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NEVADA NATIONAL
NNSS
SECURITY SITE

2018

Environmental Report Summary

September 2019

DEPARTMENT OF ENERGY
UNITED STATES OF AMERICA

NNSA
National Nuclear Security Administration

A Message from the Manager

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

The NNSA/NFO presents this environmental report to summarize actions taken in 2018 to protect the environment and the public while achieving our mission goals. It is prepared for the public and our stakeholders in hopes that it is readily understandable and usable. It is a key component in our efforts to keep the public informed of environmental conditions at the NNSS and its support facilities in Las Vegas, Nevada. The NNSA/NFO ensures the validity and accuracy of the data contained in this report.

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

Steven J. Lawrence

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Nevada Field Office
Manager

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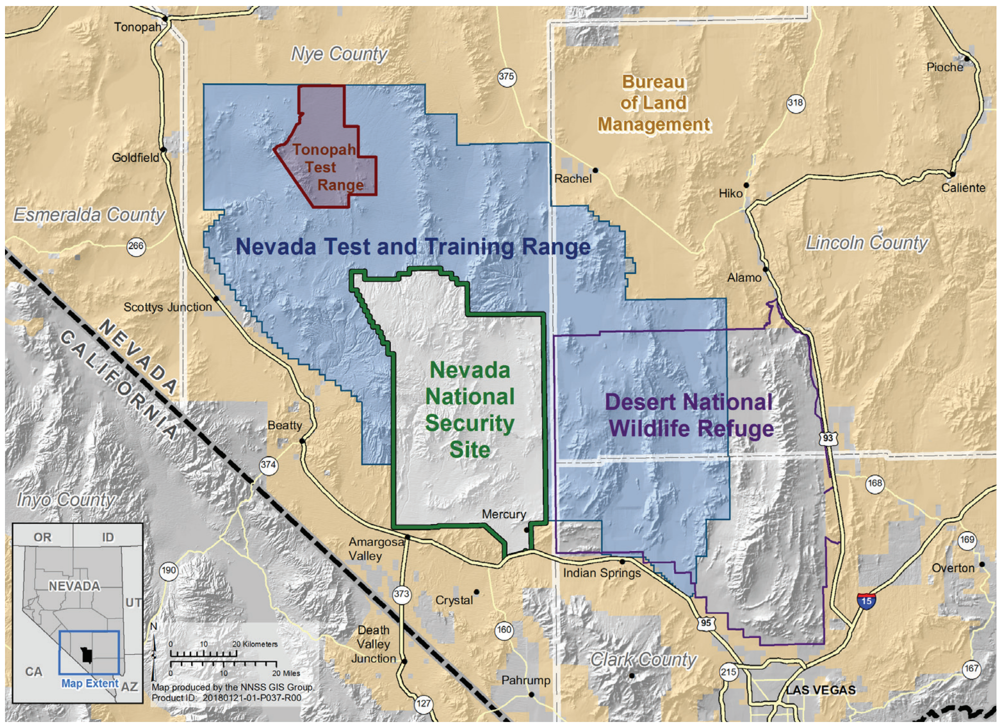
Nevada National Security Site Environmental Report Summary 2018

This document is a summary of the full *2018 Nevada National Security Site Environmental Report* (NNSSER) prepared by the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO). This summary provides an abbreviated and more readable version of the full NNSSER. The reader is provided with an electronic file of the full NNSSER and of *Attachment A: Site Description* on a compact disc (see inside back cover). The reader may obtain a hard copy of the full NNSSER as directed on the inside back cover of this summary report.

NNSA/NFO prepares the NNSSER to provide the public an understanding of the environmental monitoring and compliance activities that are conducted on the Nevada National Security Site (NNSS) to protect the public and the environment from radiation hazards and from potential nonradiological impacts. It is a comprehensive report of environmental activities performed at the NNSS and offsite facilities over the previous calendar year.

The NNSS is currently the nation's unique site for ongoing national security–related missions and high-risk operations. The NNSS is located about 65 miles northwest of Las Vegas. The approximately 1,360-square-mile site is one of the largest restricted access areas in the United States. It is surrounded by federal installations with strictly controlled access as well as by lands that are open to public entry.



History of the NNSS

Between 1940 and 1950, the area now known as the NNSS was part of the Las Vegas Bombing and Gunnery Range. In 1950, the NNSS was established as the primary location for testing the nation's nuclear explosive devices. Such testing took place from 1951 to 1992.

Tests conducted through the 1950s were predominantly atmospheric tests. These 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 which resulted in dispersion of plutonium in the test vicinity. Some of these test areas are off of the NNSS on the Nevada Test and Training Range (NTTR) and on the Tonopah Test Range (TTR).

The first underground test, a cratering test, was conducted in 1951. The first fully contained underground nuclear test was conducted in 1957. Testing was discontinued during a moratorium that began October 31, 1958, but was resumed in September 1961 after tests by the Union of Soviet Socialist Republics began. Beginning in 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 these tests were detonated near or below the water table.

Five earth-cratering (shallow-burial) tests were conducted from 1962 to 1968 as part of the Plowshare Program, which explored peaceful uses of nuclear explosives. The first and highest yield Plowshare crater test, Sedan, was detonated at the northern end of Yucca Flat. The second-highest yield crater test was Schooner

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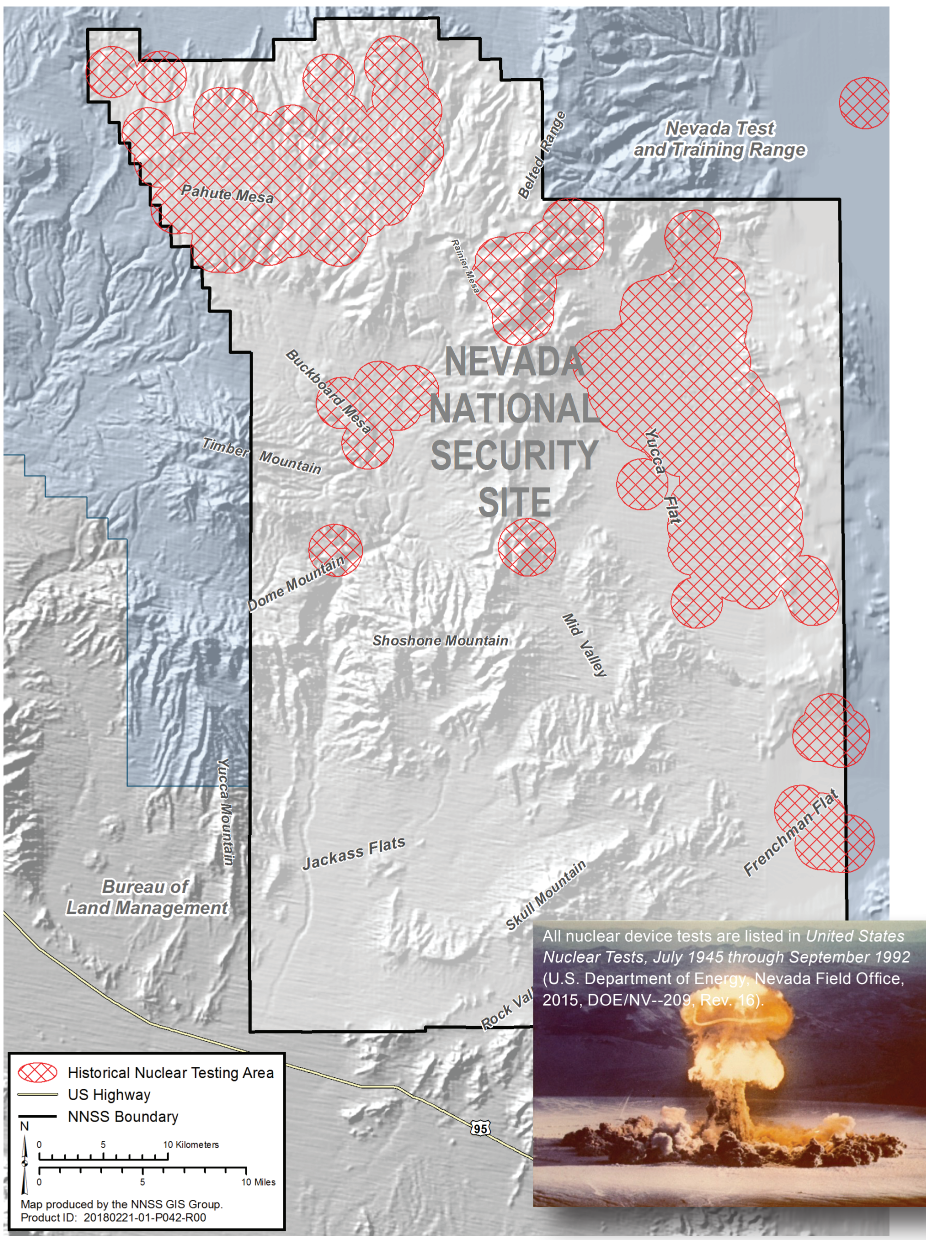
History of the NNSS *... continued from Page 1*

in the northwest corner of the NNSS. Mixed fission products, tritium, and plutonium from these tests were entrained in the soil, ejected from the craters, and deposited on the ground surrounding the craters.

Other nuclear-related experiments at the NNSS included the Bare Reactor Experiment–Nevada series in the 1960s. These tests were performed using a neutron generator mounted on a 1,527-foot steel tower to study neutron and gamma-ray interactions on various materials and to assess radiation doses experienced by the nuclear bomb survivors of Hiroshima and Nagasaki. From 1959 through 1973, a series of open-air nuclear reactor, engine, and furnace tests were conducted in Area 25, and a series of tests with a nuclear ramjet engine were conducted in Area 26. The tests released mostly gaseous radioactivity (radioiodines, radioxenons, radiokryptons) and some fuel particles that resulted in negligible deposition on the ground.



All nuclear device tests are listed in *United States Nuclear Tests, July 1945 through September 1992* (U.S. Department of Energy, Nevada Field Office, 2015, DOE/NV--209, Rev. 16).

Historical Nuclear Testing Areas on and adjacent to the NNSS

NNSS – Continental Test Site

After the end of World War II, the United States tested nuclear weapons at Bikini Atoll and Enewetak in the Marshall Islands of the Central Pacific.

In June 1950, with the outbreak of hostilities in Korea and U.S. relations with the Soviet Union continuing to deteriorate, the search began for a continental test site to overcome the difficulties with remoteness and security experienced with testing in the Pacific. The final choices included Dugway Proving Ground–Wendover Bombing Range in western Utah, Alamogordo–White Sands Guided Missile Range in south-central New Mexico, and a North Site and a South Site on the Las Vegas Bombing and Gunnery Range in southern Nevada.

On December 18, 1950, President Truman approved the recommendations of Los Alamos testing officials and the Atomic Energy Commission, christening the South Site on the Las Vegas Bombing and Gunnery Range as the nation's continental test site. It was called the Nevada Proving Ground.

On January 27, 1951, an Air Force B-50D bomber dropped a 1-kiloton yield nuclear bomb over Frenchman Flat. It was the world's tenth nuclear detonation and was the first test at the newly renamed Nevada Test Site (NTS).

On September 23, 1992, the last underground nuclear test was conducted on the NTS, after which Congress imposed a moratorium on nuclear weapons testing. Since 1951, a total of 100 atmospheric and 828 underground nuclear weapons tests have been conducted at the NTS.

Source: T. R. Fehner and F. G. Gosling, 2000. *Origins of the Nevada Test Site*, DOE/MA-0518, History Division, Executive Secretariat, Management and Administration, U.S. Department of Energy.

On August 23, 2010, the NTS was renamed the Nevada National Security Site to reflect the diversity of nuclear, energy, and homeland security activities conducted at the site.

The NNSS Now

NNSA/NFO conducts three major missions and their programs on the NNSS. Experimental programs are sponsored mainly by Los Alamos, Lawrence Livermore, and Sandia National Laboratories. During the conduct of all missions and their programs, NNSA/NFO complies with applicable environmental and public health protection regulations and strives to manage the land and facilities at the NNSS as a unique and valuable national resource. Mission Support and Test Services LLC (MSTS) is the M&O Contractor accountable for ensuring work is performed in compliance with environmental regulations.

NNSS activities in 2018 continued to be diverse, with the primary goal to ensure that the existing U.S. stockpile of nuclear weapons remains safe and reliable. Other activities included weapons of mass destruction first responder training; the controlled release of hazardous material at the Nonproliferation Test and Evaluation Complex (NPTEC); remediation of legacy contamination sites; characterization of waste destined for the Waste Isolation Pilot Plant in Carlsbad, New Mexico, or the Idaho National Laboratory in Idaho Falls, Idaho; disposal of low-level and mixed low-level radioactive waste; and environmental research. Facilities and centers that support the National Security/Defense mission include the U1a Facility, Big Explosives Experimental Facility (BEEF), Device Assembly Facility (DAF), National Criticality Experiments Research Center (NCERC) located in the DAF, Joint Actinide Shock Physics Experimental Research (JASPER) Facility, Dense Plasma Focus (DPF) Facility located in the Los Alamos Technical Facility (LATF), and the Radiological/Nuclear Countermeasures Test and Evaluation Complex (RNCTEC). Facilities that support the Environmental Management mission include the Area 5 Radioactive Waste Management Complex (RWMC) and the Area 3 Radioactive Waste Management Site (RWMS).

NNSS Missions and Their Programs

National Security/Defense

Stockpile Stewardship and Management Program — Conducts high-hazard operations in support of defense-related nuclear and national security experiments.

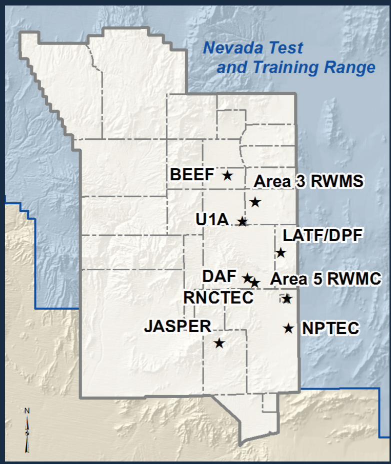
Nuclear Emergency Response, Nonproliferation, and Counterterrorism Programs — Provides support facilities, training facilities, and capabilities for government agencies involved in emergency response, nonproliferation technology development, national security technology development, and counterterrorism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

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

Environmental Management

Environmental Corrective Actions Program — Characterizes and remediates the environmental legacy of nuclear weapons and other testing at the NNSS and NTTR locations, and develops and deploys technologies that enhance environmental corrective actions.

Waste Management Program — Manages and safely disposes of low-level waste and mixed low-level waste received from U.S. Department of Energy (DOE)- and U.S. Department of Defense (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

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.

Environmental Compliance

Activities on the NNSS are subject to federal and state laws intended to protect the environment and public health. These laws define emission limits or prohibit the emission of toxic substances into the air, water, and ground; require plans to prevent spills, unplanned releases, and accidents; and call for programs to monitor, measure, document, and report on compliance to regulatory agencies and the public.

The U.S. Environmental Protection Agency (EPA) and the Nevada Division of Environmental Protection (NDEP) are the principal regulators of NNSS activities.

