the plan. Monitoring of the plots occurs regularly by the TRC personnel with the assistance of a Desert Research Institute ecologist/biologist and Navarro escort. Navarro continues to irrigate the plants as recommended by the TRC. Irrigation and monitoring are anticipated to be completed by the end of September 2020, with a summary report due by the end of March 2021.

Eight cells, developed immediately north and west of the 92-Acre Area, have been receiving wastes since 2010. They include seven LLW cells (Cells 19, 20, 21, 22, 23, 27, and 28) and two MLLW cells (Cells 18 and 25). All active Area 5 RWMS cells can accept radioactive waste contaminated with non-regulated ***polychlorinated biphenyl (PCB) bulk product waste***, but only Cells 18 and 25 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 2019. MLLW disposal services are expected to continue at the Area 5 RWMS until the remaining needs of the DOE complex are met.

Disposal Cells 18 and 25 are 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 CNRH in Cell 18 and up to 37,000 m^3 (1,306,643 ft^3) in Cell 25. The volume and weight of wastes received at Cells 18 and 25 in 2019 are shown in Table 10-1. Cell 18 waste accumulation began on January 26, 2011, and the final waste packages were disposed on August 29, 2019; a cumulative total of 21,201 m^3 (748,693 ft^3) of MLLW/CNRH was disposed. Closure activities for Cell 18 began on October 10, 2019. Cell 25 waste accumulation began on July 12, 2018; a cumulative total of 345 m^3 (12,183 ft^3) of MLLW/CNRH has been disposed through the end of 2019. Quarterly reports are submitted to the state to document the weight of MLLW/CNRH disposed.

In 2019, the Area 5 RWMS received shipments containing a total of 27,627 m^3 (975,638 ft^3) of radioactive waste for disposal (Table 10-1), which included both CNR and CNRH waste. The majority of waste disposed was received from offsite generators. The total number of waste shipments in Fiscal Year (FY) 2019 are reported annually (MSTS 2019a) and are published on the NNSS website at https://www.nnss.gov/pages/programs/RWM/Reports.html. 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 2019

Waste Type	Disposal Cell(s)	2019 Volume Received and Disposed in m^3 (ft^3)
LLW and CNR	Cells 19, 20, 21, 22, 27, and 28	20,306 (717,807)
MLLW and CNRH (includes regulated PCB-contaminated LLW)	Cells 18 and 25	2,879 (101,676) [1,051][(a)]
Total		**23,185 (818,763)**

(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). Historically, the WEF was used for the staging, characterization, repackaging, and offsite shipment of legacy TRU wastes that were disposed at the Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico.

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 WIPP. In 2019, the TRU waste remaining in storage at the TPCB consisted of two experimental spheres from Lawrence Livermore National Laboratory and 34 standard waste boxes from the Joint Actinide Shock Physics Experimental Research facility.

10.1.3 Area 5 Hazardous Waste Storage Unit

The HWSU is located on the east side of the 5-01 Road. It is a fenced area used for storage of NNSS-generated nonradioactive hazardous waste and PCB waste. These wastes may be stored for up to one year before shipment to an offsite disposal facility. The HWSU consists of a 30.3 m (100 ft) long by 9.1 m (30 ft) wide concrete pad with 6-inch curbs to contain spills and prevent run-on and/or run-off during precipitation events. A canopy roof protects waste containers from exposure to environmental conditions. A 90-day hazardous waste accumulation area is located east of the HWSU.

10.1.4 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 (Figure 10-3):

- 2 undeveloped cells: U-3az and U-3bg
- 2 inactive cells: U-3ah/at and U-3bh
- 1 closed cell: U-3ax/bl (Corrective Action Unit 110)

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. On October 1, 2018, the Area 3 RWMS was re-opened for the disposal of bulk LLW generated by environmental corrective actions conducted at the Clean Slate III site on the Tonopah Test Range, located just north of the NNSS. The final shipment of waste from this campaign was disposed at the Area 3 RWMS on August 28, 2019. At this time, only DOE waste generated within the State of Nevada may be disposed at the Area 3 RWMS. The volume of waste received at the Area 3 RWMS is detailed in Table 10-2.

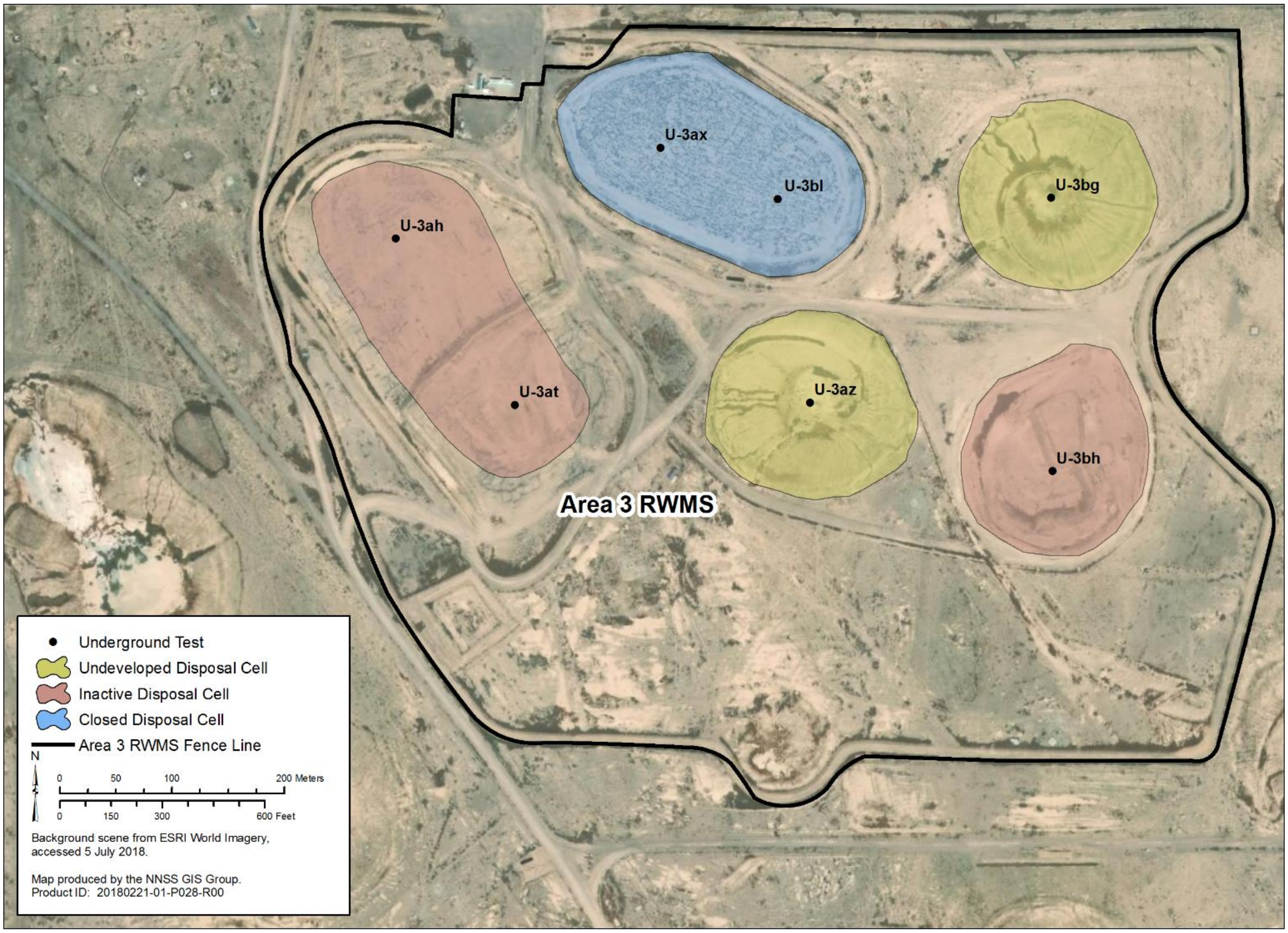

Figure 10-3. Disposal Cells of the Area 3 RWMS

Table 10-2. Total waste volumes received and disposed at the Area 3 RWMS in 2019

Waste Type	Disposal Cell	2019 Volume (m^3 [ft^3])
LLW	U-3ah/at	4,064 (143,521)

10.2 Waste Characterization

Generators of classified, LLW, and MLLW proposed for disposal at the NNSS must demonstrate eligibility for waste to be disposed, submit detailed profiles of waste characteristics, demonstrate compliance with the NNSS Waste Acceptance Criteria, and obtain EM Nevada Program approval of their site waste certification program.

Characterization of the waste is determined through process knowledge of how the waste is generated, sampling and analysis, and/or non-destructive analysis. Following the characterization of a waste stream, the 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 NNSS Waste Acceptance Review Panel for recommendation and approval or disapproval by the EM Nevada Program. Once a waste profile is approved, the generator packages and ships the approved waste streams to the Area 5 RWMC in accordance with U.S. Department of Transportation requirements. Some waste streams may first be shipped to an offsite facility for treatment, if necessary, prior to its shipment for disposal at the Area 5 RWMC.

In 2019, 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*** Exhaust and Filter Media

10.2.1 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 CNRH 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 CNRH. 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 2019, offsite visual inspections were completed on 26 MLLW packages from 11 separate waste streams. One waste stream required chemical screening. No onsite RTR was conducted. No MLLW or CNRH packages were rejected.

10.3 Annual Performance Assessments and Composite Analyses

As required by DOE Order DOE O 435.1, *Radioactive Waste Management*, NNSA/NFO must conduct a ***Performance Assessment (PA)*** and ***Composite Analysis (CA)*** of each of its radioactive waste disposal facilities. 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 an LLW disposal facility and by all other sources of residual contamination that may interact with the disposal site. Current PAs and CAs are maintained for the Area 3 and Area 5 RWMSs (Table 10-3). DOE O 435.1 further requires an annual review of the PAs and CAs to be submitted to DOE EM each March. The annual reviews include tracking all unresolved secondary issues through closure identified by EM's PA/CA assessments. The unresolved secondary issues are also tracked in a Maintenance Plan (MSTS 2019b).

In 2019, 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 2019 summary report to DOE EM (MSTS 2020a) presents data and conclusions that verify the adequacy of both the Area 3 and Area 5 PAs and CAs. Table 10-3 lists the necessary documents required and maintained for RWMS disposal operations.

Table 10-3. 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 2020
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

10.3.1 Groundwater Protection Assessment

Hazardous waste disposal in Cells 18 and 25 complies with RCRA standards and DOE O 435.1 requirements. Title 40 ***Code of Federal Regulations (CFR)*** Part 264, Subpart F (40 CFR 264.92), requires groundwater monitoring to verify that the design and construction of active hazardous waste cells are adequate to protect groundwater from contamination by 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 Nevada Division of Environmental Protection (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 samples collected semiannually from the wells in 2019 had contaminant levels below their Investigation Levels (Table 10-4). Static water levels and general water chemistry parameters are also monitored. All sample analysis results are presented in MSTS (2020b). The tritium results were all below their sample-specific ***minimum detectable concentration (MDC)*** of between 94 and 110 picocuries per liter (pCi/L). (Table 5-5 presents the sample-specific MDCs for each water sample collected from these wells in 2019.) No groundwater contamination from Cell 18 is indicated by the 2019 results.

Table 10-4. Groundwater monitoring results for Cell 18

Parameter	Investigation Level	2019 Sample Levels[a]
pH	< 7.8 or > 9.2 S.U.[b]	8.08 to 8.47 S.U.
Specific conductance	0.440 mmhos/cm[c]	0.357 to 0.383 mmhos/cm
Total organic carbon	2 mg/L[d]	ND[e] to < 1 mg/L
Total organic halides	0.1 µg/L[f]	ND[e] to < 0.01 µg/L
Tritium (^{3}H)	2,000 pCi/L[g]	ND[e] to < 206 pCi/L
Arsenic (As)	0.05 mg/L	ND[e] to < 0.03 mg/L
Barium (Ba)	1 mg/L	<0.005 to 0.015 mg/L
Cadmium (Cd)	0.01 mg/L	ND[e]
Chromium (Cr)	0.05 mg/L	< 0.005 to < 0.01 mg/L
Lead (Pb)	0.05 mg/L	ND[e] to < 0.01 mg/L
Mercury (Hg)	0.002 mg/L	ND[e]
Selenium (Se)	0.01 mg/L	ND[e] to < 0.03 mg/L
Silver (Ag)	0.05 mg/L	ND[e] to <0.005 mg/L

(a) Levels shown are the lowest and highest values for each well for each sample date. Source: MSTS (2020b)
(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 MDC.
(f) µg/L = microgram(s) per liter.
(g) pCi/L = picocuries per liter.

10.3.2 Vadose Zone Assessment

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 seven locations in six 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 2019 are reported in MSTS (2020c). 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.

10.4 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 periods of time long enough 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 (Chapter 9).

10.4.1 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 2019, 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 the most conservative 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 10-5. The highest concentration of any radionuclide was $1{,}532 \times 10^{-15}$ microcuries per milliliter (µCi/mL) for ^{3}H at RWMS 5 Lagoons. All four of the highest mean concentrations were far below their established National Emission Standards for Hazardous Air Pollutants (NESHAP) Concentration Levels (CLs) for Environmental Compliance (Table 10-5, fourth column). The highest mean concentration of each measured radionuclide is divided by its respective CL to obtain a "fraction of CL" (Table 10-5, 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 millirem/year (mrem/yr) was not exceeded at a location having all those radionuclides at those concentrations. Summing the fractions of CLs gives 0.01, which is only 0.1% of the limit in this extremely conservative 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 10 mrem/yr from the air pathway.

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

Radionuclide	RWMS Sampler	2019 Highest Annual Mean Concentration ($\times 10^{-15}$ μCi/mL)	NESHAP CL[(a)] ($\times 10^{-15}$ μCi/mL)	Fraction of CL
^{3}H	RWMS 5 Lagoons	1,532	1,500,000	0.0010
^{238}Pu	DoD	0.00087	2.1	0.0004
^{239}Pu	U-3ax/bl S	0.0130 ($^{239+240}Pu$)	2	0.0065
^{241}Am	DoD	0.0039	1.9	0.0021
			Sum of Fractions:	**0.0100**

(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 nine locations in and around the Area 3 RWMS and 14 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. 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 provided in Chapter 6. During 2019, 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.

10.4.2 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.

10.5 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 corrective actions at historically contaminated sites. The RCRA Part B Permit regulates operation of the Area 5 MWDU, consisting of a Subtitle C landfill (Cells 18 and 25) and two leachate collection tanks, the Area 5 HWSU, and the Area 11 Explosives Ordnance Disposal Unit (EODU) facilities. Included in the RCRA Part B permit is authorization for MLLW storage at the MWSU, which comprises the TRU Pad/TPCB, the SIS Building, the VERB, and the Drum Holding Pad.

The HWSU (Figure 10-2) 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 environmental corrective action sites off the NNSS (e.g., Tonopah Test Range) or generated at the North Las Vegas Facility is 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 Area 11 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.

10.5.1 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 2019 and electronically submitted to the State of Nevada on February 12, 2020. The next biennial report will be prepared for 2021 and submitted to the state in 2022. An annual waste volume report was submitted to the State of Nevada in February 2020. It includes the amount of wastes received in calendar year 2019 at the Area 5 MWDU, MWSU, HWSU; and Area 11 EODU.

Table 10-6 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 2019. 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 2019 HW volume reports were submitted on schedule to NDEP.

Table 10-6. Hazardous waste managed at the NNSS

	2019 Amount (tons)		
Waste Unit	**Received[(a)]**	**Shipped**	**Disposed**
MWDU Cell 18	861	0	861
MWSU	0	0	--
HWSU	2.54	1.777	--
HWSU – PCB Waste	0	0	--
HWAA	NA[(b)]	0	--
EODU	0.227	0	0.227[(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) 0.227 tons (454 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 15 and 16, 2019, NDEP conducted its CEI of the waste units listed in Table 10-6, selected SAAs, Universal Waste Collection Centers, and closed historic RCRA waste management units at the NNSS (Section 11.4). The April 2019 CEI documented that NNSA/NFO was compliant with the NNSS Part B Permit.

In addition, U.S. Environmental Protection Agency (EPA) Region IX conducted a CEI in August 2019 and provided an inspection report to the NNSA/NFO in April 2020. NNSA/NFO provided EPA Region IX a response in July 2020 and resolution of the CEI will be addressed in the 2020 NNSS Environmental Report.

10.6 Underground Storage Tank Management

RCRA regulates the storage of regulated substances 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. On October 13, 2018, new UST regulations went into effect that change the regulatory status of one UST at the Device Assembly Facility (DAF) and one UST at the Remote Sensing Laboratory–Nellis (RSL-Nellis). These tanks were deferred prior to the new UST regulations and now are fully regulated. NNSA/NFO operates one fully regulated UST and three excluded USTs at the DAF; one fully regulated UST at the Area 6 Helicopter pad, which is temporarily closed; and four fully regulated USTs and three excluded USTs at RSL-Nellis, three of which were put into temporary closure in 2019.

NDEP has oversight authority of the NNSS USTs, and the Southern Nevada Health District (SNHD) has oversight authority of USTs in Clark County (see Section A.2.3 of Appendix A regarding UST management at RSL-Nellis). NDEP usually conducts inspections of NNSS USTs once every 3 years. NDEP's most recent inspection of the USTs at the NNSS was in 2018 and no issues were identified. No NNSS USTs were upgraded or removed in 2019.

The SNHD has oversight authority of the RSL-Nellis USTs in Clark County. On January 1, 2019, the UST program at RSL-Nellis consisted of three excluded tanks and four regulated tanks (one for unleaded gasoline, two for diesel fuel, and one for used oil). On January 23, 2019, three of the fully regulated UTSs (one unleaded gasoline, one diesel fuel, and one used oil) were changed from active to temporarily closed. The fully regulated USTs are operated under the RSL-Nellis UST Permit PR0064276. The fully regulated active and temporarily closed tanks are inspected annually by the SNHD; in November 2019, the SNHD inspected the fully regulated USTs at RSL-Nellis and one deficiency was noted.

10.7 Solid and Sanitary Waste Management

Three landfills for ***solid waste*** disposal were operated at the NNSS in 2019. The landfills are regulated and permitted by the State of Nevada (see Table 2-3 for list of permits). No liquids, HW, or radioactive waste are accepted in these landfills. These are:

- 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 June 2019 inspection. The amount of waste disposed in each landfill is shown in Table 10-7. Biannual reports for the Area 23 solid waste landfill were submitted in July 2019 and January 2020 to NDEP (MSTS 2019c and 2020d).

The vadose zone monitoring schedule for the Area 6 hydrocarbon landfill and the Area 9 U10c solid waste landfill was amended by NDEP to biennial events beginning with 2017 and 2018. VZM is performed biennially or after a 24 hour rain event 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. Soil moisture monitoring reorts for the Area 6 and Area 9 sites were submitted in March 2017 to NDEP. The 2017 monitoring and report submittal met the requirements for 2017, 2018, and 2019 (National Security Technologies, LLC 2017).

Table 10-7. Quantity of solid wastes disposed in NNSS landfills

2019 Waste Disposed in Landfills in Metric Tons (Tons)		
Area 6	**Area 9**	**Area 23**
4,328.30 (4,771.13)	8,637.33 (9,521.03)	524.04 (577.65)

10.8 References

Mission Support and Test Services, LLC, 2019a. *Fourth Quarter and Annual Transportation Report FY 2019, Waste Shipments to and from the Nevada National Security Site (NNSS), Radioactive Waste Management Complex*. DOE/NV/03624--0630, Las Vegas, Nevada, October 2019.

———, 2019b. *Maintenance Plan for Performance Assessments and Composite Analyses for the Area 3 and Area 5 Radioactive Waste Managements Sites at the Nevada National Security Site, Revision 3.0*. DOE/NV/03624--0423, Las Vegas, Nevada, March 2019.

———, 2019c. *Area 23 Semi-Annual Solid Waste Disposal Site (SWDS) Report for the Nevada National Security Site (NNSS) – January 1, 2019 through June 30, 2019*. Las Vegas, Nevada, July 2019.

