Calendar Year 2017

Idaho National Laboratory

Site Environmental Report

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Idaho National Laboratory Site Environmental Report Calendar Year 2017

Environmental Surveillance, Education, and Research Program

U.S. Department of Energy, Idaho Operations Office

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Idaho Falls, ID 83401

Sage-grouse Candidate Conservation Agreements (CCA) Habitat Monitoring Plot

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Nest in Sagebrush

To Our Readers

The Idaho National Laboratory Site Environmental Report for Calendar Year 2017 is an overview of environmental activities conducted on and in the vicinity of the Idaho National Laboratory (INL) Site from January 1 through December 31, 2017. This report includes:

- Effluent monitoring and environmental surveillance of air, water, soil, vegetation, biota, and agricultural products for radioactivity. The results are compared with historical data, background measurements, and/or applicable standards and requirements in order to verify that the INL Site does not adversely impact the environment or the health of humans or biota.
- A summary of environmental management systems in place to protect air, water, land, and other natural and cultural resources potentially impacted by INL Site operations.
- Ecological and other scientific research conducted on the INL Site that may be of interest to the reader.

The report addresses three general levels of reader interest:

- The first level is a brief summary with a take-home conclusion. This is presented in the chapter highlights text box at the beginning of each chapter. There are no tables, figures, or graphs in the highlights. This section is intended to highlight general findings for an audience with limited scientific background.
- The second level is a more in-depth discussion with figures, summary tables, and summary graphs accompanying the text. The chapters of the annual report represent this level, which requires some familiarity with scientific data and graphs. A person with some scientific background can read and understand this report after reading the section entitled "Helpful Information."
- The third level includes links to supplemental and technical reports and websites that support the annual report. This level is directed toward scientists who would like to see original data and more in-depth discussions of the methods used and results. The links to these reports may be found in the Quick Links section of the annual report webpage (http://www.idahoeser.com/Annuals/2017/index.htm).

The Environmental Surveillance, Education, and Research Program is responsible for contributing to and producing the annual Idaho National Laboratory Site Environmental Report. In April 2016, DOE-ID awarded a five-year contract to Wastren Advantage, Inc., to manage the Environmental Surveillance, Education, and Research Program. Wastren Advantage, Inc. was purchased by VNSFS on January 17, 2018.

Other major contributors to the annual Idaho National Laboratory Site Environmental Report include the INL contractor (Battelle Energy Alliance, LLC); Idaho Cleanup Project Core contractor (Fluor Idaho, LLC); U.S. Department of Energy, Idaho Operations Office; National Oceanic and Atmospheric Administration; and U.S. Geological Survey (USGS). Links to their websites and the ESER website are:

- Idaho National Laboratory (https://www.inl.gov/)
- Idaho Cleanup Project Core (https://fluor-idaho.com/About/About-Idaho-Cleanup-Project/Project-Overview)
- U.S. Department of Energy, Idaho Operations Office (http://www.id.doe.gov/)
- Field Research Division of National Oceanic and Atmospheric Administration's Air Resources Laboratory (www.noaa.inel.gov/)
- U.S. Geological Survey (https://www.usgs.gov/centers/id-water)
- Environmental Surveillance, Education, and Research Program (http://www.idahoeser.com/)

Included in the chapter headings of this report are photographs, as well as common and scientific names of rare and sensitive plants and animals native to the INL Site. Photo credits: ESER Program, National Park Service, Idaho Fish and Game, and Fish and Wildlife Service.

Winter on the INL Site 2016-2017

Executive Summary

Introduction

In operation since 1949, the Idaho National Laboratory (INL) Site is a U.S. Department of Energy (DOE) reservation located in the southeastern Idaho desert, approximately 25 miles west of Idaho Falls (Figure ES-1). At 890 square miles (569,135 acres), the INL Site is roughly 85 percent the size of Rhode Island. It was established in 1949 as the National Reactor Testing Station, and for many years was the site of the largest concentration of nuclear reactors in the world. Fifty-two nuclear reactors were built, including the Experimental Breeder Reactor-I which, in 1951, produced the first usable amounts of electricity generated by nuclear power. Researchers pioneered many of the world's first nuclear reactor prototypes and advanced safety systems at the INL Site. During the 1970s, the laboratory's mission broadened into other areas, such as biotechnology, energy and materials research, and conservation and renewable energy.

Today the INL is a science-based, applied engineering national laboratory dedicated to supporting the DOE's missions in nuclear and energy research, science, and national defense.

The INL mission is to discover, demonstrate and secure innovative nuclear energy solutions and other clean energy options and critical infrastructure with a vision to change the world's energy future and secure the nation's critical infrastructure.

In order to clear the way for the facilities required for the new nuclear energy research mission, the Idaho Cleanup Project (ICP) Core has been charged with the environmental cleanup of the legacy wastes generated from World War II-era conventional weapons testing, government-owned reactors, and spent fuel reprocessing. The overarching aim of the project is to reduce risks to workers and production facilities, the public, and the environment and to protect the Snake River Plain aquifer.

Figure ES-1. Regional Location of the Idaho National Laboratory Site.

Purpose of the INL Site Environmental Report

The INL Site's operations, as well as the ongoing cleanup, necessarily involve a commitment to environmental stewardship and full compliance with environmental protection laws. As part of this commitment, the INL Site Environmental Report is prepared annually to inform the public, regulators, stakeholders, and other interested parties of the INL Site's environmental performance during the year. This report is published for the U.S. Department of Energy, Idaho Operations Office (DOE-ID) in compliance with DOE Order 231.1B, "Environment, Safety and Health Reporting." Its purpose is to:

- Present the INL Site, mission, and programs
- Report compliance status with applicable federal, state, and local regulations
- Describe the INL Site environmental programs and activities
- Summarize results of environmental monitoring
- Discuss potential radiation doses to the public residing in the vicinity of the INL Site
- Report on ecological monitoring and research conducted at the Idaho National Environmental Research Park
- Describe quality assurance methods used to ensure confidence in monitoring data
- Provide supplemental technical data and reports that support the INL Site Environmental Report (http://www.idahoeser.com/Annuals/2017/Data.htm).

Major INL Site Programs and Facilities

There are two primary programs at the INL Site: the INL and the ICP Core. The prime contractors at the INL Site in 2017 were: Battelle Energy Alliance, the management and operations contractor for the INL; and Fluor Idaho, which managed ongoing cleanup operations under the ICP Core and operated the Advanced Mixed Waste Treatment Project.

The INL Site consists of several primary facilities situated on an expanse of otherwise undeveloped terrain. Buildings and structures at the INL Site are clustered within these facilities, which are typically less than a few square miles in size and separated from each other by miles of undeveloped land. In addition, DOE-ID owns or leases laboratories and administrative offices in the city of Idaho Falls, some 25 miles east of the INL Site border. About 30 percent of employees work in administrative, scientific support, and non-nuclear laboratory programs and have offices in Idaho Falls.

The major facilities at the INL Site are the Advanced Test Reactor (ATR) Complex; Central Facilities Area (CFA); Critical Infrastructure Test Range Complex (CITRC); Idaho Nuclear Technology and Engineering Center (INTEC); Materials and Fuels Complex (MFC); Naval Reactors Facility (NRF); Radioactive Waste Management Complex (RWMC); and Test Area North (TAN), which includes the Specific Manufacturing Capability (Figure ES-2). The Research and Education Campus is located in Idaho Falls. The major facilities and their missions are outlined in Table ES-1.

Environmental Protection Programs

Directives, orders, guides, and manuals are DOE's primary means of establishing policies, requirements, responsibilities, and procedures for DOE offices and contractors. Among these are a series of Orders directing each DOE site to implement sound stewardship practices that are protective of the public and the environment. These orders require the implementation of an environmental management system (EMS), a Site Sustainability Plan, radioactive waste management, and radiation protection of the public and biota. Battelle Energy Alliance and Fluor Idaho have each established and implemented an EMS and each contributes to the INL Site Sustainability Plan, as required by DOE and executive orders. Each EMS integrates environmental protection, environmental compliance, pollution prevention, and waste minimization into work planning and execution throughout all work areas. The INL Sustainability Plan contains strategies and activities that will lead to continual greenhouse gas reductions as well as energy, water, and transportation fuels efficiency at the INL Site. Plan requirements are integrated into each INL Site contractor's Integrated Safety Management System and EMS.

Environmental Restoration

Environmental restoration at the INL Site is conducted under the Federal Facility Agreement

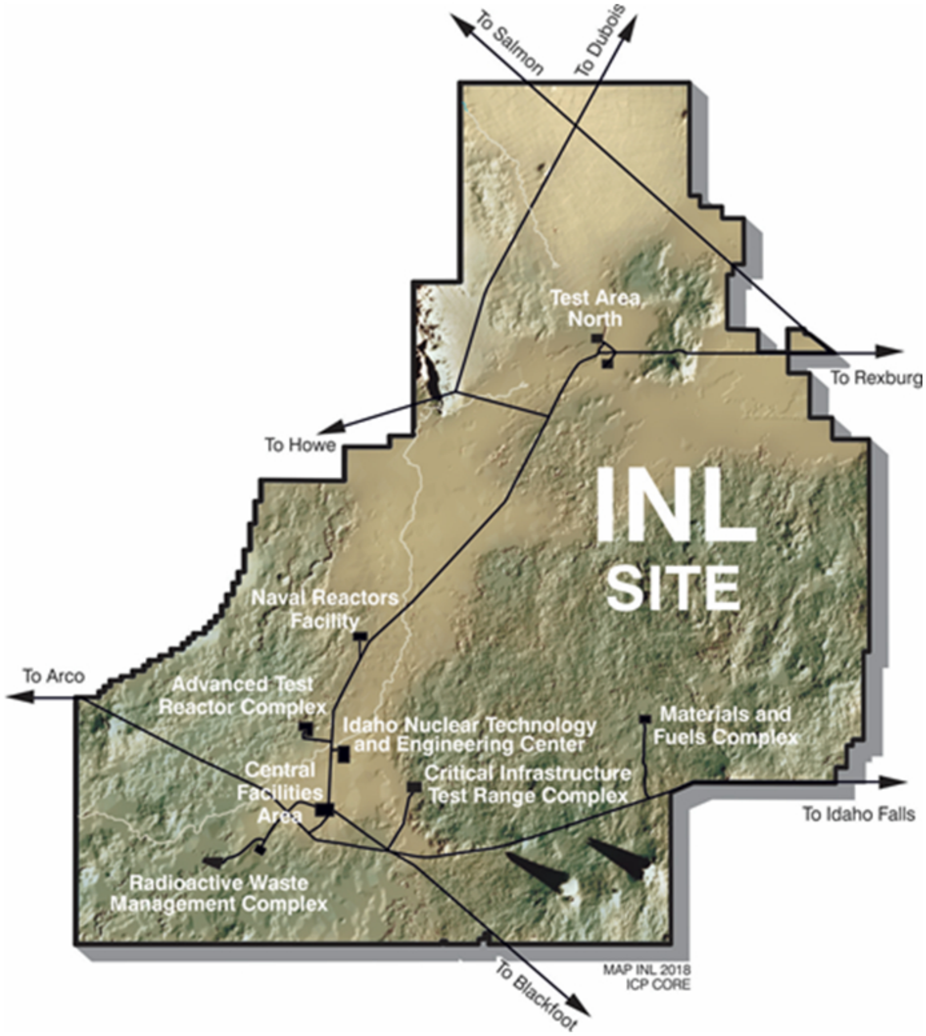


Figure ES-2. Idaho National Laboratory Site Facilities.

and Consent Order (FFA/CO) among DOE, the state of Idaho, and U.S. Environmental Protection Agency (EPA). The FFA/CO governs the INL Site's environmental remediation. It specifies actions that must be completed to safely clean up release sites at the INL Site in compliance with the Comprehensive Environmental Response, Compensation, and Liability Act and with the corrective action requirements of the Resource Conservation and Recovery Act. The INL Site is divided into ten Waste Area Groups (WAGs) as a result of the FFA/CO, and each WAG is divided into smaller cleanup areas called operable units. Since the FFA/CO was signed in 1991, the INL Site has cleaned up release sites containing asbestos, acids and bases, radionuclides, unexploded ordnance and explosive residues, polychlorinated biphenyls, heavy metals, and other hazardous materials.

Comprehensive remedial investigation/feasibility studies have been conducted at all WAGs and closeout activities have been completed at six WAGs. In 2017, all institutional controls and operational and maintenance requirements were maintained and active remediation continued on WAGs 1, 3, 7, and 10.

Radiation Dose to the Public and Biota from INL Site Releases

Humans, plants, and animals potentially receive radiation doses from various INL Site operations. The DOE sets dose limits for the public and biota to ensure

Table ES-1. Major INL Site Areas and Missions.

Major INL Site Area[a]	Operated By	Mission
Advanced Test Reactor Complex	INL	Research and development of nuclear reactor technologies. Home of the ATR, a DOE Nuclear Science User Facility and the world's most advanced nuclear test reactor.
Central Facilities Area	INL	INL Support for the operation of other INL Site facilities.
Critical Infrastructure Test Range Complex	INL	Supports National and Homeland Security missions of the laboratory, including program and project testing (i.e., critical infrastructure resilience and nonproliferation testing and demonstration).
Idaho Nuclear Technology and Engineering Center	ICP Core	Dry and wet storage of spent nuclear fuel; management of high-level waste calcine and sodium-bearing liquid waste; and operation of the Idaho Comprehensive Environmental Response, Compensation and Liability Act Disposal Facility including a landfill, evaporation ponds, and a staging and treatment facility.
Materials and Fuels Complex	INL	Research and development of nuclear fuels. Pyroprocessing, which uses electricity to separate waste products in the recycling of nuclear fuel, is also researched here. Nuclear batteries for use on the nation's space missions are made at MFC.
Radioactive Waste Management Complex	ICP Core	Environmental remediation; and waste treatment, storage, and disposal for wastes generated at the INL Site and other DOE sites. Advanced Mixed Waste Treatment Project characterizes, treats, and packages transuranic waste for shipment out of Idaho to permanent disposal facilities.
Research and Education Campus	INL	Located in Idaho Falls, is home to INL administration, the INL Research Center, the Center for Advanced Energy Studies, and other energy and security research programs. Research is conducted at INL Research Center in robotics, genetics, biology, chemistry, metallurgy, computational science, and hydropower. Center for Advanced Energy Studies is a research and education partnership between Boise State University, INL, Idaho State University, and University of Idaho to conduct energy research and address the looming nuclear energy work-force shortage.
Test Area North/Specific Manufacturing Capability	INL	Several historic nuclear research and development projects were conducted at TAN. Major cleanup and demolition of the facility was completed in 2008 and the current mission is manufacture of tank armor for the U.S. Army's battle tanks at the Specific Manufacturing Capability for the U.S. Department of Defense.

a. The Naval Reactors Facility is also located on the INL Site. It is operated for Naval Reactors by Bechtel Marine Propulsion Corporation. The Naval Nuclear Propulsion Program is exempt from DOE requirements and is therefore not addressed in this report.

that exposure to radiation from site operations are not a health concern. Potential radiological doses to the public from INL Site operations were calculated to determine compliance with pertinent regulations and limits (Table ES-2). The calculated dose to the maximally exposed individual in 2017 from the air pathway was 0.008 mrem (0.08 μSv), well below the 10-mrem standard established by the Clean Air Act. The maximally exposed individual is a hypothetical member of the public who could receive the maximum possible dose from INL Site releases. This person was assumed to live just south of the INL Site boundary. For comparison, the dose from natural background radiation was estimated in 2017 to be 383 mrem (3,830 μSv) to an individual living on the Snake River Plain.

The maximum potential population dose to the approximately 332,665 people residing within an 80-km (50-mi) radius of any INL Site facility was calculated as 0.0106 person-rem (0.000106 person-Sv), below that expected from exposure to background radiation (127,411 person-rem or 1,274 person-Sv). The 50-mi population dose calculated for 2017 is approximately 4 times lower than that calculated for 2016 (0.0442 person-rem or 0.000442 person-Sv).

The maximum potential individual dose from consuming waterfowl contaminated at the INL Site, based on the highest concentrations of radionuclides measured in edible tissue of samples collected near the ATR Complex ponds, was estimated to be 0.046 mrem (0.46 μSv). There were no gamma-emitting radionuclides detected in big game animals sampled in 2017, hence there was no dose associated with consuming big game. When the dose estimated for the air pathway was summed with the dose from consuming contaminated waterfowl, assuming that the waterfowl is eaten by the same hypothetical individual, the representative person off the INL Site could potentially receive a total dose of 0.054 mrem (0.54 μSv) in 2017. This is 0.054 percent of the DOE health-based dose limit of 100 mrem/yr (1 mSv/yr) from all pathways for the INL Site.

Tritium has been previously detected in two U.S. Geological Survey (USGS) monitoring wells located along the southern INL Site boundary. A hypothetical individual drinking water from these wells would receive a dose of less than 0.2 mrem (0.002 mSv) in one year. This is an unrealistic pathway to humans because there are no drinking water wells located along the southern boundary of the INL Site. The maximum contaminant level established by EPA for tritium corresponds to a dose of approximately 4 mrem (0.04 mSv).

A dose to a maximally exposed individual located in Idaho Falls near the DOE Radiological and Environmental Laboratory and the INL Research Center, within the Research and Education Complex, was calculated for compliance with the Clean Air Act. For

Table ES-2. Contribution to Estimated Dose to a Maximally Exposed Individual by Pathway (2017).

Pathway	Annual Dose to Maximally Exposed Individual (mrem)	(μSv)	Percent of DOE 100 mrem/yr Limit[a]	Estimated Population Dose (person-rem)	(person-Sv)	Population within 80 km	Estimated Background Radiation Population Dose (person-rem)[b]
Air	0.008	0.08	0.008	0.01	0.0001	332,665	127,411
Waterfowl	0.046	0.46	NA[c]	NA	NA	NA	NA
Big game animals	0	0	NA	0	0	NA	NA
Total pathways	**0.054**	**0.54**	**0.054**	**0.01**	**0.0001**	**NA**	**NA**

a. The DOE public dose limit from all sources of ionizing radiation and exposure pathways that could contribute significantly to the total dose is 100 mrem/yr (1 mSv/yr) total effective dose equivalent. It does not include dose from background radiation.
b. The individual dose from background was estimated to be 383 mrem (3.8 mSv) in 2017 (Table 7-7).
c. NA = Not applicable

2017, the dose was conservatively estimated to be 0.01 mrem (0.1 µSv), which is 0.10 percent of the 10-mrem/yr federal standard.

Doses were also evaluated using a graded approach for nonhuman biota at the INL Site. Based on the conservative screening calculations, there is no evidence that INL Site-related radioactivity in soil or water is harming populations of plants or animals.

Environmental Compliance

One measure of the achievement of the environmental programs at the INL Site is compliance with applicable environmental regulations, which have been established to protect human health and the environment. INL Site compliance with major federal regulations is presented in Table ES-3.

Environmental Monitoring of Air

Airborne releases of radionuclides from INL Site operations are reported annually in a document prepared in accordance with the Code of Federal Regulations, Title 40, "Protection of the Environment," Part 61, "National Emission Standards for Hazardous Air Pollutants," Subpart H, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities." An estimated total of 1,330 curies (4.92×10^{13} Bq) of radioactivity, primarily in the form of short-lived noble gas isotopes, were released as airborne effluents in 2017. These airborne releases of radionuclides are reported to comply with regulatory requirements and are considered in the design and conduct of INL Site environmental surveillance activities.

The INL Site environmental surveillance programs, conducted by the INL, ICP Core, and the Environmental Surveillance, Education, and Research (ESER) contractors, emphasize measurement of airborne radionuclides because air transport is considered the major potential pathway from INL Site releases to human receptors. During 2017, the INL contractor monitored ambient air at 16 locations on the INL Site and at five locations off the INL Site. The ICP Core contractor focused on ambient air monitoring of waste management facilities, namely INTEC and the RWMC. The ESER contractor sampled ambient air at three locations on the INL Site, at seven locations bounding the INL Site, and at five locations distant from the INL Site.

Air particulate samples were collected weekly by the ESER and INL contractors and biweekly by the ICP Core contractor. These samples were initially analyzed for gross alpha and gross beta activity. The particulate samples were then combined into monthly (ICP Core contractor), or quarterly (ESER and INL contractors) composite samples and were analyzed for gamma-emitting radionuclides, such as cesium-137. Particulate filters were also composited quarterly by the ICP Core, INL and ESER contractors and analyzed for specific alpha- and beta-emitting radionuclides, specifically strontium-90, plutonium-238, plutonium-239/240, and americium-241. Charcoal cartridges were also collected weekly by ESER and INL contractors and analyzed for radioiodine.

All radionuclide concentrations in ambient air samples were below DOE radiation protection standards for air and were within historical measurements. In addition, gross alpha and gross beta concentrations were analyzed statistically, and there were few differences between samples collected on the INL Site, at the INL Site boundary, and off the INL Site. Trends in the data appear to be seasonal in nature and do not demonstrate any INL Site influence. This indicates that INL Site airborne effluents were not measureable in environmental air samples.

The INL contractor collected atmospheric moisture samples at three stations on and two stations off the INL Site in 2017. Until April 2017 the ESER contractor collected atmospheric moisture at four offsite locations and precipitation at two stations on the INL Site and one location off the INL Site. Beginning in April, the ESER contractor changed the atmospheric moisture/precipitation sampling design and began to collect both sets of samples at one onsite and three offsite locations. The INL and ESER samples were all analyzed for tritium. The results were within measurements made historically by the EPA and were below DOE standards. Tritium measured in these samples is most likely the result of natural production in the atmosphere and not the result of INL Site effluent releases.

Environmental Monitoring of Groundwater, Drinking, and Surface Water for Compliance Purposes

The INL and ICP contractors monitor liquid effluents, drinking water, groundwater, and storm water

Table ES-3. Major Federal Regulations Established for Protection of Human Health and the Environment.

Regulator/ Regulation	Regulatory Program Description	Compliance Status	Report Sections
EPA/40 CFR 61, Subpart H	The Clean Air Act is the basis for national air pollution control. Emissions of radioactive hazardous air pollutants are regulated by EPA, via the National Emission Standards for Hazardous Air Pollutant, (40 CFR 61, Subpart H).	The INL Site is in compliance, as reported in *National Emission Standards for Hazardous Air Pollutants – Calendar Year 2017*.	2.2.1 4.2 8.2.1
DOE/Order 458.1, Change 3	The order establishes requirements to protect the public and the environment against undue risk from radiation associated with radiological activities conducted under the control of DOE pursuant to the Atomic Energy Act of 1954, as amended. The Order requires preparation of an Environmental Radiation Protection Plan which outlines the means by which facilities monitor their impacts on the public and environment.	The INL Site maintains and implements several plans and programs for ensuring that the management of facilities, wastes, effluents, and emissions does not present risk to the public, workers, or environment. Environmental monitoring plans are well documented and the results are published in the annual INL Site Environmental Report.	Chapter 4 Chapter 5 Chapter 6 Chapter 7 Chapter 8
EPA/40 CFR 300	The Comprehensive Environmental Response, Compensation and Liability Act provides the regulatory framework for remediation of releases of hazardous substances and remediation (including decontamination and decommissioning) of inactive hazardous waste disposal sites.	Nuclear research and other operations at the INL Site left behind contaminants that pose a potential risk to human health and the environment. In 1991, the DOE-ID entered into a tri-party agreement, the Federal Facility Agreement and Consent Order, with EPA and the state of Idaho. INL Site remediation is conducted by the ICP Core.	3.2
EPA/40 CFR 109-140	The Clean Water Act establishes goals to control pollutants discharged to U.S. surface waters.	The INL Site complies with two Clean Water Act permits as applicable or needed – the National Pollution Discharge Elimination System permits and Storm Water Discharge Permits for construction activity.	2.3.1
EPA/40 CFR 141-143	The Safe Drinking Water Act establishes primary standards for public water supplies to ensure it is safe for consumption.	The INL Site has 12 active drinking water systems that are routinely sampled and analyzed as required by the state of Idaho and EPA.	6.6 2.3.2
EPA/40CFR 270.13	The Resource Conservation and Recovery Act established regulatory standards for generation, transportation, storage, treatment, and disposal of hazardous waste.	The Idaho Department of Environmental Quality conducted two unannounced Resource Conservation and Recovery Act inspections of the INL Site in June and October of 2017. There were no apparent violations.	2.1.2

runoff at the INL Site, primarily for nonradioactive constituents, to comply with applicable laws and regulations, DOE orders, and other requirements. Wastewater is typically discharged from INL Site facilities to infiltration ponds or to evaporation ponds. Wastewater discharges occur at percolation ponds southwest of INTEC, a cold waste pond at the ATR Complex, and a sewage treatment facility at CFA. DOE-ID complies with the state of Idaho groundwater quality and wastewater rules for these effluents through wastewater reuse permits, which provide for monitoring of the wastewater and, in some instances, groundwater in the area. During 2017, liquid effluent and groundwater monitoring were conducted in support of wastewater reuse permit requirements. An annual report for each permitted facility was prepared and submitted to the Idaho Department of Environmental Quality. No permit limits were exceeded.

Additional liquid effluent monitoring was performed at ATR Complex, INTEC, and MFC to comply with environmental protection objectives of DOE Orders. Most results were within historical measurements. All radioactive parameters were below health-based contaminant levels.

Drinking water parameters are regulated by the state of Idaho under authority of the Safe Drinking Water Act. Drinking water was sampled in 12 drinking water systems at the INL Site in 2017. Results were below limits for all relevant drinking water standards. The CFA distribution system serves 500 workers daily and is downgradient from a historic radioactive groundwater plume resulting from past wastewater injection directly into the aquifer. Because of this, a dose was calculated to a worker who might obtain all their drinking water from the CFA drinking water system during 2017. The dose, 0.154 mrem (1.54 µSv), is below the EPA standard of 4 mrem/yr (40 µSv/yr) for public drinking water systems.

Surface water flows off the Subsurface Disposal Area (SDA) following periods of heavy precipitation or rapid snowmelt. During these times, water may be pumped out of the SDA retention basin into a drainage canal, potentially carrying radionuclides originating from radioactive waste or contaminated surface soil off the SDA. Surface water is collected when it is available. Americium-241, plutonium-239/240, and strontium-90 were detected in 2017 samples within historical levels. The detected concentrations are well below standards established by DOE for radiation protection of the public and the environment.

Environmental Monitoring of the Eastern Snake River Plain Aquifer

The eastern Snake River Plain aquifer beneath the eastern Snake River Plain is perhaps the single-most important aquifer in Idaho. Composed of layered basalt lava flows and some sediment, it covers an area of approximately 27,972 km^2 (10,800 square miles). The highly productive aquifer has been declared a sole source aquifer by the EPA due to the nearly complete reliance on the aquifer for drinking water supplies in the area.

The USGS began to monitor the groundwater below the INL Site in 1949. Currently, the USGS performs groundwater monitoring, analyses, and studies of the eastern Snake River Plain aquifer under and adjacent to the INL Site. These activities utilize an extensive network of strategically placed monitoring wells on and around the INL Site. In 2017, the USGS continued to monitor localized areas of chemical and radiochemical contamination beneath the INL Site produced by past waste disposal practices, in particular the direct injection of wastewater into the aquifer at INTEC and the ATR Complex. Results for monitoring wells sampled within the plumes show nearly all wells had decreasing trends of tritium and strontium-90 concentrations over time.

Several purgeable (volatile) organic compounds (VOCs) were detected by USGS in 26 groundwater monitoring wells and one perched well sampled at the INL Site in 2017. Most concentrations of the 61 compounds analyzed were either below the laboratory reporting levels or their respective primary contaminant standards. Trend test results for carbon tetrachloride concentrations in water from the RWMC production well indicate a statistically significant increase in concentrations has occurred for the period 1987–2015; however, trend analyses for the data collected since 2005 show a decreasing trend in the RWMC production well. The more recent decreasing trend indicates that engineering practices designed to reduce VOC movement to the aquifer are having a positive effect. Trichloroethene (TCE) was measured in another well at TAN within the plume, which was expected as there is a known groundwater plume at this location.

Groundwater surveillance monitoring continued for the Comprehensive Environmental Response, Compensation, and Liability Act WAGs on the INL Site in 2017. At TAN (WAG 1), groundwater monitoring continues to monitor the progress of remediation of the plume of TCE. Remedial action consists of three components: in situ bioremediation; pump and treat; and monitored natural attenuation. Strontium-90 and cesium-137 were present in wells in the source area at levels higher than those prior to starting in situ bioremediation. The elevated concentrations of these radionuclides are due to in situ bioremediation activities. The radionuclides will continue to be evaluated to determine if they will meet remedial action objective of declining below the EPA maximum contaminant levels by 2095.

Data from groundwater in the vicinity of the ATR Complex (WAG 2) show no concentrations of chromium, strontium-90, and tritium above their respective maximum drinking water contaminant levels established by the EPA.

Groundwater samples were collected from 18 aquifer monitoring wells at and near INTEC (WAG 3) during 2017. Stronium-90, technetium-99, and nitrate exceeded their respective drinking water maximum contaminant levels in one or more aquifer monitoring wells at or near INTEC, with strontium-90 exceeding its minimum contaminant level by the greatest margin in a well south (downgradient) of the former INTEC injection well. All well locations showed strontium-90 levels similar or slightly lower than those reported in previous samples.