The following table defines and summarizes results for a few of the many federal regulations with which NNSA/NFO must comply.

Summary of NNSA/NFO's Compliance with Major Federal Statutes in 2018

Environmental Statute or Order and What It Covers	2018 Status
Atomic Energy Act (through compliance with DOE O 435.1, "Radioactive Waste Management"): Management of low-level waste (LLW) and mixed low-level waste (MLLW) generated or disposed on site	1,057,922 cubic feet of waste was disposed on site in LLW and MLLW disposal cells at the Area 5 RWMC and Area 3 RWMS. Some of this volume also included classified low-level and nonradioactive items. Waste volumes were within permit limits; vadose zone and groundwater monitoring continued to verify that disposed LLW and MLLW are not migrating to groundwater or threatening biota or the environment.
Clean Air Act: Air quality and emissions into the air from facility operations	Onsite air sampling stations detected man-made radionuclides at levels comparable to previous years and well below the regulatory dose limit for air emissions to the public of 10 millirem per year (mrem/yr). The estimated dose from all 2018 NNSS air emissions to the maximally exposed individual (MEI) is 0.07 mrem/yr. Nonradiological air emissions from permitted equipment and facilities were all below emission and opacity limits.
Clean Water Act: Water quality and effluent discharges from facility operations	All domestic and industrial wastewater systems and groundwater monitoring well samples were within permit limits for regulated water contaminants and water chemistry parameters.
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)/Superfund Amendments and Reauthorization Act (SARA): Cleanup of waste sites containing hazardous substances	No NNSS cleanup operations are regulated under CERCLA or SARA; they are regulated under the Resource Conservation and Recovery Act (RCRA) instead *(see below)*.
DOE O 458.1, "Radiation Protection of the Public and the Environment": Measuring radioactivity in the environment and estimating radiological dose to the public due to NNSA/NFO activities	Radiological monitoring of air, water, and direct radiation was conducted. The total annual dose to the MEI from all exposure pathways due to NNSA/NFO activities was estimated to be 12.94 mrem/yr, well below the DOE limit of 100 mrem/yr.
Emergency Planning and Community Right to Know Act (EPCRA): The public's right to know about toxic chemicals being stored, released to the environment, and/or managed through recycling or treatment	269,845 lb of lead, 280 lb of mercury, 23 lb of polychlorinated biphenyls (PCBs), 133,075 lb of nitromethane, and 116 lb of polycyclic aromatic hydrocarbons (PACs) were released as a result of NNSS activities. About 24% of lead released was for offsite recycling, while nearly 100% of remaining chemicals were released onsite. No releases exceeded reportable thresholds in 2018.
Endangered Species Act (ESA): Threatened or endangered species of plants and animals	Field surveys for 33 projects in desert tortoise habitat on the NNSS were conducted, no tortoises were harmed or displaced from project sites. A total of 14.9 acres of tortoise habitat was disturbed. One desert tortoises was accidentally killed by a vehicle on the ramp to Highway 95 just outside the site. 31 desert tortoises found near roads were moved out of harms way. All actions were in compliance with permit requirements.
Federal Facility Agreement and Consent Order (FFACO): Cleanup of waste sites containing hazardous substances	All 2018 corrective action milestones under the FFACO were met and 6 corrective action sites were closed. To date, 2,151 of 3,039 have been closed in accordance with state-approved corrective action plans.
Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA): Storage and use of pesticides and herbicides	Only nonrestricted-use pesticides were applied by state-certified personnel. Storage and use of pesticides were in compliance with federal and state regulations.
Migratory Bird Treaty Act (MBTA): Protecting migratory birds, nests, and eggs from harm	No projects harmed bird nests or eggs and 10 accidental human-related bird deaths were documented (e.g., electrocutions on powerlines and vehicle collisons).
National Environmental Policy Act (NEPA): Evaluating projects for environmental impacts	60 proposed projects/activities were reviewed under the NEPA compliance procedures and none required further NEPA analysis.
National Historic Preservation Act (NHPA): Identifying and preserving historic properties	Field surveys and historical evaluations for 8 projects were conducted, 986 acres were surveyed, and 46 cultural resources were identified, 16 of which were determined eligible to the National Registry of Historic Places.
Resource Conservation and Recovery Act (RCRA): Generation, management, disposal of hazardous waste (HW) and MLLW and cleanup of inactive, historical waste sites	1,644 tons of MLLW were disposed on site, 2.39 tons of HW and 0.24 tons of PCB wastes were received for temporary onsite storage and/or treatment, and 0.06 tons of HW and 2.61 tons of PCB waste were shipped off site for disposal, all in accordance with state permits. Groundwater monitoring of wells at the Area 5 RWMS confirmed that buried MLLW remains contained, and vadose zone monitoring and post-closure inspections of historical RCRA closure sites confirmed that buried HW remains contained.
Safe Drinking Water Act: Quality of drinking water	All three permitted public water systems on the NNSS met applicable national and state water quality standards.
Toxic Substances Control Act (TSCA): Management and disposal of PCBs	23 lb of LLW containing PCBs were disposed on site and 0.05 lb was shipped off site to an approved PCB disposal facility.

The Legacy of NNSS Nuclear Testing

Approximately one-third of the 828 underground nuclear tests on the NNSS were detonated near or below the water table, resulting in radioactive contamination of groundwater in some areas. In addition, the 100 atmospheric nuclear tests conducted on the NNSS and numerous nuclear-related experiments resulted in radioactive contamination of surface soils, materials, equipment, and structures, mainly on the NNSS.

The NNSA/NFO Environmental Management mission was established to address this legacy contamination. The Environmental Management (EM) Nevada Program is responsible for remediating contaminated sites, and Waste Management is responsible for safely managing and disposing of radioactive waste.

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Aerial view of Yucca Flat showing subsidence craters from historical underground nuclear tests.

Legacy Contamination

Groundwater — The total amount of radiation remaining below the groundwater table is approximately 20 to 25 million Ci, based on the most recent estimate, which incorporates corrections for radioactive decay since the last underground test in 1992. The areas of known and potential groundwater contamination on the NNSS due to underground nuclear testing are called Underground Test Area (UGTA) corrective action units.

Soil — Radioactively contaminated surface soils, directly resulting from nuclear weapons testing, exist at over 100 locations on and around the NNSS. The soils may contain contaminants including radioactive materials, oils, solvents, and heavy metals, as well as contaminated instruments and test structures used during testing activities.

Air — Airborne radioactive contamination from the resuspension of contaminated soils at legacy sites and from current activities is monitored continuously on and off the NNSS. Airborne concentrations of monitored contaminants have been decreasing at most sample locations on the NNSS over the past decade. Total Ci estimated to be released across the entire NNSS fluctuate annually; the highest annual estimates since 1992 have been 2,240 Ci for tritium, 0.40 Ci for plutonium, and 0.069 Ci for americium. In air measured in communities surrounding the NNSS, emissions from the NNSS cannot be distinguished from background airborne radiation.

Structures/Materials — There are 1,865 sites where facilities, equipment, structures, and/or debris were contaminated by historical nuclear research, development, and testing activities. These structures/materials are referred to as Industrial Sites and include disposal wells, inactive tanks, contaminated buildings, contaminated waste sites, inactive ponds, muck piles, spill sites, drains and sumps, and ordnance sites.

Waste Disposal — Low-level and mixed low-level radioactive wastes have been generated by historical nuclear research, development, and testing activities and environmental cleanup activities. From the 1960s, when waste disposal began, through December 31, 2018, nearly 1.8 million cubic yards of waste have been safely disposed at the Area 3 and Area 5 RWMSs. The estimated cumulative radioactivity of all wastes at the time of disposal is 1.7 million Ci. The radioactive content of the waste decays over time, however, at a varied rate depending on the radionuclide.

Curie (Ci) is the traditional measure of radioactivity based on the observed decay rate of 1 gram of radium. One curie of radioactive material will have 37 billion disintegrations in 1 second.

The Legacy of NNSS Nuclear Testing *... continued from Page 5*

The Federal Facility Agreement and Consent Order (FFACO) between the State of Nevada, DOE, and DoD identifies corrective action units (CAUs), which are groupings of corrective action sites (CASs) that delineate areas of historical contamination. The FFACO establishes corrective actions and schedules for the remediation and closure of CASs. Approximately 3,000 CASs have been identified, the majority of which have already been remediated and/or closed. The public is kept informed of EM Nevada Program activities through periodic newsletters, exhibits, and fact sheets, and EM Nevada Program provides the opportunity for public input via the Nevada Site Specific Advisory Board (NSSAB), consisting of 15–20 citizen volunteers from Nevada.


Schooner Crater in Area 20 formed during a 1968 crater test exploring peaceful uses of nuclear explosives.

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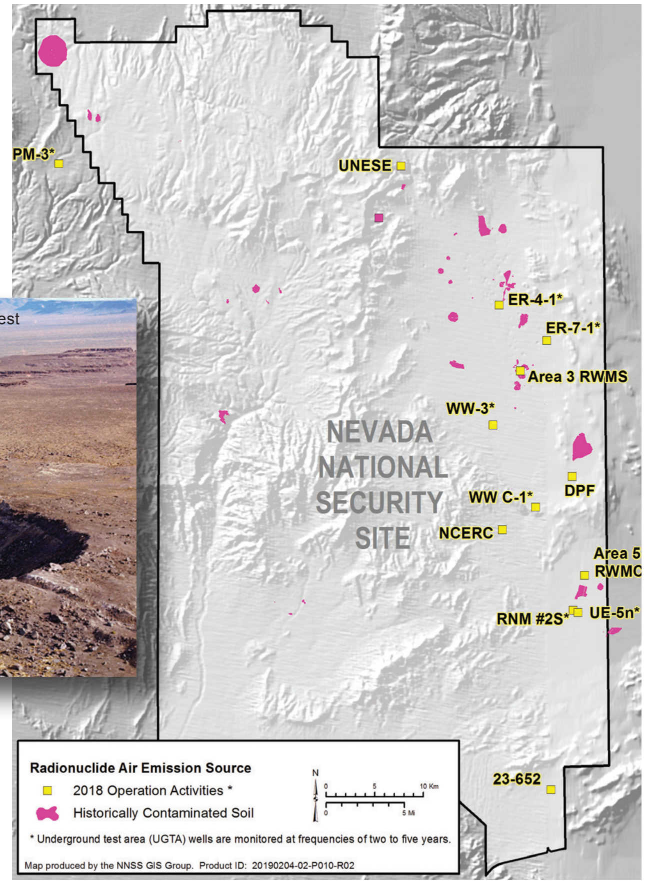
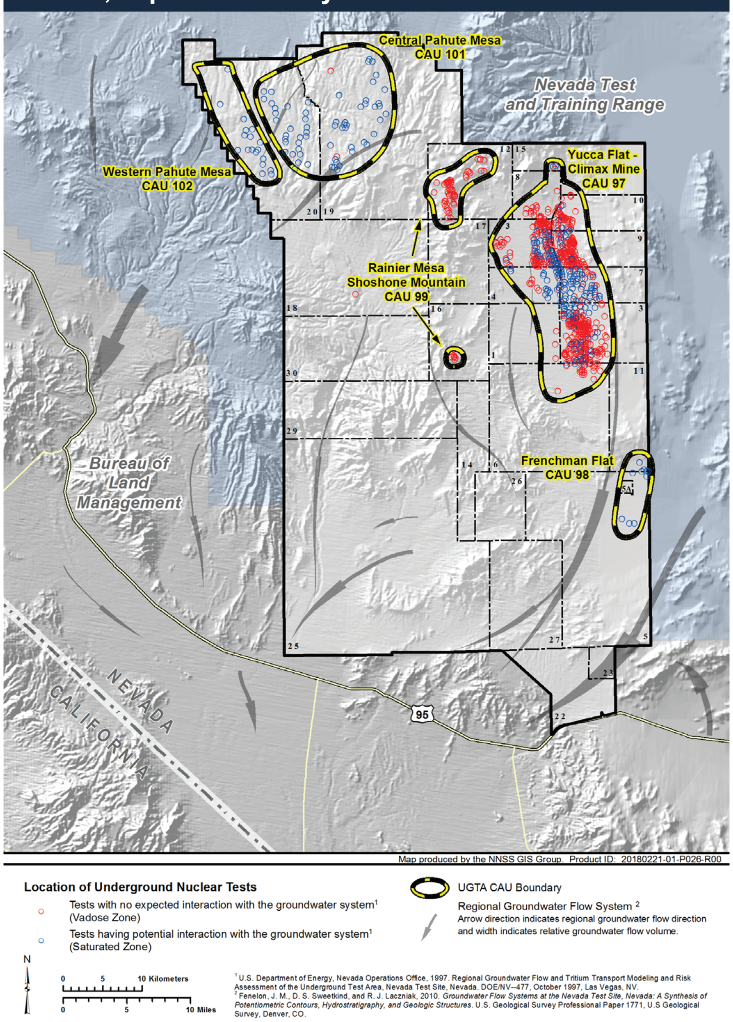
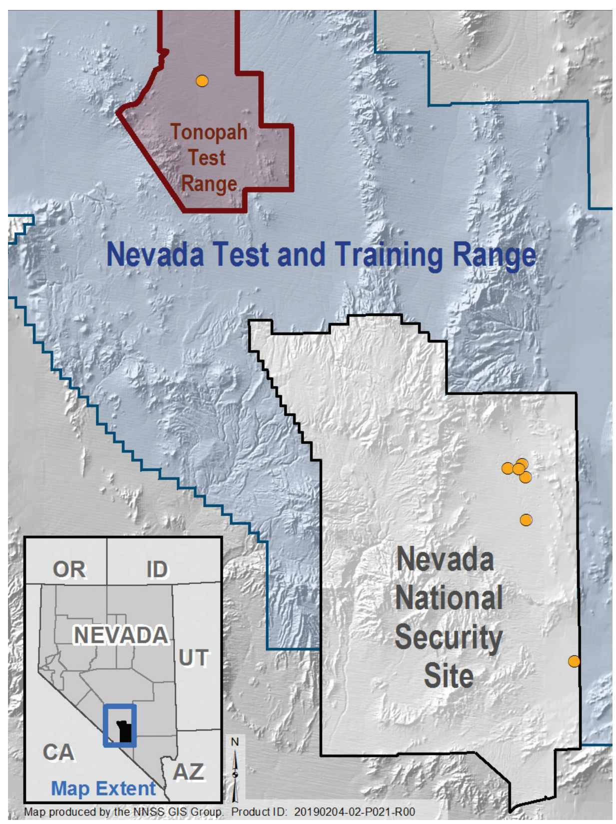


Sources of Radiological Air Emissions on the NNSS

The direction of groundwater flow, shown by the arrows, is predominantly southwest.