———, 2020a. *FY 2019 Annual Summary Report for the Area 3 and 5 Radioactive Waste Management Sites at the Nevada National Security Site, Nye County, Nevada*. DOE/NV/03624--0705, Las Vegas, Nevada, March 2020.

———, 2020b. *Nevada National Security Site 2019 Data Report: Groundwater Monitoring Program Area 5 Radioactive Waste Management Site*. DOE/NV/03624--0752, Las Vegas, Nevada, March 2020.

———, 2020c. *Nevada National Security Site 2019 Waste Management Monitoring Report, Area 3 and Area 5 Radioactive Waste Management Site (in review)*. Las Vegas, Nevada.

———, 2020d. *Area 23 Semi-Annual Solid Waste Disposal Site (SWDS) Report for the Nevada National Security Site (NNSS) – July 1, 2019 through December 31, 2019.* Las Vegas, Nevada, January 2020.

MSTS, see Mission Support and Test Services, LLC.

National Security Technologies, LLC, 2017. *Annual Soil Moisture Monitoring Reports for the Nevada National Security Site Nevada (NNSS), Area 6 Hydrocarbon and Area 9 U10c Landfills.* Las Vegas, Nevada, May 2017.

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Chapter 11: Environmental Corrective Actions

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Environmental Corrective Action Objectives for All Sites

Characterize sites contaminated by activities related to nuclear testing. Remediate contaminated sites in accordance with Federal Facility Agreement and Consent Order (FFACO)-approved planning documents. Conduct post-closure monitoring of sites in accordance with FFACO closure documents.

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) that have been impacted by atmospheric and underground nuclear tests conducted from 1951 to 1992, and by other nuclear research and development activities. These areas are referred to as corrective action sites (CASs). Multiple CASs are grouped into larger, geographic corrective action units (CAUs) according to location, physical and geological characteristics, and/or contaminants. Environmental corrective action strategies are developed based on the nature and extent of contamination, the risks posed by contamination, and future land use. The 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. UGTA is the largest component of the EM Nevada Program and includes 878 CASs in five CAUs directly related to groundwater impacted by past underground nuclear testing. Industrial sites are facilities and land that may have become contaminated due to activities conducted in support of nuclear research, development, and 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 an FFACO to address the environmental remediation of CASs. Appendix VI of the FFACO (1996, as amended), describes the strategy to plan, implement, and complete environmental corrective actions (i.e., to "close" the CASs). Environmental corrective action 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 federally appointed group of interested citizens and representatives who volunteer to provide informed recommendations to the EM Nevada Program. The NSSAB's comments are strongly considered throughout the corrective action process. This chapter summarizes the progress on actions taken by the EM Nevada Program towards the closure of UGTA, Industrial, and Soils sites and summarizes NSSAB's activities and recommendations for 2019.

11.1 Corrective Actions Progress

Figure 11-1 depicts the progress made since 1996 in the remediation of all historically contaminated sites managed under the FFACO (1996, as amended). A total of 2,158 of the 3,044 CASs managed under the FFACO (1996, as amended) have been closed; this includes 142 sites that have been closed by the DOE Office of Legacy

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

Management, the Defense Threat Reduction Agency, or other owners. One Industrial Sites CAU with five CASs was added in 2019. Of the 886 CASs yet to be closed under the FFACO (883 of which are the responsibility of the EM Nevada Program), 868 (98%) of them are UGTA CASs. 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://www.nnssremediation.dri.edu/. The website identifies all CASs that have been closed and those still open.

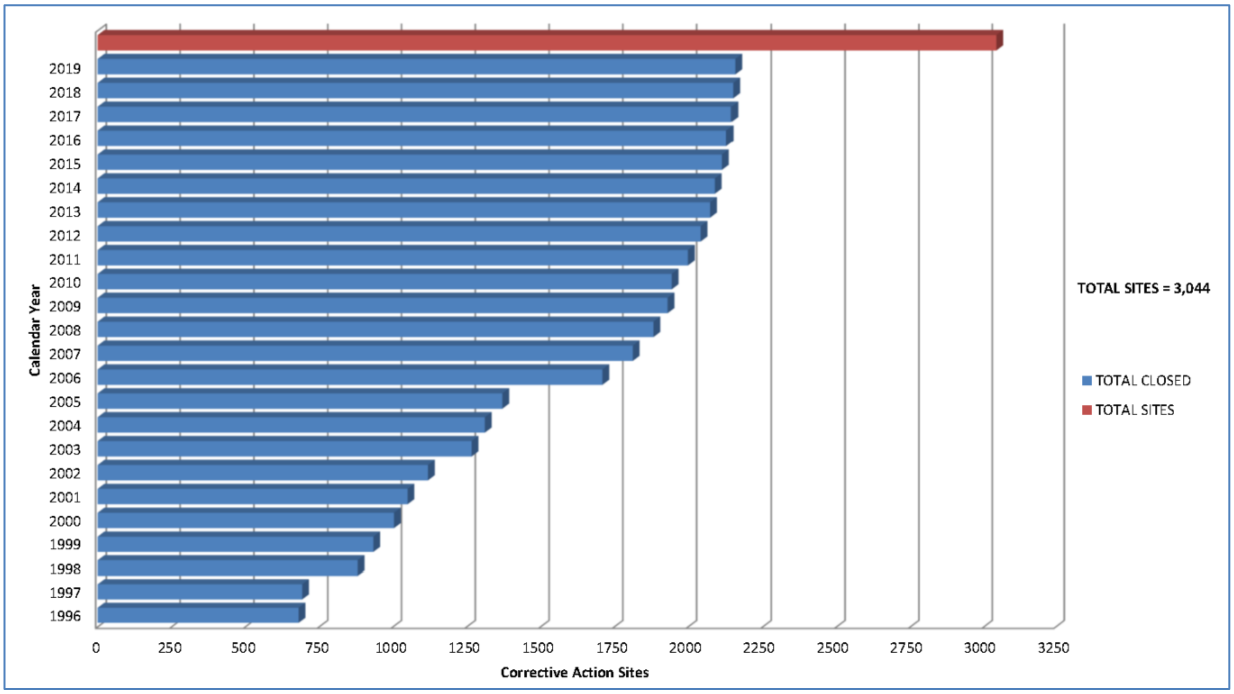

Figure 11-1. Annual cumulative totals of FFACO CAS closures

Under the FFACO (1996, as amended), a series of corrective action milestones and associated deadlines are established by Nevada Division of Environmental Protection (NDEP) and EM Nevada Program. These milestones are associated with activities considered to be high priority. Completion of these milestones requires approval by NDEP; penalties are associated with a missed or substantially deficient milestone.

All 2019 FFACO milestones were met by EM Nevada Program including, but not limited to, the following:

- Model Evaluation Report, Rev 0 for Yucca Flat/Climax Mine (CAU 97)
- Closure Report, Rev 0 for Rainier Mesa/Shoshone Mountain (CAU 99)
- Closure Path Forward Document, Rev 0 for Western and Central Pahute Mesa (CAUs 101/102)
- Calendar Year (CY) 2018 UGTA Annual Sampling Report (CAUs 101/102)
- CY 2018 Annual Closure Monitoring Report, Rev 0 for Frenchman Flat (CAU 98)
- Post-Closure Inspection Report (TTR and Non-Resource Conservation and Recovery Act [RCRA] sites)

These milestones document completion of major activities for each UGTA and many Soils CAUs. Rev. 0 documents are provided to NDEP for their review and approval. The Yucca Flat/Climax Mine (CAU 97) Model Evaluation Report (Navarro 2019) presents the results of new data and refinements of models used to forecast radionuclide migration away from CASs in this CAU. This report supports the decision to advance the Yucca Flat/Climax Mine CAU (CAU 97) to closure (Section 11.2.1.4). The Rainier Mesa/Shoshone Mountain (CAU 99) Closure Report (EM Nevada Program 2020) identifies post-closure monitoring requirements for this CAU amongst other topics related to CAU closure (Section 11.1.1.3). The Closure Path Forward Document for Western and Central Pahute Mesa identifies the specific path forward for each characterization activity identified in the Corrective Action Investigation Plan (CAIP) (U.S. Department of Energy, National Nuclear Security

Administration Nevada Site Office [NNSA/NSO] 2009). The CY 2018 UGTA Annual Sampling Report presents results from groundwater sampling in support of the integrated Goundwater Sampling Plan (Section 5.1). The final milestones provide annual monitoring supporting closure of the Frenchman Flat CAU (Section 11.1.1.3) and TTR and Non-RCRA CASs.

11.2 Underground Test Area Sites

From 1951 to 1992, 828 underground tests (UGTs), some involving multiple detonations, were conducted at the NNSS (U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office [NNSA/NFO] 2015a). Most were conducted hundreds of feet above groundwater; however, more than 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 11-2). ***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 and safely remove or stabilize deep subsurface radiological contaminants. As a result, the corrective action for UGTA CAUs is based on a combination of characterization and modeling studies, monitoring, and institutional controls.

The UGTA corrective action strategy is implemented through a four-stage approach, proceeding from one stage to the next upon approval by NDEP. The corrective action strategy begins with a *planning stage* during which characterization and modeling studies are planned and documented in a CAIP. The plan is then implemented during an *investigation stage* when new data (e.g., new wells, groundwater samples, water levels, geologic, hydrologic testing, field and laboratory studies) are collected and analyzed. These data provide the basis for developing models of the hydrogeologic setting, the radiological ***source term***, and groundwater flow and contaminant transport for each CAU. The models are used to identify ***contaminant boundaries*** that forecast areas with the potential (95th percentile) to exceed the Safe Drinking Water Act (SDWA) maximum contaminant levels for ***radionuclides*** over the next 1,000 years. Modeling studies continue in a *model evaluation stage* whereby specific model uncertainties are addressed to build confidence in the model for supporting regulatory decisions regarding development of the monitoring well network and land-use restrictions that protect the public. During the *model evaluation stage*, ***regulatory boundary*** objectives and initial use-restriction boundaries are identified. Once NDEP determines that the model is acceptable, the CAU advances to the *closure stage*. An alternative strategy for the Rainier Mesa/Shoshone Mountain CAU, following a three-stage process, was agreed upon by NDEP and DOE and implemented in 2013. The alternative strategy does not include a *model evaluation stage*. Instead, this CAU advances from the *investigation stage* directly to the *closure stage*.

The characterization and modeling studies are evaluated throughout the *investigation* and *model evaluation stage* by a preemptive review committee. CAU-specific preemptive review committees provide internal technical review of ongoing work to assure work is comprehensive, accurate, in keeping with the state of the art, and consistent with CAU goals (EM Nevada Program 2019f). In addition, an external review process follows the *investigation stage*. Recommendations are made by the reviewers to support the regulatory decisions that are the responsibility of the EM Nevada Program and NDEP. The numerous investigations and computer modeling studies 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.

During the *closure stage*, regulatory boundary(ies) and ***use-restriction boundaries*** are identified for each CAU in agreement between DOE and NDEP. A Closure Report is then developed to document these boundaries and describe the monitoring well network and land-use restrictions. The Closure Report requires NDEP approval prior to implementation of any closure actions. UGTA corrective actions are expected to be complete, and long-term closure monitoring networks established and implemented, for all CAUs by fiscal year (FY) 2030 (October 1, 2029–September 30, 2030).

[2] The definition of word(s) in ***bold italics*** may be found by referencing the Glossary, Appendix B.

Environmental Corrective Action Objectives for UGTA Sites

- *Collect data (e.g., new wells, groundwater samples, water levels, geologic, 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.*
- *Identify boundaries within which contaminants are forecasted to potentially (95th percentile) exceed the SDWA limits at any time within a 1,000-year compliance period.*
- *Negotiate and implement regulatory boundary 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 groundwater flow and transport models, compliance to the regulatory boundary, and protection of human health and the environment.*

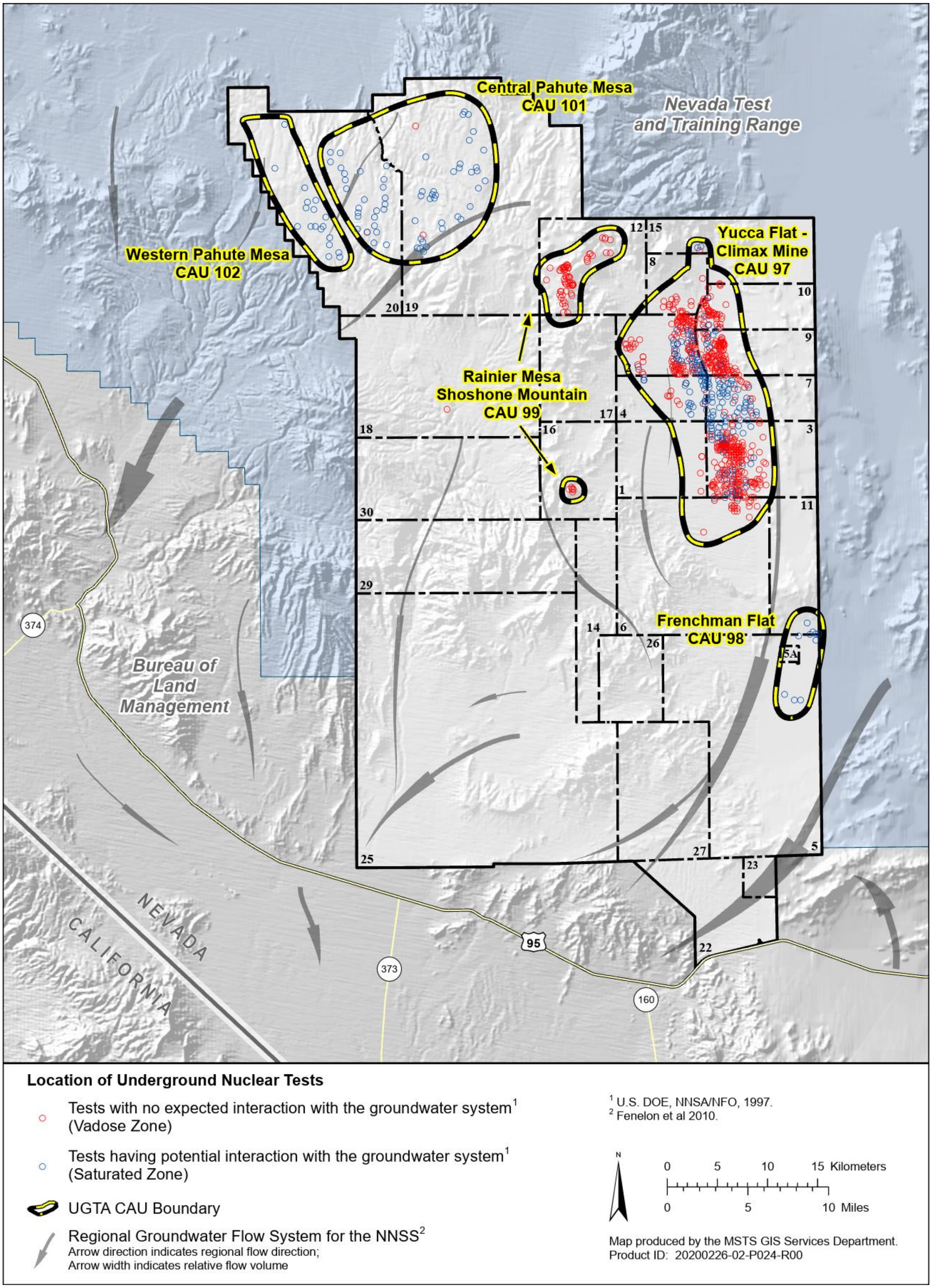

Figure 11-2. UGTA CAUs on the NNSS

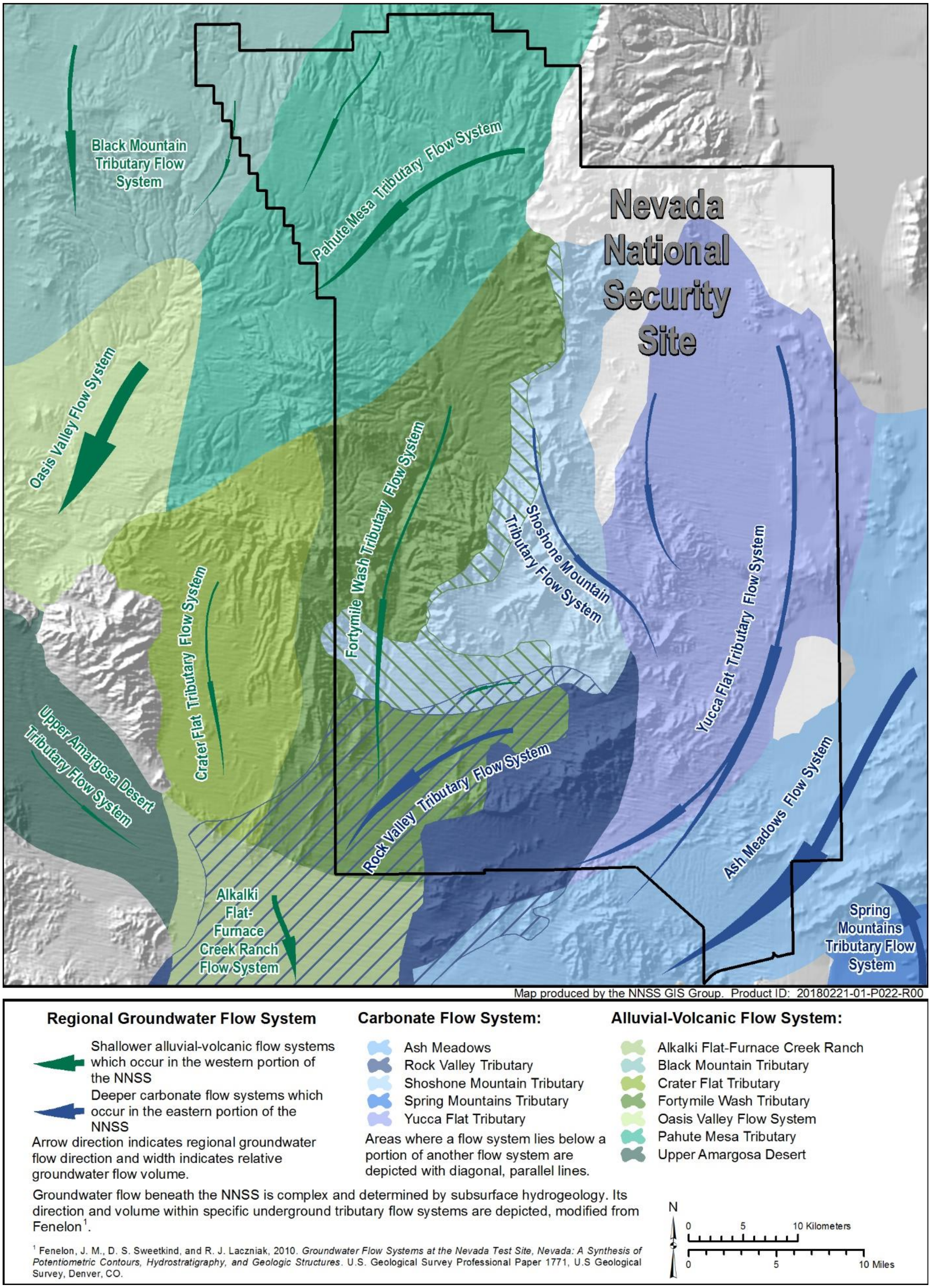

Figure 11-3. Groundwater flow systems of the NNSS

11.2.1 Underground Test Area Corrective Action Unit Corrective Action Activities

The UGTA CAUs are in various stages of the corrective action process. The following subsections provide the status to date of each CAU. The results of annual groundwater sampling, conducted for the purposes of characterizing and monitoring groundwater within the CAUs and downgradient of them, are presented in Sections 5.1.2 and 5.1.3. Figure 11-3 depicts the direction of flow and volume of groundwater within specific systems on and near the NNSS.

11.2.1.1 Frenchman Flat Corrective Action Unit 98

The Frenchman Flat CAU comprises ten CASs (Figure 11-2), and is the first of the UGTA CAUs to reach the *closure stage*. A summary of post-closure activities for this CAU is provided in Section 11.2.2.

