

NEVADA NATIONAL

**NINSS**

SECURITY SITE



# Environmental Report 2015

September 2016



National Nuclear Security Administration

**National Security Technologies LLC**

*Vision • Service • Partnership*



# A Message from the Manager

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

The NNSA/NFO presents this environmental report to summarize actions taken in 2015 to protect the environment and the public while achieving our mission goals. It is prepared for the public and our stakeholders in hopes that it is readily understandable and usable. It is a key component in our efforts to keep the public informed of environmental conditions at the NNSS and its support facilities in Las Vegas, Nevada. The NNSA/NFO ensures the validity and accuracy of the data contained in this report.

We invite you to help us improve the usefulness and readability of this Environmental Report by providing your comments and concerns to Peter A. Sanders, ([peter.sanders@nnsa.doe.gov](mailto:peter.sanders@nnsa.doe.gov)).

*Steven J. Lawrence*

## **Steven J. Lawrence**

Nevada Field Office  
Manager



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# Environmental Report 2015

*This report was prepared for:*

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*By:*

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Las Vegas, Nevada**

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## ***Executive Summary***

This report was prepared to meet the information needs of the public and the requirements and guidelines of the U.S. Department of Energy (DOE) for annual site environmental reports. It was prepared by National Security Technologies, LLC (NSTec), for the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO). This and previous years' reports, called Annual Site Environmental Reports (ASERs), Nevada Test Site Environmental Reports (NTSERs), and Nevada National Security Site Environmental Reports (NNSSERs), are posted on the NNSA/NFO website at <http://www.nv.energy.gov/library/publications/aser.aspx>.

### ***Purpose and Scope of the NNSSER***

This NNSSER was prepared to satisfy DOE Order DOE O 231.1B, "Environment, Safety and Health Reporting." Its purpose is to (1) report compliance status with environmental standards and requirements, (2) present results of environmental monitoring of radiological and nonradiological effluents, (3) report estimated radiological doses to the public from releases of radioactive material, (4) summarize environmental incidents of noncompliance and actions taken in response to them, (5) describe the NNSA/NFO Environmental Management System and characterize its performance, and (6) highlight significant environmental programs and efforts.

This NNSSER summarizes data and compliance status for calendar year 2015 at the Nevada National Security Site (NNSS) and its two support facilities, the North Las Vegas Facility (NLVF) and the Remote Sensing Laboratory–Nellis (RSL–Nellis). It also addresses environmental restoration (ER) projects conducted at the Tonopah Test Range (TTR) and the Nevada Test and Training Range (NTTR). Through a Memorandum of Agreement, NNSA/NFO is responsible for the oversight of these ER projects, and the Sandia Field Office of NNSA (NNSA/SFO) has oversight of all other TTR and NTTR activities. NNSA/SFO produces the TTR annual environmental report, which is available at <http://www.sandia.gov/news/publications/environmental/index.html>.

### ***Major Site Programs and Facilities***

NNSA/NFO directs the management and operation of the NNSS and six sites across the nation. The six sites include two in Nevada (NLVF and RSL–Nellis) and four in other states (RSL–Andrews in Maryland, Livermore Operations in California, Los Alamos Operations in New Mexico, and Special Technologies Laboratory in California). Los Alamos, Lawrence Livermore, and Sandia National Laboratories are the principal organizations that sponsor and implement the nuclear weapons programs at the NNSS. NSTec is the current Management and Operating contractor accountable for the successful execution of work and ensuring that work is performed in compliance with environmental regulations. The six sites all provide support to enhance the NNSS as a location for weapons experimentation and nuclear test readiness.

The three major NNSS missions include National Security/Defense, Environmental Management, and Nondefense. The major programs that support these missions are Stockpile Stewardship and Management, Nonproliferation and Counterterrorism, Nuclear Emergency Response, Strategic Partnership Projects, Environmental Restoration, Waste Management, Conservation and Renewable Energy, Other Research and Development, and Infrastructure. The major facilities that support the programs include the U1a Facility, Big Explosives Experimental Facility (BEEF), Device Assembly Facility, Dense Plasma Focus Facility, Joint Actinide Shock Physics Experimental Research Facility, Radiological/Nuclear Countermeasures Test and Evaluation Complex, Nonproliferation Test and Evaluation Complex (NPTEC), Radiological/Nuclear Weapons of Mass Destruction Incident Exercise Site (known as the T-1 Site), Area 5 Radioactive Waste Management Complex (RWMC), and the Area 3 Radioactive Waste Management Site (RWMS).

### ***Other Key Environmental Initiatives***

In addition to the environmental restoration efforts to clean up legacy contamination from historical nuclear testing activities, NNSA/NFO pursues several other environmental key initiatives. They are components of the Nondefense mission of NNSA/NFO to prevent pollution, minimize waste generation, conserve water, advance energy efficiency, reduce fossil fuel use, pursue renewable energy sources, and support the federal goals within all of these areas

promulgated through executive orders and DOE orders. These initiatives are pursued through the Energy Management Program and the Pollution Prevention and Waste Minimization (P2/WM) Program discussed below.

## ***Environmental Performance Measures Programs***

During the conduct of the major programs mentioned above, NNSA/NFO complies with applicable environmental and public health protection regulations and strives to manage the NNSS as a unique and valuable national resource. To identify NNSS environmental initiatives, NNSA/NFO implements an Integrated Safety Management System (ISMS) and an Environmental Management System (EMS). The ISMS is designed to ensure the systematic integration of environment, safety, and health concerns into management and work practices so that NNSS missions are accomplished safely and in a manner that protects the environment. NNSA/NFO oversees ISMS implementation through the Integrated Safety Management Council.

The NSTec EMS is designed to incorporate concern for environmental performance throughout NNSA/NFO programs and activities, with the ultimate goal being continual reduction of program impacts on the environment. NSTec's EMS attained International Organization for Standardization (ISO) 14001 certification in 2008. The ISO 14001 certifying organization, Lloyd's Register Quality Assurance (LRQA) recertified the EMS for another 3 years in June 2014. LRQA conducts annual surveillances on focused portions of the EMS, and findings and recommendations are tracked in the NSTec companywide issues tracking system, caWeb. In addition, internal independent audits, management assessments, and compliance evaluations are conducted annually to promote continual improvement. In April 2015, the LRQA conducted its annual surveillance and no issues were found. An internal EMS audit was conducted in February 2015 and throughout 2015, a total of 6 internal management assessments and 57 compliance evaluations were conducted. Fifteen regulatory and procedural non-compliance issues were found and corrected.

Each fiscal year (FY) (October 1 through September 30), an Environmental Working Group (EWG) helps determine what EMS objectives and targets will be worked on and tracked to address specific environmental aspects of NNSA/NFO operations. Some of the EMS objectives and targets support DOE in attaining their complex-wide site sustainability goals, which are published annually in a DOE Strategic Sustainability Performance Plan (SSPP), and implemented and tracked through the Energy Management Program (EMP) and the P2/WM Program. In 2015, the EWG identified two objectives. One was to develop an electronic chemical management system that will serve environmental, safety, emergency planning, and operational needs. The second was to identify biobased and environmentally preferable products that could be purchased as replacements for non-biobased and less preferable products.

The EMP advances energy efficiency, water conservation, fossil fuel reduction, greenhouse gas reduction, and the use of solar and other renewable energy sources at the NNSS, NLVF, and RSL-Nellis. The EMP prepares annually an NNSA/NFO Site Sustainability Plan (SSP), which describes all of the DOE SSPP goals, NNSA/NFO's current performance status towards reaching each goal, and planned actions to meet each goal. As of the end of 2015, NNSA/NFO has met 8 of the 15 DOE long-term goals related to reducing energy, water, petroleum fuel use, and greenhouse gas emissions.

The P2/WM Program promotes activities that reduce or eliminate waste generation, reduce the release of pollutants to the environment, and reduce the use of Class I ozone-depleting substances. In 2015, 31% of non-hazardous solid waste and 20% of construction waste was diverted from disposal in NNSS landfills through re-use and recycling. The DOE SSPP target goals for FY 2015 were 50% for both. These goals may not be reached on the NNSS without additional funding.

The 2015 Facility EMS Annual Report Data for the NNSS was entered into the DOE Headquarters' EMS database. The report includes a scorecard section that is a series of questions regarding a site's EMS effectiveness in meeting the objectives of federal EMS directives. The NNSS scored "green" (the highest score) in 2015. Progress towards meeting EMS goals and DOE sustainability goals is summarized in Chapter 3.

## Environmental Awards

The NNSS was recognized in 2015 for having one of the cleanest, most fuel-efficient government vehicle fleets in the nation. Competing with more than 38,000 public fleets, NSTec's Fleet, Fuel & Equipment Service operation was ranked fourth in the nation by the 100 Best Fleets, Green Fleet Awards Organization within the category of Government Green Fleets. To be recognized for having a top fleet, a company must demonstrate vision, outstanding operations, and strategic planning toward the future environmental role of their fleet that other public fleets can emulate; reduction in greenhouse gas emissions; and fleet composition demonstrating a commitment to the use of hybrid vehicles, plug-in electric vehicles, and alternative fueled vehicles (AFVs). Candidates must demonstrate fleet utilization goals that validate a strong commitment to a "green" approach toward keeping the environment clean. NSTec's fleet comprises over 900 vehicles ranging from sedans to large trucks. All new light duty vehicles leased in 2015 (totaling 92 vehicles) are either AFVs, zero emission, or plug-in hybrid electric vehicles.

Throughout this document, the definition of word(s) that are in **bold italics** may be found by clicking on [Glossary, Appendix B](#) adjacent to the word(s). To return from the Glossary, right click and select Previous View.

## Compliance

One measure of the effectiveness of the EMS is the degree of compliance with applicable environmental laws, regulations, and policies that protect the environment and the public from the effects of NNSA/NFO operations. In 2015, NNSA/NFO complied with all federal statutes, as shown below.

Federal Statute	What it Covers	2015 Status
<b>Radiation Protection</b>		
DOE O 458.1, "Radiation Protection of the Public and the Environment" (and its predecessor of the same name, DOE O 5400.5)	Measuring radioactivity in the environment and estimating radiological dose to the public due to NNSA/NFO activities	Radiological monitoring was conducted by NNSA/NFO at 17 onsite air stations, 1 offsite and 14 onsite groundwater sources, and 103 stations measuring direct gamma radiation. Six plant and 4 small mammal samples from 1 study location and its control location; 4 opportunistic samples of large game animals; and 20 desert bighorn sheep blood samples were collected to monitor biota.  The dose to the <b>maximally exposed individual (MEI)</b> (see <a href="#">Glossary, Appendix B</a> ) from all exposure pathways due to NNSA/NFO activities was estimated to be 2.91 millirems per year (mrem/yr), well below the DOE limit of 100 mrem/yr. The majority of this dose (2.87 mrem/yr) is estimated to come from the ingestion of game animals.
Atomic Energy Act (through compliance with DOE O 435.1, "Radioactive Waste Management")	Management of <b>low-level waste (LLW)</b> and <b>mixed low-level waste (MLLW)</b> (see <a href="#">Glossary, Appendix B</a> ) generated or disposed on site	1,334,186 cubic feet of radioactive wastes including LLW, MLLW, and non-radioactive classified items were received and disposed on site. All amounts of disposed radiological wastes for permitted disposal units were within permit limits. All vadose zone and groundwater monitoring continued to verify that disposed LLW and MLLW are not migrating to groundwater or threatening biota or the environment.
<b>Air Quality and Protection</b>		
Clean Air Act: National Emission Standards for Hazardous Air Pollutants (NESHAP) National Ambient Air Quality Standards (NAAQS) New Source Performance Standards (NSPS) Stratospheric Ozone Protection	Air quality and emissions into the air from facility operations	There are no major sources of <b>criteria pollutants</b> (see <a href="#">Glossary, Appendix B</a> ) or <b>hazardous air pollutants</b> (see <a href="#">Glossary, Appendix B</a> ) at the NNSS, NLVF, or RSL-Nellis. Monitored radioactive air emissions were below NESHAP's limits. All non-radiological air emission limits as well as all monitoring, record keeping, training, and reporting requirements of state and county air permits were met with one exception: a generator at RSL-Nellis exceeded its opacity limits. The 17 onsite continuous air sampling stations detected man-made <b>radionuclides</b> (see <a href="#">Glossary, Appendix B</a> ) at levels comparable to previous years and well below the regulatory dose limit for air emissions to the public of 10 mrem/yr. The estimated dose from all 2015 NNSS air emissions to the MEI is 0.04 mrem/yr.

Federal Statute	What it Covers	2015 Status
<b>Water Quality and Protection</b>		
Clean Water Act (CWA)	Water quality and effluent discharges from facility operations	<p>All required maintenance, monitoring, and reporting were conducted for permitted wastewater systems and monitoring wells. All domestic and industrial wastewater systems and groundwater monitoring well samples were within permit limits for regulated water contaminants and water chemistry parameters.</p> <p>Pumped groundwater samples at the NLVF were all within National Pollutant Discharge Elimination System (NPDES) permit limits. NNSS operations do not require any NPDES permits.</p>
Safe Drinking Water Act (SDWA)	Quality of drinking water	<p>All three permitted <i>public water systems (PWSs)</i> (see <a href="#">Glossary, Appendix B</a>) on the NNSS met the applicable national and state water quality standards. Levels of aluminum and iron which had exceeded Nevada’s Secondary Standards in 2014 in the Area 25 PWS, returned to within their permit limits in 2015.</p>
<b>Waste and Hazardous Materials Management and Environmental Restoration</b>		
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)/Superfund Amendments and Reauthorization Act (SARA)	Cleanup of waste sites containing hazardous substances	<p>No <i>hazardous waste (HW)</i> (see <a href="#">Glossary, Appendix B</a>) cleanup operations on the NNSS are regulated under CERCLA or SARA; they are regulated under the Resource Conservation and Recovery Act (RCRA) instead. The requirements of CERCLA applicable to the NNSS pertain to an emergency response program for hazardous substance releases (see Emergency Planning and Community Right-to-Know Act [EPCRA] below) and to how state laws concerning the removal and remediation of hazardous substances apply to federal facilities (specifically, implementation of the Federal Facility Agreement and Consent Order [FFACO]).</p>
Federal Facility Agreement and Consent Order (FFACO)	Cleanup of waste sites containing hazardous substances	<p>All 2015 milestones established under the FFACO with the State of Nevada were met for conducting corrective actions and closures of historical contaminated sites called corrective action sites (CASs). A total of 24 Soils CASs were closed in accordance with state-approved corrective action plans.</p>
Resource Conservation and Recovery Act (RCRA)	Generation, management, and/or disposal of HW and MLLW and cleanup of inactive, historical waste sites	<p>A total of 1,379 tons of MLLW were received and disposed in Cell 18; 0.75 tons of MLLW were received at, and shipped for offsite disposal from, the Mixed Waste Disposal Unit; 6.9 tons of HW and 0.005 tons of polychlorinated biphenyl (PCB) waste were received for onsite storage at the Hazardous Waste Storage Unit (HWSU); and 7.75 tons of HW and 0.92 tons of PCB waste were shipped for offsite disposal from the HWSU, all in accordance with state permits. No HW were shipped directly off site from Hazardous Waste Accumulation Areas, and no waste explosive ordnance were detonated on site.</p> <p>Semiannual water samples from three groundwater monitoring wells at the Area 5 RWMC confirmed that buried MLLW remains contained.</p> <p>All vadose zone monitoring and post-closure inspections of historical RCRA closure sites confirmed the sites’ integrity to contain HW.</p>
National Environmental Policy Act (NEPA)	Projects are evaluated for environmental impacts	<p>NNSA/NFO evaluated 25 projects; 20 of them were exempted from further NEPA analysis due to their inclusion under previous analysis in the <i>Site-Wide Environmental Impact Statement for the Nevada National Security Site and Offsite Locations in Nevada</i> published in 2014, and 5 were exempted as categorical exclusions under NEPA.</p>

Federal Statute	What it Covers	2015 Status
Toxic Substances Control Act (TSCA)	Management and disposal of PCBs	Seven drums and one pail of PCB-contaminated materials were shipped off site to permitted disposal and treatment facilities. Their contents included transformer oil, debris, fluorescent light ballasts, and immersion liquid.
<b>Waste and Hazardous Materials Management and Environmental Restoration (continued)</b>		
Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)	Storage and use of pesticides and herbicides	Only non-restricted-use pesticides/herbicides were applied by State of Nevada–certified personnel. Storage and use of pesticides were in compliance with federal and state regulations.
Emergency Planning and Community Right-to-Know Act (EPCRA)	The public’s right to know about chemicals released into the community	No accidental or unplanned release of an extremely hazardous substance occurred at the NNSS, NLVF, or RSL-Nellis in 2015. The chemical inventory for NNSS, NLVF, and RSL-Nellis was updated and submitted to the State of Nevada.  As part of routine activities and cleanup operations, reportable quantities of lead, mercury, and PCBs were released at the NNSS in 2015 and reported to the U.S. Environmental Protection Agency. Releases included onsite disposal, offsite disposal, and offsite recycling and totaled 72,323 pounds (lb) of lead, 6,473 lb of mercury, and 30.4 lb of PCBs.
<b>Other Environmental Statutes</b>		
Endangered Species Act (ESA)	Threatened or endangered species of plants and animals	Field surveys for 5 proposed projects in desert tortoise habitat and 8 projects in other habitats on the NNSS were conducted; no tortoise habitat was disturbed. No tortoises were harmed at or displaced from project sites. Two tortoises were accidentally killed by vehicles on paved roads, and 17 were moved off of roads out of harm’s way. All actions were in compliance with the U.S. Fish and Wildlife Service’s requirements for work conducted in desert tortoise habitat.
National Historic Preservation Act (NHPA)	Identifying and preserving historic properties	NNSA/NFO maintained compliance with the NHPA. Archival research for 29 proposed projects was conducted, and 318 acres were surveyed for 11 of the projects; 10 historic or prehistoric sites and 20 historic structures were identified.
Migratory Bird Treaty Act (MBTA)	Protecting migratory birds, nests, and eggs from harm	During biological surveys for proposed projects, 9 burrowing owl burrows, 3 active bird nests, and 10 inactive bird nests were found, and project personnel were instructed to avoid them. However, 15 accidental bird deaths due to human activities were documented.

## ***Occurrences and Unplanned Releases***

No unplanned airborne releases and no unplanned releases of radioactive liquids occurred from the NNSS, NLVF, or RSL-Nellis in 2015. There were 7 reportable environmental occurrences in 2015: (1) legacy cesium-137 was detected on the outside of a shield box at RSL-Nellis, (2) state drinking water standards for iron and aluminum were exceeded in two quarterly water samples from an NNSS public water system, (3) a fire involving waste drums of potassium nitrate and potassium chlorate broke out at a 90-Day Accumulation Area on the NNSS, (4) a tractor-scraper rolled over at an NNSS well construction site spilling 39 gallons of various oils, (5) radiological control technicians identified debris having elevated radiological readings that were outside posted radiological areas at two remediation sites on the NNSS and one remediation site on the TTR, (6) *tritium* (see [Glossary, Appendix B](#)) was detected at the NNSS Dense Plasma Focus Facility on the vent line from the containment tent, and (7) an emergency generator at RSL-Nellis exceeded county air permit requirements.

All proper notifications and corrective actions were taken. These 7 reportable occurrences are summarized in Table 2-8 of Chapter 2. Twenty-three minor spills occurred at the NNSS, 2 at NLVF, and 2 at RSL-Nellis, none

of which met regulatory agency reporting criteria. They consisted of small-volume releases either to containment areas or to other surfaces and did not exceed a reportable quantity. All these minor spills were cleaned up.

## ***Radiation Dose to the Public***

**Background Gamma Radiation** – Mean background gamma radiation exposure rates on the NNSS are estimated using 10 thermoluminescent dosimeter (TLD) stations located away from radiologically contaminated sites. The average mean exposure rate among these 10 stations in 2015 was 118 milliroentgen per year (mR/yr) and ranged from 79 to 159 mR/yr (Section 6.3.1). The Desert Research Institute (DRI) used TLDs at offsite locations in 2015, and their mean measurements ranged from 85 mR/yr at Pahrup, Nevada, to 150 mR/yr at Beatty, Nevada (Section 7.1.4).

**Public Dose from Direct Radiation** – Areas accessible to the public had direct external gamma radiation exposure rates in 2015 comparable to natural background rates. The TLD locations on the west and north sides of the parking area at Gate 100 (the NNSS entrance gate) had estimated annual mean exposures of 76 and 62 mR/yr, respectively, similar to the range of background exposures observed on the NNSS (Section 6.3.2). Military or other personnel on the NTTR could be exposed to direct radiation from legacy sites on Frenchman Lake playa. A TLD location in the playa and near the NNSS boundary with NTTR had an estimated annual exposure of 250 mR (Section 6.3.2). This represents an above-background exposure of 91 to 171 mrem/yr (depending on which background radiation value is subtracted), which might exceed the 100 mrem/yr dose limit if a member of the public were to reside at this location. However, there are no living quarters or full-time personnel in that area. Because the nearest resident does not live in close proximity of the site, there is no dose contribution from external gamma radiation from NNSS operations to the public.

**Public Dose from Drinking Water** – Man-made radionuclides from past nuclear testing have not been detected in offsite drinking water supply wells or springs in the past or during 2015 (Section 5.1.2). Therefore, there is no dose contribution from drinking water to the public due to NNSS operations.

**Public Dose from Inhalation** – The radiation dose limit to the public via the air transport pathway is established by NESHAP under the Clean Air Act to be 10 mrem/yr. The U.S. Environmental Protection Agency (EPA), Region 9, has approved the use of six air sampling stations on the NNSS to verify compliance with this dose limit. The following radionuclides were detected in samples from at least one of the critical receptor samplers: americium-241 ( $^{241}\text{Am}$ ), plutonium-238 ( $^{238}\text{Pu}$ ), plutonium-239+240 ( $^{239+240}\text{Pu}$ ), cesium-137 ( $^{137}\text{Cs}$ ), and tritium ( $^3\text{H}$ ) (Section 4.1.4). Concentrations of these radionuclides at each of the stations indicated that the NESHAP dose limit to the public was not exceeded. The Schooner station in the far northwest corner of the NNSS showed the highest concentrations of radioactive air emissions (Section 4.1.5). The Gate 510 sampler, however, is the closest station to a public receptor (3.5 kilometers [km] [2.2 miles (mi)]). The estimated *effective dose equivalent* (see [Glossary, Appendix B](#)) from air emissions for a hypothetical individual living year-round at the Gate 510 sampler would be 0.04 mrem/yr.

**Public Dose from Ingestion of Radionuclides in Game Animals** – Game animals are analyzed for their radionuclide content to estimate the dose to the public who might consume these animals if they were to move off the NNSS and be harvested by hunters. In 2015, tissue samples were collected from two jackrabbits from Sedan; two cottontail rabbits from the Sedan control site; and one mule deer and three pronghorn antelope accidentally killed on NNSS roads. An individual who consumes one pronghorn antelope having elevated radionuclide concentrations like the one sampled in 2015 may receive an estimated 2.87 mrem/yr dose (Section 9.1.1.2).

**Public Dose from All Pathways** – The radiation dose limit to the general public via all possible transport pathways (over and above background dose) established by DOE is 100 mrem/yr. The public dose from all pathways in 2015 was estimated to be 2.91 mrem/yr. This is 2.91% of the 100 mrem/yr dose limit and about 0.80% of the total dose the MEI receives from natural background radiation (360 mrem/yr) (Section 9.1.3).

## Monitoring of Radiological Releases into Air

**Offsite** – An offsite radiological air monitoring program is run by the Community Environmental Monitoring Program (CEMP) and is coordinated by DRI of the Nevada System of Higher Education under contract with NNSA/NFO (Chapter 7). It is a non-regulatory public informational and outreach program, and its purpose is to provide monitoring for radionuclides that might be released from the NNSS. A network of 24 CEMP stations monitor gross alpha and beta radioactivity in airborne particulates using low-volume particulate air samplers, penetrating gamma radiation using TLDs, gamma radiation exposure rates using pressurized ion chamber (PIC) detectors, and meteorological parameters using automated weather instrumentation. The stations are located in selected towns and communities of southern Nevada, southeastern California, and southwestern Utah. DRI also manages four stations having only automated weather instrumentation that are located on private ranches.

As in previous years, no airborne radioactivity related to historical or current NNSS operations was detected in any of the samples from the CEMP particulate air samplers during 2015. TLD and PIC detectors measure gamma radiation from all sources: natural background radiation from cosmic and terrestrial sources and man-made sources. The offsite TLD and PIC results remained consistent with previous years' background levels and are well within background levels observed in other parts of the United States.

**Onsite** – Radionuclide emissions on the NNSS are from the following sources: (1) evaporation of tritiated water from containment ponds; (2) diffusion of tritiated water vapor from soil at the Area 3 RWMS, the Area 5 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) release of radionuclides from current operations. A network of 17 air sampling stations and a network of 103 TLDs on the NNSS were used to monitor onsite radioactive emissions.

Total radiological atmospheric releases from the NNSS in curies (Ci) for 2015 (Section 4.1.8) are shown in the table below. An estimated 0.0024 Ci of tritium were released at the NLVF.

<sup>3</sup> H	<sup>85</sup> Kr	Noble Gases (T <sub>1/2</sub> * <40 days)	Short-Lived Fission and Activation Products (T <sub>1/2</sub> <3 hr)	Fission and Activation Products (T <sub>1/2</sub> >3 hr)	Total Radio- iodine	Total Radio- strontium	Plutonium	Other Actinides
361	0.0011	3,056	6,108	0.069	0	0	0.041 ( <sup>238</sup> Pu) 0.29 ( <sup>239+240</sup> Pu)	0.066 ( <sup>241</sup> Am)

\* T<sub>1/2</sub> = half-life

The mean tritium concentration in air samples from across all tritium sampling stations was  $5.89 \times 10^{-6}$  picocuries per milliliter (pCi/mL) and ranged from below detection to  $296.14 \times 10^{-6}$  pCi/mL at the Schooner station (Section 4.1.4.6). The mean annual exposure rate for direct gamma radiation at the 41 TLDs located near active projects, working personnel, and public access areas was 113 mR, slightly less than the mean of 118 mR for the 10 NNSS stations that measure natural background levels (Section 6.3).

## Monitoring of Radionuclides in Water

**Offsite** – An offsite monitoring program for tritium in groundwater sampled from community or private wells is run by the CEMP and coordinated by DRI (Chapter 7). In 2015, the CEMP sampled groundwater for tritium in one community well from each of four communities: Tecopa (in California) and Amargosa Valley, Beatty, and Sarcobatus Flats (all in Nevada) (Section 7.2). These groundwater wells are located within the regional groundwater flow system that are downgradient or perceived to be downgradient of the NNSS. Tritium concentrations in the four wells in 2015 were all below analytical detection limits (Section 7.2.3).

NNSA/NFO's offsite groundwater sampling network includes eight NTTR Characterization wells (wells used to support the objectives of groundwater characterization and of modeling the flow of man-made radionuclides downgradient from historical underground nuclear tests), two NTTR Early Detection wells (wells that are the first

wells downgradient of an underground nuclear test or a Source/Plume well, but which currently contain no radiological contaminants above background levels), one NTTR Distal well (a well farther downgradient from Early Detection wells), and eight Community water sources that are on Bureau of Land Management (BLM) or private lands. In 2015, NNSA/NFO sampled one of the two Early Detection wells on NTTR. Tritium was detected at very low levels (5.2 pCi/L) (Section 5.1.1.3.1). Sample results collected to date, along with future sampling of the NTTR wells and modeling will be used to further develop flow and transport contamination models of the area.

Beginning in 2015, ten other downgradient wells, all within Nye County, were sampled under Nye County's new Tritium Sampling and Monitoring Program supported by NNSA/NFO (Chapter 5, Section 5.1.2). The DOE Environmental Management (EM) office issued a 5-year grant to Nye County for this program, expanding its support of offsite community-based groundwater monitoring. The grant supports annual sampling of 10 wells in the first year and up to 20 wells every year thereafter. Nye County did not detect tritium in any of the 10 wells.

Offsite water monitoring conducted in 2015 and over the past decade continues to verify that there are no man-made radionuclides from NNSA underground contamination areas in any public or private water supply wells or springs being monitored.

**Onsite** – NNSA/NFO's groundwater sampling network includes 20 onsite Characterization wells, 20 onsite Source/Plume wells (wells that contain contaminated groundwater verified to originate from NNSA underground nuclear testing and that are within the detonation region or are downgradient of the detonation at the plume edge), 8 onsite Early Detection wells, and 6 onsite Distal wells. NNSA/NFO also samples annually six permitted NNSA public water system (PWS) wells and five onsite locations called Compliance wells/surface waters, which are monitored to demonstrate compliance with specific federal/state regulations or NNSA permits.

In 2015, NNSA/NFO sampled six Characterization, three Source/Plume, two Early Detection, and three Distal wells on the NNSA for tritium. Of these, one of the Characterization and two of the Source/Plume had elevated tritium levels, as they have in previous years (Sections 5.1.1.3.1 and 5.1.1.3.2). Along with data from the offsite wells in the groundwater sampling network, data from all onsite wells are being used to aid in the development of a long-term closure monitoring network for each of the five known areas of groundwater contamination on the NNSA. The monitoring well networks will provide an early warning and allow for protective measures to be taken if contaminants are detected. The network will also comply with all corrective actions established under the FFACO with the State of Nevada (Section 11.1).

In 2015, the six NNSA PWS wells were sampled for tritium and for gross alpha and gross beta radioactivity. None of the PWS wells had detectable concentrations of tritium (Section 5.1.1.3.6). Detectable gross alpha and gross beta radioactivity found in many of the PWS well samples likely represents the presence of naturally occurring radionuclides, and none exceeded their EPA allowable limits for drinking water.

In 2015, the five onsite Compliance wells/surface waters were sampled for tritium and for gross alpha and gross beta radioactivity. They include three RCRA permitted wells for the Area 5 Mixed Waste Disposal Unit and one monitoring well and a series of holding ponds for the NDEP permitted E Tunnel Wastewater Disposal System in Area 12. All water samples were within their permit limits for these analytes (Section 5.1.1.3.7). Groundwater and drilling fluids discharged from wells monitored in 2015 were also sampled and found to be below the fluid management criteria limits for selected radiological and non-radiological parameters (Section 5.1.1.3.7.3).

## ***Release of Property Containing Residual Radioactive Material***

No property can be released from the NNSA unless the amount of residual radioactivity on the property is less than the authorized limits, which are consistent with DOE O 458.1. Items proposed for unrestricted release are either surveyed (physically sampled), 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 2015, 338 pieces of laboratory equipment, 11 vehicles, 2 pieces of heavy equipment, 35 miles of ground surface laid cable, 146,534.25 gallons of used highly refined mineral oil (Shell Diala® Oil AX), and 420,169 pounds of scrap metal were released off site to the public (Section 9.1.5). In addition, 19,034 pounds of lead in waste (e.g., lead acid batteries) were released to vendors for recycling or reuse (Section 2.4.4.1). No released items had residual radioactivity in excess of the authorized limits.

## ***Onsite Nonradiological Releases into Air***

The release of air pollutants is regulated on the NNSS under a Class II air quality operating permit. Class II permits are issued for minor sources where annual emissions must not exceed 100 tons of any one criteria pollutant, 10 tons of any one of the 189 hazardous air pollutants (HAPs), or 25 tons of any combination of HAPs. Criteria pollutants include sulfur dioxide, nitrogen oxides (NO<sub>x</sub>), carbon monoxide, particulate matter, and volatile organic compounds. The NNSS facilities regulated by the permit include (1) approximately 14 facilities and 131 pieces of equipment throughout the NNSS, (2) NPTEC, (3) Site-Wide Chemical Release Areas, (4) BEEF, (5) Explosives Ordnance Disposal Unit, and (6) Explosives Activities Sites in Areas 5, 14, 25, 26, and 27.

An estimated 11.76 tons of criteria air pollutants were released on the NNSS in 2015 (Section 4.2.3). The majority was NO<sub>x</sub> from diesel generators. Total HAPs emissions from permitted operations was 0.03 tons. Lead air emissions from non-permitted activities, such as weapons use, are reported to the EPA, and this quantity in 2015 was 2.72 pounds (Section 2.4.4.1). No emission limits for any criteria air pollutants or HAPs were exceeded.

Two chemical release test series were conducted in 2015 at the NPTEC in Area 5. One test series consisted of four releases conducted over a 2-day period. The second test took place over 8 days and involved 34 releases (Section 4.2.6). The majority of the chemicals released were neither HAPs nor criteria pollutants, and no permit limits were exceeded. In 2015, explosives were detonated at the BEEF and Port Gaston, and no permit limits were exceeded.

## ***Onsite Nonradiological Releases into Water***

There are no liquid discharges to navigable waters, offsite surface water drainage systems, or publicly owned treatment works resulting from operations on the NNSS. Therefore, no Clean Water Act NPDES permits are required for operations on the NNSS. Industrial discharges on the NNSS are limited to three operating sewage lagoon systems: the Area 6 Yucca Lake, the Area 23 Mercury, and the Area 6 Device Assembly Facility (DAF) systems. Sewage systems are monitored quarterly for influent quality and flow rate. Influent water samples are analyzed for 5-day biological oxygen demand, total suspended solids, and pH. In 2015, all water quality results were within the permit limits (Section 5.2.3.1). The Area 6 DAF sewage system exceeded its flow limit, but NDEP issued a waiver for the exceedance. Groundwater that drains from E Tunnel in Area 12, sampled for nonradiological contaminants (mainly metals), had levels of contaminants below permit limits (Section 5.2.4).

## ***Nonradiological Releases into Air and Water at NLVF and RSL-Nellis***

Sources of air pollutants at the NLVF and RSL-Nellis are regulated by permits from the Clark County Department of Air Quality. The regulated sources of air emissions include an abrasive blaster, an aluminum sander, a spray paint booth, diesel and gasoline generators, fire pumps, cooling towers, and boilers. The calculated total emissions of criteria pollutants at NLVF and RSL-Nellis were 1.88 and 2.48 tons per year, respectively (Appendix A, Sections A.1.1 and A.2.1). HAPs emissions are minor and are not regulated at either the NLVF or RSL-Nellis.

Water discharges at the NLVF are regulated by a permit with the City of North Las Vegas (CNLV) for sewer discharges and by an NPDES discharge permit issued by the Nevada Division of Environmental Protection for dewatering operations to control rising groundwater levels that surround the facility. The NPDES permit authorizes the discharge of pumped groundwater to the groundwater of the state via percolation and to the Las Vegas Wash via the CNLV storm drain system. Sewer discharge waters at the NLVF are no longer required to be sampled and analyzed for various contaminants (Appendix A, Section A.1.2.1). In 2015, the discharge from pumped groundwater at the NLVF did not exceed NPDES permit limits, and quarterly, annual, and biennial water samples of the pumped groundwater analyzed in 2015 had water quality measurements that were all below permit limits (Appendix A, Section A.1.2.2). No wastewater quality monitoring is required by the Clark County Water Reclamation District (CCWRD) at RSL-Nellis. Instead, a Zero Discharge Form is submitted annually to the CCWRD.

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# Chapter 1: Introduction and Helpful Information

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## 1.1 Site Location

The U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) (called the Nevada Site Office [NNSA/NSO] prior to March 2013) directs the management and operation of the Nevada National Security Site (NNSS). The NNSS is located in Nye County in south-central Nevada (Figure 1-1). The southeast corner of the NNSS is about 88 kilometers (km) (55 miles [mi]) northwest of the center of Las Vegas in Clark County. By highway, it is about 105 km (65 mi) from the center of Las Vegas to Mercury. Mercury, at the southern end of the NNSS, is the main base camp for worker housing and administrative operations for the NNSS.

The NNSS encompasses about 3,522 square kilometers (km<sup>2</sup>) (1,360 square miles [mi<sup>2</sup>]) based on the most recent land survey. It varies from 46 to 56 km (28 to 35 mi) in width from west to east and from 64 to 88 km (40 to 55 mi) from north to south. The NNSS is surrounded on all sides by federal lands (Figure 1-1). 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 Range, and on the south and southwest by Bureau of Land Management lands. The combination of the NTTR and the NNSS represents one of the largest unpopulated land areas in the United States, comprising some 14,200 km<sup>2</sup> (5,470 mi<sup>2</sup>).

## 1.2 Environmental Setting

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

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

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

Throughout this document, the definition of word(s) that are in ***bold italics*** may be found by clicking on [Glossary, Appendix B](#) adjacent to the word(s). To return from the Glossary, right click and select Previous View.

## 1.3 Site History

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

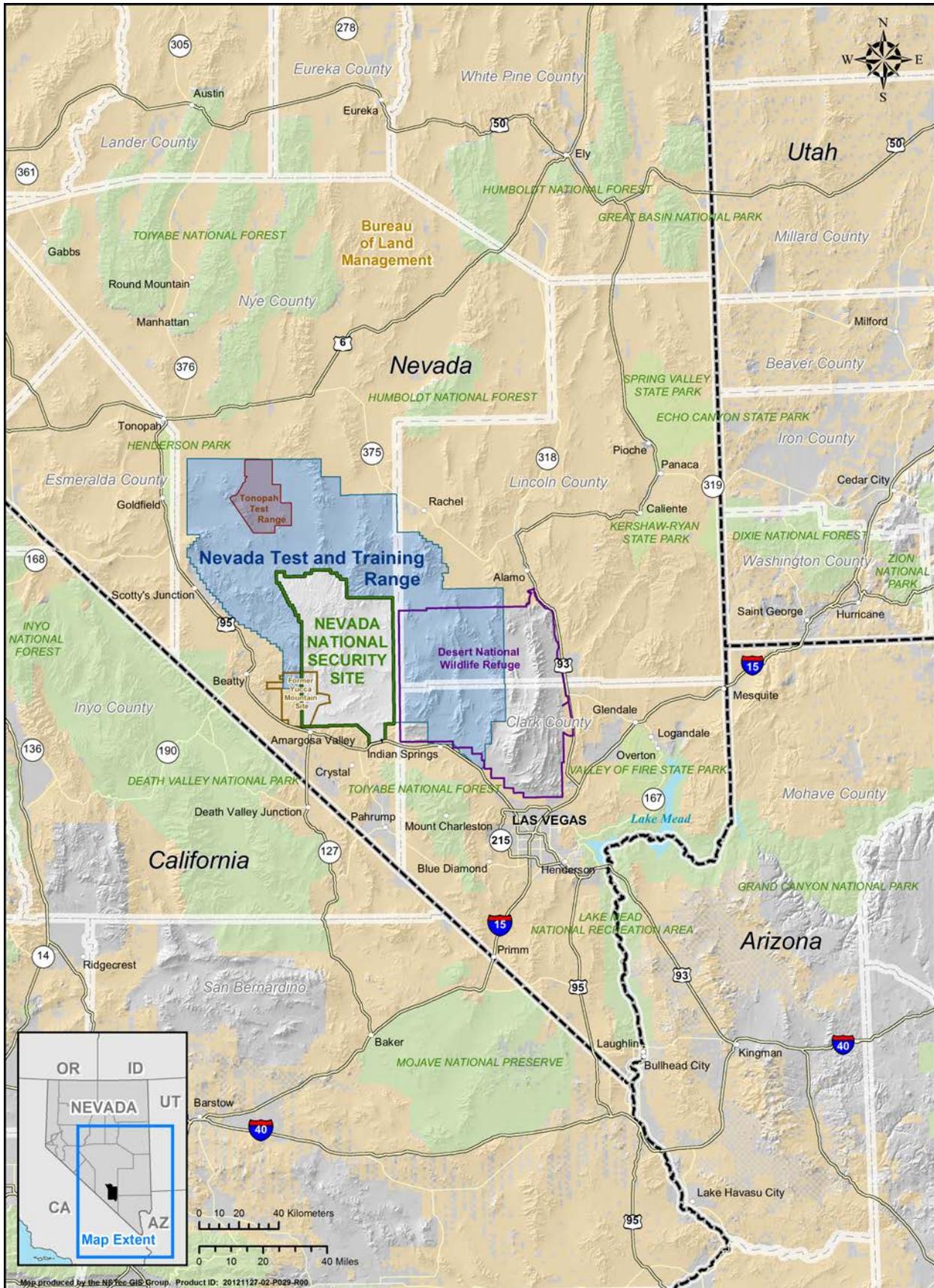


Figure 1-1. NNSS vicinity map

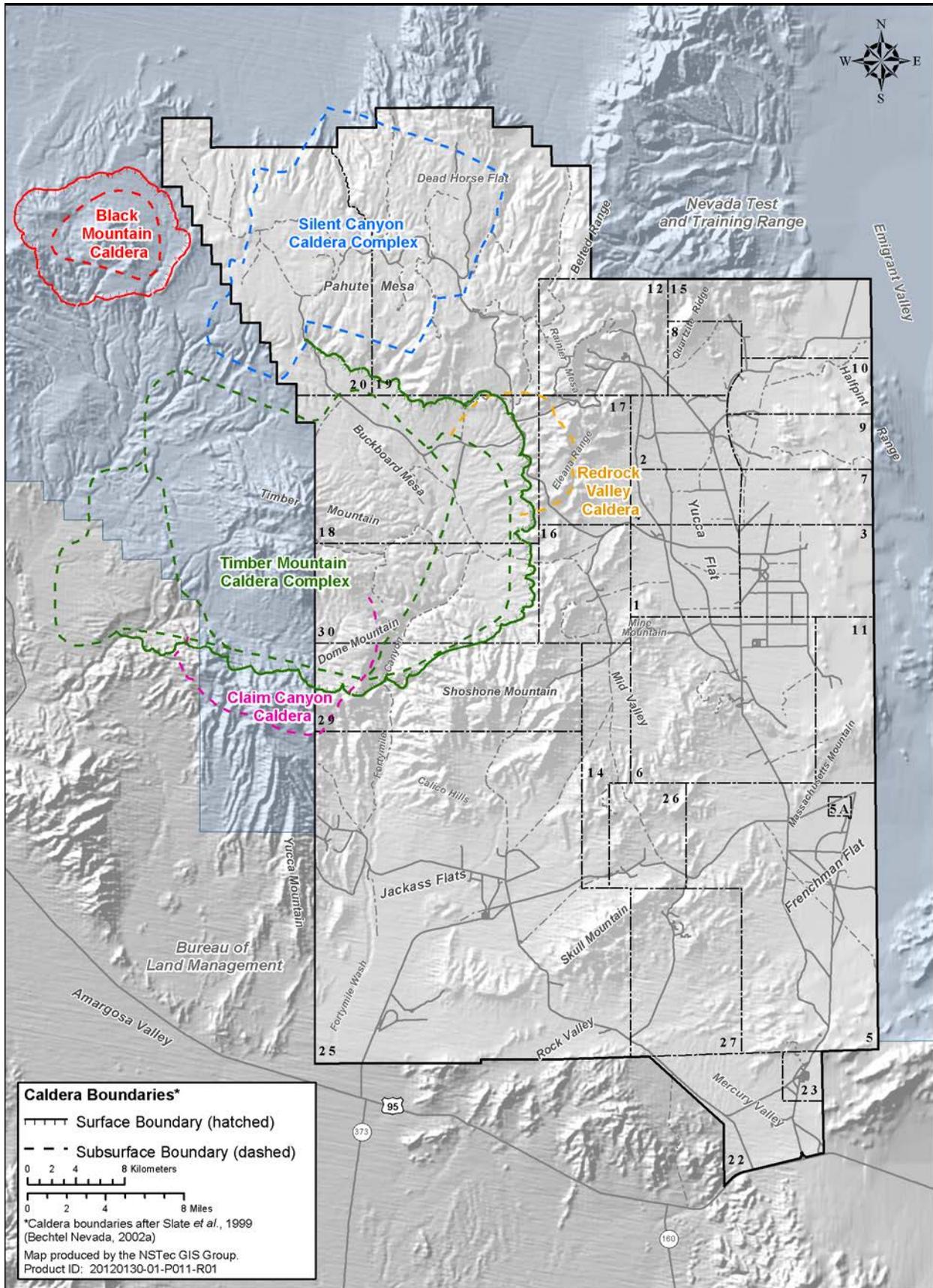


Figure 1-2. Major topographic features and calderas of the NNSS

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

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

**Underground Tests** – The first underground test, a cratering test, was conducted in 1951. The first totally contained underground test was in 1957. Testing was discontinued during a bilateral moratorium that began October 31, 1958, but was resumed in September 1961 after the Union of Soviet Socialist Republics resumed nuclear testing. After late 1962, nearly all tests were conducted in sealed vertical shafts drilled into Yucca Flat and Pahute Mesa or in horizontal tunnels mined into Rainier Mesa. 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* (see [Glossary, Appendix B](#)).

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

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

Fact sheets on many of the historical tests mentioned above can be found at <http://www.nv.energy.gov/library/factsheets.aspx>. All nuclear device tests are listed in *United States Nuclear Tests, July 1945 through September 1992* (NNSA/NFO 2015).

## 1.4 Site Mission

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

## ***NNSS Missions and Programs***

### **National Security/Defense Missions**

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

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

Strategic Partnership Projects – Provides support facilities and capabilities for other DOE programs and federal agencies/organizations involved in defense-related activities (formerly known as the Work for Others Program).

### **Environmental Management Missions**

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

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

### **Nondefense Missions**

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

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

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

## ***1.5 Primary Facilities and Activities***

The NNSS facilities or centers that support the National Security/Defense missions include the U1a Complex, Big Explosives Experimental Facility, 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 (located within the DAF), the Radiological/Nuclear Countermeasures Test and Evaluation Complex (RNCTEC), and the Radiological/Nuclear Weapons of Mass Destruction Incident Exercise Site (known as the T-1 Site). NNSS facilities that support Environmental Management missions include the currently active Area 5 Radioactive Waste Management Complex (RWMC) and the Area 3 Radioactive Waste Management Site (RWMS), which is in cold standby (Figure 1-3).

The primary NNSS activity in 2015 was helping to ensure that the U.S. stockpile of nuclear weapons remains safe and reliable. Other 2015 NNSS activities included weapons of mass destruction first responder training; the controlled release of hazardous material at NPTEC; remediation of legacy contamination sites; processing of waste destined for the Waste Isolation Pilot Plant in Carlsbad, New Mexico, or the Idaho National Laboratory in Idaho Falls, Idaho; and disposal of low-level and mixed low-level radioactive waste. Land use by each of the NNSS missions occurs within designated zones (Figure 1-4).

## ***1.6 Scope of Environmental Report***

This report summarizes data and the compliance status of the NNSA/NFO environmental protection and monitoring programs for calendar year 2015 at the NNSS and at its two support facilities, the NLVF and RSL-Nellis. This report also addresses environmental restoration (ER) projects conducted at the Tonopah Test Range (TTR) (see Figure 1-1).

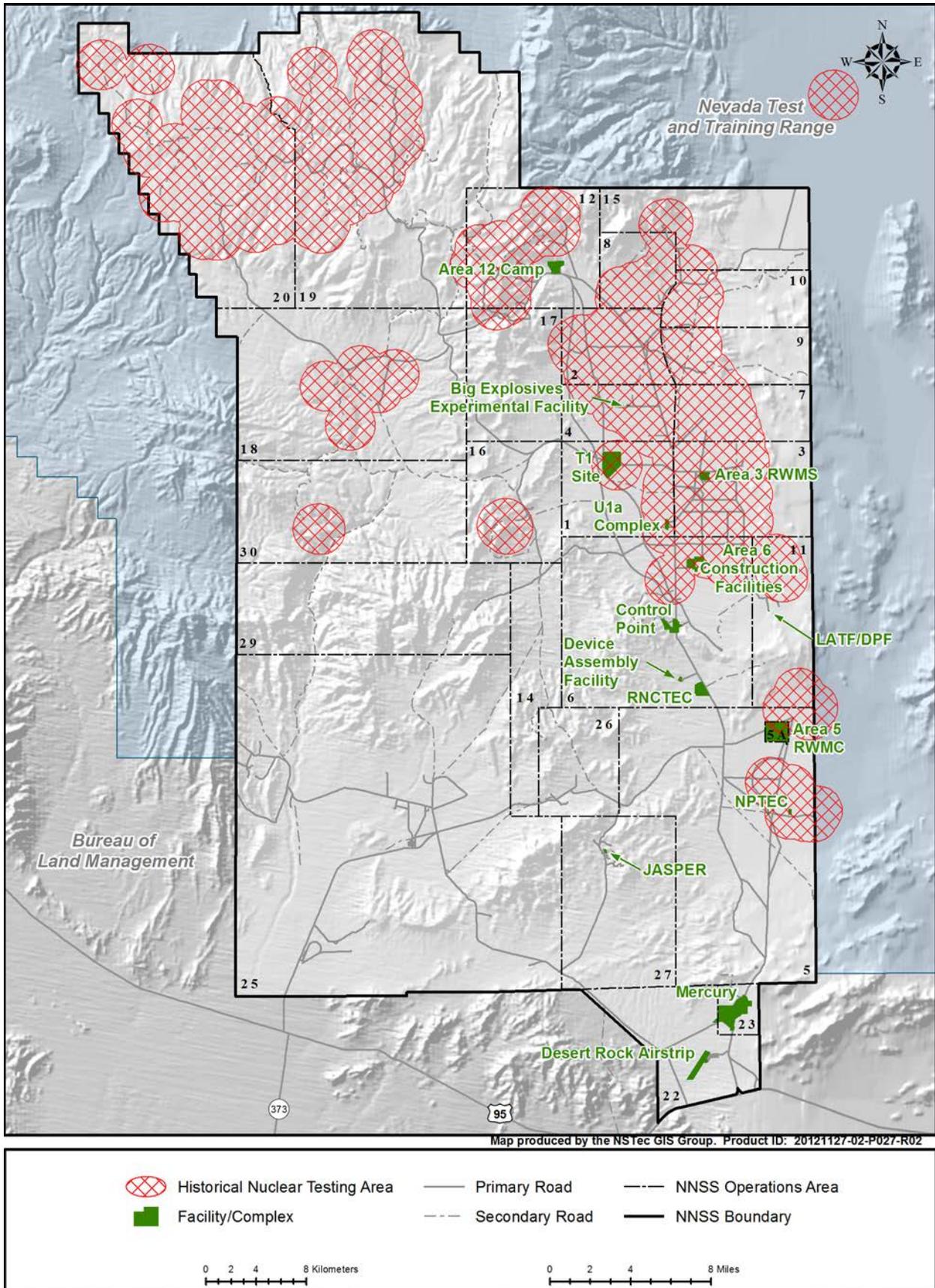


Figure 1-3. NNSS operational areas, principal facilities, and past nuclear testing areas

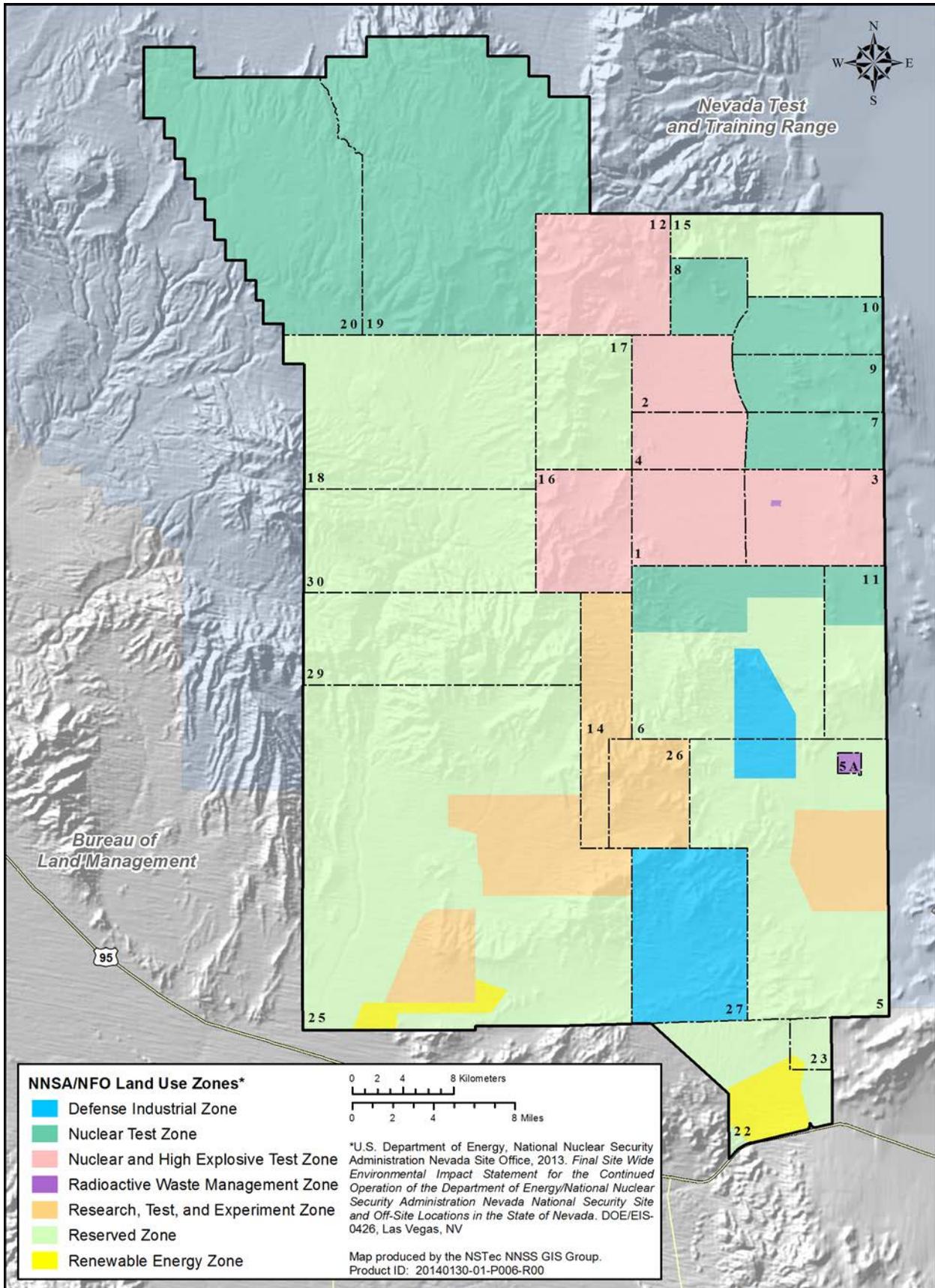


Figure 1-4. NNSA land-use map

Through a Memorandum of Agreement, NNSA/NFO is responsible for the oversight of TTR ER projects, and the U.S. Department of Energy, National Nuclear Security Administration Sandia Field Office (NNSA/SFO) has oversight of all other TTR activities. NNSA/SFO produces the TTR annual site environmental reports, which are posted at <http://www.sandia.gov/news/publications/environmental/index.html>.

## 1.7 Populations near the NNSS

The population of the area surrounding the NNSS (see Figure 1-1) is predominantly rural. The most recent population estimates for Nevada communities are for 2014 and are provided by the Nevada State Demographer’s Office (2016). The most recent population estimate for Nye County is 45,456, and the largest Nye County community is Pahrump (37,626), 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 (2,578), Amargosa (1,426), Beatty (975), Round Mountain (846), Gabbs (245), and Manhattan (133). Lincoln County to the east of the NNSS includes a few small communities including Caliente (1,056), Pioche (784), Panaca (797), and Alamo (578). Clark County, southeast of the NNSS, is the major population center of Nevada and has an estimated population of 2,069,450. The total annual population estimate for all Nevada counties, cities, and unincorporated towns is 2,843,301.

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

The extreme southwestern region of Utah is more developed than the adjacent portion of Nevada. The latest population estimates for Utah communities are for 2014 taken from the U.S. Census Bureau (2016) 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 78,505. The next largest town, Cedar City, is located 280 km (174 mi) east-northeast of the NNSS and has an estimated population of 29,483.

The northwestern region of Arizona is mostly rangeland except for that portion in the Lake Mead recreation area. In addition, several small communities lie along the Colorado River. The largest towns in the area are Bullhead City, 165 km (103 mi) south-southeast of the NNSS, with an estimated population of 40,088, and Kingman, 280 km (174 mi) southeast of the NNSS, with an estimated population of 28,942 (Arizona Department of Administration 2016).

## 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  $2.0 \times 10^{-5}$ . 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  $1.0 \times 10^9$ .

### 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.

**Table 1-1. Unit prefixes**

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

### 1.8.3 Units of Radioactivity

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

### 1.8.4 Radiological Dose Units

The amount of ionizing radiation energy absorbed by a living organism is expressed in terms of radiological dose. Radiological dose in this report is usually written in terms of effective dose equivalent 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.

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 effective dose equivalent 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.

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.

**Table 1-2. Units of radioactivity**

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

**Table 1-3. Units of radiological dose**

Symbol	Name
mrad	millirad ( $1 \times 10^{-3}$ rad)
mrem	millirem ( $1 \times 10^{-3}$ rem)
R	roentgen
mR	milliroentgen ( $1 \times 10^{-3}$ R)
$\mu$ R	microroentgen ( $1 \times 10^{-6}$ R)

**Table 1-4. Conversion table for SI units**

To Convert From	To	Multiply By
becquerel (Bq)	picocurie (pCi)	27
curie (Ci)	becquerel (Bq)	$3.7 \times 10^{10}$
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

## 1.8.6 Radionuclide Nomenclature

Radionuclides are frequently expressed with the one- or two-letter chemical symbol for the element. Radionuclides may have many different isotopes, which are shown by a superscript to the left of the symbol. This number is the atomic weight of the isotope (the number of protons and neutrons in the nucleus of the atom).

Radionuclide symbols, many of which are used in this report, are shown in Table 1-5 along with the half-life of each radionuclide. The half-life is the time required for one-half of the radioactive atoms in a given amount of material to decay. For example, after one half-life, half of the original atoms will have decayed; after two half-lives, three-fourths of the original atoms will have decayed; and after three half-lives, seven-eighths of the original atoms will have decayed, and so on. The notation  $^{236+238}\text{Ra}$  and similar notations in this report (e.g.,  $^{239+240}\text{Pu}$ ) 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 on the following page.

## 1.8.8 Measurement Variability

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

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

The uncertainty of a measurement is denoted by following the result with an uncertainty value, which is preceded by the plus-or-minus symbol,  $\pm$ . 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.,  $40 \pm 200$ ), 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 <sup>(a)</sup>
$^{241}\text{Am}$	americium-241	432.2 yr
$^7\text{Be}$	beryllium-7	53.22 d
$^{14}\text{C}$	carbon-14	$5.70 \times 10^3$ yr
$^{36}\text{Cl}$	chlorine-36	$3.01 \times 10^5$ yr
$^{134}\text{Cs}$	cesium-134	2.1 yr
$^{137}\text{Cs}$	cesium-137	30.2 yr
$^{51}\text{Cr}$	chromium-51	27.7 d
$^{60}\text{Co}$	cobalt-60	5.3 yr
$^{152}\text{Eu}$	europium-152	13.5 yr
$^{154}\text{Eu}$	europium-154	8.6 yr
$^{155}\text{Eu}$	europium-155	4.8 yr
$^3\text{H}$	tritium	12.3 yr
$^{129}\text{I}$	iodine-129	$1.6 \times 10^7$ yr
$^{131}\text{I}$	iodine-131	8 d
$^{40}\text{K}$	potassium-40	$1.3 \times 10^8$ yr
$^{85}\text{Kr}$	krypton-85	10.8 yr
$^{212}\text{Pb}$	lead-212	10.6 hr
$^{238}\text{Pu}$	plutonium-238	87.7 yr
$^{239}\text{Pu}$	plutonium-239	$2.4 \times 10^4$ yr
$^{240}\text{Pu}$	plutonium-240	$6.5 \times 10^3$ yr
$^{241}\text{Pu}$	plutonium-241	14.4 yr
$^{226}\text{Ra}$	radium-226	$1.6 \times 10^3$ yr
$^{228}\text{Ra}$	radium-228	5.75 yr
$^{220}\text{Rn}$	radon-220	56 s
$^{222}\text{Rn}$	radon-222	3.8 d
$^{103}\text{Ru}$	ruthenium-103	39.3 d
$^{106}\text{Ru}$	ruthenium-106	373.6 d
$^{125}\text{Sb}$	antimony-125	2.8 yr
$^{113}\text{Sn}$	tin-113	115 d
$^{90}\text{Sr}$	strontium-90	28.8 yr
$^{99}\text{Tc}$	technetium-99	$2.1 \times 10^5$ yr
$^{232}\text{Th}$	thorium-232	$1.4 \times 10^{10}$ yr
U <sup>(b)</sup>	uranium total	- - - <sup>(c)</sup>
$^{234}\text{U}$	uranium-234	$2.4 \times 10^5$ yr
$^{235}\text{U}$	uranium-235	$7 \times 10^8$ yr
$^{238}\text{U}$	uranium-238	$4.5 \times 10^9$ yr
$^{65}\text{Zn}$	zinc-65	244.1 d
$^{95}\text{Zr}$	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  $^{238}\text{U}$ ; thus, the half-life is approximately  $4.5 \times 10^9$  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
<b>Length</b>			
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)
<b>Volume</b>			
1 liter (L)	0.26 gallons (gal)	1 gallon (gal)	3.7853 liters (L)
1 cubic meter (m <sup>3</sup> )	35.32 cubic feet (ft <sup>3</sup> )	1 cubic foot (ft <sup>3</sup> )	0.028 cubic meters (m <sup>3</sup> )
	1.31 cubic yards (yd <sup>3</sup> )	1 cubic yard (yd <sup>3</sup> )	0.765 cubic meters (m <sup>3</sup> )
<b>Weight</b>			
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)
<b>Area</b>			
1 hectare	2.47 acres	1 acre	0.40 hectares
1 square meter (m <sup>2</sup> )	10.76 square feet (ft <sup>2</sup> )	1 square foot (ft <sup>2</sup> )	0.09 square meters (m <sup>2</sup> )
<b>Radioactivity</b>			
1 becquerel (Bq)	$2.7 \times 10^{-11}$ curie (Ci)	1 curie (Ci)	$3.7 \times 10^{10}$ becquerel (Bq)
<b>Radiation dose</b>			
1 rem	0.01 sievert (Sv)	1 sievert (Sv)	100 rem
<b>Temperature</b>			
$^{\circ}\text{C} = (^{\circ}\text{F} - 32)/1.8$		$^{\circ}\text{F} = (^{\circ}\text{C} \times 1.8) + 32$	

### 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  $\wedge$ ), about 67% of the measurements would be within the mean  $\pm$  SD, and 95% would be within the mean  $\pm$  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  $\pm$  value presented to the right of a mean value is equal to  $2 \times$  SE. The  $\pm$  value implies that approximately 95% of the time, the average of many calculated means will fall somewhere between the reported value minus the  $2 \times$  SE value and the reported value plus the  $2 \times$  SE value.

### 1.8.11 Median, Maximum, and Minimum Values

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

### 1.8.12 Less Than (<) Symbol

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

### 1.8.13 Negative Radionuclide Concentrations

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

## 1.9 References

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## Chapter 2: Compliance Summary

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Environmental regulations pertinent to operations on the Nevada National Security Site (NNSS), the North Las Vegas Facility (NLVF), and the Remote Sensing Laboratory–Nellis (RSL-Nellis) include federal, state, and local environmental regulations; site-specific permits; and binding interagency agreements. The environmental regulations dictate how the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) conducts operations to ensure the protection of the environment and the public. In 2015, NNSA/NFO operated in compliance with most of the requirements defined in these governing documents. Instances of noncompliance were reported to regulatory agencies and corrected.

As in previous years, radiological air emissions from NNSA/NFO current and past operations were well below U.S. Department of Energy (DOE) dose limits set for the public and for plants and animals on or adjacent to the NNSS. Emissions of non-radiological air pollutants from permitted equipment/facilities at NNSS, NLVF, and RSL-Nellis were all within permit limits. In 2015 at RSL-Nellis, there was one excess opacity measurement recorded for a diesel generator, which was shut down and removed from service.

No man-made *radionuclides* (see [Glossary, Appendix B](#)) were detected in any of the three state permitted public water systems on the NNSS, which are serviced by six groundwater wells. Water samples from the NNSS public water systems (PWSs) met National Primary Drinking Water Standards (health standards) and met all Nevada Secondary Drinking Water Standards (related to taste, odor, and visual aspects) with two exceptions: secondary standards for iron and aluminum from Well J-14 (part of the NNSS Area 25 PWS), for which NNSA/NFO received a violation from the Nevada Division of Environmental Protection (NDEP). NNSA/NFO conducted required quarterly water sampling from September 2014 through July 2015; sample results showed that the water met the secondary standards, and NDEP allowed NNSA/NFO to return to the routine triennial monitoring of iron and aluminum.

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

Three DOE-reportable environmental occurrences related to finding radioactive contamination outside of areas posted, controlled, and monitored for radiological contamination happened in 2015. They included finding a cesium-137 contaminated shield box lock at RSL-Nellis, finding elevated radiological readings outside posted radiological areas of legacy-contaminated Corrective Action Units (CAUs) (two on the NNSS and one on the Tonopah Test Range), and finding tritium on a vent line from the containment tent at the Dense Plasma Focus (DPF) facility on the NNSS. Areas surrounding the contaminated legacy debris at the CAUs and the DPF vent line were immediately posted as contamination areas, and the contaminated lock at RSL-Nellis was labelled and placed in a Radioactive Material Area. No personnel or equipment contamination occurred.

Corrective actions were taken for a Resource Conservation Recovery Act (RCRA) violation involving the 2013 and 2014 receipt and disposal of five waste drums from Tennessee that were not correctly identified as containing chromium, a RCRA hazardous waste. At the NNSS, the drums were characterized as containing low level radioactive waste (LLW) and placed in a non-RCRA, LLW disposal cell. Corrective actions taken in 2015 under agreement with NDEP included retrieving three of the five drums and placing them in a RCRA-permitted waste cell for mixed low level waste. NDEP granted permission for the remaining two containers to stay buried under the operational cover of the LLW cell.

Twenty-nine spills of hazardous materials occurred in 2015; only two of the spills met regulatory agency reporting criteria. All releases were cleaned up to the satisfaction of the NDEP. One of the reportable spills was a fire at the Nonproliferation Test and Evaluation Complex’s 90-Day Accumulation Area involving waste drums of potassium nitrate and potassium chlorate. The fire was allowed to burn itself out, and no injuries occurred. A root cause analysis was performed to prevent similar occurrences in the future. NNSA/NFO received a finding of alleged violation and order from NDEP for the alleged failure to comply with applicable state hazardous waste management statutes and regulations. In December 2015, NDEP issued the final findings of a Settlement Agreement calling for a cash settlement of \$100,000 for the occurrence. The second reportable spill involved the loss of oils and fluids from a tractor-scraper that rolled over; NDEP approved all corrective and site mitigation actions. The remainder of the non-reportable spills consisted of small-volume releases either to containment areas or to other surfaces.

Eight environmental inspections were conducted in 2015 by external regulatory agencies. These inspections included the NNSS hazardous waste management and disposal facilities, NLVF hazardous waste management operations, NNSS solid waste landfills, RSL-Nellis underground storage tanks, NNSS sewage lagoons, and an NNSS facility that is registered under Nevada’s Chemical Accident Prevention Program. No incidences of non-compliance were noted during the inspections.

Abbreviations for Regulators	
<b>Federal</b>	
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
<b>State/County</b>	
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

## 2.1 Compliance with Requirements

The federal, state, and local environmental statutes and regulations that NNSA/NFO operates under are summarized in Table 2-1 along with a discussion of NNSA/NFO’s compliance status with each. The “Report Section(s)” column of the table references other chapters in this document or other tables or subsections within this chapter where compliance activities for each requirement are more fully described and/or where data supporting compliance are presented.

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

Regulator: Regulation <sup>(a)</sup>	Description of Law/Regulation <sup>(b)</sup>	Compliance Status	Report Section(s)
<b>General Environmental Protection, Management, and Sustainability</b>			
CEQ: 40 CFR 1500–1508	<u>National Environmental Policy Act (NEPA)</u> , 42 USC 4321 et seq. (1969). This act requires federal agencies to consider environmental effects and reasonable alternatives before making a decision to implement a major federal action that may have a significant impact on the human environment. DOE codified its implementation of NEPA in 10 CFR 1021 and out-lined its internal requirements and responsibilities for implementing NEPA in DOE O 451.1B, Change 3, <i>National Environmental Policy Act Compliance Program</i> .	NNSA/NFO has established procedures for implementing NEPA requirements in adherence with DOE O 451.1B, Change 3. 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.	Section 2.3
DOE: 10 CFR 1021		In 2015, all proposed projects/activities were reviewed under the NEPA compliance procedures.	
DOE: Order 451.1B, Change 3			
DOE: Order 436.1	<u>Departmental Sustainability</u> . This order implements the requirements of Executive Order EO 13423, <i>Strengthening Federal</i>	National Security Technologies, LLC (NSTec), the current Management and Operating contractor for the NNSS, has	Chapter 3

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

Regulator: Regulation <sup>(a)</sup>	Description of Law/Regulation <sup>(b)</sup>	Compliance Status	Report Section(s)
	<p><i>Environmental, Energy, and Transportation Management and EO 13514, Federal Leadership in Environmental, Energy, and Economic Performance.</i> In March 2015, these EOs were replaced by EO 13963, <i>Planning for Sustainability in the Next Decade</i>. DOE's goals pertaining to the new EO are published annually in a <i>DOE Strategic Sustainability Performance Plan</i> (SSPP). This order requires DOE sites to set goals to help achieve the DOE SSPP goals, use an Environmental Management System (EMS) as the platform for establishing site-specific sustainability programs with objectives and measurable targets, develop and implement Site Sustainability Plans, and use alternative financing to the maximum extent possible for sustainability projects. In June 2015, DOE issued a Notice of Intent to update DOE Order 436.1 to align with the new EO 13963.</p>	<p>implemented an EMS, which was re-certified in 2014 for another 3 years under International Organization for Standardization (ISO) 14001:2004. The EMS includes objectives and targets that contribute to achieving the DOE Sustainable Environmental Stewardship goals outlined in DOE's most current SSPP and incorporated into NNSA/ NFO's Site Sustainability Plan. In December 2015, the fiscal year (FY) 2016 NNSA/NFO Site Sustainability Plan, which reports FY 2015 progress toward reaching goals, was completed. FY 2015 EMS progress was monitored and reported through the EMS Compliance Reporting procedure using the Fed Center DOE HQ database. 2015 successes included the certification of seven buildings using the DOE Federal Energy Management Program Guiding Principles for existing buildings and ranking fourth in the nation by the 2015 100 Best Green Fleet Awards Program.</p>	
<b>Air Quality</b>			
EPA: 40 CFR 50 40 CFR 60 40 CFR 61 40 CFR 63 40 CFR 80 40 CFR 82 40 CFR 98	<p><u>Clean Air Act (CAA), 42 USC 7401 et seq. (1970)</u>. This act and Nevada's Air Control Laws regulate the release of air pollutants through permits and air quality limits. Emissions of <i>radionuclides</i> (see <a href="#">Glossary, Appendix B</a>) are regulated via the National Emission Standards for Hazardous Air Pollutants (NESHAPs) authorizations of the CAA. Emissions of <i>criteria pollutants</i> (see <a href="#">Glossary, Appendix B</a>) are regulated via the National Ambient Air Quality Standards (NAAQS) authorizations. Criteria and <i>designated pollutants</i> (see <a href="#">Glossary, Appendix B</a>) emitted from various industrial categories of facilities are regulated via the New Source Performance Standards (NSPS) authorizations. The CAA also establishes production limits and a schedule for the phase-out of ozone-depleting substances.</p>	<p>At the NNSA, CAA and Nevada air quality regulations are met through adherence to a State of Nevada Class II Air Quality Operating Permit and various project-specific state-issued Open Burn and Surface Area Disturbance permits. NESHAP compliance activities include radionuclide air monitoring; reporting asbestos abatement; monitoring/reporting emissions from generators and boilers; and management of gasoline/diesel storage tanks. NAAQS emission limits (except ozone and lead) are based on published emission values for other similar industries and on operational data specific to the NNSA. Some screens, conveyor belts, bulk fuel storage tanks, and generators on the NNSA are subject to the NSPS.</p>	Chapter 4, Sections 4.1.5, 4.2
NDEP: NAC 445B	<p>Nevada law (NAC 445B, <i>Air Controls</i>) enforces the CAA regulations and also requires fugitive dust control and open burn authorizations.</p>	<p>At the NLVF and RSL-Nellis, CAA and state air quality requirements are met through adherence to Clark County Minor Source permits.</p> <p>NNSA/NFO pays annual state fees based on all emission sources' "potential to emit." NNSA/NFO allows Nevada's Bureau of Air Pollution Control to conduct inspections of permitted NNSA facilities and allows the Clark County Department of Air Quality to conduct inspections of NLVF and RSL-Nellis permitted equipment. All approvals, notifications, requests for additional information, and reports</p>	

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

Regulator: Regulation <sup>(a)</sup>	Description of Law/Regulation <sup>(b)</sup>	Compliance Status	Report Section(s)
		<p>required under the CAA are submitted to NDEP, Clark County, and/or EPA Region 9 in accordance with federal requirements.</p> <p>In 2015, monitored radioactive air emissions were below NESHAPs limits. All non-radiological air emission limits as well as all monitoring, record keeping, training, and reporting requirements of state and county air permits were met with one exception: a generator at RSL-Nellis exceeded its opacity limits (see Table 2-8).</p>	
<b>Water Quality</b>			
<p>EPA: 40 CFR 109–140 40 CFR 230, 231 40 CFR 401, 403</p>	<p><u>Clean Water Act (CWA), 33 USC 1251 et seq. (1972)</u>. This 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 United States without a National Pollutant Discharge Elimination System (NPDES) permit.</p>	<p>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. Because there are no wastewater discharges to surface waters on or off the NNSS, there are no NPDES permits for the NNSS.</p>	<p>Chapter 5, Sections 5.1.3.7.2, 5.1.3.7.3, 5.2.2, 5.2.3, 5.2.4</p>
<p>NDEP: NAC 444 NAC 445A NAC 534</p>	<p>NACs 444, <i>Sanitation (Sewage Disposal)</i> and 445A, <i>Water Controls (Water Pollution Control)</i> regulate the collection, treatment, and disposal of wastewater and sewage.</p> <p>NAC 534, <i>Underground Water and Wells</i> regulates the drilling, construction, and licensing of new wells and the reworking of existing wells to prevent the waste and contamination of groundwater.</p>	<p>NNSA/NFO obtains underground injection control (UIC) permits from NDEP, as required under NAC 445A.810–925, for various investigations. In 2012, a UIC permit was obtained for a noble gas migration study at borehole U-20az PS#1A in Area 20. No activities occurred at this borehole in 2015, although experiments are anticipated for 2016.</p> <p>NNSA/NFO complies with NAC 534 for the rework of old wells and the drilling of new wells for the Underground Test Area (UGTA) activity. UGTA wells are regulated by the state through an agreement between NNSA/NFO and NDEP called the <i>UGTA Fluid Management Plan</i>, which ensures compliance with the CWA. In 2015, UGTA well drilling fluids were monitored and managed in accordance with the plan.</p> <p>NLVF operates under a Class II Wastewater Control Permit issued by the City of North Las Vegas (CNLV) for sewer discharges and an NPDES permit issued by NDEP for the discharge of groundwater that is pumped to the surface to control rising groundwater levels at the facility (see Table 2-2). NLVF operates under a NDEP-issued No Exposure Waiver for exclusion from NPDES Storm Water permitting. Storm water discharged from the</p>	<p>Appendix A, Sections A.1.2, A.2.2</p> <p>Table 2-2</p>

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

Regulator: Regulation <sup>(a)</sup>	Description of Law/Regulation <sup>(b)</sup>	Compliance Status	Report Section(s)
N/A		<p>NLVF is not contaminated by exposure to industrial activities or materials.</p> <p>For RSL-Nellis operations, the Clark County Water Reclamation District (CCWRD) determined that a wastewater discharge permit is not necessary; only an annual submission of a Zero Discharge Form is required to verify compliance with the CWA.</p> <p>Both the NLVF and RSL-Nellis maintain and implement a Spill Prevention, Control, and Counter-measure Plan required by the EPA to ensure that petroleum and non-petroleum oil products do not pollute waters of the United States via discharge into the Las Vegas Wash.</p> <p>In 2015, all water chemistry parameters and contaminants that required monitoring in wastewater discharges and sewage lagoons were within permit limits, all required inspections of wastewater systems were conducted, and no reportable spills occurred.</p>	N/A
<p>EPA: 40 CFR 141-149</p> <p>NDEP: NAC 445A</p>	<p><u>Energy Independence and Security Act of 2007 (EISA) (Pub. L. 110-140)</u>, Section 438 of this act addresses storm water management and requires that any development/ redevelopment project involving a federal facility with a footprint over 5,000 gross square feet (gsf) maintain or restore, to the maximum extent feasible, the predevelopment hydrology of the property with regard to the rate, temperature, volume, and duration of storm water flow.</p> <p><u>Safe Drinking Water Act (SDWA), 42 USC 300f et seq. (1974)</u>. This act protects the quality of drinking water in the United States and authorizes the EPA to establish safe standards of purity. It requires all owners or operators of <i>public water systems</i> (PWSs) (see <a href="#">Glossary, Appendix B</a>) 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.</p> <p>NAC 445A, <i>Water Controls</i>, requires that PWSs meet both primary and secondary water quality standards. The SDWA standards for radionuclides currently apply only to PWSs designated as community water systems.</p>	<p>No new development/redevelopment projects of buildings greater than 5,000 gsf have been identified.</p> <p>The NNSS supplies drinking water from onsite wells that comply with all applicable SDWA and state water quality standards. Three PWSs on the NNSS are permitted by the state as <i>non-community water systems</i> (see <a href="#">Glossary, Appendix B</a>). NDEP also permits two potable water hauler trucks on the NNSS. Although not required under the SDWA, all potable water supply wells on the NNSS are monitored for radionuclides in compliance with DOE O 458.1, <i>Radiation Protection of the Public and the Environment</i>.</p> <p>In 2015, no radionuclides from NNSA/NFO activities were detected in NNSS drinking water wells, the PWSs met all applicable primary and secondary drinking water standards, and all NNSS potable water hauling trucks tested negative for coliform bacteria.</p>	<p>Chapter 5, Sections 5.1.3.6, 5.2.1</p>

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

Regulator: Regulation <sup>(a)</sup>	Description of Law/Regulation <sup>(b)</sup>	Compliance Status	Report Section(s)
		Water used at both the NLVF and RSL-Nellis is supplied by the CNLV and meets or exceeds federal drinking water standards.	
<b>Radiation Protection</b>			
DOE: Order 458.1, Change 3	<p><u>Radiation Protection of the Public</u>. This order requires DOE/NNSA sites to establish and document 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 <i>Derived Concentration Standards (DCSs)</i> (see <a href="#">Glossary, Appendix B</a>), defined in DOE-STD-1196-2011, <i>Derived Concentration Technical Standard</i>, are to be used in the design and conduct of environmental radiological protection programs.</p> <p>The order sets a radiation dose limit of 100 mrem/yr (1 mSv/yr) above background levels to individuals in the general public from all pathways of exposure combined. It also calls for the protection of populations of terrestrial plants and aquatic and terrestrial animals from radiological impacts through the use of DOE Standard DOE-STD-1153-2002, <i>A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota</i>.</p>	<p>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 NNS game animals. Results of radiological monitoring and protective measures are described in this report throughout several chapters.</p> <p>As in previous years, the calculated dose to the public and to the biota from NNSA/NFO operations in 2015 were below all DOE dose limits set by DOE O 458.1 and DOE-STD-1153-2002, respectively. DCSs defined in DOE-STD-1196-2011 were used to evaluate radiological monitoring results.</p>	<p>Chapter 4, Section 4.1</p> <p>Chapter 5, Section 5.1</p> <p>Chapter 6</p> <p>Chapter 7</p> <p>Chapter 8</p> <p>Chapter 9</p>
<b>Waste Management and Environmental Restoration</b>			
EPA: 40 CFR 300 40 CFR 302 40 CFR 355 40 CFR 370	<p><u>Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)</u>, 42 USC 9601 et seq (1980). These acts provide 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 (see Emergency Planning and Community Right-to-Know Act).</p>	<p>No hazardous waste cleanup operations on the NNS are regulated under CERCLA. Instead, they are regulated under the Resource Conservation Recovery Act (listed below).</p> <p>NNSA/NFO complies with the Emergency Planning and Community Right-to-Know Act under CERCLA (listed below).</p>	N/A
EPA: 40 CFR 259– 282  NDEP: NAC 444.570– 7499	<p><u>Resource Conservation Recovery Act (RCRA)</u>, 42 USC 6901 et seq. (1976). This act and the Nevada laws <i>Disposal of Hazardous Waste</i> (NAC 444.850–8746), <i>Solid Waste Disposal</i> (NAC 444.570–7499), and <i>Storage Tanks</i> (NAC 459.9921–999) regulate the generation, storage,</p>	<p>NNSA/NFO generates HW and operates a permitted HW management facility under RCRA Part B Permit NEV HW0101 issued by NDEP. In accordance with the permit, NNSA/NFO monitors groundwater from three wells downgradient of mixed low level waste (MLLW) disposal cells, conducts post-closure</p>	<p>Chapter 10, Sections 10.1.7, 10.2, 10.3, 10.4</p> <p>Table 2-8</p>

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

Regulator: Regulation <sup>(a)</sup>	Description of Law/Regulation <sup>(b)</sup>	Compliance Status	Report Section(s)
NAC 444.850–8746 NAC 459.9921–999	transportation, treatment, and disposal of solid and hazardous wastes to prevent contaminants from leaching into the environment from landfills, underground storage tanks, surface impoundments, and hazardous waste (HW) disposal facilities. RCRA also requires HW generators to have a program to reduce the amount and toxicity of HW and federal facilities to have a procurement process to ensure that they purchase product types that satisfy the EPA-designated minimum percentages of recycled material.	<p>monitoring for HW sites that were closed under RCRA prior to enactment of the Federal Facility Agreement and Consent Order (FFACO), and prepares an EPA Hazardous Waste Report of all HW and MLLW volumes generated and disposed annually at the NNS and all HW generated annually at the NLVF. All of these RCRA Part B Permit NEV HW0101 requirements were met in 2015.</p> <p>NNSA/NFO operates and monitors four state-permitted solid waste landfills on the NNS, and all permit requirements were met in 2015.</p> <p>A fire in June, 2015 at a 90-Day Accumulation Area on the NNS resulted in four RCRA violations issued by NDEP to NNSA/NFO (see Table 2-8).</p> <p>NNSA/NFO continued to implement a program to reduce the volume/ quantity and toxicity of generated HW. A procurement process was used to help ensure that EPA-designated products are purchased containing the minimum content of recycled materials.</p>	Chapter 3, Section 3.3.2
NDEP: FFACO	<u>Federal Facility Agreement and Consent Order (FFACO), as amended.</u> This consent order was agreed to by the State of Nevada, DOE Environmental Management, 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 restoration of historically contaminated sites for which the NNSA/NFO is responsible for cleanup and closure.	<p>Environmental Management Operations program is responsible for the cleanup (if possible) and closure of over 3,000 corrective action sites (CASs) identified in Nevada. ER activities follow a formal work process described in the FFACO. The State of Nevada is a participant throughout the closure process, and the Nevada Site Specific Advisory Board is kept informed of the progress made. The board is a formal volunteer group of interested citizens who provide informed recommendations to NNSA/NFO.</p> <p>In 2015, NNSA/NFO closed 24 CASs and met all of the 2015 FFACO milestones for the characterization, remediation, closures, and post-closure monitoring and inspection of historically contaminated CASs. To date, 2,115 of the 3,033 CASs have been closed.</p>	Chapter 11
DOE: Order 435.1, Change 1	<u>Radioactive Waste Management.</u> This order requires that 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 NNS.	<p>The Area 3 Radioactive Waste Management Site (RWMS) and the Area 5 RWMS operate as Category II Non-Reactor Nuclear Facilities. They are designed and operated to manage and safely dispose of low-level waste, mixed low-level waste, and hazardous waste generated by NNSA/NFO, other DOE, or selected U.S. Department of Defense operations and to manage and safely store transuranic and mixed transuranic wastes generated on the NNS for</p>	Chapter 10, Section 10.1
DOE M 435.1-1, Change 2	DOE M 435.1-1, Change 2, <i>Radioactive Waste Management Manual</i> , specifies that operations at radioactive waste management		

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

Regulator: Regulation <sup>(a)</sup>	Description of Law/Regulation <sup>(b)</sup>	Compliance Status	Report Section(s)
	<p>facilities must not contribute a dose to the general public in excess of 25 mrem/yr.</p>	<p>eventual shipment to the Waste Isolation Pilot Plant in New Mexico.</p> <p>In accordance with this order, <i>Performance Assessments (PAs)</i> (see <a href="#">Glossary, Appendix B</a>) and <i>Composite Analyses (CAs)</i> (see <a href="#">Glossary, Appendix B</a>) for both RWMSs are reviewed annually to assess their adequacy, and results are submitted annually to the DOE Office of Environmental Management. The Disposal Authorization Statements for both RWMSs also require that annual reviews be made and that secondary or minor unresolved issues be tracked and addressed. Waste Acceptance Criteria for radioactive wastes received at the RWMSs are maintained and the volumes of low level and mixed low level wastes disposed at the RWMSs are tracked. Although not required by this DOE order, <i>vadose zone</i> (see <a href="#">Glossary, Appendix B</a>) monitoring at both RWMSs is performed to validate the performance assessment criteria of the RWMSs.</p> <p>In 2015, all key documents and analyses were current and all required management practices were followed.</p>	
<b>Hazardous Materials Control and Management</b>			
<p>EPA: 40 CFR 300 40 CFR 302 40 CFR 355 40 CFR 370 40 CFR 372</p>	<p><u>Emergency Planning and Community Right-to-Know Act (EPCRA), 42 USC 11001 et seq. (1986)</u>. This act 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.</p>	<p>Some NNSA/NFO facilities store or use chemicals in quantities exceeding threshold planning quantities under EPCRA. NNSA/NFO complies with all reporting and emergency planning requirements under EPCRA as well as to the requirements of several state-issued hazardous materials permits: a site-wide NNSP permit, one for the Nonproliferation Test and Evaluation Complex on the NNSP, one for NLVF, and one for RSL-Nellis.</p> <p>In 2015, NNSA/NFO adhered to all EPCRA reporting requirements (see Table 2-5). The Nevada Combined Agency Report, containing updated chemical inventories for NNSA/NFO facilities, was submitted to NDEP, 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.</p>	<p>Section 2.4.4.1</p> <p>Appendix A, Sections A.1.5, A.2.4</p>
<p>NDEP: NAC 459.952–95528</p>	<p><u>State of Nevada Chemical Catastrophe Prevention Act (NRS 459.380–3874)</u>. This act directs NDEP to develop and implement a program called the Chemical Accident</p>	<p>The Nonproliferation Test and Evaluation Complex (NPTEC) in Area 5 of the NNSP is registered as a CAPP facility. NNSA/NFO</p>	<p>Section 2.4.4.2</p>

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

Regulator: Regulation <sup>(a)</sup>	Description of Law/Regulation <sup>(b)</sup>	Compliance Status	Report Section(s)
EPA: 40 CFR 700– 763 NDEP: NAC 444.842– 8746	<p>Prevention Program (CAPP). It requires registration of facilities storing highly hazardous substances above listed thresholds.</p> <p><u>Toxic Substances Control Act (TSCA), 15 USC 2601 et seq. (1976)</u>. This act regulates the manufacture, use, and distribution of chemical substances that enter the consumer market. Because the NNSSS does not produce chemicals, compliance is primarily directed toward the management of polychlorinated biphenyls (PCBs).</p> <p>NAC 444, <i>Sanitation</i>, enforces the federal requirements for the handling, storage, and disposal of PCBs and contains record keeping requirements for PCB activities.</p>	<p>submits an annual CAPP Registration report to the State of Nevada, whether or not a threshold was exceeded.</p> <p>In 2015, no highly hazardous substances were stored at NPTEC in quantities that exceeded reporting thresholds, and the annual compliance inspection at NPTEC conducted by NDEP found the facility was meeting regulatory requirements.</p> <p>At the NNSSS, 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. NNSSS also receives radioactive waste for onsite disposal that may contain regulated levels of PCBs. The onsite disposal of all PCB wastes and recordkeeping requirements for PCB activities are regulated on the NNSSS by the State of Nevada. In 2015, PCBs were managed in compliance with TSCA and state regulations.</p>	Section 2.4.2
EPA: 40 CFR 162– 171 NDOA: NAC 555	<p><u>Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), 7 USC 136 et seq. (1996)</u>. This act 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.</p> <p>NAC 555, <i>Nevada Control of Insects, Pests, and Noxious Weeds</i>, regulates the certification of registered pesticide and herbicide applicators in Nevada. The Nevada Department of Agriculture (NDOA) has the primary role to enforce FIFRA in Nevada.</p>	<p>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 2015, NNSA/NFO complied with all FIFRA requirements.</p>	Section 2.4.3
<b>Cultural Resources</b>			
ACHP: 36 CFR 800	<p><u>National Historic Preservation Act (NHPA), as amended, 54 USC 300101 et seq. (1966)</u>. This act identifies, evaluates, and protects historic properties eligible for listing in the National Register of Historic Places (NRHP). Such properties can be archeological sites or 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</p>	<p>NNSA/NFO has established a Cultural Resources Management (CRM) program at the NNSSS, which is implemented by the Desert Research Institute (DRI). The CRM program ensures compliance with all regulations pertaining to cultural resources on the NNSSS. Before initiating land-disturbing activities or building and structure modifications, archaeologists conduct surveys and historical evaluations to identify important cultural and historical resources, evaluate the cultural and historical significance, and assess potential impacts. Native American representatives also</p>	Chapter 12, Section 12.1

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

Regulator: Regulation <sup>(a)</sup>	Description of Law/Regulation <sup>(b)</sup>	Compliance Status	Report Section(s)
<p>DOI: 18 CFR 1312 36 CFR 79 43 CFR 7</p>	<p>project-specific planning, and to maintain archaeological collections and their associated records at professional standards.</p> <p><u>Archaeological Resources Protection Act (ARPA), as amended (16 USC 470aa–mm).</u> This act 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.</p>	<p>conduct cultural 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 that may be necessary. Determinations of NRHP eligibility, effect, and mitigation are conducted in consultation with the Nevada SHPO, the Consolidated Group of Tribes and Organizations (CGTO) and, in some cases, the federal Advisory Council on Historic Preservation. To date, more than 1,400 NRHP eligible sites/ facilities on the NNSS have been identified.</p> <p>In 2015, archival research for 29 proposed NNSS projects was conducted, and 318 acres were surveyed; 10 historic or prehistoric sites and 20 historic structures were identified.</p> <p>Archaeologists working at the NNSS must have qualifications that meet federal standards and must 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 arise.</p> <p>The CRM program curates archaeological collections from the NNSS in accordance with 36 CFR 79, Curation of Federally Owned and Administered Archeological Collections, and conducts American Indian consultations related to places and items of importance to the CGTO.</p>	<p>Chapter 12, Section 12.5</p>
<p>N/A</p>	<p><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.</p>	<p>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. No requests for access were received in 2015.</p>	<p>Chapter 12, Section 12.6</p>
<p>DOI: 43 CFR 10</p>	<p><u>Native American Graves Protection and Repatriation Act (NAGPRA), as amended (25 USC 3001–3013).</u> This act requires federal agencies to return certain types of</p>	<p>The NNSS artifact collection is subject to NAGPRA. The required inventory and summary of NNSS cultural materials accessioned into the NNSS Archaeological</p>	<p>Chapter 12, Section 12.5,</p>

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

Regulator: Regulation <sup>(a)</sup>	Description of Law/Regulation <sup>(b)</sup>	Compliance Status	Report Section(s)
	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.	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.	Section 12.6
<b>Biological Resources</b>			
FWS: 50 CFR 17	<u>Endangered Species Act (ESA), 16 USC 1531-1544 (1973)</u> . This act prohibits activities that would jeopardize the continued existence of an endangered or threatened species, or cause adverse modification to a critical habitat.	The threatened desert tortoise is the only species protected under the ESA that may be impacted by NNSS operations. NNSS activities within tortoise habitat are conducted so as to comply with the terms and conditions of Biological Opinions (BOs) issued by the FWS to NNSA/NFO. In 2015, all FWS requirements of BOs were met. Two desert tortoises were accidentally killed on roads. Other state-managed and state-protected species are monitored under the Ecological Monitoring and Compliance (EMAC) Program. Some species are collected for ecological studies under an NDOW scientific collection permit.	Chapter 13
NDOW: NAC 503.0001– 503.104 NDOF: NAC 527	Nevada Department of Wildlife (NDOW) regulations identify protected and unprotected Nevada animal species and prohibits the harm of protected species without special permit. NAC 503 also identifies game animals, which are managed by the state. Nevada Department of Forestry (NDOF) regulations prohibits removal or destruction of state protected plants without special permit.	Compliance with the MBTA is documented under the EMAC Program. Proposed construction and demolition projects are reviewed and field surveys are conducted to prevent 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.	Chapter 13
FWS: 50 CFR 21	<u>Migratory Bird Treaty Act (MBTA), 16 USC 703-712 (1918)</u> . This act 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 harming of any migratory bird, their nest, or eggs without authorization by the Secretary of the Interior.	In 2015, 15 migratory birds were accidentally killed, 13 by electrocution (including 2 golden eagles) and 2 by entrapment. Mitigation measures to reduce accidental mortalities are being pursued.	Chapter 13
NDOW: NRS 503.050	Nevada wildlife laws protect birds protected under the MBTA.	Compliance with the BGEPA, as with the MBTA, is documented under the EMAC Program. Two golden eagles electrocuted in 2015 were collected and transferred to the FWS under an FWS special purpose possession permit. Bird guards and metal spikes were installed in 2015 at several power line structures to help prevent electrocutions.	Chapter 13
FWS: 50 CFR 22  NDOW: NRS 503.050	<u>The Bald and Golden Eagle Protection Act (BGEPA), 16 USC 668a-d, 703-712</u> . This act prohibits any form of possession or taking of both bald and golden eagles.  Eagles are also protected under Nevada wildlife laws.	The NNSS is not within a BLM active herd management area. A Five-Party Cooperative Agreement exists, however, between NNSA/NFO, Nevada Test and Training Range (NTTR), FWS, BLM, and the State of Nevada,	Chapter 13
N/A	<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 requires the U.S. Bureau of Land Management (BLM) and the U.S. Forest		Chapter 13

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

Regulator: Regulation <sup>(a)</sup>	Description of Law/Regulation <sup>(b)</sup>	Compliance Status	Report Section(s)
EO 13112	<p>Service (FS) to protect, manage, and control wild horses and burros on BLM and FS lands in a manner that is designed to achieve and maintain a thriving natural ecological balance.</p> <p><u>Invasive Species.</u> This EO directs federal agencies to act to prevent the introduction of, or to monitor and control, invasive (non-native) species; to provide for restoration of native species; and to exercise care in taking actions that could promote the introduction or spread of invasive species.</p>	<p>which calls for cooperation in conducting resource inventories and developing resource management plans for wild horses and burros and maintaining favorable habitat for them on federally withdrawn lands. NNSA/NFO consults with BLM on issues of NNSS horse management, and NNSS biologists conduct periodic horse census surveys on the NNSS.</p> <p>Land-disturbing activities on the NNSS have resulted in the spread of numerous invasive plant species. Habitat reclamation and other controls are evaluated and conducted, when feasible, to control such species and meet the purposes of this EO.</p>	Chapter 13
<b>Environmental Activities and Occurrence Reporting</b>			
DOE: Order 231.1B Manual 231.1-1A	<p><u>Environment, Safety and Health Reporting.</u> This order requires the timely collection, reporting, analysis, and dissemination of information on environment, safety, and health issues as required by law or regulations or as needed to ensure that DOE is kept fully informed on a timely basis about events that could adversely affect the health and safety of the public, workers, the environment, the intended purpose of DOE facilities, or the credibility of the DOE. It requires DOE and NNSA sites to prepare an annual calendar year report, referred to as the Annual Site Environmental Report (ASER).</p>	NNSA/NFO prepares an ASER called the NNSS Environmental Report (NNSSER) and provides data for DOE to prepare annual NEPA summaries and other Safety, Fire Protection, and Occupational Health and Safety Administration (OSHA) reports. The NNSSER (i.e., this report) 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.	All chapters
DOE: Order 232.2	<p><u>Occurrence Reporting and Processing of Operations Information.</u> 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, extremely 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 regulatory agency that the site/facility is in non-compliance with a schedule or requirement.</p>	NNSA/NFO contractors enter environmental occurrences, identified as reportable in accordance with this order, into DOE’s Occurrence Reporting and Processing System (ORPS). Reported information includes significance of the identified event, notifications, development of causal factors, and corrective actions designed to prevent recurrences using a graded approach based on the significance of the event. Reportable environmental events that occurred in 2015 are presented in Table 2-8.	Section 2.5, Table 2-8
<b>Quality Assurance</b>			
DOE: Order 414.1D, Change 1	<p><u>Quality Assurance.</u> The objective of this order is to establish an effective management system using the performance requirements</p>	NNSA/NFO has QAPs in place to implement quality management methodology in adherence to this DOE order. The QAPs	Chapter 14, Chapter 15

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

<b>Regulator: Regulation<sup>(a)</sup></b>	<b>Description of Law/Regulation<sup>(b)</sup></b>	<b>Compliance Status</b>	<b>Report Section(s)</b>
DOE: 10 CFR 830, Subpart A	of this order, coupled with consensus standards, where appropriate, to ensure 1) products and services meet or exceed customers' expectations; 2) there is management support for planning, organization, resources, direction, and control; 3) performance and quality improvements occur by means of thorough, rigorous assessments and corrective actions; and 4) environmental, safety, and health risks and impacts associated with work processes are minimized while maximizing reliability and performance of work products. Using a graded approach, DOE/NNSA sites must develop a quality assurance plan (QAP) to establish additional process-specific quality requirements and implement the approved QAP.	ensure that all environmental monitoring data meet quality assurance and quality control requirements. Samples are collected to 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 verified and validated according to project-specific quality objectives before they are used to support decision making.	