Areas of Potential Groundwater Contamination on the NNSS



Locations of Soil Contamination on and off the NNSS that Remain to be Remediated and/or Closed

The Legacy of NNSS Nuclear Testing

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Numerous man-made and naturally occurring radionuclides occur on the NNSS. The radionuclides produce ionizing radiation in the form of alpha particles, beta particles, and gamma rays, which are emitted from the unstable radionuclides as they decay to form more stable atoms. Almost all human exposure to ionizing radiation (82% in the United States) comes from natural sources that include cosmic radiation from outer space, terrestrial radiation from materials like uranium and radium in the earth, and naturally occurring radionuclides in food, water, and the aerosols and gases in the air we breathe. Man-made sources and applications of ionizing radiation in our everyday life include smoke detectors, X-rays, CT scans, and nuclear medicine procedures. For people living in areas around the NNSS, less than 2% of their total radiation exposure is attributable to past nuclear testing or to current NNSS activities.

Forms of Radiation

Alpha particles are heavy, positively charged particles given off by some decaying atoms. Alpha particles can be blocked by a sheet of paper. Atoms emitting alpha particles are hazardous only if they are swallowed or inhaled.

Beta particles are electrons or positrons (positively charged electrons) ejected from the nucleus of a decaying atom. More penetrating than alpha radiation, beta particles can pass through several millimeters of skin. A sheet of aluminum only a fraction of an inch thick will stop beta radiation. Beta particles can damage skin but are most hazardous if swallowed or inhaled.

Gamma rays are waves of pure energy similar to X-rays, light, microwaves, and radio waves. Gamma rays are emitted by certain radionuclides when their nuclei transition from a higher to a lower energy state. They can readily pass into the human body. They can be almost completely blocked by about 40 inches of concrete, 40 feet of water, or a few inches of lead. Gamma rays can be both an external and internal hazard.

X-rays are a more familiar form of electromagnetic radiation, usually with a limited penetrating power, typically used in medical or dental examinations. Television sets, especially color, give off soft (low-energy) X-rays; thus, they are shielded to greatly reduce the risk of radiation exposure.

Neutrons are uncharged heavy particles contained in the nucleus of every atom heavier than ordinary hydrogen. They induce ionization only indirectly in atoms that they strike, but they can damage body tissues. Neutrons are released, for example, during the fission (splitting) of uranium atoms in the fuel of nuclear power plants. They can also be very penetrating. In general, efficient shielding against neutrons can be provided by materials containing hydrogen, such as water. Like gamma rays, neutrons are both an external and internal hazard.

Radionuclides Detected on the NNSS

	Name*	Abbreviation	Primary Type(s) of Radiation	Major NNSS Source
Man-Made	Americium-241	^{241}Am	Alpha, gamma	In soil at and near legacy sites of aboveground nuclear testing. Detected in soil and air.
	Cesium-137	^{137}Cs	Beta, gamma	
	Plutonium-238	^{238}Pu	Alpha	
	Strontium-90	^{90}Sr	Beta	
	Cobalt-60	^{60}Co	Gamma	In soil at and near legacy sites of aboveground nuclear testing. Detected in soil.
	Europium-152	^{152}Eu	Gamma	
	Europium-155	^{155}Eu	Gamma	
	Plutonium-239+240	$^{239+240}Pu$	Alpha	In soil at and near legacy sites of plutonium dispersal experiments. Detected in soil and air.
	Tritium	^{3}H	Beta	In groundwater in areas of underground nuclear tests, in surface ponds used to contain contaminated groundwater, in soil at nuclear test locations, and in waste packages buried in pits at waste management sites. Detected in groundwater and air.
Naturally Occurring	Beryllium-7	^{7}Be	Gamma	Produced by interactions between cosmic radiation from the sun and the earth's upper atmosphere. Detected in air.
	Potassium-40	^{40}K	Beta, gamma	Naturally occurring in the earth's crust. Detected in groundwater, soil, and air.
	Radium-226	^{226}Ra	Alpha, gamma	
	Thorium-232	^{232}Th	Alpha	
	Uranium-234**	^{234}U	Alpha	
	Uranium-235**	^{235}U	Alpha, gamma	
	Uranium-238**	^{238}U	Alpha	

*The number given with the name of the radionuclide is the atomic mass number, which is the total number of protons and neutrons in the nucleus of the atom. Atoms with the same number of protons are the same element; atoms of the same element with different mass numbers are called isotopes of one another.

**These uranium isotopes, though of natural origin, can also be detected at specific NNSS locations where man-made depleted uranium has been released during experiments, resulting in an alteration of the relative amounts of each isotope.

Cleanup and Closure of Corrective Action Sites

UGTA Sites

The EM Nevada Program gathers data to characterize the groundwater aquifers beneath the NNSS and adjacent lands. The data are used to develop hydrogeologic models for the CAUs and the larger UGTA model areas that will be used to forecast the groundwater movement and transport of radiological contaminants from the CAUs. Closure of the UGTA CAUs under the FFACO will involve long-term groundwater monitoring because cost-effective technologies have not been developed to effectively remove or stabilize the radiological contaminants produced during historical underground nuclear testing. The progress towards closure of each UGTA CAU is summarized below. The design and results to date of all wells in NNSA/NFO's groundwater sampling network are presented on Pages 11 and 12.

Central and Western Pahute Mesa CAUs – These CAUs are in the middle of the investigation stage of the closure process. The Phase I Central and Western Pahute Mesa Transport Model, completed in 2009, forecasts that tritium in groundwater may migrate off the northwestern boundary of the NNSS within 50 years of the first nuclear detonation (in 1965) and that offsite concentrations of tritium may be above the Safe Drinking Water Act limit of 20,000 picocuries per liter (pCi/L) *(see figure on next page)*.

A Phase II Central and Western Pahute Mesa Corrective Action Investigation Plan (CAIP), completed in 2009, outlines the field investigation program that is currently being implemented. The program's objective is to collect additional data to test the assumptions of the Phase I groundwater flow and contaminant transport models, improve data quality, and increase confidence in the transport model results used to forecast contaminant boundaries. Twelve new wells were proposed, eleven of which have been drilled. The new Phase II wells have yielded valuable new information regarding radionuclide migration within this CAU.

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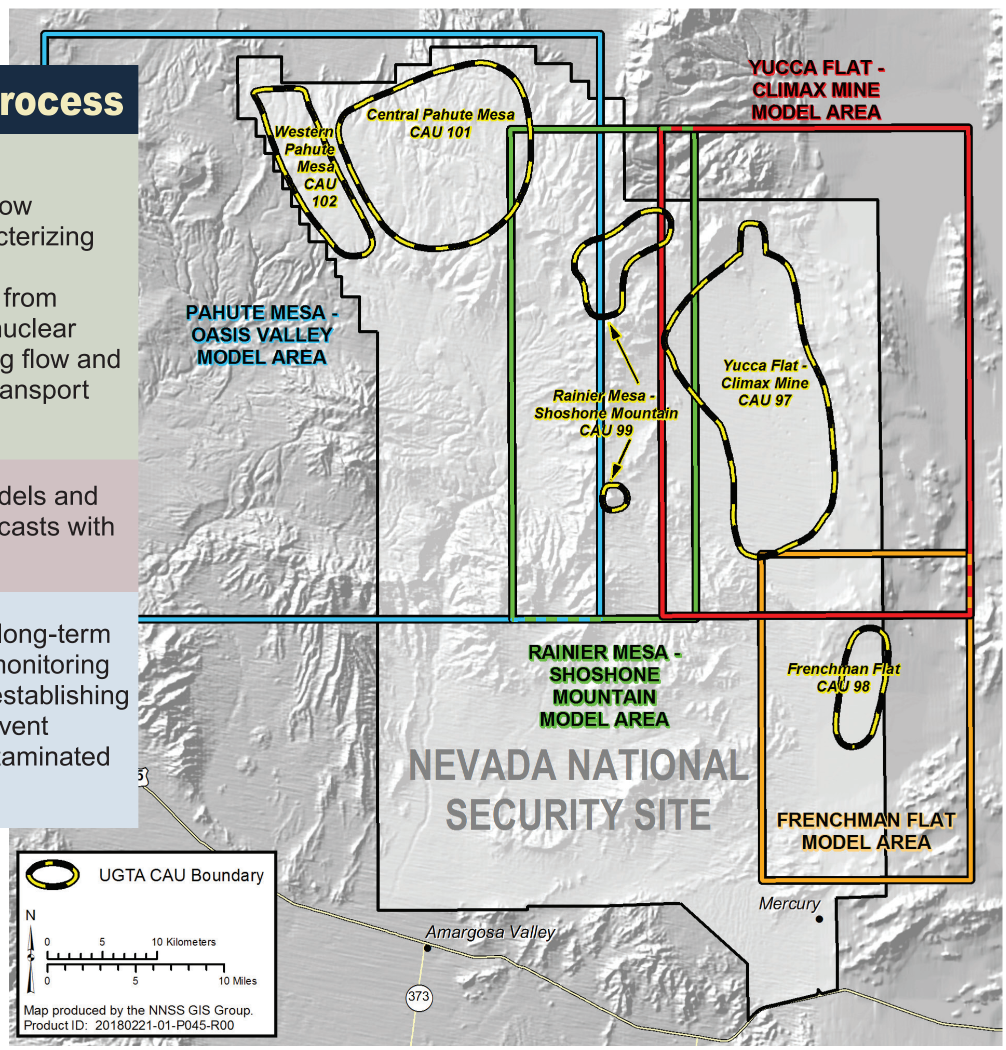
UGTA Sites Closure Process

Investigation Stage	Characterizing groundwater flow system, characterizing groundwater contamination from underground nuclear testing, building flow and contaminant transport models
Model Evaluation	Evaluating models and modelling forecasts with field data
Closure Stage	Implementing long-term groundwater monitoring program and establishing controls to prevent access to contaminated groundwater



Location of UGTA Activity CAUs and Model Areas

Other Phase II investigations continued through 2018 including groundwater sampling, measuring water levels, and a variety of analysis to evaluate the Phase II geologic, hydrologic, and chemistry data.

Consistent with the transport model forecast, tritium was detected in well ER-EC-11 on the NTTR in 2009. It is located approximately 2,350 feet west of the NNSS boundary and approximately 2 miles from the nearest underground nuclear tests, Benham and Tybo, conducted in 1968 and 1975, respectively. ER-EC-11 has the highest concentration of tritium (18,400 pCi/L measured in 2017) among the offsite NTTR wells. Elevated tritium in ER-EC-11 and in a cluster of five Area 20 monitoring wells represents the downgradient extension of the Benham-Tybo contaminant plume. Data from these wells indicate that the contaminant plume forecasted by the Phase I model may be more southerly than previously modeled. Phase II flow and transport model-

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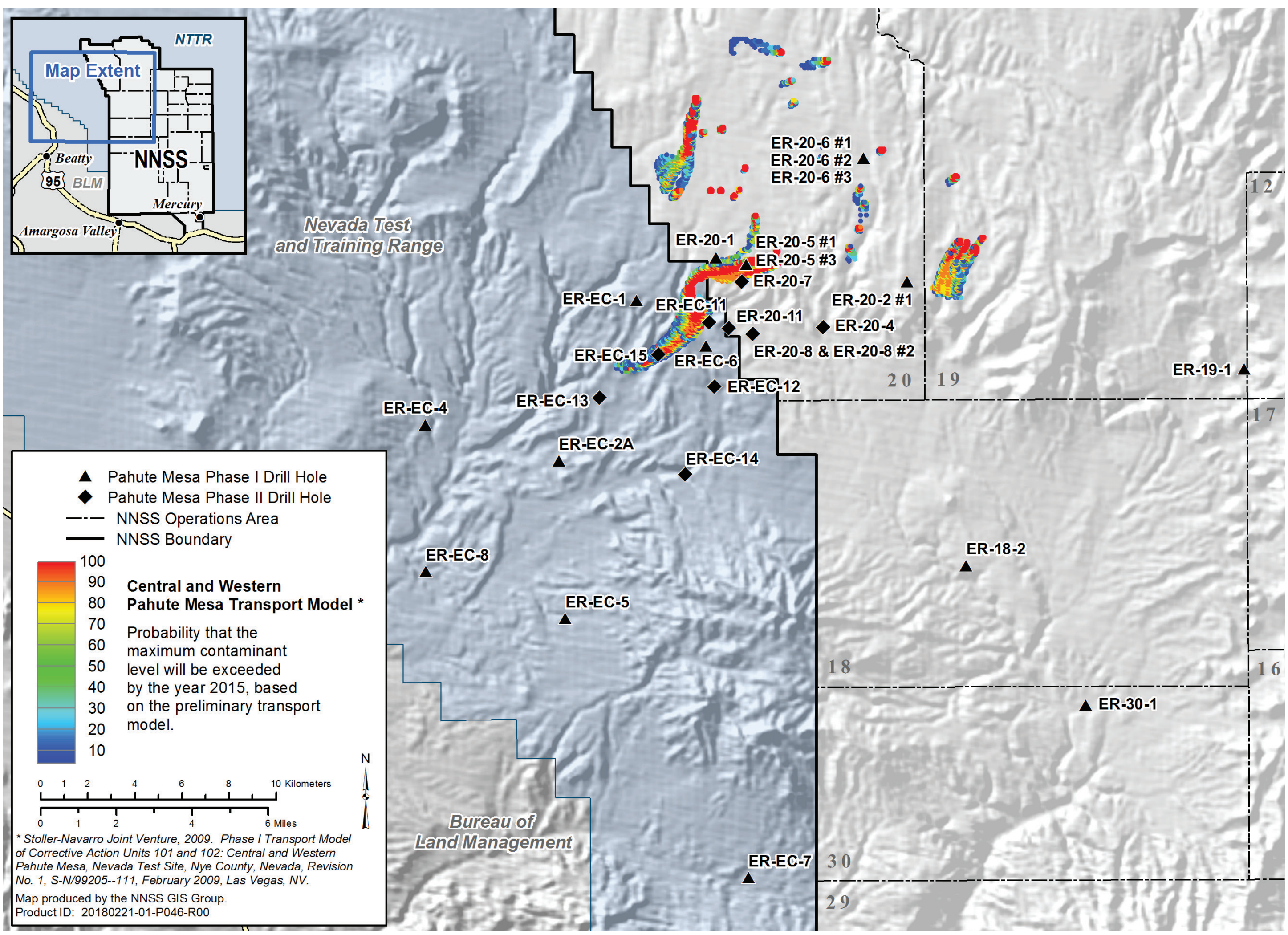
Pahute Mesa Groundwater Monitoring Results in Perspective

- **Based on conservative scientific calculations and sampling results, it will take at least 100 years for tritium to reach the closest public land boundary.**
- **In approximately 100 years, the concentration of tritium is estimated to be in compliance with safety standards at the closest public land boundary.**
- **In approximately 200 years, the concentration of tritium will be nearly zero at the closest public land boundary.**



Results of 2009 Phase I Central and Western Pahute Mesa Transport Modeling

Newly drilled well ER-20-12 on Pahute Mesa after sunset.

ing will include the new data from the Phase II drilling initiative, and will reflect recent tritium measurements. In 2018, sampling occurred at seven locations at or downgradient of Pahute Mesa.

Frenchman Flat CAU – This CAU is the first CAU to reach the closure stage and the start of long-term, or post-closure monitoring. The Closure Report was approved in 2016 and is the culmination of 20 years of characterization, modeling, and model evaluation. The Report describes the final contaminant, use restriction, and regulatory boundaries. It also prescribes a monitoring program for the first 5 years which includes sampling for water quality, water level, and institutional control monitoring.