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

Corrective action activites are combined for the Central and Western Pahute Mesa CAUs. These CAUs comprise a total of 82 CASs (Figure 11-2). Phase II of the *investigation stage* for the Pahute Mesa CAUs was initiated in 2009 as outlined in the CAIP (NNSA/NSO 2009). Eleven new wells were drilled, developed, tested, and sampled as part of the Phase II investigations. The new data from the Phase II drilling support groundwater flow and transport modeling to forecast contaminant boundaries. The status and results of the Phase II CAIP activities were evaluated in 2019 to ensure completeness of the planned work and to strategize the path forward for remaining activites.

Migration away from three UGTs (Tybo/Benham, Handley, and Cheshire) is being investigated through groundwater sampling and small-scale modeling of ***tritium (^{3}H)*** transport to downgradient wells. Several Phase II wells (ER-20-7, ER-20-8, ER-20-8-2, ER-20-11, ER-EC-11, ER-EC-12, ER-EC-13, ER-EC-14, and ER-EC-15) were drilled to characterize the Tybo/Benham plume. Additional wells, ER-20-5-1, ER-20-5-3, and ER-EC-6, were used in Phase I for this purpose. In 2019, sampling was accomplished at five locations downgradient of the Tybo/Benham UGTs (wells ER-20-5-1, ER-20-5-3, ER-EC-13, ER-EC-14, ER-EC-15); a total of 11 different depth intervals were sampled (Sections 5.1.2 and 5.1.3). The Tybo/Benham plume is defined by a decrease of ^{3}H concentrations in wells in a southward direction, with 20,000,000 picocuries per liter (pCi/L) measured at Well ER-20-5-1 (2019), 13,600,000 pCi/L at Well ER-20-7 (2017), 202,000 pCi/L at Well ER-20-11 (2017), 18,400 pCi/L at Well ER-EC-11 (2017), 6,600 pCi/L at Well ER-20-8 (2017), and 3,670 pCi/L at Well ER-20-8-2 (2017) (Table 5-4 and Figure 5-2). To date, the maximum concentration of ^{3}H observed off site (reported as 18,400 pCi/L in 2017; Table 5-4) is at the Phase II Well ER-EC-11 located approximately 3.2 kilometers (km) (2 miles [mi]) from the Benham UGT (conducted in 1968). Well ER-EC-11 is on the NTTR approximately 0.72 km (0.45 mi) west of the NNSS boundary (Figure 5-2).

Samples were also collected in 2019 from a well accessing the Cheshire cavity and chimney (U-20n PS 1D) and from a satellite well (UE-20n 1) located 380 meters (m) down gradient. The ^{3}H was reported as 13,100,000 pCi/L for the U-20n PS 1D sample and 32,600,000 pCi/L for the UE-20n 1 sample collected in the downgradient well (Table 5-4 and Figure 5-2). Although ^{3}H exceeded the 20,000 pCi/L U.S. Environmental Protection Agency (EPA) SDWA maximum contaminant level (MCL) in both sample locations, only one other radionuclide (^{137}Cs) exceeded its MCL in U-20n PS 1D samples and no other radionuclides exceeded their MCL in UE-20n 1 samples. The low concentration of ^{137}Cs in UE-20n 1 compared to U-20n PS 1D suggests that this radionuclide adsorbs to the aquifer materials and does not freely migrate away from the cavity environment.

Tritium migration from the Handley UGT is being evaluated at wells ER-20-12 and PM-3. Well ER-20-12, a Phase II well, 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 Well PM-3. Elevated ^{3}H levels in the most shallow (58,100 pCi/L) and deepest (41,600 pCi/L) intervals when compared to intermediate intervals within Well ER-20-12 suggest stratification of the Handley plume. The high ^{3}H observed at a depth above the UGT detonation point (1,209 m, or 3,967 feet [ft], below ground surface) is consistent with the conceptual model of radionuclide migration upward in the UGT chimney. The maximum ^{3}H concentration at Well PM-3, located approximately 5.1 km (3.2 mi) south-southwest of Well ER-20-12, was reported as 574 pCi/L in 2019 (Table 5-4). This is less than 3% of the SDWA limit.

The Phase II hydrostratigraphic framework model has been updated with new geological features (e.g., Thirsty Canyon Lineament) and new well information (geophysical, geologic, and hydrologic data) and was reviewed by technical experts in 2019. This model will serve as the hydrostratigraphic basis for the future groundwater flow and transport models. The USGS completed a hydrologic conceptual model for the Pahute Mesa-Oasis Valley groundwater flow system in 2019. The conceptual model is based on many years of hydrologic investigations, including water-level measurements and aquifer testing. In 2019, LLNL identified radionuclides that have exceeded their MCLs in nuclear test cavities (based on radionuclide sample analyses) or that potentially exceed their MCLs in nuclear test cavities (based on modeling results) to support selection of radionuclides to include in the flow and transport model. LANL completed a model to better understand migration from the Tybo/Benham UGTs, and to forecast the potential extent of the contaminant plume over the next 1,000 years. Final publication of these activities is planned for 2020.

11.2.1.3 Rainier Mesa/Shoshone Mountain Corrective Action Unit 99

The *investigation stage* of the closure process for the Rainier Mesa/Shoshone Mountain CAU was completed in 2019. The extent of contaminant migration along potential flow paths, identified based on the hydrogeological conceptual model and regional groundwater flow information, was evaluated. The contamination is forecast to remain well 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 Rainier Mesa/Shoshone Mountain Flow and Transport Model report (EM Nevada Program 2018b) and addendum (EM Nevada Program 2019a) describing the extensive modeling and associated results were completed in 2019. These documents served as the basis for NDEP's acceptance of the CAU model for advancement to the *closure stage*. In 2019, the use-restriction and regulatory boundaries and the regulatory boundary objective were identified for the Rainier Mesa/Shoshone Mountain CAU. The regulatory boundary objective for Rainier Mesa is to protect receptors of groundwater from radionuclide contamination within the three downgradient groundwater basins (Pahute Mesa-Oasis Valley, Ash Meadows, and Alkali Flat-Furnace Creek) that receive recharge from Rainier Mesa. The regulatory boundary objective for Shoshone Mountain is to verify that radionuclide contamination does not reach the lower carbonate aquifer (LCA) below Shoshone Mountain. The use-restriction and regulatory boundaries, regulatory boundary objective, and a description of the monitoring network are documented in the Rainier Mesa/Shoshone Mountain Closure Report, which was submitted for NDEPs approval in 2020.

11.2.1.4 Yucca Flat/Climax Mine Corrective Action Unit 97

The *model evaluation stage* of the closure process for the Yucca Flat/Climax Mine CAU was completed in 2019. During model evaluation, hydrologic and radionuclide data were evaluated for fifteen wells that access the LCA within the Yucca Flat basin. This included the three new model evaluation wells (ER-2-2, ER-3-3, and ER 4-1) drilled near UGTs considered most likely to have impacted the LCA. Understanding radionuclide transport within the LCA was identified as the highest priority for this CAU because it is the only pathway for radionuclides to migrate out of the basin (EM Nevada Program 2017b). Very low (12.2 to 53 pCi/L) to no ^{3}H was observed in the Yucca Flat LCA, with the exception of one well (Well UE-2ce) where ^{3}H was reported as 144,000 pCi/L (Table 5-4). Well UE-2ce is located 183 m (600 ft) south of the Nash UGT, which was detonated within the carbonate aquifer near the water table. Well UE-2ce was used for a radionuclide migration experiment where approximately eleven million gallons of groundwater were pumped between 1977 and 1984 and concentrations of radionculides were measured in samples collected throughout the pumping period (Buddemeier and Isherwood 1985). Although the ^{3}H activity greatly exceeded the 20,000-pCi/L SDWA limit, no radionuclides other than ^{3}H exceeded their limits in the Well UE-2ce groundwater samples. The Nash UGT, and well UE-2ce, are located in the northwestern portion of Yucca Flat; radionuclides from the Nash UGT are forecasted to remain well within the Yucca Flat basin.

The lack of ^{3}H migration in the LCA within the Yucca Flat/Climax Mine CAU demonstrates the effectiveness of the overlying ***confining units*** as barriers to contaminant migration. The lack of ^{3}H at the wells located near a fault indicates that contaminant migration within the Yucca Flat/Climax Mine CAU faults 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.

The results of model evaluation activities were used to refine the groundwater flow and contaminant transport model. In 2019, a Model Evaluation Report (Navarro 2019) describing the Yucca Flat/Climax Mine model evaluation results was completed and approved by NDEP. The next steps are to request NDEP's approval to advance this CAU to the *closure stage* and then prepare the Closure Report. These activities will take place in 2020.

11.2.2 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 5 years post-closure (NNSA/NFO 2016). The detailed monitoring reports published each year of the initial 5-year period (EM Nevada Program 2017a, 2018a, and 2019c) are available on the DOE's Office of Scientific and Technical Information (OSTI) website at https://www.osti.gov. 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 11-4.

The Frenchman Flat Post-Closure Monitoring Network includes the following 17 wells (Figure 11-4), five 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 one Characterization, two Source/Plume, and four Early Detection wells within the CAU. Records of Technical Change have been established to reclassify these wells as new data are collected and evaluated. The contaminants for which each of the six wells were sampled, based on the well type, are described in Section 5.1.1, and the 2019 analytical results for ^{3}H 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 ^{3}H concentration in Well RNM-2S is on average 14% lower than in 2018, continuing on a decline from the peak value measured in 1980. The concentration in Well UE-5n also continues to slowly decrease, being almost 2% lower than in 2018.

Depth to water measured in 2019 in the 16 water level monitoring wells is generally consistent with measurements taken in recent years. A long-term 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 levels are also declining in supply wells completed in the volcanic aquifer in the northwestern part of the basin. The lowered water level observed since 2016 in Well ER-5-3-2, completed in the carbonate aquifer, remains unexplained. However, other water level observations in the basin suggest that the abrupt change in water level in Well ER-5-3-2 is most likely caused by a mechanical problem in the well. A rising water level is observed in a former water supply well in southern Frenchman Flat.

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 11-4). If radionuclides reach this boundary, the EM Nevada Program is required to submit a plan to NDEP that will meet the CAU's regulatory boundary objectives. All monitoring results indicate that the regulatory boundary objective has been met.

Institutional control monitoring confirmed that use restrictions are recorded in land management systems maintained by the NNSA/NFO and the U.S. Air Force, 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.

11.2.3 Quality Assurance

The UGTA Quality Assurance Plan (QAP) (NNSA/NFO 2015b, 2018) provides the overall quality assurance requirements and general quality practices applied to UGTA activities, including 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 (EPA QA/G-5M)* (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 2019, quality assurance included conducting oversight assessments, identifying findings and completing corrective actions, and evaluating laboratory performance. 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.

11.2.4 Other Activities and Studies

Compiling, evaluating, and updating various databases (e.g., chemistry, water level, hydraulic properties, hydrostratigraphy) is an ongoing effort. In 2019, 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/DOE Cooperative Studies in Nevada website at http://nevada.usgs.gov/doe_nv/. The USGS also evaluated two types of technologies for collecting groundwater samples. The results suggested that one technology produced more reproducible samples with respect to tritium but that both provided representative groundwater with respect to major ions. The results of this evaluation were presented at the 2020 Waste Management Symposium (Frus and Imbrigiotta 2020).

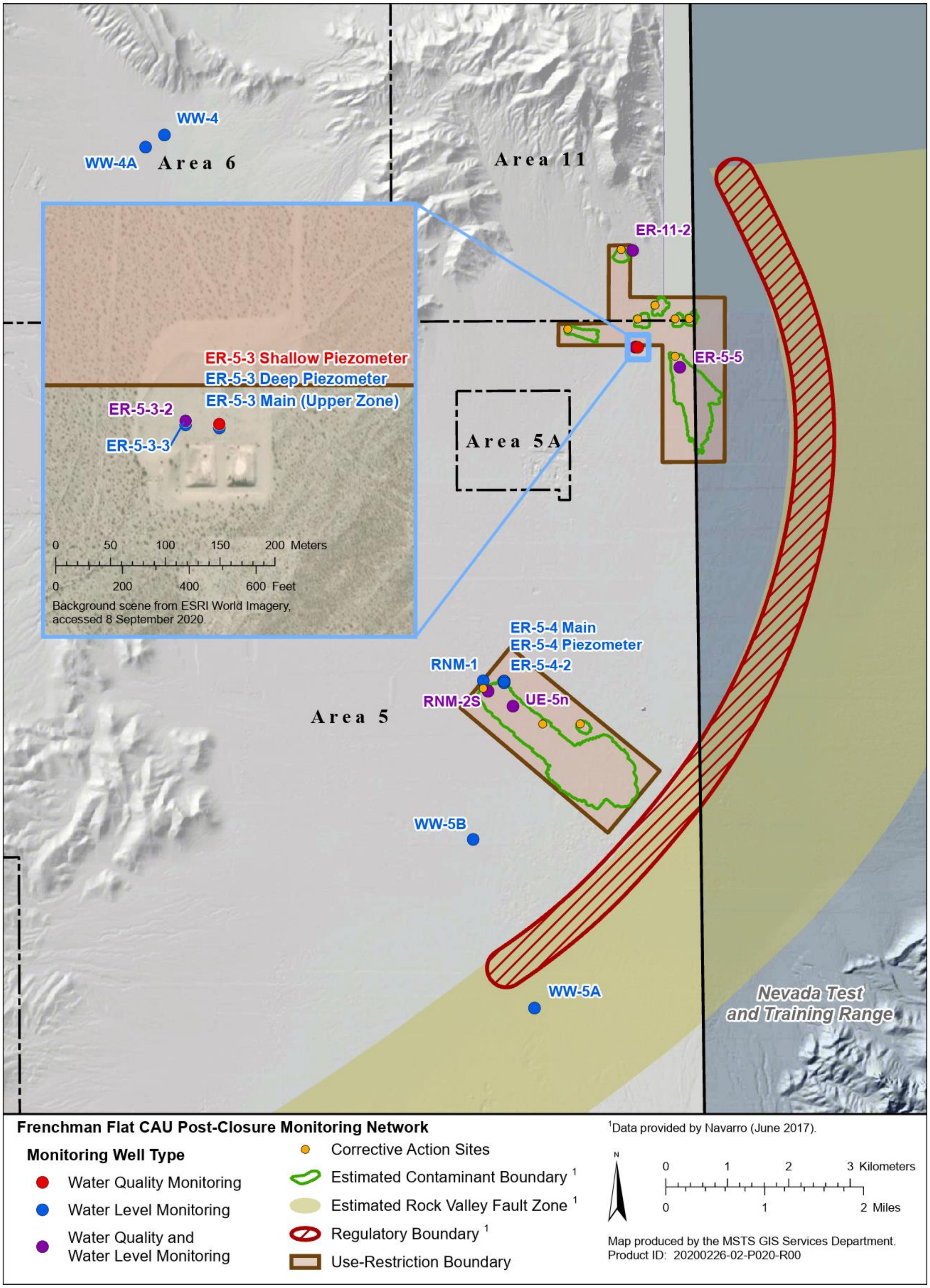

Figure 11-4. Frenchman Flat CAU post-closure monitoring network

11.2.5 Underground Test Area Publications

UGTA-related reports and publications completed in 2019 and published prior to June 2020 are listed in Table 11-1. Some of the published technical reports can be obtained from OSTI at http://www.osti.gov/bridge.

Table 11-1. UGTA publications published prior to June 2020

Report	Reference
2019 Annual Report Timber Mountain Environmental Monitoring Station. Desert Research Institute, Publication No. DOE/NV/0003590-41, TDR: UGTA-4-2132	Lyles et al. 2019
Achieving the End State for the Pahute Mesa Corrective Action Units at the Nevada National Security Site	Rehfeldt and Wilborn 2020
Addendum to the Rainier Mesa/Shoshone Mountain Flow and Transport Model, Nevada National Security Site, Nevada	EM Nevada Program 2019a
A comparison of groundwater sampling technologies, including passive diffusion sampling, for radionuclide contamination	Frus and Imbrigiotta 2020
CY2018 Annual Closure Monitoring Report for Corrective Action Unit 98, Frenchman Flat, Underground Test Area, Nevada National Security Site, Nevada (January 2018–December 2018)	EM Nevada Program 2019c
Database of groundwater levels and hydrograph descriptions for the Nevada Test Site area, Nye County, Nevada	Elliott and Fenelon 2020
Development of Upscaling Techniques and Construction of Calibrated Models for Fractured Rocks Using Discrete Fracture Network Approaches	Parashar et al. 2019
Discrete Fracture Network Modeling to Estimate Upscaled Parameters for the Topopah Spring, Lava Flow, and Tiva Canyon Aquifers at Pahute Mesa, Nevada National Security Site	Makedonska et al. 2020
Estimation of groundwater flow through Yucca Flat based on a multiple-well aquifer test at well ER-6-1–2 main, Nevada National Security Site, southern Nevada	Jackson and Halford 2019
Execution of an Alternative Modeling Strategy for Closure of the Rainier Mesa Corrective Action Unit at the Nevada National Security Site	Tompson et al. 2019
Groundwater characterization and effects of pumping in the Death Valley regional groundwater flow system, Nevada and California, with special reference to Devils Hole	Halford and Jackson 2020
Hydrologic monitoring networks in the Death Valley Regional Flow System, Nye County, Nevada and Inyo County, California	Reiner et al. 2020
*Hydrologic Source Term Processes and Models for Underground Nuclear Tests at Rainier Mesa and Shoshone Mountain, Nevada National Security Site (*Released to final status in 2019)*	Tompson et al. 2011*
Hydrothermal alteration of nuclear melt glass, colloid formation, and plutonium mobilization at the Nevada National Security Site, U.S.A	Zavarin et al. 2019
Model Evaluation Report for Corrective Action Unit 97: Yucca Flat/Climax Mine, Nevada National Security Site, Nye County, Nevada	Navarro 2019
The Nature and State of Groundwater Contamination at the NNSS: What Have We Learned from Decades of Groundwater Analysis?	Farnham et al. 2020
Nevada National Security Site Integrated Groundwater Sampling Plan (Record of Technical Change)	EM Nevada Program 2019d
Pahute Mesa-Oasis Valley Hydrostratigraphic Framework Model for Corrective Action Units 101 and 102: Central and Western Pahute Mesa, Nye County, Nevada	EM Nevada Program 2019e
A Perspective on the Successes of the Nevada National Security Site (NNSS) Underground Test Area (UGTA) Activity	Bourret and Kwicklis 2020
Underground Test Area Activity Preemptive Review Guidance, Nevada National Security Site, Nevada	EM Nevada Program 2019f
Underground Test Area Calendar Year 2018 Annual Sampling Analysis Report, Nevada National Security Site, Nevada	EM Nevada Program 2019b

Table 11-1. UGTA publications published prior to June 2020

Report	Reference
Underground Test Area Calendar Year 2018 Quality Assurance Report, Nevada National Security Site, Nevada	EM Nevada Program 2019g
Underground Test Area (UGTA) Closure Report for Corrective Action Unit 99: Rainier Mesa/Shoshone Mountain, Nevada National Security Site, Nevada	EM Nevada Program 2020
Yield-Weighting Approaches for Calculating Radiologic Inventories for Individual Underground Nuclear Tests at the Nevada National Security Site	Tompson et al. 2019

11.3 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 (1996, as amended). 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*** at the Area 5 Radioactive Waste Management Site (Section 10.1). Solid waste (e.g., demolition debris) containing asbestos is disposed of 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 cleanup of Industrial Sites conducted on the TTR have utilized the NNSS landfill for approved disposal.

Only eight Industrial Sites CASs from two CAUs remain to be closed. The two CAUs are located on the NNSS: CAU 114, Area 25 Engine Maintenance, Assembly, and Disassembly Facility (the eighth remaining D&D facility); and CAU 572, Test Cell C Ancillary Buildings and Structures. Their closures will occur prior to the end of the EM Nevada Program Activity, which is currently planned for 2030. In 2019, no field work was conducted toward their closure. In 2019, one new CAU (CAU 577) was added that included five CASs.

11.4 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 (1996, as amended). 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 2019, two Soils CASs from two CAUs were closed (Table 11-2), and work was conducted towards closure at seven CASs in two CAUs.