- (a) For federal laws, a reference to its implementing regulation, which was written by the identified federal regulatory agency, is given. The regulation is identified by its Code of Federal Regulations (CFR) Title and Part (e.g., 10 CFR 1021 means "Title 10 Part 1021"). CFR references can be accessed [here](#). 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 [here](#). NRSs can be accessed [here](#). For DOE directives (e.g., Orders, Manuals, Standards), the directive's number is given. DOE directives can be accessed [here](#).
- (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 [here](#). If there is not a USC reference, the public law (Pub. L.) number is given.

**Table 2-2. Summary of NPDES Permit NV0023507 compliance at the NLVF in 2015 for Outfalls 001 and 002**

<b>Parameter</b>	<b>Number of Permit Exceedances</b>	<b>Number of Samples Taken</b>	<b>Number of Compliant Samples</b>	<b>Percent Compliance</b>	<b>Date(s) Exceeded</b>	<b>Description/Solution</b>
Daily maximum flow	0	365 (continuous)	365	100	NA <sup>(a)</sup>	NA
Total petroleum hydrocarbons	0	1 (1/year)	1	100	NA	NA
Total suspended solids	0	4 (1/quarter)	4	100	NA	NA
Total dissolved solids	0	4 (1/quarter)	4	100	NA	NA
Total inorganic nitrogen	0	4 (1/quarter)	4	100	NA	NA
pH	0	4 (1/quarter)	4	100	NA	NA
Tritium	MR <sup>(b)</sup>	1 (1/year)	1	100	NA	NA
Metals	MR	1 (1/two years)	1	100	NA	NA
Total cyanide	MR	1 (1/two years)	1	100	NA	NA
Volatile organics	MR	1 (1/two years)	1	100	NA	NA
Pesticides	MR	1 (1/two years)	1	100	NA	NA
Polychlorinated biphenyls	MR	1 (1/two years)	1	100	NA	NA
Acid extractables	MR	1 (1/two years)	1	100	NA	NA
Base neutral extractables	MR	1 (1/two years)	1	100	NA	NA
Dioxins	MR	1 (1/two years)	1	100	NA	NA
Asbestos	MR	1 (1/two years)	1	100	NA	NA

(a) NA = not applicable

(b) MR = monitor and report, no specified daily maximum or 30-day average limit, just the requirement that there shall be no discharge of substances that would cause a violation of state water quality standards

## 2.2 Environmental Permits

Table 2-3 presents the complete list of all federal and state permits active during 2015 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. Some permit names retain the older “NTS” acronym for the NNSS because they have not been officially changed with the regulatory agencies. Reports associated with permits are submitted to the appropriate designated state or federal office. Copies of reports may be obtained upon request.

**Table 2-3. Environmental permits required for NNSA/NFO operations at NNSS, NLVF, and RSL-Nellis**

Permit Number	Permit Name or Description	Expiration Date	Reporting
<b>Air Quality</b>			
<b>NNSS</b>			
AP9711-2557	NNSS Class II Air Quality Operating Permit	June 25, 2014 (permit renewal submitted April, 2014 and not yet been issued)	Annually
15-30 and 16-27	NNSS Open Burn Authorization, Fire Extinguisher Training (Various Locations)	March 22, 2016/ March 22, 2017	None
15-31 and 16-28	NNSS Open Burn Authorization, Simulated Vehicle Burns, A-23, Facility #23-T00200 (NNSS Fire & Rescue Training Center)	March 21, 2016/ March 22, 2017	None
<b>UGTA Offsite</b>			
AP9711-2659.01	NTTR Class II Air Quality Operating Permit, Surface Area Disturbance, Wells ER-EC-13 and ER-EC-15	March 4, 2020	Annually
AP9711-2824	NTTR Class II Air Quality Operating Permit, Surface Area Disturbance, Well ER-EC-14	June 14, 2016	Annually
<b>NLVF</b>			
Source 657	Clark County Minor Source Permit	August 11, 2020	Annually
<b>RSL-Nellis</b>			
Source 348	Clark County Minor Source Permit	July 5, 2017	Annually
<b>Drinking Water</b>			
<b>NNSS</b>			
NY-0360-12NTNC	Areas 6 and 23	September 30, 2015/2016	None
NY-4098-12NC	Area 25	September 30, 2015/2016	None
NY-4099-12NC	Area 12	September 30, 2015/2016	None
NY-0835-12NP	NNSS Water Hauler #84846	September 30, 2015/2016	None
NY-0836-12NP	NNSS Water Hauler #84847	September 30, 2015/2016	None
<b>Septic Systems/Pumpers</b>			
<b>NNSS</b>			
NY-1054	Septic System, Area 3, Waste Management Offices - inactive	None	None
NY-1069	Septic System, Area 18 (Pahute Airstrip) <sup>(a)</sup>	None	None
NY-1077	Septic System, Area 27 (Baker Compound) <sup>(a)</sup>	None	None
NY-1079	Septic System, Area 12, U12g Tunnel - inactive	None	None
NY-1080	Septic System, Area 23 (Building 23-1103) <sup>(a)</sup>	None	None
NY-1081	Septic System, Area 6, Control Point-170 - inactive	None	None
NY-1082	Septic System, Area 22 (Building 22-1) <sup>(a)</sup>	None	None
NY-1083	Septic System, Area 5 (Area 5 RWMC) <sup>(a)</sup>	None	None
NY-1084	Septic System, Area 6, Device Assembly Facility - inactive	None	None
NY-1085	Septic System, Area 25 (Central Support Area) <sup>(a)</sup>	None	None
NY-1086	Septic System, Area 25 (Reactor Control Point) <sup>(a)</sup>	None	None
NY-1087	Septic System, Area 27 (Able Compound) <sup>(a)</sup>	None	None
NY-1089	Septic System, Area 12 (Area 12) <sup>(a)</sup>	None	None
NY-1090	Septic System, Area 6 (LANL) <sup>(a)</sup>	None	None

**Table 2-3. Environmental permits required for NNSA/NFO operations at NNSS, NLVF, and RSL-Nellis (continued)**

Permit Number	Permit Name or Description	Expiration Date	Reporting
NY-1091	Septic System, Area 23 (Gate 100) <sup>(a)</sup>	None	None
NY-1103	Septic System, Area 22 (Desert Rock Airstrip) <sup>(a)</sup>	None	None
NY-1106	Septic System, Area 5 (NPTEC) <sup>(a)</sup>	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) <sup>(a)</sup>	None	None
NY-1113	Commercial Sewage Disposal System, Area 1, Building 121 - inactive	None	None
NY-1124	Commercial Individual Sewage Disposal System (RNCTEC) <sup>(a)</sup>	None	None
NY-1128	Commercial Individual Sewage Disposal System (Yucca Lake Airfield) <sup>(a)</sup>	None	None
NY-1130	Commercial Individual Sewage Disposal System (Building 06-950) <sup>(a)</sup>	None	None
NY-17-06839	Septic Tank Pumper E 106785	July 31, 2015/2016	None
NY-17-06839	Septic Tank Pumper E 107105	July 31, 2015/2016	None
NY-17-06839	Septic Tank Pumper E-105918	July 31, 2015/2016	None
NY-17-06839	Septic Tank Pumping Contractor (one unit)	July 31, 2015/2016	None
NY-17-06839	Septic Tank Pumper E-106169	July 31, 2015/2016	None
NY-17-06839	Septic Tank Pumper E-107103	July 31, 2015/2016	None
<b>Wastewater Discharge</b>			
<b>NNSS</b>			
GNEV93001Rv X	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	Quarterly
<b>NLVF</b>			
MSC-833	NLVF Wastewater Contribution Permit	December 23, 2016	As Needed
NV0023507	National Pollutant Discharge Elimination System Permit	June 24, 2017	Quarterly
<b>RSL-Nellis</b>			
Not applicable	Annual certification statement of zero discharge	None	January
<b>Underground Injection Control</b>			
<b>NNSS</b>			
UNEV2012203	NNSS Underground Injection Control Permit	July, 6, 2017	Semi-annually
<b>Hazardous Materials</b>			
<b>NNSS</b>			
48663	NNSS Hazardous Materials Permit	February 29, 2016	Annually
48673	Nonproliferation Test and Evaluation Complex Hazardous Materials Permit	February 29, 2016	Annually
<b>NLVF</b>			
48694	NLVF Hazardous Materials Permit	February 29, 2016	Annually
<b>RSL-Nellis</b>			
48705	RSL-Nellis Hazardous Materials Permit	February 29, 2016	Annually
<b>Hazardous Waste</b>			
<b>NNSS</b>			
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	Biennially and annually
<b>Waste Management</b>			
<b>NNSS</b>			
SW 523	Area 5 Asbestiform Low-Level Solid Waste Disposal Site	Post-closure <sup>(b)</sup>	Annually
SW 13 097 02	Area 6 Hydrocarbon Disposal Site	Post-closure	Annually
SW 13 097 03	Area 9 U10c Solid Waste Disposal Site	Post-closure	Annually
SW 13 097 04	Area 23 Solid Waste Disposal Site	Post-closure	Biannually
<b>RSL-Nellis</b>			
PR0064276	RSL-Nellis Waste Management Permit-Underground Storage Tank	December 31, 2016	None

**Table 2-3. Environmental permits required for NNSA/NFO operations at NNSS, NLVF, and RSL-Nellis (continued)**

Permit Number	Permit Name or Description	Expiration Date	Reporting
<b>Endangered Species/Wildlife</b>			
File Nos. 84320-2008-F-0416 and 84320-2008-B-0015	U.S. Fish and Wildlife Service – Desert Tortoise Incidental Take Authorization (Biological Opinion for Programmatic NNSS Activities)	February 12, 2019	Annually
SCCL-008695-0	U.S. Fish and Wildlife Service – Migratory Bird Scientific Collecting Permit	March 31, 2016	Annually
MB037277-1	U.S. Fish and Wildlife Service – Migratory Bird Special Purpose Possession – Dead Permit	March 31, 2010 (permit renewal requested)	Annually
261454	Nevada Department of Wildlife – Scientific Collection of Wildlife Samples	December 31, 2016	Annually

(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 NEPA Assessments

The National Environmental Policy Act (NEPA) regulations require federal agencies to evaluate the environmental effects of proposed major federal activities. The prescribed evaluation process ensures that the proper level of environmental review is performed before an irreversible commitment of resources is made. NNSA/NFO performs environmental reviews with the aid of a NEPA Environmental Evaluation Checklist (Checklist), which is required for all proposed projects or activities on the NNSS. The Checklist is reviewed by the NNSA/NFO NEPA Compliance Officer to determine if the activity's environmental impacts have been addressed in a previous NEPA assessment. If a proposed project has not been covered under any previous NEPA analysis and it does not qualify for a "Categorical Exclusion" (per 10 CFR 1021), then a new NEPA analysis is initiated. The analysis may result in preparation of a new Environmental Assessment, Environmental Impact Statement, or supplemental document to the existing programmatic *Site-Wide Environmental Impact Statement for the Nevada National Security Site and Offsite Locations in Nevada* (NNSS SWEIS) (U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office 2013). The NEPA Compliance Officer must approve each Checklist before a project proceeds. Table 2-4 presents a summary of how NNSA/NFO complied with NEPA in 2015.

In 2015, NNSA/NFO completed the NNSA/NFO NEPA Annual Planning Document and submitted it to DOE HQ in January 2016. It provides the status of all EAs and EISs being developed or planned in the next 12–24 months.

**Table 2-4. NNSS NEPA compliance activities conducted in FY 2015**

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

## 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 database. Hazardous substances used or stored by contractors and subcontractors of the NNSA/NFO are entered into this database. They 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 were not purchased when less hazardous substitutes were commercially available. Requirements and responsibilities for the use and management of hazardous/toxic chemicals are provided in company documents.

The annual inventory of chemicals was completed at the end of 2015 using the new chemical inventory module of an enterprise asset management software system called Maximo. The development of this new electronic chemical management system was identified as a target under NSTec's Environmental Management System (see Chapter 3, Section 3.2.3). The new program 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 at any point in time. It provides chemical owners with additional information including purchase dates, Safety Data Sheets, storage locations, and expiration dates. In 2015, it was noted that this electronic chemical management system allowed for real time chemical inventories to be utilized for emergency planning and for more accurate planning in regards to operational needs. This new system also assisted in reducing the quantities of chemicals purchased and stored through the chemical custodian's awareness of the chemicals currently in inventory. Due to the hands-on nature of the new management system, chemical compatibility and proper storage is routinely evaluated and has improved NNSA/NFO's safety posture in regards to chemicals.

### **2.4.2 Polychlorinated Biphenyls**

The storage, handling, and use of *polychlorinated biphenyls (PCBs)* (see [Glossary, Appendix B](#)) 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 (see Chapter 11) and maintenance of fluorescent lights. PCB bulk product waste (i.e., contaminated building materials) from corrective action sites and light ballasts removed during normal maintenance are disposed of in the Area 9 U10c Solid Waste Disposal Site with prior State of Nevada approval. Soil and other remediation wastes contaminated with PCBs and large volumes of light ballasts are sent off site to an approved PCB disposal facility. Radioactive waste received from offsite waste generator facilities that contain regulated quantities of PCBs are disposed of at the Area 5 Radioactive Waste Management Site (see 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 (see Section 2.4.4.1, Table 2-7).

During 2015, NNSS routine maintenance activities generated one drum of PCB-containing immersion liquid, which weighed 5 kilograms (kg) (11 pounds [lb]). It was shipped off site from the Area 5 Hazardous Waste Storage Unit (HWSU) for disposal. A total of 0.913 tons of PCB-contaminated materials (transformer oil, debris, light ballasts) that had been generated in 2014 were also shipped off site from the HWSU for disposal in 2015. In 2015, the EPA did not conduct any TSCA inspections at the NNSS.

### **2.4.3 Pesticides**

The storage and application of pesticides (e.g., insecticides, rodenticides, and herbicides) are regulated under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). Several oversight functions are performed each year to ensure FIFRA compliance. They include the screening of all purchase requisitions for restricted-use pesticides; the review of operating procedures for handling, storing, and applying pesticide products; and monthly inspections of stored pesticides. On the NNSS, pesticides are applied under the direction of a State of Nevada-certified applicator. This service is provided by Solid Waste Operations (SWO). Pesticide applications in NNSS food service facilities are also conducted by SWO. Beginning in mid-2014, the application of restricted-use pesticides was discontinued on the NNSS. Only pesticides categorized as non-restricted-use (i.e., available for purchase and application by the general public) are used. Monthly inspections conducted in 2015 found that all pesticides were

stored in accordance with their labeling. The State of Nevada did not conduct an inspection of pesticide storage facilities in 2015.

## 2.4.4 Release and Inventory Reporting

### 2.4.4.1 EPCRA

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 2-5 identifies the reporting requirements under EPCRA Sections 302, 303, 311, 312, and 313. Table 2-6 summarizes the applicability of the regulations to NNSA/NFO operations in 2015.

**Table 2-5. Reporting criteria of the Emergency Planning and Community Right-to-Know Act**

Section	CFR Part	Reporting Criteria	Agencies Receiving Report
302	40 CFR 355: Emergency Planning Notifications	The presence of an extremely hazardous substance (EHS) in a quantity equal to or greater than the threshold planning quantity at any one time. Change occurring at a facility that is relevant to emergency planning.	SERC <sup>(a)</sup> , LEPC <sup>(b)</sup> LEPC
304	40 CFR 355: Emergency Release Notifications	Release of an EHS or a CERCLA hazardous substance <sup>(c)</sup> in a quantity equal to or greater than the reportable quantity.	SERC, LEPC
311	40 CFR 370: Material Safety Data Sheet Reporting	The presence at any one time at a facility of an OSHA hazardous chemical <sup>(d)</sup> 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.	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 or 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 2-6. Compliance with EPCRA reporting requirements**

EPCRA Section	Description of Reporting	2015 Status <sup>(a)</sup>
Section 302	Emergency Planning Notification	Yes
Section 304	EHS Release Notification	Not required
Section 311–312	MSDS/Chemical Inventory	Yes
Section 313	TRI Reporting	Yes

(a) “Yes” indicates that NNSA/NFO reported under the requirements of the EPCRA section specified (see Table 2-3).

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 NNS, NLVF, and RSL-Nellis based on the NCA Report. The 2015 chemical inventory for NNS facilities was updated and submitted to the State of Nevada in the NCA Report on February 26, 2016. No EPCRA Section 304 reporting was required in 2014 because no accidental or unplanned release of an extremely hazardous substance occurred at the NNS, 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 2015, reportable quantities of lead, mercury, and PCBs were released as a result of NNSS activities (Table 2-7). No releases at NLVF or RSL-Nellis exceeded reportable thresholds in 2015. In June 2016, NNSA/NFO submitted the TRI Report for calendar year 2015 to the EPA and the State Emergency Response Commission. No EPCRA inspections were performed by outside regulators in 2015.

**Table 2-7. Summary of 2015 reported releases under EPCRA Section 313**

Reported Release	Quantity <sup>(a)</sup> (pounds [lb])		
	Lead	Mercury	PCB
Air Emissions <sup>(b)</sup>	3.32	0.06	0
Onsite Disposal <sup>(c)</sup>	48,673	6,473	19.95
Onsite Release <sup>(d)</sup>	4,500	0	0
Offsite Recycling <sup>(e)</sup>	19,034	0.014	0
Offsite Disposal <sup>(f)</sup>	113	0.005	10.06
Cleanup Activities or One-time Events	0	0.042	0.38
<b>Totals</b>	<b>72,323</b>	<b>6,473</b>	<b>30.4</b>
<b>EPCRA Reporting Thresholds</b>	<b>100</b>	<b>10</b>	<b>10</b>

(a) The weight of the chemical released, not the weight of the waste material containing the toxic chemical.

(b) Airborne releases of lead include 2.72 lbs during weapons firing at the Mercury Firing Range and 0.60 lbs from other activities.

(c) Mixed low level waste or hazardous waste containing lead, mercury, or PCB that was received and disposed in Cell 18 at the Area 5 RWMS (see Section 10.1.1).

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

(e) Lead was from three waste streams: 18,786 lb of lead-acid batteries, 160 lb of scrap metal, and 88.3 lb of miscellaneous lead items. Mercury was from fluorescent lamps.

(f) Lead was from lead paint removal and other routinely generated waste. Mercury was from circuit board debris. PCBs were from light ballasts, contaminated debris, and PCB oil.

#### 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 highly hazardous substances above listed thresholds. The NPTEC in Area 5 of the NNSS is registered as a CAPP facility. On January 13, 2015, NDEP conducted an annual compliance inspection of NPTEC and concluded that its operations met the Nevada regulatory requirements of the CAPP. NNSA/NFO is required to submit an annual CAPP Registration report to the State of Nevada whether or not a threshold was exceeded. The CAPP Registration report for operations from June 2014 through May 2015 was submitted to NDEP on June 17, 2015. No highly hazardous substances were stored in quantities that exceeded reporting thresholds.

#### 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* (see [Glossary, Appendix B](#)) and is predictable and regular in the amount and rate of emission. No continuous releases of hazardous substances are known to occur at the NNSS, NLVF, or RSL-Nellis.

## 2.5 Environmental Occurrences

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

Seven environmental occurrences, reportable under the requirements of this DOE order, happened in 2015 (Table 2-8). Table 2-8 also includes the corrective actions taken in 2015 for a December 30, 2014 occurrence. During 2015, there were 25 spills at the NNSS, 2 at NLVF, and 2 at RSL-Nellis. Two of the 2015 spills met regulatory agency reporting criteria and included the fire at the 90-day accumulation area and the scraper roll-over, both described in Table 2-8. The remainder of 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 or at the NLVF and RSL-Nellis.

**Table 2-8. Environmental occurrences in 2015 and actions taken in 2015 in response to previous occurrences**

Description of Occurrence	Reporting Criteria <sup>(a)</sup>	Corrective Actions Taken
<p><b>Report Number/Date of Occurrence: EM--NVSO-NST-NTS-2014-0022, December 30, 2014</b></p> <p><b>Occurrence Title: Notification of Low Level Waste Drums Containing RCRA Regulated Constituents</b></p>		
<p>On December 30, 2014, received notifications that Nuclear Fuel Services (NFS) received a formal Notice of Violation from the State of Tennessee for five drums sent to NNSS in 2013 and 2014 that contained chromium, a RCRA hazardous waste. When the drums were shipped and received, they were characterized as low-level waste (LLW) in accordance with the approved profile and placed in a non-RCRA LLW disposal cell at the RWMC that operates under a solid waste permit. It was later determined by NFS that the five drums contained chromium.</p>	<p>10(2) - An event, condition, or series of events that does not meet any of the other reporting criteria, but is determined by the Facility Manager or line management to be of safety significance or of concern for that facility or other facilities or activities in the DOE complex.</p>	<p>Retrieved three of the five drums and placed them in the RCRA permitted waste cell for MLLW at the RWMC. On August 31, 2015, NDEP granted permission for the remaining two containers to stay buried under the operational cover of the LLW cell in lieu of retrieving and performing treatment. Additional mitigation actions approved by NDEP were completed in 2016 and included treatment and disposal of the three NFS MLLW drums at the RWMC.</p>
<p><b>Report Number/Date of Occurrence: NA--NVSO-NST-NLV-2015-0002, April 6, 2015</b></p> <p><b>Occurrence Title: Legacy Cs-137 Contamination Found on Padlock</b></p>		
<p>At RSL-Nellis, a radiological control technician (RCT) identified elevated background readings and a cesium-137 peak while scanning the top of a shield box. The RCT performed a direct and indirect radiological survey of the area and nearby items. The shield box had a maximum direct beta contamination of 583,000 disintegrations per minute (dpm) on the back of the lock.</p>	<p>6B(4) Identification of onsite radioactive contamination greater than 10 times the total contamination values in <a href="#">10 CFR 835 Appendix D</a> (exclusive of footnote 3), and that is found outside of areas routinely posted, controlled and monitored for radiological contamination, and areas controlled in accordance with <a href="#">10 CFR 835.1102(c)</a>. For tritium, the reporting threshold is 10 times the removable contamination values in 10 CFR 835, <i>Occupational Radiation Protection Program</i>, Appendix D.</p>	<p>Additional surveys of the lock, shield box, and immediate surroundings were conducted and showed no removable contamination. Notifications were made to the NSTec Radiological Control Manager and to NSTec and NNSA/NFO line management. The lock was labeled and placed in Radioactive Material Area 35-002.</p>
<p><b>Report Number/Date of Occurrence: NA--NVSO-NST-NTS-2015-0014, June 11, 2015</b></p> <p><b>Report Title: Violation of Secondary Drinking Water Standards</b></p>		
<p>NNSA/NFO received a violation of secondary drinking water standards for iron and aluminum from NDEP, dated May 28, 2015. This was based on analysis results of a water sample collected in May 2014 from Well J-14 (part of the permitted NNSS Area 25 Public Water System) that had iron and aluminum concentrations above their Secondary</p>	<p>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.</p>	<p>In 2015, NNSA/NFO was required to monitor each quarter for iron. In accordance with NAC 445A.456 Subsection 3, monitoring for iron must continue until the SMCL has not been exceeded during two successive quarterly periods, or until a monitor-</p>

**Table 2-8. Environmental occurrences in 2015 and actions taken in 2015 in response to previous occurrences**

Description of Occurrence	Reporting Criteria <sup>(a)</sup>	Corrective Actions Taken
<p>Maximum Contaminant Levels (SMCLs) of 0.6 and 0.2 milligrams per liter (mg/L), respectively.</p> <p>Three additional water samples for the two contaminants were collected during a 90-day period beginning in September 2014. The results from the original sample and the three follow-up samples were averaged to determine compliance for each contaminant. Based on these sample results, NDEP issued violations for exceedance of the SMCL for iron for the 4th quarter 2014 and the 1st quarter 2015. The average of the aluminum results for 2014 is 0.2 mg/L; an exceedance of the SMCL of aluminum will not occur until the level equals or exceeds 0.25 mg/L.</p>		<p>ing schedule as a condition to a variance or enforcement action to achieve compliance, becomes effective. Quarterly monitoring in April and July 2015 showed that the water met the secondary standard for iron. NDEP terminated quarterly monitoring and instructed NNSA/NFO to return to triennial monitoring, with the next sample collection in 2017.</p>
<p><b>Report Number/Date of Occurrence: EM-NVSO-NI-NTS-2015-0017, June 24, 2015</b>  <b>Report Title: Fire at 90-Day Accumulation Area</b></p>		
<p>On 6/24/15 at 7:15 pm, NNS fire units responded to a fire at the NPTEC's 90-Day Accumulation Area involving waste drums of potassium nitrate and potassium chlorate. The fire was allowed to burn itself out. Fire crews remained on scene through the night. Recovery operations commenced at daylight on 6/25/15.</p> <p>The chemicals had been declared waste, moved into the 90-Day Accumulation Area on 6/3/15, and placed under NSTec's Waste Generator Services control. As per NSTec procedures, a waste container log was completed and the drums were marked with hazardous waste labels. Weekly inspections of the pad were initiated and during those inspections, no anomalies were detected until the fire was observed.</p>	<p>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 (e.g., Notice of Violation, Notice of Intent to Sue, Notice of Noncompliance, Warning Letter, Finding of Violation, Finding of Alleged Violation, Administrative Order, or equivalent notification or enforcement action).</p>	<p>Roads were closed, and the area barricaded with access restricted to response and recovery personnel. A root cause analysis was performed to prevent similar occurrences in the future. On 8/31/15, NNSA/NFO received a Finding of Alleged Violation and Order from NDEP for the alleged failure to comply with applicable state hazardous waste management statutes and regulations. Four findings were identified. On 12/4/2015, NDEP issued the final findings of a Settlement Agreement to NNSA/NFO calling for a cash settlement of \$100,000.</p>
<p><b>Report Number/Date of Occurrence: EM--NVSO-NST-NTS-2015-0022, July 23, 2015</b>  <b>Report Title: Scraper Rolls Over</b></p>		
<p>On 7/22/15, at the UGTA ER-20-12 well construction site, a tractor-scraper rolled over. The worker was unharmed. It was determined that the tractor-scraper lost approximately 39 gallons of a combination of hydraulic oil, motor oil, and gear oil fluids when it tipped over.</p>	<p>5A(2) - Any release (onsite or offsite) 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.</p>	<p>NNSA/NFO reported the release to NDEP. The excavation of contaminated soil was completed on 12/3/15. Approximately 1-2 yards of contaminated soil, however, were left in place because site conditions (large boulders) precluded additional excavation. On 1/26/2016, NDEP closed the spill site.</p>
<p><b>Report Number/Date of Occurrence: EM--NVSO-NAVR-NTS-2015-0002, October 1, 2015</b>  <b>Report Title: Legacy Contaminated Debris Found Outside of a Posted Radiological Area</b></p>		
<p>On three separate dates at three different locations during 2015 RCTs identified debris having elevated radiological readings that were outside posted radiological areas: (1) on 2/3 at CAU 573 in Area 5 of the NNSS, (2) on 7/21 at the Clean Slate II site on the Tonopah Test Range, outside of the posted Clean Slate II Contamination Area Boundary, and 3) on 8/20 on the northern shore of Frenchman Flat lake bed on the NNSS in an area associated with CAU 573.</p>	<p>6B(4) Identification of onsite radioactive contamination greater than 10 times the total contamination values in <a href="#">10 CFR 835 Appendix D</a> (exclusive of footnote 3), and that is found outside of areas routinely posted, controlled and monitored for radiological contamination, and areas controlled in accordance with <a href="#">10 CFR 835.1102(c)</a>. For tritium, the reporting threshold is 10 times the removable contamination values in 10 CFR Part 835, Appendix D.</p>	<p>RCTs verified no personnel/equipment contamination. At each location, RCTs immediately posted the areas surrounding the contaminated debris to comply with the NNSS Radiological Control Manual and with 10 CFR 835. All appropriate notifications were made. At the Clean Slate II site, an effort to locate additional legacy debris within a 3,000-foot by 3,000-foot area was conducted between July 21</p>

**Table 2-8. Environmental occurrences in 2015 and actions taken in 2015 in response to previous occurrences**

Description of Occurrence	Reporting Criteria <sup>(a)</sup>	Corrective Actions Taken
<p>Maximum removable contamination at each site, as numbered above, and presented in units of disintegrations per minute per 100 square centimeters (dpm/100cm<sup>2</sup>) were approximately:</p> <p>(1) 12,000 alpha                      (2) 40,000 alpha, 5,000 beta/gamma                      (3) 480 alpha</p> <p>Maximum total contamination at each site (in dpm/100cm<sup>2</sup>) were approximately:</p> <p>(1) 2,800,000 alpha                      (2) 2,400,000 alpha, 6,000,000 beta/gamma                      (3) 7,314 alpha, 4,887 beta/gamma</p>		<p>and September 30 and resulted in eight additional areas being posted</p>
<p><b>Report Number/Date of Occurrence: NA--NVSO-NST-NTS-2015-0024, October 22, 2015</b>  <b>Occurrence Title: Tritium Contamination Found on Vent Line</b></p>		
<p>An NSTec operator at the Dense Plasma Focus Facility noticed a leak at a connection joint on the vent line from the containment tent. The vent line is labeled Potential Internal Contamination and is located in a posted Controlled Area. An NSTec radiological control technician surveyed the vent line and found one survey point to be 292,028 disintegrations per minute per 100 square centimeters (dpm/100cm<sup>2</sup>) for tritium. A re-survey performed the same day did not show any contamination greater than 10 CFR 835 Appendix D values. There was no contamination of personnel or equipment as a result of this incident.</p>	<p>6B(3) - Identification of onsite radioactive contamination greater than 10 times and no greater than 100 times the total contamination values in <a href="#">10 CFR 835 Appendix D</a>, exclusive of footnote 3 to Appendix D, and that is found outside of the following locations: areas routinely posted, controlled and monitored for contamination, areas controlled in accordance with <a href="#">10 CFR 835.1102(c)</a>, and, per <a href="#">10 CFR 835.604(a)</a>, any non-posted area that is under the continual observation and control of an individual knowledgeable of and empowered to implement required access and exposure control measures. For tritium, the reporting threshold is 10 times the removable contamination values in 10 CFR Part 835, Appendix D.</p>	<p>The RCT immediately roped off the area and posted it as a Contamination Area. NSTec and NNSA/NFO line management were notified and a management review and cause evaluation was initiated. The event was found to be caused by an unusual heavy rain that allowed rainwater to enter the facility's exhaust stack. The permanent corrective action taken was posting the area around the blower as a Contamination Area. Covering the stack to prevent rain from entering would increase the potential for tritium accumulation and subsequent contamination inside the facility.</p>
<p><b>Report Number/Date of Occurrence: EM--NVSO-NST-NTS-2015-0003, November 17, 2015</b>  <b>Occurrence Title: Clark County Air Permit Limit Exceeded</b></p>		
<p>An emergency generator at RSL-Nellis exceeded air permit requirements of the Clark County Department of Air Quality, Minor Source Permit, Source 348. During routine bi-weekly preventative maintenance of emergency generator A04, white smoke was observed at 25% opacity after 15 minutes of run-time. Clark County air 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.</p>	<p>5A(2) - Any release (onsite or offsite) 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.</p>	<p>Immediate action was taken to transfer back to house power and the generator was shut down. Generator repair technicians inspected the generator and suspected failed fuel injectors. The generator has been permanently removed from service. Verbal notification was made to Clark County Department of Air Quality and NNSA/NFO provided a follow-up Station Source Deviation Report on November 18, 2015.</p>

(a) Reporting requirements provided in DOE O 232.2 can be found at <https://www.directives.doe.gov/directives-documents/200-series/0232.2-BOrder-admchg1>, as accessed on July 18, 2016.

## 2.6 Environmental Reports Submitted to Regulators

Numerous reports were prepared in 2015 or 2016 to meet CY 2015 regulation requirements or to document compliance for NNSA/NFO activities conducted in 2015. These reports and the federal or state regulators to whom they were submitted are listed in Table 2-9. Full references for those reports which were published can be found in the References section of each applicable chapter of this report.

**Table 2-9. List of environmental reports submitted to regulators for 2015 NNSA/NFO activities**

<b>Regulator(s)</b>	<b>Report</b>
<b>Air Quality</b>	
EPA Region 9	<i>National Emission Standards for Hazardous Air Pollutants – Radionuclide Emissions, Calendar Year 2015</i>
NDEP, EPA Region 9	<i>Annual Asbestos Abatement Notification Form</i> , submitted to NDEP and to EPA Region 9
NDEP	<i>Calendar Year 2015 Actual Production/Emissions Reporting Form</i> , submitted to NDEP <i>Quarterly Class II Air Quality Reports</i> , submitted to NDEP <i>Nonproliferation Test and Evaluation Complex (NPTEC) Pre-test and Post-test Reports</i>
CCDAQ	<i>Department of Air Quality Annual Emission Inventory Reporting Form for North Las Vegas Facility</i> <i>Department of Air Quality Annual Emission Inventory Reporting Forms for Remote Sensing Laboratory</i>
<b>Water Quality</b>	
NDEP	<i>Quarterly Monitoring Reports for Nevada National Security Site Sewage Lagoons</i> <i>Results of water quality analyses for PWSs, sent to the state throughout the year as they were obtained from the analytical laboratory</i> <i>Water Pollution Control Permit NEV 96021, Quarterly Monitoring Reports (for first, second, and third quarters of 2015 for E Tunnel effluent monitoring)</i> <i>Water Pollution Control Permit NEV 96021, Quarterly Monitoring Report and Annual Summary Report for E Tunnel Wastewater Disposal System</i>
<b>Waste Management</b>	
NDEP	<i>Nevada National Security Area 5 Solid Waste Disposal Annual Report for CY 2015</i> <i>NNSS Quarterly Volume Reports (for all active LLW and MLLW disposal cells), April, July, and October 2015, and January 2016</i> <i>4<sup>th</sup> Quarter Transportation Report FY2015, Radioactive Waste Shipments to and from the Nevada National Security Site</i> <i>RCRA Permit for a Hazardous Waste Management Facility Permit Number NEV HW0101 – Annual Summary/Waste Minimization Report Calendar Year 2015</i> <i>Nevada National Security Site 2015 Data Report: Groundwater Monitoring Program Area 5 Radioactive Waste Management Site</i> <i>Nevada National Security Site 2015 Waste Management Monitoring Report - Area 3 and Area 5 Radioactive Waste Management Site</i> <i>Post-Closure Report for Closed Resource Conservation and Recovery Act Corrective Action Units, Nevada National Security Site, Nevada, for Fiscal Year 2015 (October 2014–September 2015)</i> <i>Annual Soil Moisture Monitoring Report for the Area 9 U10c Landfill, Nevada National Security Site, Nevada, for the Period March 2015 – February 2016</i> <i>January–June 2015 Biannual Solid Waste Disposal Site Report for the Nevada National Security Site Area 23 Sanitary Landfill</i> <i>July–December 2015 Biannual Solid Waste Disposal Site Report for the Nevada National Security Site Area 23 Sanitary Landfill</i> <i>Annual Soil Moisture Monitoring Report for the Area 6 Hydrocarbon Landfill, Nevada National Security Site, Nevada, for the Period March 2015–February 2016</i>
<b>Environmental Restoration</b>	
NDEP	<i>Post-Closure Report for Closed Resource Conservation and Recovery Act (RCRA) Corrective Action Units on the Nevada National Security Site (NNSS) for Fiscal Year 2015</i> <i>Post-Closure Inspection Letter Report for Corrective Action Units on the Nevada National Security Site</i> <i>Post-Closure Inspection Report for the Tonopah Test Range, Nevada, for Calendar Year 2015</i>

**Table 2-9. List of environmental reports submitted to regulators for 2015 NNSA/NFO activities (continued)**

<b>Regulator(s)</b>	<b>Report</b>
NDEP	CAU 97: <i>Yucca Flat/Climax Mine – Complete Peer Review Presentation</i> CAU 97: <i>Yucca Flat/Climax Mine – External Peer Review Closeout Presentation</i> CAU 97: <i>Yucca Flat/Climax Mine – Phase I Flow and Transport Model, Revision 1 - Record of Technical Change (ROTC)#2</i> CAU 98: <i>Frenchman Flat – Closure Report, (CR), Revision 0</i> CAU 98: <i>Frenchman Flat – Presentation #1 on Use Restrictions and Regulatory Boundaries</i> CAU 99: <i>Rainier Mesa/Shoshone Mountain – Phase I Transport Model Supplemental Analysis Presentation #1</i> CAUs 101/102: <i>Central and Western Pahute Mesa – Phase II Data Completion Presentation #1</i> CAU 411: <i>Double Tracks Plutonium Dispersion (Nellis) – Streamlined Approach for Environmental Restoration (SAFER) Plan</i> CAU 412: <i>Clean Slate I Plutonium Dispersion (TTR) – Streamlined Approach for Environmental Restoration (SAFER) Plan</i> CAU 541: <i>Small Boy – Corrective Action Investigation Plan (CAIP) Record of Technical Change (ROTC) #1</i> CAU 550: <i>Smoky Contamination Area – Corrective Action Decision Document/Closure Report (CADD/CR)</i> CAU 568: <i>Area 3 Plutonium Dispersion Sites – Corrective Action Decision Document (CADD)</i> CAU 575: <i>Area 15 Miscellaneous Sites – Streamlined Approach for Environmental Restoration (SAFER) Plan</i> CAU 97: <i>Yucca Flat/Climax Mine – Phase I Flow and Transport Model, Revision 1 - Record of Technical Change (ROTC)#2</i> CAU 98: <i>Frenchman Flat – Closure Report, (CR), Revision 0</i>
<b>Hazardous Materials Management</b>	
State Fire Marshal	<i>Nevada Combined Agency Hazmat Facility Report – Calendar Year (CY) 2015</i>
EPA, NDEP	<i>Toxic Release Inventory Report, Form R for CY 2015</i>
NDEP	<i>Chemical Accident Prevention Program 2016 Registration</i>
<b>Cultural and Natural Resources</b>	
NSHPO	<i>A Cultural Resources Inventory of a Proposed Pad, Access Road, and Expansion of a Borrow Pit for UGTA Well ER-20-12, Area 20, Nevada National Security Site, Nye County, Nevada</i> <i>A Cultural Resources Inventory of a Proposed Pad and Access Road for UGTA Well ER-4-1, Areas 4 and 7, Nevada National Security Site, Nye County, Nevada</i> <i>A Cultural Resources Inventory of a Proposed Pad, Access Road Upgrade, and Expansion of a Borrow Pit for UGTA Well ER-2-2, Areas 2 and 9, Nevada National Security Site, Nye County, Nevada</i> <i>A Cultural Resources Inventory of a Proposed Pad and Access Road for UGTA Well ER-3-3, Area 3, Nevada National Security Site, Nye County, Nevada</i> <i>A Class III Cultural Resources Inventory and Historical Evaluation of the Shasta Atmospheric Test, Areas 2, 4, and 8, Nevada National Security Site, Nye County, Nevada</i> <i>Cultural Resources Preliminary Assessment for Corrective Action Unit 573: GMX Alpha Contaminated Site (CAS 05-23-02), Area 5, Nevada National Security Site, Nye County, Nevada.</i> <i>Fiscal Years 2014 and 2015 Cultural Resources Monitoring, Nevada National Security Site, Nye County, Nevada</i>
FWS	<i>Annual Report of Actions Taken under Authorization of the Biological Opinion on NNSS Activities (File Nos. 84320-2008-F-0416 and 84320-2008-B-0015) – January 1, 2015, through December 31, 2015</i>
NDOW	<i>Annual Report for Handling Permit S36422</i>
FWS	<i>Annual Report for Federal Migratory Bird Scientific Collecting Permit SCCL-008695-0</i>
<b>Public Notifications/Reports</b>	
DOE	<i>Nevada National Security Site Environmental Report 2015</i>
<b>Environmental Occurrences</b>	
See Table 2-8 for ORPS Reports	

## 2.7 References

U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office, 2013. *Final Site-Wide Environmental Impact Statement for the Continued Operation of the Department of Energy/National Nuclear Security Administration Nevada National Security Site and Off-Site Locations in the State of Nevada*. DOE/EIS-0426, Las Vegas, NV.

## ***Chapter 3: Environmental Management System***

**Troy S. Belka, Savitra M. Candley and Cathy A. Wills**

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The U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) conducts activities on the Nevada National Security Site (NNSS) while ensuring the protection of the environment, the worker, and the public. This is accomplished, in part, through the implementation of an Environmental Management System (EMS). An EMS is a business management practice that incorporates concern for environmental performance throughout an organization, with the ultimate goal being continual reduction of the organization's impact on the environment. An EMS ensures that environmental issues are systematically identified, controlled, and monitored, and it provides mechanisms for responding to changing environmental conditions and requirements, reporting on environmental performance, and reinforcing continual improvement. National Security Technologies, LLC (NSTec), the current Management and Operating contractor for the NNSS, designed an EMS to meet the 17 requirements of the globally recognized International Organization for Standardization (ISO) 14001:2004 Environmental Management Standard. The EMS initially received ISO 14001:2004 certification in June 2008 and was re-certified in 2014 for another 3-year period. This chapter describes the 2015 progress made towards improving overall environmental performance under the NSTec EMS. Reported progress applies to operations on the NNSS as well as support activities conducted at the NNSA/NFO-managed North Las Vegas Facility (NLVF) and Remote Sensing Laboratory–Nellis (RSL–Nellis). NNSA/NFO uses this annual environmental report as the mechanism to communicate to the public the components and status of the EMS, which is a requirement for ISO 14001:2004 certification.

### ***3.1 Environmental Policy***

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

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

### ***3.2 Planning***

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

#### ***3.2.1 Environmental Aspects***

An "environmental aspect" is any element of an organization's activities, products, and services that can impact the environment. As required by the ISO 14001 Standard, NSTec evaluates its operations, identifies the aspects that can impact the environment, and determines which of those impacts are significant.

Operations are evaluated to determine if they have any environmental aspects by performing Hazard Assessments, preparing Health and Safety Plans and Execution Plans, and preparing and reviewing National Environmental Policy Act documents. A list of aspects is compiled, and they are ranked in order of importance to determine which aspects are significant. The factors that are considered during ranking are the potential to cause adverse environmental impact; the potential for noncompliance with regulations; the ability to meet permit requirements, contract and performance objectives, and DOE order requirements; and the potential to result in bad publicity. The likelihood of occurrence and severity of each of these factors is considered. This process is done annually to account for changing activities, regulations/DOE orders, and management priorities. For 2015, the following list of environmental aspects were identified.

**Significant environmental aspects:**

- Air quality
- Drinking water quality
- Energy and fuel use
- Environmental restoration
- Industrial chemical storage and use
- Non-hazardous waste generation and management
- Groundwater protection
- Hazardous, radioactive, and mixed waste management (generation, storage, and disposal)
- Wastewater management (generation and disposal)
- Water usage

**Other environmental aspects:**

- Building demolition
- Electronics stewardship
- Greenhouse gas emissions
- Purchase of materials and equipment
- Recycling of materials and equipment
- Surface water and stormwater runoff
- Resource protection (cultural, biological, and raw materials)

### ***3.2.2 Legal and Other Requirements***

NSTec has a system in place to review changes in federal, state, or local environmental regulations and to communicate those changes to affected staff. EO 13423, “Strengthening Federal Environmental, Energy, and Transportation Management” and EO 13514, “Federal Leadership in Environmental, Energy, and Economic Performance,” active through March 2015, impose specific sustainability goals with numerical targets through fiscal year (FY) (October 1 through September 30) 2015, or FY 2020 for federal agencies, and focus on improving their environmental, energy, and economic performance. Each governmental facility is required to have a Site Sustainability Plan in place detailing the strategy for achieving these long-term goals and to provide an annual status. The new EO 13693, “Planning for Federal Sustainability in the Next Decade,” issued in March 2015, replaces EO 13423 and EO 13514 and sets new reduction targets for energy use intensity, water use intensity, and greenhouse gas (GHG) emissions and prescribes other sustainability goals for the DOE through FY 2025. DOE publishes these new goals and targets in a DOE Strategic Sustainability Performance Plan, which is updated each year (DOE 2015). These DOE goals are pursued and tracked under the NSTec Energy Management Program (Section 3.2.4.1 below).

### ***3.2.3 Environmental Objectives and Targets***

To address the identified significant environmental aspects of NNSA/NFO operations, an Environmental Working Group (EWG) selects objectives and targets that are determined on an FY basis. Targets are tracked by the various responsible operational groups, and reported quarterly to NNSA/NFO. Two EMS targets were identified for FY 2015. One was to develop an electronic chemical management system that will serve environmental, safety, emergency planning, and operational needs. The discussion for this target is presented in Section 2.4.1. The second target was to identify biobased and Environmentally Preferable Products (EPP) for purchase that are substitutes for non-EPP, non-biobased products currently being used and which are readily available, affordable, and effective. The biobased and EPP target for FY 2015, which relates to Pollution Prevention and Waste Minimization (P2/WM) activities, is discussed in Section 3.2.4.2.

### 3.2.4 Environmental Management Programs

#### 3.2.4.1 Energy Management

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

Each FY, the EMP produces a fiscal year NNSA/NFO Site Sustainability Plan (SSP) (NSTec 2015). The SSP identifies how NNSA/NFO will help meet DOE’s sustainability goals, which were first published in the 2010 Strategic Sustainability Performance Plan (SSPP) (DOE 2010). The SSP also satisfies the requirement of EO 13423 (revoked and superseded by EO 13693) for an Energy Management Plan. The SSP describes the program, planning, and budget assumptions as well as NNSA/NFO’s performance status for the previous year for each DOE SSPP goal, and planned actions to meet each goal during the next year. To implement the SSP, an Energy Management Council (EMC) meets bimonthly to discuss the requirements and track and facilitate their completion. The EMC and the EWG coordinate to ensure that all EMS-tracked objectives and targets mirror overlapping annual goals in the SSP. Table 3-1 includes a summary of the DOE SSPP goals and NNSA/NFO’s FY 2015 status in reaching them.

**Table 3-1. Environmental sustainability goals and FY 2015 performance status**

DOE Goal <sup>(a)</sup>	NNSA/NFO Performance Status
<b>Targets highlighted in green have been met or exceeded</b>	
<b>Greenhouse Gas (GHG) Reduction</b>	
50% reduction of Scope 1 and 2 GHG emissions <sup>(b)</sup> by FY 2025, from an FY 2008 baseline (FY 2015 target is 19% reduction).	FY 2015 emissions were 47,506 MtCO <sub>2e</sub> <sup>(c)</sup> , a 0% decrease from the FY 2008 baseline <sup>(d)</sup> of 47,454 MtCO <sub>2e</sub> .
25% reduction in Scope 3 <sup>(b)</sup> GHG emissions by FY 2025, from an FY 2008 baseline (FY 2015 target is 6% reduction).	FY 2015 emissions were determined to be 17,096 MtCO <sub>2e</sub> , a 19% increase from the FY 2008 baseline of 14,398 MtCO <sub>2e</sub> .
<b>Sustainable Buildings</b>	
25% reduction of energy intensity (British Thermal Units [BTUs] per gross square foot [gsf]) in goal-subject buildings, achieving 2.5% reductions annually by FY 2025 from an FY 2015 baseline.	New goal with a new baseline; in FY 2015, energy intensity was reduced overall by 27.5% from the FY 2003 baseline (the previous goal had been a 30% reduction by FY 2015 from the FY 2003 baseline).
Energy and water assessments conducted for 25% of all facilities covered under Section 432 of the Energy Independence and Security Act to ensure that 100% of covered facilities are assessed every 4 years.	In FY 2015, 33 energy audits/assessments were conducted, meeting this goal; the audits/assessments identified energy conservation measures for several buildings at the NNSS and NLVF.
Meter all individual buildings for electricity, natural gas, water, and steam where cost-effective and appropriate.	82% of buildings are metered for electricity, 88% for natural gas, 40% for chilled water, 26% for water, and no steam is used.
At least 15% (by building count or gsf) of existing buildings greater than 5,000 gsf to be compliant with the revised Guiding Principles (GPs) for Federal Leadership in High Performance Sustainable Buildings (HPSB) design by FY 2025, with progress to 100% thereafter.	In 2015, 15% (379,495 gsf) of NNSA/NFO’s enduring buildings larger than 5,000 gsf, became HPSB certified by meeting the GPs.
Identify efforts to increase regional and local planning coordination and involvement.	Continued coordination with the Regional Transportation Center Park and Ride Facilities; introduced the Club Ride program to site employees.

**Table 3-1. Environmental sustainability goals and FY 2015 performance status (continued)**

DOE Goal <sup>(a)</sup>	NNSA/NFO Performance Status
<b>Targets highlighted in green have been met or exceeded</b>	
<b>Sustainable Buildings (continued)</b>	
Identify the percentage of the site’s existing buildings above 5,000 gsf intended to be energy, waste, or water net-zero buildings by FY 2025.	New goal; no 2015 performance status to report.
Identify the percentage of new buildings larger than 5,000 gsf entering the planning process designed to achieve energy net-zero beginning in FY 2020.	No new buildings larger than 5,000 gsf are planned for FY 2016. Net-zero energy objectives will be integrated, as feasible, into new construction activities.
Establish a power usage effectiveness (PUE) <sup>(c)</sup> target in the range of 1.2-1.4 for new data centers and less than 1.5 for existing data centers.	PUE estimates range from 2.6–3.4 for the three data centers (two at the NNSC, one at the NLVF). Metering of all building systems to accurately measure PUEs is not cost-effective and each center uses non-precision cooling systems. An approach to construct new buildings or isolated systems in existing buildings for data center consolidation in order to meet this goal is being planned for FY 2017.
<b>Clean and Renewable Energy</b>	
Not less than 10% of DOE’s total electric and thermal energy consumption in FY 2016–2017 shall be accounted for by renewable and alternative sources, working towards 25% by FY 2025 (“Clean Energy” requirement).	1% of power produced on site is from renewable sources; renewable energy credits were purchased, representing 8% of NNSA/NFO’s annual electrical consumption; no new onsite renewable and/or alternative energy generation projects.
Not less than 10% of DOE’s total electric consumption in FY 2016-2017 shall be renewable electric energy, working towards 30% by FY 2025 (“Renewable Electric Energy” requirement).	See status for preceding goal.
<b>Water Use Efficiency and Management</b>	
36% reduction in potable water intensity (gallons used per square foot [gal/ft <sup>2</sup> ]) by FY 2025 from an FY 2007 baseline (FY 2015 target is 16% reduction).	Water intensity across all NNSA/NFO facilities was 42.99 gal/ft <sup>2</sup> in FY 2015, a 39% reduction from the FY 2007 baseline of 70.42 gal/ft <sup>2</sup> , exceeding this goal.
30% reduction in water consumption for industrial, landscaping, and agricultural use by FY 2025 from an FY 2010 baseline (FY 2015 target is 10% reduction).	Non-potable water production was 39,034,000 gal in FY 2015, a 28.9% reduction from the FY 2010 baseline of 54,913,300 gal, exceeding this goal.
<b>Fleet Management</b>	
20% reduction in fleet annual petroleum consumption by FY 2015, relative to an FY 2005 baseline; maintain 20% reduction thereafter.	Petroleum consumption in FY 2015 was 396,830 gal, a 70% reduction from the FY 2005 baseline of 1,328,957 gal, exceeding the goal.
10% increase in annual fleet alternative fuel consumption by FY 2015, relative to an FY 2005 baseline; maintain 10% increase thereafter.	Alternative fuel consumption in FY 2015 was 405,795 gal, a 224% increase above the FY 2005 baseline of 125,090 gal, exceeding the goal.
30% reduction in fleet-wide, per-mile GHG emissions by FY 2025 from an FY 2014 baseline.	New goal; no performance status to report for FY 2015.
75% of light duty vehicle purchases must consist of alternative fuel vehicles.	100% of all light duty vehicle acquisitions in FY 2015 (92 vehicles) were AFVs, meeting this goal.
50% of passenger vehicle acquisitions to consist of zero emission or plug-in hybrid electric vehicles by FY 2025.	New goal; NNSA/NFO has been acquiring such vehicles since 2012 and currently has 13. Of the 92 vehicles acquired in 2015, 2 (2.2%) were plug-in hybrid electric.
<b>Sustainable Acquisition</b>	
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 2015, a significant change to the electronic procurement system was implemented in order to track and report biobased and biopreferred purchases.

**Table 3-1. Environmental sustainability goals and FY 2015 performance status (continued)**

DOE Goal <sup>(a)</sup>	NNSA/NFO Performance Status
<b>Targets highlighted in green have been met or exceeded</b>	
<b>Pollution Prevention and Waste Reduction</b>	
Divert at least 50% of non-hazardous solid waste, excluding construction and demolition materials and debris, from disposal.	31% of non-hazardous solid waste was diverted from disposal.
Divert at least 50% of construction and demolition materials and debris from disposal.	20% of construction waste was diverted from disposal.
<b>Energy Performance Contracts</b>	
Implement <i>Energy Savings Performance Contracts (ESPCs)</i> (see <a href="#">Glossary, Appendix B</a> ) and Utility Energy Service Contracts to obtain energy efficiency investments in buildings and deploy onsite renewable energy through long-term contracts with the private sector, which are paid through savings derived from those investments.	No new energy performance contracts were pursued in FY 2015; provided measurement and verification support to an existing ESPC project.
<b>Electronic Stewardship</b>	
95% of eligible electronics acquisitions are U.S. Environmental Protection Agency (EPA) Electronic Product Environmental Assessment Tool (EPEAT)-registered.	All eligible electronic acquisitions continue to be EPEAT-registered, meeting this goal.
100% of eligible personal computers, laptops, and monitors have power management capability enabled.	All such equipment purchased in FY 2015 have power management capability, but not all of the equipment currently has this feature enabled; 300 computers that are part of DOE's Common Operating Environment (DOECOE) are compliant.
100% of eligible computers and imaging equipment have automatic duplexing enabled.	All purchases of multi-function printing devices are required to have this capability, but automatic duplexing is currently not enabled in all eligible equipment.
100% of used electronics are reused or recycled using environmentally sound disposition options.	All electronic equipment that passed excess screening in 2015 was sold for reuse, meeting this goal.
<b>Climate Change Resilience</b>	
Update policies to incentivize planning for, and addressing the impacts of climate change.	New goal; climate change impacts identified include facility power and water supply disruptions, wildland fires, flooding, drought, and extreme weather events.
Update emergency response procedures and protocols to account for projected climate change, including extreme weather events	New goal; existing emergency management plans cover flood contingencies and will be expanded to incorporate other climate change impacts and response procedures/protocols.
Ensure workforce protocols and policies reflect projected human health and safety impacts of climate change.	New goal; NNSA emergency response policies and procedures have been updated to include emergency events resulting from natural phenomena events.
Ensure site/lab management demonstrates commitment to adaptation efforts through internal communications and policies.	New goal; management commitment is expressed through approval process of new and updated policies; climate change adaptation information is communicated in the energy awareness NSTec newsletter, The Joule.
Ensure that site/lab climate adaptation and resilience policies and programs reflect best available current climate change science, updated as necessary.	New goal; NNSA/NFO partners with the NOAA ARL/SORD <sup>(f)</sup> through an Interagency Agreement to provide a comprehensive meteorology program for the NNSA that includes monitoring current climate, storing climate data, and updating NNSA climatology reports. Through ARL/SORD, NNSA/NFO works with additional NOAA climate monitoring organizations to provide information to a broader regional, national, and global climate scope.

(a) The DOE goals listed are identified in DOE (2015).

(b) The GHGs targeted for emission reductions are carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride (SF6). Scope 1 GHG emissions include direct emissions from sources that are owned or controlled by a federal agency. Scope 2 includes direct emissions resulting from the generation of electricity, heat, or steam purchased by a federal agency. Scope 3 includes emissions from sources not owned or directly controlled by a federal agency but related to agency activities, such

**Table 3-1. Environmental sustainability goals and FY 2015 performance status (continued)**

- 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) MtCO<sub>2e</sub> = metric tons of carbon dioxide equivalents.
  - (d) In 2016, prior to publication of this report, the EMP requested approval from DOE Headquarters to rebase the 2008 GHG emissions due to changes in data collection and recording methods; approval is pending.
  - (e) 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.
  - (f) NOAA ARL/SORD stands for the National Oceanic and Atmospheric Administration Air Resources Laboratory, Special Operations and Research Division, which operate a network of mobile meteorological towers on the NNSS.

### 3.2.4.2 Pollution Prevention and Waste Minimization

The P2/WM Program has initiatives to eliminate or reduce the generation of waste, the release of pollutants to the environment, and the use of Class I ozone-depleting substances (ODS). These initiatives are pursued through source reduction, reuse, segregation, and recycling, and by procuring recycled-content materials and environmentally preferable products and services. They also ensure that proposed methods of treatment, storage, and disposal of waste minimize potential threats to human health and the environment. These initiatives address the DOE SSPP goals and the requirements of DOE orders, federal laws, and state regulations applicable to operations at the NNSS, NLVF, and RSL-Nellis (see Table 2.1 of Chapter 2). The following strategies are employed to meet P2/WM goals.

**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 that every project/operation address waste minimization issues during the planning phase and ensure that adequate funds are allocated to perform any identified waste minimization activities.

Source reduction was the strategy used to implement a requirement under EO 13423 to reduce ODS at all DOE sites. By the end of 2009, NNSA/NFO had discontinued the procurement of Class I ODS for all non-exempted uses, and halon-containing fire extinguishers and equipment were removed from the NNSS and NLVF facilities by 2010. All halons have been removed from RSL-Nellis, with the exception of halon fire extinguishers in the aircraft. Since 2009, only environmentally preferable alternatives to Class I ODS are purchased. All procurement of refrigerants containing ODS (referred to as ODS refrigerants) are approved by the environmental oversight organization, which verifies that only approved products are purchased. Existing ODS refrigerants in equipment are being phased out as equipment is drained for repair or replaced by new equipment with approved alternative refrigerants.

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

An Excess Property Program also exists to provide excess property to NNSA/NFO employees or subcontractors, laboratories, other DOE sites, other federal agencies, state and local government agencies, universities, and local schools. If new users are not found, excess property is made available to the public for recycle/reuse through periodic Internet sales. In 2011, an Excess Integrated Project Team was formed with members from radiological operations, materials management, and property management. The team initiated a campaign for disposing reels of cable, drill pipe, drilling equipment, heavy duty equipment, machine shop equipment, and transformers. Since it began, this integrated campaign has generated substantial revenues and extended the life of the NNSS landfill by over 3 years at a cost savings of \$835,000.

**Environmentally Preferable Purchasing** – The Resource Conservation and Recovery Act (RCRA), as amended, requires federal agencies to develop and implement an affirmative procurement program (APP). NNSA/NFO maintains an APP that stimulates a market for recycled-content products and closes the loop on recycling. The EPA maintains a list of items containing recycled materials that should be purchased. The EPA determines what the minimum content of recycled material should be for each item. Federal facilities must have a process in place for

purchasing the EPA-designated items containing the minimum content of recycled materials. EO 13423 requires federal facilities to ensure, where possible, that 100% of purchases of items on the EPA-designated list contain recycled materials at the specified minimum content. The U.S. Department of Agriculture (USDA) designates types of materials that have a required minimum amount of bio-based chemicals. Products that meet this requirement are being added to procurement lists and tracked.

A 2015 EMS target was to identify biobased and environmentally preferable products that could be purchased as replacements for non-biobased and non-environmentally preferable products if they were readily available, affordable, and effective. As a result, a Biobased Purchasing Catalog of existing Just-in-Time (JIT) items, is in development, and 97 biobased product categories are being added to the procurement system for data tracking and reporting purposes. In October 2015, a USDA BioPreferred report was prepared and documented that during FY 2015, \$2,047 was spent on janitorial biobased products. The amount spent on biobased products in FY 2015 increased by about 10% over the amount spent in FY 2014.

### ***3.3 EMS Competence, Training, and Awareness***

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

The NNSA/NFO P2/WM initiatives also include an employee and public awareness program. Awareness of P2/WM issues is accomplished by dissemination of articles through electronic mail, contractor and NNSA/NFO newsletters, the maintenance of a P2/WM intranet website, employee training courses, and participation at employee and community events. These activities are intended to increase awareness of P2/WM and environmental issues and highlight the importance of P2/WM for improving environmental conditions in the workplace and community.

### ***3.4 Audits and Operational Assessments***

The ISO 14001 certifying organization, Lloyd's Register Quality Assurance (LRQA), conducts annual surveillances on focused portions of the EMS. The frequency of the surveillances was changed from semi-annual to annual on the recommendation of LRQA due to the overall robustness of the EMS. Findings and recommendations are tracked in the companywide issues tracking system, caWeb. Corrective actions taken to close the issues help to continually improve the EMS program. In April 2015, LRQA conducted a surveillance, and no issues were found. The EMS Description document states that an independent internal audit of portions of the EMS program will be performed each year. The internal audit of the EMS was conducted in February 2015 and identified two non-compliance issues, which were immediately corrected, and one opportunity for improvement. These were entered into caWeb for tracking, and were resolved and closed in 2015.

Additionally, NSTec's Occupational Safety and Health Division conducts internal management assessments and compliance evaluations on focused portions of the EMS program. These assessments and evaluations determine the extent of compliance with environmental regulations and identify areas for overall improvement. In 2015, NSTec conducted a total of 4 internal management assessments and 79 compliance evaluations.

### ***3.5 EMS Effectiveness and Reporting***

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

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

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

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

On January 15, 2016, the 2015 Facility EMS Annual Report Data for the NNSA was entered into the DOE Headquarters EMS database accessed through the FedCenter.gov website (<http://www.fedcenter.gov/programs/ems/>). This database gathers information in several EMS areas from all DOE sites to produce a combined report reflecting DOE's overall performance compared to other federal agencies. The report includes a scorecard section, which is a series of questions regarding a site's EMS effectiveness in meeting the objectives of federal EMS directives. The NNSA scored "green," the highest score.

### **3.6 Awards and Recognition**

NNSA/NFO's Fleet, Fuel and Equipment Service Operations was rated fourth in the nation by the 2015 100 Best Fleets, Green Fleet Awards Organization (see [http://www.the100bestfleets.com/gf\\_winners\\_2015.htm](http://www.the100bestfleets.com/gf_winners_2015.htm)). This organization tracks and rates the performance of vehicle fleets throughout the continent. NFO's Fleet was recognized for having one of the cleanest, most fuel-efficient vehicle fleets.

### **3.7 References**

DOE, see U.S. Department of Energy.

National Security Technologies, LLC, 2015. *FY 2016 NNSA/NFO Site Sustainability Plan*. Prepared for U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office, Las Vegas, NV.

NSTec, see National Security Technologies, LLC.

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

U.S. Department of Energy, 2015. *2015 Strategic Sustainability Performance Plan*. Report to the White House Council on Environmental Quality. Available at: <http://energy.gov/management/spo/downloads/2015-strategic-sustainability-performance-plan> as accessed on June 6, 2016.

## Chapter 4: Air Monitoring

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Section 4.1 of this chapter presents the results of radiological air monitoring conducted on the Nevada National Security Site (NNSS) by the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) to verify compliance with radioactive air emission standards. Measurements of radioactivity 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 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

The sources of radioactive air emissions on the NNSS include the following: (1) evaporation of tritiated water from containment ponds; (2) diffusion of tritiated water vapor 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) release of radionuclides from current operations. Figure 4-1 shows the location of all known historical and 2015 radiological air emission sources. Areas of soil contamination related to historical weapon tests are depicted in Figure 4-1 as "Grouped Area Sources." The NNSS air monitoring network consists of samplers placed 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).

Data from NNSS sampling locations are analyzed to meet the specific goals listed below. The analytes monitored 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 on the volatility and availability of radionuclides for resuspension (see [Table 1-5](#) in Chapter 1 for the half-lives of these radionuclides). Uranium is included because uranium (primarily depleted uranium [DU]), either has been, or currently is, used during exercises in specific areas of the NNSS. Samples from locations near these areas are analyzed for uranium. Gross alpha and gross beta readings are used in air monitoring as a relatively rapid screening measure.

<b>Radiological Air Monitoring Goals</b>	<b>Analytes Monitored</b>
<p>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.</p> <p>Conduct point-source operational monitoring required under National Emission Standards for Hazardous Air Pollutants (NESHAP) for any facility that has 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.</p> <p>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).</p> <p>Determine if the total radiation dose to the public from all pathways (air, water, and food) complies with the 100 mrem/yr standard set by U.S. Department of Energy (DOE) Order DOE O 458.1, "Radiation Protection of the Public and the Environment."</p>	<p>Americium-241 (<sup>241</sup>Am)</p> <p>Gamma ray emitters (includes Cesium-137 [<sup>137</sup>Cs])</p> <p>Tritium (<sup>3</sup>H)</p> <p>Plutonium-238 (<sup>238</sup>Pu)</p> <p>Plutonium-239+240 (<sup>239+240</sup>Pu)</p> <p>Uranium-233+234 (<sup>233+234</sup>U)</p> <p>Uranium-235+236 (<sup>235+236</sup>U)</p> <p>Uranium-238 (<sup>238</sup>U)</p> <p>Gross alpha radioactivity</p> <p>Gross beta radioactivity</p>

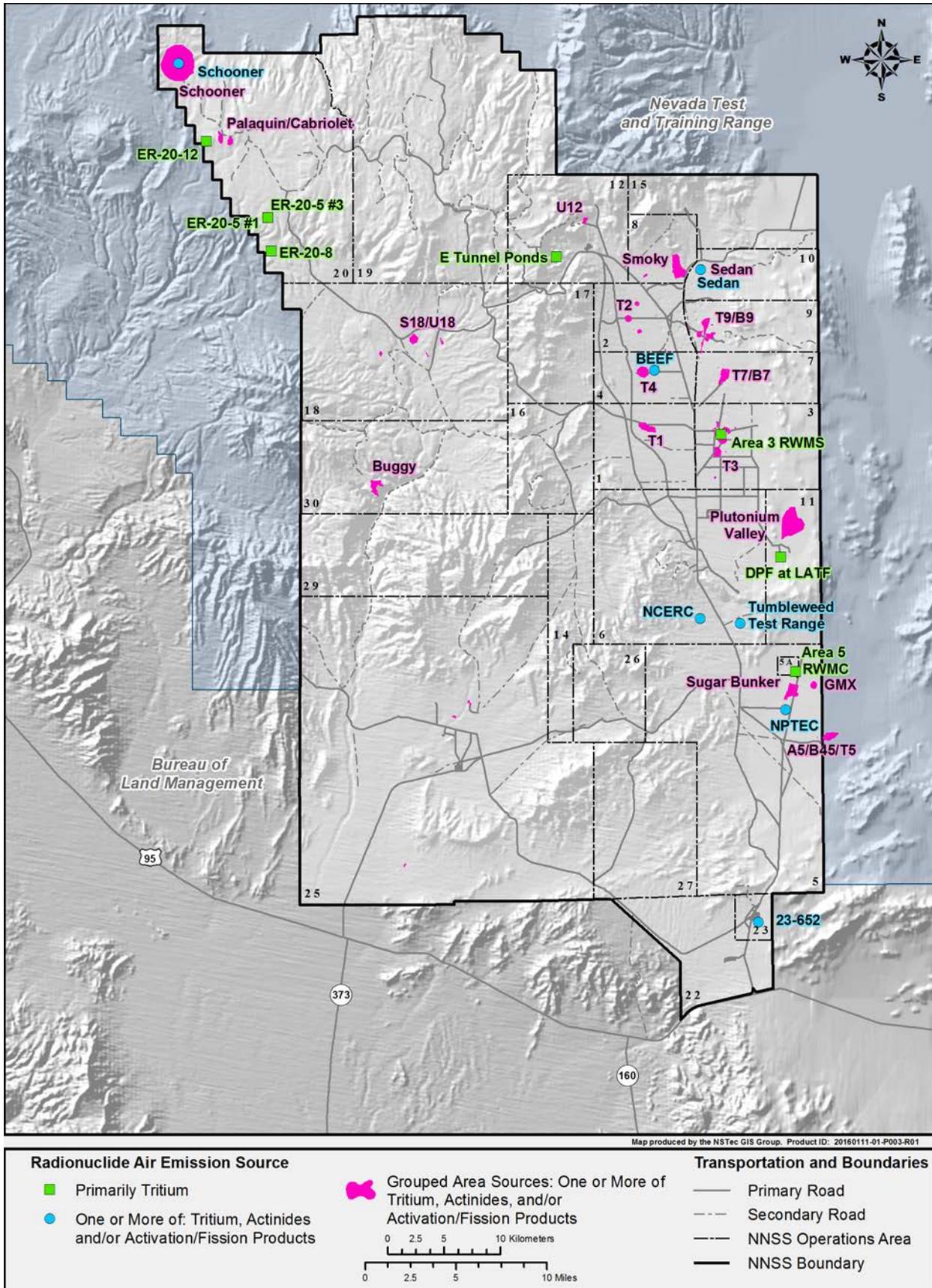


Figure 4-1. Sources of radiological air emissions on the NNSS in 2015

### 4.1.1 Monitoring System Design

**Environmental Samplers** – A total of 17 environmental sampling locations operated on the NNSS at some time during 2015 (Figure 4-2). Of these 17 samplers, 15 have both air particulate and tritium (atmospheric moisture) samplers, 1 has only an air particulate sampler, and 1 has only a tritium sampler (Figure 4-2). The NNSS air samplers are positioned in predominant downwind directions from sources of radionuclide air emissions and/or are positioned between NNSS contaminated locations and potential offsite receptors. (Wind rose data, showing predominant wind directions on the NNSS, are presented in Section A.3 of *Attachment A: Site Description*, which is included as a separate file on the compact disc of this report). Most radionuclide air emission sources are *diffuse sources* (see [Glossary, Appendix B](#)) that include areas with (1) radioactivity in surface soil that can be resuspended by the wind, (2) tritium in water (tritiated water) transpiring or evaporating from plants and soil at the sites of past nuclear tests, and (3) tritiated water evaporating from ponds receiving water either from contaminated wells or from tunnels that cannot be sealed. Sampling and analysis of air particulates and tritium were performed at these locations as described in 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 environmental sampling locations that have both air particulate and tritium samplers are approved by the U.S. Environmental Protection Agency (EPA) Region 9 as *critical receptor samplers* (see [Glossary, Appendix B](#)). They are located near the boundaries and in the center of the NNSS (Figure 4-2). Radionuclide concentrations measured at these samplers are used to assess compliance with the NESHAP public dose limit of 10 mrem/yr (0.1 mSv/yr). The annual average concentrations from each sampler are compared with the NESHAP Concentration Levels for Environmental Compliance (compliance levels [CLs]) listed in Table 4-1. Compliance with NESHAP is demonstrated when the sum of the fractions, determined by dividing each radionuclide's concentration by its CL and then adding the fractions together, is less than 1.0 at all samplers.

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

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

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

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

In addition to CLs, air concentrations measured at all locations are also compared with Derived Concentration Standard (DCS) values. They represent the annual average air concentrations that would result in a *total effective dose equivalent (TEDE)* (see [Glossary, Appendix B](#)) of 100 mrem/yr (the federal dose limit to the public from all radiological exposure pathways). Ten percent of the DCS (third column of Table 4-1) represents a 10 mrem/yr dose and is analogous to the CLs. Differences between the CL and 10% of the DCS are due to the fact that the DCS values are based on only inhalation of radionuclides in air while the CL consider external dose and ingestion of radionuclides deposited from air. This results in the CLs being the more conservative of the two and are used to demonstrate compliance. Air concentrations approaching 10% of the CLs are investigated for causes that may be mitigated in order to ensure that regulatory dose limits are not exceeded.