Monitoring of groundwater at WAG 4 consists of CFA landfill monitoring and monitoring of a nitrate plume south of the CFA. Wells at the landfills were monitored in 2017 for metals (filtered), volatile organic compounds, and anions (nitrate, chloride, fluoride, and sulfate). These contaminants were either not detected or below their respective primary drinking water standards, except that nitrate continued to exceed the EPA maximum contaminant level in one well in the plume south of the CFA in 2017, and overall the data show a downward trend since 2006.

Groundwater monitoring has not been conducted at WAG 5 since 2006. Independent groundwater monitoring in the vicinity of WAG 6 is not performed.

At the RWMC (WAG 7), carbon tetrachloride, TCE, and gross alpha and gross beta activity were detected at several locations. Carbon tetrachloride was detected most frequently, but appears to be trending downward in all wells near the RWMC. Gross beta activity was detected above regional background concentration in one well located in a well situated east of the RWMC. Gross alpha activity was also detected above the MCL for the first time in the same well. The sample was heavy in sediment and the elevated concentrations of gross alpha and gross beta may be due to presence of naturally occurring radionuclides in the sediment.

Wells at the MFC (WAG 9) were sampled for radionuclides, metals, and other water quality parameters. Overall, the results show no evidence of impacts from MFC activities.

Wells along the southern INL Site boundary (as part of WAG 10) were sampled and analyzed for chloride, nitrate/nitrite as nitrogen, gross alpha and gross beta. A subset of the samples were analyzed for sulfate, VOCs, and tritium. None of the analytes exceed EPA MCLs or secondary MCLs.

Drinking water and surface water samples were sampled downgradient of the INL Site, as well as from the Big Lost River on the INL Site, and analyzed for gross alpha and beta activity, and tritium. The Big Lost River samples were also analyzed for gamma-emitting radionuclides. Tritium was detected in some samples at levels within historical measurements and below the EPA maximum contaminant level for tritium. Gross alpha and beta results were within historical measurements and the gross beta activity was well below the EPA's screening level. No human-made gamma radionuclides were detected in Big Lost River samples. The data appear to show no discernible impacts from activities at the INL Site.

Monitoring of Agricultural Products, Wildlife, Soil and Direct Radiation Measurements

To help assess the impact of contaminants released to the environment by operations at the INL Site, agricultural products (milk, lettuce, grain, and potatoes) and wildlife were sampled and analyzed for radionuclides in 2017. The agricultural products were collected on, around, and distant from the INL Site by the ESER contractor.

Wildlife sampling included collection of big game animals killed by vehicles on roads within the INL

Site. Human-made radionuclides were not detected in any big game animal. Waterfowl were sampled from near the ATR Complex wastewater ponds in 2017. Waterfowl collected near the ATR Complex ponds showed detectable concentrations of cobalt-60, zinc-65, strontium-90, cesium-137, plutonium-238, and plutonium-239/240. Bat carcasses were also collected from INL facilities and analyzed. Cobalt-60, zinc-65, strontium-90, cesium-137, plutonium-239/240, and americium-241 were detected in some bat tissue samples indicating that the bats may visit radioactive effluent ponds on the INL Site.

Some human-made radionuclides were detected in agricultural products. However, measurements were consistent with those made historically. Strontium-90, a radionuclide measured in fallout, was detected at low levels in most lettuce, alfalfa, and milk samples collected regionally.

No gamma-emitting radionuclides were detected in the five big game animals sampled in 2017. Cobalt-60, zinc-65, strontium-90, cesium-137, and plutonium-239/240 were detected in some composited bat samples indicating that bats may have visited radioactive wastewater ponds, such as those at the ATR Complex. Cobalt-60, zinc-65, strontium-90, cesium-137, plutonium-238, and plutonium-239/240 were detected in tissues of some of the waterfowl collected near the ATR Complex ponds.

Soils were collected in 2017 by the INL contractor onsite at the Experimental Field Station, the INL Site at the U.S. Highway 20/26 Rest Stop, and near the RWMC. They were analyzed for gamma-emitting and transuranic radionuclides. Results were consistent with background and/or historical measurements.

Direct radiation measurements made at offsite, boundary, and onsite locations were consistent with historical and/or natural background levels.

Monitoring of Wildlife Populations

Field data are routinely collected on several key groups of wildlife at the INL Site for information that can be used to prepare National Environmental Policy Act documents and to enable DOE to make informed decisions for planning projects and compliance with environmental policies and executive orders related to protection of wildlife. Surveys are routinely conducted on bird, big game, and bat populations on the INL Site. Monitoring in 2017 included the midwinter eagle survey, sage-grouse lek surveys, and a breeding bird survey. During 2017, operation and monitoring of permanent bat monitoring stations continued at the INL Site.

The 2017 midwinter eagle count on the INL Site recorded higher golden eagle observations ($n = 36$) than any previous year, higher rough-legged hawk counts for the second year, and more common ravens any time since survey began in 2001. Before 2017, 49 sage-grouse leks were classified as active on or near the INL Site. After the field season, six leks were downgraded from active to inactive status, one new lek was discovered, and one inactive lek was upgraded to active status. The total number of known active leks at or near the INL Site is currently 45.

The 2017 breeding bird survey showed that two sagebrush-obligate species (sagebrush sparrow and Brewer's sparrow) are at historically low levels, most likely due to losing large amounts of sagebrush-dominated communities during large wildfires in 2010 and 2011.

The number of raven nests decreased at the INL Site in 2017 from 2016, however, the number of nests is still substantially higher than when the survey began in 2014 and may reflect natural fluctuations. It is expected that the number of raven nests on INL Site infrastructure will continue to increase. This is a concern because ravens are known to be nest predators and could present a threat to sage-grouse reproduction.

Passive acoustic monitoring at long-term stations operating at caves and facilities continues to reveal patterns of bat activity across the INL Site.

Environmental Research at the INL Site

In 1975, the mostly pristine land within the INL Site's borders became DOE's second National Environmental Research Park. All lands within the Park serve as an ecological field laboratory where scientists from government agencies, universities, and private foundations may set up long-term research. This research has covered a broad range of topics and issues, from studies on the basic ecology of native sagebrush steppe organisms to the potential natural pathways of radiological materials through the environment, and even to highly applied research on the design of landfill covers that prevent water from reaching buried waste. The research topics have included native plants and wildlife as well as attempts to understand and control non-native, invasive species. The Park also provides interpretation of research results to land and facility managers to support the National Environmental Policy Act process natural resources management, radionuclide pathway analysis, and ecological risk assessment.

The Idaho National Environmental Research Park maintains several regionally and nationally important long-term ecological data sets. It is home to one of the largest data sets on sagebrush steppe vegetation anywhere. In 1950, 100 long-term vegetation plots were established on the INL Site and were originally designed to look for the potential effects of nuclear energy research on native vegetation. Since then, the plots have been surveyed about every five to seven years.

In 2017, ecological research and monitoring projects included the collection of data at 89 active long-term vegetation plots for the fourteenth time, sagebrush habitat monitoring and restoration, and studies of ants and ant guests at the INL Site.

USGS Research

The USGS INL Project Office drills and maintains research wells which provide information about subsurface water, rock and sediment, and contaminant movement in the eastern Snake River Plain aquifer at and near the INL Site. In 2017, the USGS published four research reports.

Quality Assurance

Quality assurance and quality control programs are maintained by contractors conducting environmental monitoring and by laboratories performing environmental analyses to help provide confidence in the data and ensure data completeness. Programs involved in environmental monitoring developed quality assurance programs and documentation which follow requirements and criteria established by DOE. Environmental monitoring programs implemented quality assurance program elements through quality assurance project plans developed for each contractor.

Adherence to procedures and quality assurance project plans was maintained during 2017. Data reported in this document were obtained from several commercial, university, government, and government contractor laboratories. To ensure quality results, these laboratories participated in a number of laboratory quality check programs. Quality issues that arose with laboratories used by the INL, ICP Core, and ESER contractors during 2017 were addressed with the laboratories and have been or are being resolved.

Helpful Information

Much of the Annual Site Environmental Report deals with radioactivity levels measured in environmental media, such as air, water, soil, and plants. The following information is intended for individuals with little or no familiarity with radiological data or radiation dose. It presents terminology and concepts used in the Annual Site Environmental Report to aid the reader.

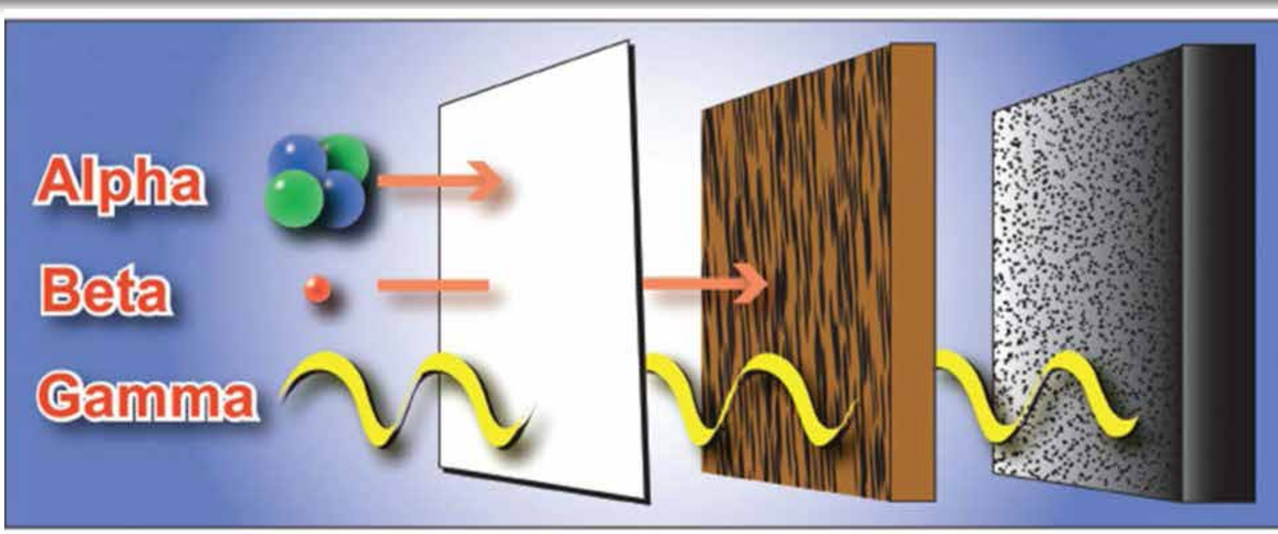
What is Radiation?

Matter is composed of atoms. Some atoms are energetically unstable and change to become more stable. During this transformation, unstable or radioactive atoms give off energy called “radiation” in the form of particles or electromagnetic waves. Generally, we refer to the various radioactive atoms as radionuclides. The radiation released by radionuclides has enough energy to eject electrons from other atoms it encounters. The resulting charged atoms or molecules are called ions, and the energetic radiation that produced the ions is called ionizing radiation. Ionizing radiation is referred to simply as “radiation” in the rest of this report. The most common types of radiation are alpha particles, beta particles, X-rays, and gamma-rays. X-rays and gamma-rays, just like visible light and radio-waves, are packets of electromagnetic radiation. Collectively, packets of electromagnetic radiation are called photons. One may, for instance, speak of X-ray photons or gamma-ray photons.

Alpha Particles. An alpha particle is a helium nucleus without orbital electrons. It is composed of two protons and two neutrons and has a positive charge of two. Because alpha particles are relatively heavy and have a double charge, they cause intense tracks of ionization, but have little penetrating ability (Figure HI-1). Alpha particles can be stopped by thin layers of materials, such as a sheet of paper or piece of aluminum foil. Alpha particles can be detected in samples containing radioactive atoms of radon, uranium, plutonium, and americium.

Beta Particles. Beta particles are electrons that are ejected from unstable atoms during the transformation or decay process. Beta particles penetrate more than alpha particles but are less penetrating than X-rays or gamma-rays of equivalent energies. A piece of wood or a thin block of plastic can stop beta particles (Figure HI-1). The ability of beta particles to penetrate matter increases with energy. Examples of beta-emitting radionuclides include tritium (^{3}H) and radioactive strontium.

Figure HI-1. Comparison of Penetrating Ability of Alpha, Beta, and Gamma Radiation.



X-Rays and Gamma-Rays. X-rays and gamma-rays are photons that have very short wavelengths compared to other electromagnetic waves, such as visible light, heat rays, and radio waves. Gamma-rays and X-rays have identical properties, behavior, and effects, but differ only in their origin. Gamma-rays originate from an atomic nucleus, and X-rays originate from interactions with the electrons orbiting around atoms. All photons travel at the speed of light. Their energies, however, vary over a large range. The penetration of X-ray or gamma-ray photons depends on the energy of the photons, as well as the thickness, density, and composition of the shielding material. Concrete is a common material used to shield people from gamma-rays and X-rays (Figure HI-1).

Examples of gamma-emitting radionuclides include radioactive atoms of iodine and cesium. X-rays may be produced by medical X-ray machines in a doctor's office.

How are Radionuclides Designated?

Radionuclides are frequently expressed with a one or two letter abbreviation for the element and a superscript to the left of the symbol that identifies the atomic weight of the isotope. The atomic weight is the number of protons and neutrons in the nucleus of the atom. Most radionuclide symbols used in this report are shown in Table HI-1. The table also shows the half-life of each radionuclide. Half-life refers to the time in which one-half of the atoms of a radioactive sample transforms or decays in the quest to achieve a more energetically stable nucleus. Most radionuclides do not decay directly to a stable element, but rather undergo a series of decays until a stable element is reached. This series of decays is called a decay chain.

How are Radioactivity and Radionuclides Detected?

Environmental samples of air, water, soil, and plants are collected in the field and then prepared and analyzed for radioactivity in a laboratory. A prepared sample is placed in a radiation counting system with a detector that converts the ionization produced by the radiation into electrical signals or pulses. The number of electrical pulses recorded over a unit of time is called a count rate. The count rate is proportional to the amount of radioactivity in the sample.

Air and water samples are often analyzed to determine the total amount of alpha and beta-emitting radioactivity present. This is referred to as a gross measurement because the radiation from all alpha-emitting and beta-emitting radionuclides in the sample is quantified. Such sample analyses measure both human-generated and naturally occurring radioactive material. Gross alpha and beta analyses are generally considered screening measurements, since specific radionuclides are not identified. The amount of gross alpha and beta-emitting radioactivity in air samples is frequently measured to screen for the potential presence of manmade radionuclides. If the results are higher than normal, sources other than background radionuclides may be suspected, and other laboratory techniques may be used to identify the specific radionuclides in the sample. Gross alpha and beta activity also can be examined over time and between locations to detect trends.

The low penetration ability of alpha-emitting particles makes detection by any instrument difficult. Identifying specific alpha-emitting radionuclides typically involves chemical separations in the laboratory to purify the sample prior to analysis with an alpha detection instrument. Radiochemical analysis is very time consuming and expensive.

Beta particles are easily detected by several types of instruments, including the common Geiger-Mueller (GM) counter. However, detection of specific beta-emitting radionuclides, such as ^{3}H and strontium-90 (^{90}Sr), requires chemical separation first.

The high-energy photons from gamma-emitting radionuclides are relatively easy to detect. Because the photons from each gamma-emitting radionuclide have a characteristic energy, gamma emitters can be simply identified in the laboratory with only minimal sample preparation prior to analysis. Gamma-emitting radionuclides, such as cesium-137 (^{137}Cs), can even be measured in soil by field detectors called in-situ detectors.

Gamma radiation originating from naturally occurring radionuclides in soil and rocks on the earth's surface is a primary contributor to the background external radiation exposure measured in air. Cosmic radiation from outer space is another contributor to the external radiation background. External radiation is easily measured with devices known as environmental dosimeters.

Table HI-1. Radionuclides and Their Half-lives.

Symbol	Radionuclide	Half-life[a,b]	Symbol	Radionuclide	Half-life
^{241}Am	Americium-241	432.2 yr	^{54}Mn	Manganese-54	312.3 d
^{243}Am	Americium-243	7,370 yr	^{59}Ni	Nickel-59	7.6×10^{4} yr
^{125}Sb	Antimony-125	2.7582 yr	^{63}Ni	Nickel-63	100.1 yr
^{41}Ar	Argon-41	109.34 min	^{238}Pu	Plutonium-238	87.7 yr
^{137m}Ba	Barium-137m	2.552 min	^{239}Pu	Plutonium-239	2.411×10^{4} yr
^{140}Ba	Barium-140	12.752 d	^{240}Pu	Plutonium-240	6.563×10^{3} yr
^{7}Be	Beryllium-7	53.12 d	^{241}Pu	Plutonium-241	14.35 yr
^{14}C	Carbon-14	5,730 yr	^{242}Pu	Plutonium-242	3.733×10^{5} yr
^{141}Ce	Cerium-141	32.5 d	^{40}K	Potassium-40	1.277×10^{9} yr
^{144}Ce	Cerium-144	284.893 d	^{226}Ra	Radium-226	1.6×10^{3} yr
^{134}Cs	Cesium-134	2.0648 yr	^{228}Ra	Radium-228	5.75 yr
^{137}Cs	Cesium-137	30.07 yr	^{220}Rn	Radon-220	55.6 s
^{51}Cr	Chromium-51	27.7025 d	^{222}Rn	Radon-222	3.8235 d
^{60}Co	Cobalt-60	5.2714 yr	^{103}Ru	Ruthenium-103	39.26 d
^{152}Eu	Europium-152	13.537 yr	^{106}Ru	Ruthenium-106	373.59 d
^{154}Eu	Europium-154	8.593 yr	^{90}Sr	Strontium-90	28.79 yr
^{3}H	Tritium	12.33 yr	^{99}Tc	Technetium-99	2.111×10^{5} yr
^{129}I	Iodine-129	1.57×10^{7} yr	^{232}Th	Thorium-232	1.405×10^{10} yr
^{131}I	Iodine-131	8.02 d	^{233}U	Uranium-233	1.592×10^{5} yr
^{55}Fe	Iron-55	2.73 yr	^{234}U	Uranium-234	2.445×10^{5} yr
^{59}Fe	Iron-59	44.503 d	^{235}U	Uranium-235	7.038×10^{8} yr
^{85}Kr	Krypton-85	10.756 yr	^{238}U	Uranium-238	4.468×10^{9} yr
^{87}Kr	Krypton-87	76.3 min	^{90}Y	Yttrium-90	64.0 hr
^{88}Kr	Krypton-88	2.84 hr	^{65}Zn	Zinc-65	244.26 d
^{212}Pb	Lead-212	10.64 hr	^{95}Zr	Zirconium-95	64.02 d

a. From http://nucleardata.nuclear.lu.se/toi/listnuc.asp?sql=
b. d = days; hr = hours; min = minutes; s = seconds; yr = years

How are Results Reported?

Scientific Notation. Concentrations of radionuclides detected in the environment are typically quite small. Scientific notation is used to express numbers that are very small or very large. A very small number may be expressed with a negative exponent, for example, 1.3×10^{-6}. To convert this number to its decimal form, the decimal point is moved left by the number of places equal to the exponent (six, in this case). The number 1.3×10^{-6} may also be expressed as 0.0000013. When considering large numbers with a positive exponent, such as 1.0×10^{6}, the decimal point is moved to the right by the number of places equal to the exponent. In this case, 1.0×10^{6} represents one million and may also be written as 1,000,000.

Unit Prefixes. Units for very small and very large numbers are often expressed with a prefix. One common example is the prefix kilo (abbreviated k), which means 1,000 of a given unit. One kilometer, therefore, equals 1,000 meters. Table HI-2 defines the values of commonly used prefixes.

Units of Radioactivity. The basic unit of radioactivity used in this report is the curie (abbreviated Ci). The curie is based on the disintegration rate occurring in 1 gram of the radionuclide radium-226, which is

Table HI-2. Multiples of Units.

Multiple	Decimal Equivalent	Prefix	Symbol
10^{6}	1,000,000	mega-	M
10^{3}	1,000	kilo-	k
10^{2}	100	hecto-	h
10	10	deka-	da
10^{-1}	0.1	deci-	d
10^{-2}	0.01	centi-	c
10^{-3}	0.001	milli-	m
10^{-6}	0.000001	micro-	µ
10^{-9}	0.000000001	nano-	n
10^{-12}	0.000000000001	pico-	p
10^{-15}	0.000000000000001	femto-	f
10^{-18}	0.000000000000000001	atto-	a

37 billion (3.7 x 10^{10}) disintegrations per second (becquerels). For any other radionuclide, 1 Ci is the amount of the radionuclide that produces this same decay rate.

Units of Exposure and Dose (Table HI-3). Exposure, or the amount of ionization produced by gamma or X-ray radiation in air, is measured in terms of the roentgen (R). Dose is a general term to express how much radiation energy is deposited in something. The energy deposited can be expressed in terms of absorbed, equivalent, and/or effective dose. The term rad, which is short for radiation absorbed dose, is a measure of the energy absorbed in an organ or tissue. The equivalent dose, which takes into account the effect of different types of radiation on tissues and therefore the potential for biological effects, is expressed as the roentgen equivalent man or "rem." Radiation exposures to the human body, whether from external or internal sources, can involve all or a portion of the body. To enable radiation protection specialists to express partial-body exposures (and the accompanying doses) to portions of the body in terms of an equal dose to the whole body, the concept of "effective dose" was developed.

Table HI-3. Names and Symbols for Units of Radioactivity and Radiological Dose Used in this Report.

Symbol	Name
Bq	Becquerel
Ci	Curie (37,000,000,000 Bq)
mCi	Millicurie (1 × 10^{-3} Ci)
µCi	Microcurie (1 × 10^{-6} Ci)
mrad	Millirad (1 × 10^{-3} rad)
mrem	Millirem (1 × 10^{-3} rem)
R	Roentgen
mR	Milliroentgen (1 × 10^{-3} R)
µR	Microroentgen (1 × 10^{-6} R)
Sv	Sievert (100 rem)
mSv	Millisievert (100 mrem)
µSv	Microsievert (0.1 mrem)

The Système International (SI) is the official system of measurement used internationally to express units of radioactivity and radiation dose. The basic SI unit of radioactivity is the Becquerel (Bq), which is equivalent to one nuclear disintegration per second. The number of curies must be multiplied by 3.7 x 10^{10} to obtain the equivalent number of becquerels. The concept of dose may also be expressed using the SI units, Gray (Gy) for absorbed dose (1 Gy = 100 rad) and sievert (Sv) for effective dose (1 Sv = 100 rem).

Concentrations of Radioactivity in Environmental Sample Media. Table HI-4 shows the units used to identify the concentration of radioactivity in various sample media.

There is always uncertainty associated with the measurement of radioactivity in environmental samples. This is mainly because radioactive decay events are inherently random. Thus, when a radioactive sample is counted again and again for the same length of time, the results will differ slightly, but most of the results will be close to the true value of the activity of the radioactive material in the sample. Statistical methods are used to estimate the true value of a single measurement and the associated uncertainty of the measurement. The uncertainty of a measurement is reported by following the result with an uncertainty value which is preceded by the plus or minus symbol, ± (e.g., 10 ± 2 pCi/L). For concentrations of greater than or equal to three times the uncertainty, there is 95 percent probability that the radionuclide was detected in a sample. For example, if a radionuclide is reported for a sample at a concentration of 10 ± 2 pCi/L, that radionuclide is considered to be detected in that sample because 10 is greater than 3 × 2 or 6. On the other hand, if the reported concentration of a radionuclide (e.g., 10 ± 6 pCi/L) is smaller than three times its associated uncertainty, then the sample probably does not contain that radionuclide (i.e., 10 is less than 3 × 6 or 18). Such low concentrations are considered to be undetected by the method and/or instrumentation used.

Mean, Median, Maximum, and Minimum Values. Descriptive statistics are often used to express the patterns and distribution of a group of results. The most common descriptive statistics used in this report are the mean, median, minimum, and maximum values. Mean and median values measure the central tendency of the data. The mean is calculated by adding up all the values in a set of data and then dividing that sum by the number of values in the data set. The median is the middle value in a group of measurements. When the data are arranged from largest (maximum) to smallest (minimum), the result in the exact center of an odd number of results is the median. If there is an even number of results, the median is the average of the two central values. The maximum and the minimum results represent the range of the measurements.

Statistical analysis of many of the air data reported in this annual report indicate that the median is a more appropriate representation of the central tendency of those results. For this reason, some of the figures present the median value of a data group. For example, Figure HI-2 is a box plot which shows the minimum, maximum, and median of a set of air measurements.

How are Data Represented Graphically?

Charts and graphs often are used to compare data and to visualize patterns, such as trends over time. Four kinds of graphics are used in this report to represent data: pie charts, column graphs, line plots, and contour lines.

Table HI-4. Units of Radioactivity.

Media	Unit
Air	Microcuries per milliliter (µCi/mL)
Liquid, such as water and milk	Picocuries per liter (pCi/L)
Soil and agricultural products	Picocuries per gram (pCi/g) dry weight
Annual human radiation exposure, measured by environmental dosimeters	Milliroentgens (mR) or millirem (mrem), after being multiplied by an appropriate dose equivalent conversion factor

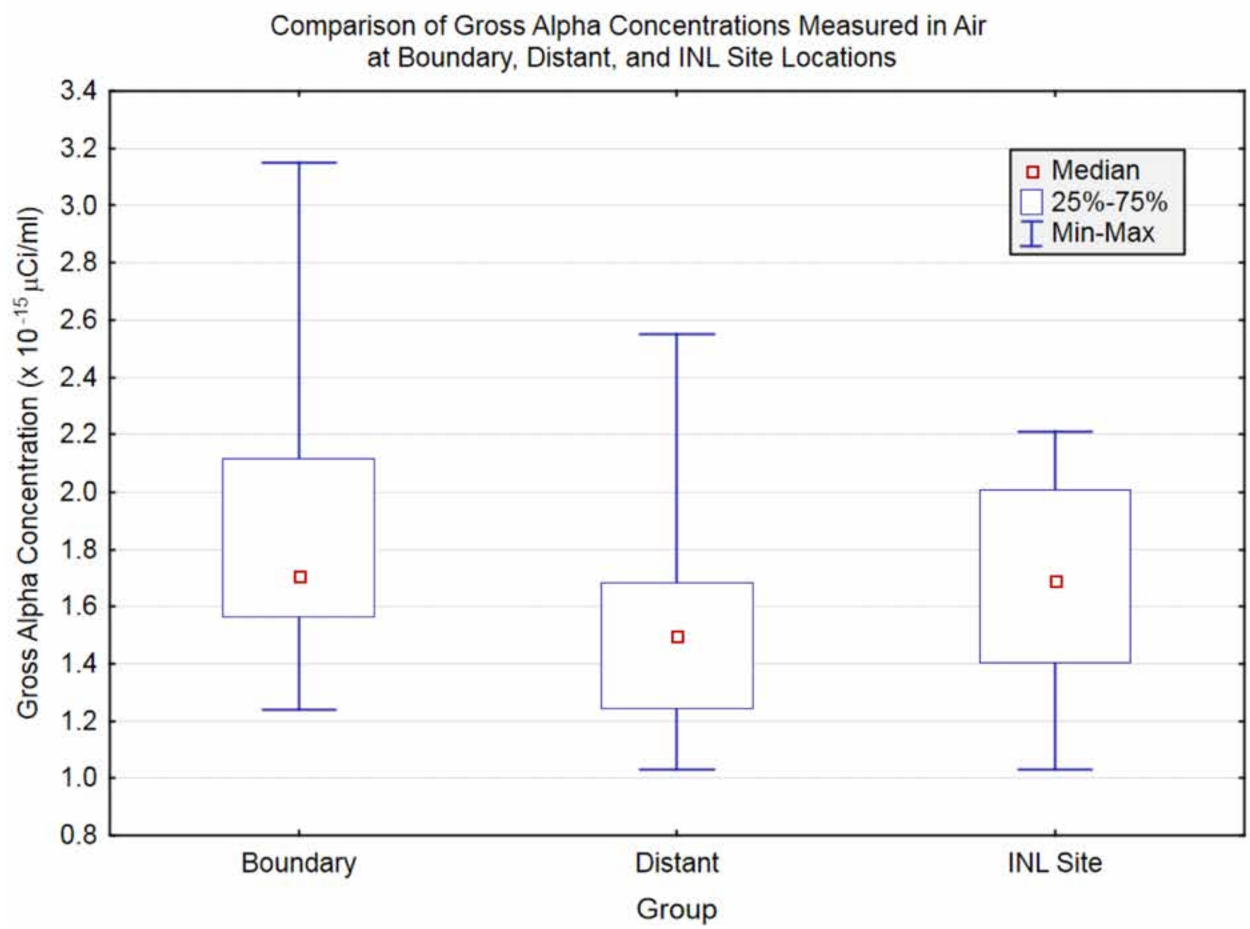


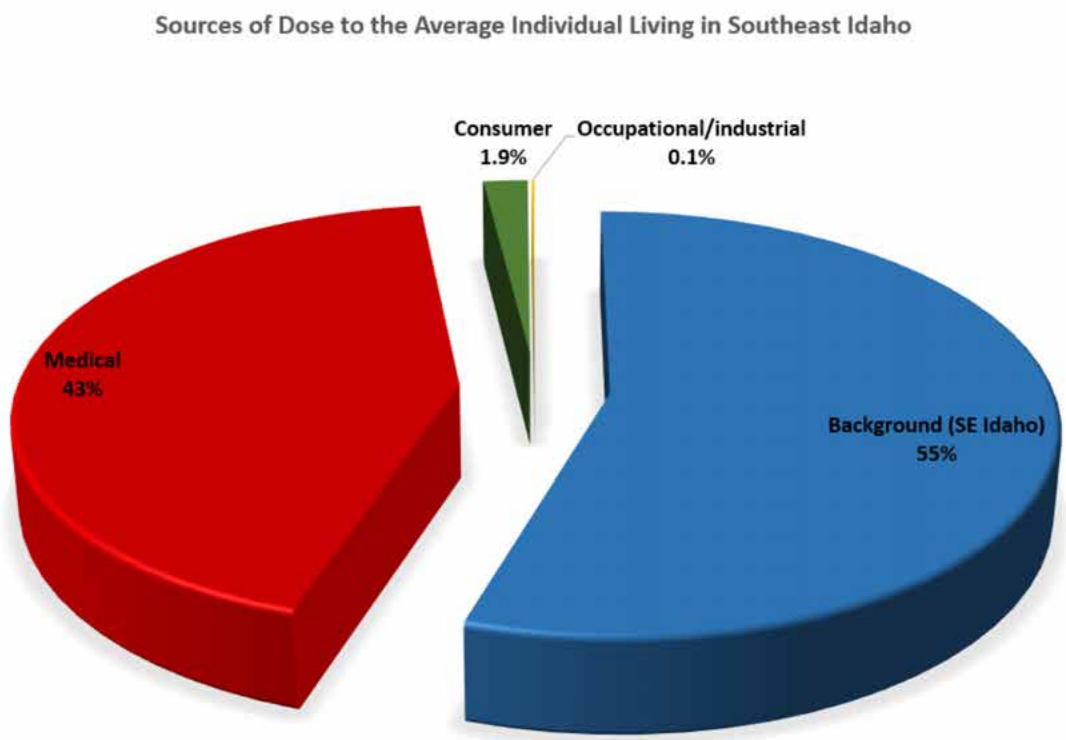
Figure HI-2. A Graphical Representation of Minimum, Median, and Maximum Results with a Box Plot. ***The 25th and 75th percentiles are the values such that 75 percent of the measurements in the data set are greater than the 25th percentile, and 75 percent of the measurements are less than the 75th percentile.***

A ***pie chart*** is used in this report to illustrate fractions of a whole. For example, Figure HI-3 shows the approximate contribution to dose that a typical person might receive while living in southeast Idaho. The percentages are derived from the table in the lower left-hand corner of the figure. The medical, consumer, and occupational/industrial portions are from National Council on Radiation Protection and Measurements Report No. 160 (NCRP 2009). The contribution from background (natural radiation, mostly radon) is estimated in Table 7-7 of this report.