Use restrictions continue to prevent exposure to the public, workers, and the environment from contaminants of concern by preventing the use of potentially contaminated groundwater.

Post-closure monitoring of the Frenchman Flat CAU continued in 2018. Seventeen wells were sampled for either water quality and/or water level. Water quality results are consistent with the groundwater flow and radionuclide transport models. The use restrictions continue to prevent exposure of the public, workers, and the environment to contaminants of concern by preventing the use of potentially contaminated groundwater within the Frenchman Flat CAU.

Rainier Mesa–Shoshone Mountain CAU – This CAU is near the end of the investigation stage of the closure process. The closure strategy, approved by NDEP in 2013, is unique from the other UGTA CAUs. It does not require the identification of contaminant boundaries because of their expected irreducible uncertainty and cost prohibitions. Instead, it requires the development of simpler models to forecast potential distances of radionuclide transport.

This new strategy is expected to save several years and several million dollars over the original process, while still protecting human health and the environment over the 1,000-year compliance period required by the FFACO. Simplified models of radionuclide transport along potential transport pathways from source locations in Rainier Mesa are being developed. Tritium levels in wells monitored in 2018 and previous years are being compared to simulation results. Documentation and peer review of the simplified models and results were complete in 2018. The NDEP will use the results and recommendations of the external Peer Review Panel to determine if the CAU 99 Flow and Transport Model meets the requirements for advancement to the closure stage.

Yucca Flat–Climax Mine CAU – The Yucca Flat/Climax Mine CAU is in the model evaluation stage of the FFACO closure process. A Corrective Action Decision Document/Corrective Action Plan describing the model evaluation plan, initial use-restriction boundaries, and regulatory boundary objective was approved by NDEP in 2017. Extensive studies were conducted in response to recommendations made by the external peer review commit-

Continued on Page 11 ...

NNSS Scientist Jenny Chapman (foreground) discusses groundwater characterization at Frenchman Flat with a resident of Amargosa Valley, Nevada, at the 2016 NNSS Groundwater Open House.

NNSS Scientists collect water samples at Well ER-20-1, a 2,065 feet deep early detection well on Pahute Mesa in 2019.

tee who reviewed the Phase I Flow and Transport Model and its supporting data. These studies included drilling three new wells, collecting additional data, reanalyzing existing data and models, and modeling. The three new wells drilled and sampled in 2016 are near three of the detonations most likely to have impacted the lower carbonate aquifer (LCA) in the Yucca Flat basin. Understanding radionuclide transport to the LCA is high priority because the LCA, a regional aquifer, is the only pathway for radionuclides to migrate out of the basin. In agreement with the conceptual model, the absence of significant tritium in water samples from these wells verified that underground tests which do not intersect the LCA have a negligible impact on migration outside of the basin. In 2018, model evaluation activities were used to refine the groundwater flow and contaminant transport model.

Soils Sites

NNSA/NFO has identified 148 Soils CASs for which they are responsible to characterize, manage, and, where necessary, clean up. Some of these sites occur on TTR and NTTR. Corrective actions range from the removal of soil to closure-in-place with restricted access controls such as fencing and posting. Historical research and the preparation of short summary reports of research findings have been completed for all 148 CASs. In 2018, 2 were closed and work was conducted towards the closure of 7 CASs. Closure of CASs on the TTR and NTTR require negotiation with the State of Nevada and coordination with the U.S. Department of Defense. The total number of Soils CASs closed and approved by the state by the end of 2018 was 141; 7 Soils CASs remain to be formally closed. The anticipated date for completing the closure of all Soils CASs is 2027.

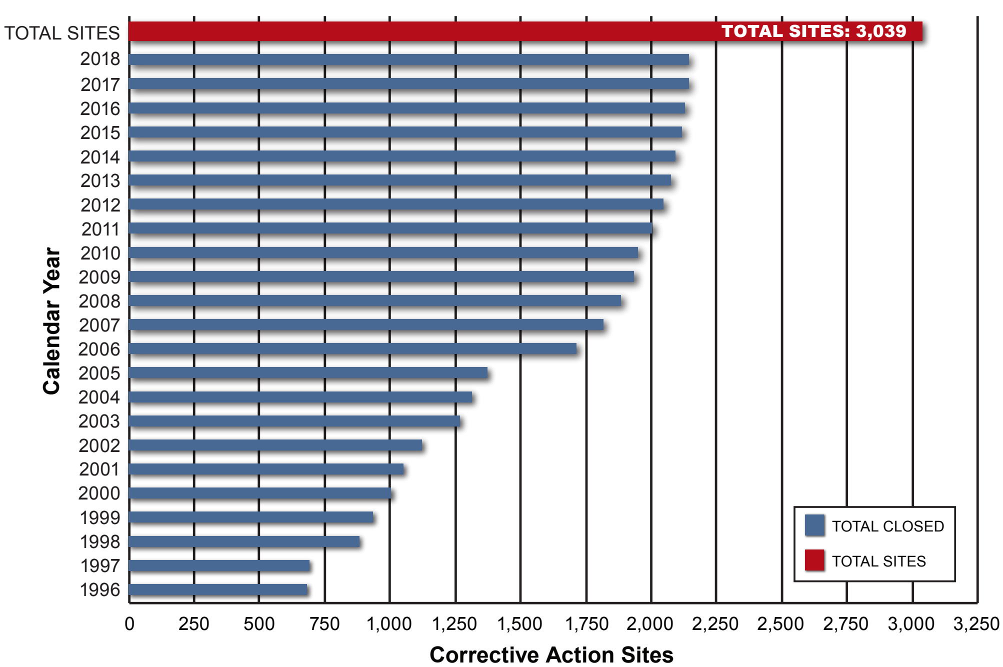
Industrial Sites

NNSA/NFO is responsible to safely close 1,865 Industrial Sites. Closure strategies have included the removal and disposal of debris, complete excavation of the site, decontamination and decommissioning activities, closure-in-place, no further action, and subsequent monitoring.

In 2018, no Industrial Sites CASs were closed although field work was conducted towards closure at several CASs. Only 2 Industrial Sites CAUs remain to be closed: CAU 114, the Area 25 Engine Maintenance, Assembly, and Disassembly (EMAD) Facility and CAU 572, the Test Cell C Ancillary Buildings and Structures. They comprise the final 8 Industrial Sites CASs to be closed. Their closure will occur prior to the end of the NNSS Environmental Restoration Activity, which is currently planned for 2030.

Federal Facility Agreement and Consent Order

Corrective Action Site Closures



Restoration Progress under FFACO

In 2018, 6 CASs were closed and all 2018 FFACO cleanup and closure activity milestones were met. The majority (868) of the remaining 888 CASs yet to be closed by NNSA/NFO are UGTA CASs for which closure-in-place with long-term monitoring is the corrective action.

Radiological Monitoring of Groundwater

For decades NNSA/NFO has sampled groundwater from monitoring wells on and off the NNSS to detect radionuclides that may be present due to historical underground nuclear testing. NNSA/NFO developed the NNSS Integrated Groundwater Sampling Plan, a comprehensive, integrated approach for collecting and analyzing groundwater samples to meet the requirements for UGTA CAU closures *(see Page 8)* and for all other compliance and environmental protection objectives.

The water sampling network under the Plan consists of 85 sampling locations categorized into five types: Characterization, Source/Plume, Early Detection, Distal, and Community locations. An additional six public water system (PWS) wells and five wells/surface waters are sampled to comply with specific federal/state regulations or permits.

The tritium analysis results for all sampling locations in the network are shown on the map on Page 13. The well sites are color coded based on the tritium concentration of their most recent water sample. The maximum contaminant level (MCL) allowed for tritium in drinking water, set by the EPA under the Safe Drinking Water Act (SDWA), is 20,000 pCi/L. The color codes represent tritium levels expressed as a percentage of this MCL. For example, the 5%–50% category means that tritium was found to be between 5% to 50% of the MCL, or between 1,000 and 10,000 pCi/L.

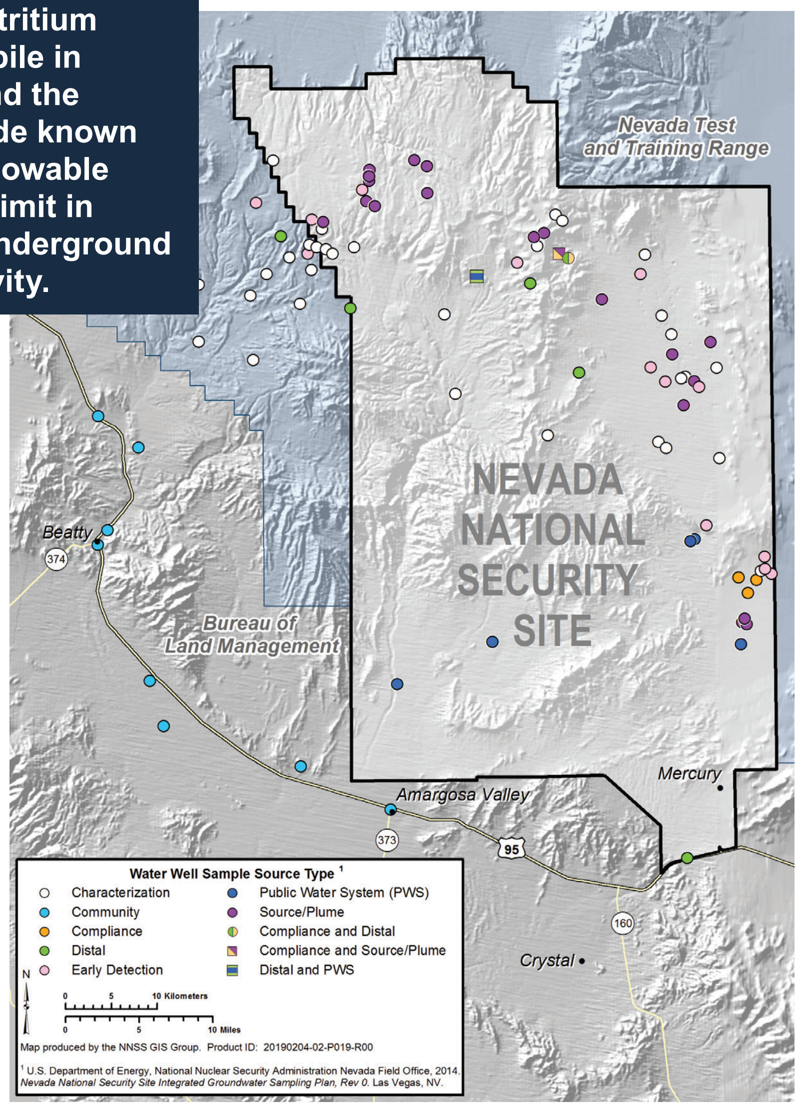
The 18 wells that currently exceed the SDWA MCL (coded red on the map) are all located on the NNSS and are either Source/Plume or Characterization wells. All Community sampling

Continued on Page 14 ...

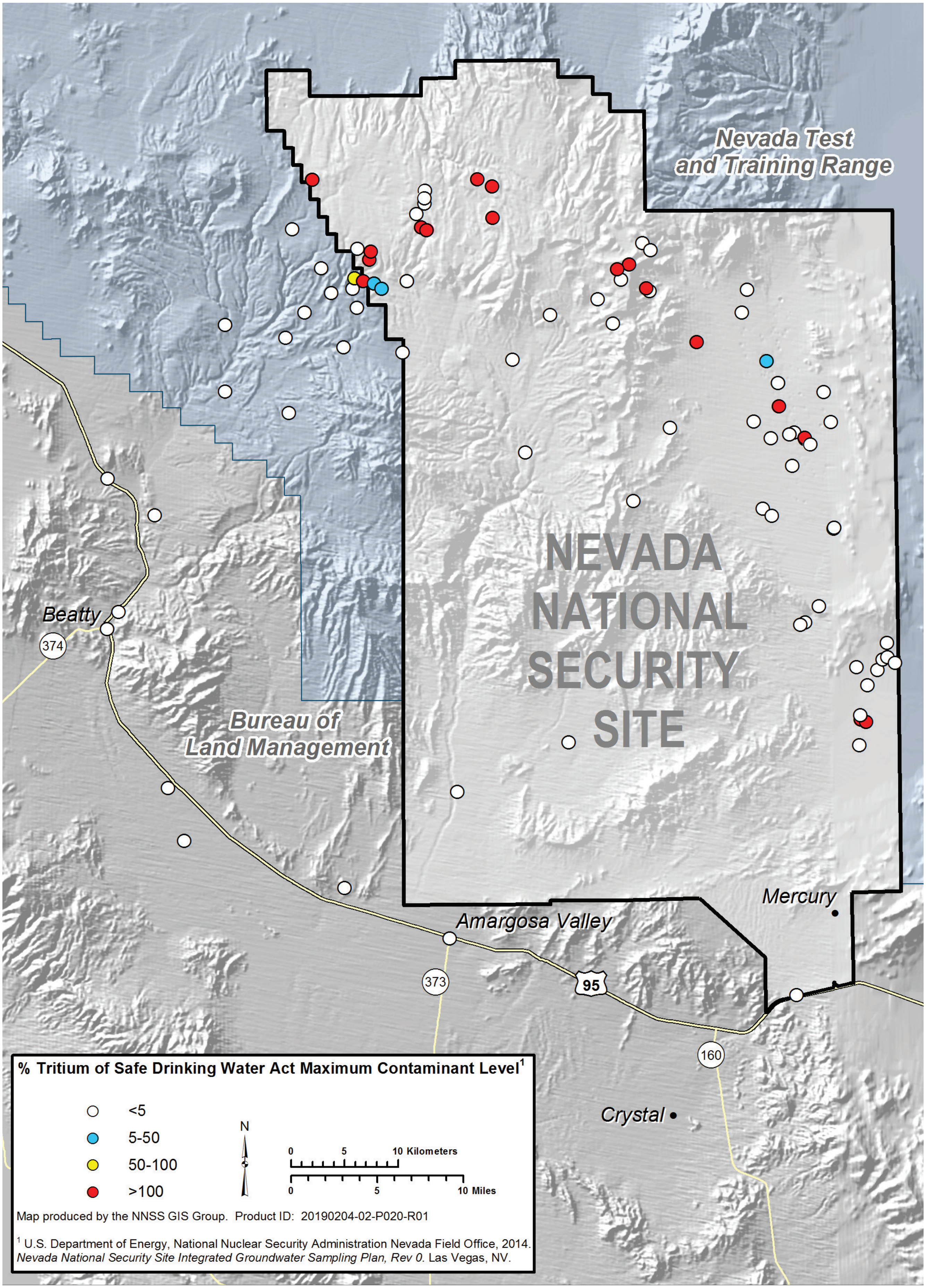
Tritium is the single contaminant of concern and is analyzed in water samples from all locations. Samples may be analyzed for other radionuclides as needed, but tritium is the most mobile in groundwater and the only radionuclide known to exceed its allowable drinking water limit in wells near an underground nuclear test cavity.