**Point-Source (Stack) Sampler** – Continuous stack monitoring has been conducted in the past at one facility on the NNSS, the Joint Actinide Shock Physics Experimental Research (JASPER) facility in Area 27 (Figure 4-2). During 2013, the potential air emissions from the facility were re-evaluated and determined to result in a potential

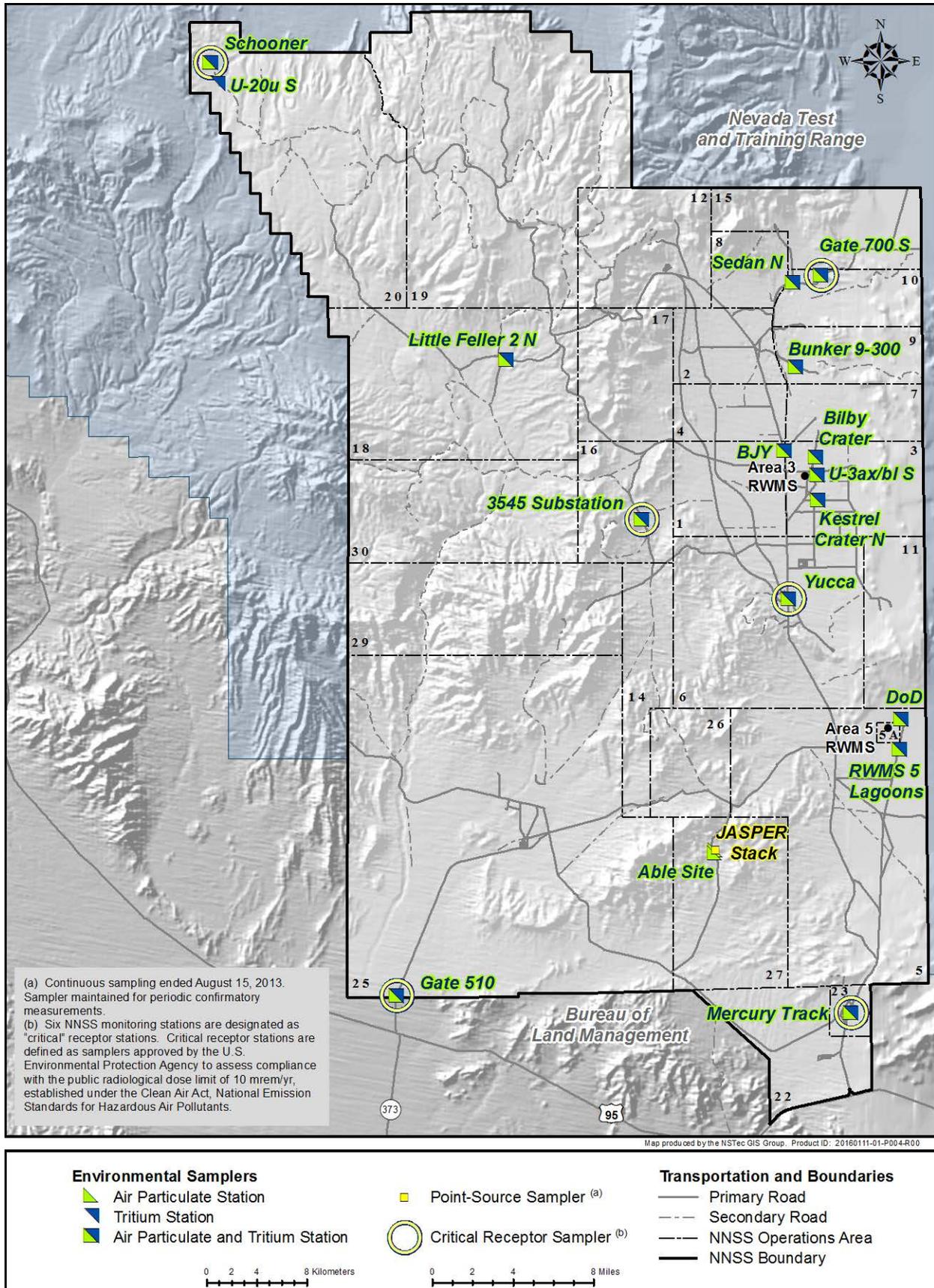


Figure 4-2. Radiological air sampling network on the NNS in 2015

dose that is much less than the 0.1 mrem/yr threshold at which stack monitoring is required under NESHAP. Therefore, only periodic sampling is recommended to verify low emissions. During 2015, one sample was taken from June 9 to June 10 for this purpose. No man-made radionuclides were detected in the sample which confirms continued low emissions.

#### 4.1.2 Air Particulate and Tritium Sampling Methods

A sample is collected from each air particulate sampler by drawing air through a 10-centimeter (cm) (4-inch [in.]) diameter glass-fiber filter at a flow rate of about 85 liters (3 cubic feet [ft<sup>3</sup>]) per minute. The particulate filter is mounted in a filter holder that faces downward at a height of 1.5 meters (m) (5 feet [ft]) above ground. A timer measures the operating time. The run time multiplied by the flow rate yields the volume of air sampled, which is about 1,720 cubic meters (m<sup>3</sup>) (60,000 ft<sup>3</sup>) 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.

The filters are analyzed for gross alpha and gross beta radioactivity after a 5-day holding time to allow for the decay of naturally occurring radon progeny. These filters are then composited quarterly for each sampler. The composite samples are analyzed for gamma-emitting radionuclides (which includes <sup>137</sup>Cs) by gamma spectroscopy and for <sup>238</sup>Pu, <sup>239+240</sup>Pu, and <sup>241</sup>Am by alpha spectroscopy after chemical separation. Samples from locations relatively near potential sources of uranium emissions are also analyzed for uranium isotopes by alpha spectroscopy. These sampling locations are RWMS 5 Lagoons (Area 5), Yucca (Area 6), Gate 700 S (Area 10), 3545 Substation (Area 16), Gate 510 (Area 25), and Able Site (Area 27).

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

Quality control air samples (e.g., duplicates, blanks, and spikes) are also routinely incorporated into the analytical suites. Chapter 16 contains a discussion of quality assurance/quality control protocols and procedures used for radiological air monitoring.

#### 4.1.3 Presentation of Air Sampling Data

The 2015 annual average radionuclide concentrations at each air sampling location are presented in the following sections. The annual average concentration for each radionuclide is estimated from uncensored analytical results for individual samples; i.e., values less than their analysis-specific *minimum detectable concentrations (MDCs)* (see [Glossary, Appendix B](#)) are included in the calculation. <sup>239+240</sup>Pu, <sup>233+234</sup>U, and <sup>235+236</sup>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 and to the upward flux of tritium from the soil at sites of past nuclear tests and buried low-level radioactive waste.

#### 4.1.4.1 Gross Alpha and Gross Beta

**Gross alpha** and **gross beta** (see [Glossary, Appendix B](#)) radioactivity measurements in air samples collected in 2015 are summarized in Tables 4-2 and 4-3. Because these radioactivity measurements include naturally occurring radionuclides (such as  $^{40}\text{K}$ ,  $^7\text{Be}$ , uranium, thorium, and the daughter isotopes of uranium and thorium) in uncertain proportions, a meaningful CL cannot be constructed. These analyses are useful in that results can be economically obtained just 5 days after sample collection to identify any increases requiring investigation.

Overall, the distribution of mean gross alpha results across the network is comparable with those of the past few years. These measurements reflect to some extent the higher values seen at some locations with  $^{241}\text{Am}$  and  $^{239+240}\text{Pu}$  (see Sections 4.1.4.2 and 4.1.4.4). The gross beta measurements also resemble those of prior years, excluding the briefly elevated values in March 2011 due to the Fukushima Daiichi nuclear power plant event. There are no sampling locations with data that stand out from the rest.

**Table 4-2. Gross alpha radioactivity in air samples collected in 2015**

Area	Sampling Location	Number of Samples	Gross Alpha ( $\times 10^{-16}$ $\mu\text{Ci/mL}$ )			
			Mean	Standard Deviation	Minimum	Maximum
1	BJY	26	26.16	9.24	5.72	45.79
3	Bilby Crater	26	25.51	13.09	3.09	66.23
3	Kestrel Crater N	26	31.93	15.03	4.94	74.62
3	U-3ax/bl S	26	31.51	14.28	5.56	73.74
5	DoD	26	26.80	8.18	12.11	42.33
5	RWMS 5 Lagoons	26	27.49	10.10	11.55	45.13
6	Yucca*	26	24.21	7.88	0.63	41.84
9	Bunker 9-300	26	29.93	16.83	2.43	69.52
10	Gate 700 S*	26	23.91	8.09	7.49	37.16
10	Sedan N	26	29.72	18.67	-0.62	88.26
16	3545 Substation*	26	21.23	7.90	1.23	31.80
18	Little Feller 2 N	26	23.55	10.24	4.28	39.53
20	Schooner*	26	19.63	8.25	-0.61	35.63
23	Mercury Track*	26	22.92	8.27	7.02	41.63
25	Gate 510*	26	24.63	9.23	2.42	40.78
27	Able Site	26	21.87	7.43	1.82	32.79
<b>All Environmental Locations</b>		<b>416</b>	<b>25.69</b>	<b>11.69</b>	<b>-0.62</b>	<b>88.26</b>

\* EPA-approved Critical Receptor Sampler

**Table 4-3. Gross beta radioactivity in air samples collected in 2015**

Area	Sampling Location	Number of Samples	Gross Beta ( $\times 10^{-15}$ $\mu\text{Ci/mL}$ )			
			Mean	Standard Deviation	Minimum	Maximum
1	BJY	26	21.39	3.73	16.29	30.88
3	Bilby Crater	26	21.21	3.59	16.89	32.47
3	Kestrel Crater N	26	21.86	3.17	17.52	29.74
3	U-3ax/bl S	26	21.52	3.08	17.89	28.63
5	DoD	26	23.32	3.45	18.96	34.15
5	RWMS 5 Lagoons	26	23.28	3.52	19.12	34.36
6	Yucca*	26	22.54	3.44	17.34	32.80
9	Bunker 9-300	26	21.14	3.25	15.68	30.04
10	Gate 700 S*	26	20.64	3.09	16.38	29.21
10	Sedan N	26	20.89	3.44	15.93	28.95
16	3545 Substation*	26	19.99	3.12	13.63	26.21

**Table 4-3. Gross beta radioactivity in air samples collected in 2015 (continued)**

Area	Sampling Location	Number of Samples	Gross Beta ( $\times 10^{-15}$ $\mu\text{Ci/mL}$ )			
			Mean	Standard Deviation	Minimum	Maximum
18	Little Feller 2 N	26	19.57	3.36	12.49	25.53
20	Schooner*	26	20.57	3.32	15.43	31.14
23	Mercury Track*	26	21.96	3.20	16.91	32.13
25	Gate 510*	26	22.43	3.32	17.89	34.03
27	Able Site	26	21.19	3.31	16.57	31.82
<b>All Environmental Locations</b>		<b>416</b>	<b>21.47</b>	<b>3.44</b>	<b>12.49</b>	<b>34.36</b>

\* EPA-approved Critical Receptor Sampler

#### 4.1.4.2 Americium-241

The mean  $^{241}\text{Am}$  concentration for environmental sampler locations is  $11.67 \times 10^{-18}$   $\mu\text{Ci/mL}$ . This is not a significant change from recent years; the annual means were 8.55, 10.09, 12.74, 15.99, 6.99, and  $6.33 \times 10^{-18}$   $\mu\text{Ci/mL}$  in 2014 through 2009, respectively. The 2015 average concentration is 0.6% of the CL. As usual, the highest concentrations are detected at the Bunker 9-300 sampler location in Area 9 (Table 4-4, Figure 4-3). This sampler is located within areas of known soil contamination from past nuclear tests, available for re-suspension on windy days; see similar results for  $^{239+240}\text{Pu}$  in Section 4.1.4.4. The annual mean concentration at Bunker 9-300 is  $43.6 \times 10^{-18}$   $\mu\text{Ci/mL}$ , 2.3% of the CL (shown at the bottom of Table 4-4). Other sampler locations with relatively higher concentrations are Sedan N (Area 10) and the samplers in Area 3. Figure 4-3 shows measurements at these locations individually (similarly, Figures 4-5 and 4-6 show Sedan N and locations in Area 3 individually for  $^{238}\text{Pu}$  and  $^{239+240}\text{Pu}$ ). These plots also show the means of quarterly concentrations at other sampler locations, with vertical bars extending from the lowest to highest quarterly measurements at those locations.

**Table 4-4. Concentrations of  $^{241}\text{Am}$  in air samples collected in 2015**

Area	Sampling Location	Number of Samples	$^{241}\text{Am}$ ( $\times 10^{-18}$ $\mu\text{Ci/mL}$ )			
			Mean	Standard Deviation	Minimum	Maximum
1	BJY	4	12.39	3.20	8.85	16.63
3	Bilby Crater	4	13.35	12.44	4.87	31.63
3	Kestrel Crater N	4	31.50	19.26	6.71	53.51
3	U-3ax/bl S	4	36.60	38.93	5.33	91.69
5	DoD	4	1.52	1.77	-0.12	3.84
5	RWMS 5 Lagoons	4	-1.20	3.41	-6.31	0.65
6	Yucca*	4	3.31	2.54	0.91	5.83
9	Bunker 9-300	4	43.59	30.67	20.41	86.75
10	Gate 700 S*	4	2.30	1.16	1.50	4.00
10	Sedan N	4	33.32	34.35	2.56	75.34
16	3545 Substation*	4	2.81	3.15	0.65	7.43
18	Little Feller 2 N	4	1.26	0.96	0.40	2.63
20	Schooner*	4	1.03	2.28	-1.85	3.67
23	Mercury Track*	4	1.94	3.70	-0.99	7.36
25	Gate 510*	4	1.00	1.26	-0.11	2.31
27	Able Site	4	1.93	3.05	-0.86	5.85
<b>All Environmental Locations</b>		<b>64</b>	<b>11.67</b>	<b>20.64</b>	<b>-6.31</b>	<b>91.69</b>

CL =  $1,900 \times 10^{-18}$   $\mu\text{Ci/mL}$   
\* EPA-approved Critical Receptor Sampler

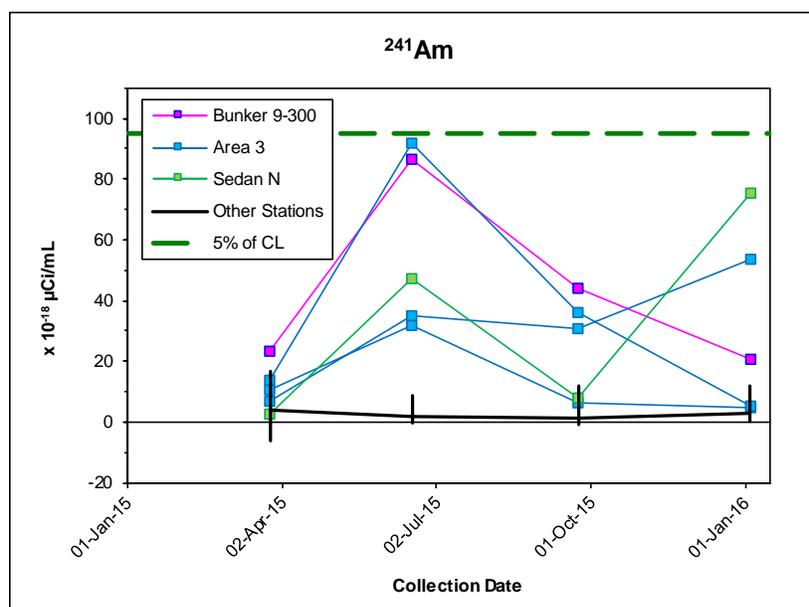


Figure 4-3. Concentrations of <sup>241</sup>Am in air samples collected in 2015

#### 4.1.4.3 Cesium-137

<sup>137</sup>Cs was detected in two samples during 2015 at levels slightly above their MDCs. These were in fourth quarter composite samples collected from the U-3ax/bl S and Gate 700 S locations, which are located near areas of known soil contamination from past nuclear tests. All measured concentrations were very low (Table 4-5, Figure 4-4). The highest single sample measurement (at U-3ax/bl S) was 1.3% of the CL; the highest annual mean (also at U-3ax/bl S) was 0.3% of the CL.

Table 4-5. Concentrations of <sup>137</sup>Cs in air samples collected in 2015

Area	Sampling Location	Number of Samples	<sup>137</sup> Cs ( × 10 <sup>-17</sup> μCi/mL)			
			Mean	Standard Deviation	Minimum	Maximum
1	BJY	4	-1.87	9.98	-14.49	9.10
3	Bilby Crater	4	-0.01	6.64	-8.73	7.44
3	Kestrel Crater N	4	2.48	7.44	-4.84	12.47
3	U-3ax/bl S	4	5.17	13.49	-4.58	24.89
5	DoD	4	1.91	8.34	-5.33	12.21
5	RWMS 5 Lagoons	4	-1.65	8.60	-12.10	6.63
6	Yucca*	4	-0.39	6.59	-10.25	3.41
9	Bunker 9-300	4	2.53	4.41	-1.88	8.45
10	Gate 700 S*	4	1.01	7.44	-8.09	7.87
10	Sedan N	4	3.44	3.81	-0.88	6.99
16	3545 Substation*	4	2.66	6.13	-1.71	11.57
18	Little Feller 2 N	4	1.94	4.56	-4.79	5.23
20	Schooner*	4	-0.17	12.61	-13.50	14.93
23	Mercury Track*	4	3.40	5.68	-4.89	7.28
25	Gate 510*	4	1.71	2.74	-0.45	5.72
27	Able Site	4	-1.31	6.73	-8.62	6.30
<b>All Environmental Locations</b>		<b>64</b>	<b>1.30</b>	<b>7.05</b>	<b>-14.49</b>	<b>24.89</b>

CL = 1,900 × 10<sup>-17</sup> μCi/mL  
\* EPA-approved Critical Receptor Sampler

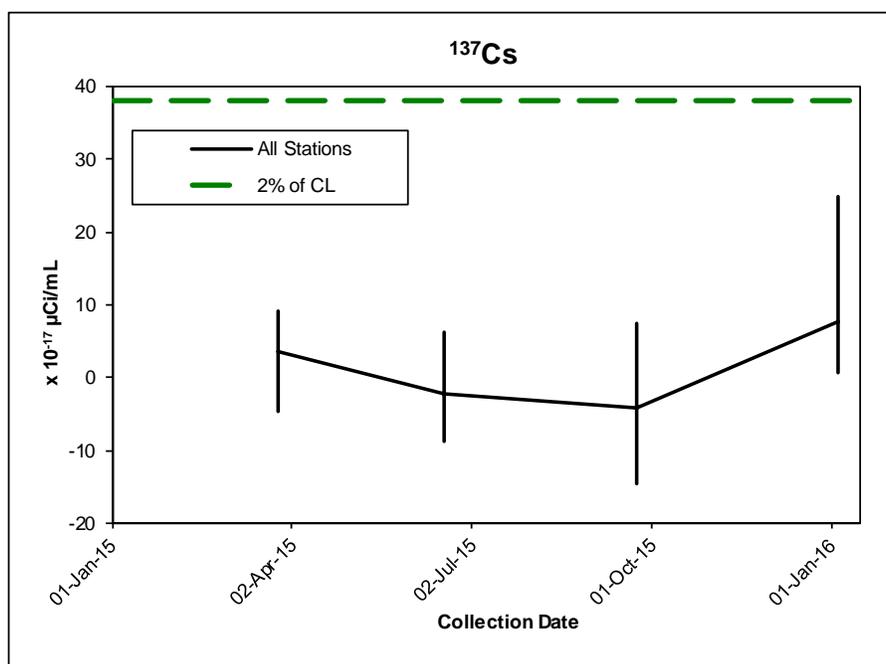


Figure 4-4. Concentrations of  $^{137}\text{Cs}$  in air samples collected in 2015

#### 4.1.4.4 Plutonium Isotopes

The overall mean concentration for  $^{238}\text{Pu}$  at environmental samplers in 2015 ( $3.49 \times 10^{-18}$   $\mu\text{Ci/mL}$ ) is within the range of values ( $1.15$  to  $3.72 \times 10^{-18}$   $\mu\text{Ci/mL}$ ) observed since 2009. Average Bunker 9-300 measurements are again higher than those of other locations (Table 4-6, Figure 4-5), although less prominently so compared with  $^{241}\text{Am}$  (Figure 4-3) and  $^{239+240}\text{Pu}$  (Figure 4-6). The highest mean concentration at environmental samplers is 0.3% of the CL.

The  $^{239+240}\text{Pu}$  isotopes are of greater abundance and hence greater interest. The overall mean of  $69.1 \times 10^{-18}$   $\mu\text{Ci/mL}$  in 2015 (Table 4-7) is within the range of values measured over the past 8 years. The location with the highest mean, as expected, is Bunker 9-300 ( $298 \times 10^{-18}$   $\mu\text{Ci/mL}$ , 14.9% of the CL; Table 4-7 and Figure 4-6). The higher plutonium values at this sampler are primarily due to diffuse sources of radionuclides from historical nuclear testing in Area 9. As with  $^{241}\text{Am}$ , other samplers with relatively higher values are Sedan N and the Area 3 samplers; these are represented individually in the plots.

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

Figure 4-7 shows long-term trends in  $^{239+240}\text{Pu}$  annual mean concentrations at locations with at least 15-year data histories since 1970. Rather than showing the time histories for all 47 locations, Figure 4-7 shows the average (geometric mean) trend lines for Areas 1 and 3; Area 5; Areas 7, 9, 10, and 15; and other areas. Areas 1, 3, 7, 9, 10, and 15, in the northeast portion of the NNSS, have a legacy of soil contamination from surface and atmospheric nuclear tests and safety shots. The average annual rates of decline for these groups range from 2.2% (Areas 1 and 3) and 2.5% (Areas 7, 9, 10, and 15) to over 10% (“Other Areas” group). This equates to an estimated environmental half-life for  $^{239+240}\text{Pu}$  in air of 30.9 years for Areas 1 and 3; 27.2 years for Areas 7, 9, 10, and 15; 7.1 years for Area 5; and 6.5 years for the “Other Areas” group. Declining rates are not attributed to radioactive decay, as the physical half-lives of  $^{239}\text{Pu}$  and  $^{240}\text{Pu}$  are 24,110 and 6,537 years, respectively. The

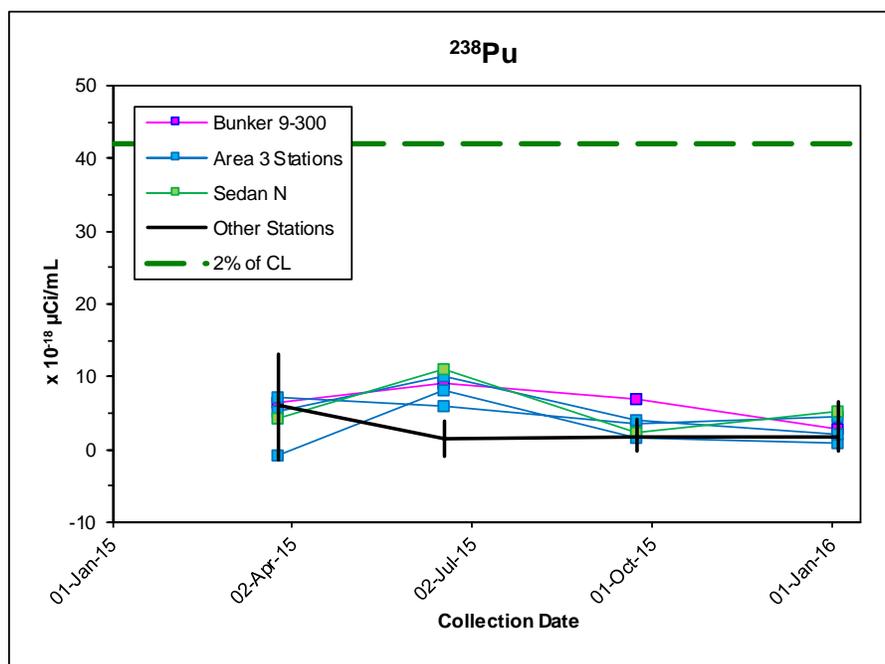
decreases are due primarily to immobilization and dilution of Pu particles in soil, resulting in reduced concentrations re-suspended in air. The half-life of the less abundant <sup>238</sup>Pu is 88 years.

**Table 4-6. Concentrations of <sup>238</sup>Pu in air samples collected in 2015**

Area	Sampling Location	Number of Samples	<sup>238</sup> Pu ( × 10 <sup>-18</sup> μCi/mL)			
			Mean	Standard Deviation	Minimum	Maximum
1	BJY	4	6.17	4.04	2.33	11.60
3	Bilby Crater	4	2.45	3.91	-0.75	8.14
3	Kestrel Crater N	4	5.38	1.60	3.62	7.24
3	U-3ax/bl S	4	5.36	3.42	2.06	10.07
5	DoD	4	2.27	3.39	0.38	7.35
5	RWMS 5 Lagoons	4	1.93	4.10	-1.00	7.98
6	Yucca*	4	2.10	1.44	0.31	3.83
9	Bunker 9-300	4	6.30	2.63	2.80	9.15
10	Gate 700 S*	4	5.02	5.59	0.92	13.21
10	Sedan N	4	5.75	3.75	2.35	11.06
16	3545 Substation*	4	1.82	2.10	-0.54	4.51
18	Little Feller 2 N	4	0.84	2.04	-1.40	3.46
20	Schooner*	4	2.51	1.08	1.24	3.79
23	Mercury Track*	4	1.77	1.76	-0.19	3.72
25	Gate 510*	4	2.13	1.36	0.85	3.66
27	Able Site	4	3.97	4.53	0.65	10.55
<b>All Environmental Locations</b>		<b>64</b>	<b>3.49</b>	<b>3.33</b>	<b>-1.40</b>	<b>13.21</b>

CL = 2,100 × 10<sup>-18</sup> μCi/mL

\* EPA-approved Critical Receptor Sampler



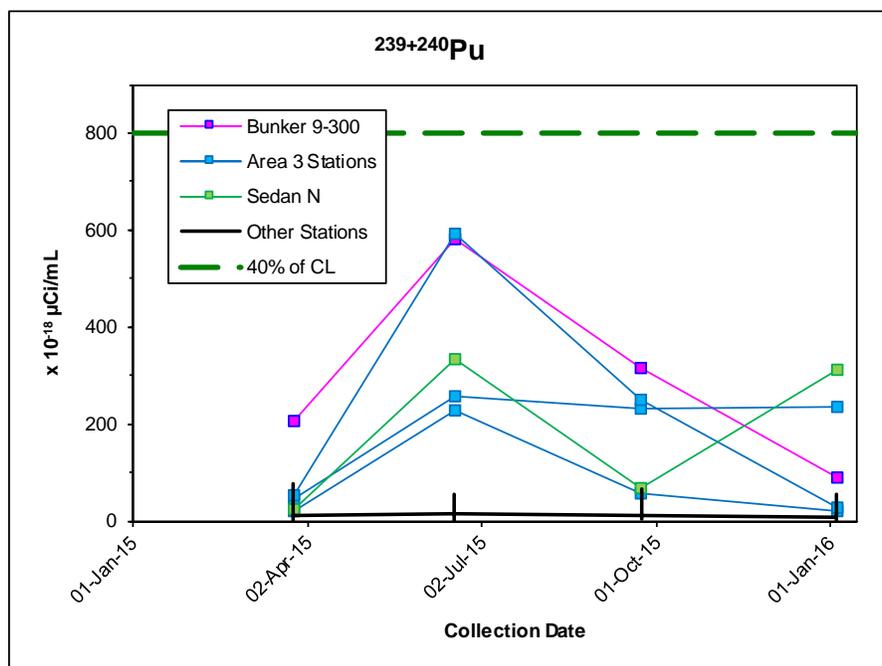
**Figure 4-5. Concentrations of <sup>238</sup>Pu in air samples collected in 2015**

Table 4-7. Concentrations of  $^{239+240}\text{Pu}$  in air samples collected in 2015

Area	Sampling Location	Number of Samples	$^{239+240}\text{Pu}$ ( $\times 10^{-18}$ $\mu\text{Ci}/\text{mL}$ )			
			Mean	Standard Deviation	Minimum	Maximum
1	BJY	4	63.24	11.07	53.41	77.20
3	Bilby Crater	4	80.82	99.98	18.70	228.59
3	Kestrel Crater N	4	191.78	99.18	44.17	258.23
3	U-3ax/bl S	4	230.46	260.76	26.26	591.58
5	DoD	4	8.54	8.21	4.26	20.85
5	RWMS 5 Lagoons	4	3.90	4.17	0.00	9.72
6	Yucca*	4	15.29	17.52	1.50	40.64
9	Bunker 9-300	4	298.06	210.90	89.23	582.28
10	Gate 700 S*	4	11.12	6.52	2.59	17.88
10	Sedan N	4	184.00	161.70	22.19	332.81
16	3545 Substation*	4	3.87	2.21	2.06	6.78
18	Little Feller 2 N	4	5.32	3.47	1.40	8.74
20	Schooner*	4	2.37	0.71	1.44	3.17
23	Mercury Track*	4	2.46	0.95	1.50	3.57
25	Gate 510*	4	2.14	0.65	1.21	2.62
27	Able Site	4	2.47	1.71	0.55	4.51
<b>All Environmental Locations</b>		<b>64</b>	<b>69.12</b>	<b>130.07</b>	<b>0.00</b>	<b>591.58</b>

CL =  $2,000 \times 10^{-18}$   $\mu\text{Ci}/\text{mL}$

\* EPA-approved Critical Receptor Sampler

Figure 4-6. Concentrations of  $^{239+240}\text{Pu}$  in air samples collected in 2015

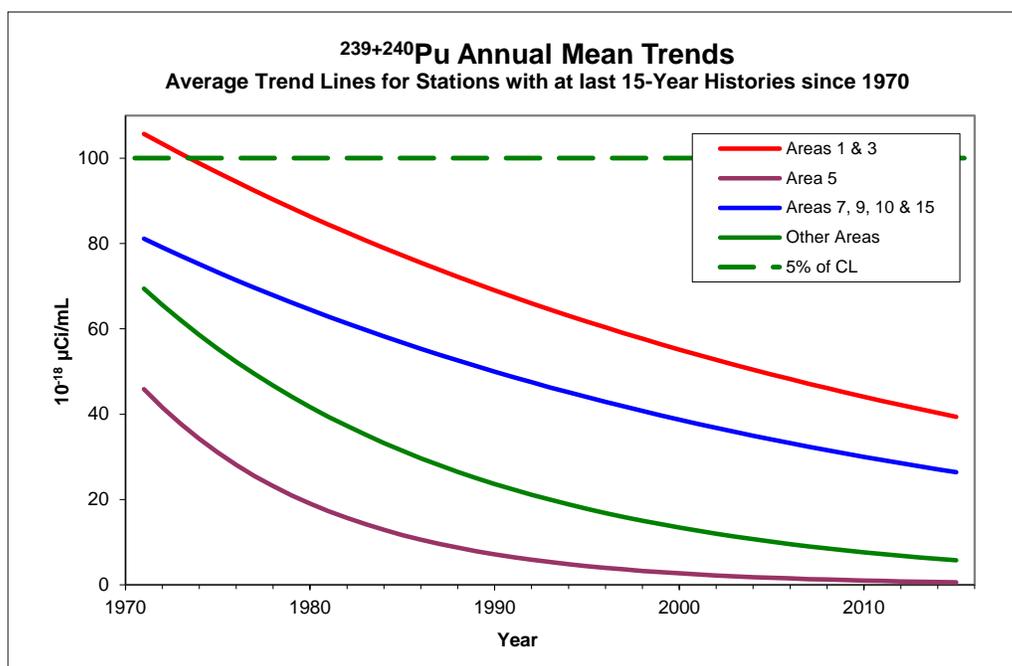


Figure 4-7. Average trends in <sup>239+240</sup>Pu in air annual means, 1971–2014

#### 4.1.4.5 Uranium Isotopes

Uranium analyses were performed in 2015 for samples from six samplers located relatively near sites where exercises using uranium (predominately DU) have been conducted. Concentrations and ratios of the U isotopes (<sup>233+234</sup>U / <sup>238</sup>U and <sup>235+236</sup>U / <sup>238</sup>U) were compared among the six samplers and compared with the ratios found in blank filters. From this, no evidence of elevated uranium or the presence of DU in air was observed.

#### 4.1.4.6 Tritium

Tritium concentrations in air vary widely across monitoring samplers on the NNSS (Table 4-8). As usual, the highest mean concentration was at the Schooner sampler ( $91.7 \times 10^{-6}$  picocuries per milliliter [pCi/mL]). The next highest are  $1.7 \times 10^{-6}$  pCi/mL at Sedan N,  $1.1 \times 10^{-6}$  pCi/mL at DoD, and  $0.8 \times 10^{-6}$  pCi/mL at RWMS 5 Lagoons. Figure 4-8 shows these data with the Schooner data plotted at one-tenth of their actual values to allow the variation at other locations to be visible. The Schooner annual mean is 6.1% of the CL; mean concentrations at other locations are at most 0.11% of the CL.

The tritium found at Schooner and Sedan N comes from past nuclear tests. Tritium associated with these tests quickly oxidizes into tritiated water, which remains in the surrounding soil and rubble until it moves to the surface and evaporates. Higher tritium concentrations in air are generally observed during the summer months. Increased tritium emissions are likely due to the movement of relatively deep soil moisture (> 2 m), containing relatively high concentrations of tritium, to the surface when temperatures are the highest and when shallow (< 2 m) soil moisture is the lowest. Rainfall can temporarily suppress these emissions by diluting tritium in the atmosphere and in the shallow soil moisture. Figure 4-8 shows the relationship between tritium and average daily temperature at Schooner Crater. Figure 4-9 shows the amount of precipitation occurring during monitoring periods in and around Pahute Mesa; note the dips in tritium emissions around the rains of mid-May, late July to early August, and October. The points plotted in these figures show the total <sup>3</sup>H emissions for the two-week periods, the average temperature at the Schooner Crater meteorological station for the period, and the highest daily precipitation recorded at any of three meteorological stations in the Pahute Mesa area.

Figure 4-10 shows average (geometric mean) long-term trends for the annual mean tritium levels at locations with at least 7-year histories since 1989, by Area groups. Tritium measurements have been decreasing fairly rapidly at

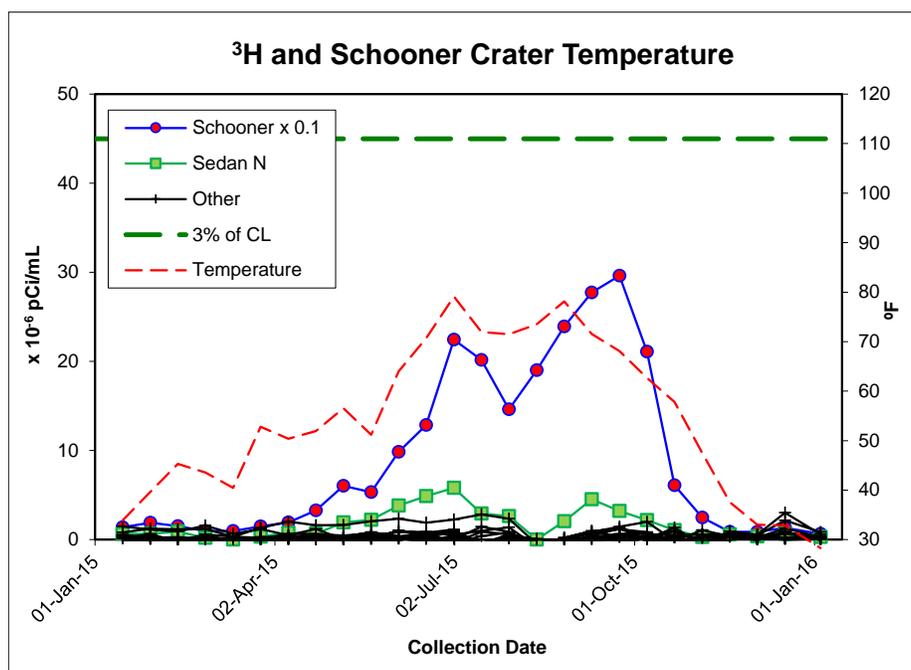
most locations; the overall average decline rate for samplers other than Schooner is around 17% per year. The decline rate for Schooner has been about 10.6% per year since 2002.

**Table 4-8. Concentrations of  $^3\text{H}$  in air samples collected in 2015**

Area	Sampling Location	Number of Samples	$^3\text{H}$ Concentration ( $\times 10^{-6}$ pCi/mL)			
			Mean	Standard Deviation	Minimum	Maximum
1	BJY	26	0.22	0.42	-0.81	0.93
3	Bilby Crater	26	0.19	0.48	-1.05	1.04
3	Kestrel Crater N	26	0.32	0.49	-0.77	1.44
3	U-3ax/bl S	26	0.14	0.50	-0.74	1.27
5	DoD	26	1.07	0.95	-0.59	2.83
5	RWMS 5 Lagoons	26	0.80	0.58	-0.81	2.16
6	Yucca*	26	0.32	0.76	-0.70	3.03
9	Bunker 9-300	26	0.39	0.53	-0.39	1.99
10	Gate 700 S*	26	0.05	0.29	-0.62	0.54
10	Sedan N	26	1.68	1.65	0.00	5.82
16	3545 Substation*	26	-0.02	0.35	-0.79	0.51
18	Little Feller 2 N	26	0.01	0.39	-0.78	0.71
20	Schooner*	26	91.74	97.20	6.45	296.14
20	U-20u S	26	0.16	0.45	-1.17	1.14
23	Mercury Track*	26	-0.08	0.33	-0.64	0.38
25	Gate 510*	26	0.07	0.37	-0.85	0.57
<b>All Environmental Locations</b>		<b>446</b>	<b>5.89</b>	<b>31.48</b>	<b>-1.17</b>	<b>296.14</b>

CL =  $1,500 \times 10^{-6}$  pCi/mL

\* EPA-approved Critical Receptor Sampler



**Figure 4-8. Concentrations of  $^3\text{H}$  in air samples collected in 2015 with Schooner Crater average air temperature per collection period**

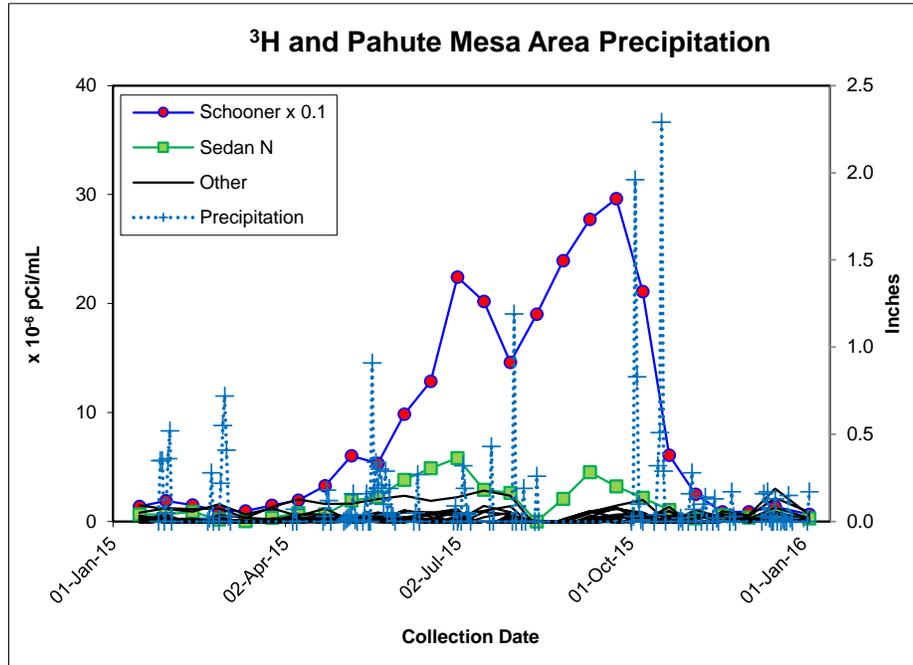


Figure 4-9. Concentrations of  $^3\text{H}$  in air samples collected in 2015 with Pahute Mesa precipitation

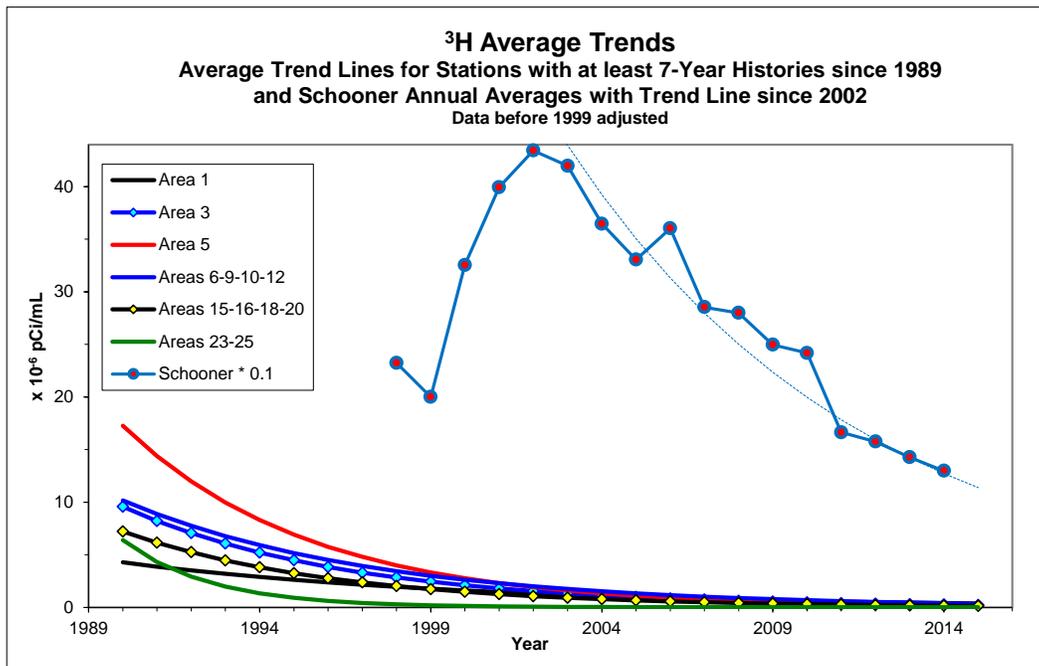


Figure 4-10. Trends in annual mean  $^3\text{H}$  air concentrations for Area groups, 1990–2015 and Schooner Crater annual means with trend since 2002

### 4.1.5 2015 Air Sampling Results from Critical Receptor Samplers

The following radionuclides from NNSS-related activities were detected at one or more of the critical receptor samplers:  $^{241}\text{Am}$ ,  $^{238}\text{Pu}$ ,  $^{239+240}\text{Pu}$ , and  $^3\text{H}$ . All of their measured concentrations were well below their CLs. No man-made uranium was detected above levels found in blank filters (see Section 4.1.4.5). The concentration of each measured man-made radionuclide at each of the six critical receptor samplers is divided by its respective CL

(see Table 4-1) to obtain a “percent of CL.” These are then summed for each sampler. The sum of these fractions at each critical receptor sampler is far less than 1; the highest sum was 0.06 at Schooner Crater. This demonstrates that the NESHAP dose limit (10 mrem/yr) at these critical receptor locations was not exceeded (Table 4-9). The highest radiation TEDE at a critical receptor location would be approximately 0.64 mrem from air to a hypothetical individual residing at Schooner for the entire calendar year. A more realistic estimate of dose to the offsite public would come from using the 0.004 sum of fractions from the Gate 510 sampler, which is closest to the nearest public receptor (about 3.5 kilometers [km] or 2.2 miles [mi]). The estimated TEDE from air emissions for a hypothetical individual living year-round at the Gate 510 sampler would be 0.04 mrem/yr.

**Table 4-9. Sum of fractions of compliance levels for man-made radionuclides at critical receptor samplers**

Radionuclides Included in Sum of Fractions	NNSS Area	Sampling Location	Sum of Fractions of Compliance Levels (CLs)
<sup>241</sup> Am, <sup>238</sup> Pu, <sup>239+240</sup> Pu, and <sup>3</sup> H	6	Yucca	0.011
	10	Gate 700 S	0.010
	16	3545 Substation	0.006
	20	Schooner	0.064
	23	Mercury Track	0.005
	25	Gate 510	0.004

#### 4.1.6 Emission Evaluations for Planned Projects

During 2015, two NESHAP evaluations for radionuclide emissions were conducted. The first was to determine dose from handling uranium during a project conducted at the Nonproliferation Test and Evaluation Complex (NPTEC) in Area 5, and the second was to estimate dose from potential emissions from the National Criticality Experiments Research Center (NCERC) in Area 6.

Both evaluations were conducted to determine if the projects had the potential to release airborne radionuclides that would expose the public to a dose equal to or greater than 0.1 mrem/yr. For any project or facility with this potential, the EPA requires approval prior to operation and point-source operational monitoring. The predicted dose at the nearest NNSS boundary for each planned project was much less than the 0.1 mrem/yr level specified under NESHAP regulations. Therefore, it was concluded that these activities constituted minor sources and did not require point-source operational monitoring. The detailed air emission dose evaluations for each project are reported in the NESHAP annual report for 2015 (National Security Technologies, LLC [NSTec], 2016).

#### 4.1.7 Unplanned Releases

There were no known unplanned radionuclide releases in 2015. Four wildland fires were documented on the NNSS during 2015. All of these were less than one acre (0.4 ha) in size and all were extinguished quickly by NNSS Fire and Rescue personnel. None of these fires occurred in radiologically contaminated areas.

#### 4.1.8 Estimate of Total NNSS Radiological Atmospheric Releases in 2015

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 used are described in detail in NSTec (2016). Total emissions in 2015, by radionuclide, are shown in Table 4-10. Radionuclide emissions by source are shown in Table 4-11. Their locations in relation to critical receptor air monitoring locations are shown in Figure 4-1.

In 2015, an estimated 9,526 Ci of radionuclides were released as air emissions. Of this amount, 96% (9,143 Ci) is from the short-lived activation and fission products <sup>41</sup>Ar, <sup>85m</sup>Kr, <sup>135m</sup>Xe, <sup>135</sup>Xe, <sup>7</sup>Be, <sup>11</sup>C, <sup>13</sup>N, <sup>15</sup>O, <sup>16</sup>N, <sup>19</sup>O, <sup>38</sup>Cl, and <sup>39</sup>Cl (see Table 4-10 for radionuclide name, half-life, and amount emitted). All of these, except <sup>7</sup>Be, decay away very quickly and are not available to contribute dose to the public at the 31 to 62 km (19 to 38 mi) distances over which they have to travel. <sup>7</sup>Be has a 54-day half-life but is emitted in quantities much lower than the

concentrations of  $^7\text{Be}$  produced in the atmosphere by naturally occurring cosmic radiation. Tritium makes up about 3.8% of the total emission. The remaining radionuclides make up only 0.2% of the total emission.

**Table 4-10. Total estimated NNSS radionuclide emissions for 2015**

Radionuclide	Symbol	Half-life <sup>(a)</sup>	Total Quantity (Ci)
<b>Primary Radionuclides</b>			
Tritium	$^3\text{H}$	12.3 years (yr)	361
Americium-241	$^{241}\text{Am}$	432.2 yr	0.066
Plutonium-238	$^{238}\text{Pu}$	87.7 yr	0.041
Plutonium-239+240	$^{239+240}\text{Pu}$	24,110 yr	0.29
<b>Noble Gases</b>			
Argon-41	$^{41}\text{Ar}$	109.6 m	855
metastable Krypton-85	$^{85\text{m}}\text{Kr}$	4.5 hours (h)	110
Krypton-85	$^{85}\text{Kr}$	10.8 y	0.0011
metastable Xenon-131	$^{131\text{m}}\text{Xe}$	11.8 d	0.04
metastable Xenon-133	$^{133\text{m}}\text{Xe}$	2.2 d	1.3
Xenon-133	$^{133}\text{Xe}$	5.2 d	20
metastable Xenon-135	$^{135\text{m}}\text{Xe}$	15.3 m	1800
Xenon-135	$^{135}\text{Xe}$	9.1 h	270
<b>Other</b>			
Beryllium-7	$^7\text{Be}$	54 days (d)	0.00081
Carbon-11	$^{11}\text{C}$	20.5 minutes (m)	65
Nitrogen-13	$^{13}\text{N}$	10 m	2300
Oxygen-15	$^{15}\text{O}$	2.1 m	3700
Nitrogen-16	$^{16}\text{N}$	7.1 seconds (s)	12
Oxygen-19	$^{19}\text{O}$	26.5 s	0.02
Chlorine-38	$^{38}\text{Cl}$	37.2 m	1.9
Chlorine-39	$^{39}\text{Cl}$	55 m	29
Cobalt-60	$^{60}\text{Co}$	5.3 y	0.0004
Strontium-90	$^{90}\text{Sr}$	28.8 y	0.056
Cesium-137	$^{137}\text{Cs}$	30.2 y	0.055
Europium-152	$^{152}\text{Eu}$	13.5 y	0.011
Europium-154	$^{154}\text{Eu}$	8.6 y	0.00012
Europium-155	$^{155}\text{Eu}$	4.8 y	0.00011
Depleted uranium	DU	>150,000 yr	0.00002

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

**Table 4-11. Radiological atmospheric releases from the NNSS for 2015**

Emission Source <sup>(a)</sup>		Type of Emissions Control	Radionuclide	Annual Quantity (Ci)
<b>Legacy Weapon Test and Plowshare Crater Locations</b>	Sedan	None	$^3\text{H}$	7.0
	Schooner	None	$^3\text{H}$	9.3
	Grouped Area Sources – All NNSS Areas	None	$^{60}\text{Co}$	0.00040
		$^{90}\text{Sr}$	0.056	
		$^{137}\text{Cs}$	0.055	
		$^{152}\text{Eu}$	0.011	
		$^{154}\text{Eu}$	0.00012	
		$^{155}\text{Eu}$	0.00011	
		$^{238}\text{Pu}$	0.041	
		$^{239+240}\text{Pu}$	0.29	
$^{241}\text{Am}$	0.066			
<b>Emanation from Building Materials</b>	NLVF, Building A-01, basement ventilation, NLVF	None	$^3\text{H}$	0.0024

Table 4-11. Radiological atmospheric releases from the NNSS for 2015 (continued)

	Emission Source <sup>(a)</sup>	Type of Emissions Control	Radionuclide	Annual Quantity (Ci)	
<b>Groundwater Characterization /Control or Remediation Activities</b>	<u>Environmental Restoration Projects</u>				
	E-Tunnel Ponds	None	<sup>3</sup> H	5.3	
	<u>UGTA Well Sumps</u>				
	ER-20-5 #1	None	<sup>3</sup> H	4.1	
	ER-20-5 #3	None	<sup>3</sup> H	0.0084	
	ER-20-8	None	<sup>3</sup> H	0.0028	
	ER-20-12	None	<sup>3</sup> H	0.056	
<b>Defense, Security, and Stockpile Stewardship</b>	DPF	None	<sup>3</sup> H	330	
	NCERC	HEPA	<sup>16</sup> N	12	
			<sup>19</sup> O	0.02	
			<sup>41</sup> Ar	4.8	
			<sup>85m</sup> Kr	109	
			<sup>85</sup> Kr	0.0011	
			<sup>131m</sup> Xe	0.04	
			<sup>133m</sup> Xe	1.3	
			<sup>133</sup> Xe	20	
			<sup>135m</sup> Xe	1800	
			<sup>135</sup> Xe	270	
		NPTEC	None	DU	0.00002
		Tumbleweed Test Range	None	<sup>7</sup> Be	0.00081
				<sup>11</sup> C	65
				<sup>13</sup> N	2300
				<sup>15</sup> O	3700
				<sup>38</sup> Cl	1.9
			<sup>39</sup> Cl	29	
			<sup>41</sup> Ar	850	
<b>Radioactive Waste Management</b>	Area 3 RWMS	Soil cover over waste	<sup>3</sup> H	3.2	
	Area 5 RWMC	Soil cover over waste	<sup>3</sup> H	3.5	
<b>Support Facility Operations</b>	Building 23-652	None	<sup>3</sup> H	0.0000016	

(a) All locations are on the NNSS except for Building A-01

### 4.1.9 Environmental Impact

The concentrations of man-made radionuclides in air on the NNSS are all less than the regulatory concentration limits specified by federal regulations. Also, air monitoring data at the six critical receptor samplers indicate that the radiological dose to the general public from the air pathway is below the NESHAP standard of 10 mrem/yr (see [Chapter 9](#) for a discussion of dose to the public from all pathways). Nearly all radionuclides detected by environmental air samplers in 2015 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 tritium from the soil at sites of past nuclear tests and low-level radioactive waste burial. Long-term trends of <sup>239+240</sup>Pu and tritium 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 Assessment

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

<i>Air Quality Assessment Program Goals</i>
Ensure that NNSS operations comply with all the requirements of the current air quality permit issued by the State of Nevada.
Ensure that emissions of criteria air pollutants (sulfur dioxide [SO <sub>2</sub> ]), nitrogen oxides [NO <sub>x</sub> ], carbon monoxide [CO], volatile organic compounds [VOCs], and particulate matter) and emissions of hazardous air pollutants do not exceed limits established under NAAQS and NESHAP, respectively.
Ensure that emissions of permitted NNSS equipment meet the opacity criteria to comply with NAAQS and NSPS.
Ensure that NNSS operations comply with the asbestos abatement reporting requirements under NESHAP.
Document usage of ozone-depleting substances (ODS) to comply with Title VI of the CAA.

### 4.2.1 Permitted NNSS Facilities

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

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

### 4.2.2 Permit Maintenance Activities

A permit application to renew the NNSS air permit (AP9711-2557) was submitted to the Nevada Division of Environmental Protection (NDEP) in April 2014 prior to the permit’s expiration in June 2014. By the end of 2015, the new permit had still not been issued, but because the application was submitted prior to the state’s deadline, 2015 operations at the NNSS continued under a permit “shield.” Also, the PM10 (particulate matter

equal to or less than 10 microns in diameter) Sampling and Meteorological Monitoring Systems Plan, required as part of permit renewal application, was reformatted to incorporate all facilities into a single plan. New operational allowances requested in the 2014 permit renewal application included:

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

Also, all operational allowances previously requested as modifications to the old permit were requested again as part of the 2014 renewal application. Because these allowances are not directly covered by the Nevada Administrative Code (NAC) but are enacted with the Director's approval, they must be requested with each permit renewal. The requested allowances for the 2014 renewal included:

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

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

### **4.2.3 Emissions of Criteria Air Pollutants and Hazardous Air Pollutants**

A source's regulatory status is determined by the maximum number of tons of criteria air pollutants and nonradiological HAPs it may emit in a 12-month period if it were operated for the maximum number of hours and at the maximum production amounts specified in the source's air permit. This maximum emission quantity, known as the *potential to emit (PTE)* (see [Glossary, Appendix B](#)), is specified in an Air Emissions Inventory of all emission units. Each year, NNSA/NFO submits Actual Production/Emissions Reporting Forms to NDEP as required by the NNSS air permit. These forms are used to report the operational information and the calculated emissions of the criteria air pollutants and HAPs for permitted emission units. The state uses the information to determine permit fees and to verify that emissions do not exceed the PTEs. Quarterly reports of emission quantities were submitted to NDEP in April, July, and October 2015, and January 2016. The Calendar Year 2015 Actual Production/ Emissions Reporting Form was submitted in February 2016.

All records examined in 2015 for permitted facilities and equipment indicated that operational parameters were being properly tracked and no PTEs were exceeded. An estimated 11.76 tons of criteria air pollutants were released (Table 4-12). The majority of the emissions were NO<sub>x</sub> from diesel generators. An estimated 0.03 tons of HAPs were released in 2015 (Table 4-13). Table 4-13 also shows the calculated tons of air pollutants released on the NNSS over the past 10 years. Fluctuations in emissions over time reflect changes in project activities and in facility operations.

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

Unless specifically exempted, the open burning of any combustible refuse, waste, garbage, or oil is prohibited. Open burning for other purposes is allowed if approved in advance by the state through issuance of an Open Burn Authorization prior to each burn. Open Burn Authorizations must be renewed annually. At the NNSS, they are issued for fire extinguisher training and for support-vehicle live-fire training activities. In 2015, 25 fire extinguisher training sessions and 10 vehicle burns were conducted at the NNSS. Most of the fire extinguisher sessions used a new system that burns propane rather than diesel fuel, resulting in greatly reduced hydrocarbon emissions. Quantities of criteria air pollutants produced by open burns are not required to be calculated or reported.

**Table 4-12. Tons of criteria air pollutant emissions released on the NNSS from permitted facilities operational in 2015**

Facility	Calculated Tons <sup>(a)</sup> per Year of Emissions										
	Particulate Matter (PM10) <sup>(b)</sup>		Carbon Monoxide (CO)		Nitrogen Oxides (NO <sub>x</sub> )		Sulfur Dioxide (SO <sub>2</sub> )		Volatile Organic Compounds (VOCs)		
	Actual	PTE <sup>(c)</sup>	Actual	PTE	Actual	PTE	Actual	PTE	Actual	PTE	
<b>Construction Equipment</b>											
Wet Aggregate Plant	0.10	2.94	NA <sup>(d)</sup>	NA <sup>(d)</sup>	NA <sup>(d)</sup>	NA <sup>(d)</sup>	NA <sup>(d)</sup>	NA <sup>(d)</sup>	NA <sup>(d)</sup>	NA <sup>(d)</sup>	NA <sup>(d)</sup>
Concrete Batch Plant	0.01	2.33	NA <sup>(d)</sup>	NA <sup>(d)</sup>	NA <sup>(d)</sup>	NA <sup>(d)</sup>	NA <sup>(d)</sup>	NA <sup>(d)</sup>	NA <sup>(d)</sup>	NA <sup>(d)</sup>	NA <sup>(d)</sup>
Cementing Services Equipment	0.01	14.86	NA <sup>(d)</sup>	NA <sup>(d)</sup>	NA <sup>(d)</sup>	NA <sup>(d)</sup>	NA <sup>(d)</sup>	NA <sup>(d)</sup>	NA <sup>(d)</sup>	NA <sup>(d)</sup>	NA <sup>(d)</sup>
<b>Fuel Burning/Storage</b>											
Diesel Fired Generators	0.41	2.86	1.42	9.31	6.50	42.94	0.36	2.59	0.46	3.20	
Gasoline Fired Generators	0.007	0.12	0.07	1.17	0.11	1.85	0.01	0.10	0.15	2.52	
Propane Generator	0.00	0.02	0.03	0.95	0.04	1.44	0.000	0.001	0.01	0.20	
Boilers	0.08	0.38	0.19	0.94	0.76	3.77	0.02	0.08	0.05	0.25	
Bulk Gasoline Storage Tank	NA <sup>(d)</sup>	NA <sup>(d)</sup>	NA <sup>(d)</sup>	NA <sup>(d)</sup>	NA <sup>(d)</sup>	NA <sup>(d)</sup>	NA <sup>(d)</sup>	NA <sup>(d)</sup>	0.98	1.45	
Bulk Diesel Fuel Storage Tank	NA <sup>(d)</sup>	NA <sup>(d)</sup>	NA <sup>(d)</sup>	NA <sup>(d)</sup>	NA <sup>(d)</sup>	NA <sup>(d)</sup>	NA <sup>(d)</sup>	NA <sup>(d)</sup>	0.01	0.02	
<b>Chemical Releases</b>											
NPTEC	0	1.50	0	1.50	0	1.50	0	1.50	0.01	10.00	
<b>Detonations</b>											
Port Gaston	0.00	0.21	0.01	1.49	0.002	0.085	<0.00	0.01	0.00	0.01	
NPTEC	0.00	0.21	0.001	1.485	0.00	0.085	0.00	0.010	0.00	0.01	
BEEF	0.02	1.8	0.02	1.99	0.01	0.50	0.000	0.04	0.03	0.03	
<b>Total by Pollutant</b>	<b>0.52</b>	<b>27.23</b>	<b>1.74</b>	<b>18.84</b>	<b>7.43</b>	<b>52.16</b>	<b>0.39</b>	<b>4.33</b>	<b>1.69</b>	<b>17.68</b>	
<b>Total Emissions</b>	<b>Actual: 11.76 PTE: 120.25</b>										

(a) For metric tons (mtons), multiply tons by 0.9072

(b) Particulate matter equal to or less than 10 microns in diameter

(c) PTE's include only those facilities that were operational in 2015.

(d) Not applicable: the facility does not emit the specified pollutant(s); therefore, there is no emission limit established in the air permit

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

Pollutant	Total Emissions (tons/yr) <sup>(a)</sup>									
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Particulate Matter (PM10) <sup>(b)</sup>	0.69	0.54	0.22	0.49	1.09	2.40	6.51	0.45	0.43	0.52
Carbon Monoxide (CO)	0.43	0.51	0.94	0.55	1.33	3.70	2.38	1.54	1.44	1.74
Nitrogen Oxides (NO <sub>x</sub> )	2.02	1.21	3.36	2.45	6.09	16.15	10.51	6.38	6.12	7.43
Sulfur Dioxide (SO <sub>2</sub> )	0.03	0.01	0.06	0.10	0.36	1.20	1.14	0.23	0.19	0.39
Volatile Organic Compounds (VOCs)	1.40	1.14	0.60	0.71	0.33	1.68	1.08	1.69	1.35	1.69
Hazardous Air Pollutants (HAPs) <sup>(c)</sup>	1.87	0.02	0.09	0.30	0.02	0.04	0.03	0.23	0.03	0.03

(a) For mtons, multiply tons by 0.9072

(b) Particulate matter equal to or less than 10 microns in diameter

(c) The site-wide PTE for HAPs is 8 tons per individual HAP and 23.3 tons for all HAPs combined

#### 4.2.4 Performance Emission Testing and State Inspection

The current NNSS air permit requires performance emission testing of equipment that vents emissions through stacks (called "point sources"). The tests must be conducted once during the 5-year life of the NNSS air permit for each specified source. Once a source accumulates 100 hours of operation (since issuance of the permit in June 2002), it must be tested within 90 days. Testing is conducted by inserting a probe into the stack while the equipment is operating. Visible emissions readings must also be conducted by a certified evaluator during the tests. No performance emission tests were conducted in 2015. It is anticipated that once the renewed NNSS air permit is issued (see Section 4.2.2), none of the equipment will require performance testing. No state air inspections were conducted in 2015, but one was scheduled for the spring of 2016.

### **4.2.5 Opacity Readings**

Visual opacity readings are conducted in accordance with permit and regulatory requirements. Personnel that take opacity readings are certified semiannually. In 2015, six employees on the NNSS were certified. Readings were taken for the following NNSS facilities regulated under the NAAQS opacity limit of 20%: Area 1 Concrete Batch Plant, Area 1 Wet Aggregate Plant, Area 6 Storage Silos, and two diesel generators located in Area 23. None of the readings exceeded the 20% limit.

### **4.2.6 Chemical Releases and Detonations Reporting**

The NNSS air permit regulates the release of chemicals at specific locations under three separate “systems”: NPTEC in Area 5 (System 29), Site-Wide Releases throughout the NNSS (System 81), and Port Gaston in Area 26 (System 95). The types and amounts of chemicals that may be released vary depending on the system. In 2015, the PRCIEST, and BAROLO chemical test series were conducted at the Area 5 NPTEC. For PRCIEST, four small chemical releases were conducted over a 2-day period. The BAROLO test took place over 8 days and resulted in 34 small chemical releases. The majority of the chemicals released were non-regulated; only minimal quantities of VOCs were released (see Table 4-12). 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 2015, explosives were detonated at BEEF and Port Gaston, and no permit limits were exceeded (see Table 4-12).

PM10 monitoring was conducted for each chemical release test and detonation at NPTEC and Port Gaston in 2015. Monitoring was conducted in accordance with the permit and met calibration and performance audit requirements.

In addition to annual reporting, the NNSS air quality operating permit requires the submittal of test plans and final analysis reports to the state for detonations and chemical releases or release series. For BEEF, quarterly test plans and final reports must be submitted for the types and weights of explosives used and estimated emissions that may be released. Completion reports are submitted at the end of each calendar quarter for all chemical releases and detonations. In 2015, all of the required quarterly reports were submitted prior to the reporting deadline.

### **4.2.7 ODS Recordkeeping**

At the NNSS, refrigerants containing ODS are mainly used 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 for 3 years, recycling/recovery equipment approval, and servicing records for appliances containing 22.7 kilograms (50 pounds) or more of refrigerant.

### **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 feet, 160 square feet, or 35 ft<sup>3</sup>. Small asbestos abatement projects are conducted throughout the year consisting of the removal of lesser quantities of ACM within a single facility per project, and a Notification of Demolition and Renovation Form is not required for these projects.

Seven Notification of Demolition and Renovation Forms were submitted during 2014. All of these were renovation projects conducted by subcontractors performing work in Area 25. Three Notification of Demolition and Renovation Forms were submitted during 2015. One renovation project was not completed, was then reassessed in January 2016, and determined to have quantities of ACM below the EPA notification requirement.

Each project was performed in a closely supervised and rigidly controlled environment with personal air monitoring and/or environmental air sampling conducted by the subcontractor. The remaining asbestos abatement activities throughout the NNSS complex were minor in scope, involving the removal of quantities of ACM less than the reporting threshold per facility. ACM was buried in the Area 23 solid waste disposal site. Asbestos abatement records continued to be maintained as required.

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 assessments.

#### **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 2015, 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 5, 22, and 25.

Off the NNSS, all NNSA/NFO surface-disturbing activities that cover 5 or more acres are regulated by stand-alone Class II Surface Area Disturbance (SAD) permits issued by the state. Current SADs exist for the operation of three Underground Test Area (UGTA) wells on the Nevada Test and Training Range: ER-EC-13, ER-EC-14, and ER-EC-15. No activities occurred at these wells during 2015, and all reporting requirements of the SADs were met.

#### **4.2.10 Environmental Impact**

During 2015, NNSS activities produced a total of 11.76 tons of criteria air pollutants and 0.03 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<sub>x</sub> in Clark County for base year 2002 through projected year 2018 is 37,549 tons per year (Pollack 2007), whereas the estimated annual release from the NNSS in 2015 of 7.43 tons of NO<sub>x</sub> represents 0.02% 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 have used such small quantities (when dispersed into the air) that downwind test-specific monitoring has not been necessary. 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 by the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) on and adjacent to the Nevada National Security Site (NNSS). NNSA/NFO monitors groundwater to ensure that drinking water for NNSS workers and visitors is safe, that NNSS groundwater is protected from contamination from current activities, and to take corrective actions to protect the public and the environment from areas of known underground radiological contamination resulting from historical nuclear testing. Monitoring is conducted to comply with all applicable state and federal water quality and water protection regulations, U.S. Department of Energy (DOE) directives, and the Federal Facility Agreement and Consent Order (FFACO) between the U.S. Department of Energy, the U.S. Department of Defense, and the State of Nevada.

The Nevada State Health Division's Bureau of Health Care Quality and Compliance is allowed access to the NNSS to independently sample onsite water supply wells at its discretion. Monitoring results from the state's independent sampling and analysis are also presented in this chapter, if the state performed sampling during the reporting year.

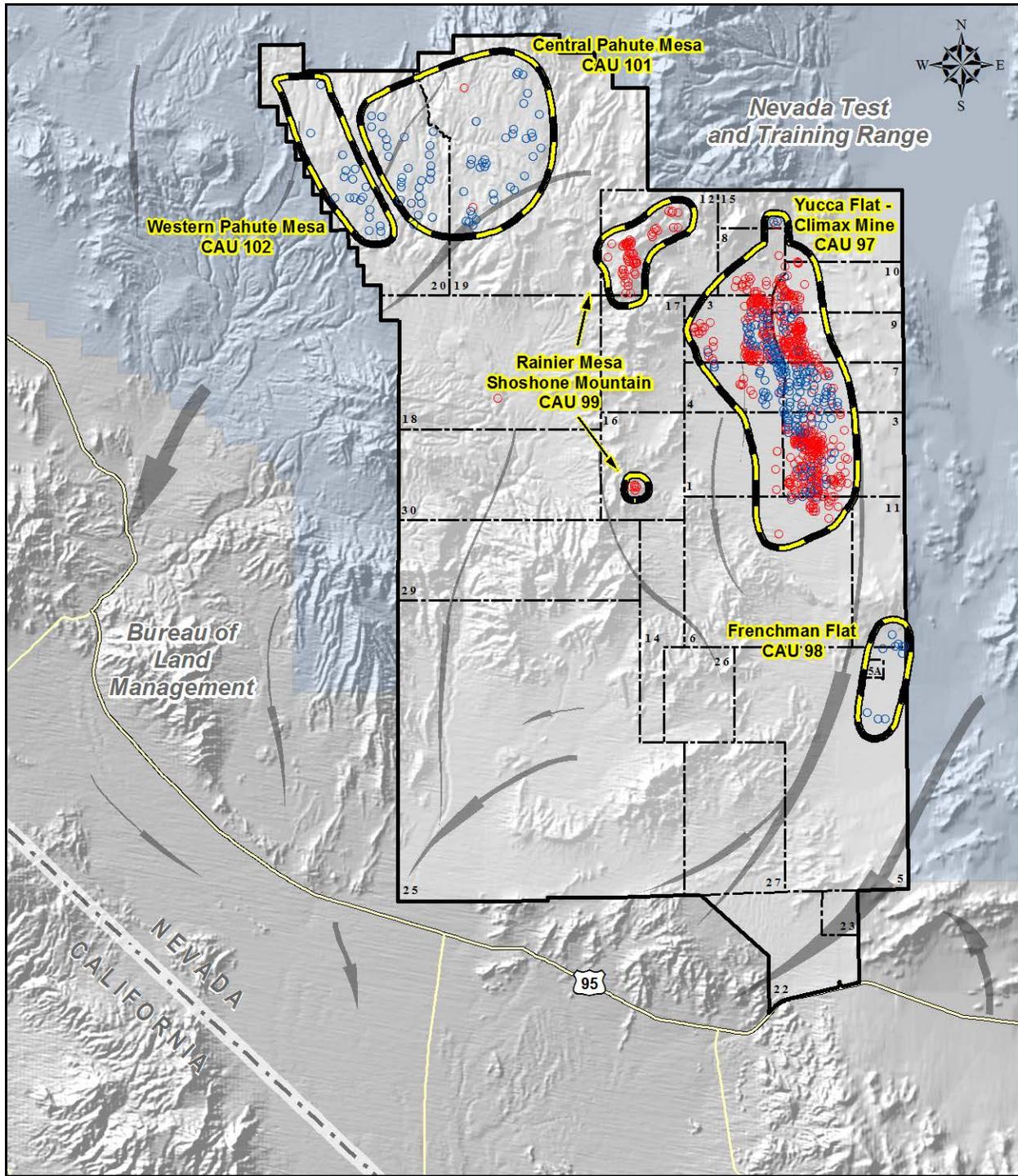
The Community Environmental Monitoring Program (CEMP), established by NNSA/NFO and administered by the Desert Research Institute (DRI) of the Nevada System of Higher Education, and the Nye County Tritium Sampling and Monitoring Program, funded through a grant from DOE Environmental Management, both perform annual, independent radiological monitoring of water supply systems in communities surrounding the NNSS and emphasize community involvement. The reader is directed to Chapter 7, Section 7.2 for the presentation of CEMP's groundwater monitoring activities in 2015. A description of the new Nye County monitoring program and its sampling results for 2015 are presented in this chapter in Section 5.1.2

### 5.1 Radiological Monitoring

#### 5.1.1 NNSA/NFO Groundwater Monitoring

**Radionuclides** (see [Glossary, Appendix B](#)) have been detected in the groundwater in some areas of the NNSS as a result of historical underground nuclear tests. Between 1951 and 1992, 828 of these tests 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 underground nuclear tests on the NNSS (Figure 5-1). A thorough description of the complex hydrogeological environment in which underground nuclear testing was conducted is presented in *Attachment A: Site Description*, which is included on the compact disc of this report and at <http://www.nv.energy.gov/library/publications/aser.aspx>.

NNSA/NFO is tasked, under the FFACO, with developing UGTA CAU-specific models of groundwater flow and radionuclide transport. These models are used to develop contaminant boundaries within which radiological contaminants are forecasted to exceed the Safe Drinking Water Act (SDWA) limits at any time within a 1,000-year period. The current status of the CAU-specific models of groundwater flow and contaminant transport is discussed in Section 11.1.2 of Chapter 11 of this report. Groundwater sampling and analyses support the development and evaluation of these models and demonstrate that there is no impact to public water sources as a result of underground nuclear testing. Other NNSS wells and surface waters are monitored by NNSA/NFO to demonstrate compliance with state-issued water discharge permits; with DOE Order 458.1, "Radiation Protection of the Public and the Environment;" with protection of groundwater from ongoing radiological waste disposal activities; and to demonstrate that the onsite drinking water supply is below SDWA radionuclide limits.



Map produced by the NSTec GIS Group. Product ID: 20160111-01-P009-R00

<b>Location of Underground Nuclear Tests</b>		Area of Potential Groundwater Contamination (Corrective Action Unit Boundary) Regional Groundwater Flow System <sup>2</sup> Arrow direction indicates regional groundwater flow direction and width indicates relative groundwater flow volume.
<ul style="list-style-type: none"> <li> Tests with no expected interaction with the groundwater system<sup>1</sup> (Vadose Zone)</li> <li> Tests having potential interaction with the groundwater system<sup>1</sup> (Saturated Zone)</li> </ul>		

<sup>1</sup> U.S. Department of Energy, Nevada Operations Office, 1997. Regional Groundwater Flow and Tritium Transport Modeling and Risk Assessment of the Underground Test Area, Nevada Test Site, Nevada. DOE/NV-477, October 1997, Las Vegas, NV.  
<sup>2</sup> Fenelon, J. M., D. S. Sweetkind, and R. J. Lacznik. 2010. *Groundwater Flow Systems at the Nevada Test Site, Nevada: A Synthesis of Potentiometric Contours, Hydrostratigraphy, and Geologic Structures*. U.S. Geological Survey Professional Paper 1771, U.S. Geological Survey, Denver, CO.

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

The design of the NNSS Integrated Groundwater Sampling Plan (NNSA/NFO 2014), referred to hereafter as the Plan, is presented in the sub-sections below. It is a comprehensive, integrated approach for collecting and analyzing groundwater samples to meet NNSA/NFO's radiological water monitoring objectives associated with underground nuclear testing. This chapter presents the most recent tritium analysis results for monitored wells and other water analysis results related to meeting NNSA/NFO's radiological water monitoring objectives.

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

### **5.1.1.1 NNSA/NFO Groundwater Sampling Design**

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

The Plan focuses on evaluating the extent and movement of contaminants resulting from underground nuclear testing. Baseline data are established at downgradient locations (see the Regional Groundwater Flow System arrows in Figure 5-2 depicting groundwater flow direction and volume) so that the presence of radioisotopes is known with a high level of certainty well before they reach SDWA limits. Wells upgradient from the UGTA CAUs are not included in the sampling network. Also, no NNSS springs are included in the network. Ten NNSS springs have been monitored periodically and reported in past annual environmental reports. They include Cane, Captain Jack, Cottonwood, Gold Meadows, John's, Tipipah, Topopah, Tub, Twin, and Whiterock springs; see [Figure A-4 of Attachment A: Site Description](#) included on the compact disc of this report for the location of NNSS springs and seeps. The groundwater that feeds these onsite springs is locally derived and is not hydrologically connected to the aquifers that may be impacted by underground nuclear tests. Detectable man-made radionuclides in onsite springs are from historical atmospheric testing activities, including global radioactive fallout (U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office [NNSA/NSO] 2008).

**Table 5-1. Type definitions and objectives for NNSA/NFO radiological water sample locations**

<b>Sample Source Type</b>	<b>Definition</b>	<b>Objective</b>	<b>Analytes</b>	<b>Frequency</b>
<b>Characterization</b>	Used for system characterization or model evaluation	<ul style="list-style-type: none"> <li>• Support development and/or evaluation of flow and transport models</li> <li>• Identify groundwater flow paths</li> <li>• Establish the presence or absence of groundwater contaminants of concern (COCs) and contaminants of potential concern (COPCs)</li> <li>• Estimate travel time of contaminants</li> <li>• To be reclassified and sampled according to its new type when above objectives are met</li> </ul>	Specific to UGTA Strategy stage (FFACO, as amended) for each UGTA CAU (may include general chemistry, metals, gamma emitters, age and migration parameters, gross alpha, gross beta, and other radioisotopes)	2–3 years, as needed

**Table 5-1. Type definitions and objectives for NNSA/NFO radiological water sampling locations (continued)**

Sample Source Type	Definition	Objective	Analytes	Frequency <sup>(a)</sup>
<b>Source/Plume</b>	Located within the plume from an underground nuclear test (i.e., test-related contamination present)	<ul style="list-style-type: none"> <li>Support development and/or evaluation of flow and transport models</li> <li>Identify COCs for downgradient wells</li> <li>Monitor contaminant migration</li> <li>Monitor natural attenuation of radiological contaminants</li> </ul>	Radiological COCs and CAU-specific COPCs (see Table 5-2)	4 years
<b>Early Detection</b>	Located downgradient of an underground test and no radioisotopes detected above the minimum detection level for standard analysis	<ul style="list-style-type: none"> <li>Support development and/or evaluation of flow and transport models</li> <li>Detect and monitor plume edge</li> </ul>	Tritium ( <sup>3</sup> H) (low-level analysis)	2–5 years
<b>Distal</b>	Downgradient of the Early Detection area	<ul style="list-style-type: none"> <li>Monitor COC (<sup>3</sup>H) below SDWA 1,000 pCi/L detection limit</li> <li>Support development and/or evaluation of flow and transport models</li> </ul>	<sup>3</sup> H (standard analysis)	5 years
<b>Community</b>	Located on Bureau of Land Management (BLM) or private land; used as a water supply source or is near one	<ul style="list-style-type: none"> <li>Monitor COC (<sup>3</sup>H) below SDWA 1,000 pCi/L detection limit</li> </ul>	<sup>3</sup> H (standard analysis)	5 years
<b>NNSS PWS</b>	Permitted water supply well that is part of a state-designated noncommunity public water system (PWS) on the NNSS	<ul style="list-style-type: none"> <li>Monitor to demonstrate safety of NNSS drinking water (radiological monitoring is not required by the state for noncommunity PWSs)</li> </ul>	<sup>3</sup> H (standard analysis), gross alpha, gross beta	Quarterly
<b>Compliance</b>	Sampled to comply with specific federal/state regulations or permits	<ul style="list-style-type: none"> <li>Determine if radiological COCs are within permit limits</li> </ul>	As specified by permit	As specified by permit

(a) The sampling frequency can be as long as every 2–5 years because of known low groundwater velocity and the resulting slow change over time in radionuclide concentrations expected within certain wells.

**5.1.1.1 Analytes**

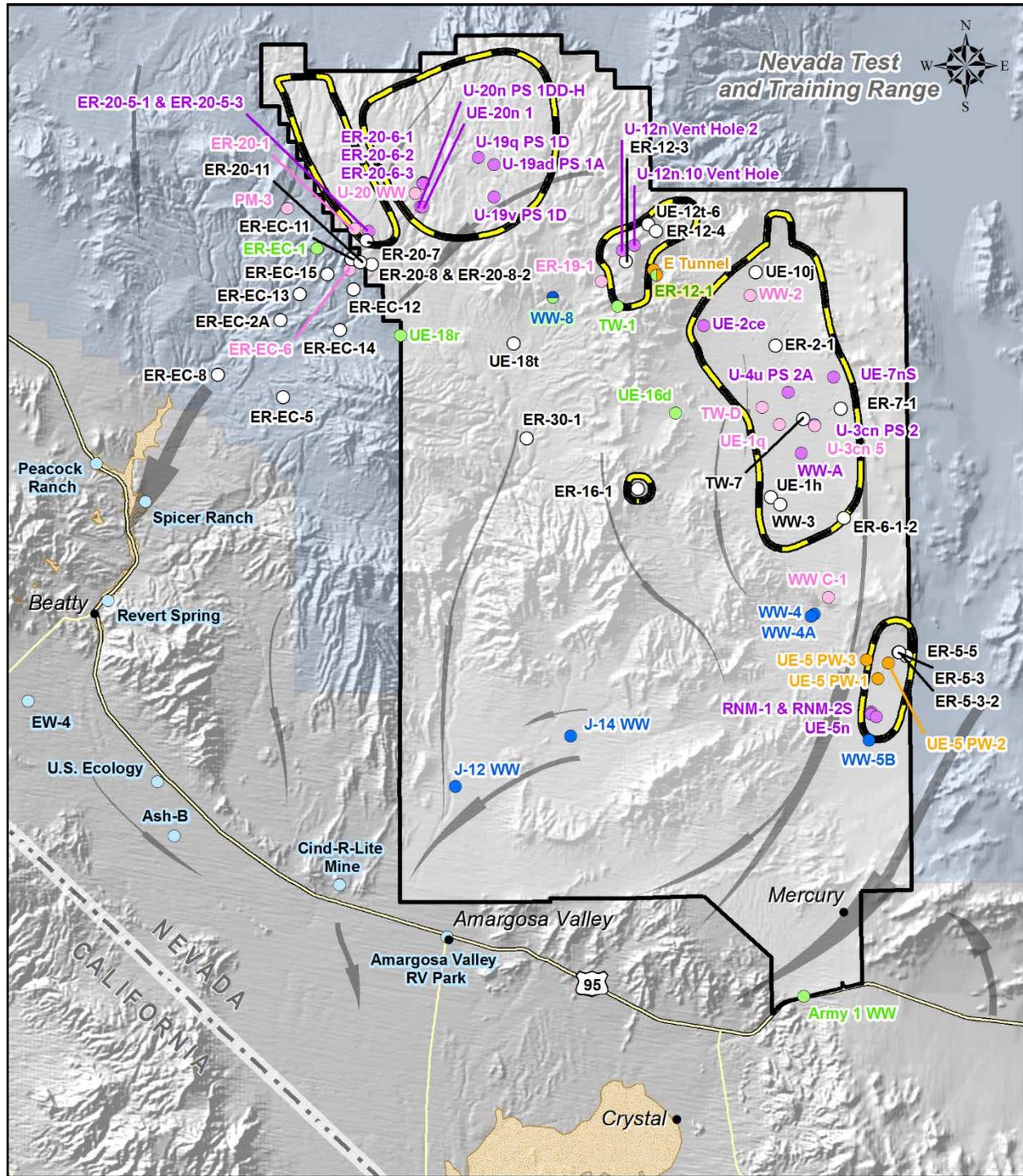
An inventory of 43 radionuclides produced by NNSS underground nuclear tests is presented in Bowen et al. (2001). Many of these radionuclides are relatively immobile because they are bound within the melt glass produced during nuclear detonation or have chemical properties that cause them to bind strongly to the aquifer rock materials. Those radionuclides that are most mobile in groundwater and are produced in high abundance from nuclear testing have the greatest potential for impacting groundwater quality.

A single contaminant of concern (COC) and, at some locations, additional contaminants of potential concern (COPCs) were identified based on the Bowen et al. (2001) inventory, an understanding of the radionuclide’s relative mobility, previous sampling and analysis data, and modeling results (Table 5-2). *Tritium* (see [Glossary, Appendix B](#)) has been identified as the single COC for all sample locations based on extensive groundwater characterization data from wells throughout each CAU. The Plan therefore prescribes tritium analysis for all sampling locations at frequencies that range from every 2 to 5 years (Table 5-1). NNSS public water system (PWS) wells are sampled quarterly, and Compliance well sampling is consistent with the applicable permit requirements.

For all CAUs except Rainier Mesa/Shoshone Mountain, tritium is the only radionuclide included in the inventory that is known to have exceeded its SDWA maximum contaminant level (MCL) of 20,000 picocuries per liter (pCi/L) in sampling locations away from the nuclear test cavity (NNSA/NFO 2014). Although plutonium (Pu) has been

**Tritium** is a radioactive form of hydrogen with a half-life of 12.3 years. The Safe Drinking Water Act (SDWA) limit for tritium in drinking water is 20,000 pCi/L. If an individual were to drink water with this amount of contamination for an entire year, it would produce approximately the same dose of radiation one would get during a single commercial flight between Los Angeles and New York City.

**pCi/L [picocurie per liter]** is a unit of measure 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 tritium, a disintegration is the emission of a beta particle.



Map produced by the NSTec GIS Group. Product ID: 20150211-0-P007-R00

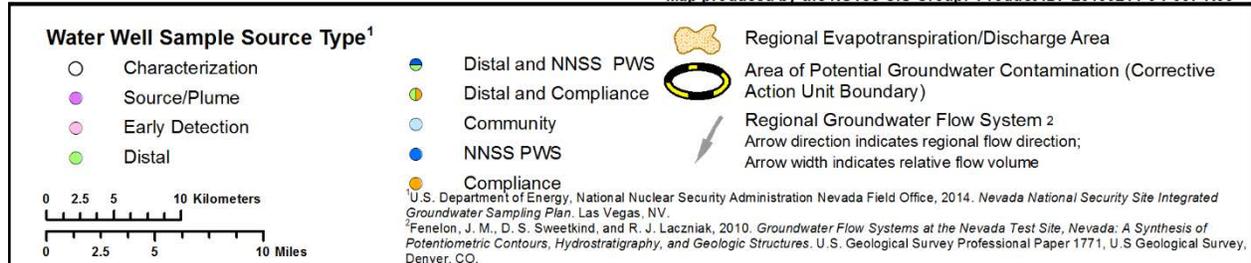


Figure 5-2. NNSA/NFO water sampling network

**Table 5-2. CAU-specific COCs and COPCs**

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

**Note:** See Chapter 1, [Table 1-5](#) for a listing of full names and half-lives of radionuclide abbreviations listed.

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

reported above its SDWA MCL of 15 pCi/L in T Tunnel, located in Rainier Mesa (Zavarin 2009), it has not been detected in downgradient wells at concentrations above 10% of its SDWA MCL. Pu has therefore been identified as a COPC for the Rainier Mesa/Shoshone Mountain CAU and is analyzed for in all Characterization and Source/Plume well samples in that CAU. Similarly, the other CAU-specific COPCs (Table 5-2) may have exceeded their SDWA MCLs in samples collected from the test cavity but have generally not exceeded 10% of their MCLs in downgradient locations.

Groundwater characterization data have shown that COPCs, if present, are at insignificant levels (i.e., < 0.1% of their MCL) unless tritium is present at concentrations that greatly exceed its 20,000 pCi/L MCL. Therefore, COPCs are only analyzed in Source/Plume wells, where tritium exceeds the detection limit for standard tritium analysis (300 pCi/L). Instrumentation capable of detecting COPCs at levels well below their MCLs are used for their analysis in Source/Plume and Characterization well samples. This ensures that a baseline for COPC levels is established and that they will be detected early. Trends in the COPC data will be evaluated to determine whether a COPC should be reclassified as a COC and monitored in Early Detection wells. Samples collected from Characterization wells are analyzed for many of the immobile radionuclides listed in Bowen et al. (2001). These radionuclides have not been found near their SDWA MCL in any of the samples, including those collected from underground nuclear test cavities. While not analyzed routinely as part of the Plan, the suite of radionuclides will be periodically expanded for some Source/Plume wells to confirm that they are not present near their MCLs in groundwater in, or downgradient of, the underground nuclear test cavities.