A column or bar chart can show data changes over a period of time or illustrate comparisons among items. Figure HI-4 illustrates the maximum dose (mrem) calculated for the maximally exposed individual from 2007 through 2017. The maximally exposed individual is a hypothetical member of the public who is exposed to radionuclides from airborne releases through various environmental pathways and the media through which the radionuclides are transported (i.e., air, water, and food). The chart shows the general decreasing trend of the dose over time.

A ***plot*** can be useful to visualize differences in results over time. Figure HI-5 shows the ^{90}Sr measurements in two wells collected by USGS for 21 years (1997–2017). The results are plotted by year. The plot shows a decreasing trend with time.

Contour lines are sometimes drawn on a map to discern patterns over a geographical area. For example, Figure HI-6 shows the distribution of strontium-90 in groundwater around the Idaho Nuclear Technology and Engineering Center (INTEC). Each contour line, or isopleth, represents a specific concentration of the



	Effective dose (mrem)	% of Total
Background	383	55
Medical	300	43
Consumer	13	1.9
Occupational/industrial	0.8	0.1
TOTAL	697	100

Figure HI-3. Data Presented Using a Pie Chart.

radionuclide in groundwater. It was estimated from measurements of samples collected from wells around INTEC. Each contour line separates areas that have concentrations above the contour line value from those that have concentrations below that value. The figure shows the highest concentration gradient near INTEC and the lowest farther away. It reflects the movement of the radionuclide in groundwater from INTEC where it was injected into the aquifer in the past.

How Are Results Interpreted?

To better understand data, results are compared in one or more ways, including:

- Comparison of results collected at different locations. For example, measurements made at Idaho National Laboratory (INL) Site locations are compared with those made at locations near the boundary of the INL Site and distant from the INL Site to find differences that may indicate an impact (Figure HI- 2).
- Trends over time or space. Data collected during the year can be compared with data collected at the same location or locations during previous years to see if concentrations are increasing, decreasing, or remaining the same with time. See, for example, Figure HI-4, which shows a general decrease in dose over time. Figure HI-6 illustrates a clear spatial pattern of radionuclide concentrations in groundwater decreasing with distance from the source.
- Comparison with background measurements. Humans are now, and always have been, continuously exposed to ionizing radiation from natural background sources. Background sources include natural radiation and radioactivity as well as radionuclides from human activities. These sources are discussed in the following section.

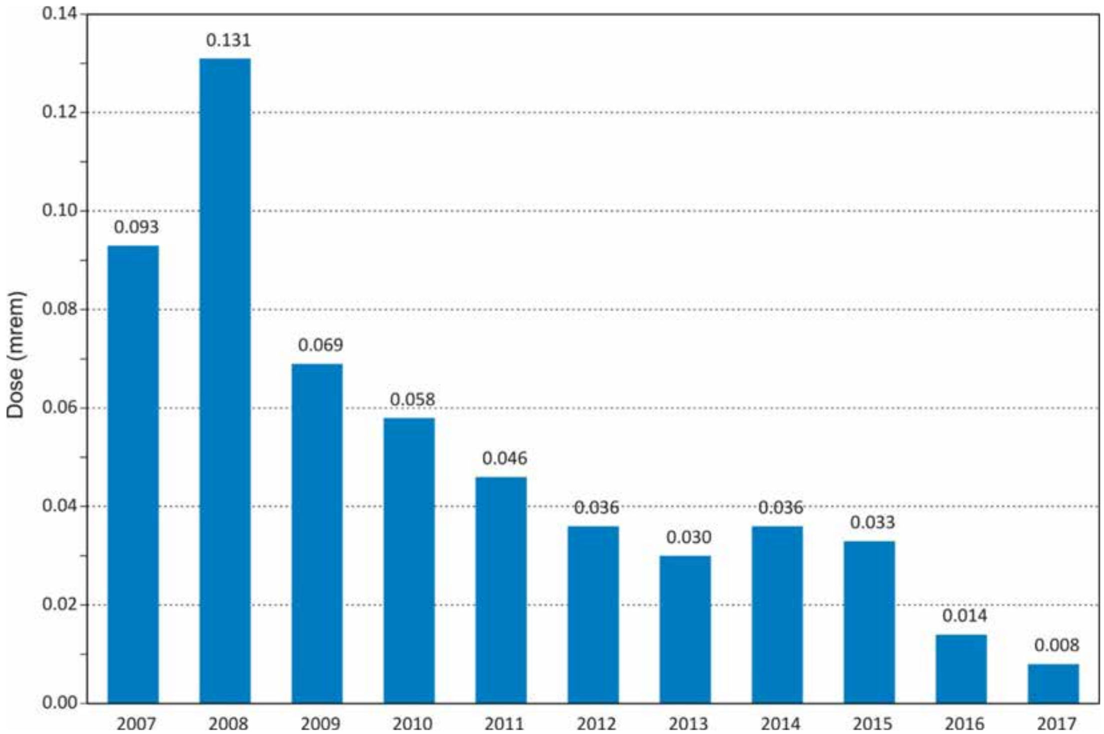


Figure HI-4. Data Plotted Using a Column Chart.

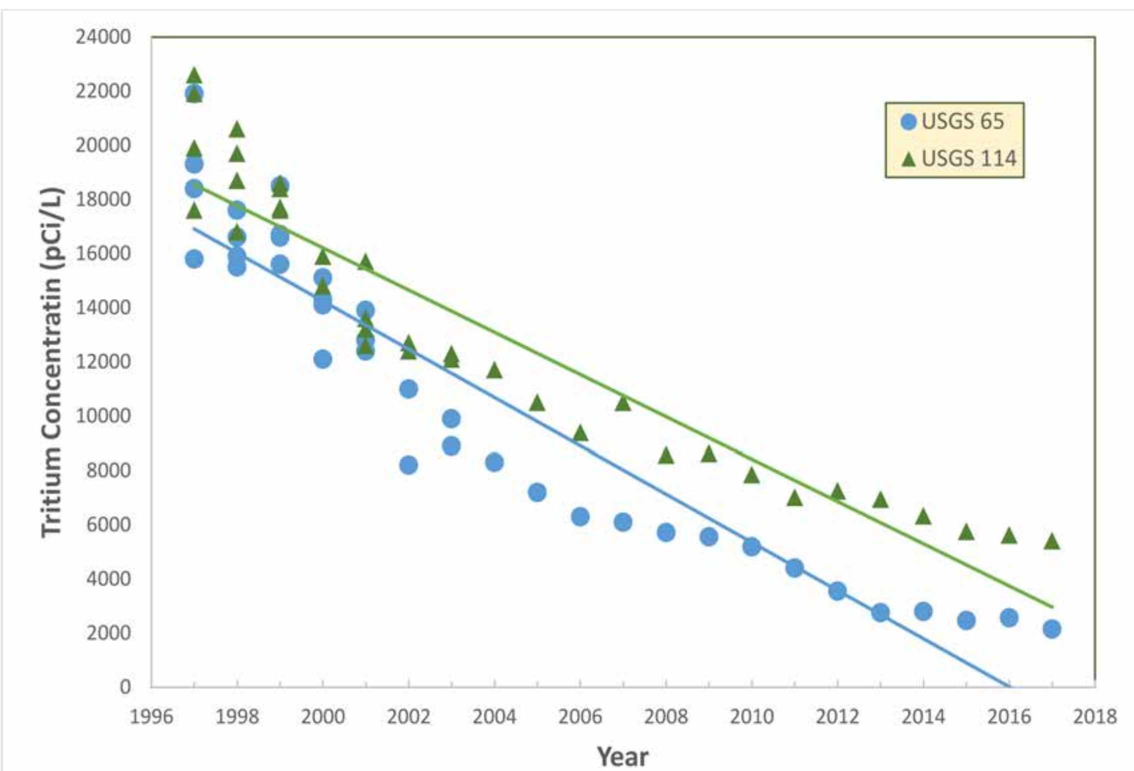


Figure HI-5. Data Plotted Using a Linear Plot.

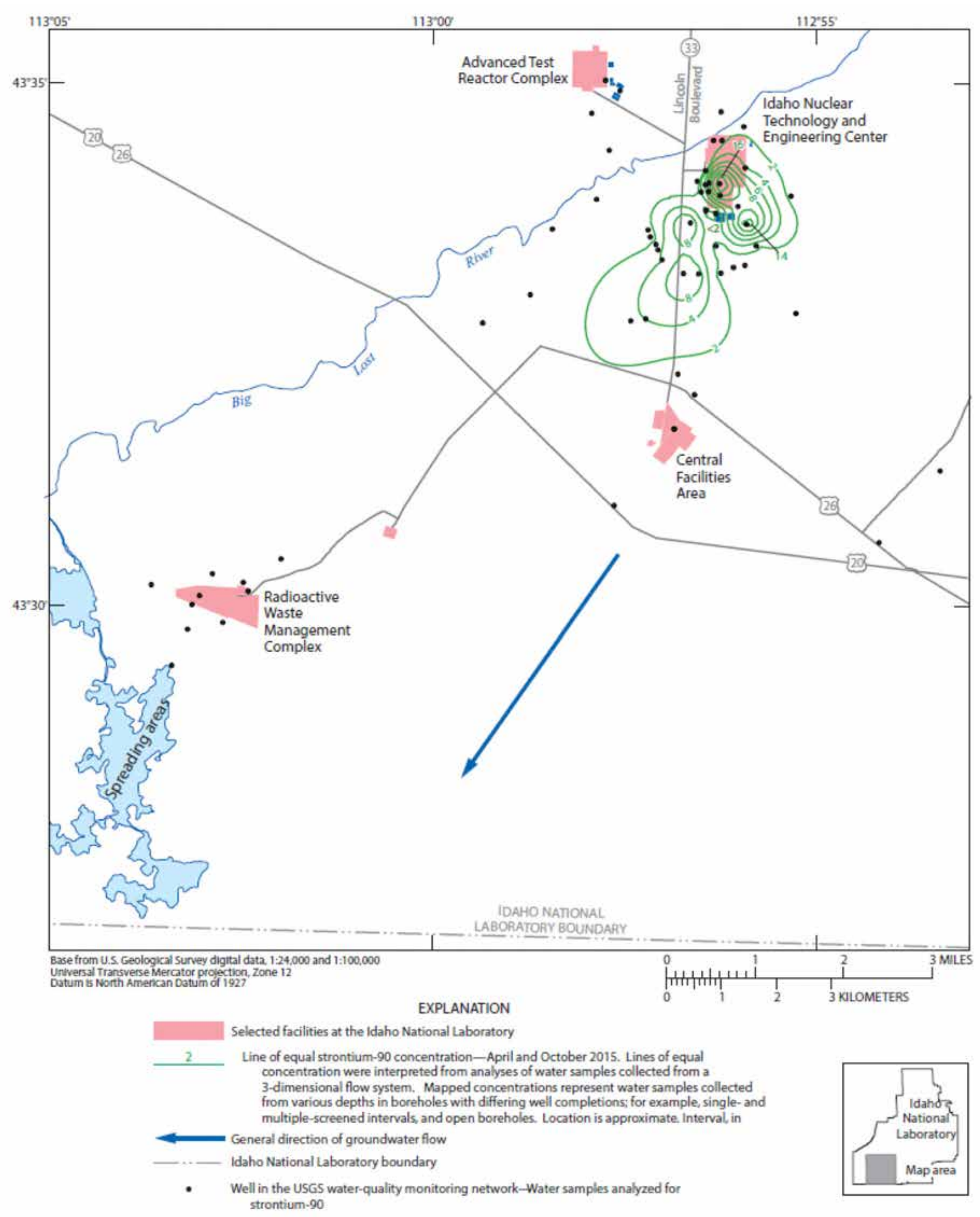


Figure HI-6. Data Plotted Using Contour Lines. Each contour line drawn on this map connects points of equal strontium-90 concentration in water samples collected at the same depth from wells on the INL Site.

What Is Background Radiation?

Radioactivity from natural and fallout sources is detectable as background in all environmental media. Natural sources of radiation include: radiation of extraterrestrial origin (called cosmic rays), radionuclides produced in the atmosphere by cosmic ray interaction with matter (called cosmogenic radionuclides), and radionuclides present at the time of the formation of the earth (called primordial radionuclides). Radiation that has resulted from the activities of modern man is primarily fallout from past atmospheric testing of nuclear weapons. One of the challenges to environmental monitoring on and around the INL Site is to distinguish between what may have been released from the INL Site and what is already present in background from natural and fallout sources. These sources are discussed in more detail below.

Natural Sources. Natural radiation and radioactivity in the environment, that is natural background, represent a major source of human radiation exposure (NCRP 1987, 2009). For this reason, natural radiation frequently is used as a standard of comparison for exposure to various human-generated sources of ionizing radiation. An individual living in southeast Idaho was estimated in 2017 to receive an average dose of about 383 mrem/yr (3.8 mSv/yr) from natural background sources of radiation on earth (Figure HI-7). These sources include cosmic radiation and naturally occurring radionuclides.

Cosmic radiation is radiation that constantly bathes the earth from extraterrestrial sources. The atmosphere around the earth absorbs some of the cosmic radiation, so doses are lowest at sea level and increase sharply with altitude. Cosmic radiation is estimated, using data in NCRP (2009), to produce a dose of about 57 mrem/yr (0.57 mSv/yr) to a typical individual living in southeast Idaho (Figure HI-7). Cosmic radiation also produces cosmogenic radionuclides, which are found naturally in all environmental media and are discussed in more detail below.

Naturally occurring radionuclides are of two general kinds: cosmogenic and primordial. Cosmogenic radionuclides are produced by the interaction of cosmic radiation within the atmosphere or in the earth. Cosmic

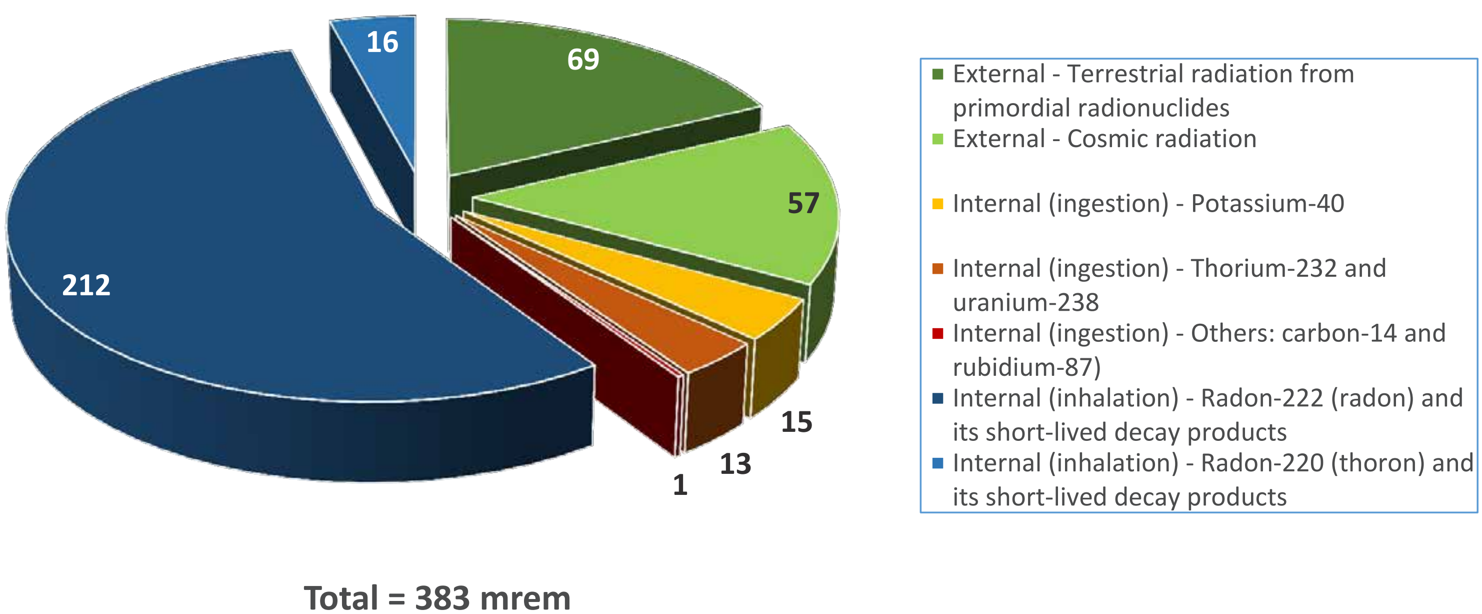


Figure HI-7. Calculated Doses (mrem per year) from Natural Background Sources for an Average Individual Living in Southeast Idaho (2017).

rays have high enough energies to blast apart atoms in the earth's atmosphere. The result is the continuous production of radionuclides, such as ^{3}H, beryllium-7 (^{7}Be), sodium-22 (^{22}Na), and carbon-14 (^{14}C). Cosmogenic radionuclides, particularly ^{3}H and ^{14}C, have been measured in humans, animals, plants, soil, polar ice, surface rocks, sediments, the ocean floor, and the atmosphere. Concentrations are generally higher at mid-latitudes than at low- or high-latitudes. Cosmogenic radionuclides contribute only about 1 mrem/yr to the total average dose, mostly from ^{14}C, that might be received by an adult living in the United States (NCRP 2009). Tritium and ^{7}Be are routinely detected in environmental samples collected by environmental monitoring programs on and around the INL Site (Table HI-5), but contribute little to the dose that might be received from natural background sources.

Primordial radionuclides are those that were present when the earth was formed. The primordial radionuclides detected today are billions of years old. The radiation dose to a person from primordial radionuclides comes from internally deposited radioactivity, inhaled radioactivity, and external radioactivity in soils and building materials. Three of the primordial radionuclides, potassium-40 (^{40}K), uranium-238 (^{238}U), and thorium-232 (^{232}Th), are responsible for most of the dose received by people from natural background radioactivity. They have been detected in environmental samples collected on and around the INL Site (Table HI-5). The external dose to an adult living in southeast Idaho from terrestrial natural background radiation exposure (74 mrem/yr or 0.74 mSv/yr) has been estimated using concentrations of ^{40}K, ^{238}U, and ^{232}Th measured in soil samples collected from areas surrounding the INL Site from 1976 through 1993. This number varies slightly from year to year based on the amount of snow cover. Uranium-238 and ^{232}Th are also estimated to contribute 13 mrem/yr (0.13 mSv/yr) to an average adult through ingestion (NCRP 2009).

Potassium-40 is abundant and measured in living and nonliving matter. It is found in human tissue and is a significant source of internal dose to the human body (approximately 15 mrem/yr [0.15 mSv/yr] according to NCRP [2009]). Rubidium-87 (^{87}Rb), another primordial radionuclide, contributes a small amount (< 1 mrem/yr) to the internal dose received by people but is not typically measured in INL Site samples.

Uranium-238 and ^{232}Th each initiate a decay chain of radionuclides. A radioactive decay chain starts with one type of radioactive atom called the parent that decays and changes into another type of radioactive atom called a progeny radionuclide. This system repeats, involving several different radionuclides. The parent radionuclide of the uranium decay chain is ^{238}U. The most familiar element in the uranium series is radon, specifically radon-222 (^{222}Rn). This is a gas that can accumulate in buildings. Radon and its progeny are responsible for most of the inhalation dose (an average of 200 mrem/yr [2.0 mSv/yr] nationwide) produced by naturally occurring radionuclides (Figure HI-7).

Table HI-5. Naturally Occurring Radionuclides that Have Been Detected in Environmental Media Collected on and around the INL Site.

Radionuclide	Half-life	How Produced?	Detected or Measured in:
Beryllium-7 (^{7}Be)	53.12 da	Cosmic rays	Rain, air
Tritium (^{3}H)	12.33 yr	Cosmic rays	Water, rain, air moisture
Potassium-40 (^{40}K)	1.277×10^{9} yr	Primordial	Water, air, soil, plants, animals
Thorium-232 (^{232}Th)	1.405×10^{10} yr	Primordial	Soil
Uranium-238 (^{238}U)	4.468×10^{9} yr	Primordial	Water, air, soil
Uranium-234(^{234}U)	2.455×10^{5} yr	^{238}U progeny	Water, air, soil
Radium-226 (^{226}Ra)	1,600 yr	^{238}U progeny	Water

The parent radionuclide of the thorium series is ^{232}Th. Another isotope of ^{220}Rn, called thoron, occurs in the thorium decay chain of radioactive atoms. Uranium-238, ^{232}Th, and their progeny often are detected in environmental samples (Table HI-5).

Global Fallout. The United States, the USSR, and China tested nuclear weapons in the atmosphere in the 1950s and 1960s. This testing resulted in the release of radionuclides into the upper atmosphere, and such a release is referred to as fallout from weapons testing. Concerns over worldwide fallout rates eventually led to the Partial Test Ban Treaty in 1963, which limited signatories to underground testing. Not all countries stopped atmospheric testing with the treaty. France continued atmospheric testing until 1974, and China until 1980. Additional fallout, but to a substantially smaller extent, was produced by the Chernobyl and Fukushima nuclear accidents in 1986 and 2011, respectively.

Most of the radionuclides associated with nuclear weapons testing and the Chernobyl and Fukushima accidents have decayed and are no longer detected in environmental samples. Radionuclides that are currently detected in the environment and typically associated with global fallout include ^{90}Sr and ^{137}Cs. Strontium-90, a beta-emitter with a 29-year half-life, is important because it is chemically similar to calcium and tends to accumulate in bone tissues. Cesium-137, which has a 30-year half-life, is chemically similar to potassium and accumulates rather uniformly in muscle tissue throughout the body.

The deposition of these radionuclides on the earth's surface varies by latitude, with most occurring in the northern hemisphere at approximately 40^{o}. Variation within latitudinal belts is a function primarily of precipitation, topography, and wind patterns. The dose produced by global fallout from nuclear weapons testing has decreased steadily since 1970. The annual dose rate from fallout was estimated in 1987 to be less than 1 mrem (0.01 mSv) (NCRP 1987). It has been nearly 30 years since that estimate, so the current dose is even lower.

What are the Risks of Exposure to Low Levels of Radiation?

Radiation protection standards for the public have been established by state and federal agencies based mainly on recommendations of the International Commission on Radiological Protection and the National Council on Radiation Protection and Measurements. The International Commission on Radiological Protection is an association of scientists from many countries, including the United States. The National Council on Radiation Protection and Measurements is a nonprofit corporation chartered by Congress. Through radiation protection standards, exposure of members of the general public to radiation is controlled so that risks are small enough to be considered insignificant compared to the risks undertaken during other activities deemed normal and acceptable in modern life.

A large amount of data exists concerning the effects of acute delivery (all at once) of high doses of radiation, especially in the range of 50 to 400 rem (0.5 to 4.0 Sv). Most of this information was gathered from the Japanese atomic bombing survivors and patients who were treated with substantial doses of X-rays. Conversely, information is limited and therefore it is difficult to estimate risks associated with low level exposure. Risk can be defined in general as the probability (chance) of injury, illness, or death resulting from some activity. Low-dose effects are those that might be caused by doses of less than 20 rem (0.2 Sv), whether delivered acutely or spread out over a period as long as a year (Taylor 1996). Most of the radiation exposures that humans receive are very close to background levels. Moreover, many sources emit radiation that is well below natural background levels. This makes it extremely difficult to isolate its effects. For this reason, government agencies make the conservative (cautious) assumption that any increase in radiation exposure is accompanied by an increased risk of health effects. Cancer is considered by most scientists to be the primary health effect from long-term exposure to low levels of radiation while each radionuclide represents a somewhat different health risk. A 2011 report by the EPA estimated a 5.8 x 10^{-2} Gy^{-1} cancer mortality risk coefficient for uniform whole-body exposure throughout life at a constant dose rate. Given a 1 gray (100 rad) ionizing radiation lifetime exposure this corresponds to 580 deaths, above normal cancer mortality rates, within an exposure group of 10,000 people. For low-LET (linear energy transfer) radiation (i.e., beta and gamma radiation) the dose equivalent in Sv (100 rem) is numerically equal to the absorbed dose in Gy (100 rad). Therefore, if each person in a group of 10,000 people is exposed to 1 rem (0.01 Sv) of ionizing radiation in small doses over a lifetime, we would expect around six people to die of cancer than would otherwise. For perspective, most people living on the eastern Snake River Plain receive over 383 mrem (3.8 mSv) every year from natural background sources of radiation.

U.S. Department of Energy limits the dose to a member of the public from all sources and pathways to 100 mrem (1 mSv) and the dose from the air pathway only to 10 mrem (0.1 mSv) (DOE Order 458.1). The doses estimated to maximally exposed individuals from INL Site releases are typically well below 1 mrem per year.