The total number of Soils CASs closed and approved by NDEP by the end of 2019 was 141; 7 Soils CASs remain to be formally closed. Closure of CASs on the TTR and NTTR requires 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 2019

CAU	CAU Description	Number of CASs	Corrective Actions	Wastes Generated
414	Clean Slate III Plutonium Dispersion (TTR)	1	Clean Closure[a]	LLW, Sanitary
576	Miscellaneous Radiological Sites and Debris	1	Closure in place[b]	LLW, Sanitary

(a) Clean closure is the removal of pollutants, contaminants, and waste from 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.

11.4.1 Monitoring Activities at Soils Corrective Action Units

Since 2008, the EM Nevada Program has monitored airborne (wind, dust) radiation and meteorological parameters at selected locations on the TTR to determine if there is wind transport of man-made radionuclides from Clean Slate I, II, and III Plutonium Dispersion CAUs (CAUs 412, 413, and 414, respectively), and to develop long-term post-closure monitoring recommendations. Monitoring occurred at five stations in 2019, with a focus on the ground disturbing environmental corrective actions at Clean Slate II and III. Design of the air monitoring stations is similar to that used in the Community Environmental Monitoring Program (CEMP) (Section 7.1).

Monitoring Station 400 is located in the general vicinity of the TTR Range Operations Center. It measures potential radionuclide concentrations associated with airborne particulates at the location of the closest to regular site workers. Stations 401 and 403 are located on the fenced perimeter of the north and south sides, respectively, of Clean Slate III. Clean Slate II is monitored by Stations 404 and 405, on its north and southeast sides, respectively. The monitoring stations at Clean Slate II and III are located downwind of the contamination areas when winds are from either of the two dominant directions (north and south). Additional information on the TTR monitoring effort is available in the 2019 TTR Annual Site Environmental Report and annual EM Nevada Program monitoring reports (such as Chapman et al. 2019).

Gross alpha, gross beta, and gamma ***spectroscopy*** were performed on all 40 airborne particulate matter samples collected at TTR in 2019. Gamma spectroscopy detected Am-241 on three filters from Station 401 at Clean Slate III. Alpha spectroscopy was performed on two filters from each station each quarter: the filter with the highest gross alpha measurement during the quarter, and one random sample. Of these 40 samples, Pu-238 was detected in 5 samples, and Pu-239/240 was detected in 26 samples, all from filters collected at the stations adjacent to Clean Slate II and III. Neither Pu-238 nor Pu-239/240 were detected in the analyzed sub-set of airborne particulate matter samples collected from the Range Operation Center. 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 (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 used to develop an understanding of meteorological conditions that may contribute to potential radionuclide-contaminated soil transport. These monitoring efforts were conducted to aid in developing post-closure monitoring requirements. Routine monitoring of meteorological and hydrologic parameters at CAU 550 and CAU 366 has been discontinued, effective at the conclusion of FY 2019. Environmental data acquisition has been completed, and all equipment from monitoring stations were removed on October 14 and 15, 2019.

During FY 2019 (October 1, 2018–September 30, 2019), data from the CAU 550 meteorological station, the flume, and visual observations of sediment transport were summarized, evaluated, and reported. A single, minimal, flow event was recorded at the flume. This occurred between March 6 and 7, 2019, in response to 1.16 inches of precipitation falling within 9.3 hours on March 6, 2019. This event produced a peak water depth of 0.39 inches in the flume and lasted about 23.5 hours. The runoff event produced insufficient flow velocities through the natural channel to cause local erosion and transport of bedload materials. Therefore, no bedload samples were collected for radiological analysis (Heintz et al. 2020, in review).

In FY 2019, 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. 2020, in review).

11.5 Post-Closure Monitoring and Inspections

Post-closure inspections are required for many of the closed remediation sites managed under the FFACO (1996, as amended) and six sites identified in the RCRA Part B Permit (DOE/NV 1999). In 2019, the EM Nevada Program conducted visual inspections at 172 closed CASs managed under the FFACO and RCRA Part B Permit. In 2019, two annual inspection reports for non-RCRA and RCRA post-closure sites on the NNSS were prepared and submitted to NDEP in May (EM Nevada Program 2018c, 2018d). A 2018 annual inspection report for post-closure sites on the TTR was prepared and submitted to NDEP in May 2019 (EM Nevada Program 2019e).

11.6 Environmental Management Nevada Program Public Outreach

Throughout CY 2019, six NSSAB Full Board meetings were held, which were all open to the public and announced by the EM Nevada Program on their NSSAB web page (http://www.nnss.gov/NSSAB/). The NSSAB is a part of the Environmental Management Site-Specific Advisory Board, a stakeholder board that provides the DOE Assistant Secretary for Environmental Management and designees with recommendations on issues affecting the EM program at various DOE sites. Among those issues are clean-up standards and environmental remediation, waste management and disposition, and clean-up science and technology activities.

The 2019 NSSAB public meetings covered a wide range of topics, which included the status of and, as applicable, NSSAB recommendations for the following items:

- Path Forward for Closed Environmental CASs at the Tonopah Test Range
- FY 2020 Baseline Prioritization
- FY 2019–2020 Membership Recommendation
- Radioactive Waste Acceptance Program Assessment Improvement Opportunities
- Location of Monitoring Well at the Area 5 Radioactive Waste Management Complex
- Community Analysis
- Offsite Groundwater Communication Plan

The meeting agendas, handouts, and minutes for CY 2019 NSSAB meetings can be found at http://www.nnss.gov/NSSAB/pages/MM_FY18 and http://www.nnss.gov/NSSAB/pages/MM_FY19.html.html.

The EM Nevada Program hosted four Low-level Waste Stakeholders Forum meetings in CY 2019, in Pahrump and Las Vegas, NV. The meetings provide participants an opportunity to discuss topics related to the transportation and disposal of low-level radioactive waste at the NNSS. Attendees included Clark County, Nye County, Lincoln County, State of Nevada, local emergency response personnel, and a member of the NSSAB.

The EM Nevada Program also hosts an educational program to promote awareness of environmental management activities at the NNSS. *Operation Clean Desert* learning materials offer activities geared toward teaching children about ongoing efforts to address environmental challenges, such as contaminated groundwater and radioactive waste disposal. In CY 2019, nearly 6,000 *Operation Clean Desert* activity books and teacher's guides were distributed to students and educators throughout the nation. Since 2008, more than 47,000 *Operation Clean Desert* activity books and teacher's guides have been distributed nationwide.

Operation Clean Desert learning materials and information can be accessed online at http://www.nnss.gov/pages/PublicAffairsOutreach/KidsZone/OpCleanDesert.html. This includes an activity book, a teacher's guide, an interactive computer game, and several videos.

Other outreach/education initiatives conducted in calendar year 2019 included:

- Community Conversations events held in Amargosa Valley, NV, and Beatty, NV, to discuss groundwater with local residents.
- "Ant farm" groundwater demonstrations held at schools and science fairs in Nevada, such as the "May Science Be With You" event hosted by DRI as part of the Las Vegas Science and Technology Festival.
- *Operation Clean Desert* promotional booths hosted for Clark County School District teachers.
- NNSS site tours hosted for Nevada students, as well as the NSSAB.

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Chapter 12: Historic Preservation and Cultural Resources Management

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Cultural Resources Management Program Goals

Ensure compliance with all regulations pertaining to cultural resources. Identify, evaluate, and manage cultural resources. Evaluate the potential impacts of proposed projects on cultural resources and, when necessary, mitigate adverse effects. Curate archaeological collections in accordance with Title 36 Code of Federal Regulations (CFR) Part 79, "Curation of Federally Owned and Administered Archeological Collections." Consult with American Indians regarding places and items of importance to the Consolidated Group of Tribes and Organizations.

The Nevada National Security Site (NNSS) contains a wide range of cultural resources—including prehistoric and historic archaeological sites, buildings, and structures—that are part of the historic built environment, as well as places of religious and cultural importance to American Indians and others interested in history. Attachment A, Section A.5, provides a summary of the known human occupation and uses of the NNSS from the Paleoamerican period, approximately 13,000 to 10,000 years ago, through the Cold War era and nuclear testing from 1951 to 1992. U.S. Department of Energy (DOE) Order DOE O 436.1, "Departmental Sustainability," requires the DOE National Nuclear Security Administration Nevada Field Office (NNSA/NFO) to develop policies and directives for the conservation and preservation of these resources. The Cultural Resources Management Program (CRMP) at the NNSS was established by NNSA/NFO. The Desert Research Institute (DRI) implemented the mandates of this program to aid in conserving and preserving cultural resources that may be affected by proposed NNSA/NFO activities. The NNSA/NFO must also comply with applicable federal and state regulations to protect and manage those 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.

To meet federal and state requirements and achieve CRMP goals, the NNSA/NFO program contains the following major components: (1) NNSS project reviews for cultural resource compliance; (2) archival research, field inventories, built-environment surveys, and evaluations of NRHP eligibility; (3) the curation of archaeological collections and program records; and (4) the American Indian Consultation Program (AICP). Guidance for CRMP work is provided in the NNSS Cultural Resources Management Plan (Rhode et al. in preparation). DRI historic preservation personnel and archaeologists, who meet the professional qualification standards set by the Secretary of the Interior, carry out these activities.

Methods used to identify cultural resources vary according to the type of resource under consideration. Archaeological sites are typically identified through an intensive pedestrian surface survey, which is sometimes supplemented by small-scale subsurface testing to assess the potential presence of intact subsurface cultural deposits at potentially significant archaeological sites. Historic architectural properties, structures, and objects are identified during surveys through the use of maps and aerial imagery, historical archives, and information from individuals who may have direct knowledge of the functions and historical events associated with particular buildings or structures. Direct communication and consultation are also necessary to identify and characterize resources that are culturally important to American Indians, such as sacred sites or traditional-use areas.

12.1 Cultural Resources Inventories and NRHP Eligibility Evaluations

Cultural resources inventories and built-environment surveys are conducted to meet the requirements of the National Historic Preservation Act (NHPA). These are completed prior to proposed projects or activities that have the potential to affect historic properties. The information resulting from these inventories and NRHP-eligibility evaluations include the following:

- Identification of the numbers and types of cultural resources at each proposed project location on the NNSS
- Evaluations and eligibility recommendations for listing in the NRHP
- Findings of effect of proposed activities
- Reports detailing the results of the identification efforts, evaluations, and findings of effect
- Recommendations for mitigating adverse effects on cultural resources, when required

In 2019, DRI completed cultural resources inventories and architectural surveys for 15 projects in seven areas of the NNSS and on the Nevada Test and Training Range (NTTR) (Table 12-1). A total of 1,408.78 acres were inventoried and 120 cultural resources were identified and recorded. Of these resources, 55 were determined eligible for the NRHP. Documented cultural resources consist of prehistoric and historic sites, buildings, and structures. In accordance with the NHPA, NNSA/NFO consults with the Nevada State Historic Preservation Office (SHPO) regarding eligibility determinations and findings of effect prior to initiating an undertaking that has the potential to affect historic properties.

Table 12-1. 2019 cultural resources inventories and NRHP eligibility evaluations

Project	NNSS Area(s)	Project Size (acres)	Cultural Resources	NRHP Eligible	Reference
		Section 110			
Project 57	NTTR	4.50	1	1	Edwards et al. 2019
		Section 106			
Removal of Buildings and Structures in Area 12 Camp	12	0.57	11	0	Menocal and Shaw 2019
CP Hill Waterline Replacement	6	3.63	4	2	Lancaster 2019a
Area 12 Drill Pads	12	0.79	1	0	Lancaster 2019b
Aqueduct Mesa Physics Experiment 1	12	172.85	19	9	Lancaster 2019c
Area 6 Batch Plant	6	10.30	2	1	Lancaster and Menocal 2019a
Photo Simulation for Area 6 Batch Plant	6	--	--	--	Lancaster and Menocal 2019b
138 kV Installation Mercury to Tweezer	5, 6, 23	805.38	51	27	Menocal et al. 2019
Supplemental Information for 138 kV Installation	5, 6, 23	--	--	--	Menocal and Rowe 2019
U1a Modernization	1	346.52	13	2	Rowe et al. 2019
U1a Modernization Visibility Analysis	1	--	--	--	Lancaster 2019d
E-MAD	25	21.00	2	2	Reno et al. 2019d
Test Cell C	25	35.75	9	9	Reno et al. 2019e
Repurpose of U12n Vent Holes	12	0.92	2	2	Lancaster 2019e
UXO Proficiency Training Range	16	6.57	5	0	Person and Lancaster 2019
Total		1,408.78	120	55	

To comply with Section 106 of the National Environmental Policy Act (NEPA), 14 cultural resources inventories were initiated by proposed NNSS undertakings with the potential to affect historic properties. One additional inventory was reported as part of Section 110 efforts.

For Section 106 compliance, DRI completed an inventory for the proposed installation of a new transmission line to upgrade the 138-kilovolt (kV) power transmission system at the NNSS (Menocal et al. 2019). The inventory area included a corridor that is 37.8 kilometers long and 60 meters wide between the Mercury Switching Station in Area 23 and the Tweezer Substation in Area 6. The inventory also included 5 access road corridors, 32 pull sites, and 6 equipment laydown areas. The total area inventoried consisted of 805.38 acres. A visual impact assessment for the entire length of the proposed transmission line was conducted to assess any potential indirect effects to surrounding historic properties resulting from the proposed transmission line installation (Menocal et al. 2019; Menocal and Rowe 2019). Although NRHP eligible properties were identified along the corridor, DRI recommended modifications to the project area and provided avoidance areas to prevent adversely affecting most of these properties. NNSA/NFO is consulting with the SHPO regarding determinations for this project.

DRI also conducted an identification and evaluation effort for a multiyear set of projects to modernize the surface infrastructure of the U1a facility, which is referred to as the U1a Modernization Project (Rowe et al. 2019). DRI identified 13 architectural resources in the project area, two of which were recommended eligible for the NRHP. A supplemental visibility analysis was conducted by Lancaster (2019d) to assess the indirect visual impacts of the undertaking on surrounding historic properties. NNSA/NFO is in the process of consulting with the SHPO regarding the identification and evaluation of the identified historic properties.

DRI conducted an inventory of 172.85 acres on Aqueduct Mesa in Area 12 in support of the sensor network installation for the Physics Experiment 1-Surface Diagnostics project (Lancaster 2019c). Nineteen prehistoric archaeological sites, including several rock rings (Figure 12-1), were previously recorded in the project area and revisited by DRI to collect information to evaluate the sites for listing in the NRHP. Nine of the sites were determined eligible for the NRHP and DRI provided avoidance areas during the sensor network design phase to prevent adverse effects to these historic properties.

Figure 12-1. Rock ring on Aqueduct Mesa, Area 12 (DRI 2019)

Other important Section 106 projects included architectural surveys of two facilities that were part of the Nuclear Rocket Development Station (NRDS) in Area 25: the Engine Maintenance and Disassembly (E-MAD) facility (Reno et al. 2019d) and Test Cell C (Reno et al. 2019e). The architectural survey of the E-MAD facility was motivated by planned closure and demolition activities by the Environmental Management Nevada Program (EM Nevada Program). The 21-acre survey resulted in the identification of two principal resources: the E-MAD Building with 28 accessory resources and the Engine Transport Maintenance Building (Figure 12-1). NNSA/NFO, in consultation with the SHPO, determined both of these resources as individually eligible for the NRHP and as contributing elements to the potential national significance of the unrecorded NRDS Historic District. Recording and evaluation of Test Cell C was authorized to support future alterations to the facility to meet National Weapons Science, Global and Homeland Security Programs, and EM Nevada Program mission requirements. DRI completed an architectural survey of the entire 35.75-acre Test Cell C complex, which was recorded as a historic district and determined eligible for the NRHP at the national level of significance. All nine resources within the district were recommended as contributing elements of the district and five of these were recommended as individually eligible. The Test Cell C Historic District is regarded as a contributor to the potential national significance of the unrecorded NRDS Historic District.

Figure 12-2. Aerial overview of E-MAD (Remote Sensing Laboratory [RSL] 2009)

The seven remaining Section 106 projects were relatively small in scale. These projects include the proposed removal of 11 resources in Area 12 Camp identified by the Management and Operating (M&O) contractor for the NNSS as environmental hazards unsafe for future use (Menocal and Shaw 2019); the proposed replacement of the CP Hill Waterline in Area 6 (Lancaster 2019a); the proposed installation of drill pads in Area 12 (Lancaster 2019b); installation of the Area 6 Batch Plant (Lancaster and Menocal 2019a) and the accompanying photo simulation and visibility analysis for the batch plant (Lancaster and Menocal 2019b); the proposed repurposing of the U12n Vent Holes for Underground Test Area ground water sampling operations (Lancaster 2019e); and the proposed construction of an Unexploded Ordnance (UXO) Proficiency Training Range (Person and Lancaster 2019). Two of the seven projects, the removal of resources from the Area 12 Camp and the repurposing of the U12n vent holes, require further consultation to mitigate the adverse effects of the proposed activities.

During 2019, DRI conducted a Section 110 condition assessment and evaluation of the Project 57 Radiological Safety (Rad-Safe) personnel decontamination building and its accessory resources (Edwards et al. 2019). Project 57 was an open-air, plutonium-dispersal safety test conducted by the United States in 1957 on a portion of the NTTR. The personnel decontamination building and its four accessory resources consisting of a disrobe area, a vehicle contamination area, animal holding pens, and an electrical service line were recorded and evaluated as part of this effort. In consultation with the SHPO, the Rad-Safe decontamination building and its accessory resources were determined eligible for the NRHP under significance criterion A for its association with nuclear testing.

12.2 Mercury Modernization

NNSA/NFO determined that the Mercury Modernization undertaking will have adverse effects on historic properties eligible for the NRHP and executed a programmatic agreement (PA) with the SHPO that specifies the approach NNSA/NFO will take to streamline the Section 106 compliance process for modernization activities in Mercury (PA 2018). The PA stipulates the level of mitigation efforts for the proposed upgrade activities and how to determine when mitigation efforts are sufficient for future activities. Reports and mitigation documents governed by the PA will be archived in the Nuclear Testing Archive. Pursuant to the PA, in 2019, DRI completed research, building surveys, and required mitigation documentation for the Mercury Fire Station; the Mercury water, sewer, and steam system; the men's trailer park lot; the 23-753 boiler building in the motor pool area; and the Mercury 1960s dorm series and Quonset hut foundations (20 standing buildings and 32 empty concrete foundations) (Table 12-2). A few of these activities are discussed below.

Table 12-2. 2019 buildings and structures evaluated for individual NRHP eligibility and mitigated pursuant to the Mercury programmatic agreement

Project	NNSS Area(s)	Project Size (acres)	Cultural Resources	NRHP Eligible	Reference
Mercury Fire Station Demolition	23	1.75	2	†	Reno et al. 2019a; Reno et al. 2019b; Reno et al. 2019c
Mercury Water/Sewer/Steam	23	NA	3	†	Collins 2019a
Mercury 23-750, 751, and 753 in the Motor Pool Area	23	NA	3	†	Collins et al. 2019b; ††King 2019 ††Collins et al. 2019a
Mercury1960s Series Dorms	23	12	20	†	Reno et al. 2020; Collins et al. 2020a,b
Mercury Men's Trailer Park Lot	23	4.20	1	†	Collins and King 2019
Total		17.95	29		

†Contributes to the eligibility of the Mercury Historic District; not individually eligible.
††Only the 23-753 boiler building was mitigated. Replacement of heating, ventilation, and air conditioning in 23-750 and -751 were determined to have no adverse effect.

The historic Mercury Fire Station, Building 23-425, at the corner of Buster Street and Sandstone Avenue (Figure 12-3) was built in 1966 and was the second fire station in Mercury. The building was in the core Mercury Modernization area and was demolished in 2019 to make way for new construction. The fire station was part of a planned development that began in the 1960s with an irregular-plan, one-story, concrete-masonry, Mid-century Modern design. The building was composed of a tall central block for the six apparatus bay doors (three in the front elevation and three in the rear) flanked on each side by wings, which had heights that correspond to the tops of the bay doors. The building had a flat roof with mechanical equipment and solar panels on the northeast corner that were installed in 1979. It was on a cut-and-fill terrace, which provided level access to adjacent streets to the north and east. The Mercury Fire Station was the most important node in a fire-supression system that extended throughout the town. The system included building alarms, sprinkler systems, and fire hydrants.