Types of Groundwater Sampling Locations

Characterization	Used for groundwater characterization or UGTA CAU model evaluation
Source/Plume	Located within the plume from an underground nuclear test; test-related contamination is currently present
Early Detection	Located downgradient of an underground test; no radioisotopes are detected above standard detection levels
Distal	Located outside the Early Detection area
Community	Located on BLM or private land; used as a water supply source or is near one
NNSS PWS	Potable water supply well that is part of a state-designated non-community PWS
Compliance	Monitored to comply with specific regulations or permits



NNSA/NFO Water Sampling Network



Tritium in NNSA/NFO Groundwater Monitoring Wells

 ... continued from Page 12

locations, which are on Bureau of Land Management (BLM) or private land, have undetectable levels of tritium (coded white on the map). Characterization well ER-EC-11 on the NTTR just west of the NNSS is the only offsite well in the network that has tritium concentrations greater than 10,000 pCi/L (coded yellow on the map). Tritum has not been detected in any NNSS PWS wells, and all wells and surface waters that are monitored to ensure compliance with NNSS permits had either undetectable levels of tritium or tritium levels that were below permit limits.

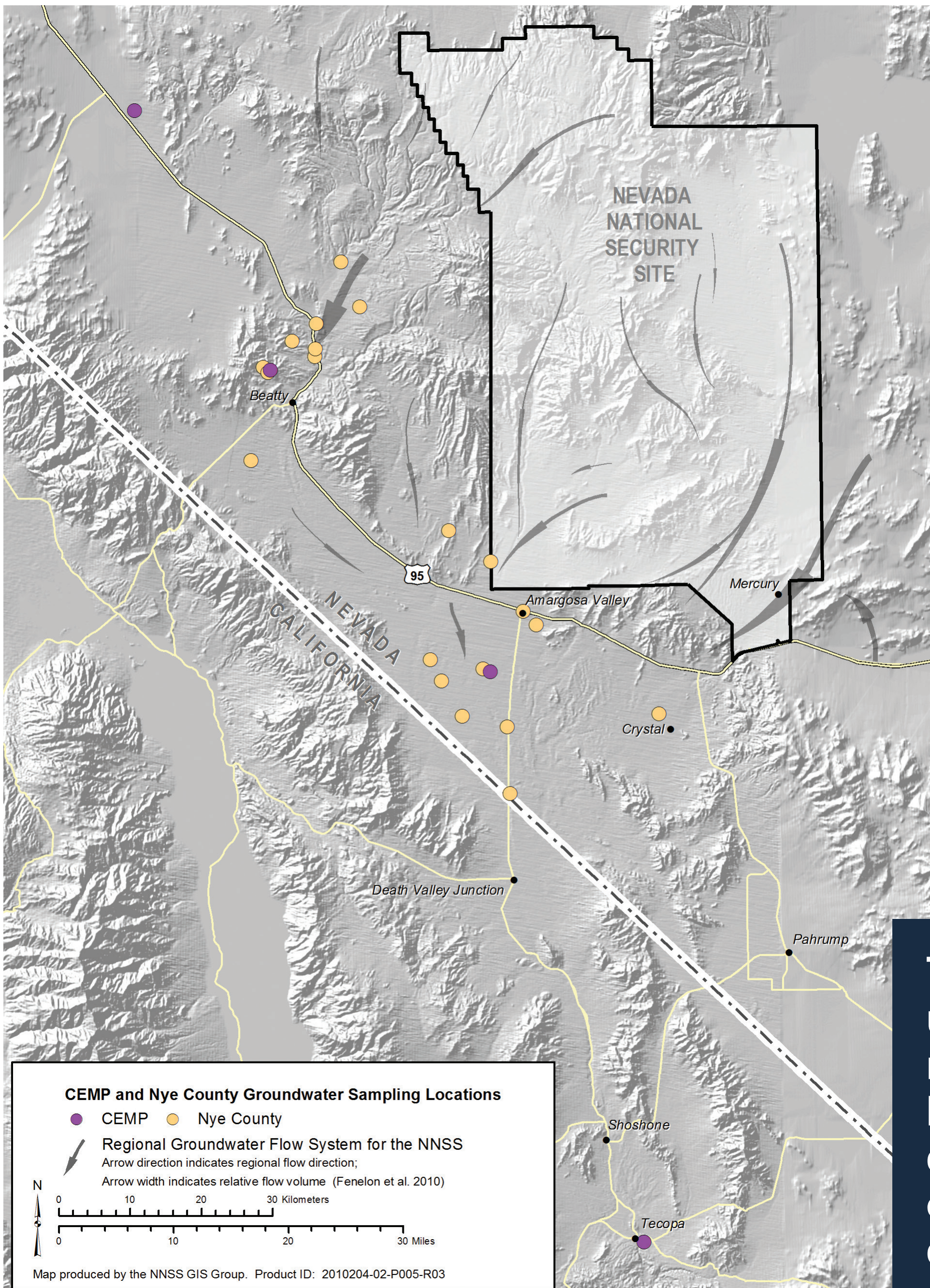
Community Environmental Monitoring Program

Offsite water supply wells are also monitored for the presence of tritium by the independent Community Environmental Monitoring Program (CEMP), which is coordinated by the Desert Research Institute (DRI) of the Nevada System of Higher Education under contract with NNSA/NFO. The CEMP provides the public with these data as part of a non-regulatory public informational and outreach program.

In 2018, the CEMP monitored four groundwater wells in communities located within the regional groundwater flow system that are downgradient or perceived to be downgradient of the NNSS. As in previous years, none of these wells had detectable levels of tritium.

Nye County Tritium Sampling and Monitoring Program

In 2015, NNSA/NFO expanded its support of offsite community-based monitoring of wells in Nye County. NNSA/NFO and EM Nevada Program issued a 5 year grant to Nye County to monitor tritium annually in 10 wells downgradient from the NNSS in the first year and up to 20 wells annually thereafter. The grant also supports Nye County's involvement in technical reviews of the UGTA sites closure process. The Nye County Tritium Sampling and Monitoring Program sampled 20 wells in 2018. None of the 20 wells had detectable levels of tritium.



2018 CEMP and Nye County Water Monitoring Locations

Tritium from underground nuclear testing has not been detected in any onsite or offsite drinking water wells.

Radiological Monitoring of Air

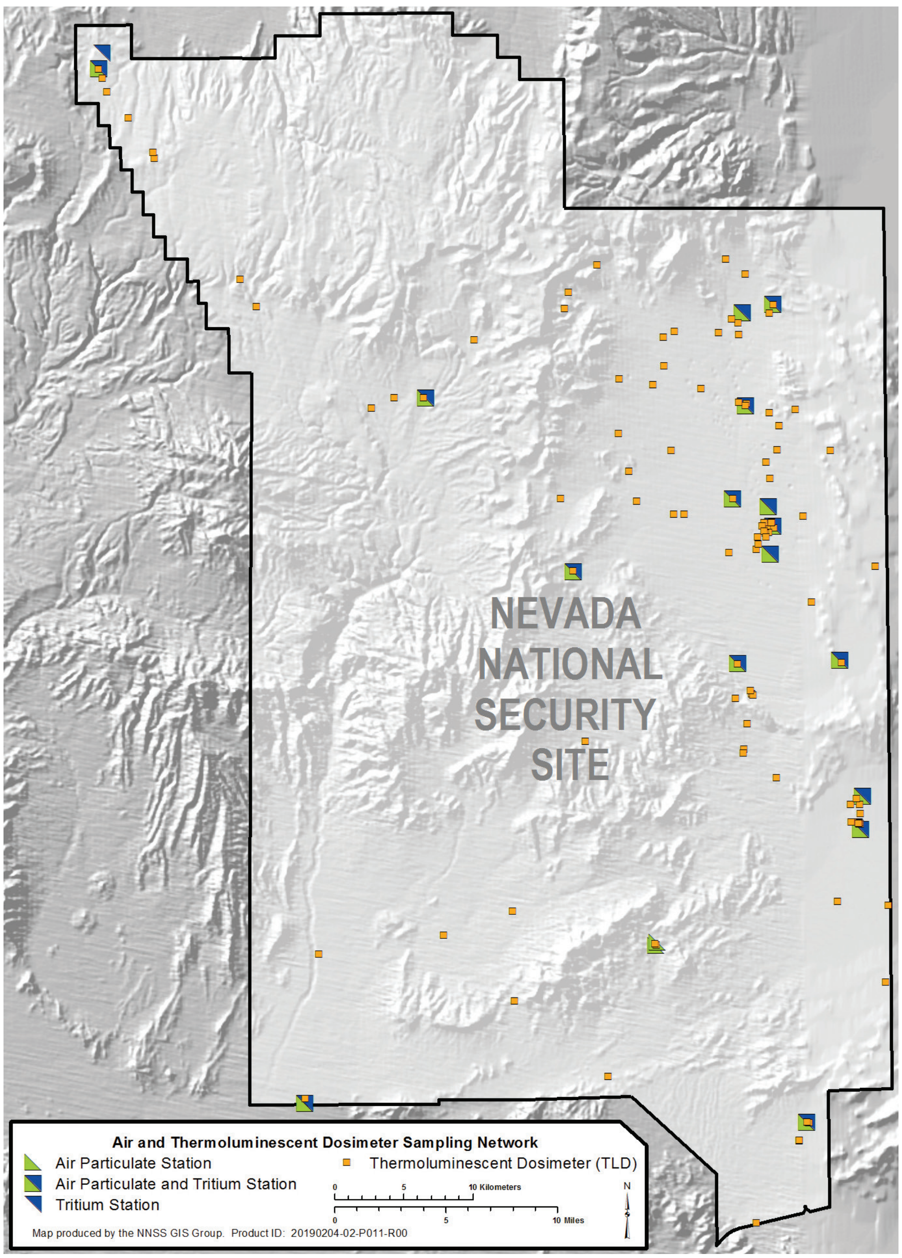
NNSS radioactive emissions are monitored to determine the public dose from inhalation and to ensure compliance with the National Emission Standards for Hazardous Air Pollutants (NESHAP) under the Clean Air Act. A network of 18 air sampling stations and a network of 103 thermoluminescent dosimeters (TLDs) are located throughout the NNSS *(see map below)*. NNSS air sampling stations monitor tritium in water vapor, man-made radionuclides, and gross alpha and beta radioactivity in airborne particles.

Range in Average Concentrations of Man-Made Radionuclides in Air Samples on the NNSS in 2018 Attributable to NNSS Operations

Radionuclide	Concentration (10^{-15} µCi/mL)[a]		
	Limit[b]	Lowest Average	Highest Average
^{241}Am	1.9	0.0018	0.1659
^{137}Cs	19	-0.2723	0.0780
^{3}H	1,500,000	70	68,560
^{238}Pu	2.1	-0.0028	0.0112
$^{239+240}$Pu	2.0	0.0002	1.0391

(a) The scale of concentration units for radionuclides shown in the table has been standardized to 10^{-15} microcuries per milliliter (µCi/mL). This scale may differ from those reported in detailed radionuclide-specific data tables in the NNSSER.

(b) The concentration established by NESHAP as the compliance limit.



2018 NNSS Air Sampling Network

The TLD stations monitor direct gamma radiation exposure.

Radioactive emissions are also monitored at stations in selected towns and communities within 240 miles of the NNSS by the CEMP. A network of 24 CEMP stations was used in 2018 *(see map on Page 16)*. The CEMP stations monitor gross alpha and beta radioactivity in airborne particles using low-volume particulate air samplers, penetrating gamma radiation using TLDs, gamma radiation exposure rates using pressurized ion chamber (PIC) detectors, and meteorological (MET) parameters using automated weather instrumentation.

Several man-made radionuclides were detected at NNSS air sampling stations in 2018: none exceeded concentration limits established by the Clean Air Act. The highest average levels of ^{241}Am, ^{238}Pu, and $^{239+240}$Pu were detected at Bunker 9-300 in Area 9, located within an area of known soil contamination from past nuclear tests. The highest average level of tritium was detected at Schooner, site of the second-highest yield Plowshare cratering experiment on the NNSS, where tritium-infused ejecta surrounds the crater. ^{137}Cs and ^{60}Co were found in only one quarterly sample at levels slightly above detection limits.

The total amount of man-made radionuclides emitted to the air from tritium, americium, and plutonium

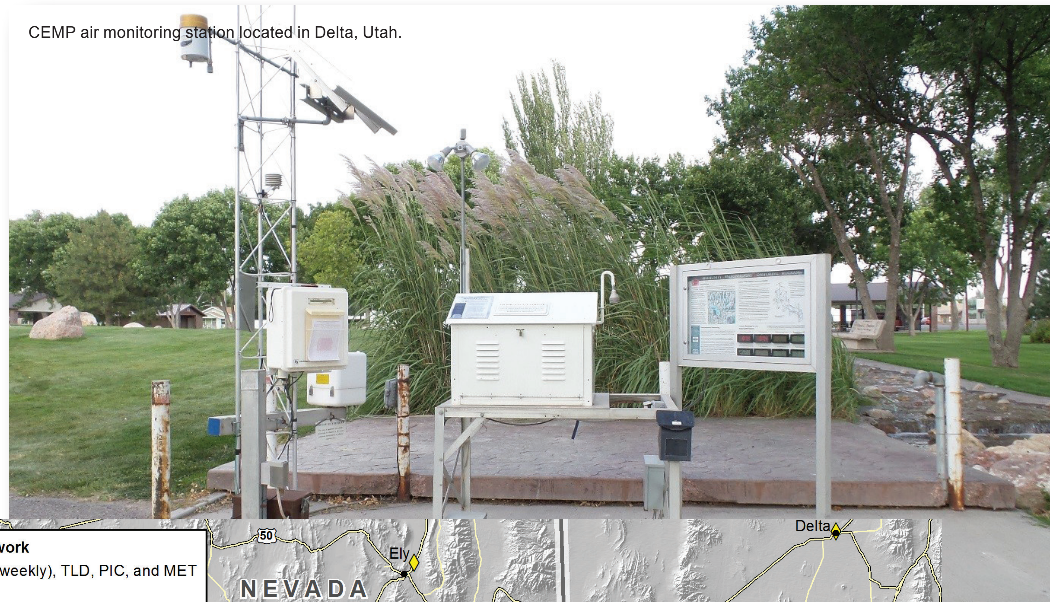
Continued on Page 16 ...

was estimated to be 1,260 Ci. Nearly all radionuclides detected by environmental air samplers in 2018 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. Over the past 10 years, total annual emissions have ranged from 42 to 1,312 Ci for tritium, 0.039 to 0.069 Ci for ^{241}Am, 0.040 to 0.050 Ci for ^{238}Pu, and 0.24 to 0.39 Ci for $^{239+240}$Pu.