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Mud Lake Air Sampler

Acronyms

ALS-FC	ALS-Fort Collins
AMWTP	Advanced Mixed Waste Treatment Project
ARP	Accelerated Retrieval Project
ATR	Advanced Test Reactor
BEA	Battelle Energy Alliance, LLC
BBS	breeding bird survey
BLM	Bureau of Land Management
bls	below land surface
CAA	Clean Air Act
CCA	Candidate Conservation Agreement
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFA	Central Facilities Area
CFR	Code of Federal Regulations
CITRC	Critical Infrastructure Test Range Complex
CTF	Contained Test Facility
CWA	Clean Water Act
CWP	Cold Waste Pond
DCS	Derived Concentration Standard
DEQ	Department of Environmental Quality (state of Idaho)
DEQ-IOP	Department of Environmental Quality – INL Oversight Program
DOE	U.S. Department of Energy
DOECAP	DOE Consolidated Audit Program
DOE-ID	U.S. Department of Energy, Idaho Operations Office
DQO	data quality objective
DWP	Drinking Water Program
EA	Environmental Assessment
EBR-I	Experimental Breeder Reactor-I
EFS	Experimental Field Station
EIS	Environmental Impact Statement
EMS	Environmental Management System
EO	Executive Order
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ESA	Endangered Species Act
ESRP	Eastern Snake River Plain
ESER	Environmental Surveillance, Education, and Research
FFA/CO	Federal Facility Agreement and Consent Order
Fluor	Idaho Fluor Idaho, LLC
FWS	U.S. Fish and Wildlife Service
FY	fiscal year
GEL	GEL Laboratories, LLC
GHG	greenhouse gas
GPRS	Global Positioning Radiometric Scanner
GWMP	Groundwater Monitoring Program
HAA5	Haloacetic Acids
HYSPLIT	Hybrid Single-particle Lagrangian Integrated Trajectory
IC	institutional control
ICDF	Idaho CERCLA Disposal Facility
ICP	Idaho Cleanup Project
IDAPA	Idaho Administrative Procedures Act
IDFG	Idaho Department of Fish and Game
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center (formerly Idaho Chemical Processing Plant)
ISA	Idaho Settlement Agreement
ISB	in situ bioremediation
ISO	International Organization for Standardization
ISU	Idaho State University
ISU-EAL	Idaho State University – Environmental Assessment Laboratory
IWTU	Integrated Waste Treatment Unit

LEMP	Liquid Effluent Monitoring Program
LET	Linear Energy Transfer
LOFT	Loss-of-Fluid Test
LTV	Long-term Vegetation
Ma	million years
MAPEP	Mixed Analyte Performance Evaluation Program
MCL	maximum contaminant level
MEI	maximally exposed individual
MFC	Materials and Fuels Complex
MLMS	Multi-level Monitoring System
MPLS	Males Per Lek Surveyed
NA	not applicable
NCRP	National Council on Radiation Protection and Measurements
ND	not detected
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NRF	Naval Reactors Facility
O&M	Operations & Maintenance
ORAU-REAL	Oak Ridge Associated Universities – Radiological and Environmental Analytical Laboratory
OSLD	optically stimulated luminescence dosimeter
PE	performance evaluation
PLN	plan
PWS	public water system
QA	Quality Assurance
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
REC	Research and Education Campus
RESL	Radiological and Environmental Sciences Laboratory
REST	Rest Stop
RI/FS	Remedial Investigation/Feasibility Study
RMA	Rocky Mountain Adventure
ROD	Record of Decision
RPD	Relative Percent Difference
RRTR-NTR	Radiological Response Training Range – Northern Test Range
RWMC	Radioactive Waste Management Complex
SDA	Subsurface Disposal Area
SGCA	Sage-grouse Conservation Area
SMC	Specific Manufacturing Capability
SMCL	Secondary Maximum Contaminant Level
SNF	spent nuclear fuel
STP	Sewage Treatment Plant
TAN	Test Area North
TCE	trichloroethylene
TLD	thermoluminescent dosimeter
TMI	Three Mile Island
TSCA	Toxic Substances Control Act
TSF	Technical Support Facility
TREAT	Transient Reactor Experiment and Test Facility
TTHM	Total Trihalomethanes
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
UTL	Upper Tolerance Limit
VNSFS	VNS Federal Services
VOC	volatile organic compound
WAG	Waste Area Group
WAI	Wastren Advantage, Inc.
WIPP	Waste Isolation Pilot Plant
WNS	White-nose Syndrome
WRP	Wastewater Reuse Permit

2017

Units

Bq	becquerel
C	Celsius
cfm	cubic feet per minute
CFU	colony forming unit
Ci	curie
cm	centimeter
cps	counts per second
d	day
F	Fahrenheit
ft	feet
g	gram
gal	gallon
Gy	gray
ha	hectare
keV	kilo-electron-volts
kg	kilogram
km	kilometer
L	liter
lb	pound
m	meter
µCi	microcurie (10^{-6}) curies
µg	microgram
µR	microroentgen
µS	microsiemen
µSv	microsievert
Ma	million years
mCi	millicurie
MeV	mega electron volt
mg	milligram
MG	million gallons
mGy	milligray
Ml	million liters
mi	mile
min	minute
mL	milliliter
mR	milliroentgen
mrad	millirad
mSv	millisievert
oz	ounce
pCi	picocurie (10^{-12} curies)
R	roentgen
rad	radiation absorbed dose
rem	roentgen equivalent man
Sv	sievert
yd	yard
yr	year

Units

Jackrabbit Population Monitoring

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Desert Striped Whipsnake
Masticophis taeniatus

1. INTRODUCTION

This annual report is prepared in compliance with the following U.S. Department of Energy (DOE) orders:

- DOE Order 231.1B, "Environment, Safety and Health Reporting"
- DOE Order 436.1, "Departmental Sustainability"
- DOE Order 458.1, "Radiation Protection of the Public and the Environment."

The purpose of the report, as outlined in DOE Order 231.1B, is to present summary environmental data to:

- Characterize site environmental performance
- Summarize environmental occurrences and responses during the calendar year
- Confirm compliance with environmental standards and requirements
- Highlight significant facility programs and efforts.

This report is the principal document that demonstrates compliance with DOE Order 458.1 requirements and, therefore, describes the DOE Idaho National Laboratory (INL) Site impact on the public and the environment with emphasis on radioactive contaminants.

1.1 Site Location

The INL Site encompasses about 2,305 square kilometers (km^2) (890 square miles [mi^2]) of the upper Snake River Plain in southeastern Idaho (Figure 1-1). Over 50 percent of the INL Site is located in Butte County and the rest is distributed across Bingham, Bonneville, Clark, and Jefferson counties. The INL Site extends 63 km (39 mi) from north to south and is approximately 61 km (38 mi) at its broadest east-west portion. By highway, the southeast boundary is approximately 40 km (25 mi) west of Idaho Falls. Other towns surrounding the INL Site include Arco, Atomic City, Blackfoot, Rigby, Rexburg, Terreton, and Howe. Pocatello is 85 km (53 mi) to the southeast.

Federal lands surround much of the INL Site, including Bureau of Land Management lands and Craters of the Moon National Monument and Preserve to the southwest, Challis National Forest to the west, and Targhee National Forest to the north. Mud Lake Wildlife Management Area, Camas National Wildlife Refuge, and Market Lake Wildlife Management Area are within 80 km (50 mi) of the INL Site. The Fort Hall Indian Reservation is located approximately 60 km (37 mi) to the southeast.

1.2 Environmental Setting

The INL Site is located in a large, relatively undisturbed expanse of sagebrush steppe. Approximately 94 percent of the land on the INL Site is open and undeveloped. The INL Site has an average elevation of 1,500 m (4,900 ft) above sea level and is bordered on the north and west by mountain ranges and on the south by volcanic buttes and open plain. Lands immediately adjacent to the INL Site are open sagebrush steppe, foothills, or agricultural fields. Agriculture is concentrated in areas northeast of the INL Site.

About 60 percent of the INL Site is open to livestock grazing. Controlled hunting is permitted but is restricted to a very small portion of the northern half of the INL Site.

The climate of the high desert environment of the INL Site is characterized by sparse precipitation (about 21.5 cm/yr [8.45 in./yr]), warm summers (average daily temperature of 18.4°C [65.1°F]), and cold winters (average daily temperature of -7.4°C [18.7°F]), based on observations at Central Facilities Area from 1950 through 2017 (NOAA 2018). The altitude, intermountain setting, and latitude of the INL Site combine to produce a semi-arid climate. Prevailing weather patterns are from the southwest, moving up the Snake River Plain. Air masses, which gather moisture over the Pacific Ocean, traverse several hundred miles of mountainous terrain before reaching southeastern Idaho. Frequently, the result is dry air and little cloud cover. Solar heating can be intense, with extreme day-to-night temperature fluctuations.

Basalt flows cover most of the Snake River Plain, producing rolling topography. Over 400 different kinds (taxa) of plants have been recorded on the INL Site (Anderson et al.1996). Vegetation is dominated by big sagebrush (*Artemisia tridentata*) with grasses and wildflowers beneath that have been adapted to the harsh climate. The INL Site is also home to many different kinds of animals.

Vertebrate animals found on the INL Site include small burrowing mammals, snakes, birds, and several large mammals. Published species records include six fishes, one amphibian, nine reptiles, 164 birds, and 39 mammals (Reynolds et al. 1986).

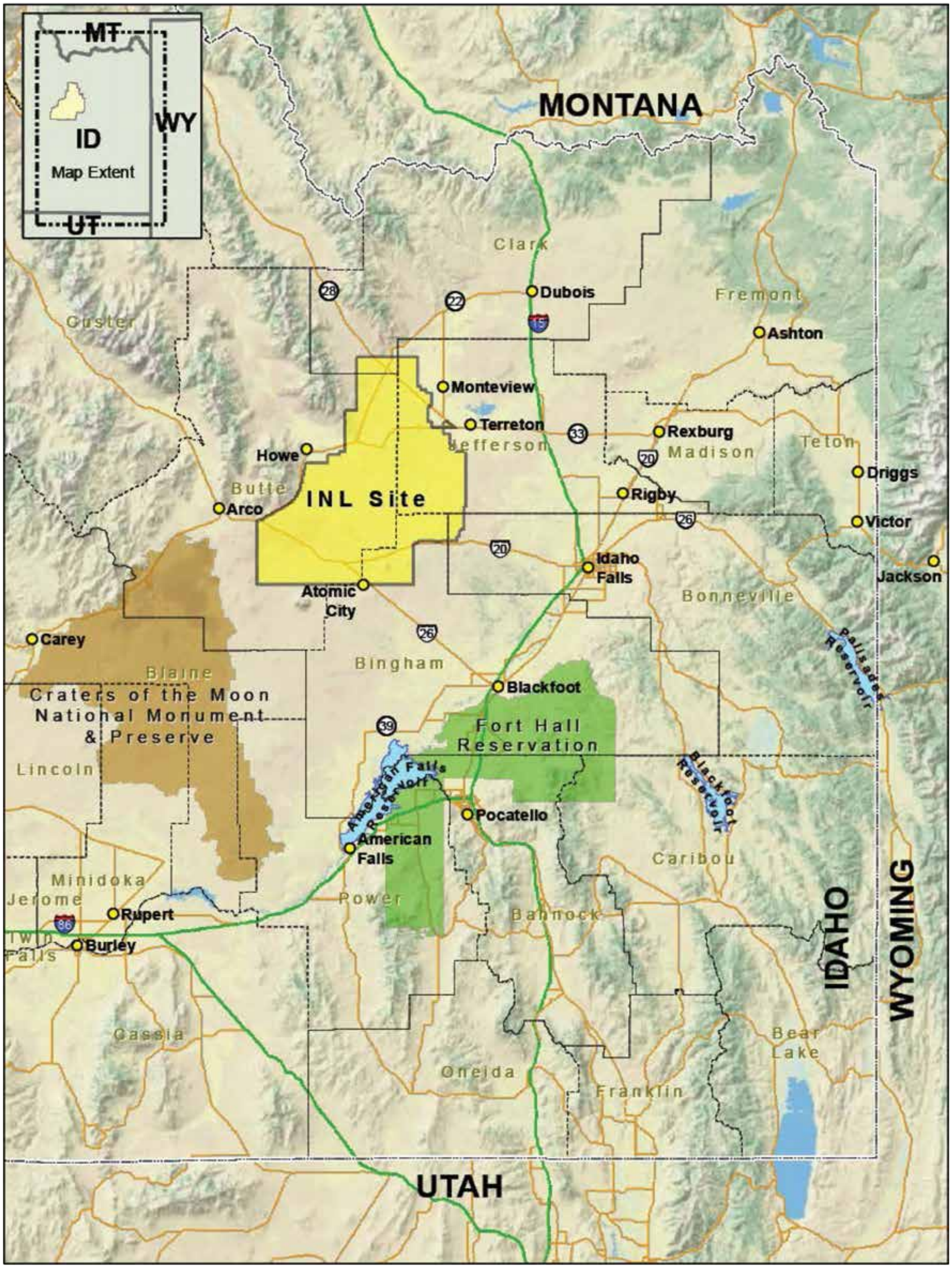

Figure 1-1. Location of the Idaho National Laboratory Site.

The Big Lost River on the INL Site flows northeast, ending in a playa area on the northwestern portion of the INL Site, called the Big Lost River Sinks. Here, the river evaporates or infiltrates the subsurface, with no surface water moving off the INL Site. Normally the river bed is dry because of upstream irrigation and rapid infiltration into desert soil and underlying basalt (Figure 1-2). The river rarely flows onto the INL Site. A wet fall season paired with a large snowpack and above-normal water levels behind the Mackay Reservoir allowed the river to spring up in 2017 and fill the Big Lost River Sinks (Figure 1-2). The last time there was enough water in the river to be sampled on the INL Site was in 2012.

Fractured volcanic rocks under the INL Site form a portion of the eastern Snake River Plain aquifer (Figure 1-3), which stretches 320 km (199 mi) from Island Park to King Hill, which is 9.7 km (6 mi) northeast of Glenns Ferry, and stores one of the most bountiful supplies of groundwater in the nation. An estimated 247 to 370 billion m^3 (200 to 300 million acre-ft) of water is stored in the aquifer's upper portions. The aquifer is primarily

Figure 1-2. Big Lost River. Dry riverbed in 2016 (upper). Flowing River in May 2017 (lower).

recharged from the Henrys Fork and the South Fork of the Snake River, and to a lesser extent from the Big Lost River, Little Lost River, Birch Creek, and irrigation. Beneath the INL Site, the aquifer moves laterally southwest at a rate of 1.5 to 6 m/day (5 to 20 ft/day) (Lindholm 1996). The eastern Snake River Plain aquifer emerges in

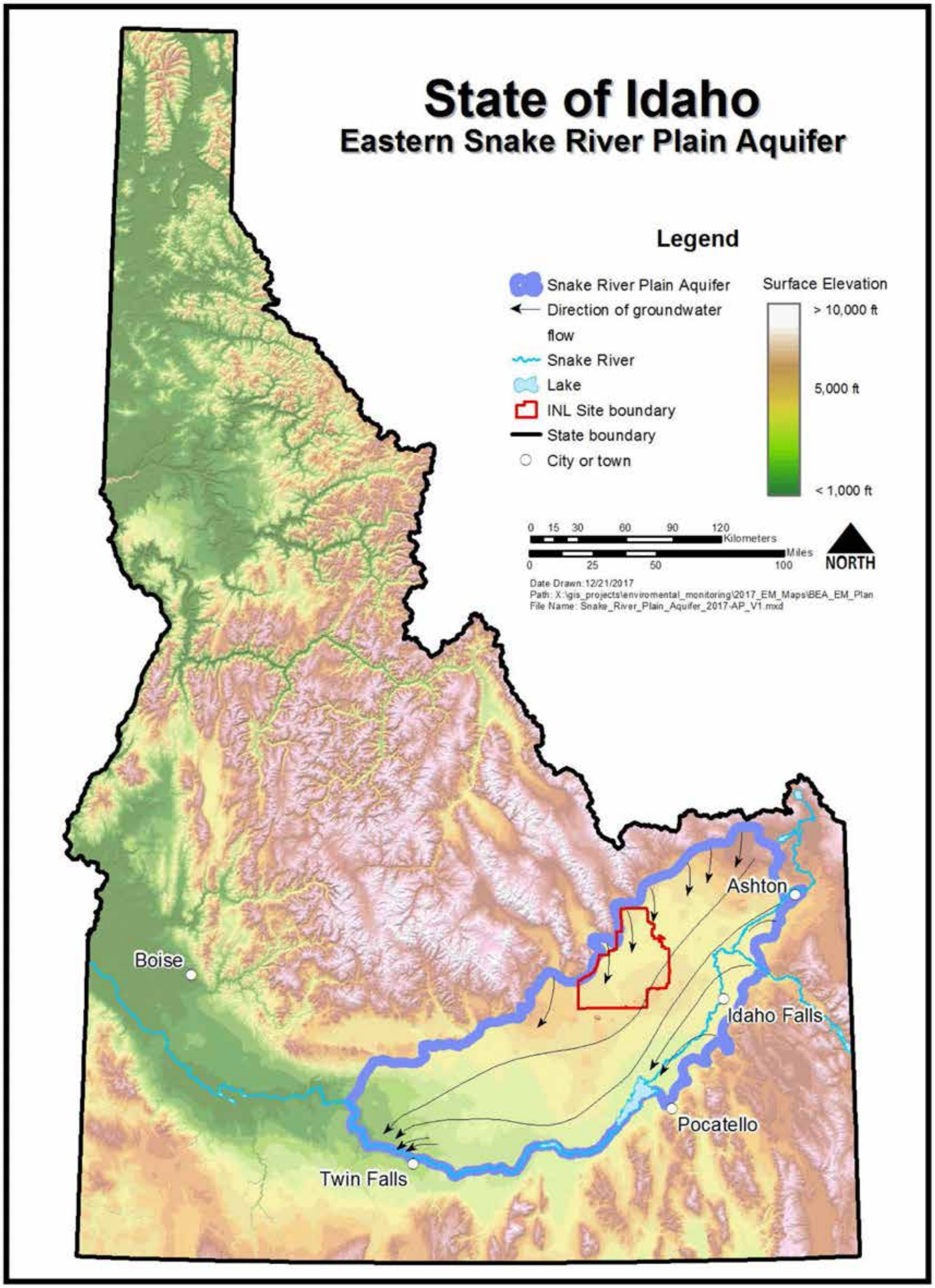

Figure 1-3. INL Site in Relation to the Eastern Snake River Plain Aquifer.

springs along the Snake River between Milner and Bliss, Idaho. Crop irrigation is the primary use of both surface water and groundwater on the Snake River Plain.

1.3 History of the INL Site

The geologic events that have shaped the modern Snake River Plain took place during the last 2 million years (Ma) (Lindholm 1996; ESRF 1996). This plain, which arcs across southern Idaho to Yellowstone National Park, marks the passage of the earth's crust over a plume of melted mantle material.

The volcanic history of the Yellowstone-Snake River Plain volcanic field is based on the time-progressive volcanic origin of the region, characterized by several large calderas in the eastern Snake River Plain, with dimensions similar to those of Yellowstone's three giant Pleistocene calderas. These volcanic centers are located within the topographic depression that encompasses the Snake River drainage. Over the last 16 Ma, a series of giant, caldera-forming eruptions occurred, with the most recent at Yellowstone National Park 630,000 years ago. The youngest silicic volcanic centers correspond to the Yellowstone volcanic field that are less than 2 Ma old and are followed by a sequence of silicic centers at about 6 Ma ago, southwest of Yellowstone. A third group of centers, approximately 10 Ma, is centered near Pocatello, Idaho. The oldest mapped silicic rocks of the Snake River Plain are approximately 16 Ma and are distributed across a 150-km-wide (93-mi-wide) zone in southwestern Idaho and northern Nevada; they are the suspected origin of the Yellowstone-Snake River Plain (Smith and Siegel 2000).

Humans first appeared on the upper Snake River Plain approximately 11,000 years ago. Tools recovered from this period indicate the earliest human inhabitants were hunters of large game. The ancestors of the present-day Shoshone and Bannock people came north from the Great Basin around 4,500 years ago (ESRF 1996).

People of European descent began exploring the Snake River Plain between 1810 and 1840; these explorers were trappers and fur traders seeking new supplies of beaver pelts.

Between 1840 and 1857, an estimated 240,000 immigrants passed through southern Idaho on the Oregon Trail. By 1868, treaties had been signed to relocate the native population to the Fort Hall Reservation. During the 1870s, miners entered the surrounding mountain ranges, followed by ranchers grazing cattle and sheep in the valleys.

In 1901 a railroad was opened between Blackfoot and Arco, Idaho. By this time, a series of acts (the Homestead Act of 1862, the Desert Claim Act of 1877, the Carey Act of 1894, and the Reclamation Act of 1902) provided sufficient incentive for homesteaders to build diversionary canals to claim the desert. Most of these canal efforts failed because of the extreme porosity of the gravelly soils and underlying basalts.

During World War II, large guns from U.S. Navy warships were retooled at the U.S. Naval Ordnance Plant in Pocatello, Idaho. These guns needed to be tested, and the nearby uninhabited plain was put to use as a gunnery range, known then as the Naval Proving Ground. The U.S. Army Air Corps also trained bomber crews out of the Pocatello Airbase and used the area as a bombing range.

After the war ended, the nation turned to peaceful uses of atomic power. DOE's predecessor, the U.S. Atomic Energy Commission, needed an isolated location with ample groundwater supply on which to build and test nuclear power reactors. In 1949, the Naval Proving Ground became the National Reactor Testing Station.

In 1951, Experimental Breeder Reactor-I became the first reactor to produce useful electricity. In 1955, the Boiling-Water Reactor Experiments-III reactor provided electricity to Arco, Idaho – the first time a nuclear reactor powered an entire community in the United States. The laboratory also developed prototype nuclear propulsion plants for Navy submarines and aircraft carriers. Over time, the Site evolved into an assembly of 52 reactors, associated research centers, and waste handling areas.

The National Reactor Testing Station was renamed the Idaho National Engineering Laboratory in 1974 and Idaho National Engineering and Environmental Laboratory in 1997 to reflect the Site's leadership role in environmental management. The U.S. Atomic Energy Commission was renamed the U.S. Energy Research and Development Administration in 1975 and reorganized to the present-day DOE in 1977.

With renewed interest in nuclear power, DOE announced in 2003 that Argonne National Laboratory-West and the Idaho National Engineering and Environmental Laboratory would be the lead laboratories for development of the next generation of power reactors.

On February 1, 2005, Battelle Energy Alliance took over operation of the laboratory, merged with Argonne National Laboratory-West, and the facility name was changed to Idaho National Laboratory. At this time the site's clean-up activities were moved to a separate contract, the Idaho Cleanup Project, which is currently managed by Fluor Idaho, LLC. Research activities, which include projects other than nuclear research such as National and Homeland Security projects, were consolidated in the newly named Idaho National Laboratory.

1.4 Populations Near the INL Site

The population of the region within 80 km (50 mi) of the INL Site is estimated, based on the 2010 census and projected growth, to be 332,665. Over half of this estimated population (178,193) resides in the census divisions of Idaho Falls (109,744) and northern Pocatello (69,159). Another 30,159 are projected to live in the Rexburg census division. Approximately 20,926 are estimated to reside in the Rigby census division and 15,808 in the Blackfoot census division. The remaining population resides in small towns and rural communities.

1.5 Idaho National Laboratory Site Primary Program Missions and Facilities

The INL Site mission is to operate a multi-program national research and development laboratory and to complete environmental cleanup activities stemming from past operations. The U.S. Department of Energy, Idaho Operations Office (DOE-ID) receives implementing direction and guidance primarily from two DOE Headquarters offices, the Office of Nuclear Energy and the Office of Environmental Management. The Office of Nuclear Energy is the Lead Program Secretarial Office for all DOE-ID-managed operations on the INL Site. The Office of Environmental Management provides direction and guidance to DOE-ID for environmental cleanup on the INL Site and functions in the capacity of Cognizant Secretarial Office. Naval Reactors operations on the INL Site report to the Pittsburgh Naval Reactors Office, fall outside the purview of DOE-ID, and are not included in this report.

1.5.1 Idaho National Laboratory

The INL mission is to discover, demonstrate and secure innovative nuclear energy solutions, other clean energy options, and critical infrastructure. Its vision is to change the worlds' energy future and secure our nation's critical infrastructure. To fulfill its assigned duties during the next decade, INL will work to transform itself into a laboratory leader in nuclear energy and homeland security research, development, and demonstration. This transformation will be the development of nuclear energy and national and homeland security leadership highlighted by achievements such as demonstration of Generation IV reactor technologies; creation of national user facilities, including the Advanced Test Reactor National Scientific User Facility, Wireless, and Biomass Feedstock National User Facilities; the Critical Infrastructure Test Range; piloting of advanced fuel cycle technology; the rise to prominence of the Center for Advanced Energy Studies; and recognition as a regional clean energy resource and world leader in safe operations. Battelle Energy Alliance, LLC, is responsible for management and operation of the INL.

1.5.2 Idaho Cleanup Project

The Idaho Cleanup Project (ICP) Core involves the safe environmental cleanup of the INL Site, which was contaminated with waste generated during World War II-era conventional weapons testing, government-owned research and defense reactor operations, laboratory research, fuel reprocessing, and defense missions at other DOE sites. The project focuses on meeting Idaho Settlement Agreement (DOE 1995) and environmental cleanup milestones while reducing risks to workers. Protection of the Snake River Plain aquifer, the sole drinking water source for more than 300,000 residents of eastern Idaho, was the principal concern addressed in the Settlement Agreement. Fluor Idaho, LLC, is responsible for the ICP Core.

The majority of cleanup work under the contract is driven by regulatory compliance agreements. The two foundational agreements are: the 1991 CERCLA-based Federal Facility Agreement and Consent Order (DOE 1991), which governs the cleanup of contaminant releases to the environment; and the 1995 Idaho Settlement Agreement (DOE 1995), which governs the removal of transuranic waste, spent nuclear fuel and high-level radioactive waste from the state of Idaho. Other regulatory drivers include the Federal Facility Compliance Act-based Site Treatment Plan (treatment of hazardous wastes), and other environmental permits, closure plans, federal and state regulations, Records of Decision and other implementing documents.

The ICP Core involves treating a million gallons of sodium-bearing liquid waste; removing targeted transuranic waste from the Subsurface Disposal Area; placing spent nuclear fuel in dry storage; treating high-level waste calcine; treating both remote- and contact-handled transuranic waste for disposal at the Waste Isolation Pilot Plant in New Mexico; and demolishing and disposing of more than 200 contaminated structures, including reactors, spent nuclear fuel storage basins, and laboratories used for radioactive experiments.

1.5.3 Primary Idaho National Laboratory Site Facilities

Most INL Site buildings and structures are located within developed areas that are typically less than a few square miles and separated from each other by miles of undeveloped land. DOE controls all land within the INL Site (Figure 1-4). In addition to the INL Site, DOE owns or leases laboratories and administrative offices in the city of Idaho Falls, 40 km (25 mi) east of the INL Site.

Central Facilities Area – The Central Facilities Area is the main service and support center for the INL Site's desert facilities. Activities at the Central Facilities Area support transportation, maintenance, medical, construction, radiological monitoring, security, fire protection, warehouses, and instrument calibration activities. It is operated by the INL contractor.

Critical Infrastructure Test Range Complex – The Critical Infrastructure Test Range Complex encompasses a collection of specialized test beds and training complexes that create a centralized location where government agencies, utility companies, and military customers can work together to find solutions for many of the nation's most pressing security issues. The Critical Infrastructure Test Range Complex provides open landscape, technical employees, and specialized facilities for performing work in three main areas: physical security, contraband detection, and infrastructure testing. It is operated by the INL contractor.

Idaho Nuclear Technology and Engineering Center – The Idaho Chemical Processing Plant was established in the 1950s to recover usable uranium from spent nuclear fuel used in DOE and Department of Defense reactors. Over the years, the facility recovered more than $1 billion worth of highly enriched uranium that was returned to the government fuel cycle. In addition, an innovative high-level liquid waste treatment process known as calcining was developed at the plant. Calcining reduced the volume of liquid radioactive waste generated during reprocessing and placed it in a more stable granular solid form. In the 1980s, the facility underwent a modernization, and safer, cleaner, and more efficient structures replaced most major facilities. Reprocessing of spent nuclear fuel was discontinued in 1992. In 1998, the plant was renamed the Idaho Nuclear Technology and Engineering Center. Current operations include startup and operation of the Integrated Waste Treatment Unit, designed to treat about 3,406,871 liters (900,000 gallons) of sodium-bearing liquid waste and closure of the remaining liquid waste storage tank, spent nuclear fuel storage, environmental remediation, disposing of excess facilities, and management of the Idaho CERCLA Disposal Facility. The Idaho CERCLA Disposal Facility is the consolidation point for CERCLA-generated wastes within the INL Site boundaries. The Idaho Nuclear Technology and Engineering Center is operated by Fluor Idaho, the ICP Core contractor.

Materials and Fuels Complex – The Materials and Fuels Complex is a prime testing center for advanced technologies associated with nuclear power systems. This complex is the nexus of research and development for new reactor fuels and related materials. As such, it will contribute to increasingly efficient reactor fuels and the important work of nonproliferation – harnessing more energy with less risk. Facilities at the Materials and Fuels Complex also support manufacturing and assembling components for use in space applications. It is operated by the INL contractor.

Naval Reactors Facility – The Naval Reactors Facility (NRF) is operated by Bechtel Marine Propulsion Corporation.

As established in Executive Order 12344 (1982), the Naval Nuclear Propulsion Program is exempt from the requirements of DOE Orders 436.1, 458.1, and 414.1D. Therefore, NRF is excluded from this report. The director of the Naval Nuclear Propulsion Program, establishes reporting requirements and methods implemented within the program, including those necessary to comply with appropriate environmental laws. The NRF's program is documented in the NRF Environmental Monitoring Report (BMPC 2018).

Radioactive Waste Management Complex – Since the 1950s, DOE has used the Radioactive Waste Management Complex (RWMC) to manage, store, and dispose of waste contaminated with radioactive elements generated in national defense and research programs. RWMC provides treatment, temporary storage, and transportation of transuranic waste destined for the Waste Isolation Pilot Plant.