Figure 12-3. The historic Mercury Fire Station, viewed to the southwest at the corner of Buster Street and Sandstone Avenue (RSL 2018)

The historic Mercury water, sewer, and steam/hot water distribution system underground utilities were installed from 1952 through 1989. The initial water distribution system at Camp Mercury connected approximately 20 buildings to a water tank with the main water line through the camp made of 8-inch cast iron pipe. According to a master plan, by 1962 water was being supplied to several buildings in Mercury from wells in Frenchman Flat via 8-inch and 6-inch cast iron pipes. The system also required four boosters and a storage reservoir station. At that time, the water provided by the system was narrowly meeting the needs of the camp and provided no surplus in case of a fire (Collins 2017). After 1963, the system was expanded to reach all new permanent buildings in Mercury, as well as out to the main gate. By 1979, the types of pipes used throughout the system included asbestos cement, steel, cement-coated steel, lined steel, cast iron, galvanized iron, and PVC [polyvinyl chloride]. In 2019, aboveground elements and exposed buried elements of the potable water distribution system, sewage system, and steam/hot water distribution system were recorded to document the historic system.

Planning for the 400 series of dormitories began in 1963 and drawings were finalized by June of that year. These plans were used to construct the 600 series. Minor modifications were made to the plans and construction of the 400 series was fully completed by June 11, 1965. All four dormitory clusters that make up the 400 and 600 series are of the same overall design and are composed of four identical dormitories constructed around a smaller central common/service building. Figure 12-4 shows a view of the 475 series. The buildings are one-story concrete block on thickened concrete slabs. The 400 and 600 series dorms represented an immense improvement in living conditions for those who were assigned to them. Additional dormitories were badly needed because nearly 2,500 people were housed in Mercury at the time. For the first time, full-size beds were installed and the rooms were much larger than before, with sufficient floor space for a desk, armchair, chest of drawers, personal vanity with a sink, a large closet, and a nightstand. These dorms contribute to the historic importance of the Mercury Historic District and adverse effects resulting from the planned demolition of the 400 series were mitigated according to stipulations in the PA (Reno et al. 2020; Collins et al. 2020a,b).

Figure 12-4. View of the 475-479 dormitory complex from Greenhouse Avenue, facing northeast (DRI 2019)

12.3 Other Cultural Resources Projects

Prior to proposed projects, cultural resources records at DRI and the Nevada Cultural Resource Information System database are consulted to identify previous cultural resources inventories and NRHP-eligible cultural resources near or within the project area. This helps determine whether an inventory is required and the potential of a proposed project to affect historic properties. In addition to the projects in Tables 12-1 and 12-2, which required cultural resources inventories and built-environment surveys, reviews also included proposed projects that were in areas previously inventoried for cultural resources. In some cases, additional inventories or evaluations were not required and no reports were prepared.

Other projects and activities carried out by DRI in 2019 that resulted in reports are listed below and referenced in Table 12-3.

- Annual report regarding the progress in the implementation of the Mercury Historic District programmatic agreement during Fiscal Year (FY) 2018
- Annual report for tasks completed in support of the NNSS artifact collection and records in the NNSA/NFO records facility managed by DRI
- CRMP Field Procedures Manual for the NNSS detailing how to conduct pre-field, field, and post-field activities for the identification of cultural resources
- Cultural resources monitoring, which entailed revisiting a sample of six historic properties, documenting current site conditions, and determining if they maintain enough integrity to still be eligible for the NRHP
- Cultural Resources Management Plan summarizing the overall NNSS cultural resource landscape and approach to management

Table 12-3. Other 2019 cultural resources projects

Project	Reference
Mercury Annual Progress Report	Collins 2019b
Annual Curation Compliance Report	Menocal 2019
CRMP Field Procedures Manual	Menocal and Lancaster 2019a
NNSS Cultural Resources Monitoring	Menocal and Lancaster 2019b
Cultural Resources Management Plan (draft)	Rhode et al. in preparation

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 it 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 2019, DRI maintained NNSA/NFO curation facility digital records and transferred them from an external drive to a dedicated network drive. These digital records consist of the master accession database and inventory catalog for the NNSS Archaeological Collection, curation forms, all active and finalized NNSA/NFO curation facility loan and transfer agreements, and chronologically organized archives for documents pertinent to the AICP, NAGPRA consultations, and various artifact collections.

Early in 2019, DRI received American Indian artifacts recovered from the NNSS in the mid-1960s during unauthorized field collections. Per NNSA/NFO curation facility protocols for unauthorized collections from the NNSS, a Field Collections Transfer Agreement was created that provided available information about the date of collection, the general area of collection, and the finder's name and past affiliation with NNSA/NFO projects. The NNSA/NFO CRMP Manager approved and signed for the artifact transfer in March 2019. The 98 lithic and ceramic artifacts were then accessioned, cataloged, and packaged following appropriate curatorial standards and incorporated into the NNSA/NFO Archaeological Collection.

As part of routine curatorial maintenance, DRI staff conducts spot-check inventories of random catalog records. In August 2019, DRI identified inaccurate or incomplete entries related to an artifact collection within the NNSA/NFO Archaeological Collection and systematically began to check the physical artifact collection against entries in the digital inventory catalog to correct errors. The effort is ongoing.

DRI staff archived 65 hard copies of cultural resources reports and associated site forms and eight documents related to the AICP. Project files associated with the NNSA/NFO CRMP from FY 2014 were also archived.

One loan agreement between NNSA/NFO and the National Atomic Testing Museum (NATM) was renewed. The loan renewal is for the McGuffin Collection, which consists of 39 chipped stone artifacts from a prehistoric site in Fortymile Canyon arranged in a glass picture frame. The McGuffin Collection has been on exhibit in the NATM since 2005 and is renewed on a yearly basis.

12.5 American Indian Consultation Program

Created in 1991, the NNSA/NFO AICP involves sixteen Southern Paiute, Western Shoshone, and Owens Valley Paiute and Shoshone tribes with cultural and historic ties to the NNSS. A history of this program and a list of the 16 culturally affiliated tribes can be found in *American Indians and the Nevada Test Site: A Model of Research and Consultation* (Stoffle et al. 2001). The program operates in accordance with DOE O 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, as part of the AICP, the tribes formed the Consolidated Group of Tribes and Organizations (CGTO) to serve as a conduit for speaking with one collective voice for the 16 tribes and organizations while retaining each tribe's individual ability to interact independently with NNSA/NFO, if desired.

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 in 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 NEPA documents.
- Work in collaboration with the AICP Coordinator to develop approaches for expanding tribal involvement in NNSA/NFO activities on the NNSS.

In 2019, NNSA/NFO management interacted with the AICP Coordinator to identify topics of interest and enhance communications with CGTO representatives. Interactions included the annual Tribal Update Meeting, quarterly teleconferences, and NNSS site visits to locations of importance to the CGTO. Summary reports were prepared for these activities (Table 12-4). NNSA/NFO distributes copies of the reports to the CGTO for tribal libraries as reference documents to expand the understanding of the AICP and NNSA/NFO activities.

Table 12-4. AICP reports

Project	Reference
AICP Annual Progress Report for FY 2019	Arnold 2019a
Tribal Update Meeting Summary	NNSA/NFO 2019
Ammonia Tanks Site Visit Summary	Arnold 2019b
Petroglyph and Power Rock, Mushroom Rock, and the Geoglyph and Arch Site Visit Summary	Arnold 2019c

The annual Tribal Update Meeting was held on April 23 to 25, 2019. The 3-day meeting brought together 25 tribal representatives from 14 of the 16 culturally affiliated tribal governments with managers from DOE and support contractors. On the first day of the meeting, NNSA/NFO provided updates on activities and experiments conducted on the NNSS, the M&O Contractor shared information about NNSS modernization activities, and DRI presented information on cultural resource compliance projects. On the second day of the meeting, tribal participants took a tour of selected facilities on the NNSS. The final day of the meeting consisted of a closed executive session for tribal participants to reflect on meeting presentations and the tour. A meeting summary report was produced that provided information on the meeting participants, presentations, and tribal comments and recommendations (NNSA/NFO 2019).

The six-member Tribal Planning Committee (TPC)—composed of CGTO representatives from Southern Paiute, Western Shoshone, and Owens Valley Paiute and Shoshone ethnic groups—participated in four quarterly teleconferences to receive NNSS project briefings and address tribal topics. Meeting agenda items included NNSA/NFO updates, discussion about activities on the NNSS, and the status of compliance activities.

In addition to the quarterly meetings, the TPC participated in spring and fall NNSS site visits (Figure 12-5). During April, the TPC and other CGTO tribal representatives went to Ammonia Tanks. During October, the TPC participated in a field visit to three locations: the Petroglyph and Power Rock site (26NY10131), Mushroom Rock (26NY101232), and the Geoglyph and Arch site (26NY6 and 26NY5191). The visits provided an opportunity for tribal participants to share their insights and perspectives about culturally significant resources. Field visit details and tribal perspectives were documented in two summary reports (Arnold 2019b, Arnold 2019c).

Another important aspect of the AICP is the program coordinator's review of DRI cultural resources inventory and built-environment survey reports for proposed projects on the NNSS. In 2019, seven project reports were reviewed and evaluated for cultural sensitivities and to integrate cultural perspectives based on cultural insights and tribal recommendations. These projects were detailed in the AICP Coordinator's annual report (Arnold 2019a).

Figure 12-5. TPC representatives on a 2019 NNSS site visit to Mushroom Rock (DRI 2019)

During 2019, the Tribal Revegetation Project at the 92-Acre Site, also known as Corrective Action Unit (CAU) 111, continued at the Radioactive Waste Management Complex. The project, managed by EM Nevada Program, involves the CGTO's Tribal Revegetation Committee (TRC)—which comprises Southern Paiute, Western Shoshone, and Owens Valley Paiute and Shoshone representatives—and DRI and Portland State University (PSU) representatives. The purpose of the project is to integrate traditional ecological knowledge with scientific ecological methods for restoring a vegetative cover at CAU 111. In 2019, the TRC participated in monitoring activities to record and evaluate plant growth and other notable characteristics relating to soil condition. Project participants held an annual revegetation project meeting with the TRC, DRI, PSU, EM Nevada Program, and the Nevada Division of Environmental Protection. Preliminary updates related to plant growth were discussed at the 2019 Tribal Update Meeting.

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Chapter 13: Ecological Monitoring

Derek B. Hall and Jeanette A. Perry
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Ecological Monitoring and Compliance Program Goals

Ensure compliance with all state and federal regulations and stakeholder commitments pertaining to Nevada National Security Site (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 assessments to examine fire risk and monitor for the success of restoration programs.

The Ecological Monitoring and Compliance (EMAC) Program provides ecological monitoring and biological compliance support for activities and programs conducted at the NNSS. Major program activities include (a) biological surveys at proposed activity sites, (b) desert tortoise permit compliance, (c) ecosystem monitoring, (d) sensitive and protected/regulated plant species monitoring, (e) sensitive and protected/regulated animal monitoring, and (f) habitat restoration monitoring. Brief descriptions of these programs and their 2019 accomplishments are provided in this chapter. Detailed information may be found in the most recent annual EMAC report (Hall and Perry 2020). 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.

13.1 Desert Tortoise Compliance Program

The Mojave Desert tortoise (*Gopherus agassizii*), which inhabits the southern one-third (544 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 Programmatic 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). NNSS activities were covered by two Opinions in 2019 (FWS 2009 and FWS 2019). The 2009 Opinion expired August 26, 2019, and NNSA/NFO provided FWS with an updated Biological Assessment and consulted with FWS for a new Opinion. The Biological Assessment describes anticipated NNSS activities in tortoise habitat and their potential impacts through 2029. As a result, FWS issued a new Opinion to cover the term of August 27, 2019, through 2029. The Opinion is effectively a permit to conduct activities in desert tortoise habitat in a specific manner. It authorizes the ***incidental take***[1] 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 continued FWS consultations.

[1] The definition of word(s) in ***bold italics*** may be found by referencing the Glossary, Appendix B.

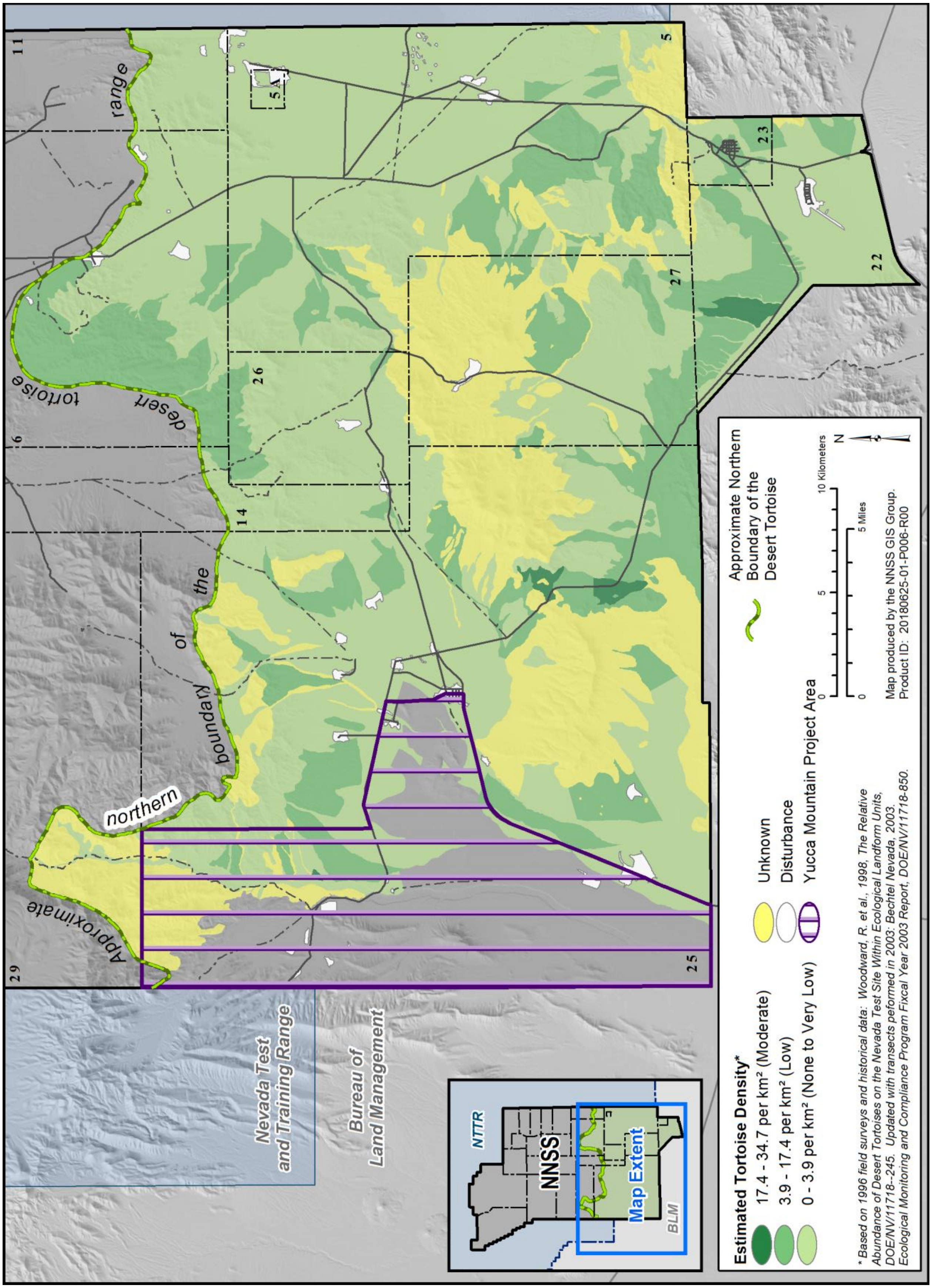

Figure 13-1. Desert tortoise distribution and abundance

13.1.1 Desert Tortoise Surveys and Compliance

In 2019, biologists reviewed 26 proposed projects occurring within the range of the desert tortoise and continued compliance on three projects carried over from 2018. Twenty-one of the projects required a biological survey prior to start of the project, one project did conduct activities in 2019, and the remaining seven projects were determined to have no impact to the desert tortoise (i.e., did not require surveys). These determinations were based on the amount of anticipated habitat disturbance, habitat quality, and location of projects (e.g., within developed or undisturbed areas). Appropriate surveys were conducted to protect desert tortoises and no desert tortoises were reported injured or killed due to project activities. No projects resulted in the disturbance to desert tortoise habitat in 2019.

With the transition to the new Opinion in August 2019, the 2009 Opinion's take limits were totaled, finalized, and reported to FWS (Table 13-1). When the threshold level established by the FWS for moving tortoises safely off of NNSS roads was exceeded, NNSA/NFO received concurrence from the FWS to continue moving tortoises off roads when in harm's way. The take limit set by the FWS was 125 and the actual amount of take was 229.

New 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 began on August 27, 2019, with the new Opinion (Table 13-1). The threshold level for moving tortoises safely off of NNSS roads was set at 350 for the term of the Opinion and includes only large tortoises (greater or equal to 180 millimeters [mm] in length). Small tortoises (less than 180 mm in length) that are encountered will be reported to FWS but not counted toward the threshold due to their low detectability.

There were 66 reported desert tortoise roadside sightings during 2019. Fifty-four of the encountered tortoises were determined to be in harm's way and moved off the road in accordance with FWS-approved tortoise handling procedures. Two of the 66 encounters were killed by vehicles and reported to FWS as incidental take.

In January 2020, NNSA/NFO submitted an annual report to the FWS Southern Nevada Field Office; the report summarizes tortoise compliance activities on the NNSS from January 1 through December 31, 2019.

Table 13-1. Cumulative totals and permit limits for take of desert tortoise and habitat

Program	Number of Acres Impacted (permit limit)		Number of Tortoises Anticipated to Be Incidentally Taken (permit limit)			
	Feb 2009 – Aug 2019[(a)]	Aug 2019 – Dec 2019[(b)]	Feb 2009 – Aug 2019[(a)]		August 2019 – Dec 2019[(b)]	
			Killed/Injured	Other	Killed/Injured	Other[(c)]
Defense	5.6 (500)	0.0 (500)	0 (1)	0 (10)	0 (2)	0 (10)
Waste Management	7.6 (100)	0.0 (250)	0 (1)	0 (2)	0 (2)	0 (10)
Environmental Restoration	0.0 (10)	0.0 (250)	0 (1)	0 (2)	0 (2)	0 (10)
Non-Defense R&D	7.3 (1,500)	0.0 (1,000)	0 (2)	0 (35)	0 (4)	0 (20)
Work for Others	35.8 (500)	0.0 (500)	0 (1)	0 (10)	0 (2)	0 (20)
Infrastructure Development	9.9 (100)	0.0 (500)	0 (1)	1 (10)	0 (4)[(d)]	0 (20)
Roads	0.0 (0.0)	0.0 (0.0)	14 (15)[(e)]	229 (125)[(f)]	0 (15)[(g)]	9 (350)[(h)]
Totals by Permit Term	**66.2 (2,211.8)**	**0.0 (3,000)**	**14 (22)**	**230 (194)**	**0 (31)**	**9 (440)**
Totals for 2019	**0.0**		**2 killed, 54 other (moved off roads)**			

(a) Permit File No. 84320-2008-F-0416.

(b) Permit File No. 8ENVS00-2019-F-0073 (permit limits for take apply only to desert tortoises ≥180 mm in length).

(c) All desert tortoises observed in harm's way may be moved to a safe location.

(d) No more than 2 tortoises killed in a given year and no more than 4 killed during the term of the permit.

(e) No more than 4 tortoises killed on roads in a given year and no more than 15 killed on roads during the term of the permit.

(f) Take limit was exceeded and the FWS granted concurrence to continue moving tortoises off roads when in harm's way.

(g) No more than 4 tortoises killed in a given year and no more than 15 killed during the term of the permit.

(h) No more than 35 handled tortoises in a given year.