Gross alpha ( $\alpha$ ) and gross beta ( $\beta$ ) radioactivity and gamma spectroscopy analyses have been conducted for some groundwater samples in the past according to a prescribed sampling schedule (see Table 5-1 of National Security Technologies, LLC [NSTec], 2012). During development of the Plan, a decision was made to analyze for gross alpha and gross beta radioactivity at Characterization wells to establish a baseline. They continue to be monitored for NNSS PWS wells and for certain Compliance water sampling locations, as required.

#### 5.1.1.1.2 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 via a wireline bailer or a portable pumping system. The majority of wells sampled are single-zone completion wells where samples are collected from one depth interval. Some wells, however, are multiple-completion wells that are sampled at multiple depths (e.g., ER-EC-11, -12, -13, -14, and -15). All water samples are collected in a manner that ensures they represent ambient formation water following the sampling methods described in standard operating procedures. This may involve purging the well until the stability of certain water quality parameters (e.g., pH, temperature, and electrical conductivity) is achieved. Stabilization of these water quality parameters indicates that formation water is being sampled instead of stagnant water from within and surrounding the wellbore. Water sampling methods also depend on the suite of analytes and the hydrogeologic system being sampled. Determination of cost-effective groundwater monitoring technologies is an active area of study for UGTA. These studies include identifying mobile sampling technologies capable of sampling the deep (up to 4,100 ft) wells included in the Plan.

### 5.1.1.1.3 Detection Limits

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

The standard tritium analysis method can detect tritium at levels  $\geq 300$  pCi/L.

The low-level tritium analysis method, which concentrates tritium in a sample through an enrichment process, can detect tritium at levels of 2–40 pCi/L.

Groundwater samples collected at all Early Detection wells are analyzed using the low-level tritium analysis method.

Highly sensitive instrumentation is used by Lawrence Livermore National Laboratory (LLNL) to analyze tritium concentrations in Characterization and Early Detection wells when standard methods are not sufficient (i.e., tritium is expected to be at levels less than the 300 pCi/L MDC for the standard method). LLNL's instrumentation is capable of detecting tritium at concentrations less than 1 pCi/L. Similarly, LLNL uses highly sensitive methods for COPC analyses for samples from Source/Plume and Characterization wells. These methods are capable of measuring natural levels of some COPCs ( $^{14}\text{C}$  and  $^{36}\text{Cl}$ ) in the groundwater.

Analytical methods routinely include quality control samples such as duplicates, blanks, and spikes. Chapter 14 discusses in more detail the quality assurance and control procedures used for sampling and analyzing groundwater.

### 5.1.1.2 NNSA/NFO Groundwater Sampling Results

The maximum tritium concentration which has been measured in each well in the Plan's sampling network is used to classify each well into one of four concentration levels relative to its percentage of the 20,000 pCi/L SDWA MCL (Table 5-3). Figure 5-3 depicts spatially the levels of tritium among all sampling locations using color codes for these four categories of tritium concentration levels. The lowest concentration category, less than 5% of the SDWA MCL, is coded blue on Figure 5-3 and includes wells in which tritium has not been detected at all, such as the Community sampling locations. The fifteen wells that currently exceed the SDWA MCL (coded red on Figure 5-3) are all located on the NNSA and are either Source/Plume or Characterization wells.

**Table 5-3. Tritium concentration categories**

Tritium Concentration (X) in pCi/L	Percent of SDWA MCL
$X < 1,000$	$< 5^{(a)}$
$1,000 < X < 10,000$	5–50
$10,000 < X < 20,000$	50–100
$X > 20,000$	$> 100$ (Exceeds SDWA MCL)

(a) includes samples in which tritium is undetectable

Table 5-4 presents the maximum tritium concentration data used to create the color-coded categories shown in Figure 5-3. Table 5-4 groups the sampling location data by CAU and then by sample location type. When tritium was not detected, the value is reported as less than the sample's MDC (i.e.,  $<1.5$  or  $<270$  when the sample's MDC is either 1.5 or 270 pCi/L, respectively). For wells at which multiple samples were collected and analyzed during a single year, Table 5-4 presents the result for the sample that had the highest tritium concentration. Similarly, for wells that are sampled at multiple depths during a single year, Table 5-4 presents the result for the depth sample that had the highest tritium. The results of analyses for those radionuclides identified as COPCs (Table 5-2) are not tabulated in this report but can be acquired upon request from NNSA/NFO.

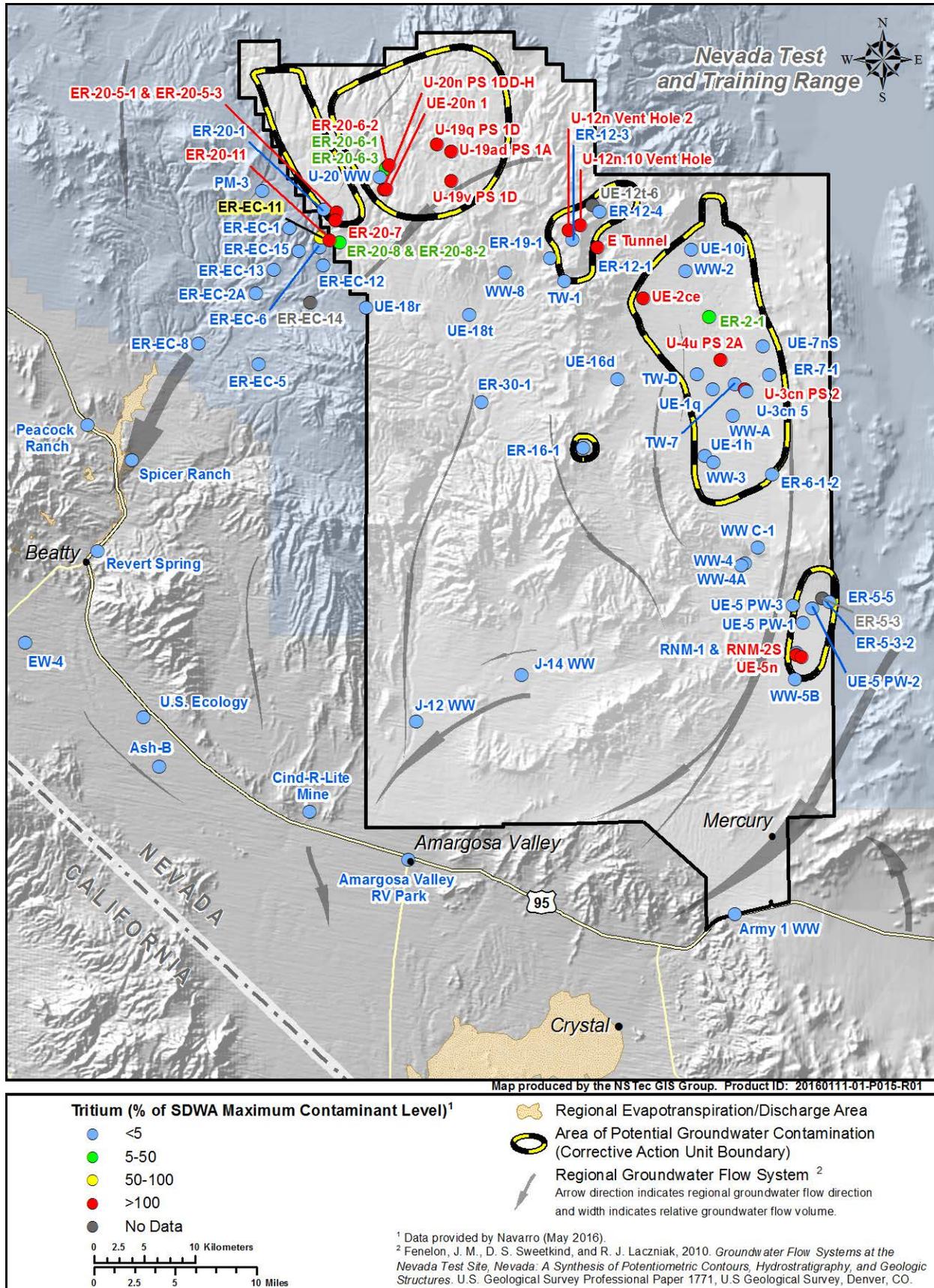


Figure 5-3. Current (2015) classification of tritium concentrations at NNSA/NFO sampling locations

The tritium, gross alpha, and gross beta levels for water samples collected and analyzed in 2015 for the NNSS PWS and Compliance sampling locations are presented in Table 5-5.

**Table 5-4. Maximum tritium concentrations for Characterization, Source/Plume, Early Detection, Distal, and Community Sampling Locations**

Sampling Locations	Land Management or NNSS Operations Area	Sample Year	Maximum Tritium Concentration (pCi/L) <sup>(a)</sup>
<b>Yellow shaded entries indicate tritium levels that exceed the SDWA MCL of 20,000 pCi/L</b>			
<b>Frenchman Flat</b>			
Characterization Wells			
ER-5-3	Area 5	2001	< 1.5
ER-5-5	Area 5	2013	1.1
Source/Plume Wells			
RNM-1	Area 5	2014	620
RNM-2S	Area 5	2014	77,000
UE-5n	Area 5	2014	153,000
<b>Pahute Mesa (Central and Western)</b>			
Characterization Wells			
ER-20-7	Area 20	2014	15,600,000
ER-20-8	Area 20	2015	4,600*
ER-20-8-2	Area 20	2014	2,670
ER-20-11	Area 20	2013	191,000
ER-EC-2A	NTTR	2010	< 270 <sup>(b)</sup>
ER-EC-5	NTTR	2003	< 320 <sup>(b)</sup>
ER-EC-8	NTTR	2010	< 340 <sup>(b)</sup>
ER-EC-11	NTTR	2014	16,100
ER-EC-12	NTTR	2012	4.2
ER-EC-13	NTTR	2013	< 3.0
ER-EC-14	NTTR	2014	< 2.2
ER-EC-15	NTTR	2014	< 2.1
Source/Plume Wells			
ER-20-5-1	Area 20	2015	24,800,000
ER-20-5-3	Area 20	2015	84,000
ER-20-6-1	Area 20	1998	3,200
ER-20-6-2	Area 20	1997	71,000
ER-20-6-3	Area 20	1998	1,110
U-19ad PS 1A	Area 19	2008	12,900,000
U-19q PS 1D	Area 19	2003	11,000,000
U-19v PS 1D	Area 19	2009	84,900,000
U-20n PS 1DD-H	Area 20	2005	33,300,000
UE-20n 1	Area 20	2012	55,500,000
Early Detection Wells			
ER-20-1	Area 20	2015	< 2.2
PM-3	NTTR	2014	237
ER-EC-6	NTTR	2015	5.2
U-20 WW	Area 20	1999	< 29
Distal Wells/Locations			
ER-EC-1	NTTR	2009	< 1
UE-18r	Area 18	2007	< 22
Community Wells/Springs			
Amargosa Valley RV Park	BLM	2012	< 24
Ash B, Piezometer 1	BLM	2014	< 183
Ash B, Piezometer 2	BLM	2014	< 177
Cind-R-Lite Mine	BLM	2012	< 24
EW-4	Private land	2011	< 30
Peacock Ranch	Private land	2012	< 21
Revert Spring	Private land	2012	< 22
Spicer Ranch	Private land	2012	< 21
U.S. Ecology	BLM	2012	< 22

**Table 5-4. Maximum tritium concentrations for Characterization, Source/Plume, Early Detection, Distal, and Community Sampling Locations (continued)**

Sampling Location	Land Management or NNSS Operations Area	Sample Year	Maximum Tritium Concentration (pCi/L)
<b>Yellow shaded entries indicate tritium levels that exceed the SDWA MCL of 20,000 pCi/L</b>			
<b>Rainier Mesa/Shoshone Mountain</b>			
Characterization Wells			
ER-12-3	Area 12	2015	< 0.5
ER-12-4	Area 12	2015	< 2.1
ER-16-1	Area 16	2008	< 340 <sup>(b)</sup>
ER-30-1	Area 30	1996	< 215 <sup>(b)</sup>
UE-12t-6	Area 12	Not yet sampled	NA <sup>(c)</sup>
UE-18t	Area 18	1999	144
Source/Plume Wells			
U-12n.10 Vent Hole	Area 12	2008	6,260,000
U-12n Vent Hole 2	Area 12	2011	1,030,000
Early Detection Wells			
ER-19-1	Area 19	2013	< 30
Distal Wells			
ER-12-1 <sup>(d)</sup>	Area 12	2013	< 366
TW-1	Area 17	2013	< 22
UE-16d	Area 16	2015	< 223
WW-8 <sup>(e)</sup>	Area 18	2015	< 229
<b>Yucca Flat/Climax Mine</b>			
Characterization Wells			
ER-2-1	Area 2	2015	1,010
ER-5-3-2	Area 5	2001	< 1.5
ER-6-1-2	Area 6	2004	< 370 <sup>(b)</sup>
ER-7-1	Area 7	2014	< 3.8
TW-7	Area 7	2015	< 2.5
UE-1h	Area 1	2014	< 2.0
UE-10j	Area 8	1997	< 210 <sup>(b)</sup>
WW-3	Area 3	2015	6.3
Source/Plume Wells			
U-3cn PS 2	Area 3	2007	7,680,000
U-4u PS 2A	Area 4	2008	24,100,000
UE-2ce	Area 2	2008	267,000
UE-7nS	Area 7	2015	53
WW-A	Area 3	2012	355
Early Detection Wells			
TW-D	Area 4	2013	< 27
U-3cn 5	Area 3	2011	< 6.5
UE-1q	Area 1	2013	< 26
WW C-1	Area 6	2012	< 27
WW-2	Area 2	2015	< 2.2
Distal Wells			
Army 1 WW	Area 22	2015	< 229

\* ER-20-8, when last sampled in 2014, had a higher concentration of 8,800 pCi/L due to sampling methodology. This lower 2015 sample result is believed to be more representative. See Section 5.1.1.3.1 for discussion.

- (a) Concentrations presented as less than (<) a number, indicate that tritium levels are less than its sample-specific MDC shown. As a result of a 2015 data review, some MDCs have changed slightly from those reported previously.
- (b) The standard tritium analysis method was used (see Section 5.1.1.3). Prior to 2013, the low-level tritium analysis method, resulting in lower MDCs, was not routinely used for analyses of all Characterization well samples.
- (c) NA = not applicable.
- (d) ER-12-1 is also a Compliance well (see Table 5-5).
- (e) WW-8 is also a NNSS PWS well (see Table 5-5).

Table 5-5. Sample analysis results from NNSS PWS wells and Compliance wells/surface waters

Sampling Location	NNSS Operations Area	Date Sampled	Concentration (pCi/L) <sup>(a)</sup>				
			<sup>3</sup> H	$\alpha$	$\beta$		
<b>NNSS PWS Wells</b>							
J-12 WW	Area 25	1/21/15	<230	<1.9	3.0		
		4/22/15	<184	<1.3	<3.0		
		4/22/15 FD <sup>(b)</sup>	<195	NA <sup>(c)</sup>	NA		
		7/7/15	<240	1.8	2.3		
		11/3/15	<229	<1.8	3.5		
J-14 WW	Area 25	1/21/15	<231	4.6	6.7		
		4/22/15	<189	5.4	7.5		
		7/7/15	<228	7.7	7.5		
		11/3/15	<231	4.9	7.5		
WW-4	Area 6	5/5/15	<296	10.3	3.0		
		7/14/15	<237	11.7	2.8		
		7/14/15 FD	<226	12.5	3.9		
		11/3/15	<227	8.3	4.1		
WW-4A	Area 6	1/21/15	<219	7.6	5.1		
		4/28/15	<195	13.1	3.5		
		7/14/15	<223	11.1	3.2		
		11/3/15	<231	7.2	3.9		
WW-5B	Area 5	11/3/15 FD	<233	7.7	4.0		
		1/21/15	<228	9.3	9.2		
		4/28/15	<187	7.2	7.1		
		7/14/15	<238	5.8	8.3		
WW-8	Area 18	11/3/15	<230	5.5	9.7		
		1/21/15	<229	<1.6	2.3		
		1/21/15 FD	<226	NA	NA		
		4/28/15	<185	<1.1	2.5		
		7/14/15	<226	<0.9	0.9		
		11/3/15	<227	<1.8	2.1		
		<b>Compliance Wells/Surface Waters</b>					
		UE-5 PW-1	Area 5	3/17/15	<245	NA	NA
3/17/15 FD	<246			NA	NA		
8/11/15	<262			NA	NA		
8/11/15 FD	<262			NA	NA		
3/17/15	<246			NA	NA		
UE-5 PW-2	Area 5	3/17/15 FD	<245	NA	NA		
		9/1/15	<238	NA	NA		
		9/1/15 FD	<241	NA	NA		
UE-5 PW-3	Area 5	3/17/15	<246	NA	NA		
		3/17/15 FD	<243	NA	NA		
		8/11/15	<259	NA	NA		
		8/11/15 FD	<264	NA	NA		
ER-12-1	Area 12	4/15/15	<348	13.9	6.9		
		4/15/15 FD	<348	14.4	7.1		
E Tunnel Waste Water Disposal System	Area 12	10/13/15	351,000	11.1	18		
		10/13/15 FD	344,000	13	13.5		

(a) Concentrations presented as less than (<) a number, indicate that tritium levels are less than its sample-specific MDC shown.

(b) FD = field duplicate sample.

(c) NA = not applicable, analysis was not performed.

### 5.1.1.3 Discussion of NNSA/NFO 2015 Sample Results

The following subsections discuss the analytical results for the seven well types that comprise the radiological water sampling network. In addition, results are presented for samples collected from two wells of interest to UGTA but not in the Plan (i.e., inactive wells, Section 5.1.3.8). As illustrated in Figure 5-2, all Characterization, Source/Plume, Early Detection, Distal, NNSS PWS, and Compliance wells are located on government-owned

property. All Community wells or springs are located on BLM or private land. As reflected in Table 5-4 and presented 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 (tritium levels are less than 300 pCi/L), low concentrations of tritium at a few locations have been detected in these wells. Sampling results from PWS wells located on the NNSS indicate that water sources used by NNSS personnel are not affected by underground nuclear tests. In addition, all regulatory requirements associated with the Compliance well samples were satisfied.

#### 5.1.1.3.1 Characterization Wells

Twenty-eight Characterization wells are currently included in the sampling network. They are either new wells, or wells that require additional radionuclide data to establish a baseline and/or to ensure that the current list of COCs and COPCs (Table 5-2) is accurate for the CAU. Once a baseline has been developed, each Characterization well will be reclassified and sampled according to its new type (Source/Plume, Early Detection, Distal, or Community). In 2015, NNSA/NFO sampled a total of six Characterization wells.

**Frenchman Flat CAU** - Two Characterization wells are present in this CAU and neither was sampled in 2015 (Table 5-4). ER-5-3 is located nearest to five underground tests (UGTs). It was last sampled in 2001 and no tritium was detected. ER-5-5, the second Characterization well in this CAU, was drilled in 2012, along with well ER-11-2. They were both drilled near detonation points in order to evaluate the Phase II flow and contaminant transport models. Low-level tritium was detected in ER-5-5 in 2013 (1.1 pCi/L, Table 5-4), which was forecasted by the models (Navarro Nevada Environmental Services, LLC, 2010), although no tritium was detected in ER-11-2. Based on extensive data and model reviews, ER-11-2 was dropped from the water sampling network in 2014 (see Section 11.1.1.1 of NSTec [2015]). ER-5-3 and ER-5-5 will be sampled in 2016 as part of closure monitoring for this CAU.

**Pahute Mesa CAUs** - Twelve Characterization wells are associated with the Central and Western Pahute Mesa CAUs, and one of them was sampled in 2015 (Table 5-4). Most of these wells were drilled in 2009 through 2012 as part of the Phase II corrective action investigation for this CAU (see [Section 11.1.1.2](#)). Tritium has been detected in six Characterization wells (ER-20-7, ER-20-8, ER-20-8-2, ER-20-11, ER-EC-11, and ER-EC-12).

The highest tritium concentration among the Characterization wells of the Pahute Mesa CAUs is at Well ER-20-7, sampled in 2014 (15,600,000 pCi/L; Table 5-4). This well is located 960 m (3,150 ft) and 2,100 m (6,890 ft) from the boreholes U-20y and U-20c, the detonation points for the Tybo and Benham UGTs, respectively. The tritium concentration in ER-20-7 decreased from 19,100,000 pCi/L, as measured in 2010. This decrease is primarily a result of tritium decay over the 4-year time period but also indicates some tritium movement away from the well. Tritium in ER-20-7, ER-20-11, ER-EC-11, ER-20-8, and ER-20-8-2 (Table 5-4) is believed to represent a downgradient extension of the Benham-Tybo contaminant plume (see [Section 11.1.1.2](#)). For wells ER-20-8 and ER-20-8-2, tritium concentrations increased from their earlier reported values: from 3,020 pCi/L in 2011 to 4,590 pCi/L in 2015 for ER-20-8 and from 1,280 pCi/L in 2009 to 2,670 pCi/L in 2014 for ER-20-8-2. In 2014, a much higher tritium concentration of 8,800 pCi/L was measured at ER-20-8, but this was based on a sample collected from the well *piezometer* (see [Glossary, Appendix B](#)) using a wireline bailer that collected water from a discrete depth - a sampling method being investigated then for its efficacy at wells lacking pumps. The 2011 and the 2015 samples at ER-20-8, however, were both collected from the equivalent depth, but from within the main completion compartment of the well using an electric submersible pump. The lower concentration in the pumped 2015 sample may be attributed to mixing with uncontaminated water from other hydrostratigraphic units sampled by the well during pumping. Since water supply wells for potable and non-potable usage are pumped, the results from the pumped samples are considered more representative of potential public exposure than the results from discrete-depth wireline bailer samples (Navarro Research and Engineering, Inc. [Navarro] 2015). Table 5-4, therefore, shows the updated 2015 tritium levels at ER-20-8 instead of its higher 2014 sample concentration.

Tritium 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 2014, it was detected at 16,100 pCi/L. This concentration is below the allowable drinking water limit of 20,000 pCi/L set by the EPA.

Groundwater at Well ER-EC-12 contained a very low concentration of tritium when it was last collected in 2012 (4.2 pCi/L; Table 5-4). Additional sampling and analyses are needed to confirm this marginally measurable amount of tritium. Tritium has not been detected in the other Characterization wells within the Pahute Mesa CAUs; these wells will be categorized as Early Detection or Distal wells depending on their proximity to the UGTs and Source/Plume wells after characterization is complete.

**Rainier Mesa/Shoshone Mountain CAU** - Six Characterization wells are located within this CAU (Table 5-4). Two (ER-12-3 and ER-12-4) were sampled in 2015 and, similar to previously analyzed samples from 2008, no tritium was detected using the low-level tritium analysis method (Table 5-4). Tritium was detected at 0.5 pCi/L by LLNL in the ER-12-3 sample. This value is near its detection limit (0.2 pCi/L) and is therefore highly uncertain. The most recent tritium concentrations for ER-16-1 and ER-30-1 from 2008 and 1996, respectively, are below sample-specific MDCs using the standard tritium analysis method (Table 5-4). UE-12t-6 has yet to be sampled under the Plan and UE-18t was last sampled in 1999 using low-level tritium analysis. Future sample analyses of all Characterization wells in this CAU will use the low-level tritium analysis method to verify the presence or absence of tritium. One location (ER-12-3 piezometer) is scheduled for sampling in 2016 and three locations (UE-18t, UE-12t-6, and ER-12-4 piezometer) in 2017. The two remaining Characterization locations, ER-16-1 and ER-30-1, are planned for sampling in 2018. Sampling priorities were placed on locations closer to the UGTs, those not previously sampled, and those with anomalous tritium results (i.e., UE-18t). The Characterization wells will likely be re-categorized as Early Detection or Distal wells depending on the presence/absence of tritium and their relative proximity to the UGTs after characterization is complete.

**Yucca Flat/Climax Mine CAU** - Eight Characterization wells are located within this CAU and three (ER-2-1, TW-7, and WW-3) were sampled in 2015 (Table 5-4). Tritium concentrations increased at Well ER-2-1 from 228 to 1,013 pCi/L since the last sample in 2003. This increase is not surprising because this well is located within 1 mile of 62 nuclear tests, 19 of which are near or below the water table. Five of the tests, which were below the water table, were within 1,500 ft of ER-2-1 (Elliott and Fenelon 2010). The 2015 sample from TW-7 had no detectable tritium using the low-level tritium analysis method. TW-7 was last sampled in 1999 and no tritium was detected then above the 55 pCi/L MDC. A very low concentration of tritium (6.3 pCi/L) was detected in Well WW-3 in 2015, which is very similar to that reported for the sample collected in 2014 (7.3 pCi/L). The 2014 sample was collected using a depth-discrete bailer, and the 2015 sample was collected using a pump. The tritium in this well is thought to result from seepage from an adjacent surface-water pond rather than from an underground nuclear test. All other Characterization wells in this CAU not sampled in 2015 have undetectable tritium, some using standard analysis and some using low-level (Table 5-4). The low-level tritium analysis method will be used in the future for all Characterization wells in this CAU to verify the presence or absence of tritium at the lower MDC. ER-6-1-2 and UE-10j are scheduled for sampling in fiscal year 2017. The Characterization wells will likely be re-categorized as Source/Plume, Early Detection or Distal wells depending on the presence/absence of tritium and their relative proximity to the UGTs after characterization is complete. However, well ER-5-3-2, which was last sampled in 2001, was identified in 2015 as a future closure monitoring well for the Frenchman Flat CAU. Although this well was initially selected to monitor potential radionuclide transport out of the Yucca Flat basin through the regional lower carbonate aquifer, it is located in Frenchman Flat and can be used as a monitoring well for the lower carbonate aquifer in this CAU. Well ER-5-3-2 will next be sampled in 2016.

#### **5.1.1.3.2 Source/Plume Wells**

Twenty Source/Plume wells are included in the sampling network. They have detectable radionuclides from NNSS underground nuclear testing and vary in location from within a test cavity where radionuclide concentrations are high, to downgradient of the detonation where radionuclide concentrations can be relatively low, in comparison to SDWA MCLs. Samples are collected every 4 years (three samples per one tritium half-life) and analyzed for tritium and CAU-specific COPCs (Table 5-2). Two Source/Plume wells in the Pahute Mesa CAUs were sampled in 2015.

**Frenchman Flat CAU** - Three Source/Plume wells are located in this CAU, and all were last sampled in 2014. Two of the wells exceeded the 20,000 pCi/L MCL for tritium in 2014 (Table 5-4; Figure 5-3). In 1974, RNM-1 was drilled directly into the explosion region of the underground nuclear test Cambric, which was detonated in

1965. Well RNM-2S was also drilled 91 m (300 ft) south of the Cambrian shot point in 1974. To evaluate radionuclide migration, groundwater flow from the detonation point to Well RNM-2S was induced by pumping Well RNM-2S from 1975 to 1991 (Bryant 1992). Tritium concentrations decreased in RNM-1 and increased in RNM-2S as a result of the pumping experiment (Stoller-Navarro Joint Venture [SNJV] 2005). Well UE-5n is located approximately 560 m (1,840 ft) southeast of RNM-1 within an unlined discharge ditch that was used to transport large volumes (approximately  $4.5 \times 10^9$  gallons) of water pumped during the experiment (Finnegan and Thompson 2002). Radionuclides detected in UE-5n waters are thought to reflect infiltration of water from the unlined ditch rather than groundwater transport from the test cavity (Rose et al. 2003). While groundwater samples from RNM-1 have exceeded the MCL for a few radionuclides ( $^{90}\text{Sr}$ ,  $^{137}\text{Cs}$ , and  $^{129}\text{I}$ ), only tritium has exceeded its MCL in groundwater from RNM-2S and UE-5n. In fact, two of the radionuclides,  $^{90}\text{Sr}$  and  $^{137}\text{Cs}$ , were not detected in RNM-2S even after 16 years of pumping (SNJV 2005) and are therefore not COPCs for this CAU.

The tritium concentrations in the 2014 samples from these three Source/Plume wells were all lower than the 2007 values of 866 and 104,000 pCi/L for RNM-1 and RNM-2S, respectively, and lower than the 2010 value of 186,000 pCi/L for UE-5n. The decreasing concentrations are consistent with tritium decay over the 7-year (RNM-1 and RNM-2S) and 4-year (UE-5n) time periods. None of the COPCs were detected in the 2014 water samples. RNM-2S and UE-5n will be sampled in 2016 as part of closure monitoring for this CAU. As a result of the extensive pumping of RNM-2S from 1975 to 1991, the groundwater of RNM-1 no longer exceeds SDWA MCLs and is not included for closure monitoring.

**Pahute Mesa CAUs** - Ten Source/Plume wells, associated with six different UGTs, are located within the Central and Western Pahute Mesa CAUs (Table 5-4). Two of these wells (ER-20-5-1 and ER-20-5-3) were sampled in 2015. The groundwater in all but two wells (ER-20-6-1 and ER-20-6-3) exceed the tritium MCL (Table 5-4; Figure 5-3). A few radionuclides ( $^{90}\text{Sr}$ ,  $^{137}\text{Cs}$ ,  $^{129}\text{I}$ , and Pu) exceed their SDWA MCLs (8, 200, 1, and 15 pCi/L, respectively) in samples from wells drilled directly into a test cavity (U-19ad PS 1A, U-19v PS 1D, and U-20n PS 1DD-H). They have not, however, exceeded their MCLs in wells located away from the test cavity, even when the wells are within 300 m of the cavity (U-19q PS 1D and UE-20n 1) and when high levels of tritium were detected (Table 5-4). In samples from U-19q PS 1D and UE-20n 1, only  $^{14}\text{C}$  was found at levels  $\geq 10\%$  of its SDWA MCL of 2,000 pCi/L. The maximum tritium concentration in well ER-20-5-3 decreased from 96,200 pCi/L in 2011 to 84,000 pCi/L in 2015. This decrease in tritium concentration is primarily a result of decay. The maximum tritium concentration in Well ER-20-5-1 decreased from 30,100,000 pCi/L in 2011 to 24,800,000 pCi/L in 2015. The  $^{129}\text{I}$  activity (0.195 pCi/L) is  $\geq 10\%$  of its SDWA MCL for well ER-20-5-1; the  $^{129}\text{I}$  activity has remained nearly constant (within measurement uncertainty) from 0.192 pCi/L in 2004 to 0.193 pCi/L in 2011 to 0.195 pCi/L in 2015. No other radionuclide exceeded  $\geq 10\%$  of its SDWA MCL in the ER-20-5-1 and ER-20-5-3 samples collected in 2015.

**Rainier Mesa/Shoshone Mountain CAU** - Two Source/Plume locations are monitored within the Rainier Mesa/Shoshone Mountain CAU, but were not sampled in 2015 (Table 5-4). They are two historical N Tunnel vent holes. The N Tunnel complex was sealed in 1994 and became flooded with groundwater, which is sampled through the vent holes to monitor radionuclides within the tunnel complex. While tritium was observed above the MCL in these vent holes (Table 5-4), no other radionuclides were observed above their MCLs. In these Source/Plume locations,  $^{90}\text{Sr}$ ,  $^{129}\text{I}$ , and Pu are within 10% of their SDWA MCLs. The N Tunnel vent holes are scheduled for sampling in 2018.

**Yucca Flat/Climax Mine CAU** - Five Source/Plume wells are located within the Yucca Flat/Climax Mine CAU (Table 5-4). One (UE-7nS) was sampled in 2015 and the tritium concentration was reported as 53 pCi/L. This low tritium concentration is rather surprising considering the sample was collected within 200 m (655 ft) of the detonation cavity. Two of the Source/Plume wells are drilled directly into a test cavity (U-3cn PS 2 and U-4u PS 2A); groundwater from these wells exceed the 20,000 pCi/L MCL for tritium. The other Source/Plume well (UE-2ce) is located within 200 m (655 ft) from detonation cavities and exceeds the tritium MCL. Well WW-A is located approximately 520 m (1,705 ft) from a test cavity. Tritium was detected in WW-A in the late 1980s, peaked at  $\sim 700$  pCi/L in 1999, and declined to 355 pCi/L by 2012 (Table 5-4). The combined presence of four radionuclides ( $^{14}\text{C}$ ,  $^{90}\text{Sr}$ ,  $^{137}\text{Cs}$ , and  $^{129}\text{I}$ ) in well U-4u PS 2A exceeds the SDWA MCL for beta- and photon-emitting radionuclides allowed in drinking water, which is the combined concentration of such emitters that would result in an exposure of 4 mrem/yr. No other radionuclides in samples from Source/Plume wells in this

CAU exceed the SDWA MCL. Except for  $^{90}\text{Sr}$  in Well UE-2ce, no radionuclides have been found at levels  $\geq 10\%$  of their SDWA MCLs in wells located away from a test cavity within the Yucca Flat/Climax Mine CAU.

#### **5.1.1.3.3 Early Detection Wells**

Ten Early Detection wells are included in the sampling network: four within the Pahute Mesa CAUs, one for the Rainier Mesa/Shoshone Mountain CAU, and five for the Yucca Flat/Climax Mine CAU; there are no Early Detection wells currently associated with the Frenchman Flat CAU (Table 5-4). They are the next wells down-gradient of a UGT or Source/Plume well and have expected tritium levels less than the MDCs for standard tritium analyses (i.e.,  $< 300$  pCi/L). In the absence of tritium, no other test-related radionuclides are present in historically sampled groundwater; therefore, Early Detection Wells are monitored solely for low levels of tritium using the low-level tritium analysis method. Early Detection wells associated with the Central and Western Pahute Mesa CAUs are sampled every 2 years to ensure that the plume front is detected in a reasonable time frame and that a time trend for tritium is established early. For the other CAUs, the sampling frequency is once every 5 years because of the low groundwater velocities and the resulting slow change in radionuclide concentration with time. Three Early Detection wells were sampled in 2015.

Wells ER-20-1 and ER-EC-ER-19-1 6, both from the Western Pahute Mesa CAU, were sampled in 2015. As in 2012, when ER-20-1 was last sampled, no tritium was detected above its MDC. Tritium was detected at 5.2 pCi/L in ER-EC-6, which is slightly higher than the 1.7 pCi/L concentration reported in 2009. Well PM-3, also within the Western Pahute Mesa CAU, is currently the only other Early Detection well in the sampling plan that has detectable tritium levels (237 pCi/L in 2014; Table 5-4). After tritium levels reach 300 pCi/L, PM-3 (and any other Early Detection well) will be re-categorized as a Source/Plume well and sampled for tritium and COPCs.

Well WW-2, within the Yucca Flat/Climax Mine CAU, was sampled in 2015. As in 2006 when it was last sampled, no tritium was detected above its MDC.

#### **5.1.1.3.4 Distal Wells**

Seven Distal wells are included in the sampling network: two for the Pahute Mesa CAUs, four for the Rainier Mesa/Shoshone Mountain CAU, and one for the Yucca Flat/Climax Mine CAU; there are no Distal wells currently associated with the Frenchman Flat CAU (Table 5-4). Distal wells are analyzed for tritium using the standard EPA method. Samples are collected at a 5-year frequency. The sampling objective for these wells is to demonstrate that tritium is not present downgradient of UGTs at levels above the SDWA-required minimum detection limit of 1,000 pCi/L. These wells also support the development and evaluation of the flow and contaminant transport models. Three Distal wells (ER-12-1, UE-16d, and WW-8) within the Rainier Mesa/Shoshone Mountain CAU and one Distal well (Army #1 WW) within the Yucca Flat/Climax Mine CAU were sampled in 2015. No tritium was detected (Tables 5-4 and 5-5). WW-8 is also an NNSS PWS well (see Section 5.1.1.3.6), and ER-12-1 is also a Compliance well (see Section 5.1.1.3.7.2).

#### **5.1.1.3.5 Community Wells/Springs**

Eight Community sampling locations occur within the sampling network, all associated with the Pahute Mesa CAUs (Table 5-4). None were sampled in 2015. These wells and springs are either used as private, business, or community water supply sources or are near such sources, and they are sampled for tritium 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 tritium at 0.01% of its MCL) long before such a plume could be detected in these private, business, or community water supply sources. Samples are analyzed using a standard EPA method. The objective is to demonstrate that tritium is not present at levels above the SDWA-required minimum detection limit of 1,000 pCi/L. Well Ash B was last sampled in 2009, Well EW 4 was last sampled in 2011, and the other six Community sampling locations were last sampled in 2012. No tritium has been detected at any of these locations (Table 5-4).

### **5.1.1.3.6 NNSS PWS Wells**

Results from the NNSS PWS water wells sampled quarterly in 2015 continue to indicate that historical underground nuclear testing has not impacted the NNSS water supply network. No tritium 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 2015 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).

### **5.1.1.3.7 Compliance Wells/Groundwater Discharges**

#### **5.1.1.3.7.1 RCRA Permitted Wells for the Area 5 Mixed Waste Disposal Unit**

Wells UE-5 PW-1, UE-5 PW-2, and UE-5 PW-3 are sampled semi-annually for tritium. They are monitored for tritium and nonradiological parameters (see [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 2015, standard tritium analyses of the wells' water samples were performed; all samples had non-detectable levels of tritium (Table 5-5), and their MDCs were well below the permit established investigation level (IL) of 2,000 pCi/L. Further groundwater analysis is required if the IL is exceeded. Results continue to indicate that Cell 18 radioactive wastes have not contaminated local groundwater. Table 10-3 in Chapter 10, Section 10.1.7 presents the 2015 sampling results for four additional indicators of groundwater contamination, and all 2015 sample analysis results for these three wells are presented in NSTec (2016).

#### **5.1.1.3.7.2 NDEP Permitted E Tunnel Waste Water Disposal System (ETDS)**

NNSA/NFO manages and operates the ETDS in Area 12 under a water pollution control permit (NEV 96021) issued by the Nevada Division of Environmental Protection (NDEP) Bureau of Federal Facilities. The permit governs the management of radionuclide-contaminated wastewater that drains from the E Tunnel portal into a series of holding ponds. The permit requires Well ER-12-1 groundwater to be monitored once every 24 months and E Tunnel discharge waters (retained in the E Tunnel Ponds) to be monitored once every 12 months for tritium, gross alpha, and gross beta as well as for numerous nonradiological parameters (see Section 5.2.4, Table 5-9).

On October 13, 2015, annual sampling for radiological analyses of ETDS discharge water was performed, and on April 15, 2015, biennial sampling of Well ER-12-1 was performed. The permissible limits for tritium, gross alpha, and gross beta in the tunnel discharge waters are 1,000,000, 35.1, and 101 pCi/L, respectively. The permissible limits for Well ER-12-1 are identical to the EPA SDWA limits of 20,000, 15, and 50 pCi/L, respectively. No tritium measurements for ER-12-1 were above their MDCs using an EPA-approved standard analysis method (Table 5-5) (Navarro 2016). Gross alpha and gross beta radioactivity were found at concentrations slightly greater than their MDCs and are believed to represent the presence of naturally occurring radionuclides. All samples for E Tunnel Ponds and Well ER-12-1 were below their permit limits (Table 5-5).

#### **5.1.1.3.7.3 UGTA Well Discharged Groundwater and Fluids**

UGTA wells are regulated by the state through an agreement between NNSA/NFO and NDEP called the UGTA Fluid Management Plan (Attachment 1 of NNSA/NSO [2009]) in lieu of having separate State-issued water pollution control permits for each well. The plan prescribes the methods of disposing groundwater and fluids pumped from UGTA wells during drilling, development, and testing based on the levels of radiological contamination. Discharge water and drilling fluids having  $\geq 400,000$  pCi/L of tritium are diverted to lined sumps to evaporate; otherwise they may be diverted to unlined sumps to evaporate. Samples of the discharge water from the wellhead or bailer are analyzed for gross alpha, gross beta, tritium, and RCRA-regulated metals to ensure discharged water is below the established fluid management criteria for these parameters. When the tritium level in discharge water and drilling fluids is  $\geq 400,000$  pCi/L, lead is monitored in the field to ensure that the RCRA limit for lead of 5 milligrams per liter (mg/L) is not exceeded; exceeding this level may result in the generation of a hazardous or mixed waste in a sump, which could cause the suspension of drilling operations.

Only one well sampled in 2015 (the Pahute Mesa CAUs Source/Plume well ER-20-5-1) exceeded 400,000 pCi/L. Its groundwater and fluids were directed to a lined sump. Groundwater purged from all other sampled wells was directed to either lined or unlined sumps. Grab samples from all sumps were below the fluid management criteria limits for all analyzed parameters. A new well (ER-20-12; see Chapter 11, Section 11.1.1.2) was drilled in Pahute

Mesa in 2015. Groundwater discharged during drilling at ER-20-12 was directed to a lined sump and monitored in accordance with the fluid management plan. The maximum tritium concentration in samples collected using a bailer from ER-20-12 was reported as 53,600 pCi/L. This well will be added as a new Characterization well to the NNSS Integrated Groundwater Sampling Plan in 2016.

#### **5.1.1.3.8 UGTA Inactive Wells**

Wells that have not been assigned to one of the seven previously discussed water sample location types are called inactive wells; they are not included in the NNSA/NFO water sampling network. In 2015, three inactive wells located near test cavities within the Pahute Mesa CAUs were sampled and analyzed for a suite of radionuclides. This work was performed to improve understanding of current radionuclide levels near the nuclear test cavities. Sampled wells U-20f PS #1D and U-20m PS #1D, both located in the Western Pahute Mesa CAU, are near the Fontina and Handley test cavity, respectively. The third sampled well, U-19e PS #2D, is located in the Central Pahute Mesa CAU near the Muenster test cavity. Samples were collected using a depth-discrete bailer and analyzed for tritium, gross alpha, gross beta, and a suite of gamma emitters (e.g., <sup>26</sup>Al, <sup>94</sup>Nb, <sup>137</sup>Cs, <sup>152</sup>Eu, <sup>154</sup>Eu, <sup>235</sup>U, <sup>241</sup>Am, <sup>243</sup>Am). Tritium levels in these three wells ranged from 2,000,000 to 20,000,000 pCi/L, as expected for groundwater collected near a nuclear test cavity. For U-19e PS #2D and U-20m PS #1D, no gamma emitters were detected, gross alpha measurements were under the EPA MCL (15 pCi/L), and gross beta measurements were under the EPA level of concern (50 pCi/L). Although gamma emitters were not detected, elevated gross alpha (49 pCi/L) and gross beta (135 pCi/L) were observed in U-20f PS #1D.

In 2015, three wells in Yucca Flat were sampled (TW-B, UE-6d, and UE-6e) because historical measurements indicated the presence of low levels of tritium, which is contrary to the current understanding of groundwater flow and transport in this CAU. No tritium was detected in these samples in 2015, which indicates that the elevated historical measurements may have been the result of cross-contamination during previous sampling or analysis and were not indicators of a contaminant plume.

### **5.1.2 Nye County Tritium Sampling and Monitoring Program**

In 2014, NNSA/NFO began to investigate expanding its support of offsite community-based monitoring of wells in Nye County in response to the county's request to become involved. As a result, the Nye County Tritium Sampling and Monitoring Program was initiated in 2015. The DOE Environmental Management (EM) office issued a 5-year grant to Nye County for this program to monitor tritium in wells downgradient from the NNSS. The grant supports annual sampling of 10 wells in the first year and up to 20 wells every year thereafter. It also supports Nye County's involvement in technical reviews of the UGTA corrective action program (see Chapter 11). To help determine sample well locations, Nye County has committed to coordinate with DRI, who conducts the CEMP (see Chapter 7), with the CEMP's Community Environmental Monitors (CEMs), and with Nye County citizens. Due to the CEMP's success at involving and educating local communities, the DOE EM grant requests that data administration and communication to the public of Nye County's monitoring program be conducted through the CEMP. Nye County's results will also be published annually in this report.

In 2015, Nye County selected and sampled ten wells (Table 5-6). Sample locations (Figure 5-4) were selected based upon groundwater flow paths off of the NNSS, proximity of wells to downgradient communities and recommendations provided by CEMs. Five of these wells are classified as Nye County Distal Monitoring Wells (Table 5-6) and were sampled using an air powered submersible positive displacement pump. A minimum of three well volumes (16 to 163 gallons) was pumped from each well prior to sampling in order to purge water from the pump tubing and well annulus. This process ensured that the resultant samples were representative of local groundwater conditions. The five other wells are classified as Nye County Community Wells (Table 5-6) and are either operating domestic or municipal wells, which were sampled from the dedicated pump discharge. These wells were purged prior to sampling to insure that representative water samples were being obtained.

The collected samples were analyzed for tritium by Radiation Safety Engineering, Inc., in Chandler, Arizona using an EPA-approved, unenriched scintillation counting method. The sample MDCs for this counting process were 278 or 313 pCi/L (depending upon the sample), which are less than 2% of the EPA limit for tritium in drinking water of 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 the tritium sampling is documented in Test

Plan TPN-11.8, “Groundwater Sampling and Analysis for the Nye County Tritium Sampling And Monitoring Program,” and Work Plan WP-11, “Groundwater Chemistry Sampling and Analysis” (available upon request).

Table 5-6 presents the sample analysis results for each well, the well locations, and the date each well was sampled. All tritium analysis results were quantifiably below background ( $\leq$  the MDC). Similar to the CEMP water sampling results (Chapter 7, Section 7.2) and those of the Community wells within NNSA/NFO’s water sampling network (Section 5.1.1.3.5), Nye County’s monitoring confirms that tritium from historical underground nuclear testing on the NNSS is not present in these wells. Public access to the 2015 monitoring data is available on the DRI CEMP website at <http://www.cemp.dri.edu/>.

**Table 5-6. Nye County water wells sampled in 2015**

Sample Location	Latitude	Longitude	Date Sampled	Tritium Concentration (pCi/L)
<b>Nye County Distal Monitoring Wells</b>				
NC-GWE-OV-1	37.0061820	-116.7207580	12/10/15 12/10/15 FD <sup>(a)</sup>	<313 <278
NC-GWE-OV-2	36.9645540	-116.7229820	12/17/15	<313
EWDP-13P	36.7444070	-116.5139540	12/9/15	<313
EWDP-24P	36.7046597	-116.4479878	12/7/15	<313
NC-GWE-8PA	36.6244220	-116.3770836	12/8/15	<278
<b>Nye County Community Wells</b>				
Amargosa Elementary School	36.5696120	-116.4609460	12/21/15 12/21/15 FD	<278 <313
Amargosa Valley RV Park	36.6417350	-116.3974740	12/16/15	<278
Beatty Water and Sanitation (W04)	36.9514580	-116.8050020	12/16/15	<278
Northwest Academy	36.4961660	-116.4235630	12/21/15	<278
Baileys Hot Springs	36.9747200	-116.7225000	12/16/15 12/16/15 FB <sup>(b)</sup>	<278 <313

(a) Field duplicate

(b) Field blank

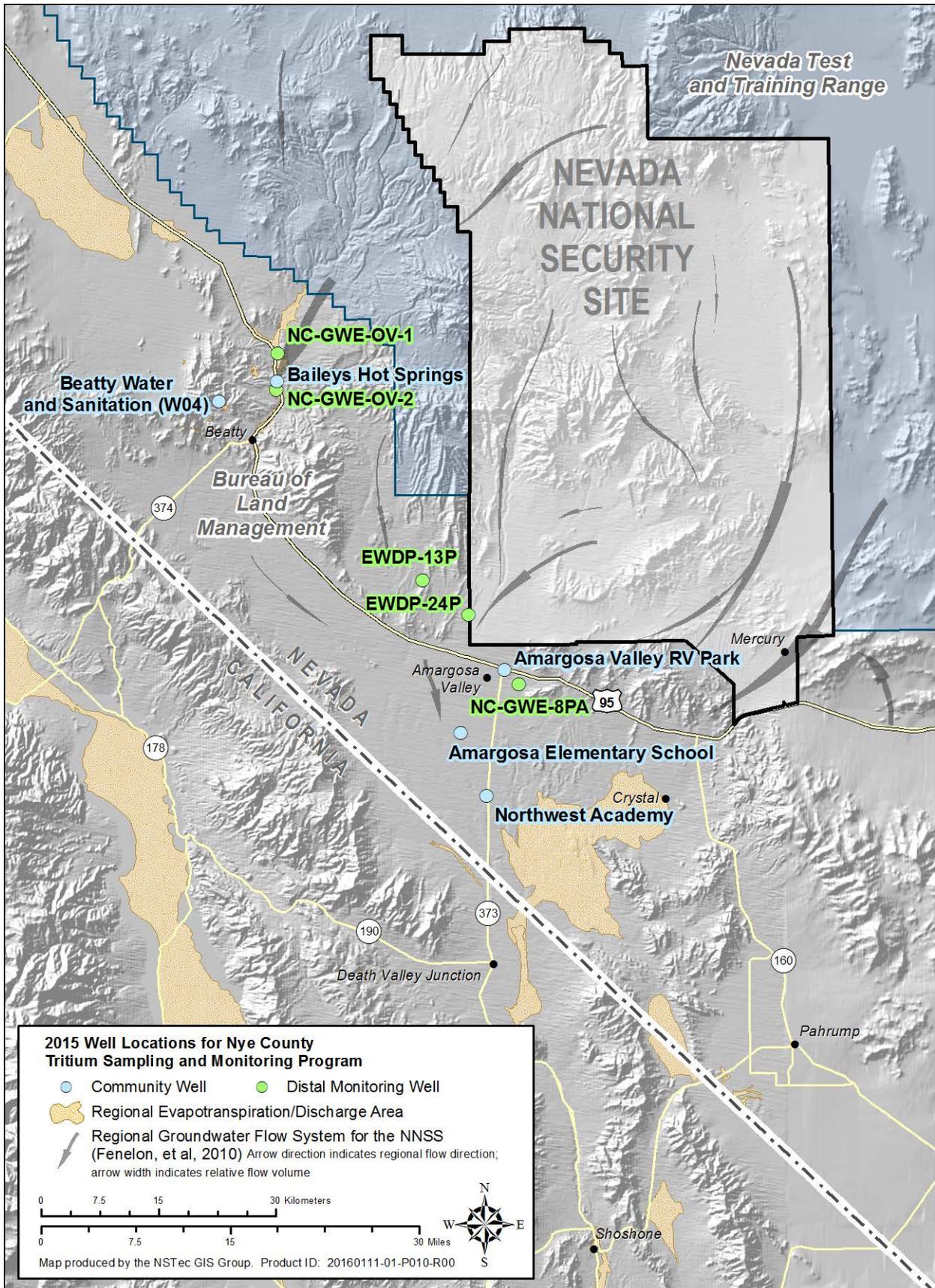


Figure 5-4 Nye County water sampling locations

## 5.2 Nonradiological Drinking Water and Wastewater Monitoring

The quality of drinking water and wastewater on the NNSS is regulated by federal and state laws. The design, construction, operation, and maintenance of many of the drinking water and wastewater systems are regulated under state permits. NNSA/NFO ensures that such systems meet the applicable water quality standards and permit requirements. The NNSS nonradiological water monitoring goals are shown below. They are met by conducting field water sampling and analyses, performing assessments, and maintaining documentation. This section describes the results of 2015 activities. Information about radiological monitoring of drinking water on and off the NNSS and of wastewater on the NNSS is presented in Sections 5.1.3.5 and 5.1.3.6.

### *Nonradiological Water Monitoring Goals*

Ensure that the operation of NNSS *public water systems (PWSs)* and *private water systems* (see [Glossary, Appendix B](#)) provides high-quality drinking water to workers and visitors of the NNSS.

Determine if NNSS PWSs are operated in accordance with the requirements in Nevada Administrative Code NAC 445A, "Water Controls," under permits issued by the state.

Determine if the operation of commercial septic systems that process domestic wastewater on the NNSS meets operational standards in accordance with the requirements NAC 445A under permits issued by the state.

Determine if the operation of industrial wastewater systems on the NNSS meets operational standards of federal and state regulations as prescribed under the GNEV93001 state permit.

### 5.2.1 Drinking Water Monitoring

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

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

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

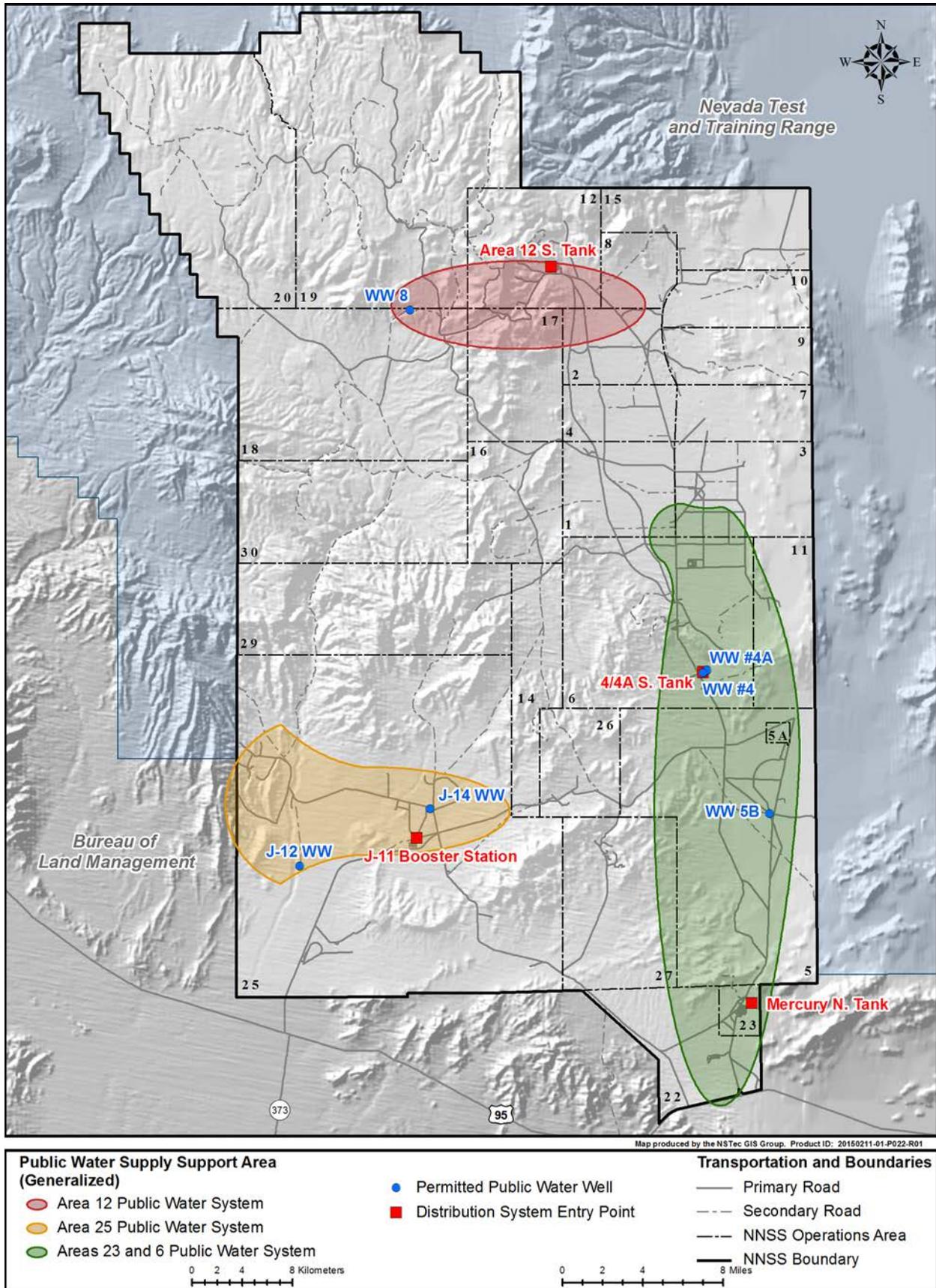


Figure 5-5. Water supply wells and drinking water systems on the NNSS

**Table 5-7. Current sampling requirements for permitted NNSP PWSs and water-hauling trucks**

System/ Truck	Contaminant or Contaminant Category	Sample Location	Sampling Cycle	Number of Samples
Area 23 and 6	<b>National Primary Standards</b>			
	Coliform	WDP-23/6 <sup>(a)</sup>	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 <sup>(b)</sup>	3 year	1
	IOCs <sup>(c)</sup> - Phase 2 and 5 <sup>(d)</sup>	POE-23/6	9 year	1
	Nitrate	POE-23/6	1 year	1
	Nitrite	POE-23/6	3 year	1
	SOCs <sup>(e)</sup> - Phase 2 and 5	POE-23/6	6 year	1
	VOCs <sup>(f)</sup> - Phase 2 and 5	POE-23/6	3 year	1
	<b>Secondary Standards</b>			
	Secondary IOCs	POE-23/6	3 year	1
Area 12 and Area 25	<b>National Primary Standards</b>			
	Coliform	WDP-12/25 <sup>(g)</sup>	quarterly	1
	Nitrate	POE-12/25 <sup>(h)</sup>	1 year	1
	Nitrite	POE-12/25	3 year	1
	<b>Secondary Standards</b>			
Secondary IOCs	POE-12/25	3 year	1	
<b>Water-Hauling Trucks</b>				
Trucks 84846 and 84847	Coliform Bacteria	Truck valve	monthly	1

(a) WDP-23/6 = Water delivery points for the Area 23 and 6 PWS: taps within Buildings 5-7, 6-609, 6-900, 22-1, 23-180, 23-701, 23-777, 23-1103, and the UIH restroom

(b) POE-23/6 = Points of entry for the Area 23 and 6 PWS: Mercury N. Tank and 4/4A S. Tank (Figure 5-5)

(c) IOCs = Inorganic chemicals

(d) Refers to sets of chemical contaminants in drinking water for which the EPA established maximum contaminant levels (MCLs) through a series of rules known as the Chemical Phase Rules issued from 1987 (Phase 1) through 1992 (Phase 5); see <http://water.epa.gov/lawsregs/rulesregs/sdwa/chemicalcontaminantrules/basicinformation.cfm>.

(e) SOCs = Synthetic organic chemicals

(f) VOCs = Volatile organic compounds

(g) WDP-12/25 = Water delivery points for the Area 12 and Area 25 PWSs: Buildings 12-909 and 25-3123 or 25-4222

(h) POE-12/25 = Points of entry for the Area 12 and Area 25 PWSs: Area 12 S. Tank, J-11 Booster Station, and J-14 WW (Figure 5-5)

### 5.2.1.1 2015 Results of PWS and Water-Hauling Truck Monitoring

All 2015 water samples were collected in accordance with accepted practices, and the analyses were performed by state-approved laboratories. The laboratories used approved analytical methods listed in NAC 445A and Title 40 Code of Federal Regulations (CFR) Part 141, “National Primary Drinking Water Standards.” The 2015 monitoring results indicated that all of the PWSs complied with applicable National Primary Drinking Water Quality Standards (Table 5-7). In 2014, Nevada’s Secondary Standards for aluminum and iron in the Area 25 PWS were exceeded, resulting in NNSA/NFO receiving a violation from NDEP in May 2015 (see Section 2.5, Table 2-8, Occurrence titled, “Violation of Secondary Drinking Water Standards”) and the initiation of quarterly monitoring of this PWS in September 2014. Quarterly sampling of the Area 25 PWS continued through July 2015. The April and July samples showed that the system had returned to compliance (Table 5-7), and NDEP approved the return to triennial monitoring for these secondary standards.

All water samples from the water-hauling trucks were negative for coliform bacteria in 2015.

**Table 5-8. Water quality analysis results for NNSS PWSs**

Contaminant	Maximum Contaminant Level (mg/L)	2015 Results (mg/L)		
		Area 23 and 6 PWS	Area 12 PWS	Area 25 PWS
<b>Coliform Bacteria</b>	Coliforms present in 1 sample/month	Absent in all samples	Absent in all samples	Absent in all samples
<b>Inorganic Chemicals – Phase II</b>				
Iron	0.6	NS <sup>(a)</sup>	NS	0.049
Aluminum	0.2	NS	NS	0.169
Nitrate	10 (as nitrogen)	3.9 and 2.8	0.99	1.9 and 1.3
Nitrite	1 (as nitrogen)	0.1 and 0.1	ND <sup>(b)</sup>	0.1
<b>Inorganic Chemicals – Phase V</b>				
Arsenic	0.01	0.00912 and 0.00769	NS	NS
<b>Disinfection By-Products</b>				
Total Trihalomethanes	0.08	0.026	NS	NS
Haloacetic Acids	0.06	.0005	NS	NS

(a) NS = Not scheduled to be sampled in 2015

(b) ND = Not detected

### 5.2.1.2 State Inspections

Periodically, NDEP conducts a sanitary survey of the permitted NNSS PWSs. It consists of an inspection of the wells, tanks, and other visible portions of each PWS to ensure that they are maintained in a sanitary configuration. As non-community water systems, the minimum survey frequency is once every 5 years. No sanitary surveys were conducted in 2015.

NDEP inspects the two water-hauling trucks annually at the time of permit renewal to make sure they still meet the requirements of NAC 445A. Inspections were performed in September 2015 and permits were renewed.

### 5.2.2 Domestic Wastewater Monitoring

A total of 17 active permitted septic systems for domestic wastewater are being used on the NNSS (Figure 5-6). These septic systems are permitted to handle up to 5,000 gallons of wastewater per day. The permitted septic systems are inspected periodically for sediment loading and are pumped as required. The NNSS Management and Operations contractor maintains a septic pumping contractor permit issued by the state. The state conducts onsite inspections of pumper trucks and pumping contractor operations. NNSS personnel perform management assessments of the permitted systems and services to determine and document adherence to permit conditions. The assessments are performed according to existing directives and procedures.

In May 2015, the state conducted one inspection of the NNSS septic pumper trucks, and NNSS personnel conducted one management assessment of the domestic wastewater systems. No compliance issues were identified relating to domestic wastewater on the NNSS.

A septic tank pumping contractor permit (NY-17-03318), four septic tank pump truck permits (NY-17-03313, NY-17-03315, NY-17-03317, NY-17-06838), and a septic tanker permit (NY-17-06839) were approved by the state and renewed in July 2015.

### 5.2.3 Industrial Wastewater Monitoring

Industrial discharges on the NNSS are limited to three operating sewage lagoon systems: Area 6 Yucca Lake, Area 6 DAF, and Area 23 Mercury (these lagoon systems also receive domestic wastewater) (Figure 5-6). The Area 6 Yucca Lake system consists of two primary lagoons and two secondary lagoons. The DAF system consists of one primary and one secondary lagoon, which were reactivated in 2014 after it was determined that the permitted DAF septic system could not adequately manage the wastewater. The Area 6 Yucca Lake and DAF

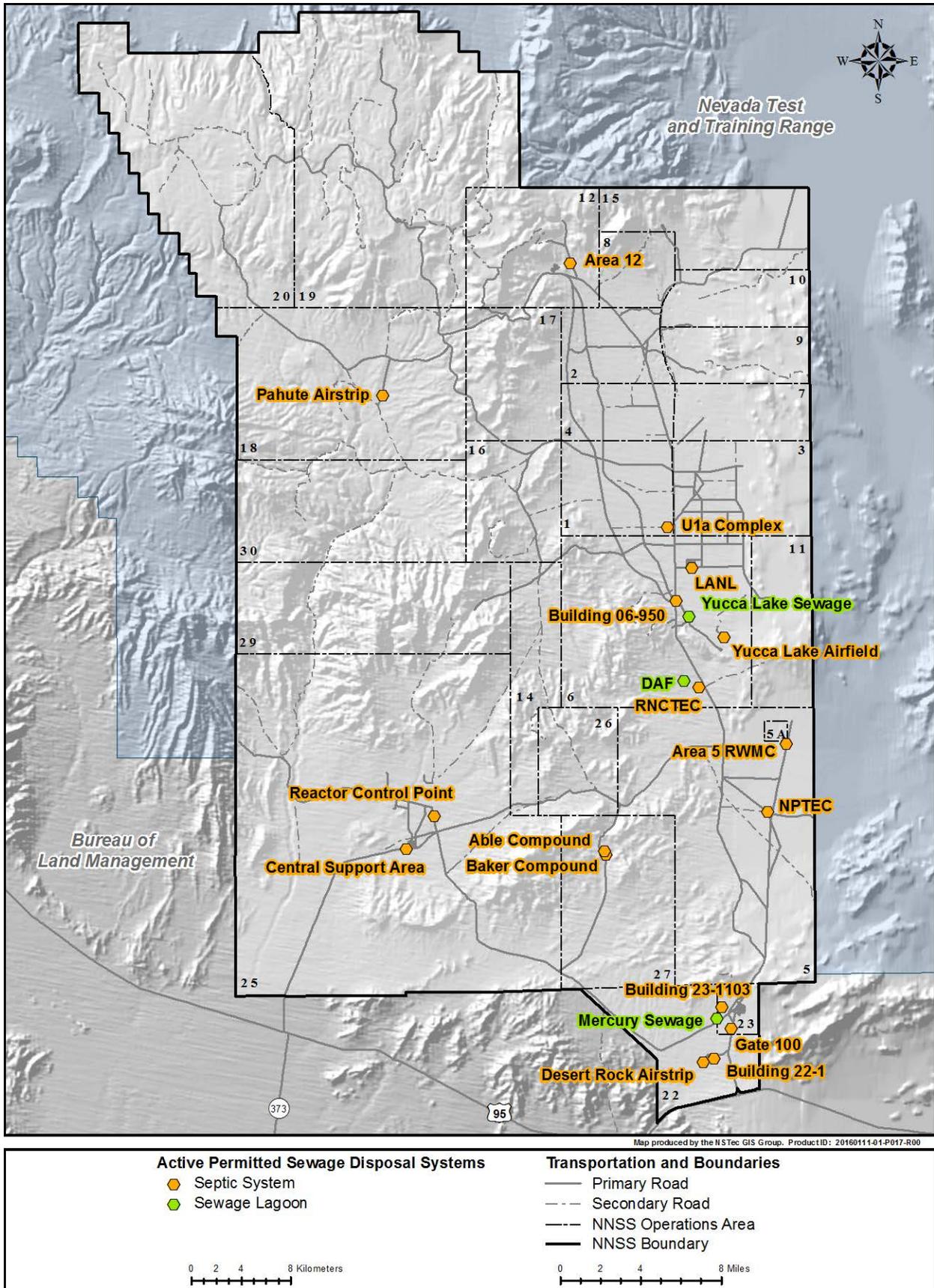


Figure 5-6. Active permitted sewage disposal systems on the NNSS

lagoons are all lined with compacted native soils that meet the State of Nevada requirements for transmissivity ( $10^{-7}$  centimeters per second). The Area 23 Mercury system consists of one primary lagoon, a secondary lagoon, and an infiltration basin. The primary and secondary lagoons have a geosynthetic clay liner and a high-density polyethylene liner. The lining of the ponds allows these systems to operate as fully contained, evaporative, non-discharging systems.

### 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 in accordance with accepted practices. The analyses are performed by state-approved laboratories. The laboratories use approved analytical methods listed in NAC 445A and 40 CFR 141. The composite samples are analyzed for three parameters: **5-day biological oxygen demand (BOD<sub>5</sub>)** (see [Glossary, Appendix B](#)), total suspended solids (TSS), and pH. In 2015, all results for BOD<sub>5</sub>, TSS, and pH for sewage system influent waters were within the limits established under Water Pollution Control General Permit GNEV93001 (Table 5-8). Quarterly monitoring reports of these results were submitted to NDEP in April, July, and October 2015 and in January 2016.

The flow is also monitored continuously in the three sewage systems. The Area 6 Yucca Lake and Area 23 Mercury systems operated within the flow limits set in the permit, but the Area 6 DAF system exceeded the flow limit (Table 5-8). On August 4, 2015, NDEP issued a waiver for the DAF permitted flow limit of 3,080 gallons/day. This limit was initially determined by a standard water balance calculation, and no metering device was in place when the permit was originally issued, so the flow had been estimated for quarterly reports. The permit was renewed in 2015 and issued on August 5, 2015 as Water Pollution Control Permit GNEV93001, Revision X by NDEP.

Toxicity monitoring of influent waters of the lagoons was not conducted in 2015. The permit requires that the lagoons be sampled and analyzed for the 29 contaminants shown 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. There were no such discharges that warranted sampling in 2015.

**Table 5-9. Water quality analysis and flow monitoring results for NNSS sewage lagoon influent waters in 2015**

Parameter	Units	Minimum and Maximum Values from Quarterly Samples		
		Area 6 Yucca Lake	Area 23 Mercury	Area 6 DAF
BOD <sub>5</sub>	mg/L	185–537	165–473	80–483
Permit Limit		None	None	None
BOD <sub>5</sub> Mean Daily Load <sup>(a)</sup>	kg/d	0.66–2.49	21.16–44.1	1.94–6.62
Permit Limit		34.43	124.31	15.29
TSS	mg/L	153–510	128–262	86–266
Permit Limit		None	None	None
pH	S.U. <sup>(b)</sup>	7.97–8.31	8.01–8.66	8.42–8.70
Permit Limit		6.0–9.0	6.0–9.0	6.0–9.0
Quarterly Average Flow Rate	Gal/day <sup>(c)</sup>	575–2,052	16,343–33,888	3,623–6,761
Permit Limit		10,850	73,407	3,080 <sup>(d)</sup>

(a) BOD<sub>5</sub> Mean Daily Load in kilograms per day (kg/d) = (mg/L BOD × liters per day (L/d) average flow × 3.785)/10<sup>6</sup>

(b) Standard units of pH

(c) Gallons per day

(d) Waiver granted by NDEP for flow rate limit in August 2015

### 5.2.3.2 Sewage System Inspections

NNSS personnel inspect active systems weekly and inactive lagoon systems quarterly. NDEP inspects both active and inactive NNSS lagoon systems annually. NNSS personnel inspect for abnormal conditions, weeds, algae blooms, pond color, abnormal odors, dike erosion, burrowing animals, discharge from ponds or lagoons, depth of staff gauge, crest level, excess insect population, maintenance/repairs needed, and general conditions. NNSS

personnel conducted weekly and quarterly inspections throughout 2015. They cover field maintenance programs, lagoons, sites, and access roads functional to operations. There were no notable findings from the onsite inspections. NDEP performed an annual inspection of the sewage lagoons in December 2015, and there were no findings.

### 5.2.4 ETDS 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 governs 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 (see Table 5-5 and Section 5.1.1.3.7.3) and for the nonradiological parameters listed in Table 5-9. It also requires nearby Well ER-12-1 to be sampled for the same parameters but at a frequency of once every 24 months. The ETDS is also monitored monthly for flow rate, pH, temperature, and specific conductance (SC) of the discharge water and the total volume and structural integrity of the holding ponds. Monitoring data are reported to the NDEP Bureau of Federal Facilities in annual and quarterly reports.

On October 13, 2015, monitoring personnel sampled the ETDS discharge water, and on April 15, 2015, ER-12-1 was sampled. All nonradiological parameters were within the threshold limits specified by the permit (Table 5-9).

**Table 5-10. Nonradiological results for Well ER-12-1 groundwater and ETDS discharge samples**

Nonradiological Parameter	ETDS Discharge Water Sampled Every 12 Months (October 2015)		Well ER-12-1 Groundwater Sampled Every 24 Months (April 2015)	
	Threshold (mg/L)	Measured Value (mg/L)	Threshold (mg/L)	Measured Value (mg/L)
Cadmium	0.045	0.005	0.005	0.00018
Chloride	360	10	250	17
Chromium	0.09	0.0051	0.09	0.0006
Copper	1.2	0.01	1.2	0.003
Fluoride	3.6	0.16	3.6	0.26
Iron	5.0	1.8	5.0	4.4
Lead	0.014	0.0022	0.014	0.00013
Magnesium	135	1.0	135	61
Manganese	0.25	0.023	0.25	0.14
Mercury	0.0018	0.0002	0.0018	0.00006
Nitrate nitrogen	9	0.3	9	0.2
Selenium	0.045	0.005	0.045	0.002
Sulfate	450	16.0	450	350
Zinc	4.5	0.027	4.5	0.018
Flow Rate (liters/minute)	MR <sup>(a)</sup>	27.9 <sup>(d)</sup>	NA	NA
pH (S.U.) <sup>(b)</sup>	6.0–9.0	7.2 <sup>(d)</sup>	6.5–8.5	7.62
Specific conductance (µS/cm) <sup>(c)</sup>	<1,500	363 <sup>(d)</sup>	<1,500	1,002

(a) Permit requires NNSA/NFO to monitor and report; there are no threshold limits

(b) S.U. = standard unit(s) (for measuring pH)

(c) µS/cm = microsiemens per centimeter

(d) Average of 12 monthly measures

## 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 hydrogeologic conditions in and around the NNSS. Hydrologic data are collected quarterly or semi-annually from wells on and off the NNSS. The USGS also maintains and develops the Death Valley Regional Groundwater Flow System Model (Belcher and Sweetkind 2010) and manages the NNSS well hydrologic and geologic information database.

During 2015, the USGS monitored water levels in 203 wells, which included 105 on the NNSS and 98 off the NNSS. Water levels are monitored to identify where water occurs in the subsurface, changes in the quantity of water in aquifers, the direction of groundwater movement, and groundwater velocity (derived from knowledge of groundwater movement and rock properties). Along with radiological groundwater data presented in Section 5.1, water level data are used to develop UGTA CAU-specific models of groundwater flow and radionuclide transport (see Section 11.1.2 of Chapter 11). A map showing the location of monitored wells and all water-level data are posted on the USGS/U.S. Department of Energy Cooperative Studies in Nevada web page at [http://nevada.usgs.gov/doe\\_nv/](http://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 during 2015 included J-12 WW, J-14 WW, UE-16d WW, WW #4, WW #4A, WW 5B, and WW 8 (see Figure 5-2). The USGS compiles the annual water-use data and reports annual withdrawals in millions of gallons. Discharge data from these wells for 2015 have been compiled, processed, and entered onto the USGS/DOE Cooperative Studies in Nevada website at [http://nevada.usgs.gov/doe\\_nv/wateruse/wu\\_map.php](http://nevada.usgs.gov/doe_nv/wateruse/wu_map.php). Discharge from these wells during 2015 was approximately 129 million gallons (Figure 5-7).

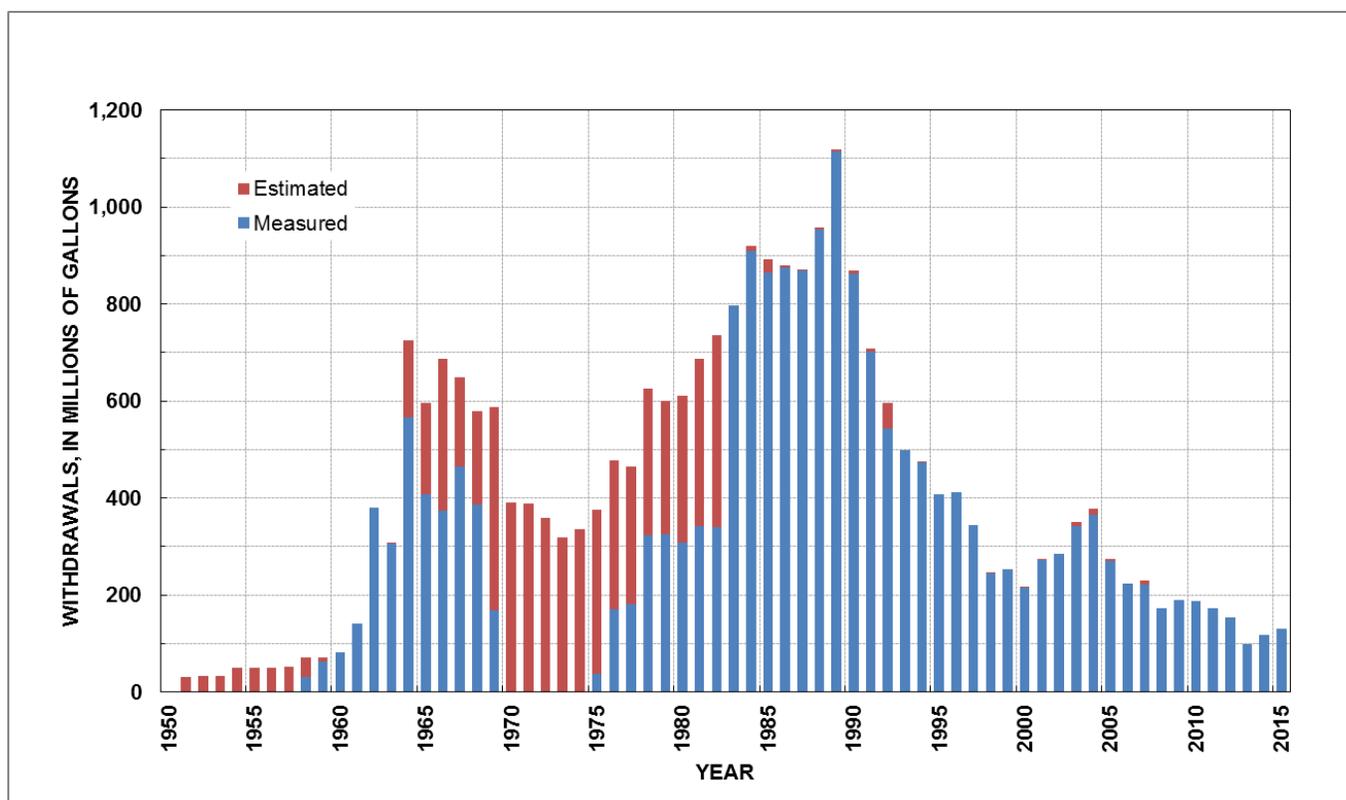


Figure 5-7. Annual withdrawals from the NNSS, 1951 to 2015

## 5.4 Water Monitoring Conclusions

The potential radiological impact to water resources from past activities on the NNSS is the migration of radionuclides in the groundwater downgradient from the UGTA CAUs. Currently, sampling and analysis data indicate that underground nuclear testing only within the Pahute Mesa CAUs has impacted groundwater off the NNSS; tritium has been detected above the tritium standard analysis method MDC of 300 pCi/L in one UGTA well on NTTR (ER-EC-11). Current data indicate, however, that the distance over which radionuclides have migrated from underground nuclear testing in the Pahute Mesa CAUs is not significant relative to the distance to offsite public water supply wells. Six Characterization wells within the Pahute Mesa CAUs intercept a contaminant plume of tritium believed to originate from the Tybo and Benham UGTs. These six well are within

900 ft to 17,000 ft (3.2 miles) of these two UGTs. Well sampling to date has not detected the presence of man-made radionuclides downgradient of Pahute Mesa in nine other UGTA wells on the NTTR. As presented in previous annual reports, samples from offsite monitoring wells in Oasis Valley, farther downgradient of Pahute Mesa, also contain no detectable man-made radionuclides. These sampling results are consistent with UGTA's Phase I Pahute Mesa flow and transport model (SNJV 2009), which forecasts migration of tritium off the NNSS within 50 years of the first nuclear detonation (1965) from the Central and Western Pahute Mesa CAUs (see Section 11.1.2.2, Figure 11-4).

Currently, groundwater contaminated by historical UGTs does not impact the public or NNSS workers who drink water from wells located off or on the NNSS. However, NNSS wildlife can be exposed to tritium in their drinking water or aquatic habitats available as a result of the NDEP-approved method of containing contaminated waters in the E Tunnel ponds and in constructed sumps that may be used to contain groundwater pumped from UGTA wells. The potential dose to NNSS biota from these water sources is routinely assessed and reported annually in Chapter 9, Section 9.2 of this report. Each year, the results have demonstrated that the doses to biota are below the limits set to protect plant and animal populations.

Potential nonradiological contaminants in drinking water and wastewater monitored on the NNSS in 2015 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. The Area 25 exceedances were determined to have been 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 that has occurred from historical underground nuclear testing 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 (see Section 5.1.3.7.3). Well effluents are monitored for nonradiological contaminants (predominantly lead) to ensure that lined sumps are used when necessary. The Area 3 and Area 5 Radioactive Waste Management Sites and the solid waste landfills are designed and monitored to ensure that contaminants do not reach groundwater (see Chapter 10). In addition, the potential for mobilization of contaminants from all these sources to groundwater is negligible due to the arid climate, the great depth to groundwater (thickness of the vadose zone), and the proven behavior of liquid and vapor fluxes in the vadose zone (primarily upward liquid movement towards the ground surface due to evapotranspiration).

The Environmental Restoration program for the Soils and Industrial Sites, conducts cleanup and closures of historical surface and shallow subsurface contamination sites, some of which have nonradiological contaminants such as metals, petroleum hydrocarbons, hazardous organic and inorganic chemicals, and unexploded ordnance (see 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 hydrogeologic factors mentioned above.

Water level monitoring continues to be used to develop and refine CAU-specific models of groundwater flow and contaminant transport. The reader is directed to Section 11.1.2 of Chapter 11 of this report for a description of 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 (see Chapter 3, Table 3-1).

## 5.5 References

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## Chapter 6: Direct Radiation Monitoring

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U.S. Department of Energy (DOE) Orders DOE O 458.1, “Radiation Protection of the Public and the Environment”, and DOE O 435.1, “Radioactive Waste Management,” have requirements to protect the public and environment from exposure to radiation (see descriptions of these orders in Table 2-1 of Chapter 2). Energy absorbed from radioactive materials outside of the body results in an external dose. On the Nevada National Security Site (NNSS), external dose comes from direct **ionizing radiation** (see [Glossary, Appendix B](#)) including natural radioactivity from cosmic and terrestrial sources as well as man-made radioactive sources. This chapter presents the data obtained to assess external dose during 2015. Chapters 4, 5, and 8 present the monitoring results of radioactivity from NNSS activities in air, water, and biota, respectively. Those results are used to 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).”

### ***Direct Radiation Monitoring Program Goals***

Assess the proportion of external dose that comes from background radiation versus NNSS operations.

Measure external radiation in order to assess the potential external dose to a member of the public from NNSA/NFO operations at the NNSS (see Chapter 9 for estimates of public dose).

Measure external radiation in order to assess the potential external dose to a member of the public from operations at the Area 3 and Area 5 Radioactive Waste Management Sites (RWMSs) (see Chapter 9 for estimates of public dose).

Monitor operational activities involving radioactive material, radiation-generating devices, and accidental releases of radioactive material to ensure exposure to members of the public are kept ALARA as stated in DOE O 458.1.

Measure external radiation in order to assess the potential external and absorbed radiation doses to NNSS plants and animals (see Chapter 9, Section 9.2 for biota dose assessments).

Determine the patterns of exposure rates through time at various soil contamination areas in order to characterize releases in the environment.

An offsite monitoring program has been established by NNSA/NFO to monitor 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 2015 direct radiation monitoring results are presented in Chapter 7, Sections 7.1.4 and 7.1.5; the DRI thermoluminescent dosimeter (TLD) data are compared with on-site data in this chapter (see 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.

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

## 6.2 Thermoluminescent Dosimetry Surveillance Network Design

A surveillance network of TLD sampling locations (Figure 6-1) has been established on the NNSS to monitor those NNSS areas that have elevated radiation levels resulting 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 currently 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  $1.0 \pm 0.3$  m (28 to 51 inches [in.]) above the ground at each monitoring location. These are exchanged quarterly for analysis. Analysis of TLDs is performed using automated TLD readers calibrated and maintained by the Radiological Control Department. Reference TLDs are exposed to a 100 mR cesium-137 source under tightly controlled conditions. These are read along with TLDs collected from the network to calibrate their responses.

There were 103 active environmental TLD locations on the NNSS during 2015 (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 are locations of interest due to the presence of people in the area and/or the potential for increased radiation exposure from a current operation.
- Environmental 2 (E2) – 35 locations where there is or has been measurable added radioactivity from past operations; these locations are of interest for monitoring direct radiation trends in the area. Some locations fitting this description are grouped with the Waste Operations category below.
- Waste Operations (WO) – 17 locations in and around the Area 3 and Area 5 RWMSs.
- Control (C) – 5 locations in Building 652 and 1 location 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 to identify 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.