The Subsurface Disposal Area is a 39-hectare (96-acre) radioactive waste landfill that was used for more

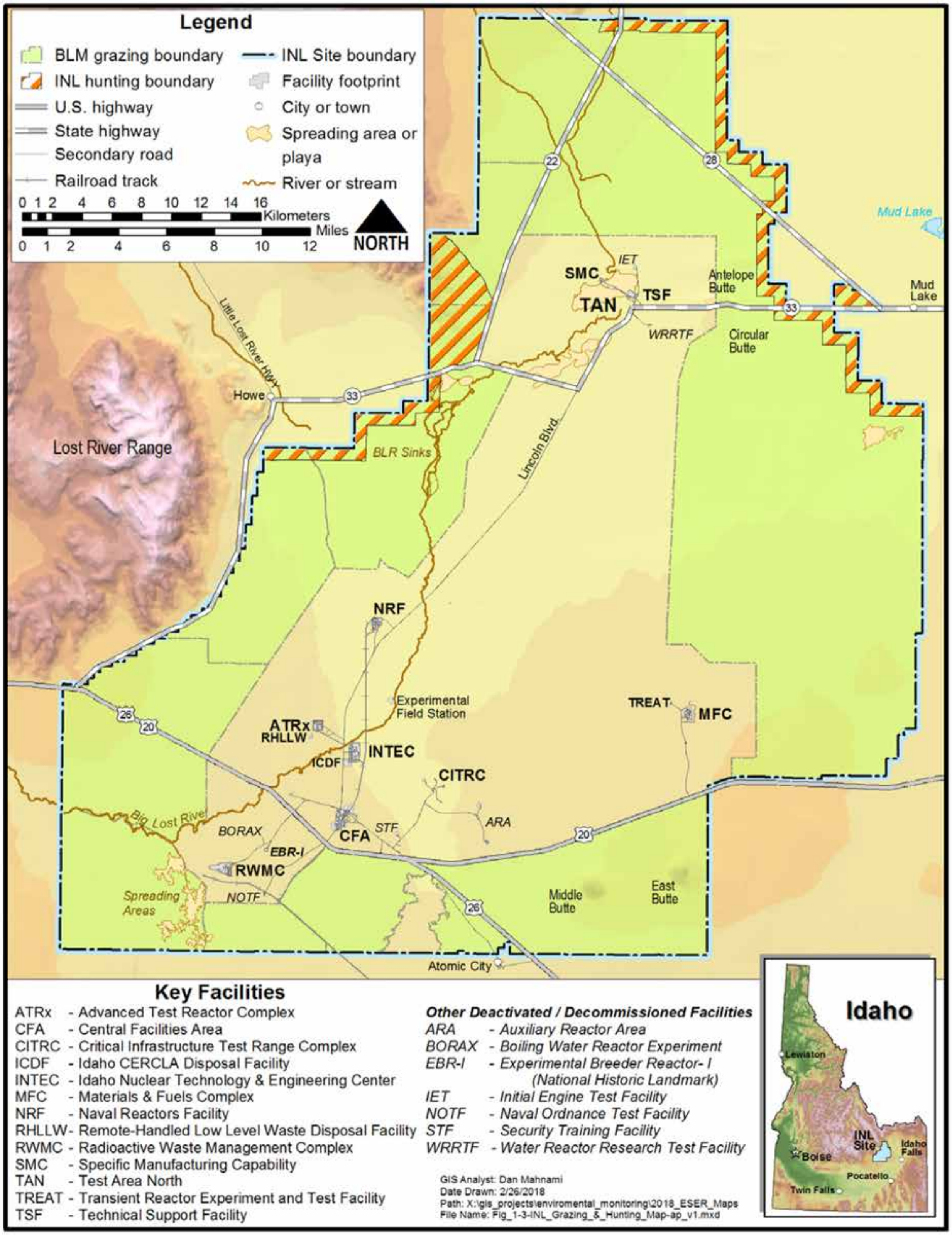

Figure 1-4. Location of the Idaho National Laboratory Site, Showing Facilities.

than 50 years. Approximately 14 of the 39 hectares (35 of 96 acres) contain waste, including radioactive elements, organic solvents, acids, nitrates, and metals from historical operations such as reactor research at the INL Site and weapons production at other DOE facilities. A CERCLA Record of Decision (OU-7-13/14) was signed in 2008 (DOE-ID 2008) and includes exhumation and off-site disposition of targeted waste. Cleanup of RWMC is managed by the ICP Core contractor.

Advanced Test Reactor Complex – The Advanced Test Reactor (ATR) Complex was established in the early 1950s and has been the site for operation of three major test reactors: the Materials Test Reactor (1952–1970), the Engineering Test Reactor (1957–1982), and the Advanced Test Reactor (1967–present). The current primary mission at the ATR Complex is operation of the Advanced Test Reactor, the world's premier test reactor used to study the effects of radiation on materials. This reactor also produces rare and valuable medical and industrial isotopes. The ATR is a National Scientific User Facility. The ATR Complex also features the ATR Critical Facility, Test Train Assembly Facility, Radiation Measurements Laboratory, Radiochemistry Laboratory, and the Safety and Tritium Applied Research Facility – a national fusion safety user facility. The ATR Complex is operated by the INL contractor.

Research and Education Campus – The Research and Education Campus (REC), operated by the INL contractor, is the collective name for INL's administrative, technical support, and computer facilities in Idaho Falls, and the in-town laboratories where researchers work on a wide variety of advanced scientific research and development projects. As the name implies, the REC uses both basic science research and engineering to apply new knowledge to products and processes that improve quality of life. This reflects the emphasis INL is placing on strengthening its science base and increasing the commercial success of its products and processes. Two new laboratory facilities, the Energy Systems Laboratory and the Energy Innovation Laboratory, were constructed in 2013 and 2014. Other facilities envisioned over the next 10 years include a national security building, a visitor's center, visitor housing, and a parking structure close to current campus buildings. In 2018, the Idaho Board of Education and INL will begin construction of two new research facilities: the Cybercore Integration Center and the Collaborative Computing Center. Facilities already in place and those planned for the future are integral for transforming INL into a renowned research laboratory.

The DOE Radiological and Environmental Sciences Laboratory (RESL) is located within the REC. RESL provides a technical component to DOE oversight of contractor operations at DOE facilities and sites. As a reference laboratory, RESL conducts cost-effective measurement quality assurance programs that help ensure key DOE missions are completed in a safe and environmentally responsible manner. By ensuring the quality and stability of key laboratory measurement systems throughout DOE, and by providing expert technical assistance to improve those systems and programs, RESL ensures the reliability of data on which decisions are based. RESL's core scientific capabilities are in analytical chemistry and radiation calibrations and measurements. In 2015, RESL expanded their presence in the REC with the addition of a new building for the DOE Laboratory Accreditation Program. The new DOE Laboratory Accreditation Program facility adjoins the RESL facility and provides irradiation instruments for the testing and accreditation of dosimetry programs across the DOE Complex.

Test Area North – Test Area North (TAN) was established in the 1950s to support the government's Aircraft Nuclear Propulsion program with the goal to build and fly a nuclear-powered airplane. When President Kennedy cancelled the nuclear propulsion program in 1961, TAN began to host a variety of other activities. The Loss-of-Fluid Test (LOFT) reactor became part of the new mission. The LOFT reactor, constructed between 1965 and 1975, was a scaled-down version of a commercial pressurized water reactor. Its design allowed engineers, scientists, and operators to create or recreate loss-of-fluid accidents (reactor fuel meltdowns) under very controlled conditions. The LOFT dome provided containment for a relatively small, mobile test reactor that was moved in and out of the facility on a railroad car. The Nuclear Regulatory Commission incorporated data received from these accident tests into commercial reactor operating codes. Before closure, the LOFT facility conducted 38 experiments, including several small loss-of-coolant experiments designed to simulate the type of accident that occurred at Three Mile Island (TMI) in Pennsylvania. In October 2006, the LOFT reactor and facilities were decontaminated, decommissioned, and demolished.

Additionally, TAN housed the TMI-2 Core Offsite Examination Program that obtained and studied technical data necessary for understanding the events leading to the TMI-2 reactor accident. Shipment of TMI-2 core samples to the INL Site began in 1985, and the program ended in 1990. INL Site scientists used the core samples to develop a database that predicts how nuclear fuel will behave when a reactor core degrades.

In July 2008, the TAN Cleanup Project was completed. The TAN Cleanup Project demolished 44 excess facilities, the TAN Hot Shop, and the LOFT reactor. Environmental monitoring continues at TAN. See Waste Area Group 1 status in Table 2-1.

The Specific Manufacturing Capability Project is located at TAN. This project is operated for the Department of Defense by the INL contractor and manufactures protective armor for the Army M1-A1 and M1-A2 Abrams tanks.

1.6 Independent Oversight and Public Involvement and Outreach

DOE encourages information exchange and public involvement in discussions and decision making regarding INL Site activities. Active participants include the public; Native American tribes; local, state, and federal government agencies; advisory boards; and other entities in the public and private sectors.

The roles and involvement of selected organizations are described in the following sections.

1.6.1 Citizens Advisory Board

The Idaho Cleanup Project Citizens Advisory Board is a federally appointed citizen panel formed in 1994 that provides advice and recommendations on ICP activities to DOE-ID. The Citizens Advisory Board consists of 12 to 15 members who represent a wide variety of key perspectives on issues of relevance to Idaho citizens. They come from a wide variety of backgrounds, including environmentalists; natural resource users; previous INL Site workers; and representatives of local government, health care, higher education, business and the general public. Their diverse backgrounds assist the ICP Environmental Management program in making decisions and having a greater sense of how the cleanup efforts are perceived by the public. Additionally, one board member represents the Shoshone-Bannock Tribes. Members are appointed by the DOE Environmental Management Assistant Secretary and serve voluntarily without compensation. Three additional liaisons (nonvoting) include representatives from DOE-ID, Environmental Protection Agency Region 10, and the Idaho Department of Environmental Quality (DEQ). The liaisons provide information to the Citizens Advisory Board on their respective agencies' policies and views.

The Citizens Advisory Board is chartered by DOE through the Federal Advisory Committee Act. The Citizens Advisory Board's charter is to provide input and recommendations to DOE on topics such as cleanup standards and environmental restoration, waste management and disposition, stabilization and disposition of nonstock pile nuclear materials, excess facilities, future land use and long-term stewardship, risk assessment and management, and cleanup science and technology activities. More information about the board's recommendations, membership, and meeting dates and topics can be found at https://www.energy.gov/em/icpcab.

1.6.2 Site-wide Monitoring Committees

Site-wide monitoring committees include the INL Site Monitoring and Surveillance Committee and the INL Site Water Committee. The INL Site Monitoring and Surveillance Committee was formed in March 1997, and meets every other month, or as needed, to coordinate activities among groups involved in environmental monitoring on and off the INL Site. This standing committee includes representatives of DOE-ID; INL Site contractors; the Environmental Surveillance, Education, and Research (ESER) contractor; Shoshone-Bannock Tribes; the state of Idaho DEQ-INL Oversight Program; the National Oceanic and Atmospheric Administration; NRF; and U.S. Geological Survey. The INL Site Monitoring and Surveillance Committee has served as a valuable forum to review monitoring, analytical, and quality assurance methodologies; to coordinate efforts; and to avoid unnecessary duplication.

The INL Site Water Committee was established in 1994 to coordinate drinking-water-related activities across the INL Site and to provide a forum for exchanging information related to drinking water systems. In 2007, the INL Site Water Committee expanded to include all Site-wide water programs: drinking water, wastewater, storm water, and groundwater. The committee includes monitoring personnel, operators, scientists, engineers, management, data entry, and validation representatives of the DOE-ID, INL Site contractors, U.S. Geological Survey, and NRF. The committee serves as a forum for coordinating water-related activities across the INL Site and exchanging technical information, expertise, regulatory issues, data, and training.

The INL Site Water Committee interacts on occasion with other committees that focus on water-related topics or programs, such as the INL Site Monitoring and Surveillance Committee.

1.6.3 Environmental Oversight and Monitoring Agreement

A new five-year Environmental Oversight and Monitoring Agreement (DOE-ID 2015) between DOE-ID, Naval Reactors Laboratory Field Office/Idaho Branch Office, and the Idaho DEQ was signed September 2015. The 2015 version is just the latest of agreements that were first implemented in 1990. The new Environmental Oversight and Monitoring Agreement governs the activities of the DEQ-INL Oversight Program and DOE-ID's cooperation in providing access to facilities and information for non-regulatory, independent oversight of INL Site impacts to public health and the environment. The first agreement established in 1990 created the state of Idaho INL Oversight Program.

The DEQ-INL Oversight Program's main activities include environmental surveillance, emergency response, and public information. More information can be found on the DEQ-INL Oversight Program website at www.deq.idaho.gov.

1.6.4 Environmental Education Outreach

The ESER program provides the DOE-ID with technical support on National Environmental Policy Act environmental analyses, such as wildlife surveys; ecological compliance, including threatened and endangered species assessment; and offsite environmental sampling of air, surface water, soil, plants, and animals. The ESER Educational Program's mission is to:

- Increase public awareness of the INL Offsite Environmental Surveillance Program and ESER ecological and radioecological research
- Increase public understanding of surveillance and research results
- Provide an education resource for local schools.

This program accomplishes this mission by providing communication and educational outreach relating to data gathered and evaluated in the performance of all ESER tasks. Priority is placed on those communities surrounding the INL Site, touching other parts of southeast Idaho as resources allow. Emphasis is placed on providing the public and stakeholders with valid, unbiased information on qualities and characteristics of the INL Site environment and impacts of INL Site operations on the environment and public.

Involvement of students, especially K–12, is emphasized. During 2017, ESER created and presented educational programs to over 15,000 students in their classrooms. Presentations covering physical science, biological science, and ecological science subjects, are adapted for grade level, and are aligned with Idaho State Science Standards.

The ESER Education Program worked together with DOE, INL contractor, ICP Core contractor, and other businesses and agencies to present community outreach programs including Earth Day and the Idaho Falls Water Festival.

The ESER Education Program, the Museum of Idaho, Idaho Fish and Game, and Idaho State University (ISU) collaborated on teacher outreach program development. This program is designed to educate teachers about native Idaho habitats, to provide tools and hands-on activities that can be adapted to their classrooms, and to introduce them to experts who may serve as classroom resources. The team taught four two-day workshops for ISU credit: 1) Contrast: Idaho Mountains and Deserts, 2) Wonderful Wetlands, 3) Water of the West (river and stream habitats), and 4) Energy Sources.

An additional teachers' workshop through ISU was initiated in 2017 after receiving a grant from the Idaho Department of Education. This workshop, called "Bring Idaho Alive in Your Classroom," consisted of four seminars presented by local scientists during the spring semester: 1) Idaho Geology, 2) Idaho Weather, 3) Idaho Plants, and 4) Idaho Animals. The summer semester for this two-credit class included a day at the INL Site with the INL Cultural Resources team, a day in Idaho Falls with Museum of Idaho and City of Idaho Falls historians, and a day learning global positioning system/geographic information system technology with ESER scientists.

In 2017, the ESER Program also partnered with the Idaho Falls Zoo to present a teacher workshop called "Exotics and Natives in Idaho." The ESER Program presented native Idaho animals and their adaptations to life in this sagebrush-steppe desert. The zoo personnel presented exotics living at the Idaho Falls Zoo and adaptations to their native habitat. Teachers learned skills to compare and contrast characteristics from these animals and were given tools to teach their students these skills in accordance with Idaho State Science Standards.

In 2017, the ESER Education Program participated in the Idaho iSTEM Conference at Eastern Idaho Technical College. As well as working on the organizing committee, ESER organized and presented one of the six tracks available for teachers at the conference. The track, entitled “In the News: Teaching Ecology in Context,” included 20 hours of coursework presented by the ESER Program; Friends of the Teton River; Idaho DEQ, Idaho Department of Water Resources; and U.S. Geological Survey.

The ESER Education Program and the Museum of Idaho offered the Rocky Mountain Adventure (RMA) summer science camp to educate students about environmental issues in their community and to encourage environmental careers. This weeklong summer camp for children in Grades 4–9 is designed to provide an appreciation for and understanding of southeastern Idaho’s native habitats (Figure 1-5). The ESER Education Program and the Museum of Idaho also offered the RMA High Adventure Camp. This camp is for students who have previously taken the RMA camp. High Adventure participants learn how to become better at observing and questioning the world around them so that they can take the next step of improving their surroundings. The hikes and activities for this camp are a little more difficult than the other camps, thus the name High Adventure.

The ESER Program, in partnership with the Idaho Falls Post Register newspaper, creates a weekly column for the Post Register called “Ask a Scientist.” The column began in 2007, and in 2017 was sponsored by the ESER Program, the Post Register, INL, Idaho Department of Fish and Game, Idaho DEQ, and the Museum of Idaho. The column calls on the experience and knowledge of a panel of about 30 scientists (including many from ESER) representing businesses, organizations, and agencies in southeastern Idaho to answer questions from local students and adults. An archive of questions and answers may be found on the ESER website: www.idahoeser.com/nie and a blog was created at www.idahoaskascientist.com.

In conjunction with “Ask A Scientist,” the ESER Program and the Museum of Idaho have teamed together on a project called “Meet A Scientist.” “Meet A Scien-

Figure 1-5. Rocky Mountain Adventure Summer Campers Imitating Moose, Island Park, Idaho.

tist" is a free-to-the-public, monthly event held at the Museum of Idaho. A guest scientist is chosen based on a monthly theme. Scientists from the ESER Program, ISU, Museum of Idaho, Idaho Museum of Natural History, INL, Brigham Young University-Idaho, Phenomenal Physics, and National Weather Service were presenters during 2017.

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Bring Idaho Alive in Your Classroom teachers’ workshop participants on the INL Site.

2. Environmental Compliance Summary

Operations at the Idaho National Laboratory (INL) Site are subject to numerous federal and state environmental statutes, executive orders, and Department of Energy (DOE) orders. As a requirement of many of these regulations, the status of compliance with the regulations and releases of non-permitted hazardous materials to the environment must be documented. Environmental compliance issues/actions in 2017 include:

- The *National Emission Standards for Hazardous Air Pollutants-Calendar Year 2017 INL Report for Radionuclides* report was submitted to U.S. Environmental Protection Agency, DOE Headquarters, and state of Idaho officials in June 2018, in compliance with the Clean Air Act. The dose to the hypothetical Maximally Exposed Individual from airborne releases was estimated to be far below the regulatory limit of 10 mrem per year.
- Naval Reactors and DOE-ID have initiated the development of a Bat Protection Plan for the INL Site. Bats are currently monitored by biologists using acoustical detectors set at hibernacula and important habitat features (caves and facility ponds) used by these mammals on the INL Site.
- Forty-nine environmental permits have been issued to the INL Site, primarily by the state of Idaho Department of Environmental Quality, to ensure clean air and water standards are met.
- In 2017, two INL Site Treatment Plan (STP) milestones were met and two INL Site Treatment Plan STP milestones were not met. Due to unplanned events at Waste Isolation Pilot Plant (WIPP) and associated continuing impacts to the Idaho Cleanup Project's (ICP) waste certification authority, the "original volume transuranic contaminated waste" treatment milestone of 4,500 m^3 will not be achieved. DEQ was also notified that the treatment milestone for sodium bearing waste would not be met due to a number of vital technical issues.
- In 2017, approximately 998 m^3 (1,308 yd^3) of mixed low-level waste and 26.6 m^3 (34.79 yd^3) of low-level waste was shipped off the INL Site for treatment, disposal, or both. Approximately 26.6 m^3 (34.79 yd^3) of newly generated, low-level waste was disposed at the SDA.
- There were no reportable environmental releases at the INL Site in 2017.
- In 2017, 33 cultural resource reviews were completed for INL Site projects with potential to cause impacts to archaeological resources. Cultural resource reviews of projects that had the potential to impact INL historic architectural properties were also completed for 14 proposed activities.

2. ENVIRONMENTAL COMPLIANCE SUMMARY

This chapter reports the compliance status of the U.S. Department of Energy (DOE) Idaho National Laboratory Site (INL Site) with environmental protection requirements. Operations at the INL Site are subject to numerous federal and state environmental protection requirements, such as statutes, acts, agreements, executive orders and DOE orders. These are listed in Appendix A.

2.1 Environmental Restoration and Waste Management

2.1.1 Comprehensive Environmental Response, Compensation, and Liability Act

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) provides the process to assess and remediate areas contaminated by the release of chemically hazardous, radioactive substances, or both. Nuclear research and other operations at the INL Site left behind contaminants that pose a potential risk to human health and the environment. The INL Site was placed on the National Priorities List under CERCLA on November 29, 1989. U.S. Department of Energy, Idaho Operations Office (DOE-ID), the state of Idaho, and U.S. Environmental Protection Agency (EPA) Region 10 signed the Federal Facility Agreement and Consent Order (FFA/CO) in December 1991 (DOE 1991).

Environmental restoration is conducted under the FFA/CO and outlines how the INL Site will comply with CERCLA. It identifies a process for DOE-ID to work with its regulatory agencies to safely execute cleanup of past release sites.

The INL Site is divided into 10 waste area groups (WAGs) (Figure 2-1) as a result of the FFA/CO, and each WAG is further divided into smaller cleanup areas called operable units. Field investigations are used to evaluate potential release sites within each WAG and operable unit when existing data are insufficient to determine the extent and nature of contamination. After each investigation is completed, a determination is made regarding whether a “No Action” or “No Further Action” listing is possible, or if it is appropriate to proceed with an interim cleanup action, the Operable Unit-10-08 Plug-In Remedy action, or further investigation using a remedial investigation/feasibility study (RI/FS). Results from the RI/FS form the basis for risk assessments and alternative cleanup actions. This information, along with regulatory agencies’ proposed cleanup plan, is presented to the public in a document called a proposed plan. After consideration of public comments, DOE, EPA and the state of Idaho develop a record of decision (ROD) that selects a cleanup approach from the alternatives evaluated. Cleanup activities can then be designed, implemented, and completed.

Since the FFA/CO was signed in December 1991, the INL Site has cleaned up release sites containing asbestos, petroleum products, acids and bases, radionuclides, unexploded ordnance and explosive residues, polychlorinated biphenyls, heavy metals, and other hazardous materials. All 24 RODs that were scheduled have been signed and are being implemented. Comprehensive RI/FSs have been completed for WAGs 1–5, 7–9, and 6/10 (6 is combined with 10). Active remediation is completed at WAGs 1 (excluding Operable Unit 1-07B), 2, 4, 5, 6, 8, and 9. Institutional controls and operations and maintenance activities at these sites are ongoing and will continue to be monitored under the *Site-wide Institutional Controls and Operations and Maintenance Plan* (DOE-ID 2017). The status of ongoing active remediation activities at WAGs 1, 3, 7, and 10 is described in Table 2-1.

Documentation associated with the FFA/CO is publicly available in the CERCLA Administrative Record and can be accessed at https://ar.icp.doe.gov.

2.1.2 Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (RCRA) established regulatory standards for generation, transportation, storage, treatment, and disposal of hazardous waste. The Idaho Department of Environmental Quality (DEQ) is authorized by EPA to regulate hazardous waste and the hazardous components of mixed waste at the INL Site. Mixed waste contains both radioactive and hazardous materials. The Atomic Energy Act, as administered through DOE orders, regulates radioactive wastes and the radioactive part of mixed wastes. A RCRA hazardous waste permit application contains two parts: Part A and Part B. Part A of the RCRA hazardous waste permit application consists of EPA Form 8700-23, along with maps, drawings and photographs, as required by 40 Code of Federal Regulations (CFR) 270.13. Part B of the RCRA hazardous waste permit application contains detailed, site-specific information as described in applicable sections of 40 CFR 262 through 270.27. The INL Site currently has two RCRA Part A permit volumes and seven Part B permit volumes. Parts A and B are considered a single RCRA permit and are comprised of several volumes.

RCRA Reports. As required by the state of Idaho, the INL Site submitted the 2017 Idaho Hazardous Waste Generator Annual Report on the types and quantities of hazardous wastes generated, shipped for treatment and disposal, and remaining in storage.

RCRA Closure Plan. There were no closure activities completed in 2017.

RCRA Inspection. For fiscal year 2017, DEQ conducted two unannounced RCRA inspections of the INL Site. The first was conducted from June 12 through June 15, 2017. On August 4, 2017, DEQ issued the inspection report stating no apparent violations were noted during the inspection. The second unannounced inspection was conducted October 23 through October 26, 2017. On December 11, 2017, DEQ issued the inspection report stating no apparent violations were noted during the inspection.

RCRA Consent Order. On January 6, 2017, due to DOE’s inability to meet commitments to initiate waste treatment in the Integrated Waste Treatment Unit (IWTU)

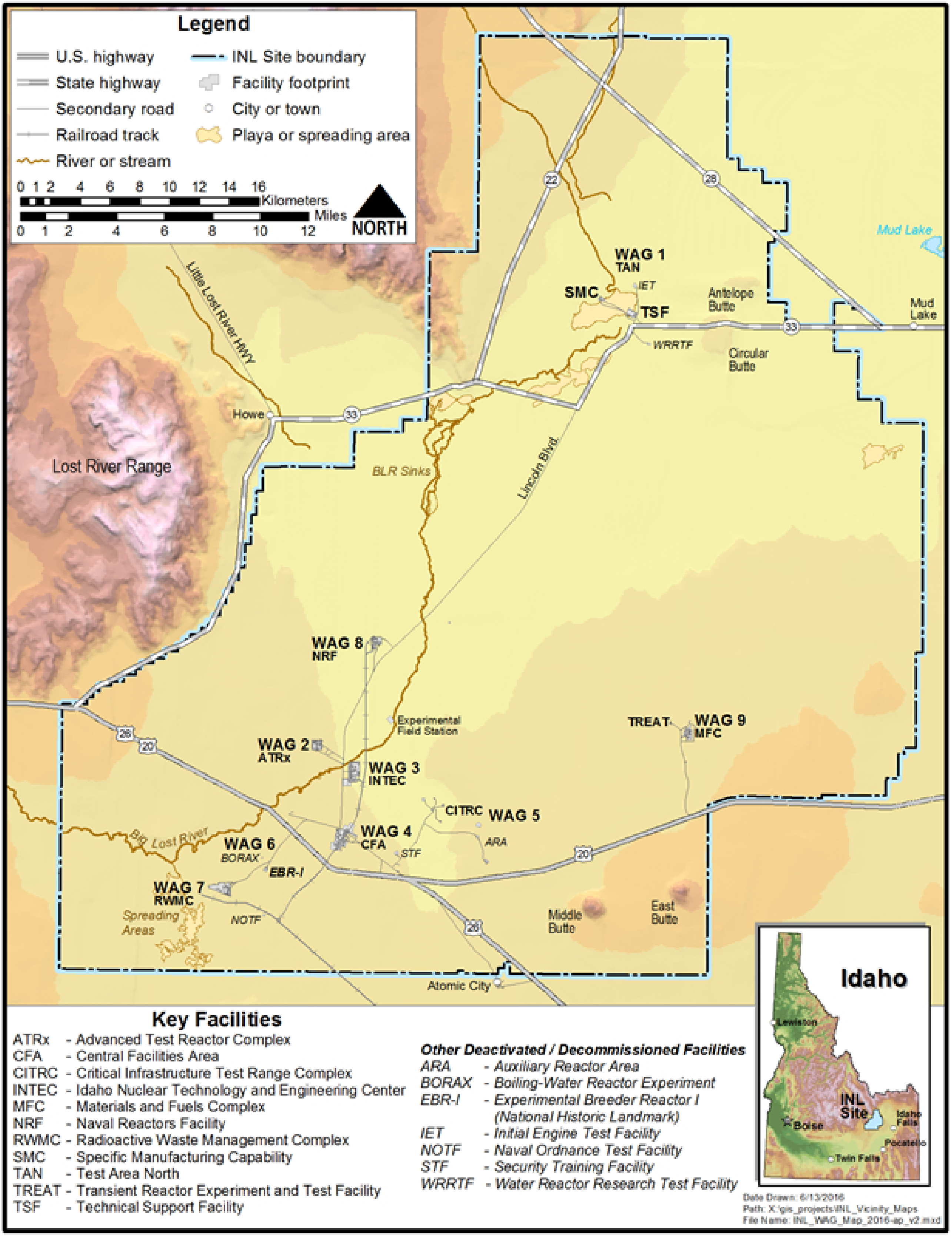

Figure 2-1. Map of INL Site Showing Facilities and Corresponding WAGs.

Table 2-1. 2017 Status of Active WAGs Cleanup.

Waste Area Group	Facility	Status
1	Test Area North	Groundwater cleanup of trichloroethene for Operable Unit 1-07B continued through 2017. The New Pump and Treat Facility generally operated four days per week, except for downtime due to maintenance, to maintain trichloroethene concentrations in the medial zone below specified targets. The in situ bioremediation transitioned into a rebound test in 2012 to determine the effectiveness of the remedy to date. The revised test plan was finalized in early 2017, to establish how the groundwater cleanup at Test Area North will continue. During 2015, two wells were constructed and further in situ bioremediation continues in a specific area where previous efforts had not achieved the desired reduction in contaminant levels. During 2017, a new well was constructed to better monitor the plume at its distal edge. All institutional controls (IC) and operations and maintenance (O&M) requirements were maintained during 2017.
3	Idaho Nuclear Technology and Engineering Center	The Idaho CERCLA Disposal Facility (ICDF) disposes of contaminated soils and debris from CERCLA remediation operations to reduce risk to the public and the environment. The facility continues to receive small amounts of liquid and solid waste periodically for disposal in the ICDF evaporation ponds and disposal cells, respectively. The ICDF evaporation ponds are sampled annually in accordance with the ICDF Complex Operational and Monitoring Sampling and Analysis Plan, and results are sent to the EPA and the state of Idaho DEQ. Remedial actions required by the WAG 3, Operable Unit 3-14 ROD, implemented in 2013, included the reduction of approximately nine million gallons of anthropogenic recharge to the northern perched water zones. Remedial actions were taken at the Tank Farm Facility to reduce water infiltration that potentially could transport contaminants from the perched water to the underlying aquifer. Perched and groundwater monitoring under and near the facility will continue until the risk posed by contamination left in place is below target levels. All ICs and O&M requirements were maintained in 2017. An interim impermeable barrier (asphalt) was placed over the western two-thirds of the Tank Farm during 2017, to further reduce infiltration of precipitation water until a final cover is constructed after Idaho Nuclear Technology and Engineering Center (INTEC) closure.
7	Radioactive Waste Management Complex	WAG 7 includes the Subsurface Disposal Area (SDA), a 39-hectare (97-acre) radioactive waste landfill that is the major focus of remedial response actions at the Radioactive Waste Management Complex (Figure 2-2). Waste is buried in approximately 14 of the 39 hectares (35 of the 96 acres) within 21 unlined pits, 58 trenches, 21 soil vault rows, and, on Pad A, an abovegrade disposal area. Disposal requirements have changed in accordance with laws and practices current at the time of disposal. Initial operations were limited to shallow, landfill disposal of waste generated at the INL Site. Beginning in 1954, the Rocky Flats Plant near Boulder, Colorado, was authorized to send waste to the Radioactive Waste Management Complex for disposal. The Rocky Flats Plant was a nuclear weapons production facility with peak operations during the Cold War era. Various types of radioactive waste streams were disposed of, including process waste (e.g., sludge, graphite molds and fines, roaster oxides, and evaporator salts), equipment, and other waste incidental to production (e.g., contaminated gloves, paper, clothing, and other industrial trash). Much of the Rocky Flats Plant waste was contaminated

Table 2-1. 2017 Status of Active WAGs Cleanup (continued).