Figure 13-2. Desert tortoise eating a perennial forb
(Photo by J.A. Perry, April 18, 2019)

13.1.2 Desert Tortoise Conservation Projects

NNSS biologists are conducting two desert tortoise projects on the NNSS, approved by the FWS. Field work for the roadside movements study was complete in 2018. The study tracked tortoise movement patterns for resident adult tortoises found along paved NNSS roads. The goals of the study were to determine patterns of habitat use near roads on the NNSS and assess the risk of road mortality. The second study, 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. 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 and supported these projects in lieu of the NNSS paying remuneration fees to the FWS for habitat loss that may result from NNSS projects (i.e., all projects except for the Work for Others Program).

The roadside movements study 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 was affixed with a GPS [global positioning system] 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. Preliminary results from the study are included in the 2018 EMAC report (Hall and Perry 2019). A more detailed topical report on the study is in progress.

Of the 60 juvenile tortoises released in 2012, 23 tortoises remain alive and continue to be monitored. One tortoise went missing in 2019; the transmitter was recovered with bite marks. The tortoise is presumed dead by means of predation but the cause of death was not confirmed with a carcass. Monitoring of the remaining animals includes location tracking and annual health assessments. The tortoises had a good year with winter and spring precipitation nearly double the average, creating an abundant, diverse community of native forbs available as food in the spring and summer. Tortoises grew an average of 10.4 mm in length (range = 6–17 mm) between spring and fall. Thirteen of the tortoises have reached the size of adults (>180 mm in length), with the remaining

10 animals approaching adult size (range = 141–225 mm). This study will continue for the next several years and will provide valuable data for future juvenile desert tortoise translocations.

13.2 Biological Surveys at Proposed Project Sites

Biological surveys are performed at proposed project sites where project activities may have 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.

> **Important Habitat Categories**
>
> Pristine Habitat: having few human-made disturbances
>
> Unique Habitat: containing uncommon biological resources such as a natural wetland
>
> Sensitive Habitat: containing vegetation associations that recover very slowly from direct disturbance or are susceptible to erosion
>
> Diverse Habitat: having high plant species diversity

In 2019, biologists surveyed a total of 349 acres (ac) for 33 proposed projects on the NNSS. Although projects target previously disturbed areas (e.g., road shoulders, utility corridors), a total of 22 ac, including 5.6 ac of unique habitat and 2.5 ac of sensitive habitat, were disturbed in 2019. The total area of disturbed important habitats has been tracked since 1999; totals to date are 23.4 ac (Pristine), 48.7 ac (Unique), 940.3 ac (Sensitive), and 215.1 ac (Diverse).

Important animal species and other biological resources observed included several predator burrows, some with sign of use by tortoises; bird nesting sites; western red-tailed skink (*Plestiodon gilberti rubricaudatus*) habitat; and bat sign (e.g., roosting sites, guano). Important plant species observed were *Camissonia megalantha* (Cane Spring suncup), yucca, cacti, including sand cholla (*Grusonia pulchella*), and pine trees. In addition, pronghorn antelope, mule deer, burro, and horse sign were 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, 241 birds, 23 mammals, 21 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 2019 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 (2020).

Table 13-2. Activities conducted in 2019 for important species and ecosystem monitoring on the NNSS

Sensitive Plants (Table A-10 of *Attachment A: Site Description*)

The sensitive plant list for the NNSS is reviewed annually to include the appropriate species in the NNSS sensitive plant monitoring program. Along with this review in 2019, a review of past monitoring surveys, known and historical populations, and the database of the known sensitive plant species on the NNSS was conducted. Both reviews revealed four plants that are now under evaluation to determine their NNSS sensitive plant species ranking, if warranted: Nye milkvetch (*Astragalus nyensis*), Clokey's cryptantha (*Cryptantha clokeyi*), sand cholla (*Grusonia pulchella*), and Lahontan beardtongue (*Penstemon palmeri var. macranthus*). Evaluations for Clokey's cryptantha and sand cholla began in 2019 with surveys of known locations and opportunistic observations. Sand cholla, confirmed to occur on the NNSS, will remain on the sensitive plant list with a ranking of "evaluate," while Clokey's cryptantha requires further evaluation to confirm its occurence on the NNSS.

Populations of six plants on the sensitive plant list were visted in 2019: Cane Spring suncup (*Camissonia megalantha*), sanicle biscuitroot (*Cymopterus ripleyi* var. *saniculoides*), weasel phacelia (*Phacelia mustelina*), black woollypod (*Astragalus funereus*), Pahute green gentian (*Frasera pahutensis*), and rock purpusia (*Ivesia arizonica* ssp. *amargosae*). Cane Spring suncup was previously known from five areas on the NNSS and with completion of monitoring surveys in 2019, a sixth location was confirmed. Sanicle biscuitroot had a good year, with two new small populations found and expansions of three previously known populations, all in Rock Valley. One population of weasel phacelia was visited on Skull Mountain with healthy plants observed and no apparent threats. Two populations of black woollypod were surveyed with healthy plants and no apparent threats, and small expansions of both populations were observed. A healthy population of Pahute green gentian was surveyed and no apparent threats were observed. Pressed plant specimans of rock purpusia were collected from a healthy population in Silent Canyon for the Department of Biology, University of Nevada in Reno.

Reptiles

No trapping or roadkill surveys were conducted in 2019. Opportunistic observations were documented.

Migratory Birds (protected under the Migratory Bird Treaty Act)

A total of 19 dead birds were documented on the NNSS in 2019. Fourteen (4 red-tailed hawks [*Buteo jamaicensis*] and 10 common ravens [*Corvus corax*]) had been electrocuted, one red-tailed hawk was found severely injured due to unknown causes and was euthanized, one northern harrier (*Circus cyaneus*) was injured due to unknown causes and died the next day, and three European starlings (*Sturnus vulgaris*) were found dead due to entrapment. No golden eagle (*Aquila chrysaetos*) deaths were documented.

Numerous poles were identified by NNSS Management and Operating (M&O) Contrator biologists and the power group to install retrofits or reconfigure to make them avian-friendly. A total of 157 poles were retrofitted or reconfigured during 2019. A variety of retrofits were made, including installing insulator covers and extenders, perch deterrents, conductor wire covers, and fuse covers. Biologists also conducted surveys at 57 pole sets to assess if they were avian-friendly and to look for bird carcasses. No dead birds were found and 10 pole sets (18%) were identified as not avian-friendly. These have been added to a list for future retrofit consideration. In addition, the FWS issued a Special Purpose Utility permit to NNSA/NFO, which allows NNSS biologists to remove active nests at project sites in emergencies, and to possess and transport carcasses of golden eagles and other bird species. All permit conditions were met in 2019, and an annual report summarizing activities was submitted to FWS.

Two winter raptor survey routes were sampled in January and February; 19 raptor sightings, representing five species, were recorded. 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.

The western burrowing owl (*Athene cunicularia*) is a National Species of Conservation Concern that has been declining in certain parts of its range for many years. Western burrowing owls have been studied on the NNSS since 1996 and much has been learned about their natural history and ecology on their summer range. Little is known about their migration ecology, including where they spend the winter, migration routes, and stopover sites. This type of information is important to understand threats to this species during migration and on their wintering range.

In June, a collaborative study between the M&O Contractor, Dr. Courtney Conway (United States Geological Survey [USGS], University of Idaho), and Carl Lundblad resulted in the capture of seven western burrowing owls. Transmitters were attached to each owl (Figure 13-3). Other data including age, sex, reproductive status, wing length, tail length and tarsus length were taken. Owl locations were monitored periodically through December 31. In mid-October, owls started migrating south. By December owls were reported near the capture location at the Big Explosives Experimental Facility in Yucca Flat, near the Salton Sea in southern California, in Baja California, Mexico, in Sheephole Valley, California, and near Joshua Tree, California. Owls will continue to be monitored as long as the transmitters are working to learn more about their migratory patterns.

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 spring and summer in 2019 to determine abundance and band distribution. Survey locations included Gold Meadows Spring, Camp 17 Pond, Airport Road, and Pahute Mesa Road. A total of 57 individuals were observed in at least seven different bands; the total includes nine juveniles and six foals.

Table 13-2. Activities conducted in 2019 for important species and ecosystem monitoring on the NNSS

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 19.8 deer/night. The observed buck/doe ratio was 87 bucks/100 does, a slight decrease from 2018. The observed fawn/doe ratio was 21 fawns/100 does.
Desert Bighorn Sheep (*Ovis canadensis nelsoni*) (managed as a game mammal by NDOW)
2019 monitoring of the NNSS sheep population was done by documenting sheep presence at several water sources using camera traps. Similar to 2017 and 2018, 13 marked sheep were observed in photos, including 8 ewes and 5 rams. At least another 11 unmarked sheep were also observed in photos..
Sensitive Bats (see Table A-11 of *Attachment A: Site Description*)
Bat monitoring in 2019 was restricted to documenting roost sites in buildings.
NNSS biologists continued to respond to reports of bats in NNSS buildings.
Mountain Lions (*Puma concolor*) (managed as a game mammal by NDOW)
A collaborative effort with U.S. Geological Survey scientist Dr. Kathy Longshore continued in 2019 to investigate mountain lion distribution and abundance on the NNSS using remote, motion-activated cameras. Cameras collected a total of 69 photographs/video clips of mountain lions from seven of 25 camera sites. A minimum of five lions (one adult male, one adult female, three subadults) inhabited the NNSS in 2019 based on photographic data.
Natural and Man-made Water Sources
Nine natural water sources, one well pond, five wildlife water troughs, and three 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. Several species of birds were photographed at the monitored well sumps.

Figure 13-3. Western burrowing owl with transmitter attached (Photo by D.B. Hall, June 17, 2019)

13.3.1 Mule Deer and Pronghorn Antelope Distribution

Mule deer and pronghorn antelope (*Antilocapra americana*) are mobile game animals that inhabit the NNSS. Both are generally considered to be migratory with distinct winter and summer ranges. Mule deer typically prefer the forested, mountainous habitats in the northern and western portions of the NNSS while pronghorn typically prefer the open valleys in the southern and eastern portions of the NNSS. Mule deer are much more abundant than pronghorn on the NNSS. Mule deer movements on the NNSS were studied more than 30 years ago (Giles and Cooper 1985) using radio-collars that lacked the accuracy of current GPS radio-collars. They identified summer and winter ranges and a couple of long-distance movements of mule deer into areas where hunting is allowed on public land. Mule deer in their study were not necessarily those known to be using radioactively contaminated locations. Pronghorn are relatively new residents to the NNSS (first observed in 1991) and their use of the NNSS has never been studied. Tsukamoto et al. (2003) report the distribution of pronghorn in Nevada as of 2002 with the nearest population to the NNSS being just north in Emigrant Valley. The NNSS represents an expansion of pronghorn range in Nevada.

A research study funded by NNSA/NFO and the Environmental Management Nevada Program (EM Nevada) was initiated on the NNSS in November 2019 to better understand the potential radiological dose to the offsite public via the hunter pathway. This was a collaborative effort involving USGS, NDOW, the Nevada Test and Training Range (NTTR), M&O Contractor biologists, and several volunteers. Native Range Capture Services captured the animals. Study objectives include: 1) determine the distribution, abundance, and range of movements of mule deer and pronghorn, 2) estimate the potential for hunters to harvest animals that use the NNSS, 3) evaluate the animal's use of contaminated areas, 4) obtain information on the potential radiological dose to someone consuming animals from the NNSS, 5) determine the potential radiological dose to animals on the NNSS, 6) document survival and causes of mortality, 7) refine habitat use patterns for both mule deer and pronghorn using resource selection functions and correlate that with phenological changes in the vegetation, and 8) assess the overall health, disease status, and genetics of NNSS mule deer and pronghorn.

In November, mule deer and pronghorn were captured, examined, tested, and GPS-collared. Six staging areas were used to capture animals from a variety of locations, focusing on sites close to contaminated areas such as Yucca Flat, Frenchman Flat, and E Tunnel Ponds. The intent was to bring as many animals as possible, especially pronghorn, which are more susceptible to capture-related injuries, to staging areas for physiological monitoring and health assessments before they were released. In addition, radiological burden measurements using a direct count method were taken on several animals. A total of 23 mule deer (16 does, 7 bucks) and 20 pronghorn (14 does, 6 bucks) were captured. All 23 mule deer were radio-collared and ear-tagged. Thermoluminescent dosimeters (TLDs) were attached to 12 mule deer doe radio-collars to estimate external radiological dose. Eighteen pronghorn (12 does, 6 bucks) were radio-collared and ear-tagged, and TLDs were attached to 8 does and 4 bucks.

By December 31, 2019, GPS data showed mule deer concentrated in the mid-elevation, mountainous regions while pronghorn were concentrated in Frenchman Flat and Yucca Flat. No long-distance migration events were recorded during this time period. There were some movements of mule deer onto the NTTR north of Pahute Mesa and west of Timber Mountain, and some pronghorn moved onto the NTTR east of Frenchman Flat. Two mortalities were documented after the captures. Two pronghorn does were apparently killed/scavenged by coyotes within a couple of days of being captured.

Blood samples for 14 of the 23 mule deer and 18 of the 20 pronghorn were sent by NDOW to the Washington Animal Disease Diagnostic Lab, where they were tested for Anaplasmosis (ELISA test), Bluetongue (ELISA test), Bovine Respiratory Syncytial Virus (Virus Neutralization), Parainfluenza Virus (Virus Neutralization), and Epizootic Hemorrhagic Disease (ELISA test). Five mule deer tested positive for Anaplasmosis and one mule deer tested positive for Parainfluenza Virus. No mule deer were positive for Bluetongue, Bovine Respiratory Syncytial Virus, or Epizootic Hemorrhagic Disease. Four pronghorn tested positive for Bluetongue. No pronghorn were positive for Anaplasmosis, Bovine Respiratory Syncytial Virus, or Parainfluenza Virus. Results for Epizootic Hemorrhagic Disease are still pending.

The distribution study will continue through 2022, at which time the GPS collars will automatically drop off the tracked animals. For more detailed information on capture method, health assessments, and distribution, refer to the EMAC (Hall and Perry 2020).

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 EM Nevada; and EM Nevada 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 Radioactive Waste Management Complex (RWMC) (CAU 111), NNSS (2011)
- Clean Slate II (CAU 413) and Clean Slate III (414), TTR (2019 and 2020)

Activities conducted in 2019 included visually assessing the vegetation at the U-3ax/bl closure cover (CAU 110) and the 92-Acre Site (CAU 111), overseeing and supporting the revegetation of Clean Slate II (CAU 413) and Clean Slate III (CAU 414) sites on the TTR, and preparing for the revegetation of Cell 18 at the Area 5 RWMC.

13.4.1 CAU 110, U-3ax/bl, Closure Cover

A qualitative assessment of the vegetation on CAU 110, U3-ax/bl closure cover was made on September 4, 2019. A meandering transect covering the entire cap was walked. The vigor of perennial plant species was assessed based on current year's growth, whether plants were flowering, and if any showed signs of stress (i.e., dead stems or leaves). Shadscale (*Atriplex confertifolia*) continues to be the most abundant shrub species on the closure cover (Figure 13-4). None of the plants observed showed signs of stress; however, some dead shadscale saltbush plants were noted. Flowering plants were uncommon because of the time of sampling. However, most of the shadscale plants were fruiting and had good seed production. There was evidence of good seed production for Nevada jointfir (*Ephedra nevadensis*), the second most common perennial species. The other shrubs occasionally encountered on the closure cover were winterfat (*Krascheninnikovia lanata)* and fourwing saltbush (*A. canescens*).

No perennial grasses have been found on the closure cover for several years and none were found in 2019. Surprisingly, with the above-average precipitation, annual plant cover was quite low, with Esteve's pincushion (*Chaenactis stevioides*) the most dominant annual. Bristly fiddleneck (*Amsinckia tessellata*) and flatcrown buckwheat (*Eriogonum deflexum*) were also observed in low numbers. Invasive species were minimal on the seeded portion of the cover cap, with cheatgrass (*Bromus tectorum*) and saltlover (*Halogeton glomeratus*) observed.

During the vegetation surveys, small mammal activity on the CAU 110, U-3ax/bl closure cover was evaluated. Several burrow complexes were noted but not counted. Signs of activity around a few of the burrow entrances were observed, but many were not active, which aligns with 2018 observations. The number of burrows on the cover cap is far less than in the native undisturbed areas in Yucca Flat. Trapping of small mammals is not recommended at this time.

In summary, the vegetative cover on the CAU 110, U-3ax/bl cover cap appears to be stable and in very good condition. The plants on the cap showed good growth this year with many producing seed due to above-average precipitation. Some dead shadscale plants were observed, but this is to be expected as the plant community matures and suffers impacts from past droughts. No perennial plant seedlings were observed; biologists will continue to monitor for this in future efforts. The annual forb component of the plant community was surprisingly low this year considering the above-normal precipitation. The non-revegetated area surrounding the cover continues to be dominated by invasive species, primarily saltlover. This highlights the importance of seeding to establish a native perennial plant community that can effectively compete with invasives.

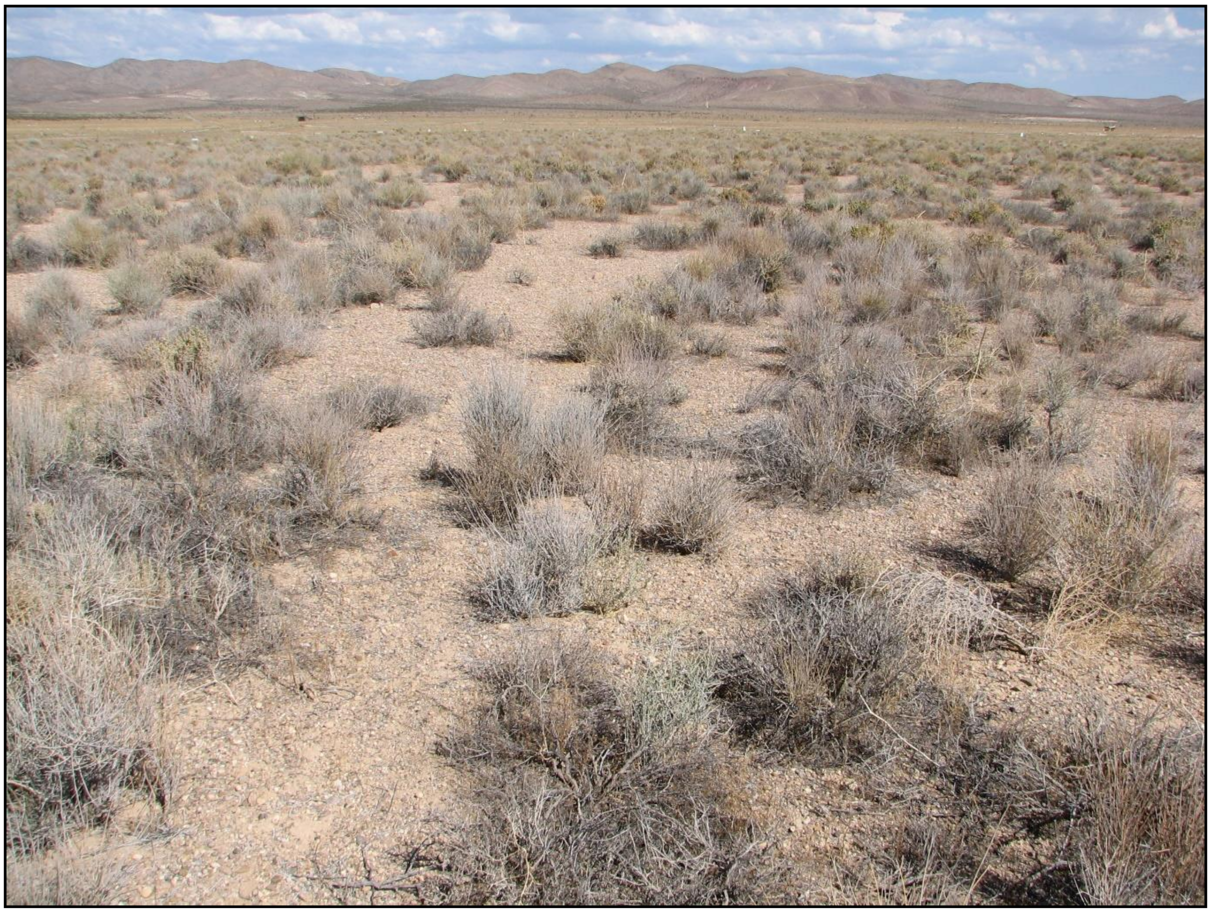

Figure 13-4. Plant community established on the U3ax/bl cover cap (Photo by D.B. Hall, September 4, 2019)

13.4.2 CAU 111, 92-Acre Site, Closure Covers

A qualitative assessment of vegetation at the 92-Acre Site found very few perennial plants on any of the cover caps. There were about 20 large fourwing saltbush plants on the North South Cover. These plants are from prior revegetation efforts that survived the extensive rabbit herbivory before the site was fenced.