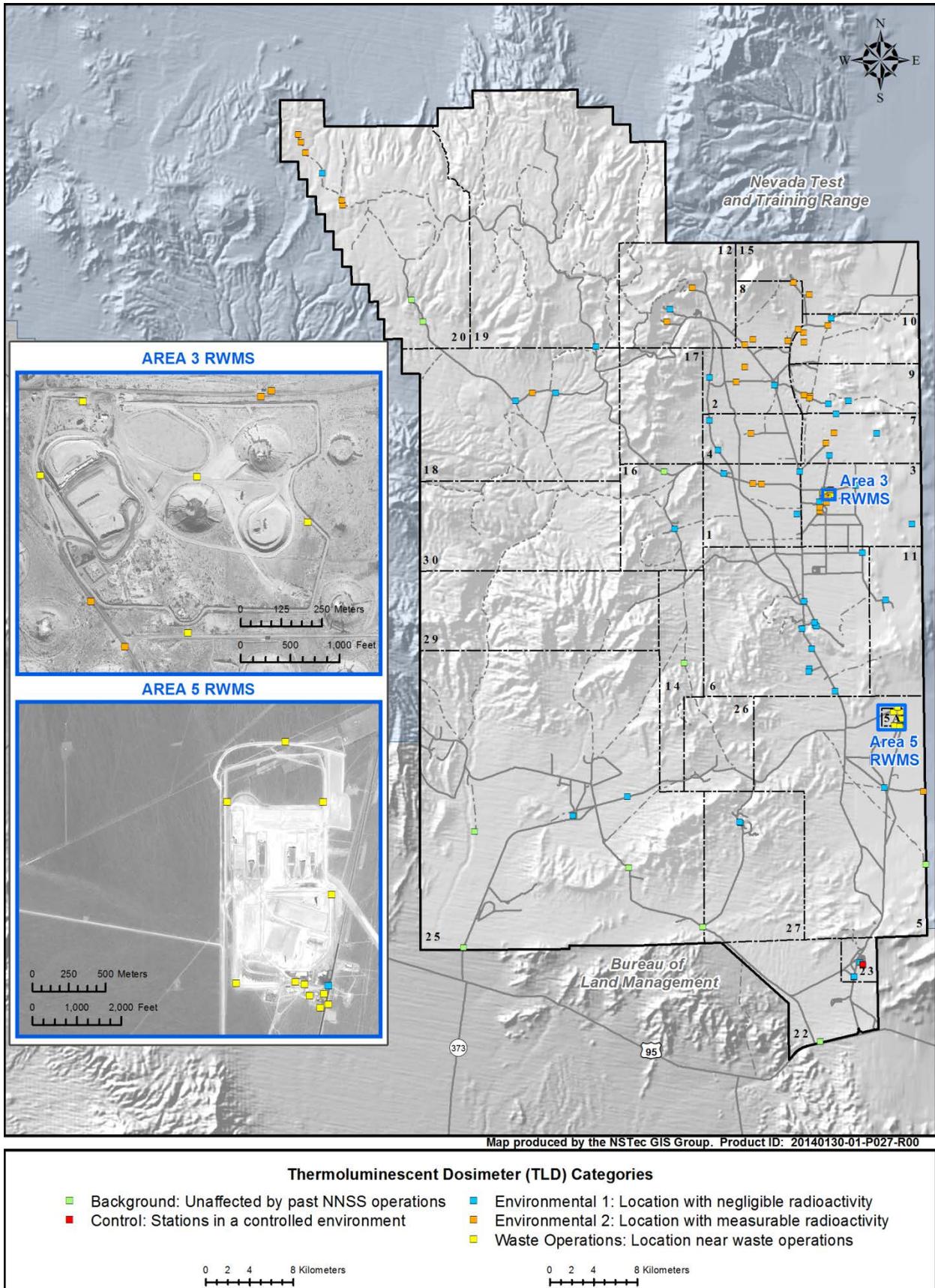


Figure 6-1. Locations of TLDs on the NNSS

### **6.2.1 Data Quality**

Quality assurance (QA) procedures for direct radiation monitoring involve comparing the readings among the three TLD elements in individual TLDs, comparing data from the paired TLDs at each location to estimate the measurement and its precision, comparing current and past data measurements at each TLD location, and reviewing 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 directed by the RREMP, QA and quality control (QC) protocols (including Data Quality Objectives) have been developed and are maintained as essential elements of direct radiation monitoring. The QA/QC requirements established for the monitoring program include the use of sample packages to thoroughly document each sampling event, rigorous management of databases, and completion of essential training (see Chapter 14). The Radiological Control Department maintains certification through the U.S. Department of Energy Laboratory Accreditation Program for dosimetry.

There are four steps in the monitoring process for each environmental TLD: the TLD is (1) annealed (i.e., heated and then cooled) to reset it to its original unexposed condition, then stored in a shielded location; (2) deployed to the field at the beginning of the quarter; (3) collected from the field at the end of the quarter; and (4) again stored in a shielded location until it is read. In the past, perturbations have been noticed in the data related to variation in the amount of time TLDs were held in shielded locations prior to deployment and following collection. An adjustment procedure was developed and implemented in 2014 to control for the variability in this additional dose. This procedure involves estimating the additional dose based on the holding time and the shielded control location measurements and subtracting that estimate 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 in estimated dose of between 0.3% and 4.8%, averaging 1.8%, in 2015.

### **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 given in Table 6-1. Summary statistics for the five location types are given in Table 6-2 and Figure 6-2. Data were successfully obtained from nearly all of the TLDs during all quarters of 2015; two measurements were rejected due to inadequate inter-element agreement. Otherwise, agreement between the results provided by the paired TLDs was quite good, with an average relative percent difference between measurements of 3.3%. The quarter-to-quarter coefficient of variation (CV) (i.e., the relative standard deviation) ranged from 0.5% to 8.1% (median = 2.9%) over all locations excluding the Gate 100 Truck Parking 1 location (see the discussion in Section 6.3.2).

### **6.3.1 Background Exposure**

During 2015, the average of the estimated annual exposures among the 10 background locations was 118 mR, ranging from 79 to 159 mR (Table 6-2). A 95% prediction interval (PI) for annual exposures based on the 2015 estimated mean annual exposures at the background locations (denoted “95% PI from B” in the plots) is 47.9 to 187.5 mR. This interval predicts mean annual background exposures at locations where radiation effects from NNSS operations are negligible.

For comparison, the CEMP’s estimated annual exposure in Las Vegas, Nevada (at 617 m [2,025 ft] elevation), was 103 mR in 2015 (see Chapter 7, Table 7-3). Estimated annual exposures at CEMP locations ranged from 85 mR at Pahrump, NV (716 m [2,400 ft] elevation), to 150 mR at Beatty, Nevada (930 m [3,216 ft] elevation). There is a general increasing relationship between natural background exposure and elevation (Figure 6-3), generally due to

cosmic radiation. The NNSS background locations with lowest and highest exposures are at elevations 1,064 m (3,490 ft) at Old Indian Springs Road in Area 5 and 1,737 m (5,700 ft) at Stake A-112 in Area 20, respectively.

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

**Table 6-1. Annual direct radiation exposures measured at TLD locations on the NNSS in 2015**

NNSS Area	Station	Location Type <sup>(b)</sup>	Number of Quarters	Estimated Annual Exposure (mR) <sup>(a)</sup>		
				Mean <sup>(c)</sup>	Minimum <sup>(c)</sup>	Maximum <sup>(c)</sup>
5	Old Indian Springs Road	B	4	79	75	81
14	Mid-Valley	B	4	141	137	144
16	Stake P-3	B	4	115	108	120
20	Stake A-112	B	4	159	153	169
20	Stake A-118	B	4	153	146	159
22	Army #1 Water Well	B	4	83	80	85
25	Gate 25-4-P	B	4	132	127	138
25	Gate 510	B	4	128	123	133
25	Jackass Flats & A-27 Roads	B	4	80	77	84
25	Skull Mtn Pass	B	4	108	108	109
23	Building 650 Dosimetry	C	4	58	56	60
23	Lead Cabinet, 1	C	4	25	24	26
23	Lead Cabinet, 2	C	4	25	24	27
23	Lead Cabinet, 3	C	4	25	24	26
23	Lead Cabinet, 4	C	4	26	25	28
23	Lead Cabinet, 5	C	4	25	24	26
1	BJY	E1	4	116	111	120
1	Sandbag Storage Hut	E1	4	111	109	114
1	Stake C-2	E1	4	117	114	120
2	Stake M-140	E1	4	131	126	137
2	Stake TH-58	E1	4	93	90	96
3	LANL Trailers	E1	4	121	118	123
3	Stake OB-20	E1	4	88	87	91
3	Well ER 3-1	E1	4	125	122	128
4	Stake TH-41	E1	4	109	108	111
4	Stake TH-48	E1	4	115	113	118
5	Water Well 5B	E1	4	111	109	116
6	CP-6	E1	4	69	65	74
6	DAF East	E1	4	96	93	99
6	DAF North	E1	4	101	96	104
6	DAF South	E1	4	136	133	139
6	DAF West	E1	4	84	82	87
6	Decon Facility NW	E1	4	127	125	130
6	Decon Facility SE	E1	4	132	128	138
6	Stake OB-11.5	E1	4	131	128	137
6	Yucca Compliance	E1	4	90	85	93
6	Yucca Oil Storage	E1	4	100	97	102
7	Reitmann Seep	E1	4	129	124	133
7	Stake H-8	E1	4	124	121	127
9	Papoose Lake Road	E1	4	89	88	93
9	U-9CW South	E1	4	104	101	106
9	V & G Road Junction	E1	4	112	109	114
10	Gate 700 South	E1	4	125	121	131
11	Stake A-21	E1	4	129	126	135
12	Upper N Pond	E1	4	130	126	133
16	3545 Substation	E1	4	135	127	141

**Table 6-1. Annual direct radiation exposures measured at TLD locations on the NNSS in 2015 (continued)**

NNSS Area	Station	Location Type <sup>(b)</sup>	Number of Quarters	Estimated Annual Exposure (mR) <sup>(a)</sup>		
				Mean <sup>(c)</sup>	Minimum <sup>(c)</sup>	Maximum <sup>(c)</sup>
18	Stake A-83	E1	4	142	139	144
18	Stake F-11	E1	4	143	137	149
19	Stake P-41	E1	4	161	154	169
20	Stake J-41	E1	4	139	135	143
23	Gate 100 Truck Parking 1	E1	4	76	68	83
23	Gate 100 Truck Parking 2	E1	4	62	60	64
23	Mercury Fitness Track	E1	4	58	56	61
25	HENRE	E1	4	127	122	136
25	NRDS Warehouse	E1	4	124	117	130
27	Cafeteria	E1	4	112	108	118
27	JASPER-1	E1	4	115	108	124
1	Bunker 1-300	E2	4	119	117	121
1	T1	E2	4	219	212	229
2	Stake L-9	E2	4	158	152	163
2	Stake N-8	E2	4	394	374	412
3	Stake A-6.5	E2	4	137	133	140
3	T3	E2	4	290	276	308
3	T3 West	E2	4	272	263	276
3	T3A	E2	4	309	286	321
3	T3B	E2	4	403	390	413
3	U-3co North	E2	4	174	168	186
3	U-3co South	E2	4	143	137	148
4	Stake A-9	E2	4	412	404	423
5	Frenchman Lake	E2	4	250	220	263
7	Bunker 7-300	E2	4	200	196	203
7	T7	E2	4	114	110	118
8	Baneberry 1	E2	4	318	308	332
8	Road 8-02	E2	4	123	120	126
8	Stake K-25	E2	4	98	92	100
8	Stake M-152	E2	4	155	152	160
9	B9A	E2	4	129	124	130
9	Bunker 9-300	E2	4	119	117	121
9	T9B	E2	4	418	413	422
10	Circle & L Roads	E2	4	116	115	117
10	Sedan East Visitor Box	E2	4	130	129	131
10	Sedan West	E2	4	205	202	208
10	T10	E2	4	225	219	232
12	T-Tunnel #2 Pond	E2	4	226	222	237
12	Upper Haines Lake	E2	4	103	100	108
15	EPA Farm	E2	4	110	106	113
18	Johnnie Boy North	E2	4	141	134	147
20	Palanquin	E2	4	206	198	213
20	Schooner-1	E2	4	497	460	524
20	Schooner-2	E2	4	222	215	229
20	Schooner-3	E2	4	139	137	143
20	Stake J-31	E2	4	157	154	163
3	A3 RWMS Center	WO	4	136	131	142
3	A3 RWMS East	WO	4	130	127	132
3	A3 RWMS North	WO	4	128	123	132
3	A3 RWMS South	WO	4	289	279	298
3	A3 RWMS West	WO	4	122	118	127
5	A5 RWMS East Gate	WO	4	99	97	102
5	A5 RWMS Expansion NE	WO	4	143	140	149
5	A5 RWMS Expansion NW	WO	4	147	146	148

**Table 6-1. Annual direct radiation exposures measured at TLD locations on the NNSS in 2015 (continued)**

NNSS Area	Station	Location Type <sup>(b)</sup>	Number of Quarters	Estimated Annual Exposure (mR) <sup>(a)</sup>		
				Mean <sup>(c)</sup>	Minimum <sup>(c)</sup>	Maximum <sup>(c)</sup>
5	A5 RWMS NE Corner	WO	4	123	119	126
5	A5 RWMS North	WO	4	141	136	144
5	A5 RWMS South Gate	WO	4	107	102	111
5	A5 RWMS SW Corner	WO	4	122	119	124
5	Building 5-31	WO	4	106	105	108
5	WEF East	WO	4	126	125	128
5	WEF North	WO	4	113	109	117
5	WEF South	WO	4	126	124	127
5	WEF West	WO	4	120	115	124

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

(b) Location types:

B: Background locations

C: Control locations

E1: Environmental locations with exposure rates near background but monitored for potential for increased exposure rates due to NNSS operations

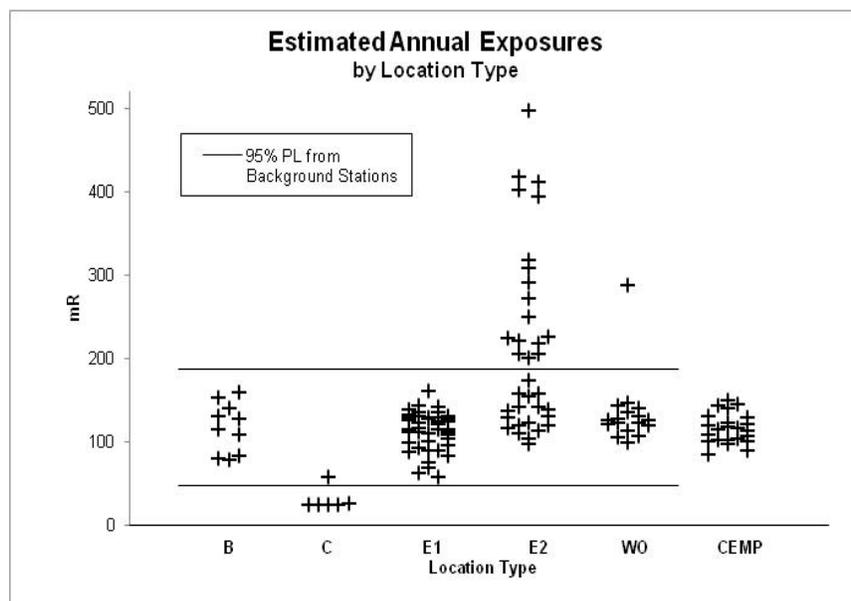
E2: Environmental locations with measurable radioactivity from past operations, excluding those designated WO

WO: Locations in or near waste operations

(c) Mean, minimum, and maximum values from adjusted quarterly estimates. Each quarterly estimate is the average of two TLD readings per location in nearly all cases.

**Table 6-2. Summary statistics for 2015 mean annual direct radiation exposures by TLD location type**

Location Type	Number of Locations	Estimated Annual Exposure (mR)		
		Mean	Minimum	Maximum
Background (B)	10	118	79	159
Environmental 1 (E1)	41	113	58	161
Environmental 2 (E2)	35	212	98	497
Waste Operations (WO)	17	134	99	289
Control, Shielded (C)	5	25	25	26
Control, Unshielded (C)	1	58	--	--



**Figure 6-2. 2015 annual exposures on the NNSS, by location type, and off the NNSS at CEMP stations**

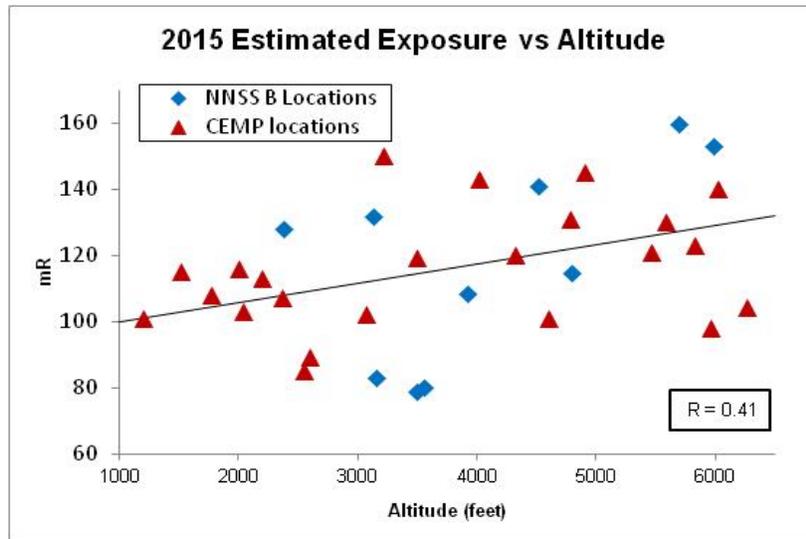


Figure 6-3. Correlation between 2015 annual exposures at NNSS Background and CEMP TLD locations and altitude

### 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. 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 62 mR during 2015, with quarterly estimates of 64, 62, 63, and 60 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 due to exposure to waste shipments. Its average value for 2015 was 76 mR, with quarterly estimates of 82, 83, 70, and 68 mR. All results for both locations are within the range of background variation; however, most quarterly exposure estimates are higher than those at the nearby Mercury Fitness Track station.

While the public has limited access to the NNSS at Gate 100 along its southern border, others may have access to other boundaries of the NNSS. Most of the NNSS is bounded by the Nevada Test and Training Range (NTTR). Military or other personnel on the NTTR who are not classified as radiation workers would also be subject to the DOE public dose limit of 100 mrem/yr (1 mSv/yr). Nuclear tests on the NTTR (Double Tracks and Project 57) consisted of experiments where weapons were exploded conventionally without going critical (safety experiments). 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) located 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 2015 TTR annual environmental report, which is posted at <http://www.sandia.gov/news/publications/environmental/index.html>.

A radioactive material area boundary extends beyond the NNSS in the Frenchman Lake region of Area 5 along the southeast boundary of the NNSS. This region was a location of atmospheric weapons testing in the 1950s and is inaccessible to the public. A TLD location was established there in July 2003 to characterize direct radiation levels from this legacy soil contaminated area and to assess the external dose to personnel not classified as radiation workers who may visit the area. The estimated annual exposure to a hypothetical person at the Frenchman Lake TLD location during 2015 was 250 mR. This has been consistently declining over time, down from 420 mR in 2003. The resulting estimated above-background dose during 2015 would be approximately 91 to 171 mrem, depending on which background value is subtracted. This might exceed the 100 mrem dose limit to a person residing year-round at this location, but there are no living quarters or full-time non-radiation workers in this vicinity. Workers specially

trained and classified as radiation workers, although they do not work in the vicinity, have a higher allowable dose limit of 5,000 mrem per year, which would not be exceeded in the vicinity of the Frenchman Lake TLD.

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

### 6.3.3 Exposures from NNSS Operational Activities

Forty-one TLDs are in locations where either workers and/or the public, have the potential to receive radiation exposure from current operations (E1 locations). E1 locations have negligible radioactivity from past operations. The mean estimated annual exposure at these locations was 113 mR during 2015, a little lower than the mean estimated annual exposure at background locations (see Table 6-2). Overall, annual exposures were not different between B and E1 locations (Figure 6-2); the estimated annual exposures at all E1 locations are well within the 95% PI of B locations. E1 location exposures were also comparable with the offsite exposures reported by the CEMP stations, as shown in Figure 6-2.

### 6.3.4 Exposures from RWMSs

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 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 three of four locations at the boundary were within the range of NNSS background exposures in 2015 (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 2015.

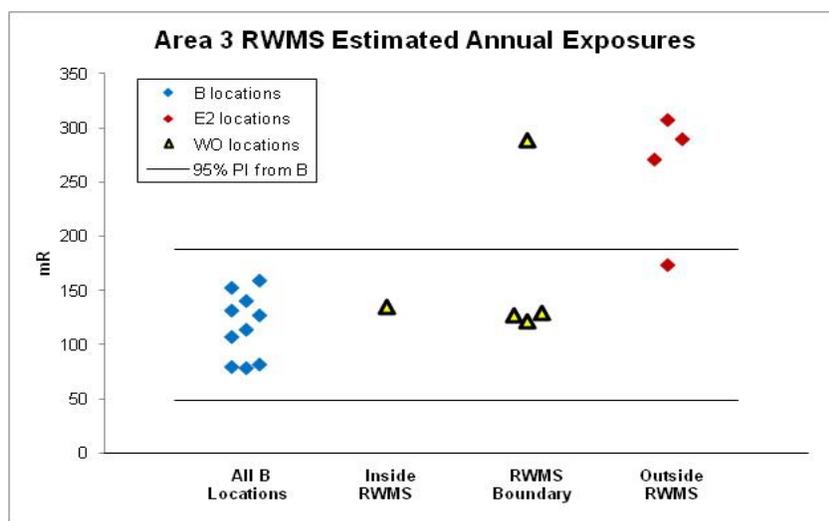


Figure 6-4. 2015 annual exposures in and around the Area 3 RWMS and at background locations

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 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.

During 2015, 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.

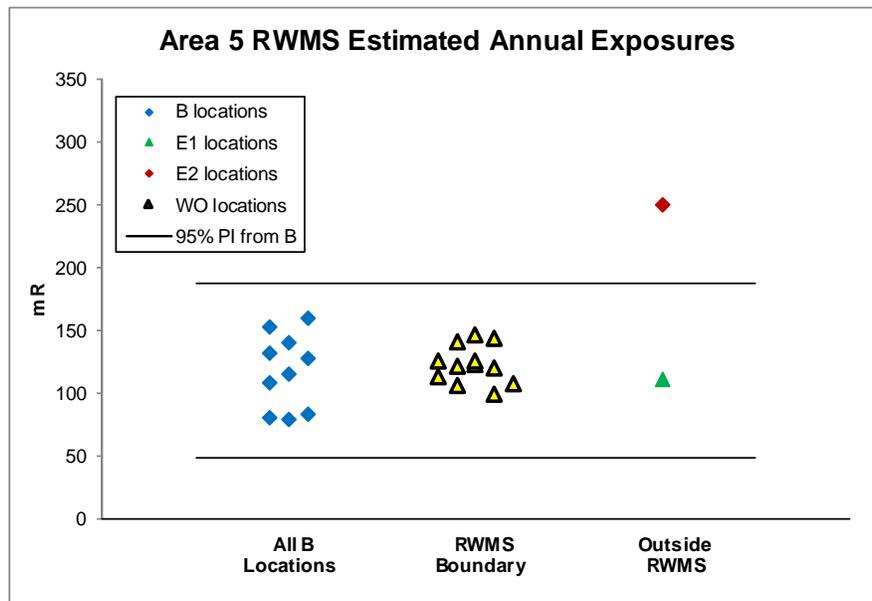


Figure 6-5. 2015 annual exposures around the Area 5 RWMS and at background locations

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 to members of the public, 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 during 2015 was 524 mR/yr (1.43 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 [1.2 in.]) where small plants and animals reside. The daily exposure rate near the ground surface would be less than 2% of the total dose rate limit to terrestrial animals and less than 1% of the limit to terrestrial plants (see Chapter 9, Section 9.2). Hence, doses to plants and animals from external radiation exposure at NNSS monitoring locations are very low compared with the dose limits. Dose to biota from both internal and external radionuclides is presented in Section 9.2 of Chapter 9.

### 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. During 2015, the CVs for measurements between quarters averaged 3.0%. Only the CV for Gate 100 Truck Parking 1 (10.5%) was above 10.0%.

Long-term trends are displayed in Figure 6-6 by location type for locations that have been monitored for at least 10 years. The average decay rates by location group are 0.10% (B), 0.31% (C), 0.37% (E1), 2.00% (E2), and 0.76% (WO). Annual exposures decreased 3.21% per year on average at those locations with significant added man-made radiation, those being the E2 and WO locations with 2015 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 2014. The observed decreases are due to a combination of natural radioactive decay, dispersal, and dilution in the environment.

The five stations with the highest exposures in 2015 are Schooner-1 (Area 20), T9B (Area 9), Stake A-9 (Area 4), T3B (Area 3), and Stake N-8 (Area 2). Their annual estimated exposures have been decreasing by half at a rate of 13, 23, 16, 41, and 15 years respectively.

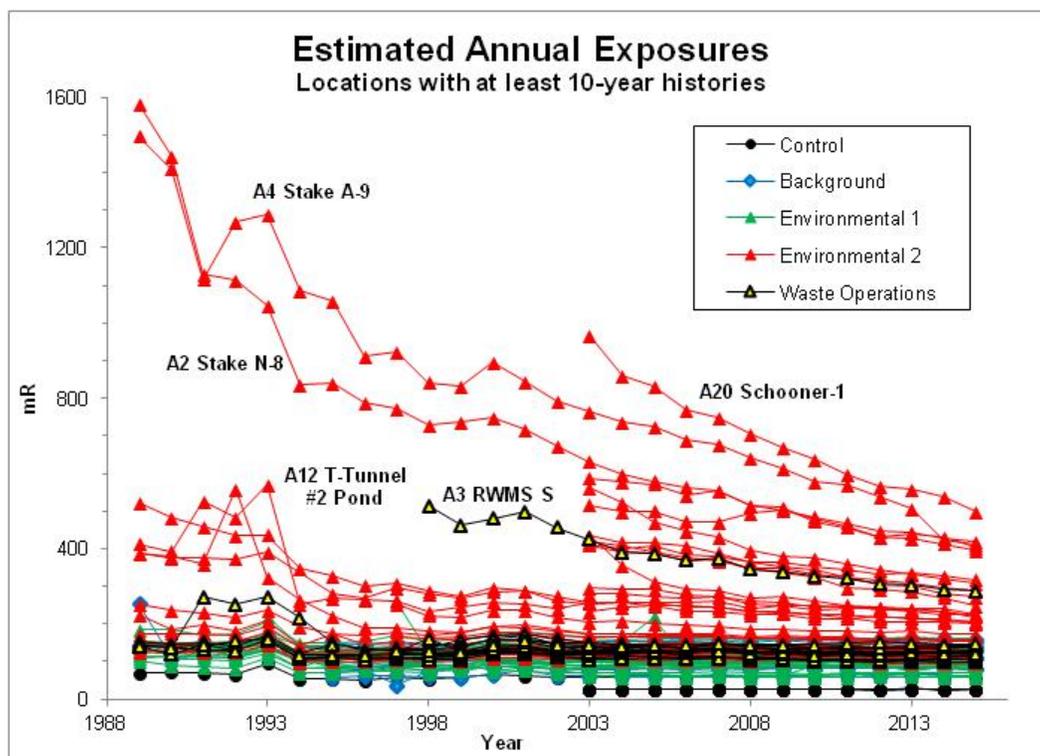


Figure 6 6. Trends in direct radiation exposure measured at TLD locations

## 6.4 Environmental Impact

Direct radiation exposure to the public from NNSS operations during 2015 was negligible. Radionuclides historically released to the environment on the NNSS have resulted in localized elevated exposures. These 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 cap waste cells. 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, prepared for U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office.

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## Chapter 7: Community Environmental Monitoring Program

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In addition to the environmental monitoring conducted by the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) on the Nevada National Security Site (NNSS) (see Chapters 4, 5, 6, and 8), independent monitoring is provided through the Community Environmental Monitoring Program (CEMP). The CEMP's mission is to provide data to the public regarding the presence of man-made radionuclides that could be the result of current operations or past nuclear testing on the NNSS. The data are collected at locations off 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. The CEMP is sponsored by the NNSA/NFO, and is administered and operated by the Desert Research Institute (DRI) of the Nevada System of Higher Education.

Monitored and collected data include, but are not necessarily limited to, background and airborne radiation data, meteorological data, and tritium concentrations in downgradient community drinking water. Network air monitoring stations, located in Nevada, Utah, and California, are managed by local citizens, many of them high school science teachers, whose routine tasks are to ensure equipment is operating normally and to collect air filters and route them to the DRI for analysis. These Community Environmental Monitors (CEMs) are also available to discuss the monitoring results with the public and to speak to community and school groups. DRI's responsibilities include maintaining the physical monitoring network through monthly visitations by environmental radiation monitoring specialists, who also participate in training and interfacing with CEMs and interacting with other local community members and organizations to provide information related to the monitoring data. DRI also provides public access to the monitoring data through maintenance of a project website at <http://www.cemp.dri.edu/>. A detailed informational background narrative about the CEMP can be found at <http://www.cemp.dri.edu/cemp/moreinfo.html> along with more detailed descriptions of the various types of sensors found at the stations and on outreach activities conducted by the CEMP.

### *CEMP Goals*

Provide independent monitoring at offsite locations and communicate environmental data relevant to past and continuing activities at the NNSS

Engage the public hands-on in monitoring environmental conditions in their communities relative 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 and concerns regarding past and present activities at the NNSS

## 7.1 Offsite Air Monitoring

In 2015, DRI managed 24 CEMP stations, which compose the Air Surveillance Network (ASN) (Figure 7-1). The ASN stations include various types of equipment used to monitor airborne radiation and meteorological conditions, as described in Section 7.1.1. The CEMP station in Caliente, Nevada, which has all of the air monitoring equipment described in Section 7.1.1, is shown in Figure 7-2.

### 7.1.1 Air Monitoring Equipment

**CEMP Low-Volume Air Sampler Network** – During 2015, the CEMP ASN included continuously operating low-volume particulate air samplers at 12 “full-time” stations that are either near to, or typically downwind from, the NNSS (Figure 7-1). The ASN in 2015 also included low-volume air samplers at 11 “standby” stations that are either farthest from the NNSS or most frequently upwind from the NNSS; these samplers collected 2-week air

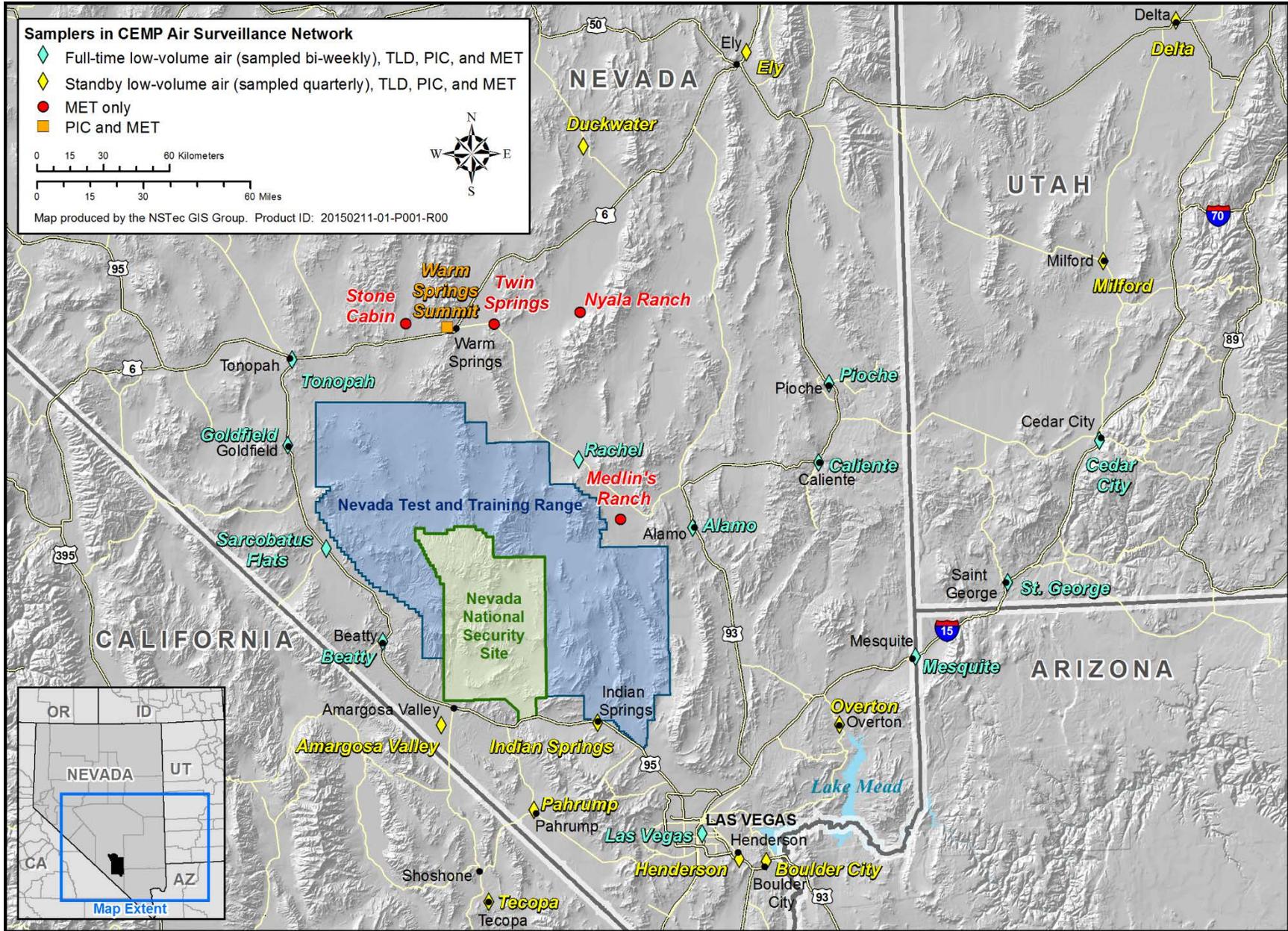


Figure 7-1. 2015 CEMP Air Surveillance Network

samples once each quarter (see Figure 7-1). Warm Springs Summit, Nevada, is the only ASN station where a low-volume air sampler is not located. Duplicate continuously operating air samplers are operated 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 by the CEMs and mailed to DRI, where they are prepared and forwarded to an independent laboratory to be analyzed for gross alpha and gross beta activity. Samples are held for a minimum of 7 days after collection to allow for the decay of naturally occurring radon progeny. Upon completion of the gross alpha/beta analyses, the filters are returned to DRI to be composited on a quarterly basis for gamma spectroscopy analysis.

**CEMP Thermoluminescent Dosimetry Network** – Thermoluminescent dosimetry is used to measure both individual and population external exposure to ambient radiation from natural and artificial sources. In 2015, this network consisted of fixed environmental thermoluminescent dosimeters (TLDs) at 23 of the 24 CEMP stations (see Figure 7-1). A TLD is not currently deployed at Warm Springs Summit due to limited access during the winter months. The TLD used 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 (QA) purposes, duplicate TLDs are deployed at three randomly selected stations. An average daily exposure rate was calculated for each quarterly exposure period. The average of the quarterly values was 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 (see Figure 7-1). 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, variations in PIC readings caused by weather events such as precipitation or changes in barometric pressure are more readily identified. Variations can be 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 (see Figure 7-1). The MET network includes sensors that measure air temperature, humidity, wind speed and direction, solar radiation, barometric pressure, precipitation, and soil temperature and moisture data. 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 7-2. CEMP Station in Caliente, Nevada

## 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<sup>3</sup>]) 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<sup>3</sup>) (36,000 to 45,000 ft<sup>3</sup>), depending on the elevation of the station and changes in air temperature and/or pressure.

During 2015, CEMP air samples were collected on a biweekly basis from the 12 full-time stations. This sampling frequency results in the possible collection of 26 samples per year from each full-time station. At the 11 standby stations, air samples were collected on a quarterly basis (one 2-week sample per quarter), resulting in the collection of only four samples per year.

## 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  $1.19 \pm 0.29 \times 10^{-15}$  microcuries per milliliter ( $\mu\text{Ci}/\text{mL}$ ) ( $4.40 \pm 1.07 \times 10^{-5}$  becquerels [ $\text{Bq}/\text{m}^3$ ]) (Table 7-1). Gross alpha was detectable in all of the 2015 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 2005 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 2015**

Sampling Location	Number of Samples	Concentration ( $\times 10^{-15} \mu\text{Ci}/\text{mL}$ [ $3.7 \times 10^{-5} \text{Bq}/\text{m}^3$ ])			
		Mean	Standard Deviation	Minimum	Maximum
Alamo	26	1.79	0.94	0.46	3.98
Amargosa Valley	4	1.08	0.15	0.85	1.25
Beatty	26	1.05	0.37	0.49	1.76
Boulder City	3	1.14	0.41	0.61	1.61
Caliente	26	1.56	0.88	0.67	4.11
Cedar City	26	0.83	0.29	0.40	1.44
Delta	4	0.87	0.09	0.79	1.03
Duckwater	4	0.97	0.29	0.72	1.44
Ely	4	0.91	0.15	0.76	1.15
Goldfield	26	1.05	0.36	0.59	1.77
Henderson	4	1.26	0.29	0.87	1.66
Indian Springs	4	1.00	0.25	0.59	1.22
Las Vegas	26	1.12	0.48	0.66	3.05
Mesquite	26	1.13	0.53	0.46	2.33
Milford	4	0.90	0.51	0.51	1.76
Overton	4	1.20	0.18	0.94	1.41
Pahrump	4	1.63	0.32	1.22	1.95
Pioche	26	1.10	0.48	0.43	2.30
Rachel	25	1.07	0.40	0.53	2.10
Sarcobatus Flats	26	1.81	1.11	0.58	5.16
St. George	26	1.08	0.42	0.58	2.33
Tecopa	4	1.69	1.05	0.60	3.44
Tonopah	26	1.02	0.30	0.42	1.82
<b>Network Mean = <math>1.19 \pm 0.29 \times 10^{-15} \mu\text{Ci}/\text{mL}</math></b>					
<b>Mean Minimum Detectable Concentration (MDC); see <a href="#">Glossary, Appendix B</a> = <math>0.33 \times 10^{-15} \mu\text{Ci}/\text{mL}</math></b>					
<b>Standard Error of Mean MDC = <math>0.07 \times 10^{-15} \mu\text{Ci}/\text{mL}</math></b>					

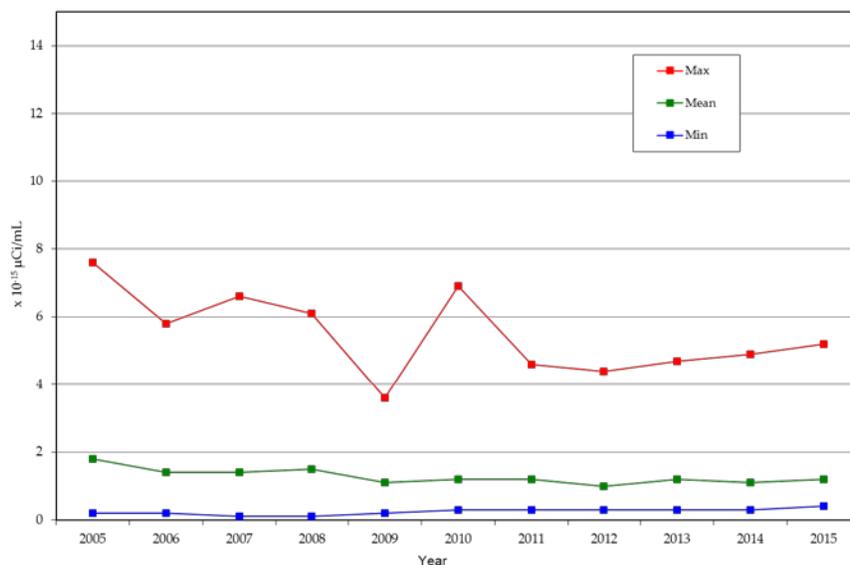


Figure 7-3. Historical trend for gross alpha analysis for all CEMP stations

The mean annual gross beta activity across all sample locations (Table 7-2) was  $1.98 \pm 0.19 \times 10^{-14}$   $\mu\text{Ci/mL}$  ( $7.33 \pm 0.70 \times 10^{-4}$   $\text{Bq/m}^3$ ). 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 2005 to 2015. 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 2015

Sampling Location	Number of Samples	Concentration ( $\times 10^{-14}$ $\mu\text{Ci/mL}$ [ $3.7 \times 10^{-4}$ $\text{Bq/m}^3$ ])			
		Mean	Standard Deviation	Minimum	Maximum
Alamo	26	2.12	0.50	1.56	3.27
Amargosa Valley	4	2.15	0.26	1.75	2.45
Beatty	26	1.94	0.38	1.34	3.23
Boulder City	3	2.09	0.43	1.74	2.69
Caliente	26	2.20	0.54	1.64	4.42
Cedar City	26	1.63	0.31	1.22	2.37
Delta	4	1.85	0.23	1.66	2.22
Duckwater	4	1.70	0.16	1.54	1.91
Ely	4	1.65	0.13	1.44	1.78
Goldfield	26	1.85	0.41	1.18	3.06
Henderson	4	2.00	0.41	1.63	2.68
Indian Springs	4	1.99	0.36	1.49	2.47
Las Vegas	26	2.08	0.47	1.58	3.32
Mesquite	26	2.21	0.68	1.49	4.53
Milford	4	1.79	0.21	1.53	2.10
Overton	4	2.18	0.49	1.81	3.02
Pahrump	4	2.03	0.22	1.78	2.30
Pioche	26	1.89	0.44	1.25	3.11
Rachel	25	1.94	0.46	1.14	3.20
Sarcobatus Flats	26	2.05	0.47	1.22	3.09
St. George	26	2.32	0.70	1.49	4.23
Tecopa	4	2.17	0.66	1.62	3.23
Tonopah	26	1.78	0.36	1.16	3.14
<b>Network Mean = <math>1.98 \pm 0.19 \times 10^{-14}</math> <math>\mu\text{Ci/mL}</math></b>		<b>Mean MDC = <math>0.04 \times 10^{-14}</math> <math>\mu\text{Ci/mL}</math></b>			
<b>Standard Error of Mean MDC = <math>0.004 \times 10^{-14}</math> <math>\mu\text{Ci/mL}</math></b>					

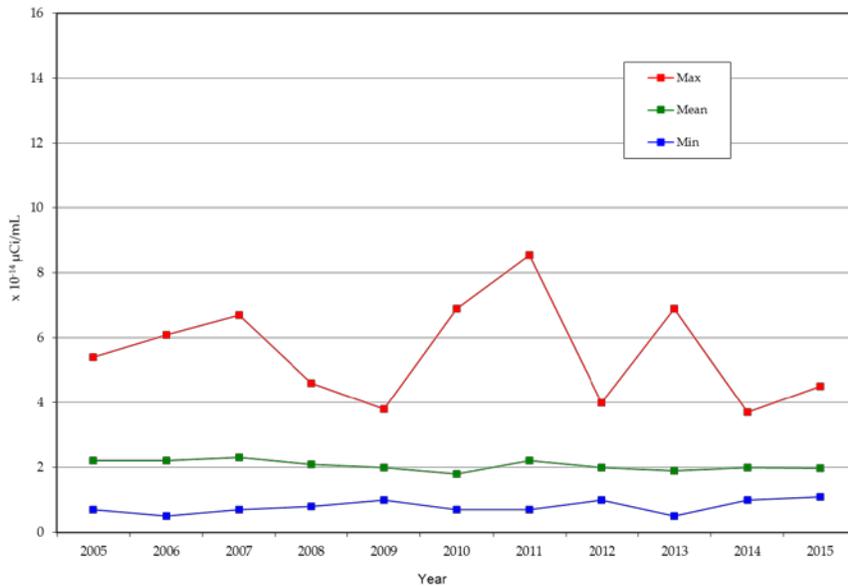


Figure 7-4. Historical trend for gross beta analysis for all CEMP stations

### 7.1.3.2 Gamma Spectroscopy

Gamma spectroscopy analysis was performed on all samples from the low-volume air sampling network. Generally, the filters were composited by station on a quarterly basis after gross alpha/beta analysis. As in previous years, man-made gamma-emitting radionuclides were not detected in any samples. In most of the samples, naturally occurring beryllium-7 (<sup>7</sup>Be) was detectable. This radionuclide is produced by cosmic ray interaction with nitrogen in the atmosphere. The mean annual activity for <sup>7</sup>Be for the sampling network was  $0.38 \pm 0.08 \times 10^{-13}$  μCi/mL.

### 7.1.4 TLD 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 at this time because its access is limited in the winter months. This does not allow for a proper quarterly change of the TLD as required. The total annual exposure for 2015 ranged from 85 milliroentgens (mR) (0.85 millisieverts [mSv]) at Pahrump, Nevada, to 150 mR (1.50 mSv) at Beatty, Nevada, with a mean annual exposure of 116 mR (1.16 mSv) for all operating locations. Results are summarized in Table 7-3 and are consistent with previous years' data. Figure 7-5 shows the long-term data trend for the CEMP stations as a whole. Overall, the TLD data show a generally increasing trend from 2010 to 2015, following a slightly decreasing trend from 2005 to 2010. The 2015 results are slightly lower than 2014.

Table 7-3. TLD monitoring results for the CEMP offsite ASN in 2015

Sampling Location	Number of Quarters	Estimated Annual Exposure (mR) <sup>(a)</sup>		
		Mean <sup>(b)</sup>	Minimum <sup>(b)</sup>	Maximum <sup>(b)</sup>
Alamo	4	119	112	128
Amargosa Valley	3	116	104	116
Beatty	3	150	145	157
Boulder City	4	107	94	120
Caliente	4	120	116	125
Cedar City	4	98	92	104
Delta	4	101	92	108
Duckwater	4	121	116	125

Table 7-3. TLD monitoring results for the CEMP offsite ASN in 2015 (continued)

Sampling Location	Number of Quarters	Estimated Annual Exposure (mR) <sup>(a)</sup>		
		Mean <sup>(b)</sup>	Minimum <sup>(b)</sup>	Maximum <sup>(b)</sup>
Ely	4	104	99	112
Goldfield	4	130	124	141
Henderson	4	113	94	124
Indian Springs	4	102	94	116
Las Vegas	4	103	98	105
Mesquite	4	108	104	112
Milford	4	145	137	153
Overton	4	101	93	109
Pahrump	4	85	75	99
Pioche	4	123	120	127
Rachel	4	131	120	149
Sarcobatus Flats	4	143	133	153
St. George	4	89	84	96
Tecopa	4	115	102	129
Tonopah	4	140	133	145

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

(b) Mean, minimum, and maximum values are from quarterly estimates

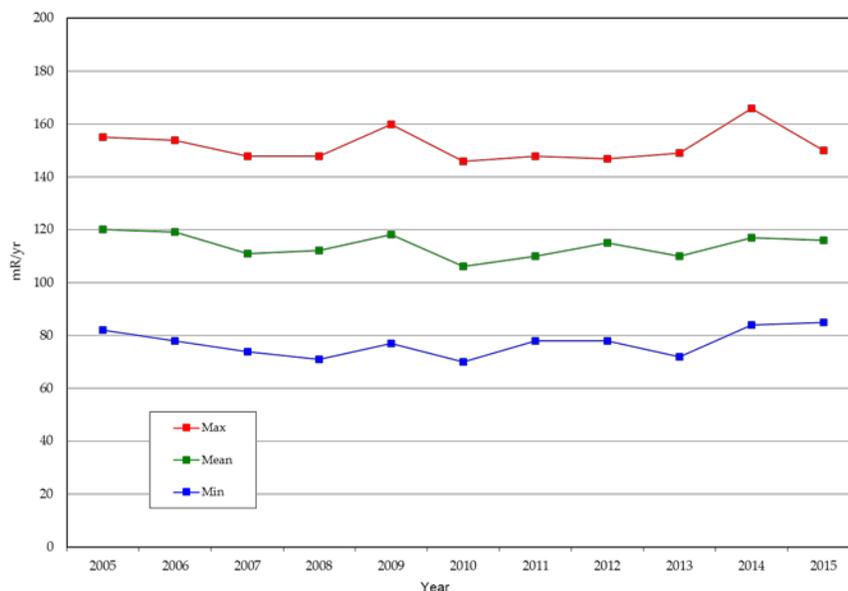


Figure 7-5. Historical trend for TLD analysis for all CEMP stations

### 7.1.5 PIC Results

The PIC data presented in this section are based on daily averages of gamma exposure rates from each station. Table 7-4 contains the maximum, minimum, and standard deviation of daily averages (in microroentgens per hour [ $\mu\text{R/hr}$ ]) for the periods during 2015 when data were available. It also shows the average gamma exposure rate for each station during the year (in  $\mu\text{R/hr}$ ) as well as the total annual exposure (in milliroentgens per year [ $\text{mR/yr}$ ]). The exposure rate ranged from 73.15 mR/yr (0.73 mSv/yr) in Pahrump, Nevada, to 170.82 mR/yr (1.71 mSv/yr) at Warm Springs, 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 (BEIR III 1980). Averages for selected regions of the United States were compiled by the U.S. Environmental Protection Agency and are shown in

Table 7-5. The annual exposure levels observed at the CEMP stations in 2015 are well within these United States background levels, and are consistent with previous years' exposure rates.

**Table 7-4. PIC monitoring results for the CEMP offsite ASN in 2015**

Sampling Location	Daily Average Gamma Exposure Rate (µR/hr)				Annual Exposure (mR/yr)
	Mean	Standard Deviation	Minimum	Maximum	
Alamo	14.25	0.33	12.7	15.8	124.83
Amargosa Valley	11.55	0.18	10.8	12.3	101.18
Beatty	16.60	0.21	15.8	17.4	145.42
Boulder City	16.40	0.15	15.7	17.1	143.66
Caliente	16.4	0.24	15.2	17.6	143.66
Cedar City	10.80	0.27	9.8	11.0	94.61
Delta	12.50	0.21	11.8	13.2	109.50
Duckwater	15.25	0.23	14.4	16.1	133.59
Ely	12.00	0.33	11.0	13.0	105.12
Goldfield	14.95	0.36	13.9	16.0	130.96
Henderson	13.6	0.51	11.9	15.3	119.14
Indian Springs	11.60	0.22	10.5	12.7	101.62
Las Vegas	11.50	0.23	10.6	12.4	100.74
Mesquite	11.90	0.19	11.2	12.6	104.24
Milford	17.30	0.34	15.9	18.7	151.55
Overton	12.25	0.22	11.5	13.0	107.31
Pahrump	8.35	0.17	7.6	9.1	73.15
Pioche	15.60	0.27	14.3	16.9	136.66
Rachel	16.65	0.57	14.2	19.10	145.85
Sarcobatus Flats	16.40	0.24	15.7	17.1	143.66
St. George	10.75	0.24	9.5	12.0	94.17
Tecopa	13.30	0.22	12.6	14.0	116.51
Tonopah	16.15	0.33	15.1	17.2	141.47
Warm Springs Summit	19.50	0.47	18.3	20.7	170.82

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

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: 7/21/2016)

### 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 station locations 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 that are 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 (see Table 7-5).

Occasional elevated gamma readings (10%–50% above normal average background) detected by the PICs in 2015 were always associated with precipitation events and/or low barometric pressure. Low barometric pressure can result in the release of naturally occurring radon and its daughter products from the surrounding soil and rock substrates. 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.

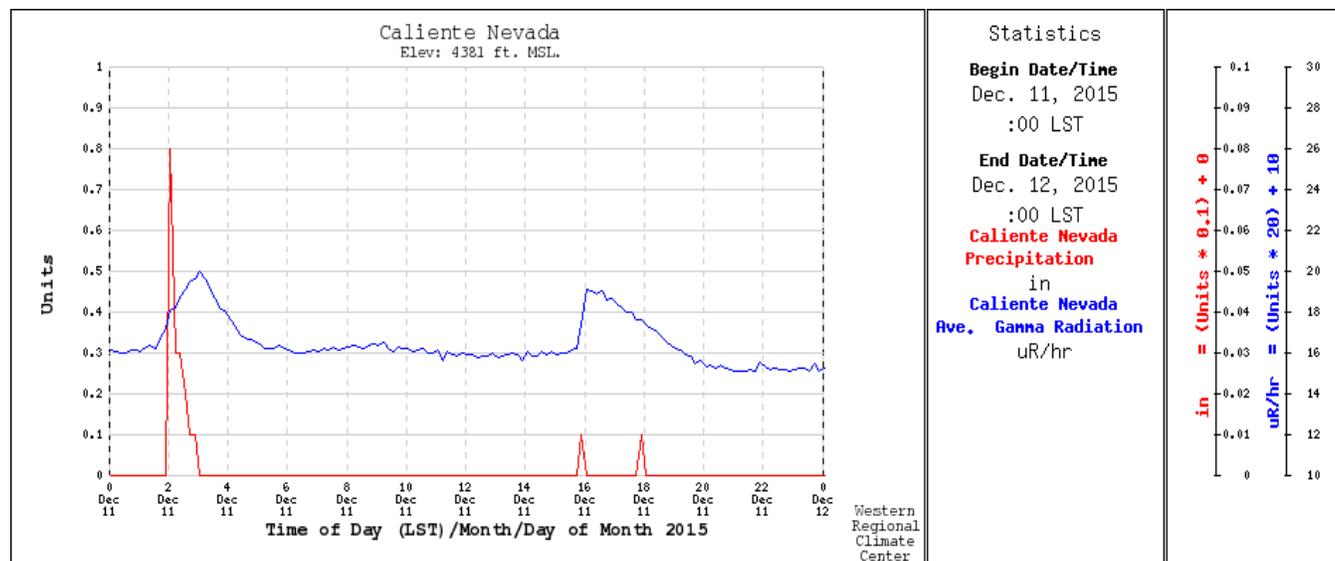


Figure 7-6. The effect of meteorological phenomena on background gamma readings

## 7.2 Offsite Surface and Groundwater Monitoring

The CEMP water monitoring program is a non-regulatory public informational and outreach program. It provides the public with water data regarding the presence of man-made radionuclides that could be the result of past nuclear testing on the NNSS. The CEMP, prior to 2014, monitored offsite groundwater wells, surface waters, and springs used for water supplies in areas surrounding the NNSS. Beginning in 2014, the CEMP limited monitoring to four groundwater wells in CEMP communities located within the regional groundwater flow system that are downgradient or perceived to be downgradient of the NNSS (Figure 7-7). This was done to increase efficiency and relevancy of the program. Water samples are collected by DRI personnel and analyzed for tritium. 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/>. Beginning in 2015, ten other downgradient wells, all within Nye County, were sampled by the county under their new Tritium Sampling and Monitoring Program supported by NNSA/NFO (see Chapter 5, Section 5.1.2). The CEMP website also provides to the public the results of Nye County’s tritium sampling.

### 7.2.1 Sample Locations and Methods

During September 2015, DRI sampled four wells. Sample locations (Figure 7-7) were selected based upon input from the CEMs participating in the CEMP project in communities located downgradient of the NNSS. All wells were sampled at a water delivery point (i.e., faucet). Each of these samples originated from water well distribution lines that connect to submersible pumps that sample the local groundwater system. Water was allowed to flow from each water delivery point for 5 to 15 minutes prior to sampling in order to purge stagnant water from the distribution lines. This process ensured that the resultant sample was representative of local groundwater. Table 7-6 describes the sample locations, the date they were sampled, and the sampling method.

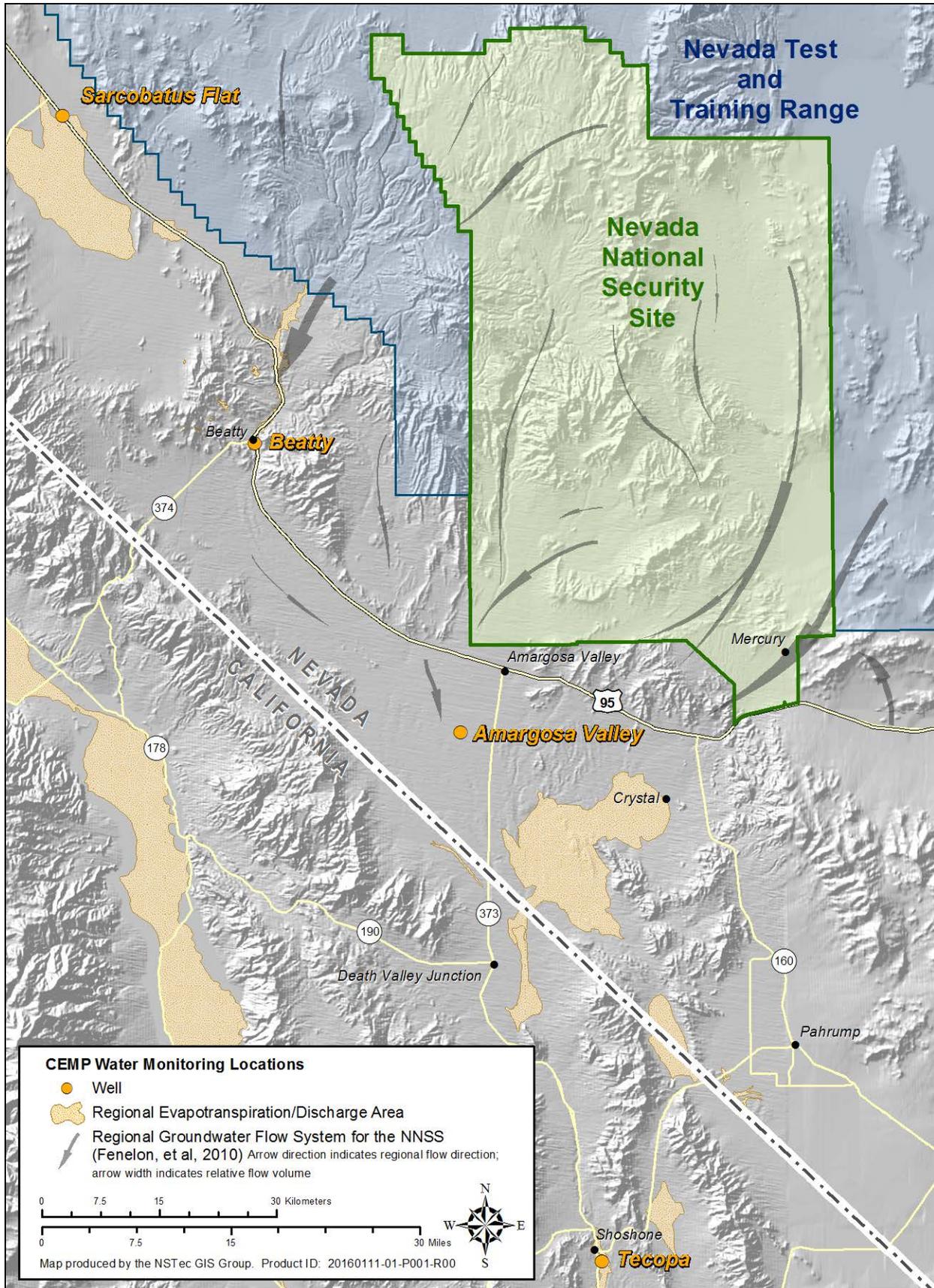


Figure 7-7. 2015 CEMP water monitoring locations

**Table 7-6. CEMP water monitoring locations sampled in 2015**

Monitoring Location Description	Latitude	Longitude	Date Sampled	Sample Collection Method
Amargosa Valley school well	36°34.16"	-116°27.66"	9/23/2015	By hand from sink in office of elementary school
Beatty Water and Sewer municipal water distribution system	36°54.93"	-116°45.66"	9/24/2015	By hand from distribution system; represents a blended sample from multiple municipal water supply wells.
Sarcobatus Flats well	37°16.76"	-117°01.10"	9/24/2015	By hand at residential source
Tecopa residential well	35°50.86"	-116°13.63"	9/23/2015	By hand at residential source

Samples collected in 2015 were analyzed using unenriched scintillation counting at ARS International laboratory in Port Allen, Louisiana. Unenriched scintillation counting is an EPA approved method for tritium analysis. The *decision level* ( $L_C$ ) (see [Glossary, Appendix B](#)) for this counting process was less than 171 picocuries per liter (pCi/L). The  $L_C$  is established solely based on the variability of multiple measures of samples used to establish laboratory background. If a sample exceeds this threshold, then it is considered to be distinguishable from background. The *minimum detectable concentration* ( $MDC$ ) (see [Glossary, Appendix B](#)) for tritium was approximately 349 pCi/L and is a more rigorous threshold that dictates that the sample be distinguishable from background at a confidence of 95%. The  $MDC$  considers both the variability associated with multiple measures of the background as well as the variability associated with multiple measures of the sample itself. The  $L_C$  and the  $MDC$  are less than 1% and 2% of the EPA limit for tritium in drinking water of 20,000 pCi/L, respectively. Chapter 17 discusses the quality assurance and control procedures used for sampling groundwater.

## 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 ( $\leq$  the  $MDC$  of approximately 349 pCi/L). Public access to the monitoring data is available on the DRI CEMP website at <http://www.cemp.dri.edu/>.

## 7.2.3 Environmental Impact

As in previous years, the wells and water supply systems within the CEMP monitoring network downgradient of the NNSS showed no evidence of tritium contamination from past underground nuclear testing on the NNSS. However, in 2009, tritium was detected by NNSA/NFO off site above the tritium standard analysis method  $MDC$  in the Underground Test Area characterization well, ER-EC-11, which is approximately 700 m (2,297 ft) west of the NNSS on the Nevada Test and Training Range (NTTR) (see Chapter 11, Section 11.1.1.2 and Figure 11-4). ER-EC-11 was last monitored in 2014 and had a tritium concentration of 16,100 pCi/L. Three wells farther off site from the NNSS on NTTR have been found to contain tritium at very low levels using enriched tritium analyses: wells ER-EC-6 (5.2 pCi/L), ER-EC-12 (4.2 pCi/L), and PM-3 (237 pCi/L) (see Chapter 5, Table 5-4 and Sections 5.1.3.1 and 5.1.3.3). Well PM-3 is the farthest well from the NNSS border (approximately 3.3 km or 2 mi). Additional sampling and analyses are needed to confirm these amounts of tritium. Groundwater characterization and modeling activities are ongoing and will be used to forecast the extent of offsite contamination over the next 1,000 years. The nearest CEMP water monitoring locations that are downgradient of the NNSS nuclear testing areas are Amargosa Valley and Beatty, approximately 70 km (43 mi) and 40 km (25 mi), respectively, southwest of Well ER-EC-11. The Amargosa Valley and Beatty wells are approximately 67 km (42 mi) and 38 km (24 mi), respectively, southwest of Well ER-EC-12, the closest of the NTTR wells mentioned above.

## 7.3 References

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

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## Chapter 8: Radiological Biota Monitoring

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

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

Plants and game animals are monitored under the Routine Radiological Environmental Monitoring Plan (RREMP) (Bechtel Nevada [BN] 2003). They are sampled annually from contaminated NNSS sites to estimate doses to persons hypothetically consuming them, to measure the potential for radionuclide transfer through the food chain, and to determine if NNSS biota are exposed to radiation levels harmful to their own populations. Measurements of gamma-emitting radionuclides in soil are made at routinely monitored locations to monitor changes over time and to establish concentration ratios between soil and plants and animals. Biota and soil samples from the Radioactive Waste Management Sites (RWMSs) are also periodically collected to assess the integrity of waste disposal cells. This chapter describes the biota monitoring program designed to meet public and environmental radiation protection regulations (see Section 2.4) and presents the field sampling and analysis results from 2015. The estimated dose to humans potentially consuming NNSS plants and animals and the dose to biota from these radionuclides are presented in Chapter 9.

### ***Radiological Biota Monitoring Goals***

Collect and analyze biota samples for radionuclides to estimate the potential dose to humans who may consume plants or game animals from the NNSS (see Chapter 9 for the estimates of dose to humans).

Collect and analyze biota samples for radionuclides to estimate the absorbed radiation dose to NNSS biota (see Chapter 9 for the estimates of dose to NNSS plants and animals).

Collect and analyze soil samples at the Area 3 and Area 5 RWMSs to provide evidence that the burrowing activities of fossorial animals have or have not compromised the integrity of the soil covered waste disposal units.

### **8.1 Species Selection**

The goal for vegetation monitoring is to sample the plants most likely to have the highest contamination within the NNSS environment. They are generally found inside demarcated radiological areas near the “ground zero” locations of historical aboveground or near-surface nuclear tests. The species selected for sampling represent the most dominant life forms (e.g., trees, shrubs, herbs, or grasses) at these sites. Woody vegetation (i.e., shrubs versus forbs or grasses) is sampled because it is reported to have deeper penetrating roots and higher concentrations of tritium ( $^3\text{H}$ ) (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.

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

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

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

## 8.2 Site Selection

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

- **Runoff areas or containment ponds associated with underground or tunnel test areas.** Contaminated water draining from test areas can form surface water sources that are important given the limited availability of surface water on the NNSS. Therefore, they have a high potential for transferring radionuclides to plants and wildlife

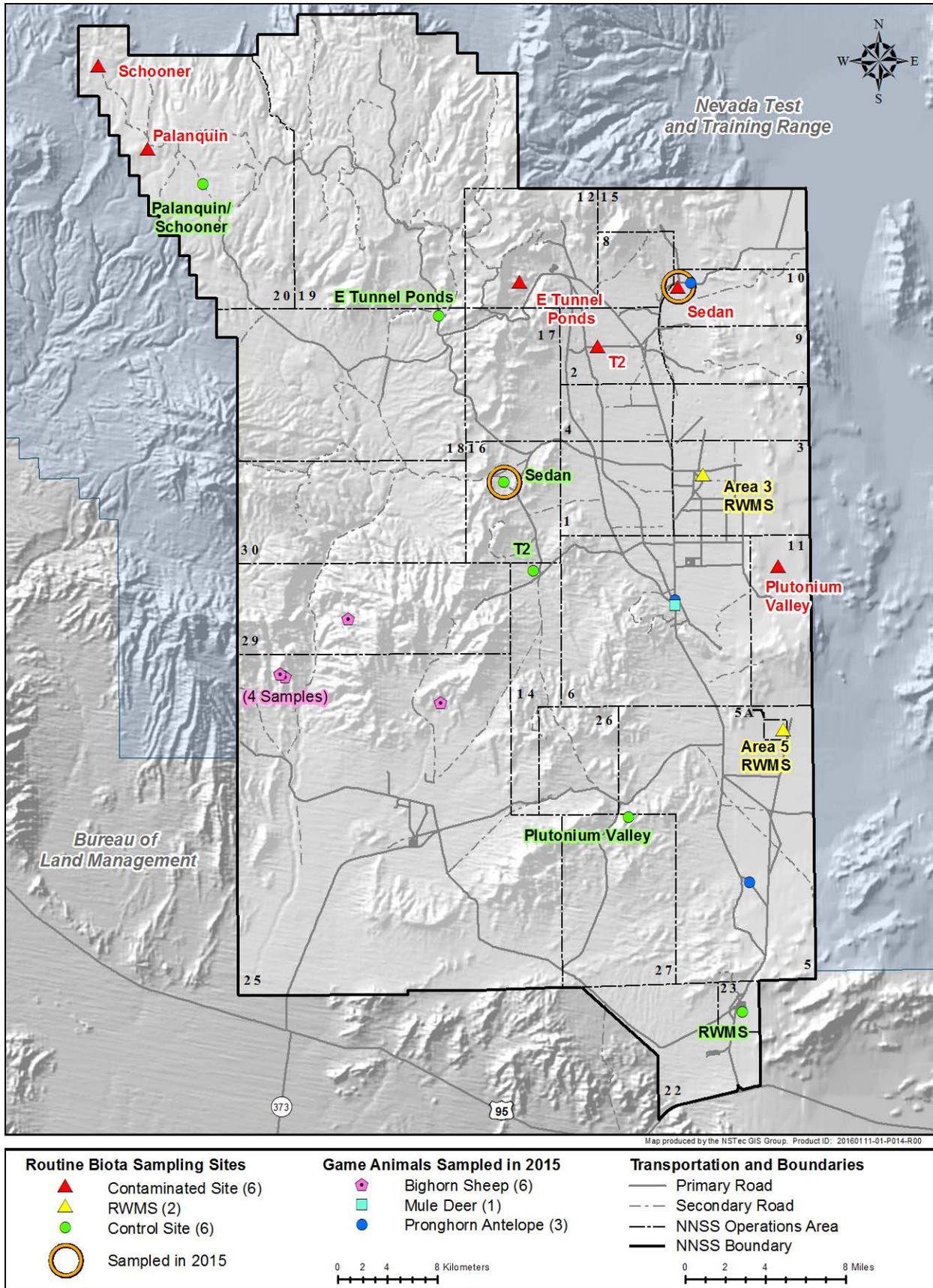


Figure 8-1. Radiological biota monitoring sites on the NNSS

seeking surface water. The associated monitoring site is E Tunnel Ponds below Rainier Mesa. It was last sampled in 2012.

- **Plowshare sites in alluvial fill at lower elevations with high surface contamination.** The historical *Plowshare Program* (see [Glossary, Appendix B](#)), conducted throughout the NNSS, explored the potential use of nuclear weapons for peaceful purposes. 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. This contaminated site, along with its control site, was sampled for biota in 2015.
- **Plowshare sites in bedrock or rocky fill at higher elevations with high surface contamination.** Subsurface nuclear detonations at these Plowshare Program sites distributed contaminants over a wide area, usually in the highest precipitation areas of the NNSS. Two monitored sites are in this category: Palanquin Crater and Schooner Crater. Both sites were last sampled in 2013.
- **Atmospheric test areas.** These sites have highly disturbed soils due to the removal of topsoil during historical cleanup efforts and due to the sterilization of soils from heat and radiation during testing. The same areas were often used for multiple nuclear tests. The associated monitoring site is T2 in Yucca Flat. It was last sampled in 2011.
- **Aboveground safety experiment sites.** These areas are typified by current radioactive soil contamination, primarily in the form of plutonium and uranium. The associated monitoring site is Plutonium Valley in Area 11. It was last sampled in 2014.

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

- **Area 3 RWMS.** Waste disposal cells within the Area 3 RWMS are subsidence craters resulting from underground nuclear testing. Two closed cells containing bulk low-level radioactive waste are craters U-3ax and U-3bl, which were combined to form the U-3ax/bl disposal unit (Corrective Action Unit 110). U-3ax/bl is covered with a vegetated, native alluvium closure cover that is at least 2.4 meters (m) (8 feet [ft]) thick. It was last sampled in 2014.
- **Area 5 RWMS.** Waste disposal has occurred at the Area 5 RWMS since the early 1960s. There are 11 closed disposal cells containing bulk low-level radioactive waste. The cells are unlined pits and trenches that range in depth from 4.6 to 15 m (15 to 48 ft). Efforts are currently being made to establish native vegetation on the cover cap of the 92-Acre Area, which caps multiple waste cells. The cover cap is approximately 2.4 m (8 ft) thick. Plants and animals from three different portions of the 92-Acre Area cover were last sampled in 2014.

### 8.3 2015 Sampling and Analysis

In 2015, the Sedan site and its control were sampled for plants and animals (Figure 8-1). The Sedan test was conducted July 6, 1962, in the northern portion of Area 10. This cratering experiment displaced 12 million tons of earth and formed a 390 m (1,280 ft) diameter by 97 m (320 ft) deep depression in the desert floor. The purpose of the test was to determine if nuclear devices could be used as cratering or earth-moving mechanisms. Contaminants resulting from this test were primarily  $^3\text{H}$ , strontium-90 ( $^{90}\text{Sr}$ ), cesium-137 ( $^{137}\text{Cs}$ ), plutonium-239+240 ( $^{239+240}\text{Pu}$ ), and americium-241 ( $^{241}\text{Am}$ ). A control area for Sedan is located about 20 kilometers (km) (12.6 miles [mi]) southwest of the sample site near a spring in Area 16. Any of the candidate game species is likely to be present at the Sedan Control site.

Measurements of gamma-emitting radionuclides in soil were made at the Sedan location on November 23, 2015, and at its control location on November 12, 2015. In September 1982, the Radionuclide Inventory and Distribution Program (RIDP) took measurements at Sedan at two locations (called points 35 and 36) (McArthur and Mead, 1987). The 2015 Sedan measurements were made at these same two locations and were compared with those made in 1982 (see Section 8.3.3). All 2015 measurements were made using an uncollimated Canberra Model GX5520 germanium detector mounted downward looking on a tripod 1 meter (m) above ground level. The spectra were analyzed using Canberra Genie 2000 (version 3.4) and ISOCS (version 4.4) software with a 10 m

circular plane geometry to a depth of 30 centimeters (cm) for the efficiency calibration. For natural radionuclides in the soil, a uniform depth distribution was used in the efficiency calibration. However, the abundance of man-made radionuclides in NNSS soil decreases with depth (McArthur and Mead 1987). The following percentages of radioactivity per 5 cm depth increment were used by McArthur and Mead (1987) for their geometry calibrations of sample measurements for the RIDP: 24.2% in 0-5 cm, 21.2% in 5-10 cm, 20.0% in 10-15 cm, 14.7% in 15-20 cm, 11.3% in 20-25 cm, and 8.6% in 25-30 cm.

In 2015, a collaborative bighorn sheep study was initiated between the Nevada Department of Wildlife; the U.S. Geological Survey; the U.S. Air Force; and the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office. The study goals are to better understand desert bighorn sheep movements, the source(s) of the sheep population on the NNSS, the prevalence of pneumonia-causing bacteria in the animals, and their radionuclide burdens and potential dose to humans via the food chain (see Chapter 13, Table 13-2). During the study, captured animals were processed by determining the sex and age of the animal, marking each individual with unique ear tags, securing a satellite radio-collar around the neck, performing a visual health assessment on the animal, and taking blood samples and nasal/oral swabs. Blood samples were analyzed for  $^3\text{H}$ ,  $^{90}\text{Sr}$ , plutonium-238 ( $^{238}\text{Pu}$ ),  $^{239+240}\text{Pu}$ ,  $^{241}\text{Am}$ , and any gamma-emitting radionuclides by gamma spectroscopy.

In 2015, no biota or soil sampling was conducted at the Area 3 or Area 5 RWMSs. The last sampling of the RWMSs in 2014 did not suggest that burrowing animals had come into contact with buried waste (NSTec 2015).

### 8.3.1 Plants

Plant sampling took place at Sedan on July 27, 2015, and at the control site on August 18, 2015. Three composite samples were collected from each location. Plants were sampled over an area of about 0.025 square kilometers (km<sup>2</sup>) (0.0097 square miles [mi<sup>2</sup>]) about 200 m south of the Sedan crater. Plants were collected over a smaller area (0.008 km<sup>2</sup> [0.003 mi<sup>2</sup>]) at the control site. All samples consisted of about 150 to 500 grams (g) (5.3 to 17.6 ounces [oz]) of fresh-weight plant material and were composites of material from 3 to 11 plants of the same species. The species sampled represent the dominant vegetation at each site (Table 8-2).

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

**Table 8-2. Plant samples collected in 2015**

Common Name	Scientific Name	Name Code	Sedan	Sedan Control
Indian ricegrass	<i>Achnatherum hymenoides</i>	ACHY	X	
Prairie sage	<i>Artemisia ludoviciana</i>	ARLU		X
Rubber rabbitbrush	<i>Ericameria nauseosus</i>	ERNA	X	X
Baltic rush	<i>Juncus balticus</i>	JUBA		X
Russian thistle (unknown species)	<i>Salsola</i> spp.	Salsola	X	

The results of radiological analyses of plant samples are shown in Table 8-3. No man-made radionuclides were detected in plants from the control site but they were detected in all of the samples from the Sedan site.  $^3\text{H}$ ,  $^{90}\text{Sr}$ ,  $^{137}\text{Cs}$ , and  $^{239+240}\text{Pu}$  were detected in 100% of the samples from Sedan while  $^{241}\text{Am}$  was detected in two of the three samples. Concentrations of  $^3\text{H}$ ,  $^{90}\text{Sr}$ , and  $^{239+240}\text{Pu}$  and, to a lesser extent  $^{137}\text{Cs}$ , in plants sampled from Sedan were higher in 2015 samples compared with samples collected in 2000, 2005 and 2010 (BN 2001; NSTec 2006, 2011). This is likely due to the fact that 2015 samples were collected closer to the ground zero than in those previous years.

**Table 8-3. Concentrations of man-made radionuclides in plants sampled in 2015**

Sample	Radionuclide Concentrations ± Uncertainty <sup>(a)</sup>				
	<sup>3</sup> H (pCi/L) <sup>(b)</sup>	<sup>90</sup> Sr (pCi/g) <sup>(c)</sup>	<sup>137</sup> Cs (pCi/g) <sup>(c)</sup>	<sup>239+240</sup> Pu (pCi/g) <sup>(c)</sup>	<sup>241</sup> Am (pCi/g) <sup>(c)</sup>
<b>Sedan</b>					
ACHY	21,800 ± 2,290	0.545 ± 0.138	0.615 ± 0.112	0.0724 ± 0.0288	0.0217 ± 0.0147
ERNA	28,900,00 ± 2,920,000	0.903 ± 0.204	0.889 ± 0.158	0.0332 ± 0.0149	0.0250 ± 0.0180
Salsola	138,000 ± 14,100	2.550 ± 0.494	0.331 ± 0.076	0.0216 ± 0.0135	0.0117 ± 0.0120
Average Concentration	9,686,600	1.333	0.612	0.0424	0.0195
Average MDC <sup>(d)</sup>	4,005	0.117	0.091	0.0140	0.0129
<b>Sedan Control</b>					
ARLU	260 ± 214	-0.002 ± 0.050	0.004 ± 0.076	0.0094 ± 0.0101	-0.0024 ± 0.0072
ERNA	115 ± 218	-0.063 ± 0.042	-0.015 ± 0.049	0.0015 ± 0.0067	-0.0014 ± 0.0041
JUBA	18 ± 195	-0.007 ± 0.043	-0.003 ± 0.086	-0.0014 ± 0.0095	0.0000 ± 0.0049
Average Concentration	131	-0.024	-0.005	0.0032	-0.0012
Average MDC <sup>(d)</sup>	355	0.093	0.125	0.0160	0.0130

(a) ± 2 standard deviations

(b) picocuries per liter water from sample

(c) picocuries per gram dry weight of sample

(d) the average sample-specific *minimum detectable concentration (MDC)* (see [Glossary, Appendix B](#))

### 8.3.2 Animals

State and federal permits were secured to trap specific small mammals and birds in 2015 and to opportunistically sample large mammal mortalities (e.g., from vehicles or from predation) on the NNSS. Animal trapping took place at the Sedan and Sedan Control locations from August 18 through October 1, 2015. All animal samples are described in Table 8-4. Two jackrabbits were collected from near Sedan and two cottontail rabbits were collected from the control site for Sedan. One mule deer and three pronghorn antelope killed by vehicles on the NNSS were also sampled during 2015 (Table 8-4). Though muscle is usually the only portion consumed by humans, the rabbits were homogenized to give a more conservative (higher) estimate of potential dose to someone consuming them (see Section 9.1.1.2). Water was distilled from the homogenized samples and submitted to a laboratory for <sup>3</sup>H analysis, and the remaining tissue samples were submitted for <sup>90</sup>Sr, <sup>238</sup>Pu, <sup>239+240</sup>Pu, <sup>241</sup>Am, and gamma spectroscopy analysis.

Bighorn sheep study samples are listed in Table 8-4. At the request of Nevada Test and Training Range (NTTR) personnel involved with the bighorn sheep study, blood samples were taken from eight sheep captured on the NTTR (five from the Cactus Range and three from Stonewall Mountain) for radiological analysis to determine the radionuclide burden of the animal and the potential dose a human would get from eating the sheep. These samples were in addition to the samples from six sheep captured on the NNSS. Additionally, blood samples from six California bighorn sheep (*Ovis canadensis californiana*) from northern Nevada were also taken to use as control samples for the NNSS and NTTR samples. Radiological analyses were performed on the 20 samples to determine the content of <sup>3</sup>H, <sup>90</sup>Sr, <sup>238</sup>Pu, <sup>239+240</sup>Pu, <sup>241</sup>Am, and any gamma-emitting radionuclides by gamma spectroscopy.

**Table 8-4. Animal or animal-related samples collected in 2015**

Location	Sample	Collection Date	Sample Description
<b>Routine Monitoring Samples</b>			
Sedan	Jackrabbit #1	8/19/2015	Whole body
	Jackrabbit #2	8/20/2015	Whole Body
Sedan Control	Cottontail #1	8/19/2015	Whole body
	Cottontail #2	8/20/2015	Whole body
<b>Opportunistic Samples</b>			
Area 6	Mule Deer	9/15/2015	Water and muscle from hind quarter of immature mule deer killed by vehicle
Area 5	Pronghorn	8/25/2015	Water and muscle from hind quarter of immature female pronghorn killed by vehicle
Area 6	Pronghorn	8/10/2015	Water and muscle from hind quarter of immature female pronghorn killed by vehicle
Area 10	Pronghorn	7/22/2015	Water and muscle from back of adult male pronghorn killed by vehicle

**Table 8-4. Animal or animal-related samples collected in 2015 (continued)**

Location	NDOW <sup>(a)</sup> Tag Number	Capture Date	Sample Description
<b>Bighorn Sheep Study Samples</b>			
Northern Nevada	3734	12/1/2015	Blood sample from a sheep captured in the Snowstorm Mountains
Northern Nevada	10191	12/1/2015	Blood sample from a sheep captured in the Trout Creek Mountains
Northern Nevada	10192	12/1/2015	Blood sample from a sheep captured in the Montana Mountains
Northern Nevada	10193	12/1/2015	Blood sample from a sheep captured in the Montana Mountains
Northern Nevada	10194	12/1/2015	Blood sample from a sheep captured in the Montana Mountains
Northern Nevada	10196	12/1/2015	Blood sample from a sheep captured in the Santa Rosa Range
NNSS (Area 25)	NNSS10171	11/17/2015	Blood sample from a sheep captured southeast of Shoshone Mountain
NNSS (Area 25)	NNSS10172	11/17/2015	Blood sample from a sheep captured near Cottonwood Spring
NNSS (Area 29)	NNSS10174	11/18/2015	Blood sample from a sheep captured in South Pah Canyon
NNSS (Area 25)	NNSS10175	11/17/2015	Blood sample from a sheep captured near Cottonwood Spring
NNSS (Area 25)	NNSS10177	11/17/2015	Blood sample from a sheep captured near Cottonwood Spring
NNSS (Area 25)	NNSS10179	11/17/2015	Blood sample from a sheep captured near Cottonwood Spring
NTTR	NTTR10071	11/14/2015	Blood sample from a sheep captured in the Cactus Range
NTTR	NTTR10072	11/14/2015	Blood sample from a sheep captured in the Cactus Range
NTTR	NTTR10073	11/14/2015	Blood sample from a sheep captured in the Cactus Range
NTTR	NTTR10074	11/14/2015	Blood sample from a sheep captured in the Cactus Range
NTTR	NTTR10076	11/14/2015	Blood sample from a sheep captured in the Cactus Range
NTTR	NTTR10079	11/14/2015	Blood sample from a sheep captured on Stonewall Mountain
NTTR	NTTR10080	11/14/2015	Blood sample from a sheep captured on Stonewall Mountain
NTTR	NTTR10086	11/14/2015	Blood sample from a sheep captured on Stonewall Mountain

(a) Nevada Department of Wildlife

Man-made radionuclides were detected in both jackrabbits collected at the Sedan site and in the one pronghorn antelope from Area 10 (Table 8-5). No man-made radionuclides were detected in the rabbits from the Sedan control site. In rabbits from Sedan,  $^3\text{H}$ ,  $^{90}\text{Sr}$ ,  $^{137}\text{Cs}$ ,  $^{239+240}\text{Pu}$ , and  $^{241}\text{Am}$  were detected. Activity levels were dominated by  $^3\text{H}$ . In the pronghorn antelope from Area 10,  $^{90}\text{Sr}$ ,  $^{238}\text{Pu}$ ,  $^{239+240}\text{Pu}$ , and  $^{241}\text{Am}$  were detected at low concentrations (Table 8-5).

Two man-made radionuclides were detected in the blood samples from bighorn sheep:  $^{238}\text{Pu}$  and  $^{239+240}\text{Pu}$  (Table 8-6). Plutonium is a component of global fallout from atmospheric nuclear weapons tests conducted by both the United States and other countries (Former Soviet Union, United Kingdom, France, and China) (UNSCEAR 2008). Furthermore, in 1964, the SNAP-9A navigational satellite accident increased the global fallout of  $^{238}\text{Pu}$  by about three-fold (Hardy et al. 1972). Thus, it is not surprising to find these low concentrations of plutonium in samples from all areas including the northern Nevada control samples.