Waste Area Group	Facility	Status
		with transuranic isotopes and solvents (e.g., carbon tetrachloride). In 1970, burial of transuranic waste was prohibited. In 1984, disposal practices were modified to eliminate disposal of mixed waste. Since 1984, only low-level waste was disposed of in the SDA. Disposal of waste from offsite generators was discontinued in the early 1990s, and disposal of contact-handled waste was discontinued at the end of Fiscal Year 2008. Currently, only remote-handled, low-level waste is being disposed in the SDA. The Operable Unit 7-13/14 ROD (DOE/ID-11359, [DOE-ID 2008]) was signed in 2008. The ROD is consistent with DOE's obligations for removal of transuranic waste under the *Agreement to Implement U.S. District Court Order Dated May 25, 2006*, between the state of Idaho and DOE, effective July 3, 2008 (U.S. District Court 2008). The ROD calls for exhuming and packaging a minimum of 6,238 m^3 (8,159 yd^3)—measured as 7,485 m^3 (9,790 yd^3) packaged—of targeted waste from a minimum combined area of 2.3 hectares (5.69 acres). Targeted waste for retrieval contains transuranic elements (e.g., plutonium), uranium, and collocated organic solvents (e.g., carbon tetrachloride). Targeted waste retrievals in specific areas of the SDA commenced in 2005. The retrieved targeted waste is packaged, certified, and shipped out of Idaho. As of December 2017, 8,613 m^3 (11,265 yd^3) of targeted waste has been retrieved and packaged from a combined area of 1.93 hectares (4.78 acres). In addition to targeted waste retrieval, the ROD addresses remaining contamination in the SDA through a combination of continued vapor-vacuum extraction and treatment of solvent vapors from the subsurface, in situ grouting of specified waste forms containing mobile contaminants (completed 2010), constructing an evapotranspiration surface barrier over the entire landfill, and long-term management and control following construction. Construction will be complete by 2028.
10	10-04 INL Site-wide Miscellaneous Sites and Comprehensive RI/FS	Operable Unit 10-04 addresses long-term stewardship functions—ICs and O&M for sites that do not qualify for Unlimited Use/Unrestricted Exposure—and explosive hazards associated with historical military operations on the INL Site. All ICs and O&M requirements were maintained in 2017, under the Site-wide IC/O&M Plan. A CERCLA five-year review was completed during 2015 and finalized in February 2016 to verify that implemented cleanup actions continue to meet cleanup objectives documented in RODs.
	10-08 INL Site-wide Groundwater, Miscellaneous Sites, and Future Sites	Operable Unit 10-08 addresses Site-wide groundwater, miscellaneous sites, and future sites. Response actions for Operable Unit 10-08 are mostly complete, and ongoing activities are groundwater monitoring and the evaluation and remediation of any potential new sites that are discovered. Groundwater monitoring continued in 2017 to verify that there is no unacceptable threat to human health or the environment from commingled plumes or along the southern INL Site boundary.

and cease use of the INTEC tanks, DEQ assessed a penalty to DOE pursuant to the provisions under Section VII of the Fifth Modification to the Notice of Noncompliance-Consent Order, in the amount $648,000 for the period of noncompliance from October 1, 2016, through March 30, 2017. Supplemental Environmental Projects were utilized in lieu of the $648,000 payment.

2.1.3 National Environmental Policy Act

The National Environmental Policy Act (NEPA) requires federal agencies to consider and analyze potential environmental impacts of proposed actions and explore appropriate alternatives to mitigate those impacts, including a no action alternative. Agencies are required to inform the public of the proposed actions, impacts, and alternatives and consider public feedback in selecting an alternative. DOE implements NEPA according to procedures in the CFR (40 CFR 1500; 10 CFR 1021) and assigns authorities and responsibilities according to DOE Policy 451.1, "National Environmental Policy Act Compliance Program." Processes specific to DOE-ID are set forth in its Idaho Operations Office Management System. DOE-ID issued the Annual NEPA Planning Summary on January 30, 2017. The summary was a requirement of DOE Order 451.1B (cancelled December 21, 2017). The NEPA Planning Summary identified a proposed Environmental Assessment (EA) and an ongoing EA. An EA was proposed to analyze the potential impacts of adding capabilities to the National Security Test Range. Later in 2017, the EA was expanded to include adding capabilities at the Radiological Response Training Range. Started in 2016, preparation of an EA to evaluate drilling two deep boreholes for disposal of DOE-managed waste forms was ongoing into 2017. Idaho was not considered as a location for the boreholes. Later in 2017, funding to the project was cancelled, and development of the EA ended.

2.1.4 Toxic Substances Control Act

The Toxic Substances Control Act (TSCA), which is administered by EPA, requires regulation of production, use, or disposal of chemicals. TSCA supplements sections of the Clean Air Act (CAA), the Clean Water Act (CWA), and the Occupational Safety and Health Act. Because the INL Site does not produce chemicals, compliance with the TSCA is primarily directed toward use and management of certain chemicals, particularly polychlorinated biphenyls. Polychlorinated biphenyls-containing light ballasts are being removed at buildings undergoing demolition. The ballasts are disposed, off the INL Site, at a TSCA-approved disposal facility.

2.1.5 INL Site Agreements

The FFA/CO requires the preparation of site treatment plans for the treatment of mixed waste stored or generated at DOE facilities. Mixed waste contains both hazardous and radioactive components. The FFA/CO and Site Treatment Plan was signed by the state of Idaho on November 1, 1995 and is updated annually (DEQ 1995). This plan outlined DOE-ID's proposed treatment strategy for Site mixed-waste streams, called the backlog, and provided a preliminary analysis of potential offsite mixed low-level waste treatment capabilities.

During 2017, two *Idaho National Laboratory Site Treatment Plan* (ICP 2017) milestones were met:

- Commercial Backlog Treatment/Disposal – 75 m^3 (98.1 yd^3)
- Sodium Components Maintenance Shop Backlog – 2 m^3 (2.6 yd^3)

During 2017, two Site Treatment Plan milestones were not met. The state of Idaho DEQ was notified that due to unplanned events at the Waste Isolation Pilot Plant (WIPP) and associated continuing impacts to the Idaho Cleanup Project (ICP) Core's waste certification authority, the "original volume transuranic contaminated waste" treatment milestone of 4,500 m^3 (5,886 yd^3) would not be achieved. Additionally, DEQ was notified that the treatment milestone for the sodium bearing waste would not be met due to a number of vital technical issues.

On October 16, 1995, DOE, the U.S. Navy, and the state of Idaho entered into an agreement (aka Idaho Settlement Agreement [ISA]) that guides management of Spent Nuclear Fuel (SNF) and radioactive waste at the INL Site. The Agreement (DOE 1995) limits shipments of DOE and Naval SNF into the state and sets milestones for shipments of SNF and radioactive waste out of the state.

The Site Treatment Plan and the ISA require DOE to ship all waste stored as transuranic waste on the INL Site in 1995, when the agreements were signed, out of Idaho by December 31, 2018. The estimated volume of that waste was 65,000 m^3 (85,016 yd^3). Fourteen years after the initial start of this project, the ICP retrieved the last box filled with transuranic waste from the Transuranic Storage Area – Retrieval Enclosure at the Radioactive Waste Management Complex-Advanced Mixed Waste Treatment Project (AMWTP) in February 2017.

In February 2014, the shipment of transuranic waste was curtailed due to the suspension of the WIPP operations in Carlsbad, New Mexico. In April of 2017, shipments resumed to WIPP. As a result, 96 shipments of the transuranic waste was shipped to WIPP, for a total of 124 m^3 (162 yd^3). The ISA includes a requirement to ship an annual three-year running average of 2,000 m^3 (2,616 yd^3) of that waste out of the state. The annual three-year running average of ISA transuranic waste shipped out of Idaho over the past three years was 1,775 m^3 (2,322 yd^3). Through December 2017, the cumulative volume of the transuranic waste shipped out of Idaho is 56,360 m^3 (73,716 yd^3).

The ICP Core manages and operates a number of projects to facilitate the disposition of radioactive waste as required by the ISA and Site Treatment Plan. The AMWTP performs retrieval, characterization, treatment, packaging, and shipment of transuranic waste currently stored at the INL Site. The vast majority of the waste the AMWTP processes resulted from the manufacture of nuclear components at DOE's Rocky Flats Plant in Colorado. This waste is contaminated with transuranic radioactive elements (primarily plutonium).

The DOE and ICP Core contractor, Fluor Idaho, LLC, continue a four-phased approach to startup of the IWTU, designed to process the remaining 3,407,000 liters (900,000 gallons) of liquid waste stored at the INTEC. These wastes are stored in three stainless steel, underground tanks and a fourth is always kept empty as a spare. All four will be closed in compliance with hazardous waste regulations. A total of 11 other liquid storage tanks have been emptied, cleaned, and closed. The waste was originally scheduled to be processed by the end of 2012, but a number of technical problems have delayed startup of IWTU.

Fluor Idaho assembled a team of nationwide experts on fluidized bed technology to resolve issues with the IWTU identified during startup testing. The four-phased approach includes: implementing design and mechanical modifications; testing and verifying the changes; and eventually operating the facility and completing processing of the remaining liquid waste.

2.1.6 Low-Level and Mixed Radioactive Waste

In 2017, approximately 998 m^3 (1,305 yd^3) of mixed low-level waste and 832 m^3 (1,088 yd^3) of low-level waste was shipped off the INL Site for treatment, disposal, or both. Approximately 26.6 m^3 (34.79 yd^3) of newly generated, low-level waste was disposed at the SDA in 2017 (Figure 2-2).

2.1.7 Spent Nuclear Fuel

Spent Nuclear Fuel (SNF) is nuclear fuel that has been withdrawn from a nuclear reactor following irradiation and the constituent elements have not been separated. SNF contains unreacted uranium and radioactive fission products. Because of its radioactivity (primarily from gamma rays), it must be properly shielded. DOE's SNF is from development of nuclear energy technology (including foreign and domestic research reactors), national defense, and other programmatic missions. At the INL Site, SNF is managed by Fluor Idaho, the ICP Core contractor at INTEC, the Naval Nuclear Propulsion Program at the Naval Reactors Facility, and the INL contractor at the Advanced Test Reactor Complex and Materials and Fuels Complex.

The *1995 Idaho Settlement Agreement* (DOE 1995) put into place milestones for the management of SNF at the INL Site:

- DOE shall complete the transfer of spent fuel from wet storage facilities by December 31, 2023 (Paragraph E.8)
- DOE shall remove all spent fuel, including naval spent fuel and Three Mile Island spent fuel, from Idaho by January 1, 2035 (Paragraph C.1).

Meeting these remaining milestones comprise the major objectives of the SNF program.

2.2 Air Quality and Protection

2.2.1 Clean Air Act

The Clean Air Act (CAA) is the basis for national air pollution control. Congress passed the original CAA in 1963, and several amendments containing key pieces of legislation have been passed with the latest in 1990, which resulted in the current CAA law. The CAA provides the EPA with broad authority to implement and enforce regulations to reduce air pollutant emissions with emphasis on cost-effective methods. In addition to EPA, states, tribes and local governments play a key role in the implementation of the CAA. The state of Idaho has been delegated authority to implement the CAA through the development of an EPA-approved state implementation plan.

During Calendar Year 2017, DEQ conducted three onsite regulatory inspections, which covered compliance for facility specific Permits to Construct and the Tier I Operating Permit. The inspections concluded that the facilities were operating in compliance with permit conditions and requirements. The INL Site has submitted a permit application to DEQ for a synthetic minor permit with a facility emission cap, which would change the INL Site's designation from a major source to an area source and replace the Tier I Operating Permit (Table 2-2). Final action on this permit application is expected in 2018.

2.3 Water Quality and Protection

2.3.1 Clean Water Act

The Clean Water Act (CWA) passed in 1972, established goals to control pollutants discharged to United States surface waters. Among the main elements of the CWA are effluent limitations for specific industry categories set by EPA as well as regulating water quality standards for surface water. The CWA also provided for the National Pollutant Discharge Elimination System permit program, requiring permits for discharges into regulated surface waters.

The INL Site complies with an Industrial Wastewater Acceptance permit for discharges to the city of Idaho Falls publicly owned treatment works. The city of Idaho Falls is required by the National Pollutant Discharge Elimination System permit program to set pretreatment standards for nondomestic discharges to publicly-owned treatment works. This program is set out in Title 8, Chapter 1 of the Municipal Code of the city of Idaho Falls. The INL Research Center is the only INL Site facility that is required to have an Industrial Wastewater Acceptance permit. The Industrial Wastewater Acceptance permit contains special conditions and compliance schedules, prohibited discharge standards, reporting

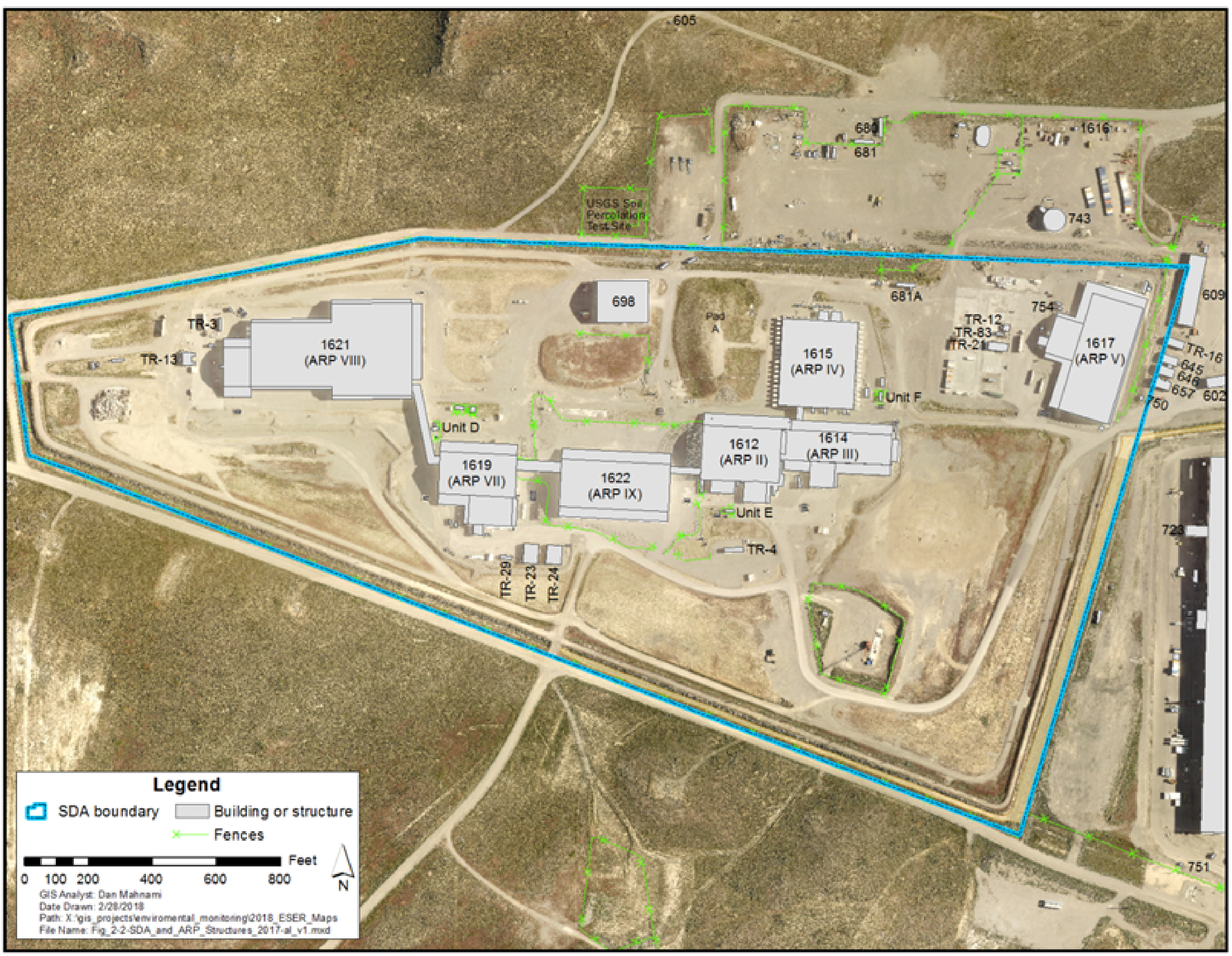

Figure 2-2. Radioactive Waste Management Complex Subsurface Disposal Area (2017).

Table 2-2. Environmental Permits for the INL Site (2017).

Permit Type	Active Permits
Air Emissions:	
Permit to Construct	13
Title I Operating Permit	1
Groundwater:	
Injection Well	3
Well construction	14
Surface Water:	
Wastewater Reuse Permits	3
Industrial Wastewater Acceptance	1
Resource Conservation and Recovery Act:	
Part A	2[a]
Part B	7[a]
Ecological:	
Migratory Bird Treaty Act Special Purpose Permit	2
Wildlife Collection/Banding/Possession Permit	3

a. Part A and B are considered a single RCRA Permit comprised of several volumes.

requirements, monitoring requirements and effluent concentration limits for specific parameters. All discharges in 2017 were within compliance levels established in the INL Research Center Wastewater Acceptance permit.

2.3.2 Safe Drinking Water Act

The Safe Drinking Water Act establishes rules governing the quality and safety of drinking water. The Idaho DEQ promulgated the Safe Drinking Water Act regulations according to the Idaho Administrative Procedures Act (IDAPA) 58.01.08, "Idaho Rules for Public Drinking Water Systems."

The eastern Snake River Plain aquifer is the source for the 12 active public water systems at all the facilities on the INL Site. All INL Site public water systems sample their drinking water as required by the state of Idaho. Chapter 6 contains details on drinking water monitoring.

2.3.3 State of Idaho Wastewater Reuse Permits

Wastewater consists of spent or used water from a home, community, farm, or industry that contains dissolved or suspended matter that may contribute to water pollution. Methods of reusing treated wastewater include irrigation, commercial toilet flushing, dust control, and fire suppression. Land application is one method of reusing treated wastewater. It is a natural way of recycling water that provides moisture and nutrients to vegetation, and it provides recharge to groundwater.

To protect health and prevent pollution of surface and ground waters, the state of Idaho requires anyone wishing to land apply wastewater to obtain a wastewater reuse permit. The Idaho DEQ issues the reuse permits in accordance with IDAPA 58.01.17 "Recycled Water Rules," IDAPA 58.01.16 "Wastewater Rules," and IDAPA 580.01.11 "Ground Water Quality Rule." All wastewater reuse permits consider site-specific conditions and incorporate water quality standards for ground water protection. The following facilities have wastewater reuse permits at the INL Site to land apply wastewater:

- Advanced Test Reactor Complex Cold Waste Ponds
- INTEC New Percolation Ponds

- Materials and Fuels Complex Industrial Waste Ditch and Industrial Waste Pond.

Chapter 5 contains details on wastewater reuse monitoring.

2.4 Other Environmental Statutes

2.4.1 Endangered Species Act

The Endangered Species Act (ESA):

- Provides a means whereby the ecosystems endangered and threatened species depend on may be conserved
- Provides a program to support the conservation of such endangered and threatened species and their habitat
- Takes steps, as appropriate, to achieve the purposes of the international treaties and conventions on threatened and endangered species.

The act requires that all federal departments and agencies seek to conserve endangered and threatened species and use their authorities to further the purposes of this act.

Personnel in the Environmental Surveillance, Education, and Research Program conduct ecological research, field surveys, and NEPA evaluations regarding ecological resources on the INL Site. Particular emphasis is given to threatened and endangered species and species of special concern identified by the U.S. Fish and Wildlife Services (FWS) and Idaho Department of Fish and Game.

One species that occurs or may occur on the INL Site has been categorized under the ESA. Table 2-3 presents a list of that species and the likelihood of its occurrence on the INL Site. Several species have been removed from the list based on the limited likelihood they would occur on the INL Site. On August 13, 2014, the FWS withdrew a proposal to list the North American Wolverine (*Gugulo luscus*) in the contiguous United States as a threatened species under the ESA. The wolverine has not been documented at the INL Site, but may pass through it.

On October 3, 2014, the FWS determined threatened status for the Western Distinct Population Segment of the Yellow-billed Cuckoo (*Coccyzus americanus*). The rare species is known to breed in river valleys in southern Idaho (Federal Register, Vol. 79 No. 192, October 3, 2014), but has only been observed once near the INL Site at Atomic City.

FWS conducted a status review and, in September 2015, announced that the greater sage-grouse does not warrant protection under the ESA. FWS made this determination based upon reduction in threats, which caused the Service to initially designate the bird "warranted but precluded" in 2010. Federal, state, and private land-use conservation efforts were major factors in accomplishing threat reduction, such as the *Candidate Conservation Agreement for Greater Sage-grouse on the INL Site* (DOE-ID and USFWS, 2014) that DOE and FWS signed in October 2014. The voluntary agreement includes conservation measures that protect sage-grouse and its habitat while allowing DOE flexibility in accomplishing its missions.

Recently, white-nose syndrome (WNS) has been identified as a major threat to many bats that hibernate in caves. This disease is caused by a cold-adapted fungus (*Geomyces destructans*) and has killed at least 5.5 to 6.7 million bats in seven species. Many species of bats could be at risk for significant decline or extinction due to this disease. At least two species of bats that occupy the INL Site could be affected by WNS if this disease arrives in Idaho: the little brown myotis (*Myotis licifugus*) and the big brown bat (*Eptesicus fuscus*). In 2010, the little brown myotis was petitioned for emergency listing under the ESA, and the FWS is collecting information on both species to determine if, in addition to existing threats, this disease may be increasing the extinction risk of these bats. Biologists from the Environmental Surveillance, Education, and Research Program have initiated a monitoring program using acoustical detectors set at hibernacula and important habitat features (caves and facility ponds) used by these mammals on the INL Site. Naval Reactors and DOE-ID have initiated the development of

Table 2-3. INL Species Designated Under the ESA and Occur, or May Occur, on the INL Site.

Species	Designation	Presence on INL Site
Yellow-billed cuckoo (*Coccyzus americanus*)	Threatened	Documented once on south border of INL Site.

a Bat Protection Plan for the INL Site. The Bat Protection Plan would allow the INL Site to proactively position itself to continue its missions if there was an emergency listing of a bat due to WNS. The monitoring data will be incorporated into the development of that plan.

2.4.2 Migratory Bird Treaty Act

The Migratory Bird Treaty Act prohibits taking any migratory bird, or any part, nest, or egg of any such bird, without authorization from the U.S. Department of the Interior. Permits may be issued for scientific collecting, banding and marking, falconry, raptor propagation, depredation, import, export, taxidermy, waterfowl sale and disposal, and special purposes. In July 2013, DOE-ID received a Special Purpose Permit for limited nest relocation and destruction and the associated take of migratory birds if absolutely necessary for mission-critical activities. The permit would be applied in very limited and extreme situations where no other recourse is practicable.

DOE-ID exercised the permit twice in 2017 to address two birds found injured on the INL Site due collisions with structures. Both birds were beyond saving and were euthanized. As required by the permit, DOE-ID submitted an annual report to FWS by January 31, detailing reportable activities related to migratory birds. Among the incidental takes reported in Calendar Year 2017 were nine golden eagles found dead beneath power poles located on the INL Site. The carcasses were sent to the FWS for necropsies, which showed all nine birds died from electrocution. The INL Site contractor took steps to retrofit the power poles where the birds were found to prevent future electrocution incidents.

DOE-ID and INL Site contractors have permits from the state of Idaho to manage migratory birds and to collect other wildlife specimens for scientific research. The permit allows for the collection of bat carcasses and sampling of big game animal carcasses found on the INL Site, and for active harvest of waterfowl from INL Site wastewater ponds (the INL contractor also has a Special Purpose Permit that allows waterfowl collection). The animal samples are analyzed for radionuclides. Wildlife sampling and analysis is further discussed in Chapter 7.

2.4.3 Emergency Planning and Community Right-to-Know Act

The Emergency Planning and Community Right-to-Know Act (EPCRA) is Title III of the 1986 Superfund Amendments and Reauthorization Act to CERCLA. EPCRA is intended to help local emergency response agencies better prepare for potential chemical emergencies and to inform the public of the presence of toxic chemicals in their communities. The INL Site's compliance with key EPCRA provisions is summarized in the following subsections and in Table 2-4.

Section 304 – Section 304 requires owners and operators of facilities where hazardous chemicals are produced, used, or stored to report releases of CERCLA hazardous substances or extremely hazardous substances that exceed reportable quantity limits to state and local authorities (i.e., state emergency response commissions and local emergency planning committees). There were no CERCLA-reportable chemicals released at the INL Site during 2017.

Sections 311 and 312 – Sections 311 and 312 require facilities manufacturing, processing, or storing designated hazardous chemicals to make safety data sheets describing the properties and health effects of these chemicals available to state and local officials and local fire departments. Facilities are also required to report inventories of all chemicals that have safety data sheets to state and local officials and local fire departments. The INL Site satisfies the requirements of Section 311 by submitting a quarterly report to state and local officials and fire departments, identifying chemicals that exceed regulatory thresholds. In compliance with Section 312, the annual Emergency and Hazardous Chemical Inventory (Tier II) Report is provided to local emergency planning committees, the state emergency response commission, and local fire departments by the regulatory due date of March 1. This report includes the types, quantities, and locations of hazardous chemicals and extremely hazardous substances stored at the INL Site and Idaho Falls facilities that exceed regulatory thresholds.

Section 313 – Section 313 requires facilities to submit a Toxic Chemical Release Inventory Form annually for regulated chemicals that are manufactured, processed, or otherwise used above applicable threshold quantities. Releases under EPCRA 313 reporting include transfers to waste treatment and disposal facilities off the INL Site, air emissions, recycling, and other activities. The INL Site submitted Toxic Chemical Release Inventory Forms for ethylbenzene, lead, naphthalene, nitric acid, and nitrate compounds to EPA and the state of Idaho by the regulatory due date of July 1.

Reportable Environmental Releases – There were no reportable environmental releases at the INL Site during Calendar Year 2017.

Table 2-4. INL Site EPCRA Reporting Status (2017).

EPCRA Section	Description of Reporting	2017 Status
Section 304	Extremely Hazardous Substance Release Notification	Not Required
Section 311-312	Material Safety Data Sheet/Chemical Inventory	Required
Section 313	Toxic Chemical Release Inventory Reporting	Required

2.4.4 Executive Order 11988 – Floodplain Management

Executive Order 11988 requires each federal agency to issue or amend existing regulations and procedures to ensure that the potential effects of any action it may take in a floodplain are evaluated and that its planning programs and budget requests consider flood hazards and floodplain management. It is the intent of Executive Order 11988 that federal agencies implement floodplain requirements through existing procedures, such as those established to implement NEPA. 10 CFR 1022 contains DOE policy and floodplain environmental review and assessment requirements through the applicable NEPA procedures. In those instances where impacts of actions in floodplains are not significant enough to require the preparation of an EIS under NEPA, alternative floodplain evaluation requirements are established through the INL Site Environmental Checklist process.

For the Big Lost River, DOE-ID has accepted the *Big Lost River Flood Hazard Study, Idaho National Laboratory, Idaho* (Bureau of Reclamation 2005). This flood hazard report is based on geomorphological models and has undergone peer review. All activities on the INL Site requiring characterization of flows and hazards are expected to use this report. For facilities at Test Area North, the 100-year floodplain has been delineated in a U.S. Geological Survey report (USGS 1997).

2.4.5 Executive Order 11990 – Protection of Wetlands

Executive Order 11990 requires each federal agency to issue or amend existing regulations and procedures to ensure wetlands are protected in decision-making. It is the intent of this executive order that federal agencies implement wetland requirements through existing procedures, such as those established to implement NEPA. The 10 CFR 1022 regulations contain DOE policy and wetland environmental review and assessment requirements through the applicable NEPA procedures. In instances where impacts of actions in wetlands are not significant enough to require the preparation of an EIS under NEPA, alternative wetland evaluation requirements are established through the INL Site Environmental Checklist process. Activities in wetlands considered waters of the United States or adjacent to waters of the United States also may be subject to the jurisdiction of Sections 404 and 402 of the CWA.