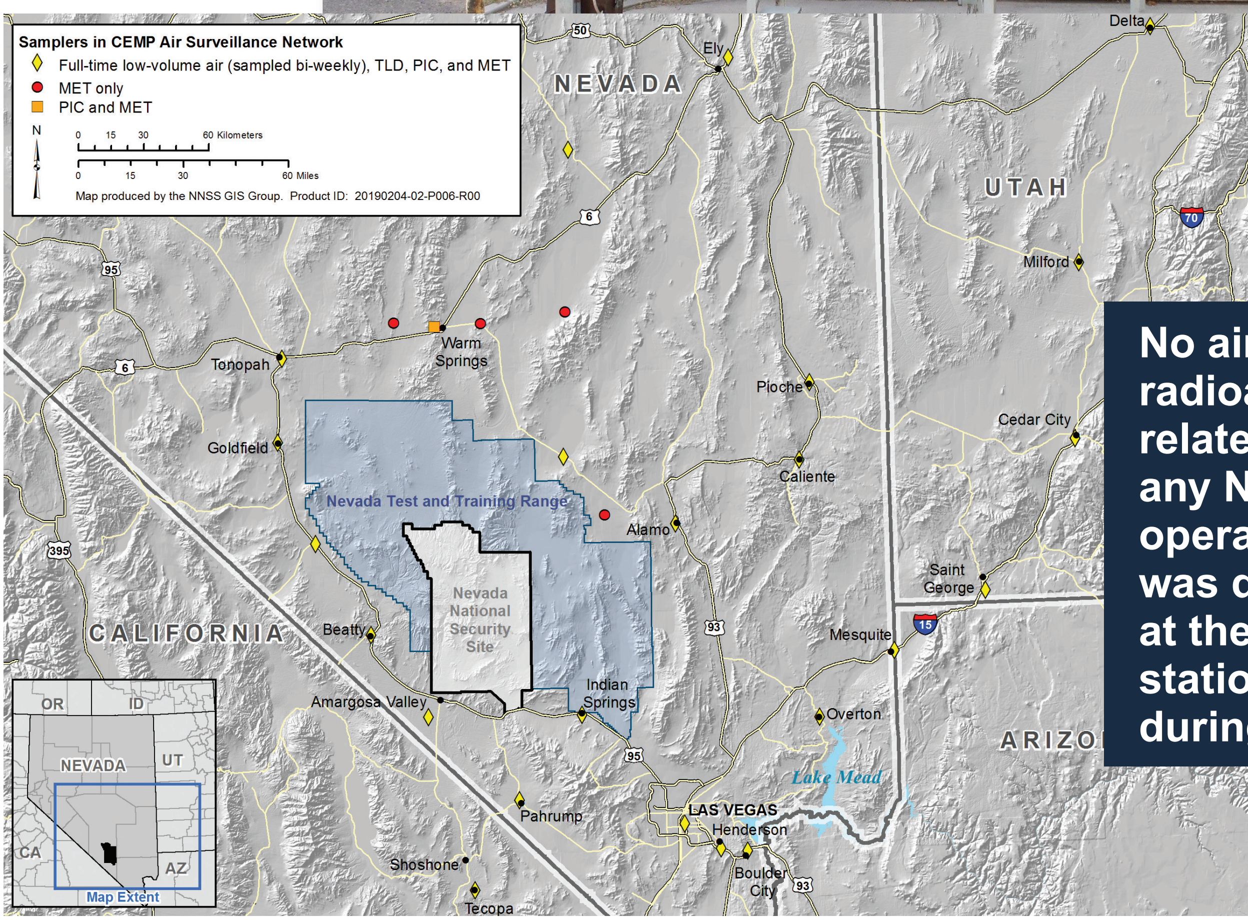
Estimated Quantity of Man-Made Radionuclides Released into the Air from the NNSS in 2018 (in Curies)

	Tritium (^{3}H)	Americium (^{241}Am)	Plutonium (^{238}Pu)	Plutonium ($^{239+240}Pu$)	Noble Gases	Other Radionuclides	
	1,260	0.069	0.040	0.29	2,136	19,275	507
Half-life*	12 years	432 years	88 years	>6,500 years	<11 years	<3 hours	>3 hours

* Half-life is the time required for one-half of the radioactive atoms in a given amount of material to decay.



CEMP air monitoring station located in Delta, Utah.



2018 CEMP Air Surveillance Network

No airborne radioactivity related to any NNSS operations was detected at the CEMP stations during 2018.

Direct Radiation Monitoring

Ten NNSS TLD stations are located where radiation effects from past or present NNSS operations are negligible, and therefore measure only natural background levels of gamma radiation from cosmic and terrestrial sources. In 2018, the mean measured background level from the 10 stations was 122 milliroentgens per year (mR/yr). This is well within the range of variation in background levels observed in other parts of the U.S. of similar elevation above sea level. Background radiation varies not only by elevation but by the amounts of natural radioactive materials in soil and rock in different geographic regions.

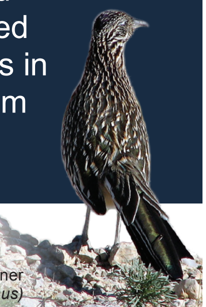
The highest estimated mean annual gamma exposure measured at a TLD station on the NNSS was 469 mR/yr at Schooner, one of the legacy Plowshare sites on Pahute Mesa.

The CEMP offsite TLD and PIC results remained consistent with previous years' background radiation levels and are also well within the range of variation in background levels observed in other parts of the U.S. and with the 122 mR/yr level measured on the NNSS. The highest annual gamma exposure measured off site, based on the PIC detectors, 150 mR at Beatty, Nevada. The lowest offsite exposure rate, based on the PIC detectors, was 96 mR at Pahrump, Nevada.

2018 NNSS Background Gamma Radiation

122 mR/yr — This is the mean background radiation measured at 10 TLD stations in areas isolated from past and present nuclear activities.

TLD station (post with TLD attached) located at Schooner Crater.



Greater Roadrunner *(Geococcyx californianus)*

Average Background Radiation of Selected U.S. Cities (Excluding Radon)
Ranked from Highest to Lowest

City	Elevation Above Sea Level (feet)	Radiation (mR/yr)
Denver, CO	5,280	164.6
Wheeling, WV	656	111.9
Rochester, NY	505	88.1
St. Louis, MO	465	87.9
Portland, OR	39	86.7
Los Angeles, CA	292	73.6
Las Vegas, NV	2,030	69.5
Fort Worth, TX	650	68.7
Richmond, VA	210	64.1
New Orleans, LA	39	63.7
Tampa, FL	0	63.7

Source: http://www.wrcc.dri.edu/cemp/Radiation.html, as accessed on August 8, 2019

Average Direct Radiation Measured in 2018 on and off the NNSS

Location	Elevation Above Sea Level (feet)	Radiation Exposure (mR/yr)
NNSS - Schooner TLD station (highest measurement)	5,660	469
NNSS - 35 Legacy Site TLD stations (includes Schooner)	3,077–5,938	209
Las Vegas, Nevada CEMP PIC station	2,030	107
NNSS - 17 Waste Operation TLD stations	3,176–4,021	137
NNSS - 10 Background TLD stations	2,755–5,938	122
Bloomington Hills, St. George, Utah CEMP PIC station	2,706	126
Pahrump, Nevada CEMP PIC station	2,639	96
NNSS Mercury Fitness Track TLD station (lowest measurement)	3,769	59

Understanding Radiation Dose

Dose is a generic term to describe the amount of radiation a person receives. The energy deposited indicates the number of molecules disrupted. The energy the radiation deposits in tissue is called the absorbed dose. The units of measure of absorbed dose are the rad or the gray. The biological effect of radiation depends on the type of radiation (alpha, beta, gamma, or X-ray) and the tissues exposed. A measure of the biological risk of the energy deposited is the dose equivalent. The units of dose equivalent are called rems or sieverts. In the NNSSER, the term dose is used to mean dose equivalent measured in rems. A thousandth of a rem is called a millirem (mrem).

An average person in the United States receives about 310 mrem each year from natural sources and an additional 310 mrem from medical procedures and consumer products (Source: https://www.epa.gov/radiation/radiation-sources-and-doses). Whether there is a "safe" radiation dose equivalent is a controversial subject. Because the topic has yet to be settled scientifically, regulators take a conservative approach and assume that there is no such thing as a 100% safe dose equivalent. It is believed that the risk of developing an adverse health effect (such as cancer) is proportionate to the amount of radiation dose received.

Many human activities increase our exposure to radiation over and above the average background radiation dose of 310 mrem per year. These activities include, for example, uranium mining, airline travel, and operating nuclear power plants. Regulators balance the benefit of these activities with the risk of increasing radiation exposures above background and, as a result, set dose limits for the public and workers specific to these activities. DOE has set the dose limit to the public from exposure to DOE-related nuclear activities to 100 mrem/yr. This is the same public dose limit set by the U.S. Nuclear Regulatory Commission (NRC) and recommended by the International Commission on Radiological Protection and the National Commission on Radiological Protection and Measurements. The NRC has set the dose limit for radiation workers to 5,000 mrem/yr. There are no common or agreed-upon dose limits for workers or the public across industries, states, or countries.

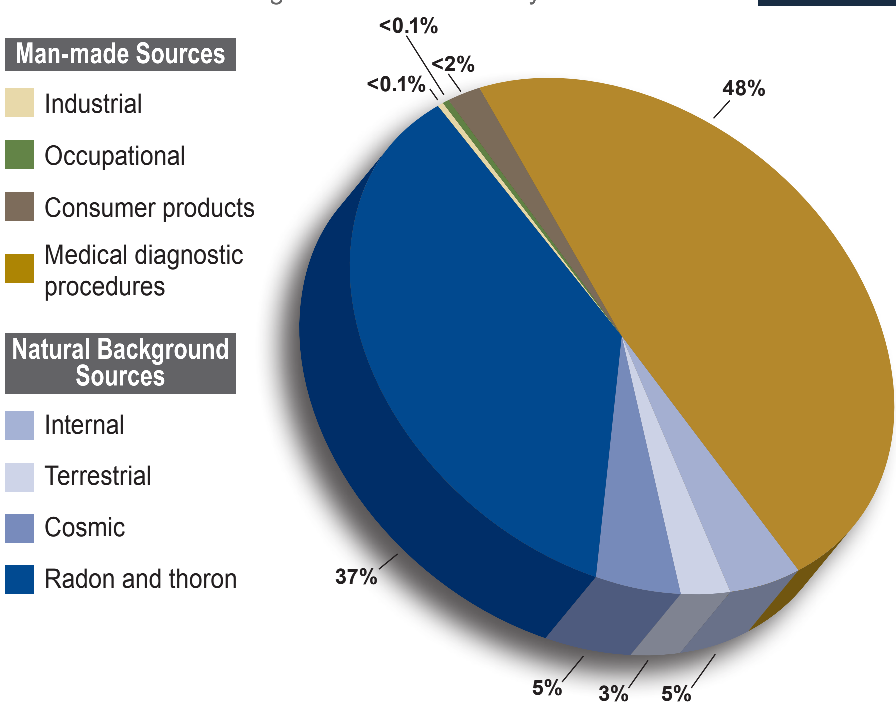
Average Doses from Radiation Sources

Source	Dose (mrem)
Living near a nuclear power station *(annual)*	<1
Chest X-ray *(single procedure)*	10
Terrestrial radioactivity *(annual)*	21
Radiation in the body *(annual)*	29
Cosmic *(at sea level) (annual)*	30
Mammogram *(single procedure)*	42
Cosmic *(in Denver) (annual)*	80
Head CT scan *(single procedure)*	200
Radon in average U.S. home *(annual)*	228
Upper gastrointestinal X-ray with fluoroscopy *(single procedure)*	600
Whole body CT scan *(single procedure)*	1,000

Source: https://www.epa.gov/radiation/radiation-sources-and-doses#tab-2, as accessed on August 8, 2019.

Sources of Radiation Exposure for the Average Person in the U.S.

Average Dose = 620 mrem/yr



Dose — The amount of radiation a person receives.

Absorbed dose — The energy the radiation deposits in tissue, where the energy deposited indicates the number of molecules disrupted. The units of measure of absorbed dose are the rad or the gray.

Dose equivalent — A measure of the biological risk of the energy deposited in tissue, which depends on the type of radiation (alpha, beta, gamma, or X-ray) and the tissues exposed. The units of measure of dose equivalent are called rems or sieverts.

Estimating Dose to the Public from NNSS Operations

The release of man-made radionuclides from the NNSS has been monitored since the first decade of atmospheric testing. After 1962, nuclear tests were conducted only underground, greatly reducing the radiation exposure in the areas surrounding the NNSS. Underground nuclear testing nearly eliminated atmospheric releases of radiation but resulted in the contamination of groundwater in some areas of the NNSS. After the 1992 moratorium on nuclear testing, radiation monitoring focused on detecting airborne radionuclides that are resuspended with historically contaminated soils on the NNSS and on detecting man-made radionuclides in groundwater.

There are three pathways in this dry desert environment by which man-made radionuclides from the NNSS might reach the surrounding public:

NNSS scientists collect air sample data for radiation monitoring.

Ingestion Pathway – Members of the public may ingest game animals that have been exposed to contaminated soil or water on the NNSS, have moved off the NNSS, and have then been hunted.

NNSS scientists collect plant samples at Cane Springs.

Air Transport Pathway – Members of the public may inhale or ingest radionuclides that are resuspended by the wind from contaminated sites on the NNSS. However, such resuspended radiation measured off and on the NNSS is much lower than natural background radiation in all areas accessible to the public.

NNSS Scientists conduct routine safety sampling of the public water system on the NNSS.

Groundwater Pathway – Based on monitoring data, drinking contaminated groundwater is currently not a possible pathway for public exposure, given the restricted public access to the NNSS and the location of known contaminated groundwater on and off the NNSS. No man-made radionuclides have been detected in drinking water sources monitored off the NNSS, and no drinking water wells on the NNSS have measurable levels of man-made radionuclides.

Continued on Page 20 ...

Public Dose Limits for NNSS Radiation

10 mrem/yr — This is the dose limit to the public (above natural background) from just the air transport pathway, as specified by the Clean Air Act National Emission Standards for Hazardous Air Pollutants (NESHAP).

100 mrem/yr — This is the dose limit to the public (above natural background) from all possible pathways combined, as specified by DOE O 458.1, "Radiation Protection of the Public and the Environment."

Estimated 2018 Inhalation Dose to the Public

Compliance with radiation dose limits to the general public from the air transport pathway is demonstrated using air sampling results from six onsite "critical receptor" sampling stations, which were approved by the EPA in 2001. The radionuclides detected at one or more of the NNSS critical receptor samplers were ^{241}Am, ^{238}Pu, $^{239+240}$Pu, and ^{3}H.

As in previous years, the 2018 data from the six critical receptor samplers show that the NESHAP dose limit to the public of 10 mrem/yr was not exceeded. The radioactive air emissions from each 2018 NNSS source were modeled using the Clean Air Package, 1988 model from EPA. The highest value is predicted to be a person residing at the north end of Amargosa Valley and received a predicted dose of 0.07 mrem/yr.