Overall the integrity of the cover caps was very good. Invasive species densities were high due to the abundant precipitation in 2019, with saltlover, Arabian schismus (*Schismus arabicus*), and prickly Russian thistle (*Salsola tragus*) being the most common. No rabbits or fresh rabbit sign were observed. Light rodent burrowing activity was detected.

Several badger burrows were noted in January. Most of the burrowing was around existing large fourwing saltbush plants. The badger may have been digging up rodents that burrowed under the plants.

13.4.3 Area 5 RWMC, Cell 18 Revegetation

It is anticipated that Cell 18 at the Area 5 RWMC will be closed and revegetated during 2020. M&O Contractor biologists will work with a subcontractor to develop a revegetation plan and then oversee implementation of that plan. The revegetation strategy includes a combination of seeding and transplanting. Evidence suggests that seed collected from plants close to the revegetation site are best adapted to survive and have a higher chance for successful establishment. Growing conditions during 2019 were favorable for seed production for several species. Multiple days were spent collecting seeds for white bursage (*Ambrosia dumosa*), creosote bush (*Larrea tridentata*), and Nevada jointfir. Some seed was given to the Nevada Division of Forestry to grow 5,000 transplants (2,500 white bursage and 2,500 creosote bush) and the remaining seed will be used in the revegetation effort to compare success from locally collected seed versus commercially available seed.

13.4.4 CAU 413, Clean Slate II, and CAU 414, Clean Slate III

In 2019, M&O Contractor biologists provided input to a revegetation plan for the Clean Slate II (CAU 413) and Clean Slate III (CAU 414) cleanup sites on the TTR (Navarro 2019) and were also involved in site preparation and seeding activities. Due to a limited budget and the constraints from working inside a radiologically contaminated area, the original revegetation plans for these two sites (Anderson and Hall 1997, Hall and Anderson 1999) were revised to include ripping the areas to be seeded, broadcast seeding a tailored mix of native seeds using a drill seeder, and then irrigating with a water truck.

Site preparation and seeding occurred in the fall and early winter. Revegetation monitoring to evaluate seeding success is planned for summer of 2020.

13.5 Wildland Fire Hazard Assessment

A NNSS Wildland Fire Management Plan requires the 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 EMAC report (Hall and Perry 2020). Between April and June 2019, NNSS biologists visited 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 5.0. Due to the above-average precipitation in winter 2018/spring 2019, production of annual forbs and grasses was high. Production of perennial herbaceous grasses and forbs was also high.

In 2019, two wildland fires occurred on the NNSS. Both of them occurred on April 29 and both were 0.1 ac in size and were extinguished by NNSS Fire and Rescue personnel or carefully monitored until they burned out.

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) and the Environmental Management (EM) Nevada Program is performed in accordance with the Quality Assurance Program (QAP) established by the current Management and Operating (M&O) Contractor, Mission Support and Test Services, LLC (MSTS), or 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***[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.

A Data Quality Objective (DQO) process is cited by most organizations as the planning approach used to ensure that environmental data collection activities produce the appropriate data needed for decision-making. 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 DOE, the Environmental Protection Agency (EPA), 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 workflow are listed below. Each element is designed to ensure that applicable ***quality assurance (QA)*** requirements are implemented. A discussion of these elements follows.

- A **Sampling and Analysis Plan** (SAP) is developed consistent with a DQO process to ensure clear goals and objectives are established for the environmental activity. The SAP is implemented in accordance with EPA, DOE, and other requirements addressing environmental, safety, and health objectives.

[1] The definition of word(s) in ***bold italics*** may be found by referencing the Glossary, Appendix B.

- **Environmental Sampling** is performed in accordance with the SAP, procedures, and site work controls to ensure defensibility of the resulting data products as well as protection of the worker and the environment.
- **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 (EPA 2020).

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 (EPA 2020) 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 later. 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. If deficiencies are noted, then causal factors are determined, corrective actions are implemented, and follow-up assessments are performed to ensure effective resolution. Field data log notes are reviewed as a first step in data evaluation. 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 that their integrity has not been compromised, either physically (leaks, tears, breakage, custody seals) or administratively (labeled incorrectly), and that 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, the EM Nevada Program, or the regulator, data used for demonstrating regulatory compliance are generated by a DOE- and contractor-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 Defense (DoD) Department of Energy (DOE) Consolidated Quality Systems Manual (QSM) for Environmental Laboratories* (DOE 2019). The QSM is based on Volume 1 of The NELAC [National Environmental Laboratory Accreditation Conference] Institute Standards (September 2009), which incorporates International Organization for Standards (ISO)/International Electrotechnical Commission (IEC) 17025:2005, *General requirements for the competence of testing and calibration laboratories*, and ISO/IEC 17025:2017. Subcontracted laboratories are assessed to comply with the QSM and are audited by the DoD Environmental Laboratory Accreditation Program Accreditation Bodies and the DOE Consolidated Audit Program – Accreditation Program (DOECAP-AP) Accreditation Bodies.

A request for proposal (RFP) is posted to the government website, laboratory responses are evaluated, and subcontracts awarded. The RFP cites the QSM as the base technical requirement, participation in the DOECAP-AP is required or advised, 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-AP, EM Nevada Program, 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-AP 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-AP 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 generally involves 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 2019 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 matrix (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)*** (or MDC + 2σ uncertainty for UGTA water samples). 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 2019 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. Also, higher average absolute

RPDs can be associated with relatively few pairs having both values above their MDCs, as low-level measurements are typically relatively "noisier" than higher-level measurements.

Table 14-1. Summary of field duplicate samples for 2019

Analyte	Matrix	Number of Duplicate Pairs[(a)]	Number of Pairs > MDC[(b)]	Average Absolute RPD[(c)]	Average Absolute RER[(d)]
Environmental Monitoring Samples					
Gross Alpha	Air	52	23	16.9	0.57
Gross Beta	Air	52	52	6.9	1.00
Tritium	Air	50	7	5.4	0.67
^{241}Am	Air	8	0	–	1.38
^{238}Pu	Air	8	1	33.7	1.02
$^{239+240}$Pu	Air	8	3	62.1	1.67
$^{233+234}$U	Air	6	6	17.0	1.21
$^{235+236}$U	Air	6	3	64.1	1.49
^{238}U	Air	6	6	5.9	0.46
^{7}Be[(e)]	Air	8	8	2.0	0.25
^{137}Cs	Air	8	0	–	0.59
^{40}K[(e)]	Air	8	5	38.9	0.98
Gross Alpha	Water	5	4	28.9	1.12
Gross Beta	Water	5	5	13.0	0.64
Tritium (standard)	Water	15	0	–	0.80
TLD	Ambient Radiation	443	NA	2.9	0.26
UGTA Samples					
Gross Alpha	Water	5	5	14.1	0.76
Gross Beta	Water	5	3	3.0	0.61
Tritium (standard)	Water	9	4	5.8	0.47
Tritium (low-level)	Water	6	0	NA	NA

(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 or MDC + 2σ (UGTA). If either the field sample or duplicate was below the MDC (+ 2σ), 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.

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 2019).

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 2019 LCSs analyzed and within control limits are summarized in Table 14-2. There were no systemic issues identified in 2019 by LCS recovery data, and no failures that invalidated the associated sample data.

Table 14-2. Summary of laboratory control samples for 2019

Analyte	Matrix	Number of LCS Results Reported	Number Within Control Limits	Control Limits (%)
Environmental Monitoring Samples				
Tritium	Air	78	78	75–125
^{60}Co	Air	5	5	75–125
^{137}Cs	Air	5	5	75–125
$^{239+240}$Pu	Air	11	11	75–125
^{241}Am	Air	20	20	75–125
Gross alpha	Water	11	11	75–125
Gross beta	Water	11	11	75–125
Tritium (standard)	Water	12	12	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	8	8	75–125
^{90}Sr	Soil	11	11	75–125
^{137}Cs	Soil	8	8	75–125
$^{239+240}$Pu	Soil	11	11	75–125
^{241}Am	Soil	19	19	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	119	119	80–120
Volatiles	Water	166	166	70–130
Semi volatiles	Water	448	447	Laboratory specific
Miscellaneous	Water	84	84	80–120
Metals	Soil	8	8	80–120
Volatiles	Soil	0	0	70–130
Semi volatiles	Soil	9	9	Laboratory specific
Miscellaneous	Soil	3	3	80–120
UGTA Samples				
Gross alpha	Water	2	0	80-120
Gross beta	Water	2	2	80-120
Tritium (standard)	Water	2	2	80-120
Tritium (low-level)	Water	8	8	75-125

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 2019). 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.
- 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.
- 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.
- 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. 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 2019 by the blank data.

Table 14-3. Summary of laboratory method blank samples for 2019

Analyte	Matrix	Number of Blank Results Reported	Number of Results < MDC
Environmental Monitoring Samples			
Tritium	Air	72	71
^{7} Be	Air	5	5
^{60}Co	Air	2	2
^{137}Cs	Air	5	5
^{238}Pu	Air	6	6
$^{239+240}$Pu	Air	6	6
^{241}Am	Air	10	9
Gross alpha	Water	11	11
Gross beta	Water	11	11
Tritium (standard)	Water	12	12
^{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	7	7
^{90}Sr	Soil	8	8
^{137}Cs	Soil	8	8
^{238}Pu	Soil	8	7
$^{239+240}$Pu	Soil	8	8
^{241}Am	Soil	15	15
^{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	124	108

Table 14-3. Summary of laboratory method blank samples for 2019

Analyte	Matrix	Number of Blank Results Reported	Number of Results < MDC
Volatiles	Water	89	89
Semi volatiles	Water	295	283
Miscellaneous	Water	235	227
Metals	Soil	16	5
Volatiles	Soil	0	0
Semi volatiles	Soil	7	6
Miscellaneous	Soil	2	2
UGTA Samples			
Gross alpha	Water	1	1
Gross beta	Water	1	1
Tritium (standard)	Water	1	1
Tritium (low-level)	Water	5	5

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 2019, and there were no issues identified by the analysis data (Table 14-4).

Table 14-4. Summary of matrix spike samples for 2019

Analyte	Matrix	Number of Matrix Spikes Reported	Number Within Control Limits	Control Limits[(a)] (%)
Environmental Monitoring Samples				
Tritium	Air	24	24	60–140
Gross alpha	Water	12	12	60–140
Gross beta	Water	12	12	60–140
Tritium	Water	5	5	60–140
UGTA Samples				
Gross alpha	Water	1	1	60-140
Gross beta	Water	1	1	60-140
Tritium (standard)	Water	3	3	60-140
Tritium (low-level)	Water	7	7	60-140

(a) These control limits apply when the sample results are < 4x the amount of spike added.

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 2019 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 operated by the DOE Idaho Operations Office. The MAPEP discontinued the requirement for several studies beginning calendar year 2016, including gross alpha/beta in air filters and water and organics (volatiles and semi-volatiles) in water and soil. For gross alpha/beta, however, several laboratories remain in the program voluntarily. 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 data from Lawrence Livermore National Laboratory for the same wells. Evaluations of duplicate samples indicated sufficient control on precision.

Table 14-5. Summary of 2019 Mixed Analyte Performance Evaluation Program reports

Analyte	Matrix	Number of Results Reported	Number within Control Limits[a]
Environmental Monitoring Samples			
^{60}Co	Filter	5	5
^{137}Cs	Filter	5	5
^{238}Pu	Filter	5	5
$^{239+240}$Pu	Filter	5	5
^{241}Am	Filter	5	5
Tritium (standard)	Water	5	5
^{60}Co	Water	5	5
^{90}Sr	Water	5	5
^{137}Cs	Water	5	5
^{238}Pu	Water	5	5
$^{239+240}$Pu	Water	5	5
^{241}Am	Water	5	5
^{60}Co	Vegetation	4	4
^{90}Sr	Vegetation	4	4
^{137}Cs	Vegetation	4	4
^{238}Pu	Vegetation	4	4
$^{239+240}$Pu	Vegetation	4	4
^{60}Co	Soil	5	5
^{90}Sr	Soil	5	5
^{137}Cs	Soil	5	5
^{238}Pu	Soil	5	5
$^{239+240}$Pu	Soil	5	5
^{241}Am	Soil	5	5
Metals	Water	92	90
Metals	Soil	94	93
Gross Alpha	Water	3	3
Gross Beta	Water	3	3

(a) Based upon MAPEP criteria.

Table 14-6 shows the summary of inter-laboratory comparison sample results for the MSTS Radiological Health Dosimetry Group. 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) Standard 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 2019

Analysis	Matrix	Number of Results Reported	Number within Control Limits[a]
Gamma Radiation	TLD	23 batches of 5 TLDs	23 batches of 5 TLDs

(a) Based upon ANSI/HPS N13.11-2009 criteria.

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 last 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 the 2017-tested environmental

TLDs was 0.10, demonstrating good agreement between the results and the controlled exposure using the blind spike.

14.6 References

DOE, see U.S. Department of Energy.

EPA, see U.S. Environmental Protection Agency

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.

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U.S. Environmental Protection Agency, Forum on Environmental Measurements (FEM) Glossary, accessed in April 2020 (https://iaspub.epa.gov/sor_internet/registry/termreg/searchandretrieve/glossariesandkeywordlists/search.do?details=&vocabName=FEM%20Glossary#formTop)

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 analytical 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 the following:

- 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 that the sampling is traceable and enhances the value of the final data. The sample package also ensures that the Community Environmental Monitor (CEM) station manager (Chapter 7 describes CEMs) followed proper procedures for sample collection. The CEMP Project Manager or QA Officer

[1] The definition of word(s) in ***bold italics*** may be found by referencing the Glossary, Appendix B.

routinely performs assessments of the station managers and field monitors to ensure that 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 at DRI. Analytical reports are kept as hard copy in file archives as well as in electronic form 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 the following:

- 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 of laboratory personnel
- 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 the 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 an 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 that 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 that 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 that 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 pertain to the organization.

15.7 2019 Sample QA Results

QA assessments were performed by the CEMP, including the laboratories responsible for sample analyses. These assessments ensure that sample collection procedures, analytical techniques, and data provided by the subcontracted laboratories comply with CEMP requirements. Data were provided by TestAmerica Laboratories, 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 2019 results for field duplicates, laboratory control samples, blank analyses, and inter-laboratory comparison studies is provided along with summary tables within this section. The 2019 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 2019 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.

Table 15-1. Summary of 2019 field duplicate samples for CEMP monitoring

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	8	8	22.5
Gross Beta	Air	8	8	10.3
Gamma – Beryllium-7	Air	8	3	15.2
^{3}H	Water	1	0	NA[(d)]
TLDs	Ambient Radiation	12	NA	6.16

(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) 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 2019 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 2019 laboratory control samples for CEMP monitoring

Analysis	Matrix	Number of LCS Results Reported	Number Within Control Limits	Control Limits
Gross Alpha	Air	7	7	75–125%
Gross Beta	Air	7	7	75–125%
Gamma (^{137}Cs, ^{60}Co, ^{241}Am)	Air	7	7	87–117%
^{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 2019 are summarized in Table 15-3. The laboratory blank results were satisfactory for all analyses for the air sample matrix.

Table 15-3. Summary of 2019 laboratory blank samples for CEMP monitoring

Analysis	Matrix	Number of Blank Results Reported	Number within Control Limits[a]
Gross Alpha	Air	7	7
Gross Beta	Air	7	7
Gamma	Air	7	7
^{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 2019 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.

Table 15-4. Summary of 2019 inter-laboratory comparison samples of the subcontract radiochemistry and tritium laboratories for CEMP monitoring

		MAPEP and ERA Results	
Analysis	Matrix	Number of Results Reported	Number Within Control Limits[a]
Gross Alpha	Air	6	6
Gross Beta	Air	6	6
Gamma	Air	5	5
^{3}H	Water	1	1

(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 is performed in accordance with National Voluntary Laboratory Program (NVLAP) tolerance levels and American National Standards Institute (ANSI) Standard ANSI N13.11-2009, *Personal Dosimetry Performance – Criteria for Testing*. For each month of 2019, nine TLD badges were tested and all performed acceptably.

Table 15-5. Summary of 2019 inter-laboratory comparison TLD samples of the subcontract dosimetry group for CEMP monitoring

Analysis	Matrix	Number of Results Reported	Number Within Control Limits[a]
TLDs	Ambient Radiation	12	12

(a) Based upon NVLAP/ANSI criteria; sum of the squares of the bias and standard deviation less than or equal to 0.09.

15.8 References

Desert Research Institute, 2009. *DOE NNSA/NSO Community Environmental Monitoring Program Quality Assurance Management and Assessment Plan*, July 2009. Las Vegas, NV.

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, Xianan Liu, and Nikolas J. Taranik
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 2019 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 2019 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 (^3H)***[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 dioxide (SO_2), 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 2019 inventory reported the estimated quantities (Table A-1) on February 25, 2020.

Table A-1. Summary of air emissions for the NLVF in 2019

	Criteria Pollutant (tons/yr)[(a)]					
Parameter	**PM10[(b)]**	**PM2.5[(c)]**	**NO_x**	**CO**	**SO_2**	**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 6 consecutive minutes. The NLVF air permit requires, at a minimum of each quarter, a visible emissions check be performed from each diesel-fired generator when operated for testing and maintenance. If emissions are observed, then U.S. Environmental Protection Agency (EPA) Method 9 opacity readings are recorded by a certified visible-emissions evaluator.

[1] The definition of word(s) in ***bold italics*** may be found by referencing the Glossary, Appendix B.