The only area of the INL Site currently identified as potentially jurisdictional wetlands is the Big Lost River Sinks. The FWS National Wetlands Inventory map is used to identify potential jurisdictional wetlands and non-regulated sites with ecological, environmental, and future development significance. In 2017, no actions took place or impacted potential jurisdictional wetlands on the INL Site.

2.5 Cultural Resources Protection

INL Site cultural resources are numerous and represent at least 13,000 years of human land use in the region. Protection and preservation of cultural resources under the jurisdiction of federal agencies, including DOE-ID, are mandated by a number of federal laws and their implementing regulations. DOE-ID has tasked the implementation of a cultural resource management program for the INL Site to Battelle Energy Alliance's Cultural Resource Management Office. Appendix B details compliance with cultural resources management requirements.

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40 CFR 1500, 2018, "National Environmental Policy Act (NEPA), Purpose, Policy, and Mandate," *Code of Federal Regulations*, Office of the Federal Register.

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IDAPA 58.01.11, 2014, "Ground Water Quality Rule," Idaho Administrative Procedures Act.

IDAPA 58.01.16, 2014, "Wastewater Rules," Idaho Administrative Procedures Act.

IDAPA 58.01.17, 2014, "Recycled Water Rules," Idaho Administrative Procedures Act.

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Big Lost River

3. Environmental Program Information

Racer
Coluber constrictor

The U.S. Department of Energy (DOE) is committed to protection of the environment and human health. DOE strives to be in full compliance with environmental laws, regulations, and other requirements that protect the air, water, land, and natural, archeological, and cultural resources potentially affected by operations and activities conducted at the Idaho National Laboratory (INL) Site.

DOE employs the environmental management system (EMS) modeled by the International Organization for Standardization (ISO) Standard 14001 to help establish policy, objectives, and targets at the INL Site to reduce environmental impacts and increase operating efficiency through a continuing cycle of planning, implementing, evaluating, and improving processes. The INL Site Sustainability program implements strategies and practices that will meet key DOE sustainability goals.

Sustainability accomplishments completed in 2017 included the retrofitting of an additional five buildings to meet the Guiding Principles; the significant decrease of INL Site water use intensity; increased diversion of construction and demolition waste from landfill primarily through reuse of old asphalt for road base in rebuilding a site road. There was 10 percent reduction of GHG per mile driven by fleet vehicles in 2017.

3. ENVIRONMENTAL MANAGEMENT SYSTEM

An Environmental Management System (EMS) provides a framework of elements following a plan-do-check-act cycle that when established, implemented, and maintained, will foster improved environmental performance. An EMS focuses on three core concepts: pollution prevention, environmental compliance, and continuous improvement. The primary system components are 1) environmental policy, 2) planning, 3) implementation and operation, 4) checking and corrective action, and 5) management review.

The framework U.S. Department of Energy (DOE) has chosen to employ for EMSs and sustainable practices is the International Organization for Standardization (ISO) Standard 14001 (Environmental Management Systems). The ISO 14001 model uses a system of policy development, planning, implementation and operation, checking, corrective action, and management review; ultimately, ISO 14001 aims to improve performance as the cycle repeats. The EMS must also meet the criteria of Executive Order (EO) 13693, "Planning for Federal Sustainability in the Next Decade," and DOE Order 436.1, "Departmental Sustainability," which require federal facilities to put into practice EMSs. Sites must maintain their EMS as being certified or conforming to the ISO 14001 standard in accordance with the accredited registrar provisions or self-declaration instructions. In 2015, ISO released a new standard, ISO 14001:2015 which replaced the ISO 14001:2004 standard. New EMSs and recertification of existing EMSs, required every three years, need to meet the new standard.

The two main Idaho National Laboratory (INL) Site contractors have established EMSs for their respective operations. The INL Site management and operating contractor, Battelle Energy Alliance, underwent a recertification audit in 2017 by an accredited registrar. The audit documented no nonconformities, one opportunity for improvement, and eleven system strengths. The INL now maintains an EMS in conformance with ISO 14001:2015. The INL Environmental Policy can be found at: https://www.inl.gov/wp-content/uploads/2017/11/16-50070-R4_ENV_Policy_WEB-1.pdf.

The Idaho Cleanup Project Core contractor, Fluor Idaho, LLC, underwent a certification audit in 2017 by an accredited registrar. The audit documented three minor nonconformities, seven opportunities for improvement, and eight system strengths. Fluor developed a corrective action plan and addressed the minor nonconformities. Fluor now maintains an EMS in conformance with ISO 14001:2015. The Idaho Cleanup Project Environmental

Policy can be found at: https://icphome.icp.gov/Portals/0/Documents/ESHQ/EMS/pol-201.pdf.

Through implementation of each EMS, the INL Site contractors have identified the aspects of their operations that can impact the environment and determine which of those aspects are significant. Aspects that have been identified as significant include: air emissions; discharging to surface, storm or ground water; disturbing cultural or biological resources; generating and managing waste; releasing contaminants; and using, reusing, recycling, and conserving resources.

Both INL Site contractors had effective EMS performance in 2017. The INL Site contractors completed over 90 percent of EMS objectives in fiscal year 2017. All EMS performance metrics reported at FedCenter scored either A or B (on an A to D scale). Additionally, both contractors received a FedCenter site score of green (the best) which focuses on sustainability goals outlined in EO 13693.

3.1 Sustainability

An objective of EO 13693, "Planning for Federal Sustainability in the Next Decade," is "to maintain federal leadership in sustainability and greenhouse gas emission reductions." To demonstrate federal leadership, this executive order expanded and extended the previously established agency-wide goals. DOE Order 436.1 "Departmental Sustainability" defines requirements and responsibilities for managing sustainability at DOE to ensure that the department carries out its missions in a sustainable manner including:

- Addressing national energy security and global environmental challenges;
- Advancing sustainable, efficient and reliable energy for the future;
- Instituting wholesale cultural change to factor sustainability and greenhouse gas (GHG) reductions into all DOE corporate management decisions; and
- Ensuring that DOE achieves the sustainability goals established in its Strategic Sustainability Performance Plan.

DOE Idaho Operations Office reported performance to sustainability related requirements and goals in the Fiscal Year (FY) 2018 INL Site Sustainability Plan (DOE-ID 2017), in addition to the planned strategies and activities to facilitate progress for the INL Site (Table 3-1).

The INL Site has made significant progress toward the High Performance Sustainability Building goal by retrofitting an additional five buildings to meet the Guiding Principles. These building improvements also support other goals by reducing energy and water use, as well as the generation of greenhouse gases. The INL Site will continue to focus on this area to support the DOE Complex which, although improving, is behind the pace needed to meet the 2025 performance goal.

The decrease in 2017 INL Site water use intensity (water volume used/building square foot) is notable because it exceeds past expectations with a 21.5 percent reduction relative to the 2007 baseline. This performance, currently on track to meet the 2025 reduction goal of 36 percent, is driven by past changes in water infrastructure, operations, and landscaping choices. Significant water leaks have also been repaired and water use is being monitored to detect anomalies that may indicate new leakage.

Seventy-nine percent of construction and demolition waste was diverted from landfills in 2017 which is greatly improved over previous years. The increased diversion was driven by the reuse of old asphalt for road base in rebuilding the road by the Lincoln Avenue repaving project. The reuse of asphalt and other materials will continue in 2018. The INL Site has also been successful in continuing to divert 50 percent of municipal waste from landfills through recycling programs.

The goal to reduce the GHG per mile driven by fleet vehicles by 30 percent by FY 2025 from a FY 2014 baseline was established by EO 13693. Historically, the INL Site performance to fleet related goals, i.e., petroleum use reduction and increasing alternative fuel use, have lead the DOE Complex. The GHG/mile goal will be more difficult to attain than past fleet related goals. However, through vehicle replacements, changing from biodiesel to renewable diesel, and implementing no-idle projects, GHG/mile was reduced by 10 percent in FY 2017.

Table 3-1. Summary Table of DOE-ID Sustainability Goals.

DOE Goal	Current Performance Status
Multiple Categories	
50% Scope 1 and 2 GHG emissions reduction by FY 2025 from a FY 2008 baseline.	Interim Target: -25% **Current Performance: -30%**
25% Scope 3 GHG emissions reduction by FY 2025 from a FY 2008 baseline.	Interim Target: -9% **Current Performance: -27%**
Energy Management	
25% energy intensity (Btu per gross square foot) reduction in goal-subject buildings by FY 2025 from a FY 2015 baseline.	Interim Target: -5% **Current Performance: -0.6%**
EISA Section 432 continuous (4-year cycle) energy and water evaluations.	The INL Site completed energy and water evaluations in 40 of 157 covered buildings in FY 2017. To date, 143 audits have been completed, accounting for 91% of the Idaho Site covered inventory since 2014.
Meter all individual buildings for electricity, natural gas, steam, and water, where cost-effective and appropriate.	The INL Site meters 100% of its natural gas and 65% of its electric usage at the building level.
Water Management	
36% potable water intensity (Gal per gross square foot) reduction by FY 2025 from a FY 2007 baseline.	Interim Target: -20% **Current Performance: -21%**
Waste Management	
Divert at least 50% of non-hazardous solid waste, excluding construction and demolition debris.	Interim Target: 50% **Current Performance: 50%**
Divert at least 50% of construction and demolition materials and debris.	Interim Target: 50% **Current Performance: 79%**
Fleet Management	
30% reduction in fleet-wide per-mile GHG emissions reduction by FY 2025 from a FY 2014 baseline.	Interim Target: -4% **Current Performance: -10%**
20% reduction in annual petroleum consumption by FY 2015 relative to a FY 2005 baseline; maintain 20% reduction thereafter.	Interim Target: -20% **Current Performance: -39%**
10% increase in annual alternative fuel consumption by FY 2015 relative to a FY 2005 baseline; maintain 10% increase thereafter.	Interim Target: 10% **Current Performance: 290%**
75% of light-duty vehicle acquisitions must consist of alternative fuel vehicles (AFV).	Acquired 102 new light-duty vehicles, 100% of which were AFVs or low greenhouse gas (LGHG) emitting vehicles.
50% of passenger vehicle acquisitions consist of zero emission or plug-in hybrid electric vehicles by FY 2025.	Idaho Site does not currently have any zero-emission PHEVs.
Clean and Renewable Energy	
"Clean Energy" requires that the percentage of an agency's total electric and thermal energy accounted for by renewable and alternative energy shall be not	Interim Target: 10% **Current Performance: 10%**

Table 3-1. Summary Table of DOE-ID Sustainability Goals (continued).

DOE Goal	Current Performance Status
less than 25% by FY 2025 and each year thereafter.	
"Renewable Electric Energy" requires that renewable electric energy account for not less than 30% of a total agency electric consumption by FY 2025 and each year thereafter.	Interim Target: 10% **Current Performance: 13%**
Green Buildings	
At least 17% (by building count) of existing buildings greater than 5,000 gross square feet to be compliant with the *revised* Guiding Principles for HPSB by FY 2025, with progress to 100% thereafter.	Interim Target: 15% **Current Performance: 12%**
Acquisitions and Procurement	
Promote sustainable acquisition and procurement to the maximum extent practicable, ensuring bio-preferred and bio-based provisions and clauses are included in 95% of applicable contracts.	Interim Target: 95% **Current Performance: 100%**
Electronic Stewardship	
Purchases – 95% of eligible acquisitions each year are EPEAT-registered products.	Interim Target: 95% **Current Performance: 91%**
Power management – 100% of eligible PCs, laptops, and monitors have power management enabled.	Interim Target: 100% **Current Performance: 100%**
Automatic duplexing – 100% of eligible computers and imaging equipment have automatic duplexing enabled.	Interim Target: 100% **Current Performance: 100%**
End of Life – 100% of used electronics are reused or recycled using environmentally sound disposition options each year.	Interim Target: 100% **Current Performance: 100%**
Data Center Efficiency. Establish a power usage effectiveness (PUE) target in the range of 1.2 to 1.4 for new data centers and less than 1.5 for existing data centers.	The Engineering Research Office Building (EROB) High-Performance Computing (HPC) core data center had a PUE of **1.37** in FY 2017.

REFERENCES

DOE Order 436.1, 2011, "Departmental Sustainability," U.S. Department of Energy.

DOE-ID, 2017, *FY 2018 INL Site Sustainability Plan with the FY 2017 Annual Report*, DOE/ID-11383, Rev.9, December 2017.

Executive Order 13693, 2015, "Planning for Federal Sustainability in the Next Decade," Washington, D.C.

ISO 14001:2015, "Environmental management systems – Requirements with guidance for use," International Organization for Standardization, September 15, 2015.

4. Environmental Monitoring Programs: Air

An estimated total of 1,330 Ci (4.92×10^{13} Bq) of radioactivity, primarily in the form of short-lived noble gas isotopes, was released as airborne effluents from Idaho National Laboratory (INL) Site facilities in 2017. The highest contributors to the total release were the Advanced Test Reactor Complex at 91.8 percent, the Radioactive Waste Management Complex at 5.09 percent, and Idaho Nuclear Technology and Engineering Center at 2.23 percent of total.

The INL Site environmental surveillance programs emphasize measurements of airborne contaminants in the environment because air is considered the most important transport media from the INL Site to off-Site receptors. Samples of airborne particulates, atmospheric moisture, and precipitation were collected and analyzed for radioactivity from locations on the INL Site, at INL Site boundary locations, and at distant communities.

Particulate samples were collected using a network of low-volume air samplers, and were analyzed for gross alpha activity, gross beta activity, and specific radionuclides, primarily strontium-90 (^{90}Sr), cesium-137 (^{137}Cs), plutonium-239/240 ($^{239/240}$Pu), and americium-241 (^{241}Am). Results were compared with detection levels, background measurements, historical results, and radionuclide-specific Derived Concentration Standards (DCSs) established by the U.S. Department of Energy to protect human health and the environment. Gross alpha and gross beta activities were used primarily for trend analyses and indicated that observable fluctuations correlate with seasonal variations in natural radioactivity.

Strontium-90 was not detected in any quarterly composited particulate samples collected on and off the INL Site. Americium-241 was detected in five composited samples collected during the first three quarters off the INL Site at Idaho Falls (first quarter), Jackson (first quarter), Sugar City (second quarter), Blackfoot (third quarter), and Mud Lake (third quarter). The reported ^{241}Am detections at Sugar City and Blackfoot were collected from duplicate samplers but ^{241}Am was not detected in the primary samples. The concentrations reported in these samples were near the detection limits and were within the range of historical measurement values which are well below the DCS for ^{241}Am. Plutonium-238 was detected in the duplicate Blackfoot sample (first quarter), in the Van Buren (second quarter), and in the Blackfoot and Jackson samples (third quarter). Plutonium-239/240 was detected in one sample collected during the third quarter from the Blackfoot duplicate sampler. The results were just above the detection limit, within historical measurements, and below the DCS for $^{239/240}$Pu. The concentrations of ^{241}Am, ^{238}Pu, and $^{239/240}$Pu measured in air samples are consistent with historical measurements associated with global fallout. No other human-made radionuclides were detected in the particulate samples.

Airborne particulates were collected biweekly around the perimeters of the Subsurface Disposal Area of the Radioactive Waste Management Complex and the Idaho Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Disposal Facility at the Idaho Nuclear Technology and Engineering Center. Gross alpha and gross beta activities measured on the filters were comparable with historical results, and no new trends were identified in 2017. Detections of americium and plutonium isotopes were comparable to past measurements and are likely to be the result of resuspended soils contaminated from past burial practices at the Subsurface Disposal Area. The results were below the DCSs established for those radionuclides

4. ENVIRONMENTAL MONITORING PROGRAMS: AIR

Idaho National Laboratory (INL) Site facilities have the potential to release radioactive and nonradioactive constituents. Pathway vectors, such as air, soil, plants, animals, and groundwater, may transport these constituents to nearby populations (Figure 4-1). Reviews of historical environmental data and environmental transport modeling indicate that air is a key pathway from INL Site releases to members of the general public. The ambient air monitoring network is thus a critical component of the INL Site's environmental monitoring programs. It monitors for routine and unforeseen releases, provides verification that the INL Site is in compliance with regulatory standards and limits, and can be used to assess impact to the environment over time.

This chapter presents results of radiological analyses of airborne effluents and ambient air samples collected on and off the INL Site. The results include those from the INL contractor; the Idaho Cleanup Project (ICP) Core contractor; and the Environmental Surveillance, Education, and Research Program (ESER) contractor. Table 4-1 summarizes the air monitoring activities on and off the INL Site. Details may be found in the *Idaho National Laboratory Site Environmental Monitoring Plan* (DOE-ID 2017).

4.1 Organization of Air Monitoring Programs

The INL contractor documents airborne radiological effluents at INL Site facilities in an annual report prepared in accordance with the 40 CFR 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities." Section 4.2 summarizes the emissions reported in *National Emission Standards for Hazardous Air Pollutants—Calendar Year 2017 INL Report for Radionuclides* (DOE-ID 2018). The report also documents the estimated potential dose received by the general public due to INL Site activities.

Ambient air monitoring is conducted by the INL contractor and the ESER contractor to ensure that the INL Site remains in compliance with the U.S. Department of Energy (DOE) Order 458.1, "Radiation Protection of the Public and the Environment." The INL contractor collects air samples and air moisture samples primarily on the INL Site (Figure 4-2). In 2017, the INL contractor collected approximately 2,000 air samples for

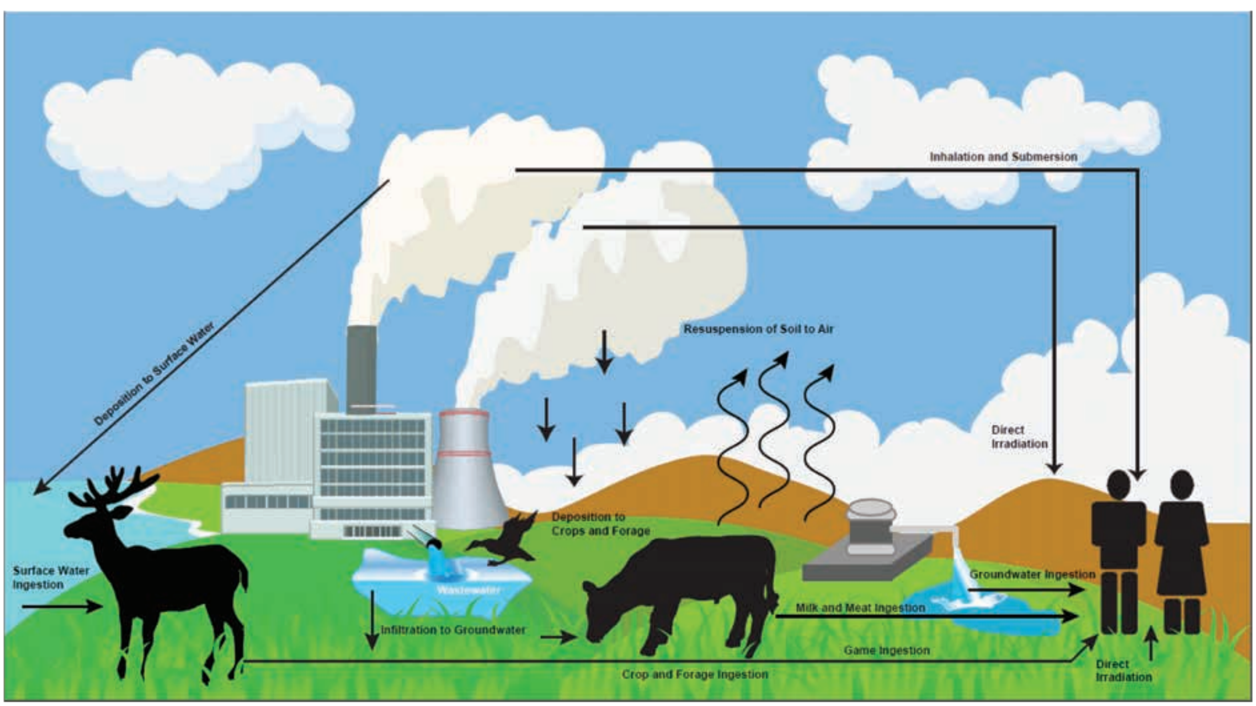


Figure 4-1. Potential Exposure Pathways to Humans from the INL Site.

Table 4-1. Air Monitoring Activities by Organization.

	Airborne Effluent Monitoring Programs	Environmental Surveillance Programs					
Area/Facility[a]	Airborne Effluents[b]	Low-volume Charcoal Cartridges (iodine-131)	Low-volume Gross Alpha	Low-volume Gross Beta	Specific Radionuclides[c]	Atmospheric Moisture	Precipitation
ICP Core Contractor[d]							
INTEC	•		•	•	•		
RWMC	•		•	•	•		
INL Contractor[e]							
MFC	•						
INL Site/Regional		•	•	•	•	•	
Environmental Surveillance, Education, and Research Program Contractor[f]							
INL Site/Regional		•	•	•	•	•	•

a. INTEC = Idaho Nuclear Technology and Engineering Center, RWMC = Radioactive Waste Management Complex, MFC = Materials and Fuels Complex.
b. Facilities that required monitoring during 2017 for compliance with 40 CFR 61, Subpart H, "National Emissions Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities."
c. Gamma-emitting radionuclides are measured by the ICP Core contractor monthly and by the ESER contractor and the INL contractor quarterly. Strontium-90, plutonium-238, plutonium-239/240, and americium-241 are measured by the INL, ICP Core, and ESER contractors quarterly.
d. The ICP Core contractor monitors waste management facilities to demonstrate compliance with DOE Order 435.1, "Radioactive Waste Management."
e. The INL contractor monitors airborne effluents at MFC and ambient air outside INL Site facilities to demonstrate compliance with DOE Order 458.1, "Radiation Protection of the Public and the Environment."
f. The ESER contractor collects samples on, around, and distant from the INL Site to demonstrate compliance with DOE Order 458.1.

various radiological analyses and air moisture samples at four sites for tritium analysis.

The ESER contractor collects air samples primarily around the INL Site encompassing a region of 23,390 km^2 (9,000 mi^2) that extends to locations near Jackson, Wyoming (Figure 4-2). In 2017, the ESER contractor collected approximately 2,000 air samples for various radionuclides. The ESER contractor also collects air moisture and precipitation samples at select locations for tritium analysis.

The ICP Core contractor monitors air around waste management facilities to comply with DOE Order 435.1, "Radioactive Waste Management." These facilities are the Subsurface Disposal Area (SDA) at the Radioactive Waste Management Complex (RWMC) and the Idaho Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Disposal Facility (ICDF) near the Idaho Nuclear Technology and Engineering Center (INTEC). These locations are shown in Figure 4-2. Section 4.4 discusses air sampling by the ICP Core contractor in support of waste management activities.

The National Oceanic and Atmospheric Administration (NOAA) has collected meteorological data at the INL Site since 1950. The data have

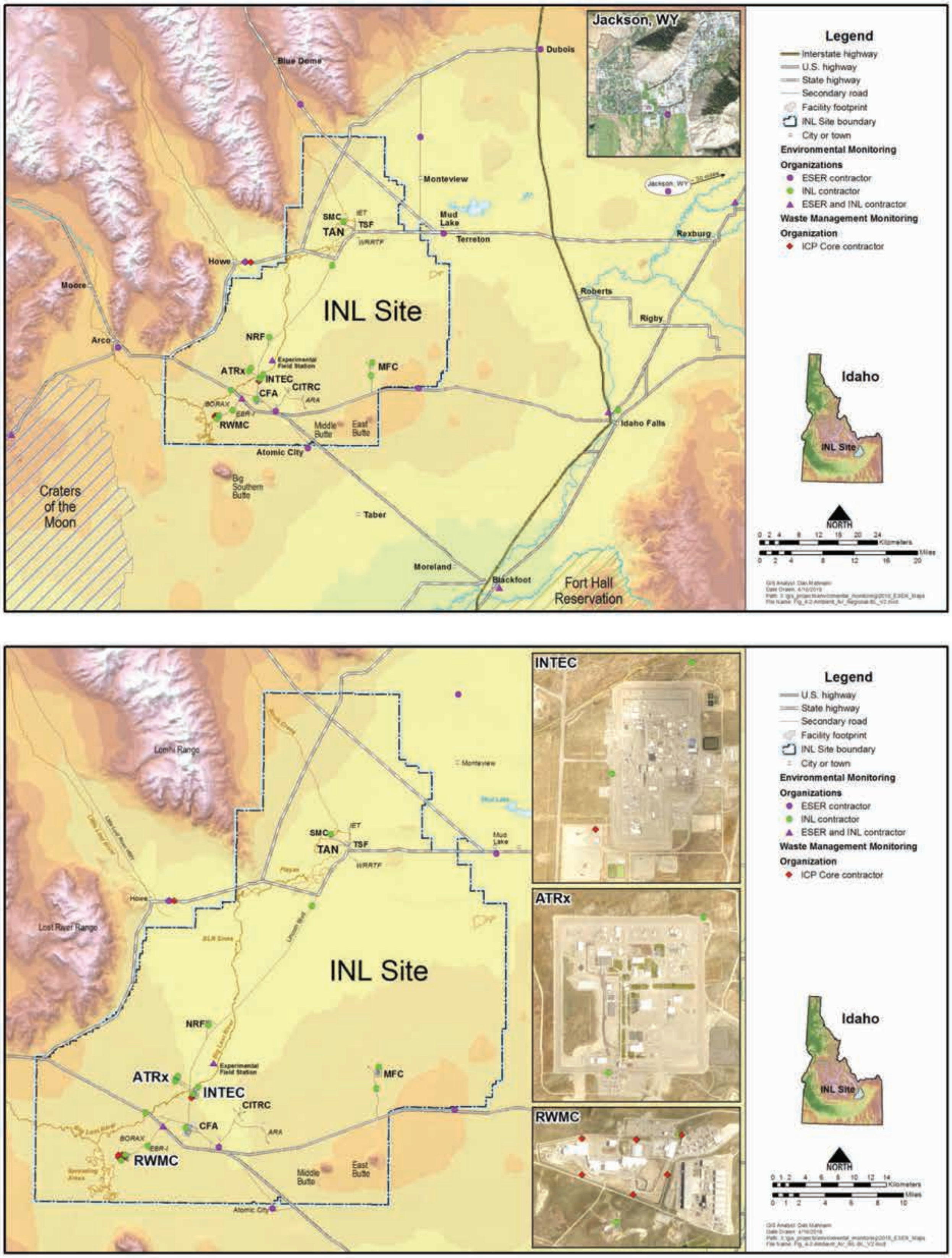


Figure 4-2. INL Site Environmental Surveillance Air Sampling Locations (regional [top] and on the INL Site [bottom]).

historically been tabulated, summarized, and reported in several climatography reports for use by scientists to evaluate atmospheric transport and dispersion. The latest report, *Climatography of the Idaho National Laboratory, 4th Edition* (Clawson et al. 2018), was prepared by the Field Research Division of the Air Resources Laboratory of NOAA and presents over 22 years (1994–2015) of quality-controlled data from the NOAA INL mesonet meteorological monitoring network (http://niwc.noaa.inel.gov/climate/INL_Climate4th_Final2.pdf). More recent data are provided by the Field Research Division to scientists modeling the dispersion of INL Site releases and resulting potential dose impact (see Chapter 8 in this annual report and *Meteorological Monitoring*, a supplement to this annual report).

4.2 Airborne Effluent Monitoring

Each regulated INL Site facility determines airborne effluent concentrations from its regulated emission sources as required under state and federal regulations. Radiological air emissions from INL Site facilities are also used to estimate the potential dose to a hypothetical maximally exposed individual (MEI), who is a member of the public (see Chapter 8 of this report). Radiological effluents and the resulting potential dose for 2017 are reported in *National Emission Standards for Hazardous Air Pollutants—Calendar Year 2017 INL Report for Radionuclides* (DOE-ID 2018), referred to hereafter as the National Emission Standards for Hazardous Air Pollutants (NESHAP) Report.

The NESHAP Report describes three categories of airborne emissions:

- Sources that require continuous monitoring under the NESHAPs regulation: these are primarily stacks at the Advanced Test Reactor (ATR) Complex, the Materials and Fuels Complex (MFC), the Advanced Mixed Waste Treatment Project (AMWTP), and INTEC
- Releases from all other point sources (stacks and exhaust vents)
- Nonpoint—or diffuse—sources, otherwise referred to as fugitive sources, which include radioactive waste ponds, buried waste, contaminated soil areas, and decontamination and decommissioning operations.

INL Site emissions include all three airborne emission categories and are summarized in Table 4-2. The radionuclides included in this table were selected because they contribute 99.9 percent of the cumulative dose to the MEI estimated for each facility area. During 2017, an estimated 1,330 Ci (4.92×10^{13} Bq) of radioactivity were released to the atmosphere from all INL Site sources. The 2017 release is within the range of releases from previous years and is consistent with the continued downward trend observed over the past 10 years. For example, reported releases for 2005, 2010, and 2015 were 6,614 Ci, 4,320 Ci, and 1,870 Ci, respectively.