Estimated 2018 Ingestion Dose to the Public

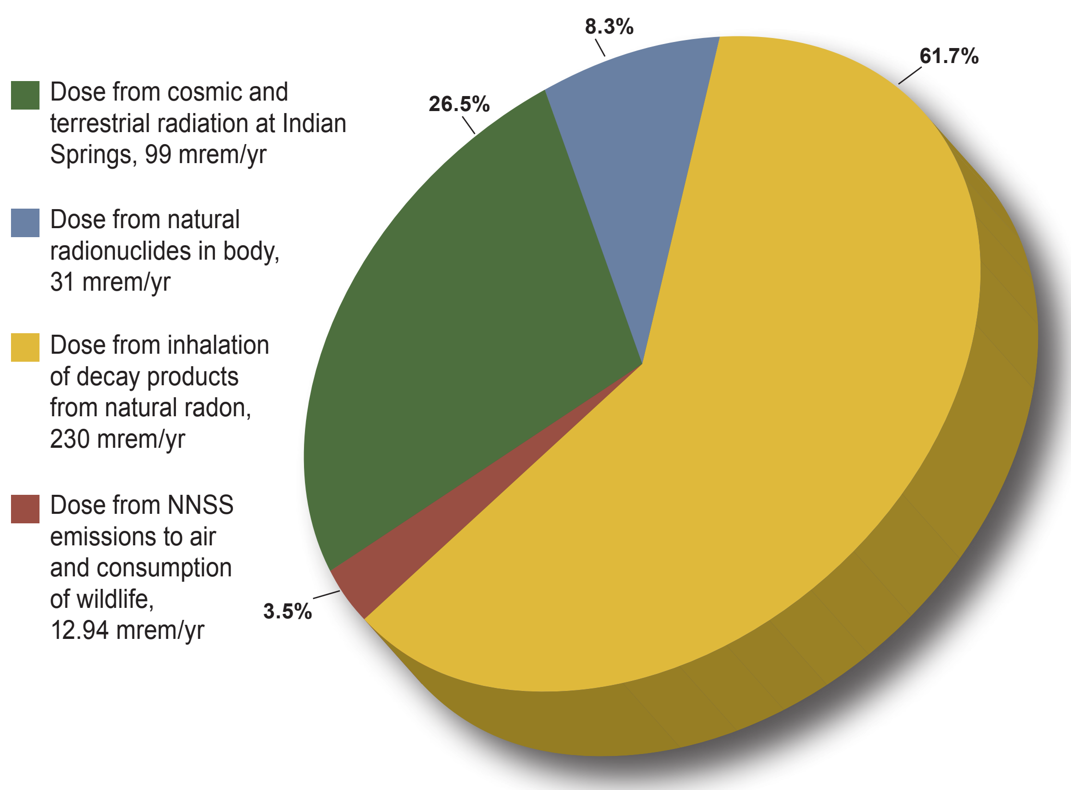
NNSS game animals include pronghorn antelope, mule deer, chukar, Gambel's quail, mourning doves, cottontail rabbits, and jackrabbits. Small game animals from different contaminated NNSS sites are trapped each year and analyzed for their radionuclide content. These results are used to construct worst-case scenarios for the dose to hunters who might consume these animals if the animals moved off the NNSS.

In 2018, tissue samples were collected from two jackrabbits captured from the Palanquin Crater and two cottontail rabbits captured from the Area 20 Control. Also, 3 pronghorn antelope and 1 mule deer were killed by vehicles and 1 bobcat was electrocuted on a power pole. These animals were opportunistically sampled. Based on data from these samples, the 2018 estimated dose to a hunter from ingestion of game animals from the NNSS is 12.87 mrem/yr. The potential dose to a person consuming these animals is well below dose limits to members of the public. Also, radionuclide concentrations are below levels considered harmful to the health of plants and animals; the dose resulting from observed concentrations is less than 4% of limits set to protect populations of plants and animals.

Direct Exposure

No members of the public are expected to receive direct gamma radiation that is above background levels as a result of NNSS operations. Areas accessible to the public, such as the main entrance gate, had direct gamma radiation exposure rates comparable to natural background rates from cosmic and terrestrial radiation.

Dose to the Public from Natural Background Sources and from the NNSS



2018 Dose to the Public from All Pathways

12.94 mrem/yr — This is the maximum dose to the public from inhalation, ingestion, and direct exposure pathways that is attributable to NNSS operations. It is well below the dose limit of 100 mrem/yr established by DOE O 458.1 for radiation exposure to the public from all pathways combined. This total dose estimate is indistinguishable from natural background radiation experienced by the public residing in communities near the NNSS.

Nonradiological Monitoring of Air and Water

Nonradioactive Air Emissions

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," or 10 tons of any one of the 189 "hazardous air pollutants" (HAPs), or 25 tons of any combination of HAPs. Common sources of such air pollutants on the NNSS include particulates from construction, aggregate production, surface disturbances, fugitive dust from driving on unpaved roads, fuel-burning equipment, open burning, fuel storage facilities, and chemical release and detonation tests.

An estimated 5.87 tons of criteria air pollutants and 0.01 tons of HAPs were released on the NNSS in 2018. The majority of the emissions were nitrogen oxides from diesel generators. No emission limits for any air pollutants were exceeded.

Estimated Quantity of Pollutants Released into the Air from NNSS Operations in 2018

Criteria Air Pollutants:	Tons
Particulate Matter[(a)]	0.45
Carbon Monoxide	0.61
Nitrogen Oxides	2.80
Sulfur Dioxide	0.18
Volatile Organic Compounds	1.83
Hazardous Air Pollutants (HAPs)	0.01

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

Nonradiological Monitoring of Drinking Water and Wastewater

NNSA/NFO operates a network of six permitted wells that comprise three permitted public water systems (PWSs) on the NNSS that supply the drinking water needs of NNSS workers and visitors. NNSA/NFO also hauls potable water to work locations at the NNSS that are not part of a PWS. Monitoring results for 2018 indicated that water samples from the three PWSs and from the potable water hauling trucks met all applicable National Primary and Secondary Drinking Water Standards.

NNSS Drinking Water

The public water systems that supply drinking water to NNSS workers and visitors meet all applicable Safe Drinking Water Act standards.

Industrial discharges on the NNSS are limited to three operating sewage lagoon systems: Area 6 Yucca, Area 23 Mercury, and Area 6 DAF. Under the requirements of the state operating permit, liquid discharges to these sewage lagoons were tested quarterly in 2018 for biological oxygen demand, pH, and total suspended solids. All sewage lagoon water measurements were within permit limits.

The discharge water from the E-Tunnel complex is sampled annually under a state water pollution control permit for 14 nonradiological contaminants, which are mainly metals. In 2018, none of these contaminants were detected at levels that exceeded permit limits.

Managing Cultural Resources

The historical landscape of the NNSS contains archaeological sites, buildings, structures, and places of importance to American Indians and others. These are referred to as "cultural resources." NNSA/NFO requires that NNSS activities and programs comply with all applicable cultural resources regulations and that such resources on the NNSS be monitored. The Cultural Resources Management program is implemented by DRI to meet this requirement.

In 2018, DRI archaeologists conducted field surveys and historical evaluations for 8 proposed NNSA/NFO projects that had the potential to impact cultural resources. DRI surveyed just over 986 acres and identified/recorded 46 cultural resources, 16 of which were determined to be eligible to the National Registry of Historical Places (NRHP). For these projects, recommendations for mitigating adverse effects to cultural resources are included in DRI's evaluations.

In 2018, DRI completed an evaluation of the architecture in the Mercury Historic District (MHD) in preparation for the Modernization Project. The MHD qualifies for listing in the NRHP due to its national significance

Overview of 1950s men's dormitories in the Mercury Historic District (REECo 1965)

Continued on Page 22 ...

Managing Cultural Resources *... continued from Page 21*

in the context of the Cold War and the development of nuclear testing. The resulting report provides historic context and results of the recording effort, including a summary of individual resources (154 primary and 348 accessory resources), architectural styles, functional architectural types, and character-defining features. Also, DRI inventoried two segments of the 138-kilovolt (kV) main transmission line in preparation for vegetation abatement to reduce fire hazards surrounding the immediate area of the wood poles. Finally, DRI recorded an instrument station associated with the Operation Teapot tests in 1955. The station was intended to evaluate the effects of an oil-based fog smoke screen in weakening the thermal radiation resulting from a nuclear detonation.

DRI continues to maintain and manage the NNSS Archaeological Collection, which contains over 467,000 artifacts.

NNSA/NFO's American Indian Consultation Program (AICP) conducts consultations with NNSS-affiliated American Indian tribes through the Consolidated Group of Tribes and Organizations (CGTO). The CGTO Spokesperson is appointed to the State Tribal Government Working Group (STGWG), joining 10 other tribes currently serving from New Mexico, Idaho, Washington, Oregon, and New York. The STGWG works closely with various DOE sites throughout the U.S. The CGTO Spokesperson is also appointed to the NSSAB to serve as a liaison giving advisory insight into activities conducted on the NNSS.

In 2018 NNSA/NFO supported the goals of the AICP by:

- interacted with the AICP Coordinator to identify topics of interest and to improve communications with CGTO representatives
- held the annual Tribal Update Meeting, which assembled 25 tribal representatives from 14 of the 16 culturally affiliated tribal governments
- participated in 2 Tribal Planning Committee (TCP) meetings
- TPC participated in two separate NNSS site visits to evaluate the condition of cultural resources sites at Ammonia Tanks and Captain Jack Springs and Cave
- supporting a tribal revegetation project at the Area 5 RWMC.

CGTO visit Ammonia Tanks in 2018

In 2018, NNSA/NFO did not receive any requests from culturally affiliated tribes to access the NNSS for ceremonial or traditional use.

Endangered Species Protection and Ecological Monitoring

The Ecological Monitoring and Compliance (EMAC) Program monitors the ecosystem of the NNSS and ensures compliance with laws and regulations pertaining to NNSS natural resources. Sensitive and protected/regulated species of the NNSS include 41 plants, 1 mollusk, 2 reptiles, 241 birds, and 23 mammals. These species are protected, regulated, or considered sensitive according to state or federal regulations and natural resource agencies and organizations.

The desert tortoise is the only resident species on the NNSS listed under the Endangered Species Act threatened. Habitat of the desert tortoise is in the southern portion of the NNSS. Activities conducted in desert tortoise habitat must comply with the terms and conditions of a Biological Opinion issued to NNSA/NFO by the U.S. Fish and Wildlife Service (FWS). In 2018, no desert tortoises were accidentally injured or killed at a project site, nor were any found, captured, or displaced from project sites. There were 34 sightings of desert tortoises on roads on the NNSS; 31 of the tortoises, thought to be in harm's way, were moved.

NNSA/NFO is committed to working collaboratively with other agencies to provide research opportunities on the NNSS that benefit ecological and conservation science.

NNSS scientists observe a desert tortoise as it waits for rain

Field work concluded for the resident adult tortoise road study in the fall. Juvenile tortoises continued to be monitored as part of a collaborative effort to study survival of translocated animals.

▶ **A radio-tracking study of adult tortoises found near roads on the NNSS, to assess the risk of road mortality and determine patterns of habitat use along roads has concluded. A total of 260 road crossing events by 15 tortoises were recorded during the study. Nine**

Continued on Page 23 ...

tortoises were not documented to have crossed roads at all.

- In 2012, 60 juvenile tortoises were moved from captivity at the Desert Tortoise Conservation Center near Las Vegas to undisturbed tortoise habitat at the NNSS to investigate the fate of translocated individuals. The San Diego Zoo Institute for Conservation Research started the study and transferred it to NNSS biologists in 2013. At the end of 2018, 24 of the 60 juveniles were still alive.

In 2018, biological surveys for the presence of sensitive and protected/regulated species and important biological resources on which they depend were conducted for 29 projects. A total of 769 acres were surveyed for these projects. Some of the sensitive species and important biological resources found included desert tortoise burrows, burrowing owls, several bat species, Joshua trees, Mojave yucca, pine trees and many cactus species.

Surveys of sensitive and protected/regulated animals in 2018 focused on birds, bats, feral horses, mule deer, desert bighorn sheep, and mountain lions. Field surveys for sensitive plants were conducted for Cane Spring suncup, Clokey's buckwheat, Inyo hulsea, and Death Valley beardtongue.

NNSS biologists found feral horse distribution was similar in 2018 to 2017 with concentrated activity around Camp 17 Pond and Gold Meadows Spring especially during the hot, dry summer months. A total of 40 individuals were identified in at least 5 different bands and at least 5 foals and 6 juveniles were observed.

Environmental Stewardship

NNSA/NFO's Environmental Management System (EMS) is a business management practice that incorporates concern for environmental performance throughout the NNSS and its support facilities. The goal of the EMS is continual reduction of NNSA/NFO'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. Environmental commitments are incorporated into an Environmental Policy with goals to protect environmental quality; mitigate environmental impacts; collaborate with employees, customers, subcontractors, and suppliers on sustainable development; comply with environmental laws and regulations; and, commit to environmental excellence in company activities.

The **Energy Management Program** was formed specifically to reduce the use of energy and water in NNSA/NFO facilities, to advance the use of solar and other renewable energy sources, and to help NNSA meet DOE's 2018 Site Sustainability Goals.

In December 2018, the Energy Management Program completed the FY 2019 NNSA/NFO Site Sustainability Plan, which reported the 2018 progress toward meeting DOE's Site Sustainability Goals. Thus far, the Energy Management Program is on track to meet the majority of the DOE long-term goals *(see Pages 24 and 25).*

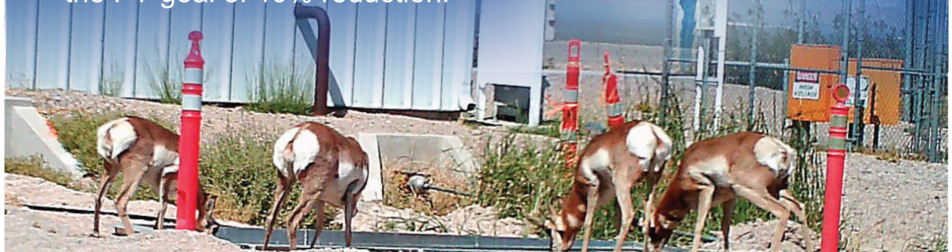
The **Pollution Prevention and Waste Minimization Program** helps to reduce the volume and toxicity of waste that must be disposed. See Page 25 for the 2018 status towards meeting DOE long-term goals for pollution prevention and waste minimization.

Energy Efficiency and Management

- Energy intensity (energy use per square foot of building space) increased 3% above the FY 2015 baseline – the goal is a 25% reduction from the baseline by FY 2025.
- Based on a 2018 assessment of appropriate buildings, 79% of buildings are metered for electricity, 94% for natural gas, 0% for chilled water, 29% for potable water, and 100% for hot water – the goal is for all individual buildings to be metered where cost-effective and appropriate.
- 57 energy audits/assessments were conducted – meeting the goal to ensure that all eligible facilities under Section 432 of the Energy Independence and Security Act are assessed once every 4 years. The assessments identified energy conservation measures for several buildings at the NNSS and the NLVF.

Water Efficiency and Management

- Water intensity (gallons used per total gross square feet [gsf] of facility space) was 45% below the FY 2007 baseline – exceeding the FY goal of 22% reduction.
- Non-potable water production was 47% below the FY 2010 baseline – exceeding the FY goal of 16% reduction.