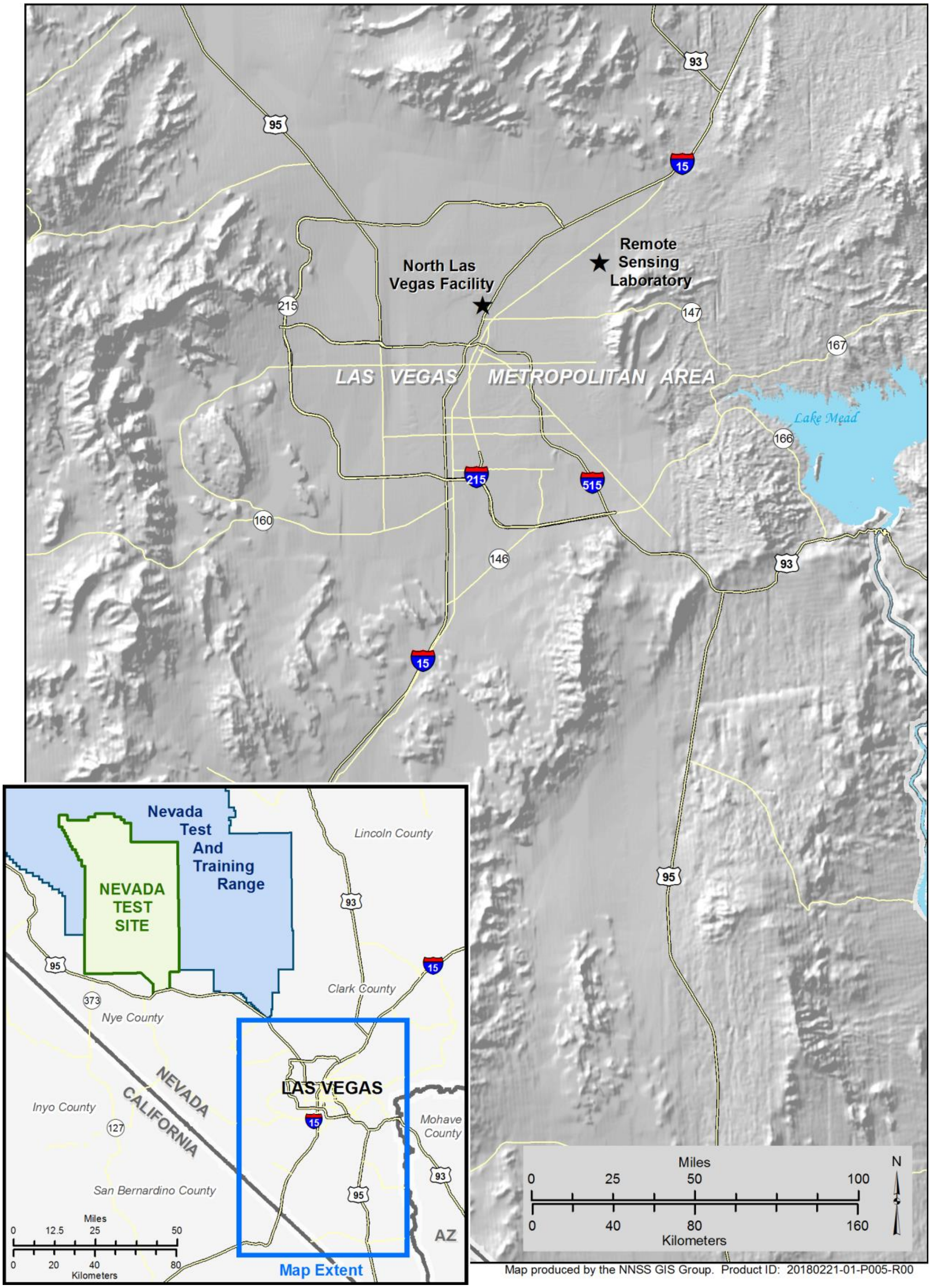

Figure A-1. Location of NNSS offsite facilities in Las Vegas and North Las Vegas

If visible emissions appear to exceed the limit, corrective actions must be taken to minimize emissions. In 2019, two NLVF Maintenance Engineers were recertified. In 2019, observations were taken for diesel-fired generators; 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 2019, two hot work live fire extinguisher training sessions were 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 2019, 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 2019, 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 water is then discharged from the storage tank into the Las Vegas Wash via direct discharge (Outfall 002) into the CNLV storm drainage system. Chemistry analyses are performed annually on water samples collected from the storage tank. 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 2019, the five dewatering wells at the NLVF produced a total of about 480,653 L (126,975 gal) per month that were directed into the storage tank. Annual water sampling for the presence of 23 analytes (listed in Section A.10.3.4 of the permit) was performed on November 13, 2019. All analytes were below permit limits, and discharge rates (i.e., daily maximum flows) did not exceed the NPDES DeMinimus general permit limits (Table A-2).

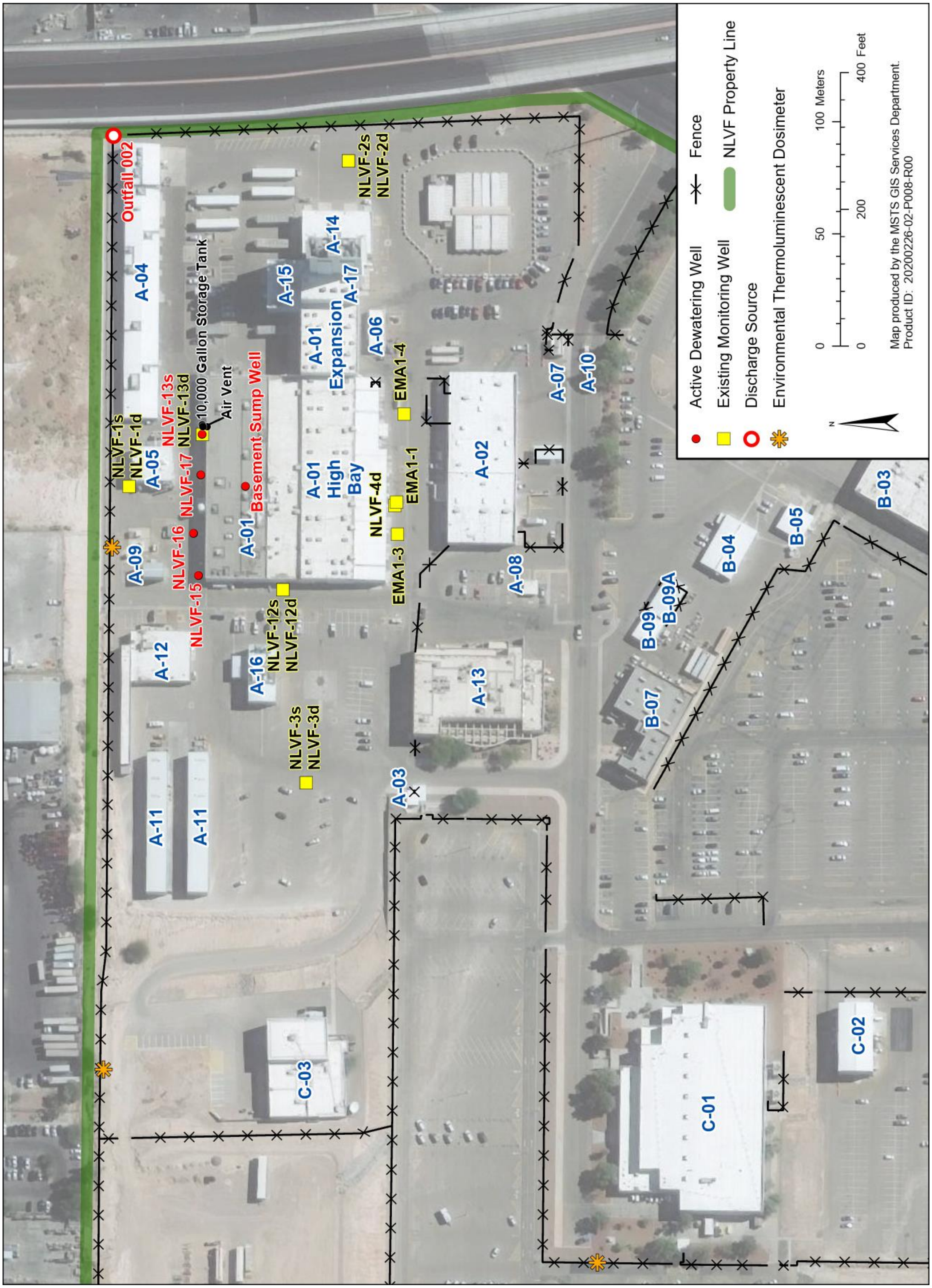

Figure A-2. Location of dewatering and monitoring wells around Building A-1

Table A-2. NLVF NPDES permit 2019 monitoring requirements and analysis results of storage tank water samples

Parameter	Monitoring Requirements: Sample Frequency	Monitoring Requirements: Sample Type	Permit Discharge Limits: Daily Maximum	Sample Results: 1st Quarter	Sample Results: 2nd Quarter	Sample Results: 3rd Quarter	Sample Results: 4th Quarter
Daily Maximum Flow (MGD)[(a)]	Continuous	Flow Meter	0.36	0.004	0.004	0.004	0.004
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	ND[(d)]
Total Dissolved Solids (mg/L)	Annually	Discrete	1900	NS	NS	NS	1190
Total Inorganic Nitrogen as N (mg/L)	Annually	Discrete	10	NS	NS	NS	1.75
pH (Standard Units)	Annually	Discrete	6.5–9.0	NS	NS	NS	7.76

(a) MGD = million gallons per day.
(b) This parameter includes three analytes, in milligrams per liter (mg/L): 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.

A.1.2.3 Groundwater Control and Dewatering Operation

In 2019, 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 2003, 2004; National Security Technologies, LLC, 2006). Monitoring for this operation includes periodic measurements of 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 as new data become available. This information is used to help characterize groundwater conditions and evaluate the dewatering operation.

When the A-01 Basement Sump Well pump is active, the water level directly beneath Building A-01 averages 39.4 centimeters (cm) (15.5 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 2019 and reflects a drop of about 61.0 cm (24.0 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 1.3 meters (4.2 feet) since 2003. Dewatering efforts must continue to counter this rising groundwater trend.

A.1.2.4 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 2019, quarterly inspections of tanks, transformers, oil-filled equipment, and drums were conducted in March, May, September, and November. Throughout 2019, all NLVF employees who handle oil received their required annual spill prevention and management training. No spills occurred in 2019 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 2019, no ^{3}H was detected above its analytical method detection limit 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 9–16 and September 11–18, 2018) in order to compute average ^{3}H emissions. A calculated annual total of 1.59 millicuries were released from the basement air that was vented to the outside. Based on this emission rate, the 2019 calculated radiation dose to the nearest member of the general public from the NLVF was very low: 0.00001 mrem/yr (Mission Support and Test Services, LLC [MSTS], 2020). 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 2020).

A.1.3.2 U.S. Department of Energy Order 458.1

U.S. Department of Energy (DOE) Order DOE O 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 2019, 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 2019 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	97	88	104
North Fence of Building A-01	4	65	65	58	69
North Fence of Building C-3	4	66	67	58	81

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 a Very 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; SNHD conducted the audit in 2019 and no issues were identified.

A.1.5 Hazardous Materials Control and Management

The 2019 NLVF chemical inventory was submitted to the state in the Nevada Combined Agency (NCA) Report in February. The inventory data were submitted in accordance with the requirements of the Hazardous Materials Permit 88642. For a description of the content, purpose, and federal regulatory driver behind the NCA Report, see 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 2-6 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 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 2019 included maintenance of an air quality permit, a waste management permit for underground storage tanks (USTs), and a hazardous materials permit (Table 2-2 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 Source 348 Minor Source Permit issued by the Clark County DAQ for the emission of criteria pollutants. 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 2019 emissions inventory of criteria air pollutants was submitted to the DAQ on March 19, 2019, and is shown in Table A-4. In a revision to replace the emergency fire pump, the DAQ removed the boilers and spray paint booth from the permitted emissions list; both fit within the revised DAQ air regulation criteria as insignificant emission units.

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 a monthly visible emissions check during equipment operations. 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 2019, one RSL-Nellis safety professional was recertified to conduct opacity readings. Visible emissions checks 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 2019

	Criteria Pollutant (tons/yr)[a]					
Parameter	**PM10[b]**	**PM2.5[c]**	**NO_x**	**CO**	**SO_2**	**VOC**
PTE[d]	0.83	0.45	6.86	2.12	0.12	1.11
Actual[e]	0.19	.10	1.84	0.45	0.02	0.16
Total Emissions = 2.76 Actual, 11.49 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 2019 was submitted to CCWRD on January 14, 2019. 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 2019, 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 2019 that met regulatory agency reporting criteria.

A.2.3 Underground Storage Tank Management

The SNHD has oversight authority of USTs in Clark County. On January 1, 2019, the UST program at RSL-Nellis consisted of four fully regulated tanks (one for unleaded gasoline, two for diesel fuel, and one for used oil), and three excluded tanks. On January 23, 2019, the statuses of three fully regulated USTs (one unleaded gasoline, one diesel, and one used oil) were changed from active to temporarily closed. The fully regulated USTs are operated under the RSL-Nellis UST Permit PR0064276 issued by SNHD. The fully regulated, active, and temporarily closed tanks are inspected annually by SNHD. In November, 2019, SNHD inspected the fully regulated USTs at RSL-Nellis. One deficiency was noted.

A.2.4 Hazardous Materials Control and Management

The chemical inventory at RSL-Nellis was submitted to the state in the NCA Report on February 27, 2020, in accordance with the requirements of the Hazardous Materials Permit 88647 (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 2019. 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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Mission Support and Test Services, LLC, 2020. *National Emission Standards for Hazardous Air Pollutants - Radionuclide Emissions Calendar Year 2019.* DOE/NV/03624--XXXX, prepared for U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office, Las Vegas, NV.

MSTS, see Mission Support and Test Services, LLC.

National Security Technologies, LLC, 2006. *Groundwater Control at Building A-01, North Las Vegas Facility Enhanced Dewatering Initiative*. Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office, 1996. *National Emission Standards for Hazardous Air Pollutants Submittal – 1995*. DOE/NV/11718--032, Las Vegas, NV. OSTI ID: 436417

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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.

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. CAP88 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 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 (DU): 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.

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.

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.

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.

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.

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.

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	American National Standards Institute
ANSI/HPS	American National Standards Institute/Health Physics Society
AP	Accreditation Program
ARL	Army Research Laboratory
ARL/SORD	Air Resources Laboratory, Special Operations and Research Division
ASN	Air Surveillance Network
B	Background
BCG	Biota Concentration Guide
Be	beryllium
BEEF	Big Explosives Experimental Facility
BH	Bloomington Hills
BLM	Bureau of Land Management
BN	Bechtel Nevada
BOD_5	5-day biological oxygen demand
Bq	Becquerel(s)
Bq/m^3	Becquerels per cubic meter
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”)
°C	degrees Centigrade
CA	Composite Analysis
CAA	Clean Air Act
CADD	Corrective Action Decision Document
CAIP	Corrective Action Investigation 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
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
CNR	Classified Non-Radiological
CNRH	Classified Non-Radiological Hazardous
Co	cobalt
CO	carbon monoxide
COC	contaminant of concern
COPC	contaminant of potential concern
cpm	counts per minute
CR	Closure Report
CRMP	Cultural Resources Management Program
Cs	cesium
CV	coefficient of variation
CY	calendar year
d	day(s)
DAF	Device Assembly Facility

DAQ	Department of Air Quality (Clark County)
DCS	Derived Concentration Standard
D&D	decontamination and decommissioning
DEAR	U.S. Department of Energy Acquisition Regulation
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
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
DSA	Documented Safety Analysis
DU	depleted uranium
E1	Environmental 1
E2	Environmental 2
EDE	effective dose equivalent
EHS	extremely hazardous substance
EM	Environmental Management
EMAC	Ecological Monitoring and Compliance
E-MAD	Engine Maintenance and Disassembly
EMS	Environmental Management System
E.O.	Executive Order
EODU	Explosive Ordnance Disposal Unit
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ER	Environmental Restoration
ERA	Environmental Research Associates
ETDS	E-Tunnel Waste Water Disposal System
Eu	europium
EWDP	Early Warning Drill Program
°F	degrees Fahrenheit
FD	field duplicate
FFACO	Federal Facility Agreement and Consent Order
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
ft	foot or feet
ft^2	square feet
ft^3	cubic feet
FS	field sample
FWS	U.S. Fish and Wildlife Service
FY	fiscal year
g	gram(s)
gal	gallon(s)
gal/ft^2	gallons used per square foot
GHG	greenhouse gas
GIS	Geographic Information System
GPD	gallon(s) per day
gsf	gross square feet
Gy	gray(s)
Gy/d	gray(s) per day
h	hour(s)
^3H	tritium
HAP	hazardous air pollutant
HENRE	High-Energy Neutron Reactions Experiment
HEPA	high-efficiency particulate air
HEST	High Explosives Simulation Test
HPSB	High Performance Sustainable Building
hr	hour(s)
HW	hazardous waste
HWAA	Hazardous Waste Accumulation Area
HWSU	Hazardous Waste Storage Unit
I	iodine
IA	Independent Assessment
ICRP	International Comission on Radiological Protection
ID	identification number
IEC	International Electrotechnical Commission
IL	investigation level
ILA	industrial, landscaping, and agricultural
in.	inch(es)
IOC	inorganic chemical
ISO	International Organization for Standardization
JASPER	Joint Actinide Shock Physics Experimental Research
K	potassium

kg	kilogram(s)
kg/d	kilogram(s) per day
km	kilometer(s)
km^2	square kilometer(s)
kV	kilovolt(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
LEPC	Local Emergency Planning Commission
LLNL	Lawrence Livermore National Laboratory
LLW	low-level waste
log	logarithmic
LQAP	Laboratory Quality Assurance Plan
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
MHD	Mercury Historic District
mi	mile(s)
mi^2	square mile(s)
min	minute(s)
mL	milliliter
MLLW	mixed low-level waste
mm	millimeter(s)
mmhos/cm	millimhos per centimeter
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
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	microcurie(s)
µCi/mL	microcurie(s) per milliliter
µg/L	microgram(s) per liter
µm	micrometer(s)
µR	microroentgen(s)
µR/hr	microroentgen(s) per hour
µS/cm	microseimen(s) per centimeter
N	nitrogen
NA	not applicable
NAAQS	National Ambient Air Quality Standards
NAC	Nevada Administrative Code
NATM	National Atomic Testing Museum
NCA	Nevada Combined Agency
NCERC	National Criticality Experiments Research Center
NC-GWE	Nye County Groundwater Evaluation
nCi	nanocurie(s)
ND	not detected
NDEP	Nevada Division of Environmental Protection
NDOA	Nevada Department of Agriculture
NDOF	Nevada Department of Forestry
NDOW	Nevada Department of Wildlife
NELAC	National Environmental Laboratory Accreditation Conference
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act

NLVF	North Las Vegas Facility
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
NNSS	Nevada National Security Site
NNSSER	Nevada National Security Site Environmental Report
NOV	Notice of Violation
NO_x	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NPTEC	Nonproliferation Test and Evaluation Complex
NRDS	Nuclear Rocket Development Station
NRHP	National Register of Historic Places
NRS	Nevada Revised Statutes
NS	not required to be sampled
NSHPO	Nevada State Historic Preservation Office
NSPS	New Source Performance Standards
NSSAB	Nevada Site Specific Advisory Board
NSTec	National Security Technologies, LLC
NTS	Nevada Test Site
NTTR	Nevada Test and Training Range
NV	Nevada
NVLAP	National Voluntary Laboratory Accreditation Program
ODS	ozone-depleting substance
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
PAC	polycyclic aromatic hydrocarbon
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
PI	prediction interval
PIC	pressurized ion chamber
PM	particulate matter
PM10	particulate matter equal to or less than 10 microns in diameter
ppm	part(s) per million
POE	point of entry
PSU	Portland State University
PT	proficiency testing
PTE	potential to emit
Pu	plutonium
PUE	Power Utilization Effectiveness
PV	photovoltaic
PVC	polyvinyl chloride
PWS	public water system
Q	water quality
QA	quality assurance
QAMAP	Quality Assurance Management and Assessment Plan
QAP	Quality Assurance Program (or Plan)
QC	quality control
Q/L	water quality and water level
QSM	Quality Systems Manual
R	roentgen(s)
Ra	radium
rad	radiation absorbed dose (a unit of measure)
rad/d	rad(s) per day
RCRA	Resource Conservation and Recovery Act
rem	roentgen equivalent man
RER	relative error ratio
RFP	request for proposal
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
RWMC	Radioactive Waste Management Complex
RWMS	Radioactive Waste Management Site
s	second(s)

SAA	Satellite Accumulation Area
SAD	surface area disturbance
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
SHPO	State Historic Preservation Office
SI	International System of Units
SIS	Sprung Instant Structure
SLEIS	State and Local Emissions Inventory System
SNHD	Southern Nevada Health District
SOC	synthetic organic chemical
SO_2	sulfur dioxide
SPCC	Spill Prevention, Control, and Countermeasure
Sr	strontium
SSP	Site Sustainability Plan
SSPP	Strategic Sustainability Performance Plan
S.U.	standard unit(s) (for measuring pH)
Sv	sievert(s)
SWEIS	Site-Wide Environmental Impact Statement
Tc	technetium
TDS	total dissolved solids
TEDE	total effective dose equivalent
Th	thorium
TLD	thermoluminescent dosimeter
TPC	Tribal Planning Committee
TPCB	Transuranic Pad Cover Building
TRC	Tribal Revegetation Committee
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
UGT	underground test
UGTA	Underground Test Area
U.S.	United States
USAF	U.S. Air Force
USC	United States Code
USGS	U.S. Geological Survey
UST	underground storage tank
UXO	unexploded ordnance
VERB	Visual Examination and Repackaging Building
VOC	volatile organic compound
VZM	vadose zone monitoring
WDP	water delivery point
WEF	Waste Examination Facility
WIPP	Waste Isolation Pilot Plant
WO	Waste Operations
WW	water well
yd	yard(s)
yd^3	cubic yard(s)
yr	year(s)

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