**Table 8-5. Concentrations of man-made radionuclides in animals sampled during routine monitoring in 2015**

Sample	Radionuclide Concentrations $\pm$ Uncertainty <sup>(a)</sup>					
	$^3\text{H}$ (pCi/L) <sup>(b)</sup>	$^{90}\text{Sr}$ (pCi/g) <sup>(c)</sup>	$^{137}\text{Cs}$ (pCi/g) <sup>(c)</sup>	$^{238}\text{Pu}$ (pCi/g) <sup>(c)</sup>	$^{239+240}\text{Pu}$ (pCi/g) <sup>(c)</sup>	$^{241}\text{Am}$ (pCi/g) <sup>(c)</sup>
<b>Sedan</b>						
Jackrabbit #1	43,800 $\pm$ 4,460	0.166 $\pm$ 0.039	0.290 $\pm$ 0.048	0.0034 $\pm$ 0.0035	0.0052 $\pm$ 0.0043	0.0005 $\pm$ 0.0029
Jackrabbit #2	13,200 $\pm$ 1,420	0.300 $\pm$ 0.062	0.194 $\pm$ 0.044	0.0015 $\pm$ 0.0027	0.2614 $\pm$ 0.0429	0.0635 $\pm$ 0.0219
Average Concentration	28,500	0.233	0.242	0.0024	0.1333	0.0320
Average MDC <sup>(d)</sup>	329	0.021	0.025	0.0037	0.0040	0.0061
<b>Sedan Control</b>						
Cottontail #1	130 $\pm$ 197	-0.002 $\pm$ 0.015	0.005 $\pm$ 0.010	-0.0003 $\pm$ 0.0012	-0.0007 $\pm$ 0.0013	-0.0002 $\pm$ 0.0014
Cottontail #2	-1 $\pm$ 187	0.004 $\pm$ 0.017	0.005 $\pm$ 0.020	0.0009 $\pm$ 0.0030	0.0005 $\pm$ 0.0030	0.0013 $\pm$ 0.0036
Average Concentration	64	0.001	0.005	0.0003	-0.0001	0.0006
Average MDC <sup>(d)</sup>	331	0.030	0.033	0.0044	0.0051	0.0048

**Table 8-5. Concentrations of man-made radionuclides in animals sampled during routine monitoring in 2015 (continued)**

Sample	Radionuclide Concentrations $\pm$ Uncertainty <sup>(a)</sup>					
	<sup>3</sup> H (pCi/L) <sup>(b)</sup>	<sup>90</sup> Sr (pCi/g) <sup>(c)</sup>	<sup>137</sup> Cs (pCi/g) <sup>(c)</sup>	<sup>238</sup> Pu (pCi/g) <sup>(c)</sup>	<sup>239+240</sup> Pu (pCi/g) <sup>(c)</sup>	<sup>241</sup> Am (pCi/g) <sup>(c)</sup>
<b>Opportunistic Sampling</b>						
Mule Deer (Area 6)	24 $\pm$ 197	-0.020 $\pm$ 0.023	0.011 $\pm$ 0.034	0.0010 $\pm$ 0.0019	0.0000 $\pm$ 0.0019	0.0110 $\pm$ 0.0125
Pronghorn (Area 5)	-67 $\pm$ 144	0.033 $\pm$ 0.054	0.002 $\pm$ 0.033	0.0050 $\pm$ 0.0067	0.0030 $\pm$ 0.0078	0.0097 $\pm$ 0.0104
Pronghorn (Area 6)	39 $\pm$ 175	-0.001 $\pm$ 0.030	-0.020 $\pm$ 0.062	0.0123 $\pm$ 0.0117	0.0035 $\pm$ 0.0050	0.0021 $\pm$ 0.0093
Pronghorn (Area 10)	250 $\pm$ 198	0.016 $\pm$ 0.007	0.033 $\pm$ 0.033	0.0089 $\pm$ 0.0048	0.0960 $\pm$ 0.0163	0.0163 $\pm$ 0.0061
Average Concentration	62	0.007	0.006	0.0068	0.0256	0.0098
Average MDC <sup>(d)</sup>	303	0.048	0.073	0.0090	0.0061	0.0146

(a)  $\pm$  2 standard deviations

(b) picocuries per liter water from sample

(c) Picocuries per gram wet weight of sample

(d) Average sample specific MDC

**Table 8-6. Man-made radionuclide concentrations in bighorn sheep blood samples collected in 2015**

Location	NDOW Tag Number	Radionuclide Concentrations (pCi/g) <sup>(a)</sup> $\pm$ Uncertainty <sup>(b)</sup>	
		<sup>238</sup> Pu	<sup>239+240</sup> Pu
Northern Nevada	3734	0.0005 $\pm$ 0.0005	0.0004 $\pm$ 0.0005
Northern Nevada	10191	0.0004 $\pm$ 0.0005	0.0006 $\pm$ 0.0005
Northern Nevada	10192	0.0006 $\pm$ 0.0005	0.0005 $\pm$ 0.0005
Northern Nevada	10193	0.0005 $\pm$ 0.0005	0.0002 $\pm$ 0.0004
Northern Nevada	10194	0.0002 $\pm$ 0.0004	0.0003 $\pm$ 0.0004
Northern Nevada	10196	0.0000 $\pm$ 0.0005	0.0004 $\pm$ 0.0005
	Average	0.0004	0.0004
	Average MDC <sup>(c)</sup>	0.0007	0.0006
NNSS (Area 25)	NNSS10171	0.0005 $\pm$ 0.0005	0.0001 $\pm$ 0.0004
NNSS (Area 25)	NNSS10172	0.0001 $\pm$ 0.0023	0.0045 $\pm$ 0.0032
NNSS (Area 29)	NNSS10174	0.0003 $\pm$ 0.0004	0.0006 $\pm$ 0.0005
NNSS (Area 25)	NNSS10175	0.0011 $\pm$ 0.0009	0.0005 $\pm$ 0.0006
NNSS (Area 25)	NNSS10177	0.0000 $\pm$ 0.0004	0.0004 $\pm$ 0.0004
NNSS (Area 25)	NNSS10179	0.0002 $\pm$ 0.0004	0.0003 $\pm$ 0.0003
	Average	0.0004	0.0011
	Average MDC <sup>(c)</sup>	0.0014	0.0007
NTTR	NTTR10071	0.0005 $\pm$ 0.0006	0.0032 $\pm$ 0.0013
NTTR	NTTR10072	0.0006 $\pm$ 0.0013	0.0012 $\pm$ 0.0011
NTTR	NTTR10073	0.0011 $\pm$ 0.0018	0.0024 $\pm$ 0.0023
NTTR	NTTR10074	0.0016 $\pm$ 0.0014	0.0024 $\pm$ 0.0020
NTTR	NTTR10076	0.0007 $\pm$ 0.0006	0.0000 $\pm$ 0.0004
NTTR	NTTR10079	0.0004 $\pm$ 0.0018	0.0008 $\pm$ 0.0018
NTTR	NTTR10080	0.0005 $\pm$ 0.0005	0.0004 $\pm$ 0.0005
NTTR	NTTR10086	0.0007 $\pm$ 0.0006	0.0007 $\pm$ 0.0005
	Average	0.0007	0.0014
	Average MDC <sup>(c)</sup>	0.0016	0.0015

(a) Picocuries per gram wet weight of sample

(b)  $\pm$  2 standard deviations

(c) Average sample-specific MDC

### 8.3.3 Soil

Results from measurements of gamma-emitting radionuclides in soil at the Sedan and Sedan control locations are listed in Table 8-7. One natural radionuclide (potassium-40 [ $^{40}\text{K}$ ]) is reported because it is ubiquitous and has a very long half-life (1,251,000,000 years) so it makes for a good marker for comparison between measurements (it should not change through time). Man-made radionuclides detected at the Sedan location were Cobalt-60 ( $^{60}\text{Co}$ ),  $^{137}\text{Cs}$ , europium-152 ( $^{152}\text{Eu}$ ), and  $^{241}\text{Am}$ . The only man-made radionuclide detected at the control location was  $^{137}\text{Cs}$ . Comparison of 2015 activity in soil with those measured in 1982 by the RIDP are remarkably similar. This suggests very little loss of man-made radionuclides has occurred in the past 33 years.

Ratios of plant-to-soil and animal-to-soil concentrations are presented in Table 8-8. Soil concentrations were converted to pCi/g by taking the activity per area reported in Table 8-7 and dividing them by the number of grams of soil in 1 m<sup>2</sup> to a depth of 30 cm (450,000 g) (soil density = 1.5 g/cm<sup>3</sup>). Ratios are only calculated for  $^{137}\text{Cs}$  and  $^{241}\text{Am}$  because they were the only man-made radionuclides detected in both soil and the plants and animals. These values can be useful in estimating concentrations in plants and animals on the NNSS (particularly near Sedan) based on soil concentrations.

**Table 8-7. Gamma-emitting radionuclides detected in soil**

Radionuclide	Activity (nanocuries per square meter [nCi/m <sup>2</sup> ]) <sup>(a)</sup>				
	Sedan				Sedan Control
	September, 1982 <sup>(b)</sup>		November, 2015		November, 2015
	Point 35	Point 36	Point 35	Point 36	
$^{40}\text{K}$	9,405	12,487	11,458 ± 1,021	11,794 ± 1,047	13,363 ± 1,196
$^{60}\text{Co}$	168	138	156 ± 14	129 ± 14	ND <sup>(c)</sup>
$^{137}\text{Cs}$	14,475	12,305	11,414 ± 1,390	10,920 ± 1,316	42 ± 25
$^{152}\text{Eu}$	230	237	ND	279 ± 32	ND
$^{241}\text{Am}$	6,664	7,859	9,450 ± 982	7,931 ± 1,662	ND

(a) November, 2015, measurements include ±2 standard deviations of sample counting uncertainty. No uncertainty was reported for the RIDP measurements.

(b) RIDP measurements from 1982 were corrected for physical decay of radionuclides to November, 2015.  $^{241}\text{Am}$  includes ingrowth from decay of plutonium-241.

(c) ND = not detected (no significant peak(s) detected for that radionuclide in gamma spectroscopy measurement).

**Table 8-8. Vegetation-to-soil and animal-to-soil concentration ratios for Sedan in 2015**

Sample	Concentration Ratio <sup>(a)</sup>			
	$^{137}\text{Cs}$		$^{241}\text{Am}$	
	Average	Range	Average	Range
Vegetation : Soil	0.0246	0.0133 – 0.0358	0.0010	0.0006 – 0.0013
Animal : Soil	0.0098	0.0078 – 0.0117	0.00166	0.0003 – 0.00329

(a) vegetation = pCi/g dry weight, animal = pCi/g wet weight, soil = pCi/g dry weight

## 8.4 Data Assessment

Biota sampling results confirm that man-made radionuclide concentrations are higher at the Sedan location compared with its control location. Though NNSS-related radionuclides are detected in some plants and animals, the levels pose negligible risk to humans and biota. The potential dose to a person hunting and consuming these animals is well below dose limits to members of the public (see Section 9.1.1.2). Also, radionuclide concentrations were below levels considered harmful to the health of the plants and animals; the dose resulting from observed concentrations were less than 4 percent of dose limits set to protect populations of plants and animals (see Section 9.2).

## **8.5    *References***

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## Chapter 9: Radiological Dose Assessment

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The U.S. Department of Energy (DOE) requires DOE facilities to estimate the radiological dose to the general public and to plants and animals in the environment caused by past or present facility operations. These requirements are specified in DOE Orders DOE O 435.1, “Radioactive Waste Management,” and DOE O 458.1, “Radiation Protection of the Public and the Environment” (see Section 2.4). To estimate these radiological doses, radionuclide concentration data gathered on the Nevada National Security Site (NNSS) are used along with dose conversion factors published in DOE Technical Standard DOE-STD-1196-2011, “Derived Concentration Technical Standard.” The dose conversion factors take into account the different population fractions of age and sex to give representative dose coefficients for a reference person within the U.S. population. The 2015 data used 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 Environmental Monitoring Program (CEMP), provide extra assurance to the public that estimated doses do not underestimate potential offsite exposures to NNSS-related radiation. The specific goals for the dose assessment component of radiological monitoring are shown below.

### *Radiological Dose Assessment Goals*

Determine the maximum radiation dose to a member of the general public from airborne radionuclide emissions at the NNSS complies with the Clean Air Act, National Emission Standards for Hazardous Air Pollutants (NESHAP) limit of 10 millirems per year (mrem/yr) (0.1 millisieverts per year [mSv/yr]).

Determine if radiation levels from the Radioactive Waste Management Sites (RWMSs) comply with the 25 mrem/yr (0.25 mSv/yr) dose limit to members of the public as specified in DOE Manual DOE M 435.1-1, “Radioactive Waste Management Manual.”

Determine if the total radiation dose (*total effective dose equivalent [TEDE]*, see [Glossary, Appendix B](#)) to a member of the general public from all possible pathways (direct exposure, inhalation, ingestion of water and food) as a result of NNSS operations complies with the limit of 100 mrem/yr (1 mSv/yr) established by DOE O 458.1.

Determine if the radiation dose (in a unit of measure called a *rad* [see [Glossary, Appendix B](#)]) to NNSS biota complies with the following limits set by DOE Standard DOE-STD-1153-2002, “A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota”:

- < 1 rad per day (rad/d) for terrestrial plants and aquatic animals
- < 0.1 rad/d for terrestrial animals

### 9.1 Dose to the Public

This section identifies the possible pathways by which the public could be exposed to radionuclides 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 2015 public dose attributable to U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) activities from each pathway and 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 that can be used to assess the radiation dose received by the general public from several pathways.

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

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

The subsections below address all of the potential pathways and their contribution to public dose estimated for 2015.

### 9.1.1.1 Dose from NNSS Air Emissions

Six air particulate and tritium (<sup>3</sup>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]) (see Table 4-1 of Section 4.1.1). 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 radio-nuclides 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 much closer to emissions sources. 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 (see Chapter 4, 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 <sup>(a)</sup> and Direction <sup>(b)</sup> 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	54 km SE Indian Springs	6.3 km SSE Area 6, National Criticality Experiments Research Center
Area 10, Gate 700	49 km ENE Medlin’s Ranch	56 km NNE Rachel	77 km ENE Alamo	2.4 km WSW Area 10, Sedan Crater
Area 16, Substation 3545	46 km SSW Amargosa Valley	46 km SSW Amargosa Valley	58 km SSW Amargosa Valley	14 km ENE Area 3 RWMS
Area 20, Schooner	36 km WSW Sarcobatus Flat	20 km WSW Tolicha Peak	56 km SSW Beatty	0.2 km SE Area 20, Schooner Crater
Area 23, Mercury Track	24 km SW Crystal	6.0 km SE American Silica	31 km SSW Indian Springs	0.2 km ESE Area 23, Building 652
Area 25, Gate 510	4 km S Amargosa Valley	3.5 km S Amargosa Valley	15 km SW Amargosa Valley	5.1 km NE Area 25, nearest portion of Grouped Area Sources

(a) Distance is shown in kilometers (km). For miles, multiply by 0.62.

(b) N=north, S=south, E=east, W=west in all direction combinations shown

In 2015, the man-made radionuclides detected in samples from at least one of the six critical receptor air monitoring stations included <sup>3</sup>H, cesium-137 (<sup>137</sup>Cs), americium-241 (<sup>241</sup>Am), plutonium-238 (<sup>238</sup>Pu), and plutonium-239+240 (<sup>239+240</sup>Pu) (see 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 (see Section 4.1.5,

Table 4-9). As in previous years, the 2015 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 shortest distance between where a member of the public resides and a critical receptor monitoring station is 4 km (2.5 miles [mi]): between the Gate 510 sampler in the southwest corner of the NNSS and the northern edge of the community of Amargosa Valley. Because it is the closest, the results from the Gate 510 sampler (see Table 4-9) are believed to be most representative of air concentrations to which the public is continuously exposed. Scaling the 0.004 sum of fractions for the Gate 510 station to the 10 mrem/yr (0.1 mSv/yr) limit gives an estimated dose of 0.04 mrem/yr (0.0004 mSv/yr) from radionuclides in air. More detailed information regarding the estimation of the dose to the public from airborne radioactivity in 2015 from all activities conducted by NNSA/NFO on the NNSS and its Nevada support facilities is reported in National Security Technologies, LLC (NSTec) (2016).

### 9.1.1.2 Dose from Ingestion of Game Animals from the NNSS

Two game species, mule deer and mourning doves, have been shown to travel off the NNSS and be available to hunters (Giles and Cooper 1985; NSTec 2009). Because of this, game animals on the NNSS are sampled annually near known radiologically contaminated areas to give conservative (worst-case) estimates of the level of radionuclides that hunters may consume if these animals are harvested off of the NNSS. In 2015, the following animals were sampled (see Chapter 8, Figure 8-1 and Tables 8-4, 8-5, and 8-6):

- Two jackrabbits from near the Sedan Crater (Area 10)
- Two cottontail rabbits from the Sedan Control location (Area 16)
- Three pronghorn antelope accidentally killed by vehicles (one each from Areas 5, 6, and 10)
- One mule deer accidentally killed by a vehicle (Area 6)
- Twenty bighorn sheep captured as part of a research project: six from the NNSS (five from Area 25 and one from Area 29), eight from the Nevada Test and Training Range (NTTR), and six from northern Nevada. Blood samples were collected prior to the animals being released and radionuclide concentrations in blood were assumed equal to that in muscle tissue.

The potential *committed effective dose equivalent (CEDE)* (see [Glossary, Appendix B](#)) to an individual from consuming game animals was calculated for each animal sampled in 2015. The following assumption/parameters were used to estimate dose:

- Analysis results from all samples were included in calculating dose from consuming a particular species as long as the radionuclide was detected, i.e., the analysis result was above the *minimum detectable concentration (MDC)*, (see [Glossary, Appendix B](#)) 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).
- If the analytical result for a radionuclide concentration in the sample was a negative value (resulting from a background measurement higher than what was observed in the sample), then the concentration for that sample was set to zero.
- An individual consumes all meat from one of each species of animal sampled during 2015: one jackrabbit (513 grams [g]), one cottontail rabbit (167 g), one pronghorn antelope (20.0 kilograms [kg]), one mule deer (35.4 kg), and one bighorn sheep (35.4 kg) during the year.
- The moisture content of the muscle tissue samples of all species is 73%.
- Dose coefficients for a reference person as defined by DOE-STD-1196-2011 are used; they are for a hypothetical person representing an aggregate of individuals in the U.S. population.
- The entire committed dose is considered to be received during the calendar year.

Dose coefficients (mrem per picocurie [pCi] ingested), based on values listed in DOE-STD-1196-2011, were multiplied by the amount of radioactivity (pCi) potentially ingested to obtain the potential dose (CEDE) (Table 9-2). The average and maximum CEDEs for each monitored location and for each animal species opportunistically sampled are presented in Table 9-2. No man-made radionuclides were detected in animals sampled from the Sedan control site or in the mule deer from Area 6, so dose from consuming these animals is essentially zero. They are therefore not displayed in Table 9-2. Based on the 2015 samples, an individual who consumes one animal of each sampled

species taken from the NNSS may receive an estimated 2.22 mrem (0.0222 mSv) dose based on the averages. To put this dose in perspective, the dose from naturally occurring cosmic radiation received during a 2-hour airplane flight at 39,000 feet is about 1 mrem (0.01 mSv). From consuming just one animal, the maximum would come from the pronghorn sampled in Area 10 (see Chapter 8, Table 8-5) and result in a dose of 2.87 mrem (0.0287 mSv).

**Table 9-2. Hypothetical CEDE from ingesting game animals sampled in 2015**

Samples	Sample Location	Committed Effective Dose Equivalent (mrem) <sup>(a)</sup>							Location/Species			
		<sup>3</sup> H <sup>(b)</sup>	<sup>90</sup> Sr	<sup>137</sup> Cs	<sup>238</sup> Pu	<sup>239+240</sup> Pu	<sup>241</sup> Am	Total	Average	Max		
Jackrabbit #1	Sedan (Area 10)	1.2745	0.0113	0.0073	0.0017	0.0028	0.0002	1.2979	0.9398	1.2979		
Jackrabbit #2		0.3841	0.0205	0.0049	0.0007	0.1429	0.0287	0.5818				
<b>Opportunistic samples from accidental road kills:</b>												
Pronghorn antelope #1	Area 5	0.0000	0.0870	0.0021	0.0983	0.0645	0.1712	0.4231	1.2292	2.8687		
Pronghorn antelope #2	Area 6	0.0442	0.0000	0.0000	0.2399	0.0750	0.0367	0.3958				
Pronghorn antelope #3	Area 10	0.2842	0.0415	0.0323	0.1726	2.0506	0.2875	2.8687				
<b>Bighorn Sheep Study:<sup>(c)</sup></b>												
NNSS10171	Area 25	0.0000	0.0000	0.0000	0.0179	0.0040	0.0000	0.0219	0.0527	0.1716		
NNSS10172	Area 25	0.0000	0.0000	0.0000	0.0038	0.1677	0.0000	0.1716				
NNSS10174	Area 29	0.0000	0.0000	0.0000	0.0094	0.0238	0.0000	0.0332				
NNSS10175	Area 25	0.0000	0.0000	0.0000	0.0372	0.0178	0.0000	0.0549				
NNSS10177	Area 25	0.0000	0.0000	0.0000	0.0000	0.0145	0.0000	0.0145				
NNSS10179	Area 25	0.0000	0.0000	0.0000	0.0078	0.0122	0.0000	0.0200				
NTTR10071	NTTR	0.0000	0.0000	0.0000	0.0167	0.1191	0.0000	0.1358	0.0779	0.1460		
NTTR10072	NTTR	0.0000	0.0000	0.0000	0.0221	0.0464	0.0000	0.0684				
NTTR10073	NTTR	0.0000	0.0000	0.0000	0.0368	0.0905	0.0000	0.1273				
NTTR10074	NTTR	0.0000	0.0000	0.0000	0.0540	0.0920	0.0000	0.1460				
NTTR10076	NTTR	0.0000	0.0000	0.0000	0.0250	0.0007	0.0000	0.0257				
NTTR10079	NTTR	0.0000	0.0000	0.0000	0.0120	0.0296	0.0000	0.0417				
NTTR10080	NTTR	0.0000	0.0000	0.0000	0.0154	0.0146	0.0000	0.0299				
NTTR10086	NTTR	0.0000	0.0000	0.0000	0.0226	0.0255	0.0000	0.0481				
3734	Northern Nevada	0.0000	0.0000	0.0000	0.0175	0.0148	0.0000	0.0323			0.0275	0.0375
10191	Northern Nevada	0.0000	0.0000	0.0000	0.0144	0.0230	0.0000	0.0375				
10192	Northern Nevada	0.0000	0.0000	0.0000	0.0188	0.0185	0.0000	0.0373				
10193	Northern Nevada	0.0000	0.0000	0.0000	0.0172	0.0067	0.0000	0.0239				
10194	Northern Nevada	0.0000	0.0000	0.0000	0.0053	0.0129	0.0000	0.0182				
10196	Northern Nevada	0.0000	0.0000	0.0000	0.0000	0.0158	0.0000	0.0158				
<b>Totals (for animals from the NNSS only)</b>								<b>2.2217</b>	<b>4.3383</b>			
<b>CEDE from consuming one NNSS animal of each species = 2.22 mrem (using averages) and 4.34 mrem (using maximums)</b>												

(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) Sample identifications are Nevada Department of Wildlife eartag numbers of each bighorn sheep captured and released

It is possible for someone to consume animals from locations on the NNSS other than where samples were collected in 2015; therefore, Table 9-3 presents the maximum CEDE for humans consuming various species of wildlife from all animals sampled from 2001 through 2015. 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 observations of radionuclides in game animals over the past 15 years.

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

**Table 9-3. Maximum CEDEs to a person hypothetically ingesting NNSS game animals sampled from 2001–2015**

Game Animal	Sample Location	Year Sampled	Amount Consumed	CEDE for Consumption of One Animal (mrem)
Bobcat	Area 25 (roadkill)	2012	all muscle	0.032
Chuckar	Area 12 (E-Tunnel)	2001	breast muscle	0.006
Gambel's quail	Area 2 (T2)	2002	all muscle	0.004
Jackrabbit	Area 10 (Sedan)	2015	all muscle	1.298
Mountain lion	NTTR (natural mortality of study lion NNSS4)	2013	all muscle	0.095
Mourning dove	Area 20 (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 antelope	Area 10 (roadkill)	2015	all muscle	2.869

### 9.1.1.3 Dose from Ingestion of Plants from the NNSS

Current NNSS land use practices discourage the harvest of plants or plant parts for direct consumption by humans. However, it is possible that individuals with access might collect and consume edible plant material. One species in particular, the pinyon pine tree, produces pine nuts that are harvested and consumed across the western United States. Pinyon pine trees grow throughout regions of higher elevation on the NNSS. During 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 2015.

### 9.1.1.4 Dose from Drinking Contaminated Groundwater

The 2015 groundwater monitoring data indicate that groundwater from offsite private and community wells and springs has not been impacted by past NNSS nuclear testing operations (see Sections 5.1.3.5 and 7.2). 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 (see 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 annually (see Chapter 6). In 2015, the only place where the public has the potential to be exposed to direct radiation from NNSS operations is 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 possible 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, no members of the public could access these areas for significant periods of time. However, for purposes of documenting potential impacts, the possible pathways for radionuclide movement from waste disposal facilities are monitored.

During 2015, 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 (see 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.

The dose from the air pathway can be estimated from air monitoring results from stations near the RWMSs (see Chapter 4, Figure 4-2 and Chapter 10, Table 10-4). Mean concentrations of radionuclides in air at the Area 3 and Area 5 environmental sampler locations were, at the most, only 14% of their CLs (see Chapter 10, Table 10-4). Scaling this to the 10-mrem dose that the CL represents would be 1.4 mrem (0.014 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 no man-made radionuclides have been detected in wells accessible to the offsite public or in private wells or springs (see Chapter 5, Section 5.1.1.3.5 and Chapter 7, Section 7.2). 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 (see Section 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 DOE facility operations is 100 mrem/yr (1 mSv/yr) excluding background radiation, while considering air transport, ingestion, and direct exposure pathways. For 2015, 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 below to present an estimate of the total 2015 dose to the *maximally exposed individual (MEI)* (see [Glossary, Appendix B](#)) residing off site.

In the recent past, the MEI for the air pathway was considered to be a hypothetical person residing at the critical receptor station with the highest dose (Schooner). However, in an effort to give a more realistic estimate, the 0.04 mrem/yr (0.0004 mSv/yr) dose estimate for the Gate 510 critical receptor station is now used for the dose estimate for an offsite MEI (see Section 4.1.5). If the offsite MEI is assumed to also eat wildlife from the NNSS, additional dose would be received. The additional dose may be 0.05 mrem (0.0005 mSv) from eating one bighorn sheep from the NNSS (Table 9-2) and could range up to 3.23 mrem (0.0323 mSv) if a person ate a mule deer having elevated radionuclide concentrations like the mule deer sampled in 2014 in Area 19 (Table 9-3). The maximum dose someone would receive from eating animals sampled in 2015 would be 2.87 mrem (0.0287 mSv) from the pronghorn antelope sampled in Area 10. Since this is a 2015 result, it will be used for the game ingestion pathway dose for this year. When the 0.04 mrem (0.0004 mSv) dose from the air pathway is added, the TEDE to this hypothetical MEI from all exposure pathways combined and solely due to NNSA/NFO activities would be 2.91 mrem/yr (0.0291 mSv/yr) (Table 9-4).

**Table 9-4. Estimated radiological dose to a hypothetical MEI of the general public from 2015 NNSS operations**

Pathway	Dose to MEI		Percent of DOE 100 mrem/yr Limit
	(mrem/yr)	(mSv/yr)	
Air <sup>(a)</sup>	0.04	0.0004	0.04
Water <sup>(b)</sup>	0	0	0
Wildlife <sup>(c)</sup>	2.87	0.0287	2.87
Direct <sup>(d)</sup>	0	0	0
<b>All Pathways</b>	<b>2.91</b>	<b>0.0291</b>	<b>2.91</b>

(a) Based on annual average concentrations at the compliance station nearest the offsite public (Section 4.1.5, Table 4-8)

(b) Based on all offsite groundwater sampling conducted by NNSA/NFO to date (Section 5.1)

(c) Based on consuming one animal sampled in 2015 which would result in the highest dose (Table 9-2)

(d) Based on 2015 gamma radiation monitoring data at the NNSS entrance (Section 6.3.1)

The total dose of 2.91 mrem/yr to the hypothetical MEI is 2.91% of the DOE limit of 100 mrem/yr and about 0.81% 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 CEMP (101.6 milliroentgens per year [mR/yr], rounded to 102 mR/yr; see Chapter 7, Table 7-4). The radiation exposure in air, measured by the PIC in units of mR/yr, is approximately 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).

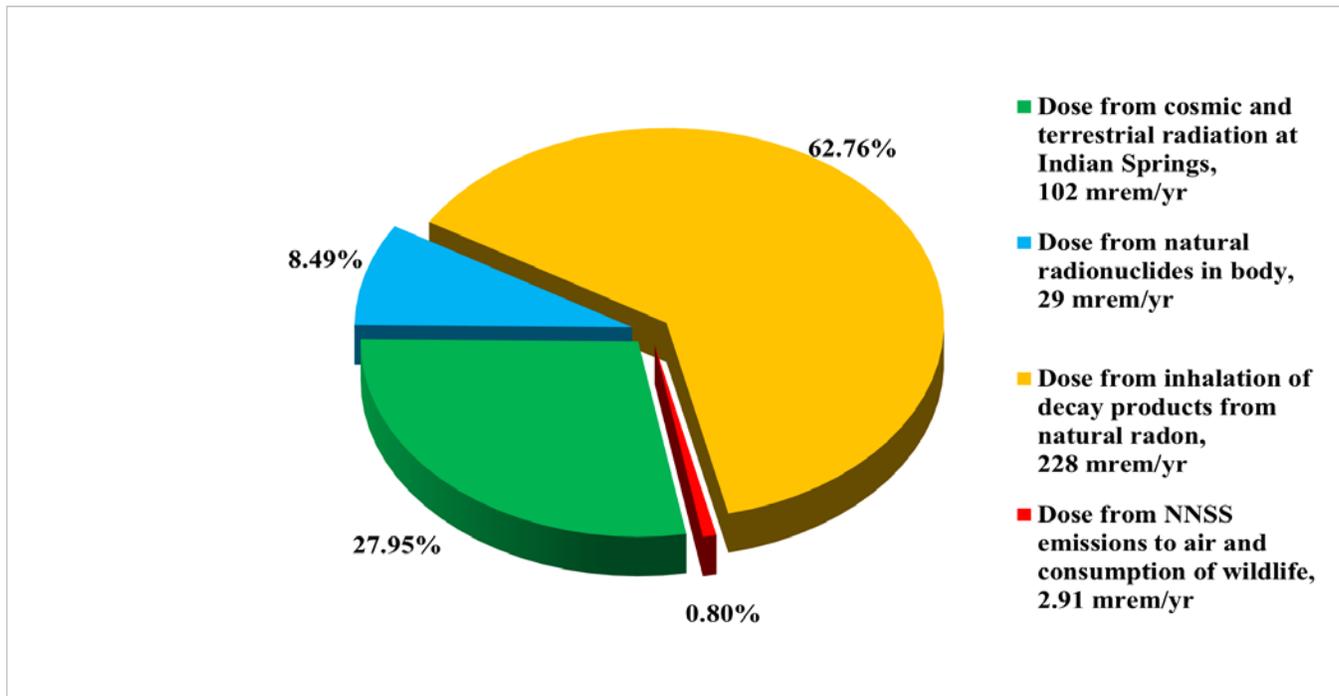


Figure 9-1. Comparison of radiation dose to the MEI from the NNSS and natural background (percent of total)

#### 9.1.4 Collective Population Dose

The *collective population dose* (see [Glossary, Appendix B](#)) to residents within 80 km (50 mi) of the NNSS emission sources was not estimated in 2015. DOE approved the discontinuance of reporting collective population dose from NNSS operations after 2004 because it is so low for the NNSS. It has been below 0.6 person-rem/yr for the period from 1992, when it was first calculated and reported to DOE, through 2004 (Figure 9-2). The relatively large increase in collective population dose seen in 1994 in Figure 9-2 was due to two changes. The first was the inclusion of plutonium resuspension in air from soils across all areas of the NNSS instead of from soils from only a few areas of the NNSS in 1992 and 1993. The second was a large increase in the surrounding population in 1994, as Pahrump's population increased by 7,000 and the population of Tonopah (4,200) was added to the calculation.

DOE recommended that NNSA/NFO should consider reporting collective population dose once again if ever it exceeds 1.0 person-rem/yr (DOE 2004). It will be recalculated when either the radionuclide emissions from NNSS activities or the population within 80 km (50 mi) of the NNSS increase significantly (e.g.,  $\geq 50\%$ ), both of which are estimated annually (see Section 1.7 for population estimates).

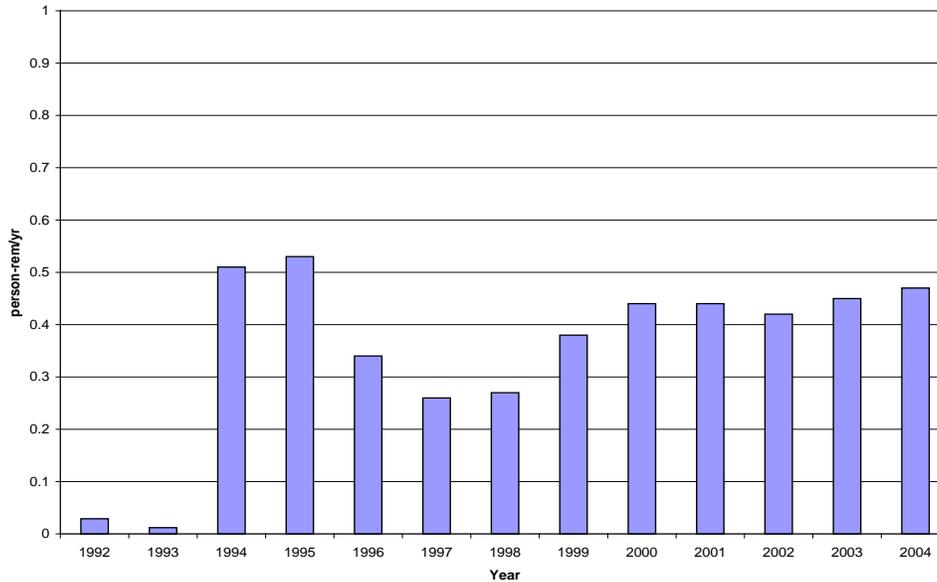


Figure 9-2. Collective population dose within 80 km (50 mi) of NNSS emission sources from 1992 to 2004

### 9.1.5 Release of Property Containing Residual Radioactive Material

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

All NNSA/NFO contractors use a graded approach for release of material and equipment for unrestricted public use. Items are either surveyed prior to release to the public, or a process knowledge evaluation is conducted to verify that the material has not been exposed to radioactive material or beams of radiation capable of generating radioactive material. In some cases, both a radiological survey and a process knowledge evaluation are performed (e.g., a radiological survey is conducted on the outside of the item, and a process knowledge form is signed by the custodian to address inaccessible surfaces). Items are evaluated/surveyed prior to shipment to the NNSA/NFO property/excess warehouse. All contractors also complete material surveys prior to release and transport to the Area 23 landfill. The only exception is for items that could be internally contaminated; these items are submitted to Waste Generator Services for disposal using one of the facilities that can accept LLW. Excess items that can be free-released are either donated to interested state agencies, federal agencies, or universities; redeployed to other onsite users; or sold on an auction website.

In 2015, 338 pieces of laboratory equipment, 11 vehicles, 2 pieces of heavy equipment, 35 miles of ground surface laid cable, 146,534.25 gallons of used highly refined mineral oil (Shell Diala® Oil AX), and 420,169 pounds of scrap metal were released off site to the public. No released items had residual radioactivity in excess of the limits specified in Table 9-5.

Independent verification of radiological surveys and process knowledge evaluations performed by NSTec (the Management and Operating contractor) 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 Managers' Council Internal Assessment Schedule, and DOE O 458.1 assessments are scheduled to occur once every three years. The last assessment was conducted in 2013. In 2013, NNSS property release activities were found to be in compliance with the order.

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

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

(a) Disintegrations per minute per 100 square centimeters (cm<sup>2</sup>)

Source: Radiological Control Manager's Council (2012)

(b) Averaged over an area of not more than 100 cm<sup>2</sup>(c) Applicable to an area of not more than 100 cm<sup>2</sup>

## 9.2 Dose to Aquatic and Terrestrial Biota

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

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

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

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

- Identification of terrestrial and aquatic habitats on the NNSS that have radionuclides in soil, water, or sediment
- Identification of terrestrial and aquatic biota on the NNSS that occur in contaminated habitats and are 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). This dose 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 that NNSS surface contamination conditions have not worsened; therefore, this biota dose evaluation conclusion remains the same for 2015.

### 9.2.1 2015 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 2015, the RESRAD-BIOTA, Version 1.5, computer model (DOE 2004) was used. Maximum concentrations of man-made radionuclides detected in plant and animal tissue (see Table 8-3 in Section 8.3.1 and Table 8-5 in Section 8.3.2) were used as input to the model. External dose was based on the measured annual exposure rate using the maximum quarterly thermoluminescent dosimeter (TLD) measurement made closest to each biota sampling site (see Table 6-1 of Chapter 6), minus the average NNSS background exposure rate (see Table 6-2 of Chapter 6). If the average background exposure rate was higher than the monitored location, then man-made external dose was set to zero. The TLD locations used are shown in Table 9-6.

The 2015 site-specific estimated dose rates to biota were all below the DOE limits for both plants and animals (Table 9-6). No man-made radionuclides were detected in samples from the Sedan control site or in the mule deer or pronghorn antelope from Areas 5 and 6. Therefore, no dose is calculated for these plants and animals. The highest dose was predicted for plants at Sedan in Area 10 followed by jackrabbits at that location. Internal dose accounted for an average of 93% of the total dose over all.

**Table 9-6. Site-specific dose assessment for terrestrial plants and animals sampled in 2015**

Location and Species <sup>(a)</sup>	Nearest TLD Location	Estimated Radiological Dose (rad/d)		
		Internal <sup>(b)</sup>	External <sup>(c)</sup>	Total
<b>Terrestrial Plants</b>				
Sedan (Area 10) (3 species)	T10	0.0043467	0.00031	0.00466
			<b>DOE Dose Limit:</b>	<b>1</b>
<b>Terrestrial Animals</b>				
Sedan (Area 10) (2 jackrabbits)	T10	0.0018168	0.00031	0.00213
Pronghorn (animal receiving maximum dose) (Area 10)	Circle & L Roads	0.0006577	0.00000	0.00066
			<b>DOE Dose Limit:</b>	<b>0.1</b>

(a) For information on plants and animals sampled, see Chapter 8, Tables 8-3 and 8-5

(b) Based on maximum concentrations of each man-made radionuclide detected in plants and animals sampled at that location

(c) Based on maximum TLD measured exposure rates at or near the sample location, see Chapter 6

### 9.2.2 Dose Assessment Summary

Radionuclides in the environment from past or present NNSS activities result in a potential dose to the public or biota much lower than dose limits set to protect health and the environment. The estimated dose to the MEI for 2015 was 2.91 rem/yr (0.0291 mSv/yr), which is 2.91% of the dose limit set to protect human health. Dose to biota at the NNSS sites sampled in 2015 were less than 3% 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.

## 9.3 References

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## Chapter 10: Waste Management

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Several federal and state regulations govern the safe management, storage, and disposal of radioactive, hazardous, and solid wastes generated or received on the Nevada National Security Site (NNSS) (see Section 2.5). This chapter describes the waste management operations conducted by Environmental Management of the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) and summarizes the activities performed in 2015 to meet all environmental/public safety regulations and to meet the major goals of the program shown below.

### Waste Management Goals

Manage and safely dispose of *low-level waste (LLW)*, *mixed low-level waste (MLLW)* (see [Glossary, Appendix B](#)), and non-radioactive classified waste/matter, which are generated by NNSA/NFO, other U.S. Department of Energy (DOE) approved generators, or selected U.S. Department of Defense (DoD) operations.

Manage and safely store *transuranic (TRU)* (see [Glossary, Appendix B](#)) and mixed transuranic (MTRU) wastes generated on site for eventual shipment to the Waste Isolation Pilot Plant (WIPP) in Carlsbad, New Mexico.

Manage, safely store, and ship hazardous wastes generated on the NNSS to approved offsite treatment/storage/disposal facilities, and treat by open detonation explosive ordnance wastes generated on the NNSS.

Ensure that wastes received for disposal meet NNSS waste acceptance criteria.

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).

Manage 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."

Manage and safely dispose of solid/sanitary wastes generated by NNSA/NFO operations.

Manage underground storage tanks (USTs) to prevent environmental contamination.

Ensure that disposal systems meet performance objectives.

### 10.1 Radioactive Waste Management

The NNSS Radioactive Waste Management facilities include the *Area 5 RWMC* (see [Glossary, Appendix B](#)) and the Area 3 RWMS. They operate as Category II non-reactor nuclear facilities. The Area 5 RWMC (Figure 10-1) is composed of the Area 5 RWMS, the Waste Examination Facility (WEF), and the Hazardous Waste Storage Unit (HWSU). The HWSU is discussed in Section 10.2. This Section describes the facilities and processes that comprise the safe receipt, storage, disposal, and disposal unit monitoring of radioactive wastes at the NNSS.

#### 10.1.1 Area 5 RWMS

The Area 5 RWMS is a DOE-owned radioactive waste disposal facility. It encompasses approximately 740 acres (ac), including 200 ac of historical and active disposal cells used for burial of LLW, MLLW, Non-Radiological Classified (NRC) waste, and Non-Radiological Classified Hazardous (NRCH) waste, and 540 ac of land available for future radioactive disposal cells. Waste disposal at the Area 5 RWMS occurred in a 92-ac portion of the site starting in the early 1960s. This "92-Acre Area" (Figure 10-1) consists of 31 disposal cells and 13 Greater Confinement Disposal (GCD) 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 and continue to be monitored and reseeded as necessary to aid the

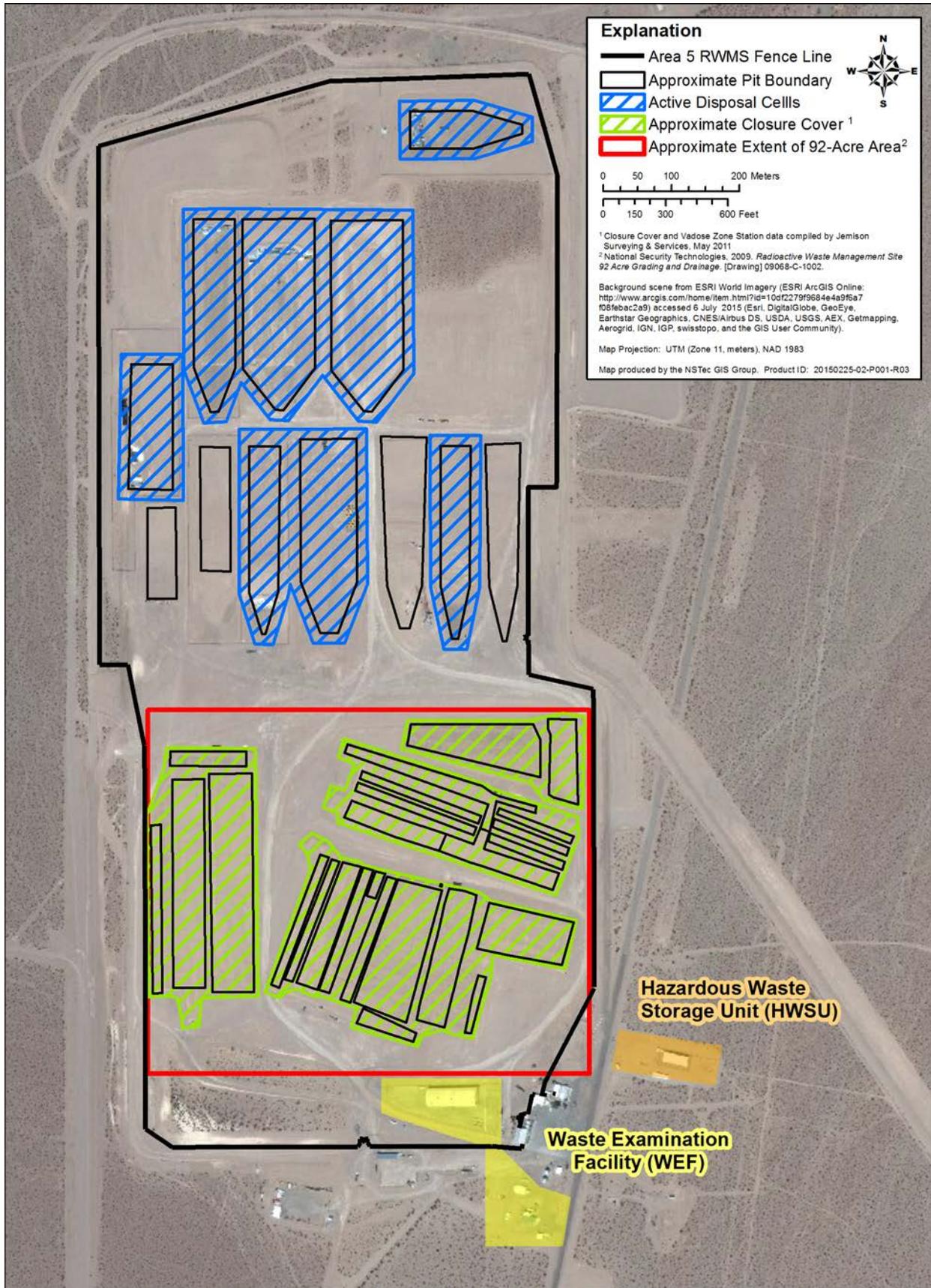


Figure 10-1. The Area 5 RWMC

establishment of a successful vegetative cover (see Section 15.4). Seven cells, developed immediately north and west of the 92-Acre Area, have been receiving wastes since 2010. They include six LLW cells (Cells 19, 20, 21, 22, 27, and 28) and a MLLW cell (Cell 18). All active Area 5 RWMS cells can accept radioactive waste contaminated with non-regulated polychlorinated biphenyl (PCB) bulk product waste, but only Cell 18 can accept waste contaminated with regulated PCB remediation waste as well as asbestos-contaminated MLLW. Cells 18, 19, 20, 21, 22, 27, and 28 can accept asbestos-contaminated LLW. All disposal cells that were active in 2015 are shown in Table 10-1. MLLW disposal services are expected to continue at the Area 5 RWMS until the remaining needs of the DOE complex are met.

Disposal Cell 18 is operated under a Resource Conservation and Recovery Act (RCRA) Part B Permit (NEV HW0101), which authorizes the disposal of up to 25,485 cubic meters (m<sup>3</sup>) (899,994 cubic feet [ft<sup>3</sup>]) of MLLW and NRCH. The volume and weight of wastes that Cell 18 received in 2015 are shown in Table 10-1. A cumulative total of 11,413 m<sup>3</sup> (403,022 ft<sup>3</sup>) of MLLW/NRCH has been disposed in Cell 18 through the end of 2015. Quarterly reports were submitted to the State of Nevada in 2015 to document the weight in tons of MLLW/NRCH disposed each quarter in Cell 18.

In 2015, the Area 5 RWMS received shipments containing a total of 37,780 m<sup>3</sup> (1,334,186 ft<sup>3</sup>) of radioactive waste for disposal (Table 10-1), which included both NRC and NRCH waste. The majority of waste disposed was received from offsite generators. The total number of waste shipments during fiscal year (FY) 2015 (October 1, 2014–September 30, 2015) were reported in an annual transportation report (NSTec 2016a). In 2015, all offsite waste generators delivering MLLW for disposal in Cell 18 that contained regulated quantities of PCBs were issued Certificates of Disposal, as required under the Toxic Substances Control Act.

**Table 10-1. Total waste volumes received and disposed at the Area 5 RWMS in calendar year 2015**

Waste Type	Disposal Cell(s)	Volume Received and Disposed in m <sup>3</sup> (ft <sup>3</sup> )
LLW and NRC	Cells 19, 20, 21, 22, 27, and 28	35,062 (1,238,210)
MLLW and NRCH (includes regulated PCB-contaminated LLW)	Cell 18	2,718 (95,975); 1,379 tons <sup>(a)</sup>
	<b>Total</b>	<b>37,780 (1,334,186)</b>

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

### 10.1.2 WEF

The 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, and the Visual Examination and Repackaging Building. The WEF was used for the staging, characterization, repackaging, and offsite shipment of legacy TRU wastes that had been stored for many years at the NNSS. This activity was completed in 2009.

Currently, The TRU Pad and TPCB are authorized for the safe storage of radioactive mixed waste under the current RCRA Permit (NEV HW0101). The TPCB accepts TRU/MTRU waste from NNSS generators including the Joint Actinide Shock Physics Experimental Research (JASPER) facility. The TPCB stores the waste until it is characterized for disposal at the WIPP in Carlsbad, New Mexico. In 2015, the TRU waste remaining in storage at the TPCB consisted of two experimental spheres from Lawrence Livermore National Laboratory and 29 standard waste boxes from JASPER.

### 10.1.3 Area 3 RWMS

Disposal operations at the Area 3 RWMS (Figure 10-2) began in the late 1960s. The Area 3 RWMS consists of seven subsidence craters configured into five disposal cells. Each subsidence crater was created by an underground weapons test. Until July 1, 2006, when the site was placed into inactive status, the site was used for disposal of bulk LLW, such as soils or debris, and waste in large cargo containers. The site consists of the following seven craters:

2 Disposal Cells (Inactive Status):

U-3ah/at  
U-3bh

1 Closed Cell:

U-3ax/bl  
(Corrective Action Unit 110)

2 Undeveloped Cells:

U-3az  
U-3bg

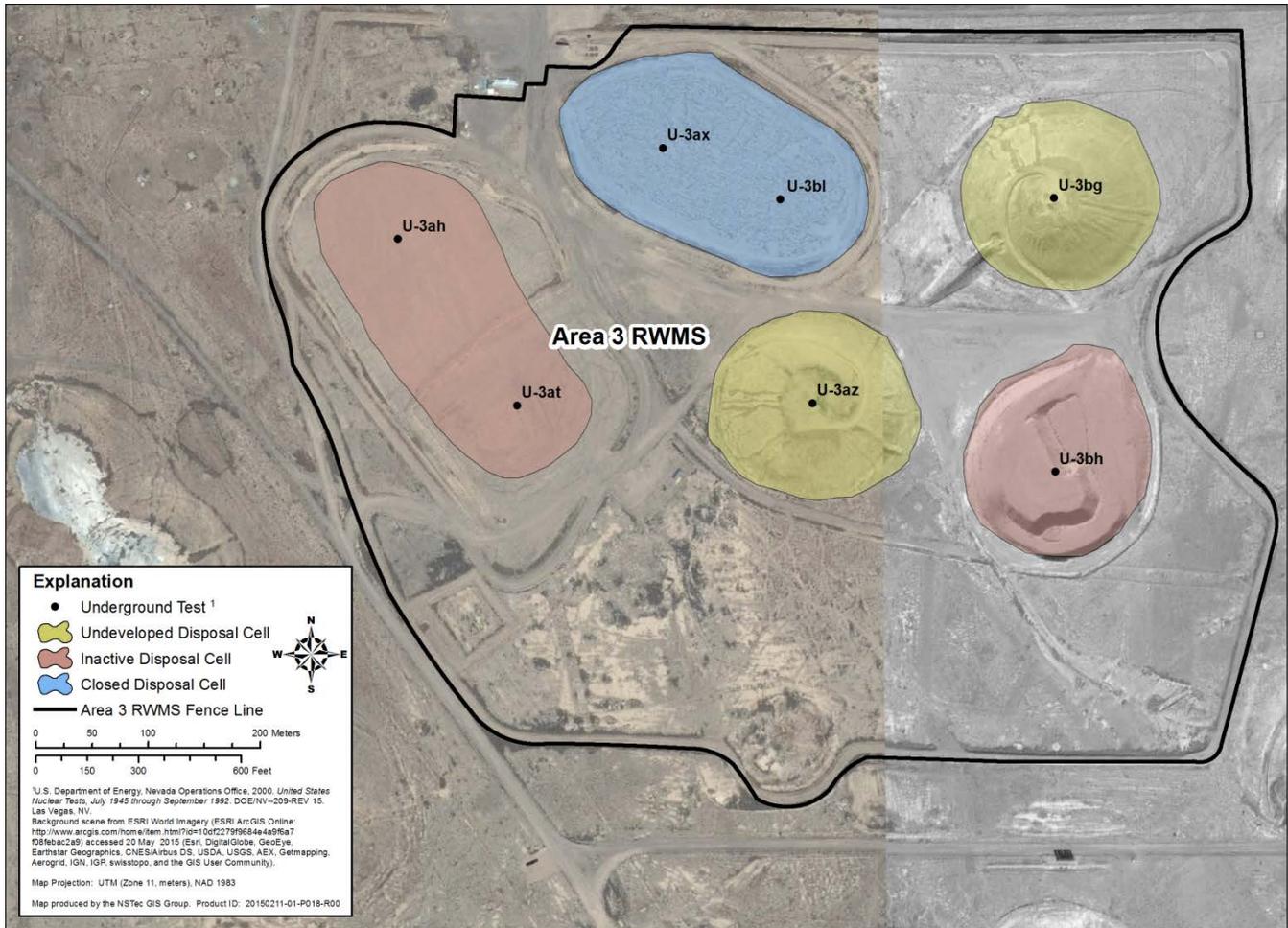


Figure 10-2. The Area 3 RWMS

### 10.1.4 Waste Characterization

All generators of waste streams must demonstrate eligibility for waste to be disposed at the NNSS, submit profiles characterizing specific waste streams, meet the NNSS Waste Acceptance Criteria, and receive programmatic approval from NNSA/NFO for their site waste certification programs.

Characterization is performed by approved NNSA/NFO waste generators using knowledge of the generating process, sampling and analysis, or non-destructive analysis. Following the characterization of a waste stream, the approved NNSA/NFO waste generator develops a waste profile. The waste profile delineates the pedigree of the waste, including, but not limited to, a description of the waste generating process, physical and chemical characteristics, radioactive isotope activity and quantity, and packaging information. The waste profile is reviewed by the Waste Acceptance Review Panel for eventual approval or disapproval by NNSA/NFO. The approved waste generator then packages and ships approved waste streams in accordance with U.S. Department of Transportation requirements to the Area 5 RWMC or to an offsite facility for treatment, if necessary, prior to its return shipment for disposal at the Area 5 RWMC.

In 2015, 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
- Contaminated PCB Waste
- Compactable Trash
- Contaminated Soils
- Depleted Uranium
- Contaminated Asbestos Waste
- Non-radioactive Classified Matter/Waste

### 10.1.5 Mixed Waste and Classified Non-Radioactive Hazardous Matter Verification

Waste verification is an inspection process that confirms the waste stream data supplied by approved waste generators before MLLW or non-radioactive classified hazardous waste is accepted for disposal at the NNSS. Verification may involve visual inspection, Real-Time Radiography (RTR), and/or chemical screening on a designated percentage of MLLW or non-radioactive classified hazardous matter. The objectives of waste verification include verifying that hazardous waste 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 2015, offsite visual inspections were completed on 66 MLLW packages from 15 separate waste streams, on one radioactive classified hazardous matter package from one matter stream, and on three non-radioactive classified hazardous matter packages from two separate matter streams. No RTR or chemical screening was required in 2015. No onsite visual inspection was conducted in 2015. No MLLW or non-radioactive classified hazardous matter packages were rejected during 2015.

### 10.1.6 Performance Assessments, Analyses, and Annual Reviews

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

In 2015, NNSA/NFO 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 2015 annual summary report to DOE (NSTec 2016b) presented data and conclusions that verified the adequacy of both the Area 3 and Area 5 PAs and CAs. Table 10-2 lists the key documents that must be current and in place for RWMS disposal operations to occur. In 2015, all of these key documents were maintained.

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

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**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  
 2015 Annual Summary Report for Area 3 and 5 RWMSs at NNSS (Review of Performance Assessments and Composite Analyses), February 2016

**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

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**Table 10-2. Key documents required for Area 3 RWMS and Area 5 RWMS disposal operations (continued)****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 Area 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 Area 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 Area 3 and 5 RWMS LLW Activities, Revision 7, Change Notice 4, May 2012

**10.1.7 Groundwater Monitoring**

Disposal Cell 18 is operated according to RCRA standards for the disposal of MLLW. Title 40 Code of Federal Regulations (CFR) Part 264, Subpart F (40 CFR 264.92) requires groundwater monitoring to verify the performance of Cell 18 to protect groundwater from buried hazardous wastes. Wells UE5 PW-1, UE5 PW-2, and UE5 PW-3 are monitored for this purpose. Investigation levels (ILs) for five indicators of groundwater contamination (Table 10-3) were established by NNSA/NFO and the Nevada Division of Environmental Protection (NDEP) for these three wells in 1998. All samples collected semiannually in 2015 from the wells had contaminant levels below their ILs (Table 10-3). Static water levels and general water chemistry parameters are also monitored. All sample analysis results are presented in NSTec (2016c). The tritium levels were very low, all below the sample-specific *minimum detectable concentration (MDC)* (see [Glossary, Appendix B](#)) of about 250 pCi/L. (Table 5-5 of Chapter 5, Section 5.1.1.2, presents the sample-specific MDCs for each water sample collected from these wells in 2015.) No groundwater contamination from Cell 18 is indicated by the 2015 results.

**Table 10-3. Results of groundwater monitoring of UE5 PW-1, UE5 PW-2, and UE5 PW-3 in 2015**

Parameter	Investigation Level (IL)	Sample Levels <sup>(a)</sup>
pH	< 7.6 or > 9.2 S.U. <sup>(b)</sup>	8.19 to 8.38 S.U.
Specific conductance (SC)	0.440 mmhos/cm <sup>(c)</sup>	0.360 to 0.382 mmhos/cm
Total organic carbon (TOC)	1 mg/L <sup>(d)</sup>	<0.33 to 0.60 mg/L
Total organic halides (TOX)	50 µg/L <sup>(e)</sup>	<3.3 µg/L
Tritium ( <sup>3</sup> H)	2,000 pCi/L <sup>(f)</sup>	ND <sup>(g)</sup>

(a) Levels shown are the lowest and highest values for each well for each sample date.

Source: NSTec (2016c)

(b) S.U. = standard unit(s) (for measuring pH)

(c) mmhos/cm = millimhos per centimeter

(d) mg/L = milligrams per liter

(e) µg/L = microgram(s) per liter

(f) pCi/L = picocuries per liter

(g) ND = not detected; levels were below sample-specific MDCs

**10.1.8 Vadose Zone Monitoring**

Monitoring of the vadose zone (unsaturated zone above the water table) is conducted at the RWMC to demonstrate that (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 eight nests of instruments in five waste disposal cell covers that measure water content and water potential profiles in the covers. 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 2015 are reported in NSTec (2016d). All VZM results in 2015 continued to demonstrate that there is negligible infiltration of precipitation into zones of buried waste at the RWMC and that the performance criteria of the waste disposal cells are being met to prevent contamination of groundwater and the environment.

### 10.1.9 Assessment of Radiological Dose to the Public

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

#### 10.1.9.1 Dose from Air and Direct Radiation

Air samplers operate continuously to collect air particulates and atmospheric moisture near each RWMS. These samples are analyzed for radionuclides, and results are used to assess potential dose. Details of the air sampling and a summary of the analysis results can be found in Chapter 4. In 2015, three environmental sampling stations operated in/near the Area 3 RWMS (U-3ax/bl S, Bilby Crater, and Kestrel Crater N), and two air monitoring stations operated near the Area 5 RWMS (DoD and RWMS 5 Lagoons). The dose from the air pathway was estimated based on the highest annual mean concentration results for each measured radionuclide from among these five stations in order to estimate a worst-case dose for a member of the public at either of the RWMSs.

The highest annual mean concentration of each measured radionuclide among the five stations, and the station at which the highest concentration occurred, are shown in Table 10-4. The highest concentration of any radionuclide was 3,180 microcuries per milliliter ( $\mu\text{Ci/mL}$ ) for  $^3\text{H}$  at RWMS 5 Lagoons. All four of the highest mean concentrations shown in Table 10-4 were far below their established National Emission Standards for Hazardous Air Pollutants (NESHAP) Concentration Levels for Environmental Compliance (CLs) (Table 10-4, fourth column). The highest mean concentration of each measured radionuclide is divided by its respective CL to obtain a “fraction of CL” (Table 10-4, right-most column). The fractions are then summed, and if the sum is less than 1, it demonstrates that the NESHAP dose limit of 10 mrem/yr was not exceeded at a location having all those radionuclides at those concentrations. Summing the fractions of CLs gives 0.14, which is only 14% of the limit in this worst-case scenario. Scaling this to the 10 mrem dose that the CLs represent would mean that a hypothetical person residing near the RWMS would receive an annual dose of about 1.4 mrem/yr from the air pathway.

**Table 10-4. Highest annual mean concentrations of radionuclides detected in 2015 at Area 3 and Area 5 RWMS**

Radionuclide	RWMS Sampler with Highest Concentration	Highest Annual Mean Concentration ( $\times 10^{-15} \mu\text{Ci/mL}$ )	NESHAP CL <sup>(a)</sup> ( $\times 10^{-15} \mu\text{Ci/mL}$ )	Fraction of CL
$^3\text{H}$	DOD	1,071	1,500,000	0.00071
$^{238}\text{Pu}$	Kestrel Crater N	0.00538	2.1	0.0026
$^{239}\text{Pu}$	U-3ax/bl S	0.230 ( $^{239+240}\text{Pu}$ )	2	0.12
$^{241}\text{Am}$	U-3ax/bl S	0.0366	1.9	0.019
<b>Sum of Fractions:</b>				<b>0.14</b>

(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 5 locations in and around the Area 3 RWMS and 12 locations in and around the Area 5 RWMS. The TLDs have three calcium sulfate elements used to measure the total exposure rate from penetrating gamma radiation, including background radiation. The penetrating gamma radiation makes up the deep dose, which is compared to the 25 mrem/yr limit when background exposure is subtracted. Details of the direct radiation monitoring can be found in Chapter 6. During 2015, the external radiation measured near the boundaries of the Area 3 and Area 5 RWMSs could not be distinguished from background levels (see Section 6.3.4). Area 3 and Area 5 RWMS operations would have contributed negligible external exposure to a hypothetical person residing near the boundaries of these sites and no dose to the offsite public.

### **10.1.9.2 Dose from Groundwater**

Groundwater and vadose zone monitoring at the RWMSs is conducted to verify the performance of waste disposal facilities. Such monitoring has not detected the migration of radiological wastes into groundwater (see 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 (see Chapter 5, Table 5-4 and Section 5.1.1.3.5, and Chapter 7, Section 7.2). Based on these results, potential doses to members of the public from LLW disposal facilities on the NNSS from groundwater, and from all pathways combined, are negligible.

## **10.2 Hazardous Waste Management**

Hazardous waste regulated under RCRA is generated at the NNSS from a broad range of activities, including onsite laboratories, site and vehicle maintenance, communications operations, and environmental restoration of historical contaminated sites (see Chapter 11). The RCRA Part B Permit NEV HW0101 regulates the operation of the Area 5 Mixed Waste Disposal Unit (MWDU), consisting of a Subtitle C landfill (Cell 18) and 3,000 gallon leachate collection tank, the Area 5 Hazardous Waste Storage Unit (HWSU), and the Area 11 Explosive Ordnance Disposal Unit (EODU) facilities. Included in the RCRA Part B permit is authorization for the storage of MLLW at the Mixed Waste Storage Unit (MWSU), which comprises the following four facilities at the Area 5 RWMC: the TPCB and TRU Pad, the Sprung Instant Structure Building, the Visual Examination and Repackaging Building, and the Drum Holding Pad.

The HWSU (Figure 10-1) is a pre-fabricated, rigid-steel-framed, roofed shelter that is permitted to store a maximum of 61,600 liters (16,273 gallons) of approved waste at a time. Hazardous waste generated at NNSA/NFO environmental restoration sites off the NNSS (e.g., at the Tonopah Test Range) or generated at the North Las Vegas Facility are direct-shipped to approved disposal facilities. Hazardous waste 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 hazardous waste that is not accepted at the HWSU for storage. Hazardous waste would also be direct-shipped from NNSS sites in the unlikely case when the waste volume capacity of the HWSU is approaching its permitted limits. Satellite Accumulation Areas (SAAs) and 90-day Hazardous Waste Accumulation Areas (HWAAs) are used at the NNSS for the temporary storage of hazardous waste prior to direct shipment off site or to the HWSU.

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

### **10.2.1 2015 Hazardous Waste Activities**

The RCRA permit requires preparation of a U.S. Environmental Protection Agency Biennial Hazardous Waste Report of all hazardous waste volumes generated and disposed or stored at the NNSS. This report is prepared for odd-numbered years only. It was most recently prepared for 2015 and electronically submitted to the State of Nevada February 1, 2016. The next biennial report will be prepared for 2017 and submitted to the state in 2018. An annual waste volume report was prepared in 2015 and submitted to the State of Nevada in March 2016 (NSTec 2016e). It includes the amount of wastes received in calendar year 2015 at the Area 5 MWDU, MWSU, HWSU, and Area 11 EODU.

Table 10-5 presents the quantities of hazardous waste generated either on or off site that were managed (received, stored, shipped, or disposed) at the various NNSS waste units during calendar year 2015. 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 hazardous waste with and without PCBs received, stored, and shipped off site from the HWSU; and the tons of hazardous waste stored and then shipped off site from one or more HWAAAs. In 2015, no hazardous waste was direct-shipped from NNSS HWAAAs or SAAs. Quarterly 2015 hazardous waste volume reports were submitted on schedule to NDEP.

No waste explosive ordnance were detonated at the EODU in 2015.

**Table 10-5. Hazardous waste managed at the NNSS in 2015**

Unit	Amount Received (tons) <sup>(a)</sup>	Amount Shipped (tons)	Amount Disposed (tons)
MWDU Cell 18	1,338	0	1,338
MWSU	0.29	0.75	--
HWSU	6.90	7.75	--
HWSU – PCB Waste	0.005	0.92	--
HWAA	NA <sup>(b)</sup>	0	--
EODU	0	0	0

(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 HWAAAs are not tracked, only the length of time they are stored and the amounts shipped off from all HWAAAs combined are tracked.

Each year, NDEP performs a Compliance Evaluation Inspection (CEI) of the RCRA permitted hazardous waste units at the NNSS. On April 27 and 28, 2015, NDEP conducted its CEI of the waste units listed in Table 10-5 as well as of closed historic RCRA waste management units at the NNSS (see Chapter 11, Section 11.4). The 2015 CEI documented that NNSA/NFO was compliant with the NNSS Part B Permit.

### 10.3 Underground Storage Tank (UST) Management

RCRA regulates the storage, transportation, treatment, and disposal of hazardous wastes to prevent contaminants from leaching into the environment from USTs. Nevada Administrative Code NAC 459.9921–459.999, “Storage Tanks,” enforces the federal regulations under RCRA pertaining to the maintenance and operation of USTs and the regulated substances contained in them so as to prevent environmental contamination. NNSA/NFO operates one deferred UST and three excluded USTs at the Device Assembly Facility; one fully regulated UST at the Area 6 Helicopter pad, which is not in service; and three fully regulated USTs, one deferred UST, and three excluded USTs at the Remote Sensing Laboratory–Nellis (RSL–Nellis). NDEP has oversight authority of the NNSS USTs, and the Southern Nevada Health District has oversight authority of USTs in Clark County (see Appendix A, Section A.2.3 regarding UST management at RSL–Nellis). NDEP usually conducts inspections of NNSS USTs once every 3 years. No inspections were conducted in 2015 since they were last conducted in 2013. In 2015, no NNSS USTs were upgraded or removed.

### 10.4 Solid and Sanitary Waste Management

Three landfills for solid waste disposal were operated at the NNSS in 2015. The landfills are regulated and permitted by the State of Nevada (see Table 2-3 for list of permits). No liquids, hazardous waste, or radioactive waste are accepted in these landfills. They include:

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

These landfills are designed, constructed, operated, maintained, and monitored in adherence to the requirements of their state permits. NDEP visually inspects the landfills and checks the records on an annual basis to ensure compliance with the permits. No non-compliance issues were noted during the July 2015 NDEP inspection. The

amount of waste disposed in each solid waste landfill is shown in Table 10-6. Biannual reports for the Area 23 Solid Waste Landfill were submitted in July 2015 and January 2016 to NDEP (NSTec 2015, 2016f).

The vadose zone is monitored at the Area 6 Hydrocarbon Landfill and the Area 9 U10c Solid Waste Landfill. VZM is performed once annually in lieu of groundwater monitoring to demonstrate that contaminants from the landfills are not leaching into the groundwater. VZM in 2015 indicated that there was no soil moisture migration and, therefore, no waste leachate migration to the water table. Annual 2015 soil moisture monitoring reports for the Area 6 and Area 9 sites were submitted in May 2016 to NDEP (NSTec 2016g, 2016h).

**Table 10-6. Quantity of solid wastes disposed in NNSS landfills in 2015**

Waste Disposed in Landfills in Metric Tons (Tons)		
Area 6	Area 9	Area 23
20.5 (22.5)	759.1 (835)	339.1 (373)

## 10.5 References

- National Security Technologies, LLC, 2007. *Maintenance Plan for Performance Assessments and Composite Analyses of the Area 3 and Area 5 Radioactive Waste Management Sites at the Nevada Test Site*. DOE/NV/25946--091, prepared for U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office, Las Vegas, NV. OSTI ID: 914419
- National Security Technologies, LLC, 2015. *January–June 2015 Biannual Solid Waste Disposal Site Report for the Nevada National Security Site Area 23 Sanitary Landfill*, prepared for U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office, Las Vegas, NV, July 2, 2015.
- National Security Technologies, LLC, 2016a. *4<sup>th</sup> Quarter/Annual Transportation Report FY2015, Waste Shipments to and from the Nevada National Security Site (NNSS), Radioactive Waste Management Complex*. DOE/NV/25946--2686, prepared for U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office, Las Vegas, NV, January 2016.
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- National Security Technologies, LLC, 2016g. *Annual Soil Moisture Monitoring Report for the Area 9 U10c Landfill, Nevada National Security Site, Nevada, for the Period March 2015 – February 2016*, prepared for U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office, Las Vegas, NV.
- National Security Technologies, LLC, 2016h. *Annual Soil Moisture Monitoring Report for the Area 6 Hydrocarbon Landfill, Nevada National Security Site, Nevada, for the Period March 2015–February 2016*, prepared for U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office, Las Vegas, NV.

# Chapter 11: Environmental Restoration

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Environmental Management (EM) Operations of the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) is responsible for evaluating and implementing corrective actions on those portions 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. These sites are referred to as corrective action sites (CASs). Environmental restoration strategies and corrective actions are developed based on the nature and extent of contamination, the risks posed by that contamination, and future land use. EM is responsible for approximately 3,000 CASs in Nevada.

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

In April 1996, the DOE, the U.S. Department of Defense, and the State of Nevada entered into a Federal Facility Agreement and Consent Order (FFACO) to address the environmental restoration of CASs. Appendix VI of the FFACO (as amended), describes the strategy that will be employed to plan, implement, and complete environmental corrective actions (i.e., to "close" the CASs). ER activities follow a formal work process described in the FFACO. The State of Nevada is a participant throughout the closure process, and the [Nevada Site Specific Advisory Board \(NSSAB\)](#) is kept informed of the progress made. The NSSAB is a formal volunteer group of interested citizens and representatives who provide informed recommendations to NNSA/NFO EM. The NSSAB's comments are strongly considered throughout the corrective action process. This section summarizes actions taken by EM towards the closure of UGTA, Industrial, and Soils sites in 2015.

## *Environmental Restoration Objectives for All Sites*

- Characterize sites contaminated by NNSA/NFO nuclear testing activities.
- Remediate contaminated sites in accordance with FFACO-approved planning documents.
- Conduct post-closure monitoring of sites in accordance with FFACO closure documents.

### **11.1 UGTA Sites**

From 1951 to 1992, more than 800 underground nuclear tests, some involving multiple detonations, were conducted at the NNSS (NNSA/NFO 2015a). Most were conducted hundreds of feet above groundwater; however, over 200 were within or near the water table. The test locations (i.e., CASs) are grouped into five CAUs

based primarily on geographically distinct areas of underground testing (Figure 11-1). Closure-in-place with institutional controls (e.g., restricting land and groundwater access) and monitoring is considered to be the only feasible corrective action for these sites because cost-effective groundwater technologies have not been developed to effectively remove or stabilize deep subsurface radiological contaminants.

Corrective actions for each CAU begin with data collection and analysis activities, called characterization studies. In addition, water levels, which are routinely measured in wells throughout the NNSS and surrounding area, are evaluated to determine groundwater flow directions (e.g., Fenelon et al. 2010) (Figure 11-2). The characterization studies, NNSS water-level monitoring data, and regional three-dimensional groundwater flow models (International Technology Corporation 1996; Belcher and Sweetkind 2010) provide the basis for developing models of the hydro-geologic setting, the radiological source term, and flow and contaminant transport for each CAU. The spatial extent of these models for each CAU is presented in Figure 11-3. The numerous surface and subsurface investigations and computer modeling conducted for UGTA CAUs are performed by various participating organizations including National Security Technologies, LLC (NSTec); Los Alamos National Laboratory (LANL); Lawrence Livermore National Laboratory (LLNL); the U.S. Geological Survey (USGS); the Desert Research Institute (DRI); and Navarro Research and Engineering, Inc. (Navarro).

The groundwater flow and contaminant transport models will ultimately be used to design monitoring well networks and land-use restrictions that protect the public. For four of the five UGTA CAUs, these models will be used to identify contaminant boundaries that forecast areas that potentially could exceed the Safe Drinking Water Act (SDWA) maximum contaminant levels for *radionuclides* (see [Glossary, Appendix B](#)) over the next 1,000 years. Such contaminant boundary forecasts are not required by the FFACO for the Rainier Mesa/Shoshone Mountain CAU due to the determination that field data are, and will be, insufficient to develop models which could reliably identify a contaminant boundary in this geologically complex area (NNSA/NFO 2013). For this CAU, the models must instead demonstrate that institutional controls will not be challenged by radionuclides originating from underground tests conducted in the CAU within the 1,000-year compliance period.

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

***Environmental Restoration Objectives for UGTA Sites***

Develop a regional three-dimensional computer groundwater model to identify immediate risks and provide a basis for developing more detailed CAU-specific models.

Develop CAU-specific models of groundwater flow and contaminant transport that geographically cover the five former NNSS underground nuclear testing areas.

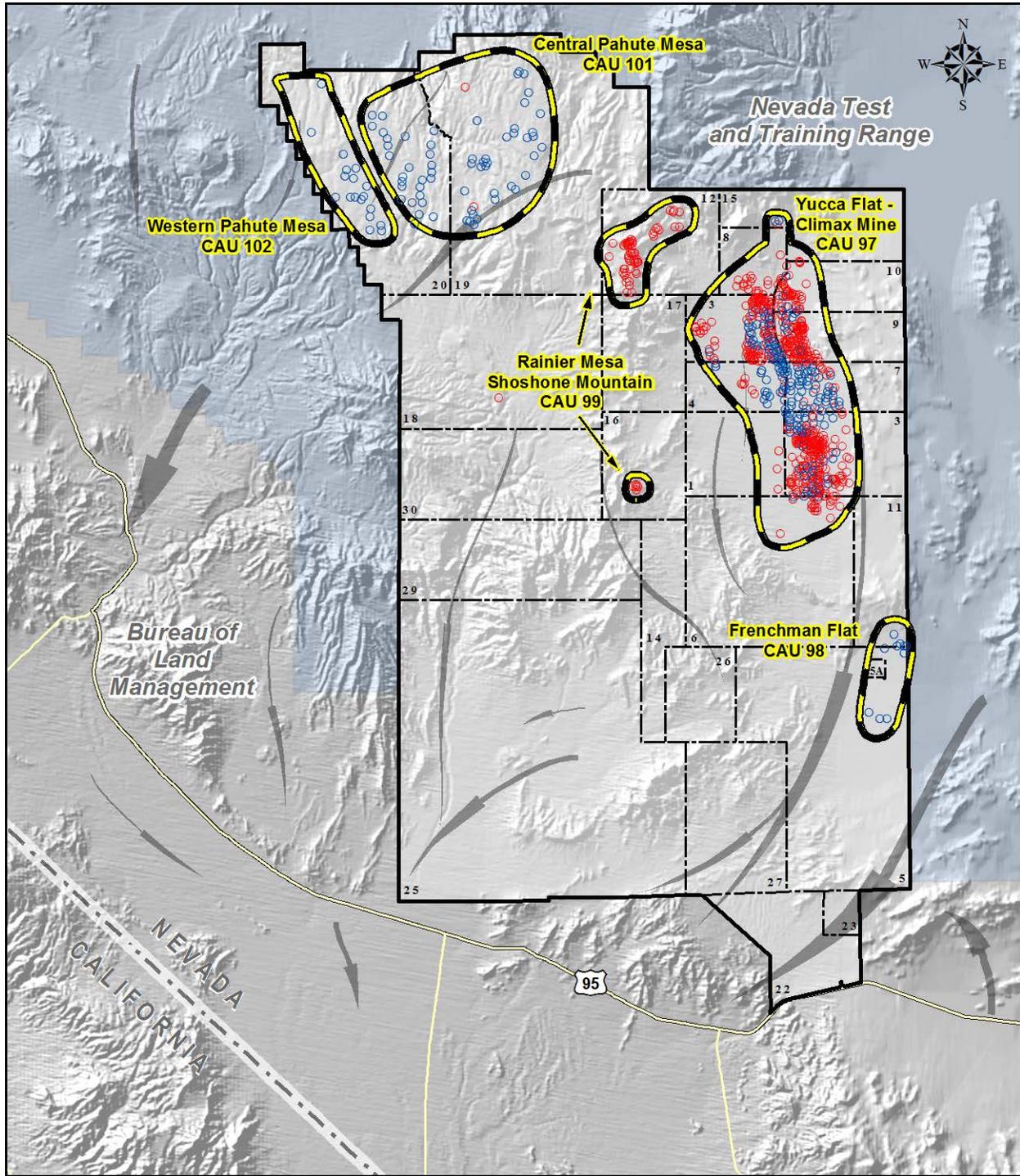
Identify contaminant boundaries<sup>(a)</sup> (which support regulatory decision-making processes) where contaminants are forecasted to exceed the SDWA limits at any time within a 1,000-year compliance period.

Negotiate regulatory objectives and regulatory boundaries to protect the public and environment from the effects of radioactive contaminant migration.

Negotiate use-restriction boundaries to restrict access to contaminated groundwater.

Develop a long-term closure monitoring network to verify consistency with the flow and transport models, compliance to the regulatory boundary, and protection of human health and the environment.

<sup>(a)</sup> The identification of contaminant boundaries are objectives for all UGTA CAUs except for the Rainier Mesa/Shoshone Mountain CAU, for which it must be demonstrated that institutional controls will not be challenged by radionuclides from underground tests conducted in the CAU within the 1,000-year compliance period.



Map produced by the NS Tec GIS Group. Product ID: 20160111-01-P009-R00

**Location of Underground Nuclear Tests**

- Tests with no expected interaction with the groundwater system<sup>1</sup> (Vadose Zone)
- Tests having potential interaction with the groundwater system<sup>1</sup> (Saturated Zone)

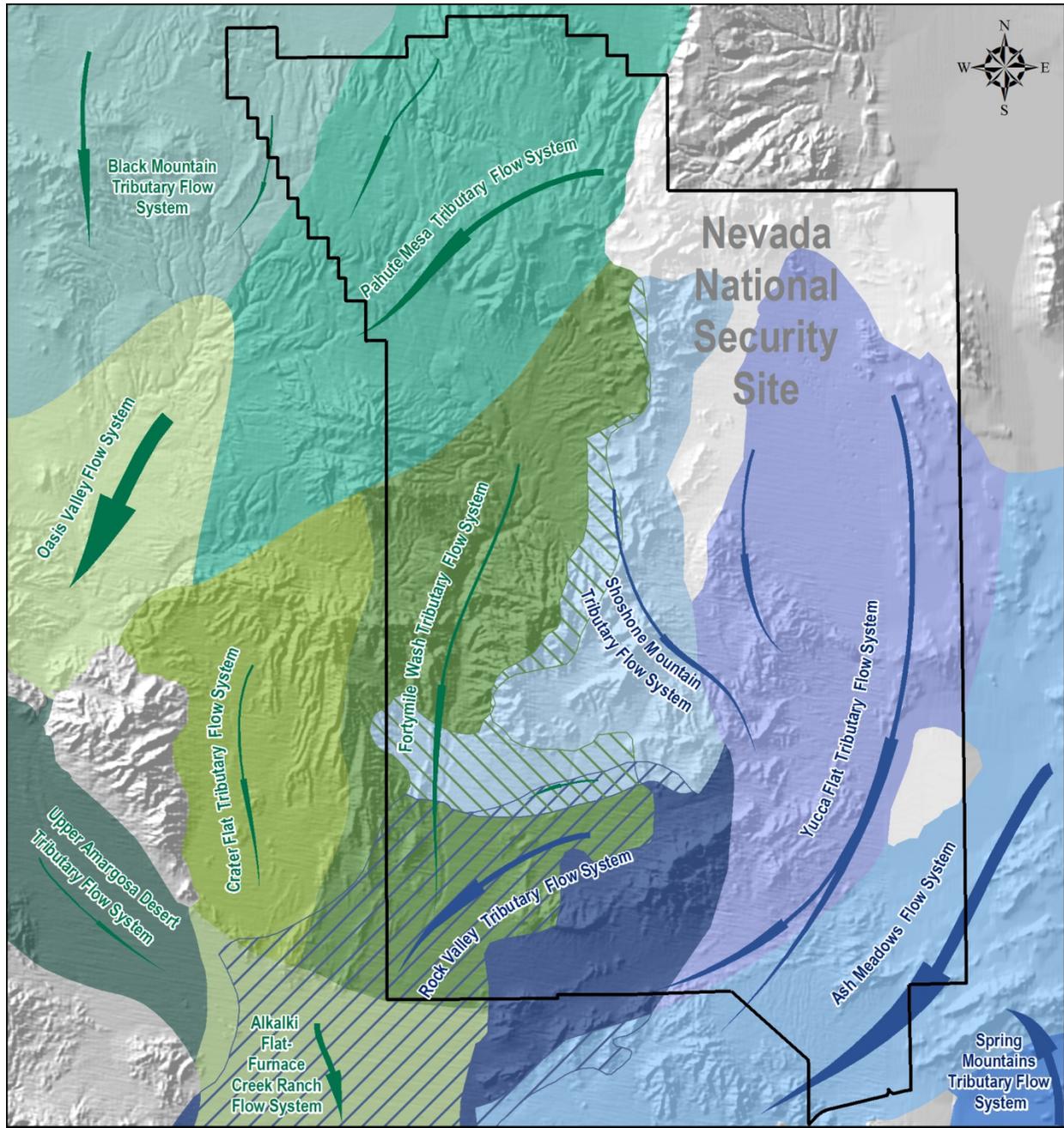
○ Area of Potential Groundwater Contamination (Corrective Action Unit Boundary)

Regional Groundwater Flow System<sup>2</sup>  
 Arrow direction indicates regional groundwater flow direction and width indicates relative groundwater flow volume.

0 2.5 5 10 Kilometers  
 0 2.5 5 10 Miles

<sup>1</sup> U.S. Department of Energy, Nevada Operations Office, 1997. Regional Groundwater Flow and Tritium Transport Modeling and Risk Assessment of the Underground Test Area, Nevada Test Site, Nevada. DOE/NV-477, October 1997, Las Vegas, NV.  
<sup>2</sup> Fenelon, J. M., D. S. Sweetkind, and R. J. Lacznik, 2010. *Groundwater Flow Systems at the Nevada Test Site, Nevada: A Synthesis of Potentiometric Contours, Hydrostratigraphy, and Geologic Structures*. U.S. Geological Survey Professional Paper 1771, U.S. Geological Survey, Denver, CO.

Figure 11-1. UGTA CAUs on the NNSS



Map produced by the NSTec GIS Group. Product ID: 20160211-01-P021-R08

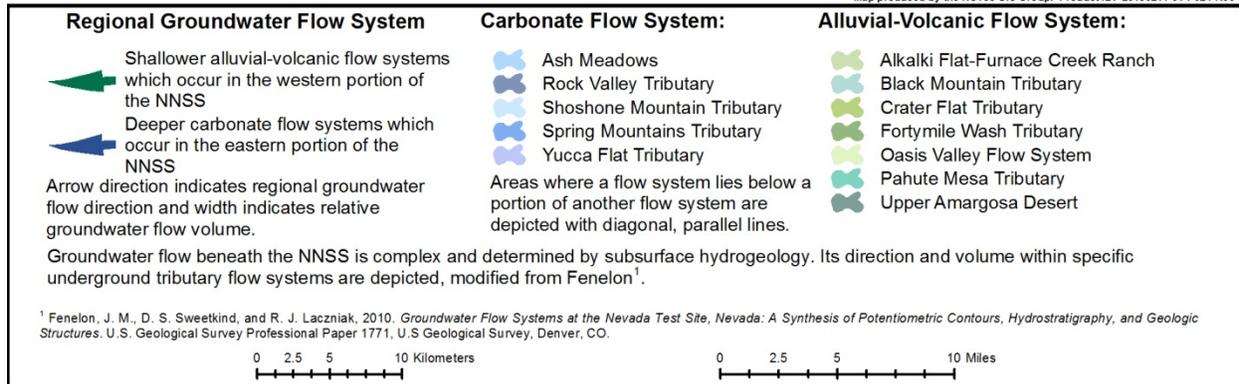


Figure 11-2. Groundwater flow systems of the NNSS

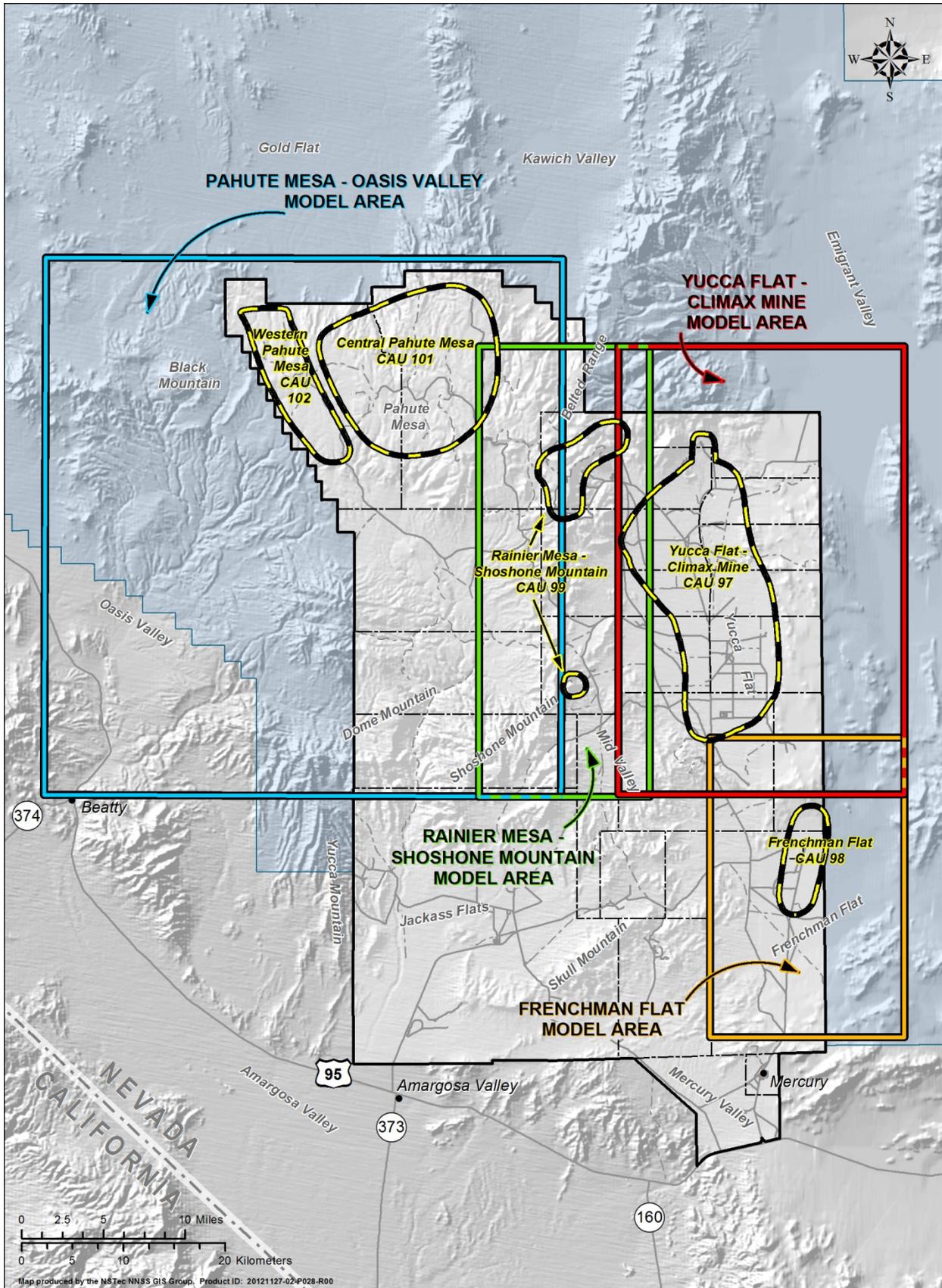


Figure 11-3. Location of UGTA model areas

### **11.1.1 UGTA CAU Corrective Action Activities**

The UGTA CAU closure strategy is a process of conducting characterization and modeling studies during the *investigation stage* to support 1,000-year contaminant boundary forecasts. Sufficient confidence in the flow and transport models and supporting data must be demonstrated to earn NDEP's approval to advance from the investigation stage to the *model evaluation stage* and then to the *closure stage* for each CAU. The long-term monitoring program and institutional controls to protect the public from consuming potentially contaminated groundwater are initiated in the closure stage. The five UGTA CAUs are in various stages of this process. The following subsections provide a brief history of the actions taken to date towards the closure-in-place of each CAU. The results of groundwater sampling conducted in 2015, for the purposes of characterizing groundwater within the CAUs and monitoring groundwater downgradient of them, are presented and discussed in Chapter 5, Sections 5.1.2 and 5.1.3.