Wildlife watering trough that replaced the closed Well 5b sump.

Fleet Management

- Use of alternative fuel was 192% above the FY 2005 baseline – exceeds the goal of a 10% increase above the FY 2005 baseline by FY 2015, maintaining a 10% increase thereafter.
- Use of petroleum was 58% less than the FY 2005 baseline – exceeds the goal of a 20% decrease from the FY 2005 baseline by FY 2015, maintaining 20% reduction thereafter.
- 93% (831) of all light duty vehicle purchases were alternative fuel vehicles – exceeds the goal of 75%.
- Fleet-wide greenhouse gas emissions were 3% lower than the FY 2014 baseline – meeting the FY goal of 3% and on track to meet 30% reduction by FY 2025.

Clean and Renewable Energy

- 18.5% of NNSA/NFO's annual electrical consumption is from renewable sources (acquired mainly through the purchase of renewable energy credits) – the goal is at least 10% for FY 2018, working towards 25% by FY 2025.

High Performance Sustainable Buildings (HPSBs)

- Based on a 2018 assessment, 12% of enduring buildings larger than 5,000 gsf are compliant with the Guiding Principles (GPs) for Federal Leadership in HPSB design – on track to meet the goal to have at least 17% by FY 2025, with progress to 100% thereafter.
- Planning continues for a new NNSS Consolidated Mercury Campus to meet the goal that all new buildings larger than 5,000 gsf entering the planning process be designed to achieve energy net zero beginning in FY 2020.
- A solar array at Mercury Fire Station No. 1 is installed in order for it to become an energy net-zero building – on track to meet the goal that 1% of existing buildings above 5,000 gsf be energy, waste, or water net-zero buildings by FY 2025.

Pollution Prevention and Waste Minimization

- 33% of non-hazardous solid waste generated at NNSA/NFO facilities was diverted from landfills through recycling – the goal is 50%.
- 98% of construction materials were recycled and diverted from the landfill – the goal is 50%.

Electronic Stewardship and Data Centers

- Average Power Utilization Effectiveness (PUE) values range across the 3 data centers, where an ideal PUE is 1.0. The goal is a PUE of 1.2-1.4 for new data centers and a PUE less than 1.5 for existing data centers. Installation on a Performance Optimized Data Center at the NNSS to meet this goal in near future.
- All leased computers continue to be Electronic Product Environmental Assessment Tool (EPEAT) registered.
- All eligible computing systems have power management capability enabled.
- The U.S. General Services Administration (GSA) Energy Asset Disposal System program called GSAXcess® is used to recycle all eligible electronics. 100% of used electronic equipment that pass GSAXcess® screening is sold for reuse, and equipment considered high risk property is shredded through a certified recycler.

Greenhouse Gas (GHG) Emissions

- FY 2018 Scope 1 and 2 GHG emissions were 52% lower than the FY 2008 baseline – the goal is a 50% reduction by FY 2025.
- FY 2018 Scope 3 GHG emissions were 68% less than those of the FY 2008 baseline – on track to meet the goal of a 25% reduction by FY 2025.

GHG emissions targeted for reduction are carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride (SF_6) and are classified depending on their source:

Scope 1 — from sources owned or controlled by a federal agency.

Scope 2 — resulting from the generation of electricity, heat, or steam purchased by a federal agency.

Scope 3 — from sources not owned or directly controlled by a federal agency but related to agency activities.

Climate Change Resilience

- Regional risks to NNSA/NFO facilities are flooding, wildland fires, facility power and water supply disruptions, and extreme weather events. Program and site evaluations are conducted, policies and procedures updated, and areas for improvement identified to ensure that NNSA/NFO missions and activities are resilient to climate change in accordance with the goals of DOE's Climate Change Adaptation Plan.

Green Awards and Outreach

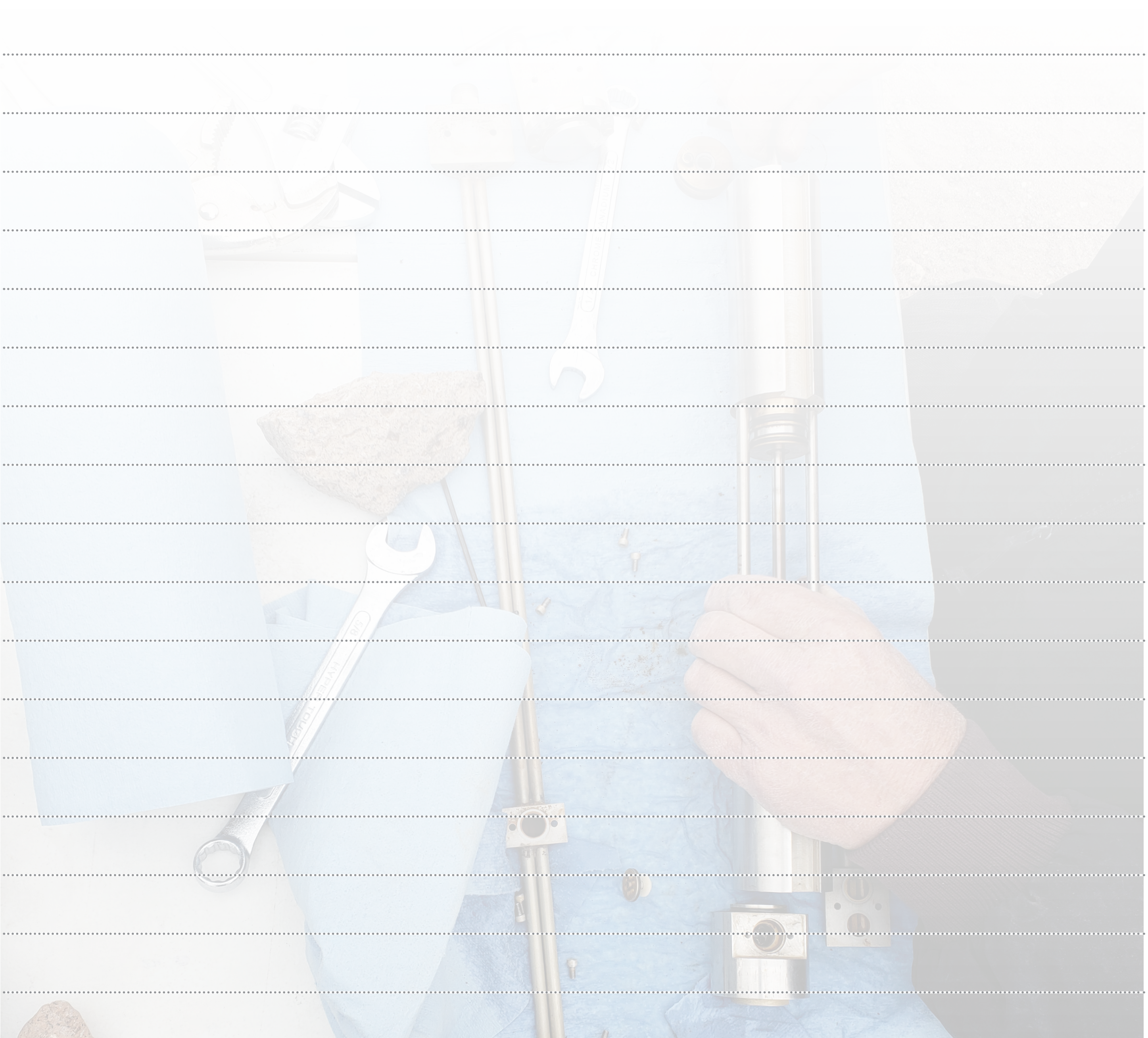
2018 Government Green Fleets Award

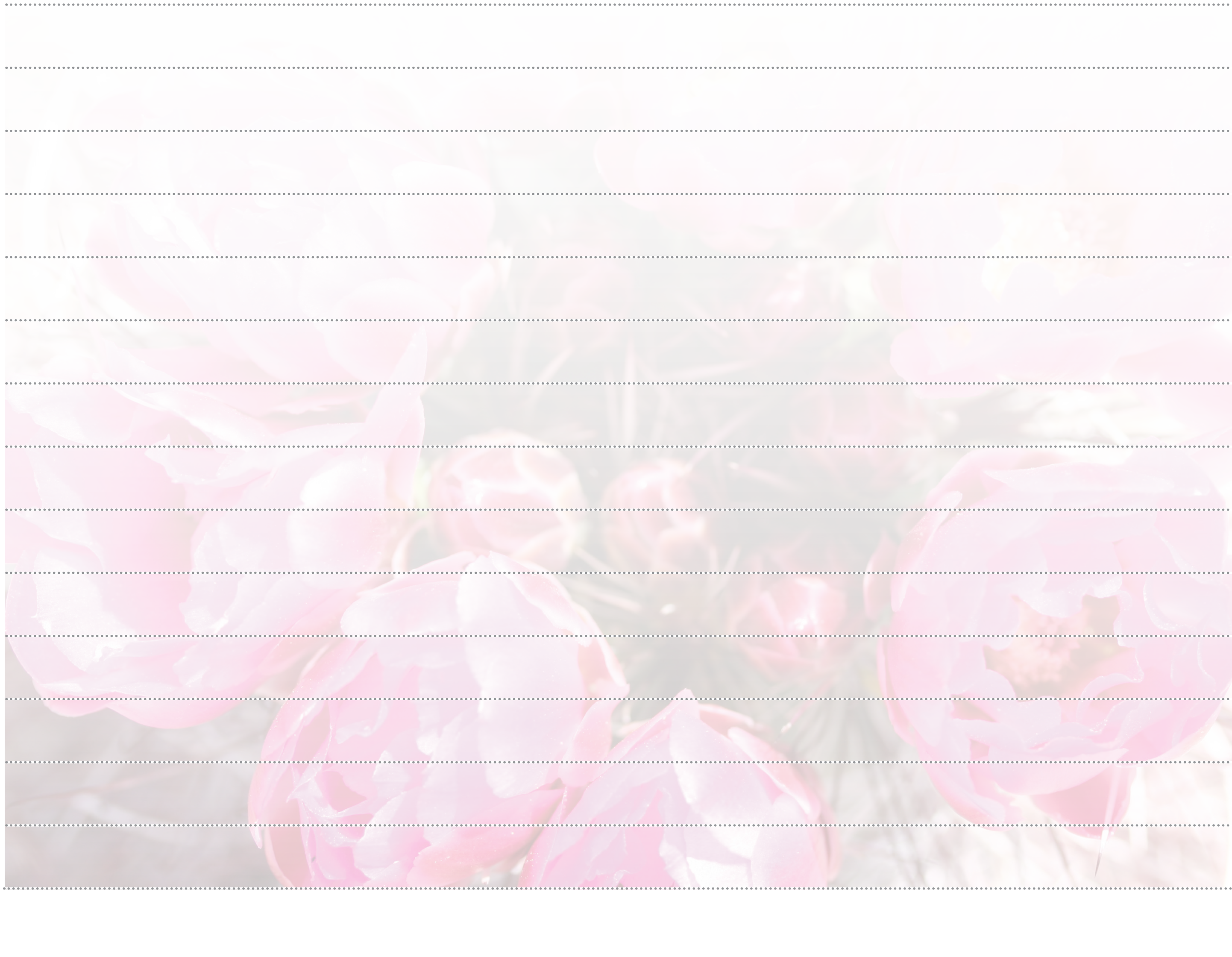
In 2018, the NNSS' Fleet, Fuel, and Equipment (FFE) department received the NNSA Outstanding Sustainability Program, recognized for "consistently demonstrates leadership and exceptional environmental stewardship of NNSS' fleet by instituting processes and developing procedures that achieve DOE's sustainability goals."

Our Energy Hero

The **Green Reaper** cartoon character and costumed "live" character represent the Energy Program and are used in NNSS literature, employee activities, and in community outreach presentations to local elementary schools. In 2018, the Green Reaper and the Environmental Management Nevada Program held an Earth Day event promoting energy awareness, recycling, water conservation, and site sustainability.

Employees enjoy the 2017 "There is no Planet B" Earth Day Event.





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The information presented in this document is explained in greater detail in the ***Nevada National Security Site Environmental Report 2018*** (DOE/NV/03624--0612). A compact disc of this document is included on the back inside cover. This document can also be downloaded from the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office at **http://www.nnss.gov**.

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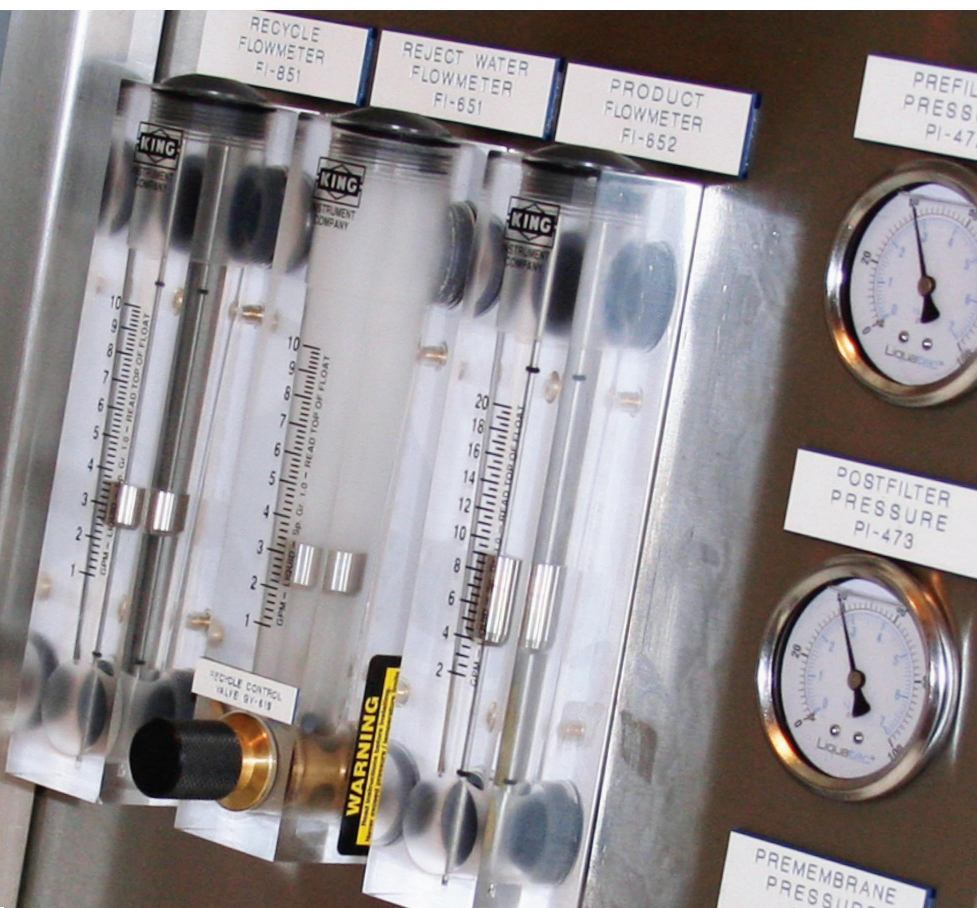

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