#### **11.1.1.1 Frenchman Flat CAU**

The Frenchman Flat CAU is the first of the five UGTA CAUs at the NNSS to advance to the closure stage. Advancement to the closure stage followed a 4-year evaluation process that began with completion of the Phase II transport model (Navarro Nevada Environmental Services, LLC, 2010), review of the groundwater flow and transport model by an external peer review panel (Navarro-Intera, LLC [N-I] 2010), development and approval by NDEP of a Corrective Action Decision Document/Corrective Action Plan (CADD/CAP) (U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office [NNSA/NSO] 2011a), and completion of a model evaluation report (N-I 2014a). The Phase II model and the current understanding of groundwater flow and radionuclide transport within Frenchman Flat are supported by over fifty years of characterization activities.

The CADD/CAP described the activities planned to reduce model uncertainty, and the model evaluation report presented the results of these activities. The model evaluation stage activities were completed in 2014, and the modeling team, the preemptive review committee, and NDEP agreed that there was sufficient confidence in the model to advance to the closure stage. By the end of 2014, DOE and NDEP had begun discussions regarding the development and implementation of a monitoring program and identification of final use-restriction and regulatory boundaries protective of the public, which would be presented in a Closure Report.

In 2015, the draft Closure Report was written and then reviewed by UGTA participants (DRI, Navarro, and USGS), NDEP, and NSSAB. The Closure Report will also be reviewed by the USAF before it is finalized and approved by NDEP. The use restrictions presented in the report are associated with subsurface activities and include controls to limit drilling and groundwater pumping. 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 underground nuclear testing are not forecasted to migrate out of the basin within the next 1,000 years, the Rock Valley fault system is the expected groundwater pathway out of the Frenchman Flat basin. The negotiated regulatory boundary is established at the interface of the Alluvial/Volcanic aquifer and the Rock Valley fault. If radionuclides reach this boundary, NNSA/NFO is required to submit a plan to NDEP which will meet the CAU's regulatory boundary objectives.

The monitoring program described in the Closure Report will use the five Frenchman Flat wells included in the NNSS Integrated Groundwater Sampling Plan (see Chapter 5, Section 5.1.1), along with Well ER-11-2. They will be sampled annually for the next 5 years, beginning in 2016. Water levels will be measured in 16 wells located within and adjacent to the Frenchman Flat basin on a quarterly basis for the first 5 years of closure stage monitoring. After 5 years, the sampling and water-level monitoring networks and frequencies will be evaluated and possibly modified. The Closure Report is expected to be approved by NDEP in 2016, and all monitoring and use restrictions implemented.

#### **11.1.1.2 Central and Western Pahute Mesa CAUs**

The Central and Western Pahute Mesa CAUs are in the middle of the investigation stage of the closure process. In 2009, a Phase I Central and Western Pahute Mesa Transport Model (Stoller-Navarro Joint Venture 2009) was

completed for the Pahute Mesa–Oasis Valley model area. An additional phase of data collection and model development (Phase II) was needed in order to establish the necessary confidence to move forward with the closure process. Phase II data collection activities were recommended by an ad hoc subcommittee that included the NNSA/NFO UGTA Federal Activity Lead, UGTA participants (NSTec, DRI, LLNL, LANL, Navarro, and USGS), a representative from NDEP, and two representatives of NSSAB.

A Phase II Central and Western Pahute Mesa Corrective Action Investigation Plan (CAIP) was completed in 2009 (NNSA/NSO 2009) that outlines the investigations that are currently being implemented. The program's objective was to institute a second phase of data collection to test the assumptions of the Phase I groundwater flow and contaminant transport models, improve the quality of data used in the models, and increase confidence in the transport model results used to forecast contaminant boundaries. Twelve locations for new wells were proposed, ten of which were drilled between 2009 and 2012. Development, testing, and sampling the ten Phase II wells was completed in May 2014. Drilling of an additional Phase II well, ER-20-12, was initiated in October 2015 and was completed in January 2016.

The Phase I Central and Western Pahute Mesa Transport Model forecasts that *tritium* (see [Glossary, Appendix B](#)) and carbon-14 may migrate off the NNSS from the Central and Western Pahute Mesa CAUs within 50 years of the first nuclear detonation (1965) and that offsite concentrations of tritium may be above the SDWA limit of 20,000 picocuries per liter (pCi/L) within the 1,000-year compliance period (Figure 11-4). Consistent with this flow and transport model forecast, tritium was detected at 10,600 pCi/L in Well ER-EC-11 on the NTTR in 2009 (NSTec 2010). It is the first offsite well in which radionuclides from underground nuclear testing activities at the NNSS were detected. Well ER-EC-11 is located approximately 716.3 m (2,350 ft) west of the NNSS boundary (see Figure 5-2, Chapter 5) and approximately 3.2 km (2 mi) from the nearest underground nuclear tests, Benham and Tybo, which were conducted in 1968 and 1975, respectively. In 2014, samples were collected from the same aquifer where high tritium was previously reported using a newly available technology. The maximum tritium concentration measured in these samples was 16,100 pCi/L (see Table 5-4, Section 5.1.2, Chapter 5). Because this sample was collected after purging several well volumes from the well, it is considered more representative of the shallow groundwater at ER-EC-11 than those bailed during the drilling operation and reported in 2009. Well ER-EC-11 is scheduled to be sampled again in 2016.

Tritium detected in Well ER-20-11 (see Table 5-4, Chapter 5) is believed to represent the downgradient extension of the Benham-Tybo contaminant plume. This contaminant plume was first encountered at ER-20-5 (DOE/NV 1997) and further defined by Well ER-20-7 (NNSA/NSO 2010a) and peripheral Wells ER-EC-11 (NNSA/NSO 2010b) and ER-20-8/20-8#2 (NNSA/NSO 2011b). This cluster of contaminated wells is increasing the understanding of flow and transport of radionuclides from underground tests on Pahute Mesa. The discovery of tritium at Well ER-20-11 indicates that the contaminant plume forecasted by Phase I flow and transport modeling may be more southerly (ER-20-5 to ER-20-7 to ER-20-11; see Figure 11-4) than previously modeled. Phase II flow and transport modeling will include the new data from the Phase II drilling initiative, and will reflect the recent tritium measurements.

The detection of very low concentrations of tritium in Well PM-3 in 2011 prompted an investigation, which was completed in 2015, to determine its source (N-I 2015a). Well PM-3 is located 3.2 km (2 mi) west of NNSS Area 20 in the Western Pahute Mesa CAU, and 7.2 km (4.5 mi) southwest from the Handley underground nuclear test. The tritium observed at PM-3 is likely the leading edge of a plume resulting from groundwater transport downgradient from Handley, one of the largest underground nuclear tests. If this hypothesis is correct, additional sampling at PM-3 over the next few decades may show an increase of tritium from the current concentration of approximately 250 pCi/L. It is important to recognize that the tritium at this location and other locations along the possible transport path will also undergo decay and that if the observed concentrations are the result of groundwater transport from Handley, PM-3 serves as an excellent monitoring location. In 2015, UGTA began drilling an additional Phase II well, ER-20-12, between Handley and PM-3 to further evaluate the source of tritium observed at PM-3. Well ER-20-12 is located in the far northwestern portion of the NNSS. Hydrologic testing at this well will provide additional data to improve the hydrogeologic understanding within this area. In 2015, three wells located near test cavities (including the Handley test cavity) were sampled and analyzed for a suite of radionuclides. This work was performed to improve understanding of current radionuclide levels near the nuclear test cavities.

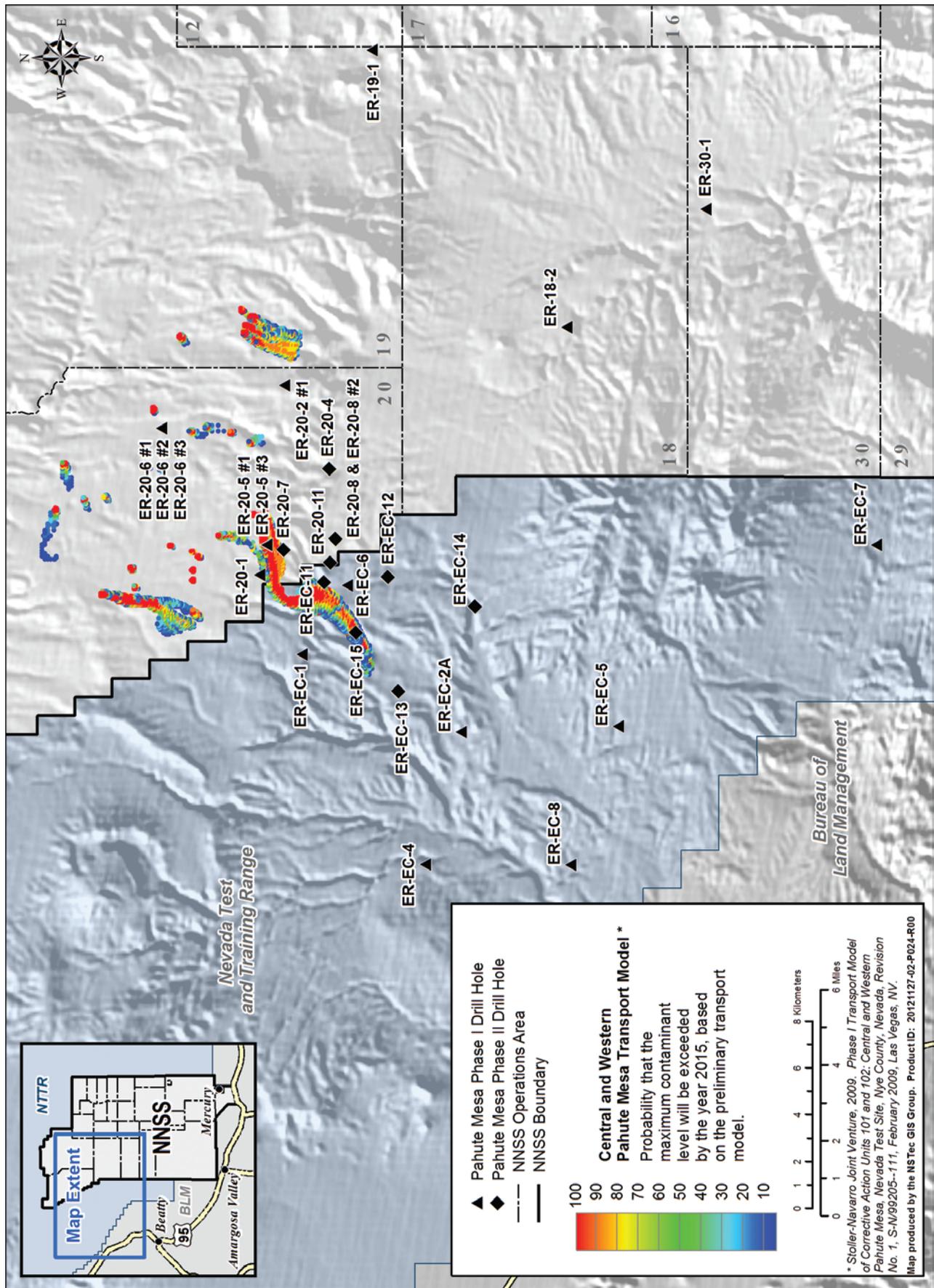


Figure 11-4. Results of Phase I Central and Western Pahute Mesa Transport Modeling

Investigations described in the Phase II CAIP continued throughout 2015. A draft documentation report describing the Phase II hydrostratigraphic framework model was developed and reviewed by the UGTA preemptive review committee in 2014, and by the end of 2015 was being revised in response to the review. Analysis of faults and fracture characteristics and of hydraulic properties of selected hydrostratigraphic units is being used to enhance conceptual models for the Phase II hydrostratigraphic framework model as well as to provide attributes for specific aquifers on and immediately downgradient of Pahute Mesa. Several hydrologic studies were conducted in 2015 to refine recharge models, evaluate groundwater discharge-recharge relationships, delineate groundwater flow paths, and update the water-level database. Additional characterization activities performed in 2015 included sampling groundwater, measuring water levels, and performing a variety of analyses tasks to evaluate the Phase II geologic, hydrologic, and chemistry data.

#### **11.1.1.3 Rainier Mesa/Shoshone Mountain CAU**

The Rainier Mesa/Shoshone Mountain CAU is near the end of the investigation stage of the closure process. In 2013, the draft groundwater flow and contaminant transport models were completed, and a revised modeling and closure strategy for the Rainier Mesa/Shoshone Mountain CAU, which is unique from the other UGTA CAUs, was accepted by NDEP (NNSA/NFO 2013). The closure strategy for this CAU does not involve the identification of contaminant boundaries due to their expected irreducible uncertainty and cost prohibitions. The ensemble of draft contaminant transport models was subjected to several cycles of preemptive reviews and summary presentations to NDEP. Efforts to develop a more robust conceptual model for the unsaturated zone began in 2013 and will be included in the final flow and transport model documentation. Additional modeling activities were initiated in 2015 to support this new conceptual model and the implementation of the revised closure strategy. To facilitate this effort, the initial hydrostratigraphic framework model (NSTec 2007) was rebuilt, and the resultant, revised hydrostratigraphic framework model was reviewed in 2015 by the preemptive review committee.

#### **11.1.1.4 Yucca Flat/Climax Mine CAU**

The Yucca Flat/Climax Mine CAU is in the latter part of the investigation stage of the closure process. The groundwater flow and contaminant transport model was completed in 2013 (N-I 2013) and a formal independent peer review was completed in 2014 (N-I 2015b). Although the peer review committee recommended moving forward into the model evaluation stage, they provided several recommendations for model-evaluation activities they believed should be performed. In 2015, an effort to address these recommendations was initiated and included providing clarification on decisions and assumptions made during flow and transport model development, sampling five wells with historically reported tritium detections (ER-2-1, ER-6-2, UE-6d, UE-6e, and TW-B), performing additional model simulations, and drilling three new wells in Yucca Flat. These activities will be completed prior to closing out the external peer review and advancing to the model evaluation stage.

The results of the additional sampling performed in 2015 were consistent with the current understanding of groundwater flow and contaminant transport within the Yucca Flat Basin and do not warrant additional study as recommended by the peer review panel. The tritium results for wells ER-6-2, TW-B, UE-6d, and UE-6e show that they are currently free of measurable tritium, and these four wells are not included in the NNS Integrated Groundwater Sampling Plan (see Chapter 5, Section 5.1.1). Although historical measurements have indicated that low levels of tritium may have been present at these wells, the new data indicate that even if the historical measurements were accurate and not the result of cross-contamination during sampling or analysis, the low levels of tritium were not indicators of a contaminant plume. However, at ER-2-1, the increase from 228 to 1,013 pCi/L in tritium concentration over a 12-year period is consistent with radionuclides migrating from a near detonation. There were five detonations, all below the water table, within 1,500 ft of this well.

The locations for the three new model evaluation wells in Yucca Flat (ER-2-2, ER-4-1, and ER-3-3) were determined by a combined guidance team and preemptive review committee. They are located near the Calabash, Strait, and Wagtail detonations, respectively, which were identified as three of the most likely detonations to have impacted the lower carbonate aquifer (LCA) within the Yucca Flat basin. Understanding radionuclide transport to the LCA was identified as the highest priority for siting the wells because the LCA, a regional aquifer, is the only pathway for radionuclides to migrate out of the basin. These wells will be used to evaluate the tuff confining unit

as a barrier and faults as pathways for radionuclide transport into the LCA and to improve understanding of the extent of contamination within the LCA. Drilling was initiated and will be completed in 2016.

### 11.1.2 Quality Assurance

The UGTA Quality Assurance Plan (QAP) (NNSA/NFO 2015b) provides the overall quality assurance requirements and general quality practices that are applied to UGTA drilling, laboratory analyses, and modeling. The UGTA QAP complies with DOE Order DOE O 414.1D, “Quality Assurance;” Guidance for Quality Assurance Project Plans for Modeling (U.S. Environmental Protection Agency [EPA] 2002); and Guidance on the Development, Evaluation, and Application of Environmental Models (EPA 2009). UGTA work is conducted under the UGTA QAP in conjunction with other UGTA participants’ quality assurance programs. In 2015, quality assurance activities included conducting oversight assessments, identifying findings and completing corrective actions, and evaluating laboratory performance. These activities are described in an annual quality assurance report (NNSA/NFO 2016). In addition, UGTA documents and models undergo thorough preemptive reviews throughout the investigation and model evaluation stages of the CAU closure process as well an independent formal peer review at the end of the investigation stage. Chapter 14 discusses the quality assurance and quality control procedures used for collecting and analyzing groundwater samples.

### 11.1.3 Other Activities and Studies

Compiling, evaluating, and updating various databases (e.g., chemistry, water-level, hydraulic properties, hydrostratigraphy) continued in 2015 as an ongoing effort. In 2015, The USGS continued to populate a photo archive of samples related to UGTA investigations and continued their water-level monitoring program. The photo archive can be accessed at <http://nevada.usgs.gov/mercury/>. Water levels, and other pertinent NNS information and data sets can be accessed through the USGS/U.S. Department of Energy Cooperative Studies in Nevada website at [http://nevada.usgs.gov/doe\\_nv/](http://nevada.usgs.gov/doe_nv/). In addition, Navarro evaluated three technologies for collecting samples from three wells in Pahute Mesa (ER-EC-11, ER-20-8, and ER-20-8-2). The technologies evaluated included the electric submersible pump, jack pump, and the depth discrete bailer (Navarro 2015a). The study showed that depth-discrete bailer sampling of wells that have been previously developed (drilling fluids removed) resulted in tritium concentrations that are consistent with samples collected using the electric submersible pump and jack pump. This indicates that depth-discrete bailer sampling may be used for collecting representative tritium samples from these wells. This is particularly significant for sampling early detection, distal, and community wells for which tritium is the only required analyte. It was shown that the bailer may not provide representative samples for the entire characterization suite of contaminants. The investigation also confirmed that the jack pump is an acceptable alternative method to collect samples in characterization wells.

### 11.1.4 UGTA Publications

All reports and publications that were completed in 2015 and published by June 2016 are listed in Table 11-1. Some of the published technical reports can be obtained from DOE’s Office of Scientific and Technical Information (OSTI) at <http://www.osti.gov/bridge>, and the OSTI identification number (ID) for those reports is provided.

**Table 11-1. UGTA publications published in 2015 or prior to June 2016**

Report	Reference
Handbook: Collecting Groundwater Samples from Monitoring Wells in Frenchman Flat, CAU 98	Chapman et al. 2015
Approximating Dose and Risk for Contaminants in Groundwater from the Underground Nuclear Test Areas of the Nevada National Security Site (NNS)	Daniels et al. 2015
Delineation of the Pahute Mesa–Oasis Valley Groundwater Basin, Nevada	Fenelon et al. 2016
Nevada National Security Site Underground Radionuclide Inventory, 1951-1992: Accounting for Radionuclide Decay through September 30, 2012	Finnegan et al. 2016
A Suite of Programs for Extracting Transmissivity from MODFLOW Models	Halford 2016

**Table 11-1. UGTA publications published in 2015 or prior to June 2016 (continued)**

Report	Reference
Laboratory Experiments to Evaluate Matrix Diffusion of Dissolved Organic Carbon Carbon-14 in Southern Nevada Fractured-rock Aquifers.	Hershey and Fereday 2016
Testing the Suitability of Geologic Frameworks for Extrapolating Hydraulic Properties Across Regional Scales	Mirus et al. 2016
2014 Annual Timber Mountain Environmental Monitoring Station	Lyles et al. 2015
Underground Test Area Activity Sampling Technologies Evaluation Report, Nevada National Security Site, Nye County, Nevada	Navarro 2015a
Pahute Mesa Well Development and Testing Analyses for Wells ER-EC-14 and ER-EC-15, Nevada National Security Site, Nye County, Nevada	Navarro 2015b
Yucca Flat Drilling and Completion Criteria Wells ER-2-2, ER-3-3, and ER-4-1	Navarro 2015c
Addendum #3 to the Central and Western Pahute Mesa Phase II Hydrogeologic Investigation Wells Drilling and Completion Criteria for Investigation Well ER-20-12	Navarro 2015d
UGTA Chemistry Database User's Manual	Navarro 2016
Evaluation of PM-3 Chemistry Data and Possible Interpretations of <sup>3</sup> H Observations	Navarro-Intera 2015a
External Peer Review Team Report for Corrective Action Unit 97: Yucca Flat/Climax Mine, Nevada National Security Site, Nye County, Nevada, Revision 0	Navarro-Intera 2015b
United States Nuclear Tests July 1945 through September 1992 (Revision 16)	NNSA/NFO 2015a
Underground Test Area (UGTA) Activity Health and Safety Plan	NNSA/NFO 2015b
Underground Test Area Activity Quality Assurance Plan Nevada National Security Site, Nevada	NNSA/NFO 2015c
Underground Test Area Fiscal Year 2015 Annual Quality Assurance Report Nevada National Security Site, Nevada	NNSA/NFO 2016
Stress Field Inversions of Earthquake Focal Mechanisms and Influence of Regional Stress on Fault Permeability at Pahute Mesa, Nevada National Security Site	Reeves et al. 2016
Field-Based Description of Rhyolite Lava Flows of the Calico Hills Formation, Nevada National Security Site, Nevada	Sweetkind and Bova 2015
Digitally Available Interval-Specific Rock-Sample Data Compiled from Historical Records, Nevada National Security Site and Vicinity, Nye County, Nevada (Version 2.1)	Wood 2007 (Revised in 2015)
Evaluating Groundwater Interbasin Flow Using Multiple Models and Multiple Types of Data	Ye et al. 2016
Hydrothermal Alteration of Glass from Underground Nuclear Tests: Formation and Transport of Pu-Clay Colloids at the Nevada National Security Site	Zavarin et al. 2015

## 11.2 Industrial Sites

NNSA/NFO has identified 1,865 Industrial Sites CASs on and off the NNSS for which they are responsible for characterization and closure under the FFACO. Closure strategies include removal of debris, excavation of soil, decontamination and decommissioning of facilities, and closure-in-place with subsequent monitoring. The contaminants of concern include hazardous chemicals/materials, unexploded ordnance, and low-level radiological materials. "Clean closures" are those where pollutants, hazardous wastes, and solid wastes have been removed and properly disposed, and where verification that all contaminants have been removed has been conducted, all 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 were either disposed as low-level waste (LLW) or mixed low-level waste (MLLW) at the Area 5 Radioactive Waste Management Site (RWMS) (see Section 10.1). Solid waste (e.g. demolition debris) containing asbestos was disposed of onsite at the Area 9 U10c Solid Waste Landfill. Hazardous waste (HW) removed from the CASs was shipped to approved offsite treatment and disposal facilities or recycled. Beyond remediation, the Industrial Sites Activity ensures that long-term monitoring programs are in place to 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 have been closures-in-place while the remainder have been 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 have been closed under the FFACO with state approval. They include the Pluto Disassembly; Reactor Maintenance, Assembly, and Disassembly (RMAD), 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 on unexploded ordnance at sites on the TTR. Large volumes of remediation wastes have been disposed on the NNSS since the mid 1990s, while cleanups conducted on the TTR have utilized the TTR landfill for approved disposal

Only 12 Industrial Sites CASs from three CAUs remain to be closed. The three CAUs are CAU 114, Area 25 Engine Maintenance, Assembly, and Disassembly (EMAD) Facility (the eighth remaining D&D facility); CAU 572, Test Cell C Ancillary Buildings and Structures; and CAU 575, Area 15 Miscellaneous sites. Their closure will occur prior to the end of the NNSS Environmental Management Activity, which is currently planned for 2030. In 2015, no Industrial Sites CASs were closed, and no interim work related to their closure was conducted.

### 11.3 Soils

NNSA/NFO has identified a total of 142 Soils CASs on and off the NNSS for which they are/were responsible for characterization and closure under the FFACO. This total includes eight new Soils CASs that were identified and added in 2015. 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 142 CASs. In 2015, 24 Soils CASs from two CAUs on the NNSS were closed (Table 11-2), and work was conducted towards closure at 15 CASs in 8 CAUs (Table 11-3). Noteworthy progress was made towards closure of Clean Slate II (CAU 413) on the TTR, where U.S. Air Force personnel participated in sampling and radiological surveys to determine the nature and extent of contamination.

The total number of Soils CASs closed and approved by the state by the end of 2015 was 119; 23 Soils CASs remain to be formally closed. Closure of CASs on the TTR and NTTR require negotiation with the State of Nevada and the U.S. Department of Defense. The anticipated date for Soils closure is FY 2027.

**Table 11-2. Soils Sites closed in 2015**

CAU	CAU Description	Number of CASs	Corrective Actions	Wastes Generated
550	Smoky Contamination Area	19	Clean closure <sup>(a)</sup> , closure-in-place with use restrictions, <sup>(b)</sup> and no further action	MLLW, LLW, Sanitary
567	Miscellaneous Soils Sites	5	Closure-in-place with use restrictions, no further action	LLW, Sanitary

(a) Clean closure is the removal of pollutants, contaminants, and waste at a CAS in accordance with Corrective Action Plans.

(b) Closure-in-place with use restrictions is the isolation of contamination with restricted access controls.

**Table 11-3. Other Soils Sites where work was conducted in 2015**

CAU	CAU Description	Number of CASs	Activity	Wastes Generated
411	Double Tracks Plutonium Dispersion (Nellis)	1	Closure field verification	LLW, Sanitary
412	Clean Slate I Plutonium Dispersion (TTR)	1	Closure field verification	LLW, Sanitary
413	Clean Slate II Plutonium Dispersion (TTR)	1	Investigation of nature and extent of contamination	LLW, Sanitary
414	Clean Slate III Plutonium Dispersion (TTR)	1	Preliminary investigation and waste disposition	LLW, Sanitary
415	Project 57 No. 1 Plutonium Dispersion (NTTR)	1	Preliminary investigation	LLW
541	Small Boy	2	Preliminary investigation	LLW, MLLW
568	Area 3 Plutonium Dispersion Sites	6	Investigation of nature and extent of contamination	LLW, MLLW, Hazardous, Sanitary
573	Alpha Contaminated Sites	2	Preliminary investigation	LLW

### 11.3.1 Monitoring Activities at Soils CAUs

NNSA/NFO monitors airborne radiation and meteorological parameters on the TTR and NTTR to determine if there is wind transport of man-made radionuclides from the contaminated Operation Roller Coaster CAUs: Double Tracks Plutonium Dispersion (Nellis) (CAU 411), and the Clean Slate I, II, and III Plutonium Dispersion (TTR) CAUs (412, 413, and 414, respectively). In 2008, NNSA/NFO established air monitoring stations at Clean Slate III and the Range Operations Center. In 2011, a third air monitoring station was installed at Clean Slate I. The design of these stations is similar to that used in the Community Environmental Monitoring Program (CEMP) (see Chapter 7, Section 7.1). These monitoring efforts are not required under the FFACO. In 2015, no man-made radionuclides were detected in any of the air samples collected from these stations; only naturally occurring radionuclides were identified. 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>.

NNSA/NFO 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. These stations are similar in design and function to those used in the CEMP with the exception of not including air filter monitoring or pressurized ion chambers. The equipment at both sites collect data to develop an understanding of meteorological conditions that contribute to contaminated soil transport. These monitoring efforts are not required under the FFACO but are conducted to aid in developing closure designs and post-closure monitoring requirements.

During FY 2015 (October 1, 2014 – September 30, 2015), data from the CAU 550 meteorological station, the flume, and visual observations of sediment transport were summarized, evaluated, and reported (Miller et al., 2016a). Although surface water flow was measured at the flume in the monitored channel during one or more precipitation events at CAU 550, no measurable transport of radionuclide-contaminated soils occurred. In FY 2015, 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 although none produced significant runoff. Therefore, no suspended sediment or bedload transport sediment samples at CAU 366 were collected (Miller et al., 2016b).

## 11.4 Post-Closure Monitoring and Inspections

All nine of the historical waste management units on the NNSS identified for closure under the Resource Conservation and Recovery Act (RCRA) have been closed (Table 11-4). The NNSS RCRA Part B Permit prescribes post-closure monitoring requirements for six of these sites (Table 11-4). CAUs 110 and 111 require vadose zone monitoring (VZM) of the engineered covers over the craters/waste pits. The covers were designed to limit infiltration into the disposal units and are monitored using time-domain reflectometry soil water content sensors buried at various depths in the waste covers to provide water content profile data. The data are used to demonstrate whether the covers are performing as expected. The covers were vegetated with native plants and are monitored routinely for revegetation success. Various revegetation techniques have been studied and implemented on the covers in attempts to produce sustainable native plant communities (see Chapter 13, Section 13.4, Habitat Restoration Program).

**Table 11-4. Historical RCRA closure sites and their post-closure monitoring requirements**

CAU	Remediation Site	2015 Post-closure Requirements
90	Area 2 Bitcutter Containment	Semi-annual <sup>(a)</sup> site inspection
91	Area 3 U-3fi Injection Well	Semi-annual <sup>(a)</sup> site inspection
92	Area 6 Decon Pond Facility	Quarterly <sup>(b)</sup> site inspection Inspection if precipitation >0.5 inches/24-hour <sup>(c)</sup> period
93	Area 6 Steam Cleaning Effluent Ponds	None
94	Area 23 Building 650 Leachfield	None
109	Area 2 U-2bu Crater	None

**Table 11-4. Historical RCRA closure sites and their post-closure monitoring requirements (continued)**

CAU	Remediation Site	Post-closure Requirements
110	Area 3 Waste Management Division (WMD) U-3ax/bl Crater	Quarterly <sup>(b)</sup> site inspection VZM of the engineered cover caps Biennial subsidence survey Annual vegetation survey
111	Area 5 WMD Retired Mixed Waste Pits	Quarterly site inspection Inspection if precipitation >0.5 inches/24-hour period Annual subsidence survey Annual vegetation survey Quarterly TLD readings Tritium air analyses Gamma-emitting and isotopic radionuclide air analyses Annual measurements of radon flux Groundwater monitoring of Wells UE5 PW-1, -2, and -3 VZM of the engineered cover caps
112	Area 23 Hazardous Waste Trenches	Quarterly <sup>(a)</sup> site inspection

- (a) Site inspection frequency was changed to annual during December 2015 permit revisions.
- (b) Site inspection frequency was changed to semi-annual during December 2015 permit revisions.
- (c) Precipitation threshold was changed to >1 inch/24-hour period during December 2015 permit revisions.

In 2015, VZM results for CAUs 110 and 111 indicated that surface water is not migrating into buried wastes and that the covers are functioning as designed (NSTec 2016a). For CAU 111, external radiation measurements from thermoluminescent dosimeters (TLDs), air and groundwater sample analyses for radionuclides, and radon flux measurements indicate that the closure covers are performing within expectations and parameter assumptions of performance assessment models and there is no impact on the surrounding environment (NSTec 2016a; 2016b). One report for all RCRA closure sites monitored in FY 2015 was submitted to NDEP in January 2016 (NNSA/NFO 2016b). In April 2015, NDEP performed a Compliance Evaluation Inspection of CAUs 90, 91, 92, 110, 111, and 112 and documented that NNSA/NFO was managing them in compliance with the NNS Part B Permit.

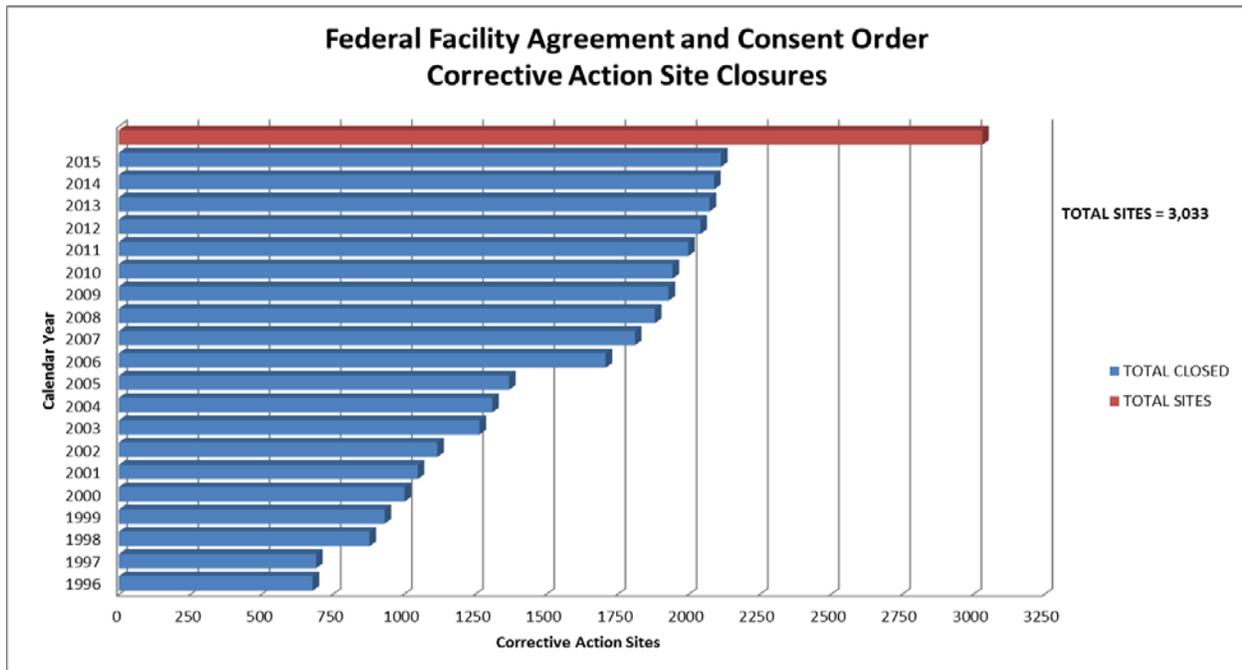
Post-closure inspections are also required for many of the closed remediation sites managed under the FFACO that are not included in the RCRA Part B Permit (non-RCRA CASs). In 2015, NNSA/NFO conducted visual inspections at 166 closed non-RCRA CASs managed under the FFACO. Several CASs that do not require inspections were inspected as a best management practice to ensure that the signs are intact. A 2015 annual inspection report for non-RCRA post-closure sites on the NNS was prepared and submitted to NDEP in May 2016 (NNSA/NFO 2016c). A 2015 annual inspection report for post-closure sites on the TTR was prepared and submitted to NDEP in March 2016 (NNSA/NFO 2016d).

### ***11.5 Restoration Progress under the FFACO***

In 2015, NNSA/NFO met all of the 2015 FFACO milestones (Table 11-5), and closed 24 CASs. Figure 11-5 depicts the progress made since 1996 in the remediation of all historically contaminated sites managed under the FFACO. A total of 2,115 of the 3,033 CASs have been closed; they include 142 sites that have been closed by the DOE Office of Legacy Management, the Defense Threat Reduction Agency, or other owners. Of the remaining 918 CASs yet to be closed under the FFACO (913 of which are the responsibility of NNSA/NFO), 878 (94%) of them are UGTA CASs, which will be closed in place with monitoring in perpetuity. The public can view an interactive map that shows all CASs on the NNS, NTTR, and TTR at the following NNS Remediation Sites website: <http://nnsremediation.dri.edu/>. The website identifies all CASs that have been closed and those that are still open.

**Table 11-5. FFACO milestones for 2015**

CAU	CAU Name	# of CASs	Milestone	Due Date	Date Submitted	Date NDEP Approved
<b>DOE Industrial Sites</b>						
575	Area 15 Miscellaneous Sites	4	Streamlined Approach for Environmental Restoration (SAFER) Plan	1/16/15	12/16/14	12/24/14
<b>DOE Soil Sites</b>						
567	Miscellaneous Soil Sites	4	Corrective Action Decision Document/ Closure Report (CADD/CR)	12/31/14	12/18/14	1/6/15
550	Clean Slate I Plutonium Dispersion (TTR) <sup>(d)</sup>	19	CADD/CR	2/16/15	2/11/15	3/2/15
411	Double Tracks Plutonium Dispersion (NTTR) <sup>(e)</sup>	1	SAFER Plan	3/30/15	3/16/15	3/30/15
412	Clean Slate I Plutonium Dispersion (TTR)	1	SAFER Plan	5/15/15	4/22/15	4/30/15
568	Area 3 Plutonium Dispersion Sites	6	Corrective Action Decision Document (CADD)	8/18/15	8/10/15	8/19/15
<b>DOE UGTA Sites</b>						
98	Frenchman Flat	11	Presentation #1 on Use Restriction and Regulatory Boundaries	1/28/15	1/16/15	1/27/15
97	Yucca Flat/Climax Mine	720	Complete Peer Review	2/3/15	1/30/15	2/5/15
97	Yucca Flat/Climax Mine	720	External Peer Review Closeout Presentation	7/30/15	7/30/15	8/6/15
99	Rainier Mesa/Shoshone Mountain	66	Phase I Transport Model Supplemental Analysis Presentation #1	9/30/15	9/16/15	9/28/15
101	Central Pahute Mesa	64	Phase II Data Completion Presentation #1	9/30/15	9/24/15	9/29/15
102	Western Pahute Mesa	18	Phase II Data Completion Presentation #1	9/30/15	9/24/15	9/29/15
98	Frenchman Flat	11	Closure Report, Revision 0	3/4/2016	8/7/15	8/31/15



**Figure 11-5. Annual cumulative totals of FFACO CAS closures**

## 11.6 Public Outreach

On February 18, 2015, NNSA/NFO held the Sixth Annual Groundwater Open House for the public in conjunction with an NSSAB meeting in Beatty, Nevada. Each year, NNSA/NFO conducts an open house to share current information on UGTA groundwater monitoring activities. A series of 19 posters was prepared for the February open house. They presented an overview of the groundwater monitoring program, the current sampling results for tritium and other radionuclides, the status of model development for each CAU model area, and the various investigation and decision/action stage activities that are planned for each CAU. Attendees of the open house, in addition to the public, included representatives from NNSA/NFO, the State of Nevada, NSTec, N-I, DRI, USGS, Nye County, and members of the NSSAB. EM maintains a public outreach [NNSG Groundwater Characterization](#) web page specific to NNSG groundwater characterization activities. Summary brochures and detailed documents on project activities (such as the Phase I Central and Western Pahute Mesa Transport Model) can be found at this website. Links to the posters presented at the 2015 public meeting can be found at the [NNSA/NFO Groundwater Open House](#) web page. Also, a video about ongoing groundwater characterization activities at the NNSG can be viewed on YouTube [here](#).

Throughout 2015, five NSSAB meetings were held, which were all open to the public and announced by NNSA/NFO on their [Outreach/Public Affairs](#) web page. The NSSAB is a part of the [Environmental Management Site-Specific Advisory Board](#), a stakeholder board that provides the Assistant Secretary for Environmental Management and designees with independent advice, information, and recommendations on issues affecting the EM program at various DOE/NNSA sites. Among those issues are clean-up standards and environmental restoration, waste management and disposition, and clean-up science and technology activities. The 2015 NSSAB public meetings covered the development of recommendations for the prioritization of FY 2017 EM activities at the NNSG, the cleanup of historic above-ground nuclear testing locations at the NNSG, and the NNSG long-term groundwater monitoring plan. Educational briefings and workshops related to radiation and radioactive decay, radioactive waste transportation, and groundwater levels were also presented at the meetings. The meeting agendas, handouts, and minutes for all of the 2015 NSSAB meetings can be found at [NSSAB Meetings](#).

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## Chapter 12: Historic Preservation and Cultural Resources Management

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The historic landscape of the Nevada National Security Site (NNSS) contains archaeological sites, buildings, structures, and places of importance to American Indians and others. These are referred to as “cultural resources.” U.S. Department of Energy (DOE) Order DOE O 436.1, “Departmental Sustainability,” requires the development and maintenance of policies and directives for the conservation and preservation of cultural resources. On the NNSS, cultural resources are monitored, and site activities and projects comply with applicable federal and state regulations related to their protection. The Cultural Resources Management (CRM) program at the NNSS has been established by the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) and is implemented by the Desert Research Institute (DRI) to aid in the conservation and preservation of cultural resources that may be impacted by NNSA/NFO activities. The CRM program is designed to meet the specific goals shown below.

<b>Cultural Resources Management Program Goals</b>
Ensure compliance with all regulations pertaining to cultural resources on the NNSS.
Inventory and manage cultural resources on the NNSS.
Provide information that can be used to evaluate the potential impacts of proposed projects and programs to cultural resources on the NNSS and 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.”
Conduct American Indian consultations related to places and items of importance to the Consolidated Group of Tribes and Organizations.

In order to achieve the program goals and meet federal and state requirements, the CRM program is multifaceted and contains the following major components: (1) archival research, inventories, and historical evaluations; (2) curation of archaeological collections; and (3) the American Indian Consultation Program. The guidance for the CRM program work is provided in the *Cultural Resources Management Plan for the Nevada Test Site* (Drollinger and Beck 2010). Historic preservation personnel and archaeologists of DRI who meet the qualification standards set by the Secretary of the Interior conduct the work, and the archaeological efforts are permitted under the Archaeological Resources Protection Act (ARPA).

A brief description of the CRM program components and their 2015 accomplishments is provided in this chapter. The methods used to conduct inventories and historical evaluations in support of NNSS operations were summarized in the *Nevada Test Site Environmental Report 2003* (Bechtel Nevada 2004). The reader is directed to the *Nevada National Security Site Environmental Report 2015 Attachment A: Site Description*. It is a separate file on the compact disc of this report and is also accessible on the NNSA/NFO web page at <http://www.nv.energy.gov/library/publications/aser.aspx>. Attachment A summarizes the known human occupation and use of the NNSS from the Paleo-Indian Period, about 12,000 years ago, until the mining and ranching period of the 20<sup>th</sup> century, just before NNSS lands were withdrawn for federal use.

## 12.1 Cultural Resources Inventories and Historical Evaluations

Cultural resources inventories are field surveys that are conducted at the NNSS to meet the requirements of the National Historic Preservation Act (NHPA) and the ARPA. The inventories are completed prior to proposed projects that may disturb or otherwise alter the environment. Historical evaluations are completed to evaluate historic buildings and structures for eligibility to the National Register of Historic Places (NRHP). The following types of information collected during inventories and historical evaluations, or produced based on them, are maintained in databases:

- Number of cultural resources inventories conducted
- Location of each inventory
- Number of acres surveyed at each project location
- Types of cultural resources identified at each project location
- Number of cultural resources determined eligible to the NRHP
- Eligible properties avoided by project activities
- Cultural resources requiring mitigation to address an adverse effect
- Occurrences of damage to archaeological sites
- Final report on results

In 2015, DRI conducted archival research for 29 proposed NNSA/NFO projects that had the potential to impact cultural resources on the NNSS. The archival research results led archeologists to conduct 11 field inventories, which resulted in the identification of 10 sites and 20 historic structures and buildings. NRHP determinations are pending. A total of 318 hectares (785 acres) were examined during the inventories. In 2015, there were no reported occurrences of damage to archaeological sites.

## 12.2 Evaluations of Historic Structures

In 2015, no new evaluations of historic structures were undertaken. Work was completed on one historical evaluation, the Shasta atmospheric test. The Shasta atmospheric test location, including its outlying instrument stations, was recorded as the Shasta Historic District in Areas 2, 3, and 8. Shasta was a nuclear explosives test conducted on a 152.4-m (500-ft) tower in Area 2 on August 18, 1957 as part of Operation Plumbbob. The primary objectives of the test were to evaluate newly designed devices, to estimate the nuclear yield and blast of the Shasta device, and to investigate thermal and nuclear radiation phenomena. Cultural resources recorded as part of the district are features, artifacts, and structures associated with the test (King 2015a).



**Figure 12-1. Entrance to a shelter used during the 1957 Shasta test to evaluate operational characteristics of an underground shelter in a nuclear fallout zone. The shelter entrance was modified in the early 60s for a simulated radiological experiment.**

## 12.3 General Reconnaissance

Nine field activities and one preliminary assessment were conducted in 2015. The first field activity was site monitoring of ten cultural resources in various areas of the NNSS to document their current condition. Six prehistoric sites and four historic nuclear testing related sites were monitored. During the second field activity DRI archaeologists monitored the excavation of a trench from the National Oceanic and Atmospheric Administration weather building to an electrical panel to replace existing cable. The third field activity was photographing tanks at the Phoenix Facility in response to proposed work to remove and store them elsewhere in

order to construct a shade structure. The fourth activity was establishing boundaries around several known historic sites and one prehistoric site near the Source Physics Experiment testing location. The fifth field activity was documenting a set of military trenches associated with the Shasta atmospheric nuclear test as part of its historical evaluation. The sixth field activity was a walkthrough of the more than 80 rooms and associated outside facilities at the CP-1 Building to understand the scope of a historical evaluation scheduled to start there in 2016. The seventh field activity was photographing the exterior of several buildings in Mercury listed for disposition. The eighth activity was a field review of basement stabilization work completed at one of the two buildings still standing at the historical Apple-2 shot site where the effect of a nuclear blast was tested on various types of building construction. The last activity was field work at corrective action site (CAS) 05-23-3 associated with the Gadgets, Mechanics, and Explosive experiment area and was a follow-up to work completed in 2014. DRI archaeologists conducted a walk over around the fenced perimeter of a High Contamination Area and recorded visible cultural resources.

## ***12.4 Cultural Resources Reports***

Seven cultural resources reports were completed in 2015. The first report was a historical evaluation for the Shasta atmospheric test (King 2015a). The second report was a cultural resources monitoring report (Menocal 2015a). The third report was a preliminary assessment for cultural resources at CAS 05-23-3 (King 2015b). The other four reports were in response to various Underground Test Area (UGTA) well activities (Drollinger and Holz 2015a, 2015b, 2015c, 2015d). The data on NNSS archaeological activities conducted by DRI for the NNSA/NFO in 2015 were provided to DOE Headquarters in the Federal Archeology Questionnaire for transmittal to the Secretary of the Interior and, ultimately, to the U.S. Congress as part of the Secretary of the Interior's Annual Archeology Report to Congress.

## ***12.5 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 over 400,000 artifacts and is curated in accordance with 36 CFR 79. Curation requirements for the NNSS Archaeological Collection include:

- Maintain a catalog of the items in the NNSS collection.
- Package the NNSS collection in materials that meet archival standards (e.g., acid-free boxes).
- Store the NNSS collection and records in a facility that is secure and has environmental controls.
- Establish and follow curation procedures for the NNSS collection and facility.
- Comply with the Native American Graves Protection and Repatriation Act (NAGPRA).

In the 1990s, the U.S. Department of Energy, Nevada Operations Office completed the required inventory and summary of NNSS cultural materials accessioned into the NNSS Archaeological Collection, and distributed the inventory list and summary to the tribes affiliated with the NNSS and adjacent lands. Consultations followed, and all artifacts the tribes requested were repatriated to them. This process was completed in 2002; it will be repeated periodically for new additions to the collection in the future.

In 2015, the artifact catalog and accession records databases were maintained and updated as needed. Forty-seven boxes of historic nuclear testing related materials were catalogued, accessioned, and placed in the permanent collection (Menocal 2015b). The artifact catalog was updated to include 227 historic resources from five historic nuclear testing related buildings or structures. All artifacts in the collection are stored in current archival-quality materials, and almost 40 years of archaeological survey reports, technical reports, and site records are linked to a Geographical Information System. Although the work schedule in the curation facility is variable, the state of the collection is monitored weekly to ensure that the materials remain in good condition.

## 12.6 American Indian Consultation Program

DOE Order 144.1, “American Indian Tribal Government Interaction Policy” establishes guiding principles and a framework for interacting with American Indian and Alaska Native Tribal Governments. NNSA/NFO administers an American Indian Consultation Program (AICP) in accordance with DOE O 144.1 by interacting with 16 culturally affiliated American Indian tribes with cultural and historic ties to the NNSS. Collectively, these tribes operate through the Consolidated Group of Tribes and Organizations (CGTO) comprised of Southern Paiute, Western Shoshone, and Owens Valley Paiute-Shoshone. The 16 tribes are listed in the 2007 NNSS environmental report (National Security Technologies, LLC 2008) and in the *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* (U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office 2013). A history of this program is contained in *American Indians and the Nevada Test Site, A Model of Research and Consultation* (Stoffle et al. 2001). The scope of the program includes:

- Providing a government-to-government forum for the CGTO to interface directly with NNSA/NFO management on topics of interest.
- Providing the CGTO with opportunities to actively participate and help guide decisions that involve culturally significant places, resources, and locations on the NNSS.
- Involving the CGTO in the curation, display, and protection of American Indian artifacts from the NNSS.
- Enabling the CGTO and its constituency to practice and participate in religious and traditional activities within the boundaries of the NNSS.
- Providing opportunities for CGTO subgroups to participate in the review and evaluation of program documents on an interim basis between regularly scheduled meetings.
- Including the CGTO in the development of tribal text in the agency’s National Environmental Policy Act (NEPA) documents.

Throughout 2015, NNSA/NFO interacted with the CGTO spokesperson and received regular updates relating to tribal activities and interactions. The spokesperson serves as a designated liaison to the Nevada Site Specific Advisory Board (NSSAB), attending regularly scheduled meetings and sharing insight from a tribal perspective. Liaison involvement provides useful information for the NSSAB in their deliberations on recommendations to NNSS/NFO.

Ongoing updates about the CGTO and NNSS activities are provided through a series of DOE-sponsored groups, meetings, and activities. One primary example was the Secretary’s National Tribal Energy Summit on September 23–25 in Washington, D.C. The Summit provided opportunities for the Department’s tribal working groups to assemble and discuss ideas while sharing emerging topics of interest throughout the DOE Complex.

Another important meeting is the State Tribal Government Working Group (STGWG) sponsored by DOE Environmental Management. STGWG is comprised of representatives from various state governments and 10 other designated tribes from New Mexico, Idaho, Washington, Oregon, and New York that are involved in DOE activities. STGWG meetings were held in Pasco, Washington on May 19–21, 2015 and again in New Orleans, Louisiana on November 17–20, 2015. STGWG meetings are an important forum for sharing information of mutual interest and engaging in discussions with DOE leadership and colleagues, as were accomplished between the CGTO spokesperson and the Acting Assistant Secretary for the DOE Office of Environmental Management during the 2015 New Orleans STGWG meeting. Discussion topics focus on environmental management activities and methods for enhancing communications and expanding interactions between the tribes and DOE.

In 2015, NNSA/NFO finalized plans and hosted an AICP tribal update meeting on October 20–22, 2015 in Las Vegas, Nevada. The meeting was coordinated with the CGTO Spokesperson, NNSA/NFO, along with NNSA and DOE Environmental Management (EM) representatives from Washington, D.C. Key personnel from NNSA/NFO, NNSA, and DOE EM attended the meeting, providing updates and interacting directly with tribal leadership and their designated representatives. AICP tribal update meetings remain a priority and are integral to fostering tribal

interactions with NNSA/NFO and providing opportunities to discuss environmental and mission-driven activities on the NNSS.

Following the 2015 tribal update meeting, NNSA/NFO initiated support for a tribal revegetation project in Area 5 on the NNSS. A tribal planning committee will be appointed to convene a meeting in March 2016 to identify methods using ecological knowledge and expanding activities based on tribal perspectives.

In 2015, NNSA/NFO did not receive any requests from culturally affiliated tribes to access the NNSS for ceremonial or traditional use. CGTO interests focus on expanding traditional management activities and conducting ethnographic studies to document traditional ecological knowledge relating to land use and cultural resource protection and preservation.

To comply with NAGPRA, NNSA/NFO initiated and completed consultations with NNSS culturally affiliated tribes in the 1990s. NNSA/NFO remains committed to maintaining compliance with curation standards and ensuring that positive relations continue to exist between NNSA/NFO and the tribes (Arnold 2015).

In 2015, one letter report was completed, which provides an annotated bibliography of documents related to NAGPRA consultations (Menocal 2015c). Also completed was a second letter report containing an annotated bibliography of archived documents specific to the history of the AICP (Menocal 2015d).

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## Chapter 13: Ecological Monitoring

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The Ecological Monitoring and Compliance (EMAC) Program provides ecological monitoring and biological compliance support for activities and programs conducted at the Nevada National Security Site (NNSS). The major sub-programs and tasks within EMAC include (1) the Desert Tortoise Compliance Program, (2) biological surveys at proposed project/activity sites, (3) important species and ecosystem monitoring, (4) the Habitat Restoration Program, and (5) wildland fire hazard assessment. Brief descriptions of these sub-programs and their 2015 accomplishments are provided in this chapter. Detailed information may be found in the most recent annual EMAC report (Hall et al. 2016). EMAC annual reports are available at <http://www.nv.energy.gov/library/publications/emac.aspx>. The reader is also directed to *Attachment A: Site Description*, a separate file on the compact disc of this report, where the ecology of the NNSS is described.

### ***Ecological Monitoring and Compliance Program Goals***

Ensure compliance with all state and federal regulations and stakeholder commitments pertaining to NNSS flora, fauna, wetlands, and sensitive vegetation and wildlife habitats (see Table 2-1).

Delineate NNSS ecosystems.

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.

### ***13.1 Desert Tortoise Compliance Program***

The desert tortoise, which inhabits the southern one-third of the NNSS (Figure 13-1), is federally protected as a threatened species under the Endangered Species Act. Activities conducted in desert tortoise habitat on the NNSS must comply with the terms and conditions of a Biological Opinion (Opinion) issued to the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) by the U.S. Fish and Wildlife Service (FWS) (FWS 2009). The Opinion is effectively a permit to conduct activities in desert tortoise habitat in a specific manner. It authorizes the *incidental take* (see [Glossary, Appendix B](#)) 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 of the species and that no critical habitat would be destroyed or adversely modified. It sets compliance 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, or relocated tortoises (Table 13-1). It also establishes mitigation requirements for habitat loss. The Desert Tortoise Compliance Program was developed to implement the Opinion's terms and conditions, document compliance actions taken, and assist NNSA/NFO in FWS consultations.

#### ***13.1.1 Surveys and Compliance Documentation***

In 2015, biologists conducted surveys for five projects that were within the distribution range of the desert tortoise on the NNSS. At the project sites, no desert tortoises were accidentally injured or killed, nor were any found, captured, or displaced from the project sites. All five projects occurred on previously disturbed land. No undisturbed desert tortoise habitat was disturbed in 2015, no mitigation fees to compensate for the disturbance of desert tortoise habitat were assessed, and no compliance limits of the Opinion were exceeded (Table 13-1). Two desert tortoises were accidentally killed by vehicles on paved roads, and 17 were moved out of harm's way off of roads.

Four desert tortoises that had been moved off of roads and an additional two desert tortoises found by field biologists were fitted with radio transmitters for an FWS-approved study (see Section 13.1.2). In January 2016, NNSA/NFO submitted a report to the FWS Southern Nevada Field Office that summarizes tortoise compliance activities conducted on the NNSS from January 1 through December 31, 2015.

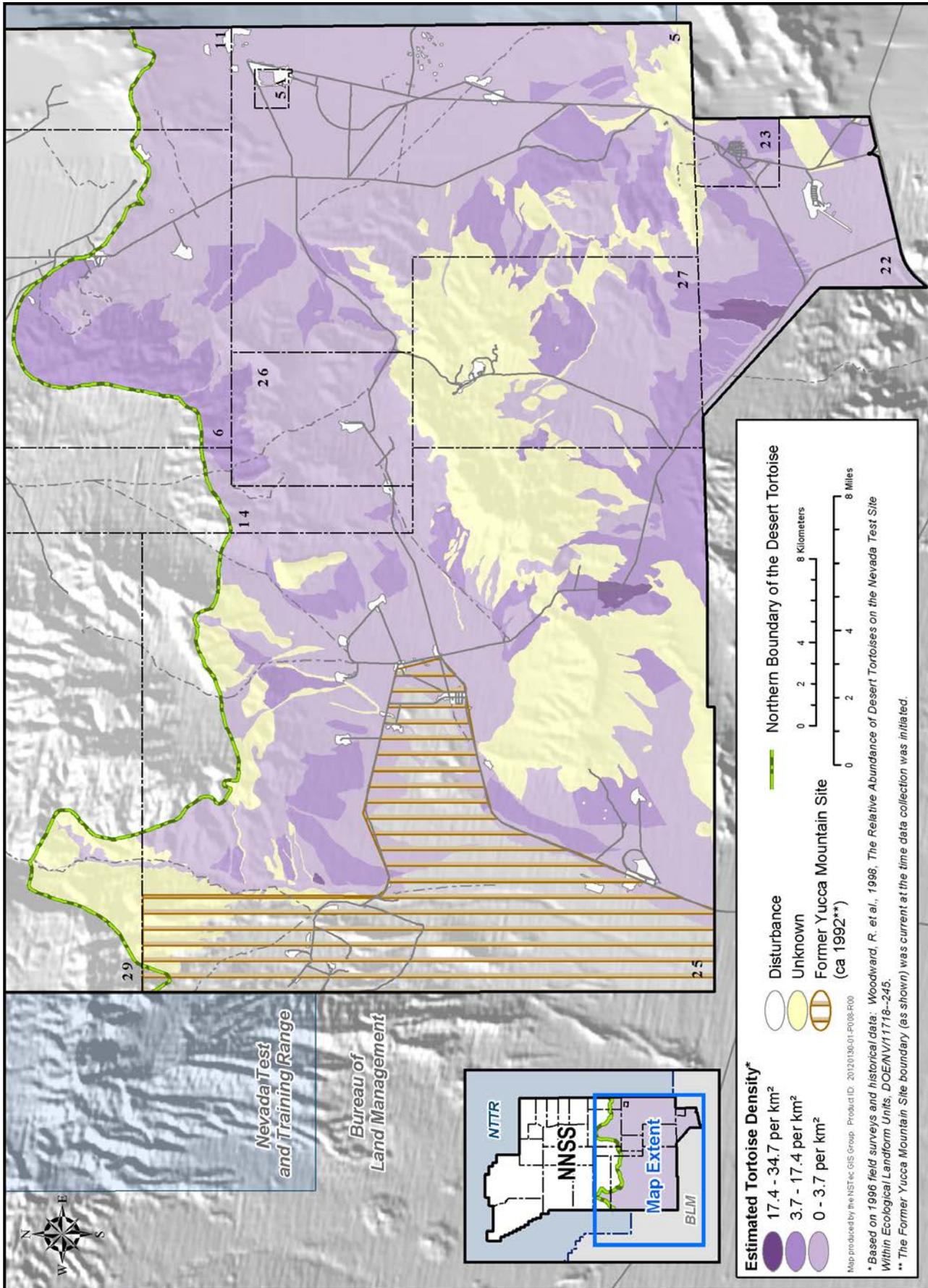


Figure 13-1. Desert tortoise distribution and abundance on the NNSS

**Table 13-1. Annual totals (2015), cumulative totals (2009–2014), and compliance limits for take of acres and tortoises**

Program/Activity	Acres Impacted			Tortoises Killed or Injured			Other Incidental Take <sup>(a)</sup>		
	Annual Total	Cumulative Total	Permit Limit	Annual Total	Cumulative Total	Permit Limit	Annual Total	Cumulative Total	Permit Limit
Defense	0	5.61	500	0	0	1	0	0	10
Waste Management	0	0	100	0	0	1	0	0	2
Environmental Restoration	0	0	10	0	0	1	0	0	2
Nondefense Research and Development	0	0	1,500	0	0	2	0	0	35
Work for Others	0	32.49	500	0	0	1	0	0	10
Infrastructure Development	0	8.43	100	0	0	1	0	0	10
Vehicle Traffic on Roads	-	-	-	2	9	15 <sup>(b)</sup>	19	95	125
<b>Totals</b>	0	46.53	2,710	2	9	22	19	95	194

(a) The number of desert tortoises that a qualified biologist can take by capture, displacement, relocation, or disruption of behavior if desert tortoises are found in harm's way within a project area or on a heavily trafficked road.

(b) No more than 4 desert tortoises killed during any calendar year and 15 during the term of the Opinion (2009–2019).

### 13.1.2 Desert Tortoise Conservation Projects

Three desert tortoise projects on the NNSS have been approved by the FWS and are being conducted solely or in part by NNSS biologists. They include (1) a tortoise movements study of up to 30 tortoises found along paved NNSS roads, (2) a study of the fate of 60 juvenile tortoises translocated in 2012 from captivity at the Desert Tortoise Conservation Center (DTCC) located near Las Vegas, Nevada, to undisturbed tortoise habitat in Area 22 of the NNSS by staff and volunteers from the San Diego Zoo Institute for Conservation Research (ICR), and (3) a collaborative behavioral/health study of up to 20 translocated tortoises within each of three existing fenced enclosures in Rock Valley (Area 25) led by the U.S. Geological Survey (USGS) in collaboration with the FWS, the ICR, and Pennsylvania State University.

NNSS biologists use radiotelemetry to document the location and condition of tortoises included in these three studies. In November 2013, the FWS approved NNSS biologists to conduct/support these studies in lieu of paying mitigation fees for habitat loss for NNSS projects that were not under the Work for Others Program (see Table 13-1, first column). The mitigation fees paid to date have provided no protection benefits to onsite tortoise populations; they have been used to support the operation of the DTCC operated by the ICR. The studies were approved because they are anticipated to reduce onsite tortoise road mortality and enhance tortoise conservation and regional recovery of the species.

In 2015, an additional six tortoises were radio-tagged for inclusion in the tortoise roadside movements study, bringing the total number of tortoises in the study to 30. Analysis of the movement data and resultant recommendations to reduce road mortality are expected to be completed in 2017. Monitoring of the 60 juvenile tortoises was transferred from ICR personnel to NNSS biologists in the fall of 2013. In 2015, NNSS biologists monitored the juveniles at varying frequencies throughout the year: once in January, February, and December, weekly during the tortoise activity season (March through October), and three times in November; health assessments were also performed. At the end of December 2015, 27 of the 60 translocated juveniles (45%) were still alive. The surviving juveniles will be monitored for the next several years. In 2015, NNSS biologists were not requested by USGS biologists to provide support gathering data at the Rock Valley enclosures.

### 13.2 Biological Surveys at Proposed Project Sites

Biological surveys are performed at proposed project sites where land disturbance will occur or where significant impacts to plants and animals might occur (e.g., during the demolition of structures that may contain bird nests or the release of toxic chemicals into habitat of protected species). The goal is to minimize the adverse effects of land disturbance and other impacts on important plants and animals (see Section 13.3), their associated habitat, and important biological resources. Important biological resources include such things as cover sites, nest/burrow sites, roost sites, wetlands, or water sources that are vital to important species.

During 2015, biologists surveyed a total of 645.8 acres for 13 projects on or near the NNSS, 9 of which were on lands previously disturbed (e.g., road shoulders, existing well pads, building sites). The 13 projects combined have the potential to disturb 48.5 acres. Important species and biological resources found included nine predator burrows, nine burrowing owl (*Athene cunicularia*) burrows, three active bird nests, and ten inactive bird nests. Biologists provided to project managers written summary reports of all survey findings and mitigation recommendations, which are summarized by project in Hall et al. (2016). No important species or important biological resources were known to be harmed by project activities in 2015, although accidental bird mortalities occurred (Table 13-2).

### 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 18 sensitive plants, 1 mollusk, 2 reptiles, 236 birds, and 27 mammals. They are identified in [Table A-11](#) of *Attachment A: Site Description* (see file 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. Over the past several decades, 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).

Ecosystem monitoring includes monitoring a wide variety of terrestrial and aquatic habitats and species not classified, as in the text above, as “important.” Such monitoring over time can identify impacts of climate and other environmental changes on the NNSS that are unrelated to NNSS project activities. In 1996, biologists began mapping plant communities and wildlife habitat on the NNSS within field mapping units called ecological landform units (ELUs). ELUs are landforms with similar vegetation, soil, slope, and hydrology. Boundaries of ELUs were defined using aerial photographs, satellite imagery, and field confirmation. ELU mapping resulted in the identification of 10 vegetation alliances and 20 vegetation associations on the NNSS (Ostler et al. 2000).

Field monitoring activities in 2015 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 et al. (2016).

**Table 13-2. Activities conducted in 2015 for important species and ecosystem monitoring on the NNSS**

**Sensitive Plants (see [Table A-11](#) of *Attachment A: Site Description*)**

- No field surveys were conducted in 2015 for sensitive plants due to poor growing conditions.

**Western Red-Tailed Skink (*Plestiodon gilberti rubricaudatus*)**

- This species is ranked by the Nevada Natural Heritage Program (NNHP) as either “imperiled” or “vulnerable” within Nevada (Table A-11 of *Attachment A: Site Description*).
- All Nevada museum records of this species were examined to validate the species’ range; 54 of the 98 records are from the NNSS and 44 are from various mountain ranges in southern Nevada. This information was shared with the Nevada Department of Wildlife (NDOW), and the NNHP and was included in the Nevada chapter of The Wildlife Society Fall Newsletter.

**Reptiles**

- Limited reptile trapping and roadkill surveys were conducted to better define species distributions on the NNSS; 47 reptiles were captured in pitfall and funnel traps at four sampling sites, and included 5 lizard species. Roadkill surveys identified 38 incidents of killed snakes representing 6 species and 101 killed lizards representing 6 species.

**Table 13-2. Activities conducted in 2015 for important species and ecosystem monitoring on the NNSS (continued)****Migratory Birds (protected under the Migratory Bird Treaty Act)**

- During biological surveys for proposed projects, 9 burrowing owl (*Athene cucularia*) burrows, 3 active bird nests, and 10 inactive bird nests were found, and project personnel were instructed to avoid them.
- Two winter raptor survey routes were sampled in January and February. A total of 20 raptors representing 3 species were observed.
- Removed an active nest of a red-tailed hawk (*Buteo jamaicensis*) from a drill rig with approval from FWS; took 2 birds (1 injured American kestrel [*Falco sparverius*] and 1 immature red-tailed hawk) to Wild Wing Project for treatment/care; and released a trapped barn owl (*Tyto alba*) from an underground facility.
- 27 bird mortalities were documented, 15 of which were due to human activities: 13 birds were electrocuted and two died from accidental entrapment. The remaining 12 deaths could not be attributed to NNSA/NFO activities.
- Biologists assisted in the development of a draft NNSA/NFO avian protection plan, which is anticipated to be finalized in 2016.

**Wild Horses (*Equus caballus*) (protected under the Wild Free Roaming Horses and Burros Act)**

- Annual horse monitoring has been conducted from 1980-2014 to determine abundance, foal survival, and population distribution on the NNSS. No horse surveys were conducted in 2015. However, opportunistic sightings were 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 23 deer/night, down from the average 28 deer/night in 2014 and 30 deer/night in 2013. The observed sex ratio of 57 bucks/100 does is the lowest recorded on the NNSS since 2006, and the observed fawn/doe ratio of 43 fawns/100 does is the second highest recorded since 2006.

**Desert Bighorn Sheep (*Ovis canadensis nelsoni*) (managed as a game mammal by NDOW)**

- A major effort among NDOW, USGS, U.S. Air Force, and NNSA/NFO to capture, radio-collar, and sample sheep was conducted in October and November 2015; 27 sheep were captured from the Nevada Test and Training Range (NTTR), 3 were radio-collared from the Bare Mountains near Beatty, 3 were radio-collared from the Specter Range, and 6 were captured and 5 of these radio-collared from the NNSS and tracked (Figure 13-2). Blood samples were taken from 8 sheep on the NTTR and 6 on the NNSS to assess disease prevalence, radiological burden, and relatedness to other southern Nevada populations. Radioanalysis results indicate that bighorn sheep from the NNSS and NTTR do not have radionuclide concentrations that could pose a hazard to them or to anyone eating them.

**Sensitive Bats (see [Table A-11](#) of *Attachment A: Site Description*)**

- The recording of bat vocalizations and climatic data (e.g., temperature, humidity, wind, barometric pressure) at Camp 17 Pond was continued. Analysis of bat vocalizations to identify species is conducted as funding is available. No analyses were conducted in 2015.
- NNSS biologists responded to five reports of bats found in buildings/structures. Live bats found are captured and released if necessary, and all roosting sites are recorded and left undisturbed whenever possible.

**Mountain Lions (*Puma concolor*) (managed as a game mammal by NDOW)**

- A collaborative effort with USGS scientists Dr. Erin Boydston and Dr. Kathy Longshore continued in 2015 to investigate mountain lion distribution and abundance on the NNSS using remote, motion-activated cameras. Cameras collected a total of 110 photographs/video clips of mountain lions from 14 of 33 camera sites, and 3 visual sightings by workers/biologists were recorded (Figure 13-3). A minimum of 3 lions (1 adult male, 1 adult female, and 1 subadult) inhabited the NNSS during 2015 based on photographic data.
- A collaborative effort with Kathy Longshore and David Choate of the USGS to investigate the movements, habitat use, and food habits of mountain lions on the NNSS using radio-collared individuals continued. Of the 4 mountain lions captured and collared for this study in 2012, none were still alive or had functioning collars in 2015. Efforts were made to trap and radio-collar 4 mountain lions to include in the study, but none were trapped over 27 days of setting snare traps and hunting with hounds.

**Natural and Man-made Water Sources**

- One new natural water source was discovered in the northwest corner of Area 20 on the NNSS. It is a natural formation of rock tanks, or catchments, in volcanic tuff which were given the name Schooner Wash Tanks (see Figure A-20 of *Attachment A: Site Description*).
- 10 natural water sources, 1 well pond, 5 wildlife water troughs, and 6 well sumps which periodically retain tritium contaminated groundwater discharged from monitoring wells (see Chapter 5, Section 5.1.1.3.7.3) were monitored with motion-activated cameras to document wildlife use. At natural water sources, water surface area, surface flow, and any disturbances were also monitored. Tritium contaminated well sumps are monitored to identify which species are being exposed and which may provide an exposure pathway to offsite hunters who may consume them. Mule deer, which can move off site and be harvested by hunters, were photographed at two of the well sumps.

**Long-Term Vegetation Plots**

- Between May and August 2015, plant cover and density were measured in the 10 plots established in 2008 in the pinyon pine (*Pinus monophylla*)–black sagebrush (*Artemisia nova*) vegetation association.
- Plant cover, density, and species richness data from 2008-2015 from 29 of the 41 plots established in 2008 were analyzed and summarized. They included 8 plots in black sagebrush, 11 in big sagebrush (*Artemisia tridentata*), and 10 in pinyon pine–black sagebrush associations.

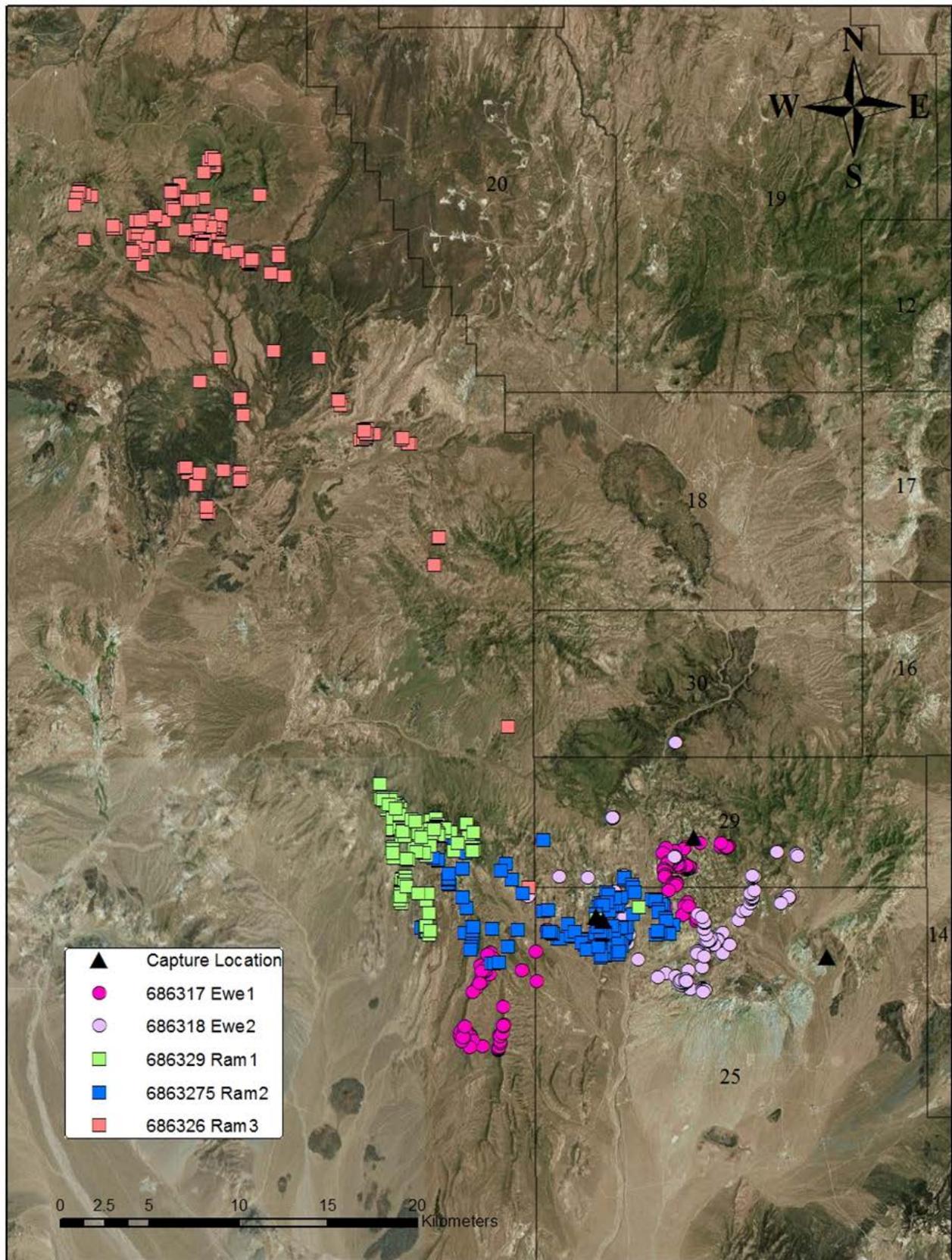


Figure 13-2. Capture locations and distribution of five radio-collared desert bighorn sheep (November 17–December 31, 2015)

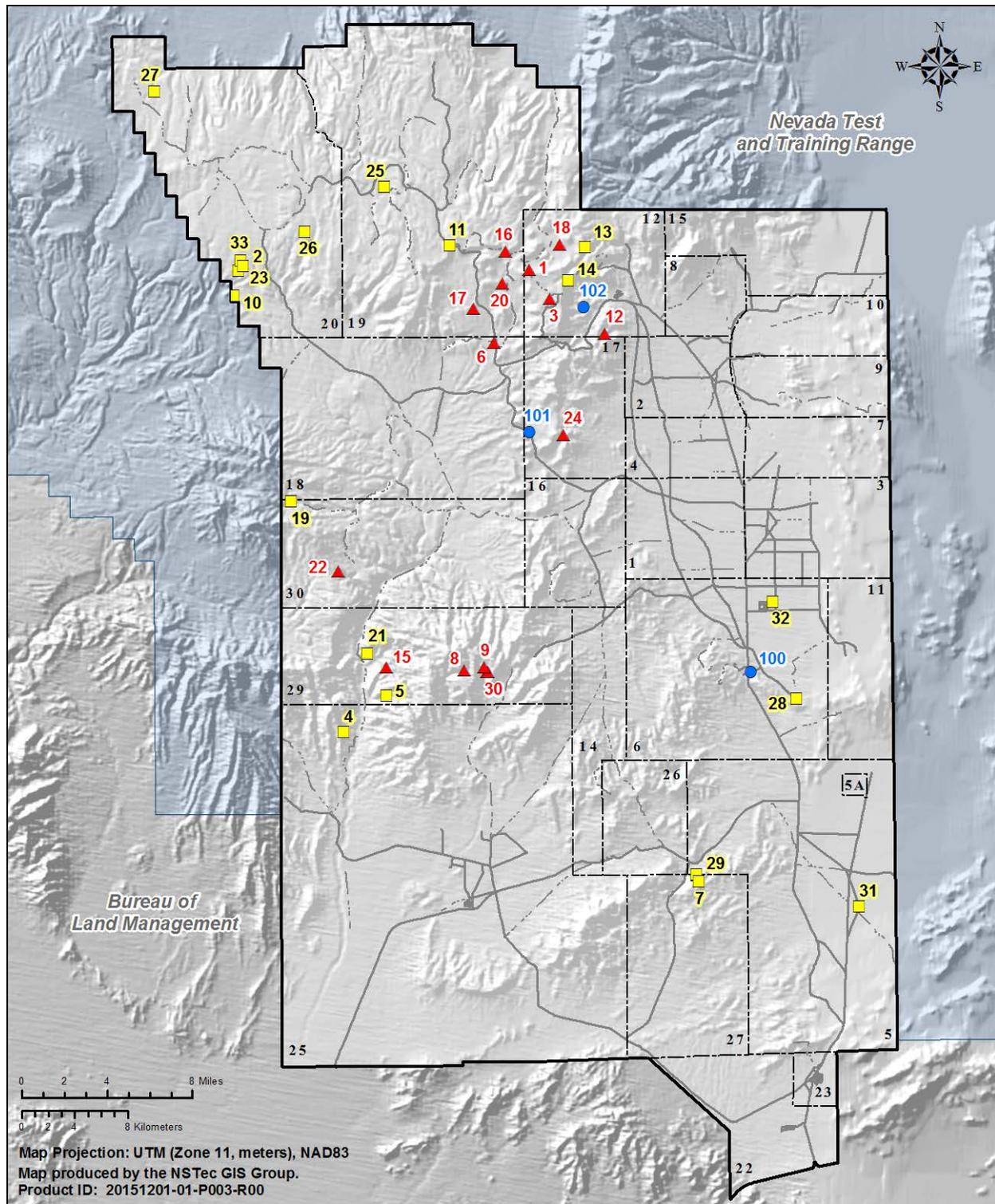


Figure 13-3. Mountain lion observations on the NNSS during 2015

### ***13.4 Habitat Restoration Program***

The Habitat Restoration Program revegetates disturbances and evaluates previous revegetation efforts. Sites that have been revegetated are periodically sampled, and the information obtained is used to develop site-specific revegetation plans for future restoration efforts on the NNSS. Revegetation supports the intent of Executive Order EO 13112, “Invasive Species,” to prevent the introduction and spread of non-native species and restore native species to disturbed sites. Revegetation also may qualify as mitigation for the loss of desert tortoise habitat under the current Opinion. NNSA/NFO revegetation projects include lands disturbed in desert tortoise habitat; wildland fire sites; abandoned industrial or nuclear test support sites classified into Corrective Action Units (CAUs) that are remediated by Environmental Management Operations (EM); and EM soil closure covers (or cover caps) over closed waste disposal pits. Sites that have been revegetated are periodically sampled as needed to monitor success or identify further needed actions. All monitoring information is used to develop site-specific revegetation plans for future restoration efforts on the NNSS. Sites at which revegetation has occurred in past years are listed below (the year each was revegetated is shown in parentheses). Field sampling and revegetation efforts performed in 2015 are discussed below.

- Double Tracks (CAU 411), Tonopah Test Range (TTR) (1996)
- Bomblet Pit and Five Points Landfill (CAU 400), TTR (1997)
- Cactus Spring Waste Trenches (CAU 426), TTR (1997)
- Roller Coaster Lagoons and Trench (CAU 404), TTR (1997)
- U3ax/bl Closure Cover (CAU 110), Area 3, NNSS (2000)
- Egg Point Fire, Area 12, NNSS (2002)
- Roller Coaster RadSafe Area (CAU 407), TTR (2004)
- NTS Waterline Replacement, Area 6, NNSS (2005)
- CP Hill Waterline, Area 6, NNSS (2009)
- 92 Acre Site, Area 5 RWMC (CAU 111), NNSS (2011)

In 2015, the North-North Closure Cover of CAU 111 at the Area 5 RWMC (see Chapter 10, Figure 10-1) was monitored. This waste disposal site was filled and permanently closed in 2011. Closure requires evapo-transpirative soil cover caps to be stabilized with native vegetation for each of four semi-rectangular areas separated by drainage channels and access roads, which are called the North-North Cover, the South-North Cover, the South Cover and the West Cover. The original attempt in 2011 to establish a native perennial plant community on each closure cover incorporated reclamation techniques successfully employed at other sites on the NNSS and the Tonopah Test Range, which included soil ripping, seeding with native species, straw mulching and supplemental irrigation as described in Ostler et al. (2002). Vegetation monitoring in the spring of 2013, however, showed that seed germination and plant establishment were below expectations (Hall et al. 2014) and that remedial revegetation would be required to establish a viable plant community on the covers. The approach taken was to evaluate different remedial revegetation scenarios on one of the covers. Once a successful revegetation methodology was identified, then the remaining CAU 111 covers would be revegetated using that methodology. The North-North Cover was selected in 2013 for the first series of research trials, and the South-North Cover was selected in 2014 for a second series of trials.

In March and August 2015, NNSS biologists monitored the revegetation trial plots at the South-North Cover of CAU 111. The density of seeded species and the percent cover of non-seeded species were recorded. Rabbit-proof fencing, which was planned for installation around the South-North plot, was not completed quickly and resulted in the failure of seeded species to become established. Based on results of both the 2013 and 2014 revegetation trials, Hall et al. (2016) summarizes the recommended seeding, irrigation, mulch, wildlife control, and invasive weed control techniques that should be employed for all closure cover caps of CAU 111.

### ***13.5 Wildland Fire Hazard Assessment***

A Wildland Fire Management Plan is maintained, which requires protection of site resources from wildland and operational fires. An annual vegetation survey to determine wildland fire hazards is conducted on the NNSS each spring. Survey findings are submitted to the NNSS Fire Marshal and summarized in the annual EMAC report

(Hall et al. 2016). In April and May 2015, NNSS biologists visited roadside sampling stations to assess a fuel index that can range from 0 to 10 (lowest to highest risk of wildfires). The mean combined fuels index (which includes both fine [non-woody] and woody fuels) for all sampling stations was 3.87, the second lowest ranking since 2004 when index values were initiated (the lowest since 2004 was 3.83 in 2014). Results from the wildland fuel surveys showed a very low risk of wildland fire due to reduced fuel loads caused by limited natural precipitation. Average precipitation during December–April, 2015, when it most influences plant growth and thus the availability of fine fuels for wildland fires, was 2.94 inches, 28% below the average for this period over the last 30 years. Four wildland fires occurred on the NNSS in 2015, each less than 0.9 acres in size, and were extinguished quickly.

### 13.6 References

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## Chapter 14: Quality Assurance Program

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The environmental monitoring work conducted for the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) is performed in accordance with the Quality Assurance Program (QAP) established by the current Management and Operations (M&O) contractor, National Security Technologies, LLC (NSTec), and with the Underground Test Area (UGTA) QAP implemented by Navarro Research and Engineering, Inc. (Navarro). Both QAPs describe the methods used to ensure that quality is integrated into the monitoring work. Both QAPs comply with Title 10 Code of Federal Regulations (CFR) 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.

### 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 Data Quality Objective (DQO) process developed by the U.S. Environmental Protection Agency (EPA) is generally used to provide the quality assurance (QA) structure for designing, implementing, and improving upon environmental monitoring efforts when environmental sampling and analysis are involved. Sampling and Analysis Plans are developed prior to performing an activity to ensure complete understanding of the data use objectives. Personnel are trained and qualified in accordance with company- and task-specific requirements. Access to sampling locations is coordinated with organizations conducting work at or having authority over those locations in order to avoid conflicts in activities and to communicate hazards to better ensure successful execution of the work and protection of the safety and health of sampling personnel. Sample collection activities adhere to organization instructions and/or procedures that are 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 that are based on methodologies developed by nationally recognized organizations such as the EPA, DOE, and ASTM International (formerly the American Society for Testing and Materials). Key quality-affecting procedural areas cover sample collection, preparation, instrument calibration, instrument performance checking, testing for precision and accuracy, obtaining a measurement, and laboratory data review. Data users perform reviews as required by the project-specific objectives before the data are used to support decision making.

The key elements of the environmental monitoring process work flow are listed below. Each element is designed to ensure that applicable QA requirements are implemented. A discussion of these elements follows.

- A **Sampling and Analysis Plan** (SAP) is developed using the EPA DQO process to ensure that clear goals and objectives are established for the environmental monitoring activity. The SAP is implemented in accordance with EPA, DOE, and other requirements addressing environmental, safety, and health concerns.
- **Environmental Sampling** is performed in accordance with the SAP and site work controls to ensure defensibility of the resulting data products and protection of the workers and the environment.
- **Laboratory Analyses** are performed to ensure that the resultant data meet DOE, NSTec (as the current M&O contractor), and UGTA regulation-defined requirements.

- **Data Review** is done to ensure that the SAP DQOs have been met, and thereby determine whether the data are suitable for their intended purpose.
- **Assessments** are employed to ensure that monitoring operations are conducted according to procedure and that 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 that those requirements are considered in the planning stage. The following statistical concepts and controls are vital in designing and evaluating the system design and implementation.

### **14.1.1 Precision**

Precision is the degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to themselves. Precision is a data quality indicator and is usually expressed as standard deviation, variance, or range, in either absolute or relative terms (DOE 2013).

Practically, precision is determined by comparing the results obtained from performing analyses on split or duplicate samples taken at the same time from the same location or locations very close to one another, maintaining sampling and analytical conditions as nearly identical as possible.

### **14.1.2 Accuracy**

Accuracy refers to the degree of agreement between an observed value and an accepted reference value. Accuracy includes a combination of random error (precision) and systematic error (bias) components that are due to sampling and analytical operations. Accuracy is a data quality indicator (DOE 2013). Accuracy 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, subsamples of the medium of interest are obtained. The challenge is to ensure that each subsample maintains the character of the larger sampled population. From a field sample collection standpoint, representativeness is managed through sampling plan design and execution. Representativeness related to laboratory operations concerns the ability to appropriately subsample and characterize for analytes of interest. For example, in order 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.

### **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 concerning sample collection and handling, laboratory analyses, and data review. This is ensured 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 the 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 to ensure protection of the 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 in order to ensure that, as methods are revised, sample collection is performed appropriately and that viable samples are obtained.

### ***14.2.3 Field Documentation***

Field documentation is generated for each sample collection activity. This may include chain of custody, sampling procedures, analytical methods, equipment and data logs, maps, Safety Data Sheets, and other materials needed to support the safe and successful execution and defense of the sampling effort. Chain-of-custody practices are employed from point of generation through disposal (cradle-to-grave); these are critical to the defensibility of the decisions made as a result of the sampling and analysis. Sampling data and documentation are stored and archived so they are readily retrievable for use at a later date. In many cases the data are managed in electronic data management systems. Routine assessments or surveillances are performed to ensure that sampling activities are performed in accordance with applicable requirements. Deficiencies are noted, causal factors are determined, corrective actions are implemented, and follow-up assessments are performed to ensure effective resolution. This data management approach ensures the quality and defensibility of the decisions made using analytical environmental data.

### ***14.2.4 Inspection and Acceptance Testing***

Sample collection data are reviewed for appropriateness, accuracy, and fit with historical measurements. In the case of groundwater sampling, water quality parameters are monitored during purging. Stabilization of these parameters generally indicates that the water is representative of the aquifer, at which time sample collection may begin. After a sampling activity is complete, data are reviewed to ensure the samples were collected in accordance with the SAP. Samples are further inspected to ensure 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 or the regulator, all data used for reporting purposes are generated by a DOE- and NSTec-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 DOE Quality Systems for Analytical Services (QSAS) (DOE 2013). The QSAS is based on the National Environmental Laboratory Accreditation Conference Chapter 5, “Quality Systems,” as implemented in 2005, based on International Organization for Standardization Standard ISO 17025, “General Requirements for the Competence of Testing and Calibration Laboratories.” Subcontracted laboratories must be assessed to be in compliance with the QSAS and are routinely audited under the DOE Consolidated Audit Program (DOECAP).

A request for proposal (RFP) is posted to the government website, laboratory responses are evaluated, and subcontracts awarded. The RFP cites the QSAS and DOECAP participation as base requirements and addresses site-specific conditions. Multiple laboratories may receive a subcontract through one RFP.

The laboratories are primarily those providing a wide range of analytical services to DOE. Other services can be subcontracted by the laboratory (i.e., lower-tier subcontractor) or contracted directly from a vendor. In either case, requirements are established for the specific services provided.

The subcontract places numerous requirements on the laboratory, including the following:

- Maintaining the following documents:
  - A Quality Assurance Plan and/or Manual describing the laboratory’s policies and approach to the implementation of QA requirements
  - An Environment, Safety, and Health Plan
  - A Waste Management Plan
  - Procedures pertinent to subcontract scope
- The ability to generate data deliverables, both hard copy reports and electronic files
- Responding to all data quality questions in a timely manner
- Mandatory participation in proficiency testing programs
- Maintaining specific licenses, accreditations, and certifications
- Conducting internal audits of laboratory operations as well as audits of vendors
- Allowing external audits by DOECAP and NNSA/NFO contractors and providing copies of other audits considered by NSTec 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, NSTec or Navarro will consider performing an audit (or participating in a DOECAP audit) of those laboratories awarded the contract. Neither contractor will initiate work with a laboratory without authorized approval from those NSTec or Navarro 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 as follows:

- Conducting regular audits or participating in evaluation of DOECAP audit products
- Monitoring for continued successful participation in proficiency testing programs such as:
  - National Institute of Standards and Technology Radiochemistry Intercomparison Program
  - Studies that support certification by the State of Nevada or appropriate regulatory authority for analyses performed in support of compliance monitoring
- Routine ongoing monitoring of the laboratory's adherence to the quality requirements

### **14.3.3 Data Evaluation**

Data products are continuously 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 continuous assessment tracks the recurrence and efficacy of corrective actions.

## **14.4 Data Review**

A systematic approach to thoroughly evaluating the data products generated from an environmental monitoring effort is essential for understanding and sustaining the quality of data collected under the program. This allows the programs to determine whether the DQOs established in the planning phase were achieved and whether the monitoring design performed as intended or requires review.

Because decisions are based on environmental data, and the effectiveness of operations is measured at least in part by environmental data, reliable, accurate, and defensible records are essential. Detailed records that must be kept include temporal, spatial, numerical, geotechnical, chemical, and radiological data as well as all sampling, analytical, and data review procedures used. Failure to maintain these records in a secure but accessible form may result in exposure to legal challenges and the inability to respond to demands or requests from regulators and other interested organizations.

An electronic data management system is a key tool used by many programs for achieving standardization and integrity in managing environmental data. The primary objective is to store and manage in an easily and efficiently retrievable form unclassified environmental data that are directly or indirectly tied to monitoring events. This may include information on monitoring system construction (groundwater wells, ambient air monitoring), and analytical, geotechnical, and field parameters at the Nevada National Security Site. Database integrity and security are enforced through the assignment of varying database access privileges commensurate with an employee's database responsibilities.

### **14.4.1 Data Verification**

Data verification is defined as a subcontract compliance and completeness review to ensure that all laboratory data and sample documentation are present and complete. Additional critical sampling and analysis process information is also reviewed at this stage, which may include, but is not limited to, sample preservation and temperature, defensible chain-of-custody documentation and integrity, and analytical hold-time compliance. Data verification also ensures that electronic data products correctly represent the sampling and/or analyses performed, and includes evaluation of QC sample results.

### **14.4.2 Data Validation**

Data validation supplements verification and is a more thorough process of analytical data review to better determine if the data meet the analytical and project requirements. Data validation ensures that the reported results

correctly represent the sampling and analyses performed, determines the validity of the reported results, and assigns data qualifiers (or “flags”), if required.

### **14.4.3 Data Quality Assessment (DQA)**

DQA is a scientific and statistical evaluation to determine if the data obtained from environmental operations are of the right type, quality, and quantity to support their intended use. The DQA includes reviewing data for accuracy, representativeness, and fit with historical measurements to ensure that the data will support their intended uses.

## **14.5 Assessments**

The overall effectiveness of the environmental program is determined through routine surveillance and assessments of work execution as well as review of program requirements. Deficiencies are identified, causal factors are investigated, corrective actions are developed and implemented, and follow-on monitoring is performed to ensure effective resolution. The assessments discussed below are broken down into general programmatic and focused measurement data areas.

### **14.5.1 Programmatic**

Assessments and audits under this category include evaluations of work planning, execution, and performance activities. Personnel independent of the work activity perform the assessments to evaluate compliance with established requirements and report on deficiencies identified. Organizations responsible for the activity are required to develop and implement corrective actions, with the concurrence of the deficiency originator or recognized subject matter expert. NNSA/NFO contractors maintain companywide issues tracking systems to manage assessments, findings, and corrective actions.

### **14.5.2 Measurement Data**

This type of assessment includes routine evaluation of data generated from analyses of QC and other samples. QC sample data are used to monitor the analytical control on a given batch of samples and are indicators over time of potential biases in laboratory performance. Discussions of the 2015 results for field duplicates, laboratory control samples, blank analyses, matrix spikes, and proficiency testing programs are provided, and summary tables are included below.

#### **14.5.2.1 Field Duplicates**

Samples obtained at nearly the same locations and times as initial samples are termed field duplicates. These are used to evaluate the overall precision of the measurement process, including small-scale heterogeneity in the medium (air, water, or direct radiation) being sampled as well as analytical and sample preparation variation. The absolute relative percent difference (RPD) compares the absolute difference of initial and field duplicate measurements with the average of the two measurements (Table 14-1, footnote c); it is computed only from pairs for which both values are above their respective minimum detectable concentrations (MDCs). The relative error ratio (RER) compares the absolute difference of initial and field duplicate measurements to the laboratory’s reported analytical uncertainty (Table 14-1, footnote d).

The average absolute RPD and average RER values for all 2015 radiological air and water duplicate pairs are shown in Table 14-1. They are similar to those seen in prior years. The higher average absolute RPDs (those greater than 25) are associated with two types of phenomena. RPDs for actinides in air, in particular, and consequently for gross alpha in air, can be elevated when one sampler of a pair intercepts a particle with high americium (Am) or plutonium (Pu), while the other sampler in the pair had a typical background value. For example, RPDs for <sup>241</sup>Am and <sup>239+240</sup>Pu were 43.3 and 21.7 respectively. Also, higher average absolute RPDs are often associated with relatively few pairs having both values above their MDCs, as low level measurements are typically “noisier” than higher-level measurements (again, <sup>241</sup>Am in 2015).

Table 14-1. Summary of field duplicate samples for 2015

Analyte	Medium	Number of Duplicate Pairs <sup>(a)</sup>	Number of Pairs > MDC <sup>(b)</sup>	Average Absolute RPD <sup>(c)</sup> of Pairs > MDC	Average Absolute RER <sup>(d)</sup> of All Pairs
<b>Environmental Monitoring Samples</b>					
Gross alpha	Air	52	42	19.7	0.62
Gross beta	Air	52	52	5.9	1.04
Tritium	Air	50	13	18.2	0.71
<sup>241</sup> Am	Air	8	1	43.3	0.59
<sup>238</sup> Pu	Air	8	0	----	0.71
<sup>239+240</sup> Pu	Air	8	3	21.7	0.94
<sup>233+234</sup> U	Air	5	5	10.7	0.78
<sup>235+236</sup> U	Air	5	3	18.7	0.47
<sup>238</sup> U	Air	5	5	4.2	0.32
<sup>7</sup> Be <sup>(e)</sup>	Air	8	8	7.8	0.97
<sup>137</sup> Cs	Air	8	0	----	1.04
<sup>40</sup> K <sup>(e)</sup>	Air	8	4	29.9	1.08
Gross alpha	Water	3	3	4.0	0.20
Gross beta	Water	3	3	8.9	0.36
Tritium (standard)	Water	17	0	----	0.87
TLD	Ambient Radiation	434	NA	3.3	0.31
<b>Underground Test Area (UGTA) Samples</b>					
Gross alpha	Water	26	12	14.2	0.80
Gross beta	Water	26	13	16.6	1.00
Tritium (standard)	Water	30	17	4.1	0.32
Tritium (low-level)	Water	6	2	13.3	0.50

(a) Represents the number of field duplicates reported for evaluating precision.

(b) Represents the number of field duplicate–field sample pairs with both values above their MDCs. If either the field sample or duplicate was below the MDC, the RPD was not determined. This does not apply to thermoluminescent dosimeter (TLD) measurements; because TLDs virtually always detect ambient background radiation, MDCs are not computed.

(c) Represents the average absolute RPD calculated as follows:

$$\text{Absolute RPD} = \frac{|S - D|}{(D + S)/2} \times 100$$

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.

$$\text{Absolute RER} = \frac{|S - D|}{\sqrt{(SD_s)^2 + (SD_d)^2}}$$

Where: S = Sample result  
D = Duplicate result  
SD<sub>s</sub> = Standard deviation of the sample result  
SD<sub>d</sub> = Standard deviation of the duplicate result

(e) <sup>7</sup>Be and <sup>40</sup>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 2013).

The results are calculated as a percentage of the true value (i.e., percent recovery), and must fall within established control limits to be considered acceptable. If the LCS recovery falls outside control limits, evaluation for potential sample data bias is necessary. The numbers of the 2015 LCSs analyzed and within control limits are summarized in Table 14-2. There were no systemic issues identified in 2015 by LCS recovery data, and no failures that invalidated the associated sample data.

**Table 14-2. Summary of LCSs for 2015**

Analyte	Matrix	Number of LCS Results Reported	Number Within Control Limits	Control Limits (%)
<b>Environmental Monitoring Samples</b>				
Tritium	Air	71	71	75–125
<sup>60</sup> Co	Air	5	5	75–125
<sup>137</sup> Cs	Air	5	5	75–125
<sup>239+240</sup> Pu	Air	15	15	75–125
<sup>241</sup> Am	Air	18	18	75–125
Gross alpha	Water	11	11	75–125
Gross beta	Water	11	11	75–125
Tritium (standard)	Water	19	19	75–125
<sup>60</sup> Co	Water	0	0	75–125
<sup>90</sup> Sr	Water	0	0	75–125
<sup>137</sup> Cs	Water	0	0	75–125
<sup>239+240</sup> Pu	Water	0	0	75–125
<sup>241</sup> Am	Water	0	0	75–125
Tritium	Soil	2	2	75–125
<sup>60</sup> Co	Soil	7	7	75–125
<sup>90</sup> Sr	Soil	11	11	75–125
<sup>137</sup> Cs	Soil	7	7	75–125
<sup>239+240</sup> Pu	Soil	14	14	75–125
<sup>241</sup> Am	Soil	20	20	75–125
<sup>60</sup> Co	Vegetation	1	1	75–125
<sup>90</sup> Sr	Vegetation	2	2	75–125
<sup>137</sup> Cs	Vegetation	7	7	75–125
<sup>239+240</sup> Pu	Vegetation	1	1	75–125
<sup>241</sup> Am	Vegetation	2	2	75–125
Metals	Water	91	91	80–120
Volatiles	Water	437	434	70–130
Semi volatiles	Water	645	645	Laboratory specific
Miscellaneous	Water	84	84	80–120
Metals	Soil	40	39	80–120
Volatiles	Soil	179	179	70–130
Semi volatiles	Soil	176	176	Laboratory specific
Miscellaneous	Soil	0	0	80–120
<b>UGTA Samples</b>				
Gross alpha	Water	18	18	80-120
Gross beta	Water	18	18	80-120
Tritium (standard)	Water	20	19	80-120
Tritium (low-level)	Water	16	14	80-120

### 14.5.2.3 Blank Analysis

In general, a blank is a sample that has not been exposed to the targeted environment and is analyzed in order to monitor “no exposure” analyte levels and contamination that might be introduced during sampling, transport, storage, or analysis. The blank is subjected to the usual analytical and measurement process to establish a baseline or background value, and is sometimes used to adjust or correct routine analytical results (DOE 2013). Blanks are processed simultaneously with and under the same conditions as samples through all steps of the analytical procedures. The following list identifies the blanks routinely used during environmental monitoring activities.

- A trip blank is a sample of analyte-free media taken from the laboratory to the sampling site and returned to the laboratory unopened. A trip blank is used to document contamination attributable to shipping and field handling procedures. This type of blank is useful in documenting contamination of volatile organics samples (DOE 2013).
- An equipment blank is a sample of analyte-free media that has been used to rinse common sampling equipment to check effectiveness of decontamination procedures (DOE 2013).
- A field blank is prepared in the field by filling a clean container with purified water (appropriate for the target analytes) and appropriate preservative, if any, for the specific sampling activity being undertaken. The field blank is used to indicate the presence of contamination due to sample collection and handling (DOE 2013).
- A method blank is a sample of a matrix similar to the associated sample batch in which no target analytes or interferences are present at concentrations that would impact the sample analyses results (DOE 2013). Method blank data are summarized in Table 14-3.

There were no systemic issues and no failures that required invalidating the associated sample data identified in 2015 by the blank data.

**Table 14-3. Summary of laboratory method blank samples for 2015**

Analyte	Matrix	Number of Blank Results Reported	Number of Results < MDC
<b>Environmental Monitoring Samples</b>			
Tritium	Air	64	64
<sup>7</sup> Be	Air	5	5
<sup>60</sup> Co	Air	2	2
<sup>137</sup> Cs	Air	5	5
<sup>238</sup> Pu	Air	8	8
<sup>239+240</sup> Pu	Air	8	8
<sup>241</sup> Am	Air	9	9
Gross alpha	Water	11	11
Gross beta	Water	11	11
Tritium (standard)	Water	17	17
<sup>60</sup> Co	Water	0	0
<sup>90</sup> Sr	Water	0	0
<sup>137</sup> Cs	Water	0	0
<sup>238</sup> Pu	Water	0	0
<sup>239+240</sup> Pu	Water	0	0
<sup>241</sup> Am	Water	0	0
Tritium	Soil	1	1
<sup>60</sup> Co	Soil	6	6
<sup>90</sup> Sr	Soil	7	7
<sup>137</sup> Cs	Soil	7	7
<sup>238</sup> Pu	Soil	9	9
<sup>239+240</sup> Pu	Soil	9	9
<sup>241</sup> Am	Soil	14	14
<sup>60</sup> Co	Vegetation	0	0
<sup>90</sup> Sr	Vegetation	2	2
<sup>137</sup> Cs	Vegetation	1	1
<sup>238</sup> Pu	Vegetation	1	1
<sup>239+240</sup> Pu	Vegetation	1	1
<sup>241</sup> Am	Vegetation	1	1
Metals	Water	91	90
Volatiles	Water	382	376
Semi volatiles	Water	313	313
Miscellaneous	Water	124	124
Metals	Soil	56	54
Volatiles	Soil	131	119
Semi volatiles	Soil	196	178
Miscellaneous	Soil	0	0

**Table 14-4. Summary of laboratory method blank samples for 2015 (continued)**

Analyte	Matrix	Number of Blank Results Reported	Number of Results < MDC
<b>UGTA</b>			
Gross alpha	Water	15	15
Gross beta	Water	15	15
Tritium (standard)	Water	21	21
Tritium (low-level)	Water	8	7

#### 14.5.2.4 Matrix Spike Analysis

A matrix spike is a sample spiked with a known concentration of analyte. This spike 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 2015, and there were no issues identified by the analysis data (Table 14-4).

**Table 14-4. Summary of matrix spike samples for 2015**

Analyte	Matrix	Number of Matrix Spikes Reported	Number Within Control Limits	Control Limits (%)
<b>Environmental Monitoring Samples</b>				
Tritium	Air	17	17	60–140
Gross alpha	Water	6	6	60–140
Gross beta	Water	6	6	60–140
Tritium	Water	14	14	60–140
<b>UGTA Samples</b>				
Gross alpha	Water	11	11	60-140
Gross beta	Water	11	11	60-140
Tritium (standard)	Water	20	18	60-140
Tritium (low-level)	Water	8	7	60-140

#### 14.5.2.5 Proficiency Testing Program Participation

All contracted laboratories are required to participate in proficiency testing programs. Laboratory performance supports decisions on work distribution and may also be a basis for state certifications. Table 14-5 presents the 2015 results for the laboratory performance in the March and August studies of the Mixed Analyte Performance Evaluation Program (MAPEP) (<http://www.id.energy.gov/resl/mapep/mapepreports.html>) administered by the Radiological and Environmental Sciences Laboratory of the Idaho National Laboratory. Proficiency testing programs are not available for the low-level tritium analytical method. Therefore, for UGTA groundwater samples, Navarro compared sample results from the commercial laboratory and from Lawrence Livermore National Laboratory to demonstrate proficiency.

**Table 14-5. Summary of 2015 MAPEP reports**

Analyte	Matrix	Number of Results Reported	Number within Control Limits <sup>(a)</sup>
<b>Environmental Monitoring Samples</b>			
Gross alpha	Filter	6	6
Gross beta	Filter	6	6
<sup>60</sup> Co	Filter	6	6
<sup>137</sup> Cs	Filter	6	6
<sup>238</sup> Pu	Filter	6	6
<sup>239+240</sup> Pu	Filter	6	5
<sup>241</sup> Am	Filter	6	5
Gross alpha	Water	6	6
Gross beta	Water	6	6
Tritium (standard)	Water	6	6
<sup>60</sup> Co	Water	6	6
<sup>90</sup> Sr	Water	6	6

**Table 14-5. Summary of 2015 MAPEP reports (continued)**

Analyte	Matrix	Number of Results Reported	Number within Control Limits <sup>(a)</sup>
<b>Environmental Monitoring Samples (continued)</b>			
<sup>137</sup> Cs	Water	6	6
<sup>238</sup> Pu	Water	6	6
<sup>239+240</sup> Pu	Water	6	6
<sup>241</sup> Am	Water	6	6
<sup>60</sup> Co	Vegetation	6	6
<sup>90</sup> Sr	Vegetation	6	6
<sup>137</sup> Cs	Vegetation	6	5
<sup>238</sup> Pu	Vegetation	6	6
<sup>239+240</sup> Pu	Vegetation	6	6
<sup>60</sup> Co	Soil	6	6
<sup>90</sup> Sr	Soil	6	6
<sup>137</sup> Cs	Soil	6	6
<sup>238</sup> Pu	Soil	6	6
<sup>239+240</sup> Pu	Soil	6	6
<sup>241</sup> Am	Soil	6	6
Metals	Water	90	86
Organics	Water	480	457
Metals	Soil	96	93
Organics	Soil	444	440

(a) Based upon MAPEP criteria

Table 14-6 shows the summary of inter-laboratory comparison sample results for the NSTec Radiological Health Dosimetry Group. The DOE Standard DOE-STD-1095-2011, “Department of Energy Laboratory Accreditation for External Dosimetry,” establishes the methodology for determining acceptable performance testing of dosimeter systems. It also establishes the technical basis for performance testing and the testing categories and performance criteria, which are outlined in the American National Standards Institute/Health Physics Society (ANSI/HPS) N13.11-2009, “American National Standard for Dosimetry–Personnel Dosimetry Performance–Criteria for Testing,” and in ANSI/HPS N13.32-2008, “An American National Standard, Performance Testing of Extremity Dosimeters.” The Dosimetry Group participated in the Battelle Pacific Northwest National Laboratory proficiency testing program during the course of the year.

**Table 14-6. Summary of inter-laboratory comparison TLD samples (UD-802 dosimeters) for 2015**

Analysis	Matrix	Number of Results Reported	Number within Control Limits <sup>(a)</sup>
TLD	Ambient Radiation	65	65

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

## 14.6 References

DOE, see U.S. Department of Energy.

Stanley, T. W., and S. S. Verner, 1985. The U.S. Environmental Protection Agency’s Quality Assurance Program. In: Taylor, J. K., and T. W. Stanley (eds.), *Quality Assurance for Environmental Measurements*, ASTM STP-867, Philadelphia, PA.

U.S. Department of Energy, 2013. *DOE Quality Systems for Analytical Services Version 3.0*, July 2013.

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## ***Chapter 15: Quality Assurance Program for the Community Environmental Monitoring Program***

**Craig Shadel**

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The Community Environmental Monitoring Program (CEMP) Quality Assurance Management and Assessment Plan (QAMAP) (Desert Research Institute 2009) was 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 appropriate 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 that is 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 as discussed in Chapter 14.

### ***15.2 Measurement Quality Objectives (MQOs)***

The MQOs are basically equivalent to DQOs for analytical processes. The MQOs provide direction to the laboratory concerning performance objectives or requirements for specific method performance characteristics. Default MQOs are established in the subcontract with the laboratory, but may be altered in order to satisfy changes in the DQOs. The MQOs for the CEMP project are described in terms of precision, accuracy, representativeness, completeness, and comparability requirements. These terms are defined and discussed in Section 14.1 for onsite activities.

### ***15.3 Sampling Quality Assurance Program***

Quality Assurance (QA) in field operations for the CEMP includes sampling assessments, surveillances, 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 items:

- 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 to sampling ensures that the sampling is traceable and enhances the value of the final data available to the project manager. The sample package also ensures that the Community Environmental Monitor (CEM) station manager (see Chapter 7 for a description of CEMs) has followed proper procedures for sample collection. The CEMP Project Manager or QA Officer routinely performs assessments of the station managers and field monitors to ensure that standard operating procedures and sampling protocols are being followed properly.

Data obtained in the course of executing field operations are entered in the documentation accompanying the sample package during sample collection and in the CEMP database along with analytical results upon their receipt and evaluation.

Completed sample packages are kept as hard copy in file archives. Analytical reports are kept as hard copy in file archives as well as on read-only compact discs by calendar year. Analytical reports and databases are protected and maintained in accordance with the Desert Research Institute'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., 2012). 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 items:

- 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
- Facility design/description
- Accreditations and certifications
- Licenses
- Audits performed by an acceptable DOE program covering comparable scope
- Past performance surveys
- Pricing

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 of 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 policies and approach to the implementation of DOE O 414.1D must be verified in an LQAP prepared by the laboratory. The elements of an LQAP required for the CEMP are similar to those required by National Security Technologies, LLC, for onsite monitoring, and are described in 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 shall be 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 the reported results, and assigns data qualifiers (or “flags”), if required. The process of data validation consists of the following:

- Evaluating the quality of the data to ensure that 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 the CEMP databases for the purposes of defining 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 it pertains to the organization.

## 15.7 2015 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 and the University of Nevada, Las Vegas, Radiation Services Laboratory (gross alpha/beta and gamma spectroscopy data); Mirion Technologies (thermoluminescent dosimeter [TLD] data); and the University of Miami Tritium Laboratory (tritium data). A brief discussion of the 2015 results for field duplicates, laboratory control samples, blank analyses, and inter-laboratory comparison studies is provided along with summary tables within this section. The 2015 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 following 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 2015 samples and is listed in Table 15-1. An RPD of zero indicates a perfect duplication of results of the duplicate pair, whereas an RPD greater than 100% generally indicates that a duplicate pair falls beyond QA requirements and is not considered valid for use in data interpretation. These samples are further evaluated to determine the reason for QA failure and if any corrective actions are required. Overall, the RPD values for all analyses indicate very good results, with only three alpha duplicates exceeding an RPD of 100%.

**Table 15-1. Summary of field duplicate samples for CEMP monitoring in 2015**

Analysis	Matrix	Number of Samples Reported <sup>(a)</sup>	Number of Samples Reported above MDC <sup>(b)</sup>	Average Absolute RPD of those above MDC (%) <sup>(c)</sup>
Gross Alpha	Air	52	51	54.3
Gross Beta	Air	52	51	31.4
Gamma – Beryllium-7	Air	12	8	83.5
Tritium	Water	1	0	NA <sup>(d)</sup>
TLDs	Ambient Radiation	12	NA	1.5

- (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:

$$\text{Absolute RPD} = \frac{|FD - FS|}{(FD + FS) / 2} \times 100\% \quad \text{Where: } \begin{array}{l} FD = \text{Field duplicate result} \\ FS = \text{Field sample result} \end{array}$$

### 15.7.2 Laboratory Control Samples (Accuracy)

Laboratory control samples (LCSs) (also known as matrix spikes) are performed by the subcontract laboratory to evaluate analytical accuracy, which is the degree of agreement of a measured value with the true or expected value. Samples of known concentration are analyzed using the same methods as employed for the project samples. The results are determined as the measured value divided by the true value, expressed as a percentage. To be considered valid, the results must fall within established control limits (or percentage ranges) for further analyses to be performed. The LCS results obtained for 2015 are summarized in Table 15-2. The LCS results were satisfactory, with all samples falling within control parameters for the air sample matrix.

**Table 15-2. Summary of laboratory control samples (LCSs) for CEMP monitoring in 2015**

Analysis	Matrix	Number of LCS Results Reported	Number Within Control Limits <sup>(a)</sup>
Gross Alpha	Air	40	40
Gross Beta	Air	40	40
Gamma	Air	12	12
Tritium	Water	1	1

(a) Control limits are as follows: 75% to 125% for gross alpha, 75% to 125% for gross beta, 87% to 120% for gamma (<sup>137</sup>Cs, <sup>60</sup>Co, <sup>241</sup>Am), and 80% to 120% for tritium.

### 15.7.3 Blank Analysis

Laboratory blank sample analyses are essentially the opposite of LCSs discussed in Section 15.7.2. 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 2015 are summarized in Table 15-3. The laboratory blank results were satisfactory with only one of the beta blank samples (2%) outside of control parameters for the air sample matrix.

**Table 15-3. Summary of laboratory blank samples for CEMP monitoring in 2015**

Analysis	Matrix	Number of Blank Results Reported	Number within Control Limits <sup>(a)</sup>
Gross Alpha	Air	41	41
Gross Beta	Air	41	40
Gamma	Air	12	12
Tritium	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 2015 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 tritium laboratory also participated in the MAPEP program. Overall, all of the subcontractors performed very well during the year by passing all of the parameters analyzed.

**Table 15-4. Summary of inter-laboratory comparison samples of the subcontract radiochemistry and tritium laboratories for CEMP monitoring in 2015**

Analysis	Matrix	MAPEP and ERA Results	
		Number of Results Reported	Number Within Control Limits <sup>(a)</sup>
Gross Alpha	Air	4	4
Gross Beta	Air	4	4
Gamma	Air	4	4
Tritium	Water	2	2

(a) Control limits are determined by the individual inter-laboratory comparison study.

Table 15-5 shows the summary of the in-house performance evaluation results conducted by the subcontract dosimetry group. This internal evaluation was based on National Voluntary Laboratory Accreditation Program (NVLAP) criteria and was performed biannually. The dosimetry group performed very well during the year, passing 12 out of 12 TLDs analyzed.

**Table 15-5. Summary of inter-laboratory comparison TLD samples of the subcontract dosimetry group for CEMP monitoring in 2015**

Analysis	Matrix	Number of Results Reported	Number Within Control Limits <sup>(a)</sup>
TLDs	Ambient Radiation	12	12

(a) Based upon NVLAP criteria; absolute value of the bias plus one standard deviation < 0.3.

## 15.8 References

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

Testamerica, Inc., 2012. *Quality Assurance Manual*. Version 8.0, February 2015.

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*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. Mercadante, Phyllis M. Radack, and Ronald W. Warren

National Security Technologies, 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 all environmental monitoring and compliance activities conducted in 2015 at these support 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 2015 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 (see Chapter 2, Table 2-3 for a list of all NNSA/NFO permits). NNSA/NFO also monitors tritium in air and ambient gamma-emissions to comply with federal radiation protection regulations, although this monitoring is not required by any city or state permits.

### 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* (see [Glossary, Appendix B](#)). These pollutants include particulate matter (PM), nitrogen oxide (NO<sub>x</sub>), carbon monoxide (CO), sulfur dioxide (SO<sub>2</sub>), and volatile organic compounds (VOCs). Because the NLVF is considered a true minor source, there is no requirement to report *hazardous air pollutants (HAPs)* (see [Glossary, Appendix B](#)). 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 2015 emissions inventory, which reported the estimated quantities shown in Table A-1, was submitted to the DAQ on March 28, 2016.

**Table A-1. Summary of air emissions for the NLVF in 2015**

Parameter	Criteria Pollutant (Tons/yr) <sup>(a)</sup>					
	PM10 <sup>(b)</sup>	PM2.5 <sup>(c)</sup>	NO <sub>x</sub>	CO	SO <sub>2</sub>	VOC
PTE <sup>(d)</sup>	1.49	0.87	20.40	4.54	0.09	0.93
Actual <sup>(e)</sup>	0.23	0.08	1.17	0.43	0.01	0.07
<b>Total Emissions = 1.99 Actual, 28.32 PTE</b>						

(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 air pollutant that 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 that at least one visual emissions observation be performed each month of operating

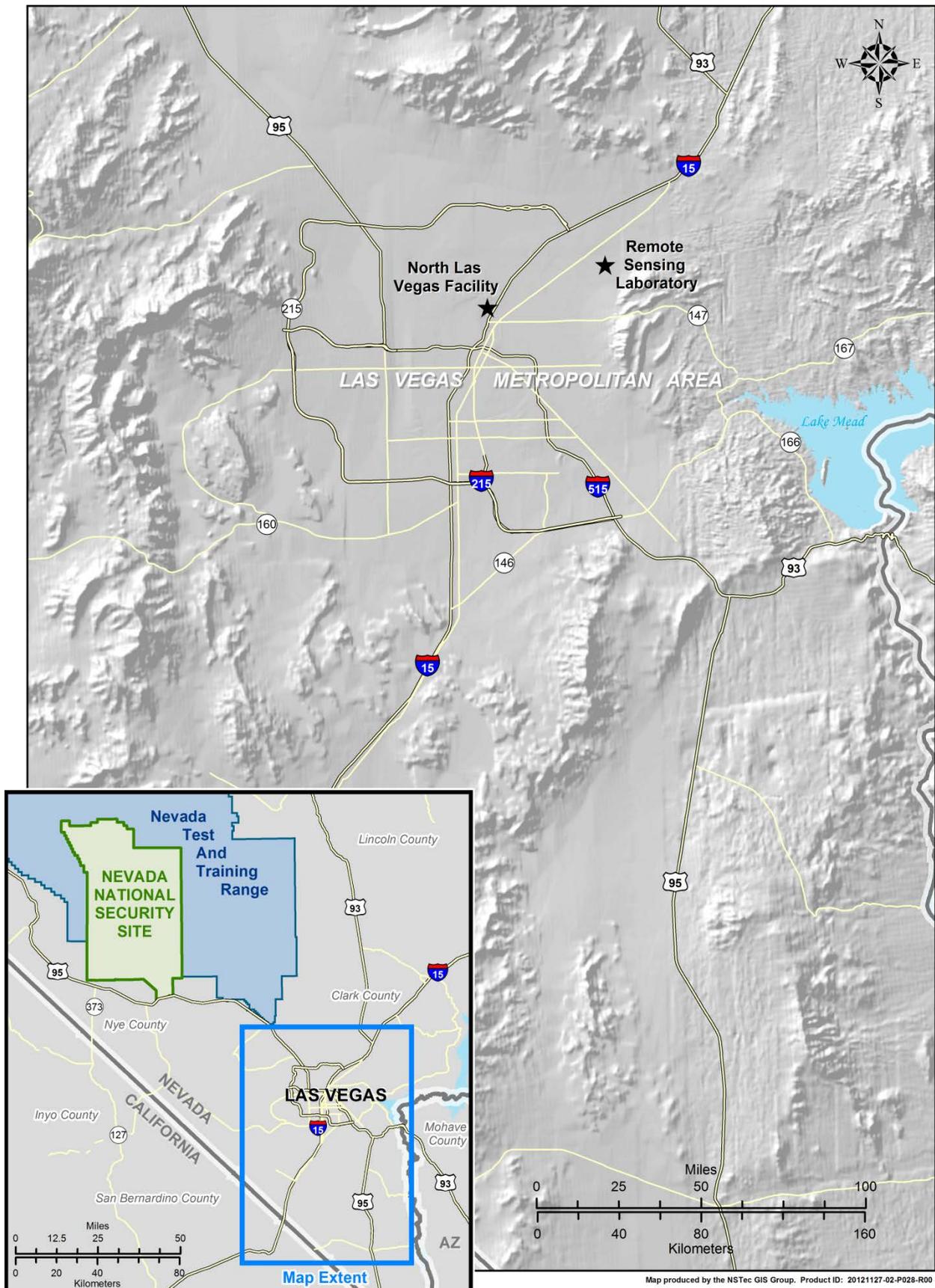


Figure A-1. Location of NNSS offsite facilities in Las Vegas and North Las Vegas

equipment, i.e., boilers, generators, emergency fire pump, emergency generator, and the cooling towers. If emissions are observed, then U.S. Environmental Protection Agency (EPA) Method 9 opacity readings are recorded by a certified visible emissions evaluator. If visible emissions appear to exceed the limit, corrective actions must be taken to minimize emissions. In 2015, two NLVF Maintenance Engineers were recertified and two new employees were certified to conduct opacity readings. In 2015, observations were taken for the boilers, generators, the fire pump, and cooling towers; emissions were below the NAAQS opacity limit of 20%.

At NLVF, a verbal notification to the City of North Las Vegas (CNLV) Fire Department is required before each fire extinguisher training session. In 2015, one hot work live fire extinguisher training session was conducted at the NLVF. Quantities of criteria air pollutants produced by the open burns during training are not required to be calculated or reported.

### ***A.1.2 Water Quality and Protection***

Water used at the NLVF is supplied by the CNLV and meets or exceeds federal drinking water standards. Water quality permits issued to NNSA/NFO are for wastewaters discharged from the NLVF. NLVF wastewater permits in 2015 included a Class II Wastewater Control Permit from the CNLV for sewer discharges, and an NPDES permit issued by 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 City of North Las Vegas.

#### ***A.1.2.1 Wastewater Contribution Permit MSC-833***

This permit, issued in December 2013, specifies operations and maintenance practices and identifies substances which are prohibited from being discharged in NLVF wastewater. The permit requires that CNLV be notified when there are changes in discharge flow rates, deviations in operations or maintenance, spills, or other off-normal events. The permit does not require wastewater to be sampled and analyzed. In 2015, no changes, deviations, spills, or other off-normal events requiring notification occurred at the NLVF.

#### ***A.1.2.2 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 2015, no storm water exposures to such activities or materials occurred.

#### ***A.1.2.3 National Pollution Discharge Elimination System Permit NV0023507***

An NPDES permit (NV0023507) covers the dewatering operation conducted at the NLVF (see Section A.1.2.3). Dewatering wells (NLVF-13s, -15, -16, -17) pump groundwater into a 37,854-liter (L) (10,000-gallon [gal]) storage tank (Figure A-2). The permit allows for the discharge of water from the storage tank to groundwater via percolation, when used for landscape irrigation and dust suppression, and into the Las Vegas Wash via direct discharge into the CNLV storm water drainage system. The permit defines the discharge source via percolation as “Outfall 001” and via the storm water drainage system as “Outfall 002.” Water produced from the dewatering wells may also be used for purposes that do not require a groundwater discharge permit or an NPDES permit (e.g., evaporative cooling). Chemistry analyses are performed quarterly, annually, and biennially for water samples collected from the storage tank (Table A-2). The total quantities of groundwater produced and discharged and the results of groundwater chemistry analyses are reported quarterly to NDEP’s Bureau of Water Pollution Control.

In 2015, the four dewatering wells produced a total of about 10,221 L (2,700 gal) per day that were directed into the storage tank (Figure A-2). The average pumping rates varied from 2.7 liters per minute (Lpm) (0.71 gallons per minute [gpm]) at Well NLVF-17 to 0.79 Lpm (0.21 gpm) at Well NLVF-16. The average combined discharge from all four wells was about 304,726 L (80,500 gal) per month. Discharge rates did not exceed the NPDES permit limits (Table A-2). Quarterly and annual water samples from the holding tank had total petroleum



**Table A-2. NLVF NPDES permit monitoring requirements and 2015 analysis results of storage tank water samples**

Parameter	Monitoring Requirements		Permit Discharge Limits Daily Maximum	Sample Results			
	Sample Frequency	Sample Type		1 <sup>st</sup> Quarter	2 <sup>nd</sup> Quarter	3 <sup>rd</sup> Quarter	4 <sup>th</sup> Quarter
Daily Maximum Flow (MGD) <sup>(a)</sup>	Continuous	Flow Meter	0.0052	0.0027	0.0027	0.0026	0.0026
Total Petroleum Hydrocarbons <sup>(b)</sup> (mg/L)	Annually (4 <sup>th</sup> Qtr)	Discrete	1.0	NS <sup>(c)</sup>	NS	NS	0.072 <sup>(d, e)</sup>
Total Suspended Solids (mg/L)	Quarterly	Discrete	135	ND <sup>(f)</sup>	ND	ND	1.5 <sup>(d)</sup>
Total Dissolved Solids (mg/L)	Quarterly	Discrete	1900	1370	1350	1710	1820
Total Inorganic Nitrogen as N (mg/L)	Quarterly	Discrete	20	1.23	1.28	0.99	1.14
pH (Standard Units)	Quarterly	Discrete	6.5–9.0	7.95	7.97	8.04	8.02
Tritium (picocuries per liter [pCi/L])	Annually (4 <sup>th</sup> Qtr)	Discrete	MR <sup>(g)</sup>	NS	NS	NS	ND
<b>Permit Attachment A Analytes (mg/L):</b>							
46 Base Neutral Extractables	Biennial	Discrete	MR	NS	NS	NS	ND
12 Acid Extractables	Biennial	Discrete	MR	NS	NS	NS	ND
31 Volatile Organics*	Biennial	Discrete	MR	NS	NS	NS	ND
Chloroform				NS	NS	NS	0.0018
Tetrachloroethylene				NS	NS	NS	0.00071 <sup>(d)</sup>
24 Pesticides/PCBs <sup>(h)</sup>	Biennial	Discrete	MR	NS	NS	NS	ND
Dioxins	Biennial	Discrete	MR	NS	NS	NS	ND
13 Metals**	Biennial	Discrete	MR	NS	NS	NS	ND
Arsenic				NS	NS	NS	0.16
Cadmium				NS	NS	NS	0.000066 <sup>(e)</sup>
Copper				NS	NS	NS	0.011
Lead				NS	NS	NS	0.0033
Nickel				NS	NS	NS	0.0033
Selenium				NS	NS	NS	0.0051
Thallium				NS	NS	NS	0.00019 <sup>(e)</sup>
Zinc				NS	NS	NS	0.068
Cyanide	Biennial	Discrete	MR	NS	NS	NS	ND
Asbestos	Biennial	Discrete	MR	NS	NS	NS	<0.2

(a) MGD = million gallons per day

(b) This parameter includes three analytes: diesel range organics, gasoline range organics, and oil range organics. During the 4<sup>th</sup> quarter sampling, only oil range organics were detected.

(c) NS = not required to be sampled that quarter

(d) Concentration shown is estimated; it is between the method detection and method reporting limits.

(e) The target analyte was detected in the associated blank.

(f) ND = not detected; values were less than the laboratory detection limits

(g) MR = monitor and report; no specified daily maximum or 30-day average limit, just the requirement that there shall be no discharge of substances that would cause a violation of state water quality standards

(h) PCBs = polychlorinated biphenyls

\* All 31 volatile organics were ND except chloroform and tetrachloroethylene as shown

\*\* Eight of the 13 metals were detected as shown

hydrocarbons, total suspended solids, total dissolved solids, total inorganic nitrogen (as nitrogen [N]), pH, and tritium levels that were all below permit limits (Table A-2). Biennial water sampling for the presence of over 100 analytes (listed in Attachment A of the permit) was done in January/February 2015 and reported in the fourth quarter report.

#### **A.1.2.4 Groundwater Control and Dewatering Operation**

During 2015, the groundwater control and dewatering project at the NLVF continued efforts to reduce the intrusion of groundwater below Building A-1. The project has transitioned from initial groundwater investigations and characterization phases in 2002 to a long-term/permanent dewatering operational project. A review of the rising groundwater situation and past efforts to understand and remediate the problem is presented in previous reports (Bechtel Nevada [BN] 2003, 2004; NSTec 2006). Groundwater monitoring for this operation includes taking periodic water-level measurements at 24 accessible wells out of the 27 NLVF monitoring wells, taking continuous water-level measurements at the A-1 Basement Sump well, measuring the total volume of discharged groundwater, and conducting groundwater chemistry analyses in accordance with the NPDES permit. Groundwater data are assessed quarterly or as new data become available. This information is used to help characterize groundwater conditions, validate the conceptual hydrologic model, and evaluate the dewatering operation.

In 2015, about 304,726 L (80,500 gal) per month were pumped from the dewatering wells. Groundwater also continued to be pumped from the A-1 Basement Sump well (Figure A-2), totaling about 105,992 L (28,000 gal) per month in 2015. When the A-1 Basement Sump well pump is active, the water level directly beneath Building A-1 averages 41.7 centimeters (cm) (16.4 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 the daily measurements taken in 2015 and reflects a drop of about 63.5 cm (25 in.) in the local water table beneath Building A-1 since full-scale dewatering operations began in 2006. The general trend for the NLVF site-wide monitoring network shows an average rise in the water level of 1.2 meters (3.9 feet) since 2003. Although recently the water levels in many of the wells appear to be stabilizing or decreasing, the dewatering efforts must continue to counter this rising groundwater trend.

#### **A.1.2.5 Discharge of Groundwater from Building A-1 Sump Well**

During 2001, the sump well was installed in the basement of Building A-1 and used in operations to remediate tritium contamination in the basement that occurred between 1994 and 1995 (BN 2000). The discharge water, which contained tritium, was disposed of at the NNSS. The sump well was turned off after the remedial operations were completed. However, beginning in early 2003, the sump well has been used to help control the encroaching water below Building A-1. The water contains some residual tritium, and it is segregated from the uncontaminated water from the dewatering operation. The amount of tritium in the sump well water has decreased over the last 12 years from about 1,970 pCi/L to 68 pCi/L (less than the average analytical minimum detection limit of 300 pCi/L) and less than 1/300<sup>th</sup> of the Safe Drinking Water Act limit of 20,000 pCi/L). In 2015, a total of 1,273,746 L (336,488 gal) of water were pumped from the sump well and transported to the NNSS for disposal.

#### **A.1.2.6 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 2015, quarterly inspections of tanks, transformers, oil-filled equipment, and drums were conducted on March 4, May 27, September 15, and December 3. Throughout 2015 all NLVF employees who handle oil received their required annual spill prevention and management training. A small quantity (about 3.5 gallons) of oil leaked from a commercial vehicle driven onto the NLVF and was cleaned up. No spills occurred in 2015 that met regulatory agency reporting criteria.

### A.1.3 Radiation Protection

#### A.1.3.1 National Emission Standards for Hazardous Air Pollutants (NESHAP)

In compliance with 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. Building A-1's basement was contaminated with tritium in 1995 when a container of tritium foils was opened, emitting about 1 curie of tritium (U.S. Department of Energy, Nevada Operations Office 1996). Complete cleanup of the tritium was unsuccessful due to the tritium being absorbed into the building materials. This has resulted in a continuous but decreasing release of tritium 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 2015, no tritium was detected above its analytical minimum detection limit in groundwater pumped from the sump well in the basement of Building A-1 during dewatering operations. However, there is still an emission from tritium emanating from building materials in the building's basement. This tritium emission was determined by taking two air samples from the basement (on April 6–13 and September 8–15, 2015) in order to compute average tritium emissions. A calculated annual total of 2.39 millicuries were released from the basement air that was vented to the outside. Based on this emission rate, the 2015 calculated radiation dose to the nearest member of the general public from the NLVF was very low: 0.000012 mrem/yr (NSTec 2016). The nearest public place is 100 meters (328 feet) northwest of Building A-1. 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 (NSTec 2016).

#### A.1.3.2 DOE O 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 2015, radiation exposure was measured at two locations along perimeter fences for Buildings A-1 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 103 mR/yr for total annual exposure reported by the Desert Research Institute from their Las Vegas air monitoring station (see 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 2015 direct radiation exposure monitoring at the NLVF**

Location	Number of Samples	Mean	Gamma Exposure (mR/yr)		
			Median	Minimum	Maximum
West Fence of Building C-1 (Control)	4	95	94	89	100
North Fence of Building A-1	4	64	65	60	68
North Fence of Building C-3	4	65	65	64	67

### ***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 Conditionally Exempt Small Quantity Generator; therefore, no HW permit is required by the State of Nevada. However, once a year, the Southern Nevada Health District (SNHD) conducts an onsite audit to validate proper handling and storage. SNHD personnel conducted the annual audit on June 10, 2015, and found existing HW procedures acceptable.

### ***A.1.5 Hazardous Materials Control and Management***

In 2015, the chemical inventory at the NLVF was updated and submitted to the state in the Nevada Combined Agency (NCA) Report on February 26, 2016. The inventory data were submitted in accordance with the requirements of the Hazardous Materials Permit 48694. For a description of the content, purpose, and federal regulatory driver behind the NCA Report, see Chapter 2, 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 in 2015. Also, the quantities of toxic chemicals kept at the NLVF that are used annually did not exceed the specified reporting thresholds (see Chapter 2, Table 2-5 concerning Toxic Chemical Release Inventory, Form R).

## ***A.2 Remote Sensing Laboratory–Nellis***

RSL-Nellis is approximately 13.7 kilometers (km) (8.5 miles [mi]) northeast of the Las Vegas city center, and approximately 11.3 km (7 mi) northeast of the NLVF. It occupies six facilities on approximately 14 secured hectares (35 acres) at the Nellis Air Force Base. The six NNSA/NFO facilities were constructed on property owned by the U.S. Air Force (USAF). There is a Memorandum of Agreement between the USAF and NNSA/NFO whereby the land belongs to the USAF but is under lease to the NNSA/NFO for 25 years (as of 1989) with an option for a 25-year extension. The 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 2015 included maintenance of an air quality permit, a wastewater discharge permit, a waste management permit for underground storage tanks, and a hazardous materials permit (see Chapter 2, Table 2-3 for a list of all 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 protection of personnel who work within the facility.

### ***A.2.1 Air Quality and Protection***

Sources of air pollutants at RSL-Nellis are regulated by the Minor Source Permit 348 for the emission of criteria pollutants issued by the Clark County DAQ, which was revised in February 2015. This revised permit reclassified RSL-Nellis as a minor source of regulated air pollutants; previously the facility was classified as a synthetic minor source. The 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. In the 2015 revised permit, 16 generators were added, nine were removed, ten generators were reclassified from insignificant activity to permitted, one boiler was removed, and two boilers were added. The 2015 emissions inventory of criteria air pollutants was submitted to the DAQ on March 28, 2016, and is shown in Table A-4. Note that HAPs emissions are not included in Table A-4 as they had been in previous years since they are not required to be reported under Minor Source permits.

Clark County air regulations specify that the opacity from any emission unit may not exceed the Clean Air Act NAAQS opacity limit of 20% for more than 6 consecutive minutes. The RSL-Nellis air permit requires that equipment be observed each day it is operated. If visible emissions are observed, then EPA Method 9 opacity readings are recorded by a certified visible emissions evaluator. If visible emissions appear to exceed the limit, corrective actions must be taken to minimize emissions. In 2015, two RSL-Nellis Maintenance Engineers were

recertified to conduct opacity readings. Observations were taken for the permitted emission units. With one exception, emissions for all equipment were well below the Clean Air Act NAAQS opacity limit of 20%. On November 10, 2015 during routine maintenance of an emergency generator, white smoke of approximately 25% opacity was observed. Immediate action was taken to shut down the generator. A Stationary Source Deviation Report was submitted to the Clark County DAQ on November 18, 2015. This generator was removed from service and will be replaced.

On June 2, 2015, the Clark County DAQ conducted an air permit inspection at RSL-Nellis. No issues were identified by the inspector.

**Table A-4. Summary of air emissions for RSL-Nellis in 2015**

Parameter	Criteria Pollutant (Tons/yr) <sup>(a)</sup>					
	PM10 <sup>(b)</sup>	PM2.5 <sup>(c)</sup>	NO <sub>x</sub>	CO	SO <sub>2</sub>	VOC
PTE <sup>(d)</sup>	1.23	0.85	13.55	5.49	0.66	1.58
Actual <sup>(e)</sup>	0.25	0.11	1.52	0.41	0.08	0.11
<b>Total Emissions = 2.48 Actual, 23.36 PTE</b>						

(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 air pollutant that 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 were being 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 Form for 2015 was submitted to CCWRD on January 12, 2016. There were no regulatory inspections of RSL-Nellis by the CCWRD in 2015, and no findings or corrective actions for the facility 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 (see 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 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 2015, quarterly inspections of tanks, transformers, and oil-filled equipment were conducted on January 29, June 25, September 15, and December 3. Throughout 2015, all RSL-Nellis employees who handle oil received their required annual spill prevention and management training. There were two small spills at RSL in 2015, 0.5 gallons of shredder oil inside the building, and 1 gallon of unleaded gasoline spilled during tank filling. No spills occurred in 2015 that met regulatory agency reporting criteria.

### A.2.3 Underground Storage Tank (UST) Management

The SNHD has oversight authority of USTs in Clark County. The UST program at RSL-Nellis consists of three fully regulated tanks (one for unleaded gasoline, one for diesel fuel, and one for used oil), one deferred tank (in accordance with Title 40 Code of Federal Regulations Part 280.10[d]) for emergency power generation, and three

excluded tanks. They are managed under the RSL-Nellis Waste Management Permit PR0064276 issued by SNHD. The active tanks are inspected annually by SNHD. In November 2015, SNHD inspected the fully regulated and deferred USTs at RSL-Nellis. No deficiencies were noted.

#### **A.2.4 Hazardous Materials Control and Management**

In 2015, the chemical inventory at RSL-Nellis was updated and submitted to the state in the NCA Report on February 26, 2016, in accordance with the requirements of the Hazardous Materials Permit 48705 (see Chapter 2, Section 2.4.4.1 for a description of the content, purpose, and federal regulatory driver behind the NCA Report). No accidental or unplanned release of an EHS occurred at RSL-Nellis in 2015. Also, no annual usage quantities of toxic chemicals kept at RSL-Nellis exceeded specified thresholds (see Chapter 2, Section 2.4.4.1, Table 2-5 concerning Toxic Chemical Release Inventory, Form R).

### **A.3 References**

- Bechtel Nevada, 2000. *Characterization Report - Building A-1 at the U.S. Department of Energy, Nevada Operations Office, North Las Vegas Facility*. DOE/NV/11718--413, Las Vegas, NV.
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- National Security Technologies, LLC, 2006. *Groundwater Control at Building A-1, North Las Vegas Facility Enhanced Dewatering Initiative*. Las Vegas, NV.
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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.

**Accuracy:** the closeness of the result of a measurement to the true value of the quantity measured.

**Action level:** defined by regulatory agencies as the level of pollutant(s) that, if exceeded, requires regulatory action.

**Alluvium:** a sediment deposited by flowing water.

**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.

**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.

**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.

**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.

**C CAP88-PC:** a computer code required by the U.S. Environmental Protection Agency for modeling air emissions of radionuclides.

**Code of Federal Regulations (CFR):** a codification of all regulations promulgated by federal government agencies.

**Collective population dose:** the sum of the total effective dose equivalents of all individuals within a defined population. The unit of collective population dose is person-rem or person-sievert. Collective population dose may also be referred to as “collective effective dose equivalent” or simply “population dose.”

**Committed dose equivalent:** the dose equivalent to a tissue or organ over a 50-year period after an intake of a radionuclide into the body. Committed dose equivalent is expressed in units of rem or sievert.

**Committed effective dose equivalent (CEDE):** the sum of the committed dose equivalents to various tissues in the body, each multiplied by an appropriate weighting factor representing the relative vulnerability of different parts of the body to radiation. Committed effective dose equivalent is expressed in units of rem or sievert.

**Community water system:** as defined in Nevada Revised Statute 445A.808, it is 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.

**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.

**Cool roof:** a low-sloped roof (pitch less than or equal to 2:12) that is designed and installed with a minimum 3-year aged solar reflectance of 0.55 and a minimum 3-year aged thermal emittance of 0.75, or with a minimum 3-year aged solar reflectance index (SRI) of 64. Cool steep-sloped roofs (pitch exceeding 2:12) have a 3-year SRI of 29 or higher.

**Cosmic radiation:** radiation with very high energies originating outside the earth’s atmosphere; it is one source contributing to natural background radiation.

**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<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>), carbon monoxide (CO), ozone, lead, and particulate matter equal to or less than 10 microns in diameter (PM<sub>10</sub>). The State of Nevada, through an air quality permit, establishes emission limits on the Nevada National Security Site for SO<sub>2</sub>, NO<sub>x</sub>, CO, PM<sub>10</sub>, and volatile organic compounds (VOCs). Ozone is not regulated by the permit as an emission, as it is formed in part from NO<sub>x</sub> 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<sub>C</sub>):** 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; called the Critical Level (L<sub>C</sub>) or the decision level.

**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  $3.7 \times 10^{10}$  (37 billion) disintegrations per second; one Ci is approximately equal to the decay rate of one gram of pure radium.

**D Daughter nuclide:** a nuclide formed by the radioactive decay of another nuclide, which is called the parent.

**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; also known as the Critical Level ( $L_C$ ).

**Depleted uranium:** uranium having a lower proportion of the isotope  $^{235}\text{U}$  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  $5 \times 10^{-4}$ , respectively.

**Derived Concentration Guide (DCG):** previously published standard in U.S. Department of Energy (DOE) Order DOE O 5400.5 from 1993, which was the concentration of a given radionuclides in water or air that could be continuously consumed or inhaled for 1 year and not exceed the DOE primary radiation dose limit to the public of 100 millirem per year effective dose equivalent. DCGs were replaced in 2011 by Derived Concentration Standards (DCSs).

**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 DCGs 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.

**Diffuse source:** an area source from which radioactive air emissions are continuously distributed over a given area or emanate from a number of points randomly distributed over the area (generally, all sources other than point sources). Diffuse sources are not actively ventilated or exhausted. Diffuse sources include: emissions from large areas of contaminated soil, resuspension of dust deposited on open fields, ponds and uncontrolled releases from openings in a structure.

**Dose:** the energy imparted to matter by ionizing radiation; the unit of absorbed dose is the rad, equal to 0.01 joules per kilogram for irradiated material in any medium.

**Dose equivalent:** a measure of the biological damage to living tissue as a result of radiation exposure. Also known as the "biological dose," the dose equivalent is calculated as the product of absorbed dose in tissue multiplied by a quality factor and then sometimes multiplied by other necessary modifying factors at the location of interest. The dose equivalent is expressed numerically in rems or sieverts (Sv).

**Dosimeter:** a portable detection device for measuring the total accumulated exposure to ionizing radiation.

**Dosimetry:** the theory and application of the principles and techniques of measuring and recording radiation doses.

**E Effective dose equivalent (EDE):** an estimate of the total risk of potential effects from radiation exposure; it is the summation of the products of the dose equivalent and weighting factor for each tissue. The weighting factor is the decimal fraction of the risk arising from irradiation of a selected tissue to the total risk when the whole body is irradiated uniformly to the same dose equivalent. These factors permit dose equivalents from non-uniform exposure of the body to be expressed in terms of an EDE that is numerically equal to the dose from a uniform exposure of the whole body that entails the same risk as the internal exposure. The EDE includes the committed effective dose equivalent from internal deposition of radionuclides and the EDE caused by penetrating radiation from sources external to the body, and is expressed in units of rem or sievert.

**Effluent:** used in this report to refer to a liquid discharged to the environment.

**Emission:** used in this report to refer to a vapor, gas, airborne particulate, or to radiation discharged to the environment via the air.

**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.

**ESPC ENABLE:** a program provided through DOE's Federal Energy Management Program (FEMP) that provides a standardized and streamlined process for small, federal facilities to install targeted, energy conservation measures (ECMs) in 6 months or less. Projects are administered through the General Services Administration (GSA) Federal Supply Schedule 84, Special Identification Number (SIN) 246-53 using a set of pre-established procurement and technical tools. The program allows sites an opportunity to implement specific ECMs pertaining to lighting, water, simple heating, ventilation, and air conditioning (HVAC) controls, HVAC system replacement, and solar photovoltaics.

**Exposure:** the absorption of ionizing radiation or ingestion of a radioisotope. Acute exposure is a large exposure received over a short period of time. Chronic exposure is exposure received over a long period of time, 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.

**Federal facility:** a facility that is owned or operated by the federal government, subject to the same requirements as other responsible parties when placed on the Superfund National Priorities List.

**Federal Register:** a document published daily by the federal government containing notification of government agency actions, including notification of U.S. Environmental Protection Agency and U.S. Department of Energy decisions concerning permit applications and rule-making.

**Fiscal year:** the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office's fiscal year is from October 1 through September 30.

**G Gamma ray:** high-energy, short-wavelength, electromagnetic radiation emitted from the nucleus of an atom, frequently accompanying the emission of alpha or beta particles.

**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.

**Inorganic compounds:** compounds that either do not contain carbon or do not contain hydrogen along with carbon, including metals, salts, various carbon oxides (e.g., carbon monoxide and carbon dioxide), and cyanide.

**Instrument detection limit (IDL):** the lowest concentration that can be detected by an instrument without correction for the effects of sample matrix or method-specific parameters such as sample preparation. IDLs are explicitly determined and generally defined as three times the standard deviation of the mean noise level. This represents 99 percent confidence that the signal is not random noise.

**Interim status:** a legal classification allowing hazardous waste incinerators or other hazardous waste management facilities to operate while the U.S. Environmental Protection Agency considers their permit applications, provided that they were under construction or in operation by November 19, 1980, and can meet other interim status requirements.

**International System of Units (SI):** an international system of physical units that includes meter (length), kilogram (mass), kelvin (temperature), becquerel (radioactivity), gray (radioactive dose), and sievert (dose equivalent). The abbreviation, SI, comes from the French term *Système International d’Unités*.

**Ion:** (1) an atom that has too many or too few electrons, causing it to have an electrical charge, and therefore, be chemically active. (2) An electron that is not associated (in orbit) with a nucleus.

**Ionizing radiation:** a form of radiation, which includes alpha particles, beta particles, gamma rays, x-rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions. Compared to non-ionizing radiation, such as radio- or microwaves, or visible, infrared, or ultraviolet light, ionizing radiation is considerably more energetic. When ionizing radiation passes through material such as air, water, or living tissue, it deposits enough energy to produce ions by breaking molecular bonds and displace (or remove) electrons from atoms or molecules. This electron displacement may lead to changes in living cells. Given this ability, ionizing radiation has a number of beneficial uses, including treating cancer or sterilizing medical equipment. However, ionizing radiation is potentially harmful if not used correctly, and high doses may result in severe skin or tissue damage.

**Isotopes:** 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 ( $^{12}\text{C}$ ), the most common form of carbon, has six protons and six neutrons, whereas carbon-14 ( $^{14}\text{C}$ ), the radioactive isotope of carbon, has six protons and eight neutrons.

**L L<sub>C</sub>:** see Critical Level (L<sub>C</sub>).

**Less than detection limits:** a phrase indicating that a chemical constituent or radionuclide was either not present in a sample, or is present in such a small concentration that it cannot be measured as significantly different from zero by a laboratory’s analytical procedure and, therefore, is not identified at the lowest level of sensitivity.

**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.

**Lower limit of detection:** the smallest concentration or amount of analyte that can be detected in a sample at a 95-percent confidence level; also known as minimum detectable concentration.

**Lysimeter:** an instrument for measuring the water percolating through soils and determining the dissolved materials.

**M Maximally exposed individual (MEI):** a hypothetical member of the public at a fixed location who, over an entire year, receives the maximum effective dose equivalent (summed over all pathways) from a given source of radionuclide releases to air. Generally, the MEI is different for each source at a site.

**Maximum contaminant level (MCL):** the highest level of a contaminant in drinking water that is allowed by U.S. Environmental Protection Agency regulation.

**Metric units:** metric units, U.S. customary units, and their respective equivalents are shown in Table 1-6. Except for temperature, for which specific equations apply, U.S. customary units can be determined from metric units by multiplying the metric units by the U.S. customary equivalent. Similarly, metric units can be determined from U.S. customary equivalent units by multiplying the U.S. customary units by the metric equivalent.

**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.

**Mixed low-level waste (MLLW):** defined by U.S. Department of Energy Manual DOE M 435.1-1, “Radioactive Waste Management Manual,” as low-level waste determined to contain both source, special nuclear, or byproduct material subject to the Atomic Energy Act of 1954, as amended, and a hazardous component subject to the Resource Conservation and Recovery Act (RCRA), as amended.

**N Non-community water system:** as defined in Nevada Revised Statute 445A.828, it is a public water system that is not a community water system.

**Nuclide:** any species of atom that exists for a measurable length of time. A nuclide can be distinguished by its atomic mass, atomic number, and energy state.

**P Part B Permit:** the second, narrative section submitted by generators in the Resource Conservation and Recovery Act permitting process that covers in detail the procedures followed at a facility to protect human health and the environment.

**Parts per million (ppm):** a unit of measure for the concentration of a substance in its surrounding medium; for example, one million grams of water containing one gram of salt has a salt concentration of 1 ppm.

**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.

**pH:** a measure of hydrogen ion concentration in an aqueous solution. Acidic solutions have a pH from 0 to 7, basic solutions have a pH greater than 7, and neutral solutions have a pH of 7.

**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>

**PM10:** a fine particulate matter with an aerodynamic diameter equal to or less than 10 microns.

**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.

**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.

**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.

**Public water system (PWS):** as defined in Nevada Revised Statute 445A.235, it is a system, regardless of ownership, that provides the public with water for human consumption through pipes or other constructed conveyances, if the system has 15 or more service connections, as defined in NRS 445A.843, or regularly serves 25 or more persons. The three PWSs on the NNSS are permitted by the State of Nevada as non-community water systems.

**Q Quality assurance (QA):** a system of activities whose purpose is to provide the assurance that standards of quality are attained with a stated level of confidence.

**Quality control (QC):** procedures used to verify that prescribed standards of performance are attained.

**Quality factor:** the factor by which the absorbed dose (rad) is multiplied to obtain a quantity that expresses (on a common scale for all ionizing radiation) the biological damage to exposed persons, usually used because some types of radiation, such as alpha particles, are biologically more damaging than others. Quality factors for alpha, beta, and gamma radiation are in the ratio 20:1:1.

**R Rad:** one of the two units used to measure the amount of radiation absorbed by an object or person, known as the “absorbed dose,” which reflects the amount of energy that radioactive sources deposit in materials through

which they pass. The radiation-absorbed dose (rad) is the amount of energy (from any type of ionizing radiation) deposited in any medium (e.g., water, tissue, air). An absorbed dose of 1 rad means that 1 gram of material absorbed 100 ergs of energy (a small but measurable amount) as a result of exposure to radiation. The related international system unit is the gray (Gy), where 1 Gy is equivalent to 100 rad.

**Radioactive decay:** the spontaneous transformation of one radionuclide into a different nuclide (which may or may not be radioactive), or de-excitation to a lower energy state of the nucleus by emission of nuclear radiation, primarily alpha or beta particles, or gamma rays (photons).

**Radioactivity:** the spontaneous emission of nuclear radiation, generally alpha or beta particles, or gamma rays, from the nucleus of an unstable isotope.

**Radioisotope:** same as radionuclide.

**Radionuclide:** may also be called a radioactive nuclide, radioisotope, or radioactive isotope. It is an atom that has excess nuclear energy, making it unstable. This excess energy can either create and emit from the nucleus new radiation (gamma radiation) or a new particle (alpha particle or beta particle), or transfer this excess energy to one of its electrons, causing it to be ejected (conversion electron). During this process, the radionuclide is said to undergo radioactive decay.

**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 Sanitary waste:** most simply, waste generated by routine operations that is not regulated as hazardous or radioactive by state or federal agencies.

**Saturated zone:** a zone below the earth's surface below which all pore spaces between rocks or soil are completely filled with water.

**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.

**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.

**Specific conductance:** the measure of the ability of a material to conduct electricity; also called conductivity.

**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.

**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 dissolved solids (TDS):** the total mass of particulate matter per unit volume that is dissolved in water and that can pass through a very fine filter.

**Total effective dose equivalent (TEDE):** The sum of the external exposures and the committed effective dose equivalent (CEDE) for internal exposures.

**Total organic carbon (TOC):** the sum of the organic material present in a sample.

**Total organic halides (TOX):** the sum of the organic halides present in a sample.

**Total suspended solids (TSS):** the total mass of particulate matter per unit volume suspended in water and wastewater discharges that is large enough to be collected by a very fine filter.

**Transpiration:** a process by which water is transferred from the soil to the air by plants that take the water up through their roots and release it through their leaves and other aboveground tissue.

**Transuranic (TRU) waste:** material contaminated with alpha-emitting transuranium nuclides that have an atomic number greater than 92 (e.g., <sup>239</sup>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:** 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<sub>2</sub>O, and is called tritiated water (HTO). Like H<sub>2</sub>O, 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.

**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.

**Volatile organic compound (VOC):** liquid or solid organic compounds that have a high vapor pressure at normal pressures and temperatures and thus tend to spontaneously pass into the vapor state.

**W Waste accumulation area (WAA):** an officially designated area that meets current environmental standards and guidelines for temporary (less than 90 days) storage of hazardous waste before offsite disposal.

**Wastewater treatment system:** a collection of treatment processes and facilities designed and built to reduce the amount of suspended solids, bacteria, oxygen-demanding materials, and chemical constituents in wastewater.

**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 in question has no water table.

**Weighting factor:** a tissue-specific value used to calculate dose equivalents that represents the fraction of the total health risk resulting from uniform, whole-body irradiation that could be contributed to that particular tissue. The weighting factors used in this report are recommended by the International Commission on Radiological Protection.

**Wind rose:** a diagram that shows the frequency and intensity of wind from different directions at a specific location.

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## *Appendix C: Acronyms and Abbreviations*

ac	acre(s)	CAPP	Chemical Accident Prevention Program
Ac	actinium	CAP88-PC	Clean Air Package 1988
ACM	asbestos-containing material	CAS	Corrective Action Site
AEA	Atomic Energy Act	CAU	Corrective Action Unit
AEC	Atomic Energy Commission	CCWRD	Clark County Water Reclamation District
AFV	alternative fuel vehicle	CEDE	committed effective dose equivalent
AICP	American Indian Consultation Program	CEM	Community Environmental Monitor
ALARA	as low as reasonably achievable	CEMP	Community Environmental Monitoring Program
Am	americium	CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
ANSI/HPS	American National Standards Institute/Health Physics Society	CFR	Code of Federal Regulations
APP	affirmative procurement program	CGTO	Consolidated Group of Tribes and Organizations
ARL	Army Research Laboratory	Ci	curie(s)
ARL/SORD	Air Resources Laboratory, Special Operations and Research Division	CL	compliance level (used in text for the Clean Air Act National Emission Standards for Hazardous Pollutants Concentration Level for Environmental Compliance)
ARPA	Archaeological Resources Protection Act	cm	centimeter(s)
ASER	Annual Site Environmental Report	cm <sup>2</sup>	square centimeter(s)
ASN	Air Surveillance Network	CNLV	City of North Las Vegas
B	Background	Co	cobalt
BCG	Biota Concentration Guide	CO	carbon monoxide
Be	beryllium	COC	contaminant of concern
BEEF	Big Explosives Experimental Facility	COPC	contaminant of potential concern
BFF	Bureau of Federal Facilities	CR	Closure Report
BGEPA	Bald and Golden Eagle Protection Act	CRM	Cultural Resources Management
bgs	below ground surface	Cs	cesium
BLM	Bureau of Land Management	CV	coefficient of variation
BN	Bechtel Nevada	CWA	Clean Water Act
BO	Biological Opinion	CX	Categorical Exclusion
BOD <sub>5</sub>	5-day biological oxygen demand	CY	calendar year
Bq	becquerel	DAF	Device Assembly Facility
BREN	Bare Reactor Experiment–Nevada	DAQ	Department of Air Quality (Clark County)
BSDW	Bureau of Safe Drinking Water	DCG	Derived Concentration Guide
BTU	British thermal unit	DCS	Derived Concentration Standard
C	carbon	DNWR	Desert National Wildlife Refuge
CA	Composite Analysis	DoD	U.S. Department of Defense
CAA	Clean Air Act		
CADD	Corrective Action Decision Document		
CAI	Corrective Action Investigation		
CAIP	Corrective Action Investigation Plan		
CAP	Corrective Action Plan		

DOE	U.S. Department of Energy	ERA	Environmental Research Associates
DOE/COE	Department of Energy Common Operating Environment	ESA	Endangered Species Act
DOECAP	U.S. Department of Energy Consolidated Audit Program	ESCO	energy service company
DOE/NV	U.S. Department of Energy, Nevada Operations Office	ESPC	Energy Savings Performance Contract
DOI	U.S. Department of Interior	ETDS	E-Tunnel Waste Water Disposal System
DPF	Dense Plasma Focus	Eu	europium
dpm	disintegrations per minute	EWG	Environmental Working Group
DQA	Data Quality Assessment	EWO	Environmental Waste Operations
DQO	Data Quality Objective	F&I	Facility and Infrastructure
DRI	Desert Research Institute	FD	field duplicate
DTCC	Desert Tortoise Conservation Center	FEMP	Federal Energy Management Program
DSA	Documented Safety Analysis	FFACO	Federal Facility Agreement and Consent Order
DU	depleted uranium	FFCA	Federal Facility Compliance Act
E1	Environmental 1	FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
E2	Environmental 2	ft	foot or feet
EA	Environmental Assessment	ft <sup>2</sup>	square feet
E&EM	Ecological and Environmental Monitoring	ft <sup>3</sup>	cubic feet
ECM	energy conservation measure	FS	U.S. Forest Service
EDE	effective dose equivalent	FWS	U.S. Fish and Wildlife Service
EHS	extremely hazardous substance	FY	fiscal year
EIS	Environmental Impact Statement	g	gram(s)
EISA	Energy Independence and Security Act of 2007	gal	gallon(s)
ELU	ecological landform units	gal/ft <sup>2</sup>	gallons used per square foot
EM	Environmental Management	GCD	Greater Confinement Disposal
EMAC	Ecological Monitoring and Compliance	GHG	greenhouse gas
EMAD	Engine Maintenance, Assembly, and Disassembly	GIS	Geographic Information System
EMC	Energy Management Council	gpm	gallon(s) per minute
EMP	Energy Management Program	GP	Guiding Principle
EMS	Environmental Management System	GSA	General Services Administration
EO	Executive Order	gsf	gross square feet
EODU	Explosive Ordnance Disposal Unit	Gy	gray(s)
EP	Environmental Programs	Gy/d	gray(s) per day
EPA	U.S. Environmental Protection Agency	<sup>3</sup> H	tritium
EPCRA	Emergency Planning and Community Right-to-Know Act	ha	hectare(s)
EPEAT	Electronic Product Environmental Assessment Tool	HAP	hazardous air pollutant
EPP	Environmentally Preferable Product	HENRE	High-Energy Neutron Reactions Experiment
ER	Environmental Restoration	HEPA	high-efficiency particulate air
		HEST	High Explosives Simulation Test
		HMA	Herd Management Area
		HPSB	High Performance Sustainable Building
		HQ	Headquarters

HTO	tritiated water	LRQA	Lloyd's Register Quality Assurance
HVAC	heating, ventilation, and air conditioning	m	meter(s)
HW	hazardous waste	m <sup>2</sup>	square meter(s)
HWAA	Hazardous Waste Accumulation Area	m <sup>3</sup>	cubic meter(s)
HWSU	Hazardous Waste Storage Unit	M&O	Management and Operating
I	iodine	MAPEP	Mixed Analyte Performance Evaluation Program
IAEA	International Atomic Energy Agency	MBTA	Migratory Bird Treaty Act
ICR	San Diego Zoo Institute for Conservation Research	mCi	millicurie(s)
ID	identification number	MCL	maximum contaminant level
IL	investigation level	MDC	minimum detectable concentration
in.	inch(es)	MEI	maximally exposed individual
ISMS	Integrated Safety Management System	MET	meteorological
ISO	International Organization for Standardization	MGD	million gallons per day
ISWG	Interagency Sustainability Working Group	mg/L	milligram(s) per liter
IT	International Technology Corporation	mGy/d	milligray(s) per day
JASPER	Joint Actinide Shock Physics Experimental Research	mi	mile(s)
JIT	Just-In-Time	mi <sup>2</sup>	square mile(s)
K	potassium	mL	milliliter
kg	kilogram(s)	MLLW	mixed low-level waste
kg/d	kilogram(s) per day	mm	millimeter(s)
km	kilometer(s)	mmhos/cm	millimhos per centimeter
km <sup>2</sup>	square kilometer(s)	Mod.	Modification
L	liter(s)	MQO	Measurement Quality Objectives
LANL	Los Alamos National Laboratory	MR	monitor and report
lb	pound(s)	mR	milliroentgen(s)
L <sub>c</sub>	Critical Level (synonymous with Decision Level)	mR/d	milliroentgen(s) per day
LCA	lower carbonate aquifer	mR/yr	milliroentgen(s) per year
LCS	laboratory control sample	mrad	millirad(s)
L/d	liter(s) per day	mrem	millirem(s)
LED	light emitting diode	mrem/yr	millirem(s) per year
LEED	Leadership in Energy and Environmental Design	MSDS	Material Safety Data Sheet
LLNL	Lawrence Livermore National Laboratory	mSv	millisievert(s)
LLW	low-level waste	mSv/yr	millisievert(s) per year
Lpm	liter(s) per minute	mTCO <sub>2</sub> e	metric ton(s) of carbon dioxide equivalent
LoC	Level of Concern	mton	metric ton(s)
log	logarithmic	MTRU	mixed transuranic
LQAP	Laboratory Quality Assurance Plan	MWDU	Mixed Waste Disposal Unit
		MWSU	Mixed Waste Storage Unit
		μCi/mL	microcurie(s) per milliliter
		μg/L	microgram(s) per liter
		μR/hr	microroentgen(s) per hour
		μS/cm	microseimen(s) per centimeter
		N	nitrogen

NAAQS	National Ambient Air Quality Standards	NSSAB	Nevada Site Specific Advisory Board
NAC	Nevada Administrative Code	NSTec	National Security Technologies, LLC
NAGPRA	Native American Graves Protection and Repatriation Act	NTS	Nevada Test Site
NCA	Nevada Combined Agency	NTSER	Nevada Test Site Environmental Report
NCRP	National Council on Radiation Protection	NTTR	Nevada Test and Training Range
NDEP	Nevada Division of Environmental Protection	NVLAP	National Voluntary Laboratory Accreditation Program
NDOA	Nevada Department of Agriculture	ODS	ozone-depleting substance
NDOF	Nevada Department of Forestry	ORPS	Occurrence Reporting and Processing System
NDOW	Nevada Department of Wildlife	OSTI	Office of Scientific and Technical Information
NEPA	National Environmental Policy Act	oz	ounce(s)
NESHAP	National Emission Standards for Hazardous Air Pollutants	P2/WM	pollution prevention/waste minimization
NFS	Nuclear Fuel Services	PA	Performance Assessment
NHPA	National Historic Preservation Act	PAAA	Price-Anderson Amendments Act
N-I	Navarro-Intera, LLC	Pb	lead
NLVF	North Las Vegas Facility	PCB	polychlorinated biphenyl
NNES	Navarro Nevada Environmental Services, LLC	pCi	picocurie(s)
NNHP	Nevada Natural Heritage Program	pCi/g	picocurie(s) per gram
NNSA	U.S. Department of Energy, National Nuclear Security Administration	pCi/L	picocurie(s) per liter
NNSA/NFO	U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office	pCi/mL	picocurie(s) per milliliter
NNSA/NSO	U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office	PEV	plug-in electric vehicle
NNSA/SFO	U.S. Department of Energy, National Nuclear Security Administration Sandia Field Office	PI	prediction interval
NNSS	Nevada National Security Site	PIC	pressurized ion chamber
NNSSER	Nevada National Security Site Environmental Report	PLall	prediction limit for all enriched tritium measurements
NO <sub>x</sub>	nitrogen oxides	PM	particulate matter
NPDES	National Pollutant Discharge Elimination System	PM10	particulate matter equal to or less than 10 microns in diameter
NPTEC	Nonproliferation Test and Evaluation Complex	POE	point of entry
NRC	Non-Radiological Classified	PT	proficiency testing
NRCH	Non-Radiological Classified Hazardous	PTE	potential to emit
NRHP	National Register of Historic Places	Pu	plutonium
NRS	Nevada Revised Statutes	PUE	Power Utilization Effectiveness
NSPS	New Source Performance Standards	PWS	public water system
		QA	quality assurance
		QAP	Quality Assurance Program
		QAMAP	Quality Assurance Management Assessment Plan
		QAPP	Quality Assurance Program Plan
		QC	quality control
		QPID	Quality and Performance Improvement Division

QSAS	Quality Systems for Analytical Services	SMCL	Secondary maximum Contaminant Level
R	roentgen(s)	SNHD	Southern Nevada Health District
Ra	radium	SNJV	Stoller-Navarro Joint Venture
rad	radiation absorbed dose (a unit of measure)	SNL	Sandia National Laboratories
rad/d	rad(s) per day	SOC	synthetic organic chemical
RC	Radiological Control	SORD	Special Operations and Research Division
RCRA	Resource Conservation and Recovery Act	SO <sub>2</sub>	sulfur dioxide
RCT	Radiological Control Technician	SPCC	Spill Prevention, Control, and Countermeasure
rem	roentgen equivalent man	Sr	strontium
RER	relative error ratio	SSC	structures, systems, and components
RFP	request for proposal	SSP	Site Sustainability Plan
RIDP	Radionuclide Inventory and Distribution Program	SSPP	Strategic Sustainability Performance Plan
RNCTEC	Radiological/Nuclear Countermeasures Test and Evaluation Complex	STGWG	State Tribal Government Working Group
ROTC	Record of Technical Change	S.U.	standard unit(s) (for measuring pH)
RPD	relative percent difference	Sv	sievert(s)
RREMP	Routine Radiological Environmental Monitoring Plan	SWEIS	Site-Wide Environmental Impact Statement
RSL	Remote Sensing Laboratory	SWO	Solid Waste Operations
RTR	Real-Time Radiography	T <sub>1/2</sub>	half-life
RW	Radioactive Waste	Tc	technetium
RWAP	Radioactive Waste Acceptance Program	TDS	total dissolved solids
RWMC	Radioactive Waste Management Complex	TEDE	total effective dose equivalent
RWMS	Radioactive Waste Management Site	Th	thorium
SA	Supplement Analysis	TLD	thermoluminescent dosimeter
SAA	Satellite Accumulation Area	TOC	total organic carbon
SAD	surface area disturbance	TOX	total organic halides
SAFER	Streamlined Approach for Environmental Restoration	TPCB	Transuranic Pad Cover Building
SAP	Sampling and Analysis Plan	TPH	total petroleum hydrocarbons
SARA	Superfund Amendments and Reauthorization Act	TRI	Toxic Release Inventory
SC	specific conductance	TRU	transuranic
SD	standard deviation	TSCA	Toxic Substances Control Act
SDWA	Safe Drinking Water Act	TSR	Technical Safety Requirements
SE	standard error of the mean	TSS	total suspended solids
SER	Safety Evaluation Report	TTR	Tonopah Test Range
SF <sub>6</sub>	Sulfur hexafluoride	U	uranium
SHPO	State Historic Preservation Office	UESC	Utility Energy Service Contract
SI	International System of Units	UGT	underground test
		UGTA	Underground Test Area
		UIC	underground injection control
		U.S.	United States
		USACE	U.S. Army Corps of Engineers
		USAF	U.S. Air Force
		USC	United States Code

USDA	U.S. Department of Agriculture	WEF	Waste Examination Facility
USGS	U.S. Geological Survey	WIPP	Waste Isolation Pilot Plant
UST	underground storage tank	WMD	Waste Management Division
VOC	volatile organic compound	WO	Waste Operations
VZM	vadose zone monitoring	WW	water well
WDP	water delivery point	yr	year(s)

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**Front cover photo:** Historical tower structure in Area 6 used for electromagnetic pulse experiments during atmospheric nuclear testing in the 1950s (*photo taken in June 2014*).

**Title page photo:** Sedan Crater in Area 10 (*photo taken in October 2015*).

**Back cover photo:** Wild burros in Area 25 (*photo taken in October 2015*).



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