The following facilities were contributors to the total emissions (Figure 4-3):

- ***ATR Complex Emissions Sources (91.8 percent of total INL Site source term)*** – Radiological air emissions from ATR Complex are primarily associated with ATR operations. These emissions include noble gases, iodines, and other mixed fission and activation products, but they are primarily relatively short-lived noble gases. Other radiological air emissions are associated with sample analysis, site remediation, and research and development activities. Another emission source is the INL Radioanalytical Chemistry Laboratory, in operation since 2011. Activities at the lab include inorganic and general purpose analytical chemistry and wet chemical analysis to determine trace radionuclides and higher level radionuclides. High-efficiency particulate air filtered hoods are located in the laboratory, including the radiological control room, which is used for analysis of contaminated samples.
- ***RWMC– AMWTP Emissions Sources (5.09 percent of total INL Site source term)*** – Emissions from RWMC-AMWTP result from various activities associated with the facility's mission to complete environmental cleanup of the area, as well as to store, characterize, and treat contact-handled and remote-handled transuranic waste prior to shipment to off-site licensed disposal facilities. Under the current contractor, various projects are being conducted to achieve these objectives: Waste retrieval activities at the various Accelerated Retrieval Projects (ARPs); operation of the Resource Conservation and Recovery Act (RCRA) Sludge Repackage and Debris Repackage waste processing projects; operation of the three organic contaminated vadose zone treatment units; storage of waste within the Type II storage modules at AMWTP; storage and characterization of waste at the Drum Vent and Characterization facilities; and treatment of wastes at the Transuranic Storage Area-Retrieval Enclosure.

Table 4-2. Radionuclide Composition of INL Site Airborne Effluents (2017).[a]

		Airborne Effluent (Ci)[b]								
Radionuclide[c]	Half-Life[d]	ATR Complex[e]	CFA[e]	CITRC[e]	INTEC[e]	MFC[e]	NRF[e]	RWMC[e]	TAN[e]	Total
Am-241	432.2 y	2.30E-05	4.17E-10	—[f]	5.29E-06	2.09E-06	—	2.97E-04	—	3.28E-04
Am-243	7,370 y	NS[g]	1.81E-09	—	—	2.63E-06	—	NS	—	2.63E-06
Ar-41	1.822 h	8.55E+02	NS	—	—	6.37E+00	—	—	NS	8.62E+02
Br-80m	4.42 h	—	—	—	—	—	—	—	1.34E-03	1.34E-03
Br-82	35.3 h	—	NS	—	—	—	—	—	2.72E-03	2.72E-03
C-14	5,730 y	NS	5.81E-07	—	1.01E-02	1.97E-03	5.30E-01	8.30E-02	—	6.25E-01
Cl-36	301,000 y	—	2.25E-08	—	1.84E-06	NS	—	—	NS	1.86E-06
Cm-244	18.1 y	NS	1.46E-08	—	NS	NS	—	NS	—	1.46E-08
Co-60	5.2714 y	9.44E-03	NS	—	NS	NS	3.30E-06	NS	—	9.44E-03
Cs-137	30.07 y	6.02E-03	NS	—	1.45E-04	2.62E-06	4.80E-05	NS	—	6.22E-03
Eu-152	13.537 y	9.35E-05	NS	—	NS	NS	—	—	—	9.35E-05
Eu-154	8.593 y	8.38E-05	NS	—	NS	NS	—	—	—	8.38E-05
H-3	12.33 y	3.01E+02	5.70E-01	—	2.58E+01	2.03E-01	NS	6.76E+01	3.26E-02	3.95E+02
I-125	59.408 d	1.00E-03	—	—	—	—	—	—	—	1.00E-03
I-129	15,700,000 y	NS	—	—	1.59E-03	4.58E-05	2.60E-05	—	—	1.66E-03
I-131	8.0207 d	NS	—	—	—	8.89E-02	3.80E-06	—	—	8.89E-02
K-42	12.36 h	—	NS	—	—	—	—	—	2.45E-04	2.45E-04
Kr-85	10.756 y	—	—	—	3.83E+00	NS	NS	NS	—	3.83E+00
Kr-85m	4.48 h	NS	—	—	—	7.87E-01	—	—	—	7.87E-01
Kr-87	76.3 m	8.35E+00	—	—	—	8.25E-01	—	—	—	9.18E+00
Kr-88	2.84 h	2.29E+00	—	—	—	7.50E-01	—	—	—	3.04E+00
Np-237	2,144,000 y	NS	NS	—	NS	8.21E-07	—	NS	—	8.21E-07
Pu-238	87.7 y	NS	NS	—	9.08E-07	2.88E-08	—	6.37E-05	—	6.47E-05
Pu-239	24,110 y	8.46E-06	NS	—	3.06E-06	5.01E-07	2.30E-06	1.20E-04	—	1.34E-04
Pu-240	6,563 y	NS	NS	—	8.22E-07	NS	—	1.18E-05	—	1.26E-05
Pu-242	377,300 y	NS	NS	—	—	4.45E-07	—	NS	—	4.45E-07
Rn-222	3.8235 d	—	4.96E-06	—	—	—	—	—	—	4.96E-06
Sb-125	2.7582 y	NS	—	—	NS	6.10E-05	—	NS	—	6.10E-05
Sr-90	28.79 y	2.04E-02	NS	—	1.23E-04	1.14E-06	4.80E-05	NS	1.02E-06	2.06E-02
Tc-99m	6.01 h	NS	—	1.52E-05	—	—	—	—	—	1.52E-05
U-233	159,200 y	NS	1.48E-08	—	NS	7.14E-06	—	NS	—	7.15E-06
U-234	245,500 y	NS	NS	—	NS	2.82E-07	—	NS	NS	2.82E-07
U-238	4,468,000,000 y	NS	NS	—	NS	2.41E-07	—	NS	NS	2.41E-07
Xe-135	9.14 h	1.51E+01	—	—	—	2.06E-01	—	—	—	1.53E+01

Sixteen emission point sources located at RWMC-AMWTP were reported in the 2017 NESHAP Report for Radionuclides (DOE-ID 2018), of which three of these sources are continuously monitored stacks. Monitoring of the radionuclide emissions from the CERCLA ARP facilities and WMF-1617 (ARP V) and WMF-1619 (ARP VII) is achieved with the Environmental Protection Agency (EPA)-approved ambient air monitoring program, which has been in place since 2008.

Estimates of radiological emissions from the RWMC-AMWTP sources show that transuranic radionuclides americium-241 (^{241}Am), plutonium-238 (^{238}Pu), and plutonium-239/240 ($^{239/240}Pu$) account for the majority of emissions from waste exhumation and processing activities, while releases of tritium (^{3}H) and carbon-14 (^{14}C) are associated with buried beryllium reflector blocks and operation of the organic contaminated vadose zone treatment units. Smaller releases of ^{3}H are associated with groundwater pumped from the RWMC production well.

- ***INTEC Emissions Sources (2.23 percent of total INL Site source term)*** – Radiological air emissions from INTEC are primarily associated with sources exhausted through the Main Stack, including liquid waste operations, such as the Process Equipment Waste Evaporator and the Liquid Effluent Treatment and Disposal. These radioactive emissions include both particulate and gaseous radionuclides. Other releases are associated with waste disposal in the landfill and evaporation pond operations at ICDF which is located outside the fenced

Table 4-2. Radionuclide Composition of INL Site Airborne Effluents (2017) (continued).[a]

		Airborne Effluent (Ci)[b]								
Radionuclide[c]	Half-Life[d]	ATR Complex[e]	CFA[e]	CITRC[e]	INTEC[e]	MFC[e]	NRF[e]	RWMC[e]	TAN[e]	Total
Xe-138	14.08 m	2.89E+01	—	—	—	1.27E+00	—	—	—	3.02E+01
Total Ci released[h]		1.22E+03	5.70E-01	1.52E-05	2.97E+01	1.07E+01	5.54E-01	6.77E+01	3.84E-02	1.33E+03
Dose (mrem)[i]		5.44E-03	4.98E-06	1.44E-11	8.11E-04	1.56E-05	9.72E-05	1.66E-03	1.73E-07	8.02E-03

a. Radionuclide release information provided by the INL contractor.
b. One curie (Ci) = 3.7×10^{10} becquerels (Bq).
c. Includes only those radionuclides which collectively contribute ≥ 99.9 percent of the total dose to the MEI estimated for each INL Site facility (see footnote i). Other radionuclides not shown in this table account for less than 0.1 percent of the dose estimated for each facility.
d. m = minutes, d = days, h = hours, y = years.
e. ATR = Advanced Test Reactor, CFA = Central Facilities Area, CITRC = Critical Infrastructure Test Range Complex, INTEC = Idaho Nuclear Technology and Engineering Center, MFC = Materials and Fuels Complex, NRF = Naval Reactors Facility, RWMC = Radioactive Waste Management Complex (including Advanced Mixed Waste Treatment Project), TAN = Test Area North (including Specific Manufacturing Capability and Radiological Response Training Range-Northern Test Range).
f. A long dash signifies the radionuclide was not reported to be released to the air from the facility in 2017.
g. NS = not significant. The radionuclide contribution was estimated to be < 0.1% of the total facility dose.
h. Each column total includes all radionuclides released from that specific area, including those not shown in this table, and thus may be greater than the sum of the row values.
i. The annual dose (mrem) for each facility was calculated at the location of the hypothetical MEI using estimated radionuclide releases and methodology recommended by the Environmental Protection Agency. See Chapter 8 for detail.

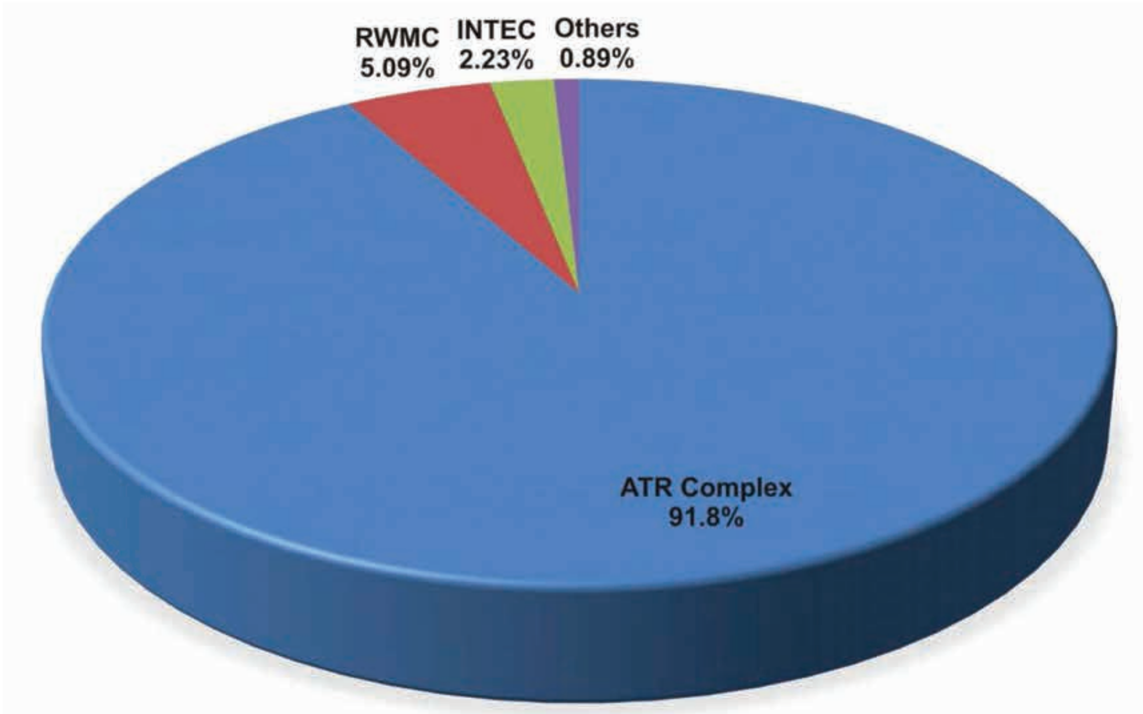


Figure 4-3. Percent Contributions in Ci, by Facility, to Total INL Site Airborne Releases (2017).

boundary of INTEC; and the Three Mile Island Unit 2 Independent Spent Fuel Storage Installation (CPP-1774). Additional radioactive emissions are associated with remote-handled transuranic and mixed waste management operations, dry storage of spent nuclear fuel, and maintenance and servicing of contaminated equipment. The marked decrease from 2016 to 2017 in radiological air emissions at INTEC is attributable to (1) adjustments made to the particulate radionuclide emissions for the Main Stack, and (2) using a revised radiological inventory for the TMI-2 fuel core assembly for emission calculations.

- ***CFA Emissions Sources (0.04 percent of total INL Site source term)*** – Minor emissions occur from CFA where work with small quantities of radioactive materials is conducted. This includes sample preparation and verification and radiochemical research and development. Other minor emissions result from groundwater usage.
- ***MFC Emissions Sources (0.80 percent of total INL Site source term)*** – Radiological air emissions at MFC are primarily associated with spent fuel treatment at the Fuel Conditioning Facility, waste characterization at the Hot Fuel Examination Facility, and fuel research and development at the Fuel Manufacturing Facility. These facilities are equipped with continuous emission monitoring systems. On a regular basis, the effluent streams from the Fuel Conditioning Facility, Hot Fuel Examination Facility, Fuel Manufacturing Facility, and other non-continuous emission monitoring radiological facilities are sampled and analyzed for particulate radionuclides. Gaseous and particulate radionuclides may also be released from other MFC facilities during laboratory research activities, sample analysis, waste handling and storage, and maintenance operations.
- ***TAN Emissions Sources (0.003 percent of total INL Site source term)*** – The main emissions sources at TAN are the SMC project, the New Pump and Treat Facility, and the nearby Northern Test Range of the Radiological Response Training Range. Radiological air emissions from the Specific Manufacturing

Capability project are associated with processing of depleted uranium. Potential emissions are uranium isotopes and associated radioactive progeny. Low levels of strontium-90 (^{90}Sr) and ^{3}H are present in the treated water from the New Pump and Treat Facility and are released to the atmosphere by the treatment process. Emissions from Radiological Response Training Range are the result of training activities such as contamination control, site characterization, and field sampling techniques for response to radiological incidents using short-lived radioactive materials.

The estimated radionuclide releases (Ci/yr) from INL Site facilities, shown in Table 4-2, were used to calculate the dose to the hypothetical MEI member of the public, who is assumed to reside near the INL Site perimeter. The estimated dose to the MEI in Calendar Year 2017 was 0.008 mrem/yr (0.0822 µSv/yr). Potential radiation doses to the public are discussed in more detail in Chapter 8 of this report. Tritium contributed to 30.3 percent of the MEI dose, followed by argon-41 (^{41}Ar) at 21.4 percent. Other main contributors to the MEI dose include ^{90}Sr (14.3 percent), iodine-129 (^{129}I) (8.7 percent), cobalt-60 (^{60}Co) (7 percent), cesium-137 (^{137}Cs) (6 percent), ^{241}Am (5.5 percent), plutonium isotopes (4.2 percent), and ^{14}C (1.6 percent). Numerous other radionuclides contributed to the remaining one percent of the total dose.

4.3 Ambient Air Monitoring

Ambient air monitoring is conducted on and off the INL Site to identify regional and historical trends, to detect accidental and unplanned releases, and to determine if air concentrations are below 10 percent of derived concentration standards (DCSs) established by DOE for inhaled air (DOE 2011). Each radionuclide-specific DCS corresponds to a dose of 100 mrem for continuous exposure during the year. The Clean Air Act NESHAP standard is 10 mrem per year (or 10 percent of 100 mrem per year).

4.3.1 Ambient Air Monitoring System Design

Figure 4-2 shows the regional and INL Site ambient air monitoring locations. A total of 37 low-volume air samplers, one high-volume air sampler, eight atmospheric moisture samplers, and three precipitation samplers operated in the network in 2017 (Table 4-3).

Historically, air samplers were positioned near INL Site facilities or sources of contamination, in predominant downwind directions from sources of radionuclide air emissions, at potential offsite receptor population centers, and at background locations. In 2015, the network was evaluated quantitatively, using atmospheric transport modeling and frequency of detection methods (Rood, Sondrup, and Ritter 2016). A Lagrangian Puff air dispersion model (CALPUFF) was used to model atmospheric transport of radionuclides released from six major facilities and predict air concentrations at each sampler location for a given release time and duration. Frequency of detection is defined as the fraction of “events” that result in a detection at either a single sampler or network. The frequency of detection methodology allowed for evaluation of short-term releases that included effects of short-term variability in meteorological conditions. Meteorological data from 2006 through 2008 were obtained from the Field Research Division of the Air Resources Laboratory of NOAA. Results showed the detection frequency was over 97.5 percent for the entire network considering all sources and radionuclides. Network intensity results (the fraction of samplers in the network that have a positive detection for a given event) ranged from 3.75 percent to 62.7 percent. Evaluation of individual samplers indicated some samplers were poorly located and added little to the overall effectiveness of the network. Using the frequency of detection methods, alternative sampler placements were simulated that could substantially improve the performance and efficiency of the network. The low-volume sampler network was optimized based on this study.

Tritium is present in air moisture due to natural production in the atmosphere and is also released by INL Site facilities (Table 4-2). Historical NESHAP data show that most tritium is released from ATR and INTEC. Tritium enters the environment as tritiated water (HTO) and behaves like water in the environment. The air monitoring network evaluation described in the previous paragraph was also used to locate atmospheric moisture samplers. The Experimental Field Station (EFS) and Van Buren Boulevard samplers are located onsite and appear to be in or near the highest projected air dispersion concentrations. Atomic City and Howe are communities that are downwind of INL Site operations and/or are situated in areas of maximum projected offsite concentrations and close to the INL Site boundary. Idaho Falls and Craters of the Moon are good offsite locations for measuring background concentrations because they do not appear to be impacted by modelled dispersion of tritium. Thus, one or two atmospheric moisture samplers are currently placed at each of six locations: Atomic City, Craters of the Moon, EFS (two samplers), Howe, Idaho Falls (two samplers), and Van Buren Boulevard. Two other samplers at Blackfoot and Sugar City were removed from the monitoring system in March 2017. Although there are more particulate air monitoring stations, additional atmospheric moisture and precipitation monitoring stations are not warranted. This is because the calculated dose for INL Site releases is less than 0.1 mrem, which is the recommended DOE limit for routine surveillance (DOE 2015).

Historical tritium concentrations in precipitation and atmospheric moisture samples collected by ESER during the 10-year period from 2007 through 2016 were compared statistically, and results indicate that there are no differences between data sets. For this reason, ESER precipitation samplers were placed at the same locations as the ESER atmospheric moisture samplers (Atomic City, EFS, Howe, and Idaho Falls). In addition, Idaho Falls can be easily and readily accessed by ESER personnel after a precipitation event. The EPA has a precipitation collector here and subsamples are collected for the ESER program. A sampler used in the past at CFA was removed from the monitoring network in March 2017.

4.3.2 Air Particulate, Radioiodine, and Tritium Sampling Methods

4.3.2.1 Air Particulates and Radioiodine

Filters are collected weekly by the INL and ESER contractors from a network of low-volume air monitors (Table 4-3). At each low-volume air sampler, a pump pulls air (about 57 L/min [2 ft^3/min]) through a 5-cm (2-in.), 1.2-µm particulate filter and a charcoal cartridge. After a five-day holding time to allow for the decay of naturally occurring radon progeny, the filters are analyzed in a laboratory for gross alpha and gross beta activity. Gross alpha and gross beta results are considered screenings because specific radionuclides are not identified. Rather, the results reflect a mix of alpha- and beta-emitting radionuclides. Gross alpha and gross beta radioactivity in air samples are dominated by the presence of naturally occurring radionuclides. Gross beta radioactivity is, with rare exceptions, detected in each air filter collected. Gross alpha activity is only occasionally detected, but it becomes more commonly detected during wildfires and temperature inversions. If the results are higher than those typically observed, sources other than background radionuclides may be suspected, and other analytical techniques can be used to identify specific radionuclides of concern. Gross alpha and gross beta activity are also examined over time and between locations to detect trends, which might indicate the need for more specific analyses.

The filters are composited quarterly by the ESER and INL contractors for laboratory analysis of gamma-emitting radionuclides, such as ^{137}Cs, which is a man-made radionuclide present in soil both on and off the INL Site due to historical INL Site activities and global fallout. The contaminated soil particles can become airborne and subsequently filtered by air samplers. Naturally occurring gamma-emitting radionuclides that are typically detected in air filters include beryllium-7 (^{7}Be) and potassium-40 (^{40}K).

The ESER and INL contractors also use a laboratory to radiochemically analyze the quarterly composited samples for selected alpha- and beta-emitting radionuclides. These radionuclides include ^{241}Am, ^{238}Pu, $^{239/240}$Pu, and ^{90}Sr. They were selected for analysis because they have been detected historically in air samples and may be present due to resuspension of surface soil particles contaminated by INL Site activities or global fallout.

4.3.2.2 Radioiodine

Charcoal cartridges are collected and analyzed weekly for iodine-131 (^{131}I) by the INL and ESER contractors. Iodine-131 is of particular interest because it is produced in relatively large quantities by nuclear

What is an inversion?

Usually within the lower atmosphere, the air temperature decreases with height above the ground. This is largely because the atmosphere is heated from below as solar radiation warms the earth's surface, which, in turn, warms the layer of the atmosphere directly above it. A meteorological inversion is a deviation from this normal vertical temperature gradient such that the temperature increases with height above the ground. A meteorological inversion is typically produced whenever radiation from the earth's surface exceeds the amount of radiation received from the sun. This commonly occurs at night or during the winter when the sun's angle is very low in the sky.

Table 4-3. INL Site Ambient Air Monitoring Summary (2017).

Medium Sampled	Type of Analysis	Frequency	Locations: Onsite INL[a]	Onsite ESER[b]	Onsite *Total*	Offsite INL[a]	Offsite ESER[b]	Offsite *Total*	Minimum Detectable Concentration (MDC)
Air (low volume)	Gross alpha	Weekly	16	3	**19**	5	13	**18**	1×10^{-15} µCi/mL
	Gross beta	Weekly	16	3	**19**	5	13	**18**	2×10^{-15} µCi/mL
	Specific gamma[c]	Quarterly	16	3	**19**	5	13	**18**	2×10^{-16} µCi/mL
	Plutonium-238	Quarterly	16	2	**18**	5	4-5	**9-10**	3.5×10^{-18} µCi/mL
	Plutonium-239/240	Quarterly	16	2	**18**	5	4-5	**9-10**	3.5×10^{-18} µCi/mL
	Americium-241	Quarterly	16	2	**18**	5	4-5	**9-10**	4.6×10^{-18} µCi/mL
	Strontium-90	Quarterly	16	2	**18**	5	4-5	**9-10**	3.4×10^{-17} µCi/mL
	Iodine-131	Weekly	16	3	**19**	5	13	**18**	1.5×10^{-15} µCi/mL
	Total particulates	Weekly	–	3	**3**	–	13	**13**	10 µg/m^3
Air (high volume)[d]	Gross beta scan	Biweekly	–	–	–	–	1	**1**	1×10^{-15} µCi/mL
	Gamma scan	Continuous	–	–	–	–	1	**1**	Not applicable
	Specific gamma[c]	Annually[e]	–	–	–	–	1	**1**	1×10^{-14} µCi/mL
	Isotopic U and Pu	Every 4 yrs	–	–	–	–	1	**1**	2×10^{-18} µCi/mL
Air (atmospheric moisture)[f]	Tritium	3–6/quarter	2	1	**3**	2	3	**5**	2×10^{-13} µCi/mL (air)
Air (precipitation)[g]	Tritium	Monthly	–	0	**0**	–	1	**1**	88 pCi/L
		Weekly	–	1	**1**	–	2	**2**	

a. Low volume air samplers are operated on the INL Site by the INL contractor at the following locations: ATR Complex (two air samplers), CFA, EBR-I, EFS, Highway 26 Rest Area, INTEC (two air samplers), Gate 4, MFC (two air samplers), NRF, RWMC (two air samplers), SMC, and Van Buren. In addition, there are two rotating duplicate samplers for QA. In 2017, they were at RWMC and INTEC. The INL contractor also samples offsite (i.e., outside INL Site boundaries) at Blackfoot, Craters of the Moon, Idaho Falls, IRC, and Sugar City. (ATR = Advanced Test Reactor; CFA = Central Facilities Area; EBR-I = Experimental Breeder Reactor-1; EFS = Experimental Field Station, INTEC = Idaho Nuclear Technology and Engineering Center; IRC = INL Research Center; MFC = Materials and Fuels Complex; NRF = Naval Reactors Facility; RWMC = Radioactive Waste Management Complex; SMC = Specific Manufacturing Capability)

b. The ESER contractor operates low volume samplers on the INL Site at Main Gate, EFS, and Van Buren. Offsite locations include Arco, Atomic City, Blackfoot, Blue Dome, Craters of the Moon, Dubois, FAA Tower, Howe, Idaho Falls, Jackson (WY), Monteview, Mud Lake, and Sugar City. In addition, there are two rotating duplicate samplers for quality assurance. In 2017, these were placed at Blackfoot and Sugar City.

c. The minimum detectable concentration shown is for cesium-137.

d. The EPA RadNet stationary monitor at Idaho Falls runs 24 hours a day, seven days a week, and sends near-real-time measurements of gamma radiation to EPA's National Analytical Radiation Environmental Laboratory (NAREL). Filters are collected by ESER personnel for the EPA RadNet program and sent to NAREL. Data are reported by the EPA's RadNet at http://www.epa.gov/radnet/radnet-databases-and-reports.

e. If gross beta activity is greater than 1 pCi/m^3, then a gamma scan is performed at NAREL. Otherwise an annual composite is analyzed.

f. Atmospheric moisture samples are currently collected onsite at EFS by ESER and INL and at Van Buren Boulevard by INL. Samples are collected offsite at Atomic City by ESER, at Craters of the Moon by INL, at Howe by ESER, and at Idaho Falls by ESER and INL. Stations historically located at Blackfoot and Sugar City were removed on March 22, 2017 and are not included in the tabulation.

g. Precipitation samples are currently collected onsite at EFS. Samples are collected offsite at Atomic City, Howe, and Idaho Falls (also used as the EPA RadNet location). A station historically located at CFA was removed on 3/22/17 and are not included in the tabulation.

fission, is readily accumulated in human and animal thyroids, and has a half-life of eight days. This means that any elevated level of ^{131}I in the environment could be from a recent release of fission products.

4.3.2.3 Tritium

The ESER and INL contractors monitor tritium in atmospheric water vapor in ambient air on the INL Site at the EFS and Van Buren Boulevard, and off the INL Site at Atomic City, Howe, Craters of the Moon, and Idaho Falls. Air passes through a column of molecular sieve, which is an adsorbent material that adsorbs water vapor in the air. The molecular sieve is sent to a laboratory for analysis when the material has adsorbed sufficient moisture to obtain a sample. The laboratory extracts water from the material by distillation and determines tritium concentrations through liquid scintillation counting.

Precipitation samples are collected by the ESER contractor at Atomic City, EFS, Howe, and Idaho Falls and analyzed for tritium using liquid scintillation counting in a laboratory.

4.3.3 Ambient Air Monitoring Results

Gaseous Radioiodines – The INL contractor collected and analyzed approximately 1,200 charcoal cartridges (blanks and duplicates are in this count) in 2017. There were no statistically positive measurements of ^{131}I. During 2017, the ESER contractor analyzed 1,040 cartridges (including blanks and duplicate samples), usually in batches of 10 cartridges, looking specifically for ^{131}I. Analyses of cartridges found no detectable ^{131}I.

Gross Activity – Gross alpha and gross beta results cannot provide concentrations of specific radionuclides. Because these radioactivity measurements include naturally occurring radionuclides (such as ^{40}K, ^{7}Be, uranium, thorium, and the daughter isotopes of uranium and thorium) in uncertain proportions, a meaningful limit cannot be adopted or constructed. However, elevated gross alpha and gross beta results can be used to indicate a potential problem, such as an unplanned release, on a timely basis. Weekly results are reviewed for changes in patterns between locations and groups (i.e., onsite, boundary, and offsite locations) and for unusually elevated results. Anomalies are further investigated by reviewing sample or laboratory issues, meteorological events (e.g., inversions), and INL Site activities that are possibly related. If indicated, analyses for specific radionuclides may be performed. The data also provide useful information for trending of the total activity over time.

The concentrations of gross alpha and gross beta radioactivity detected by ambient air monitoring conducted by INL and ESER contractors are summarized in Tables 4-4 and 4-5. (Note that the ESER contractor collects 52 weekly samples per year, whereas the INL contractor collects 51 samples per year – 50 times weekly and once biweekly over the Christmas holiday.) Results are discussed further below.

- ***Gross Alpha.*** Gross alpha concentrations measured on a weekly basis in individual air samples ranged from a low of $(-0.56 \pm 0.53) \times 10^{-15}$ µCi/mL collected by the INL contractor at the Experimental Breeder Reactor-1 on April 19, 2017, to a high of (10.3 ± 2) x 10^{-15} µCi/mL collected by the INL contractor at Sugar City on September 6, 2017 (Table 4-4). The maximum result is attributed to naturally occurring gross alpha activity in smoke particles from regional wildfires. The region on and around the INL Site was very smoky due to wildfires from the beginning of August through the first part of September. Analyses of airborne particulates during fires at Los Alamos show that smoke includes resuspended radon decay products that had been accumulating for many years on vegetation and litter that have burned (Eberhart 2010). According to this study, radon-222 decay products are virtually always detected by gross alpha activity (polonium-210). The maximum result measured at Sugar City was lower than the maximum concentration (12.2×10^{-15} µCi/mL) reported in previous Annual Site Environmental Reports from 2007–2016. The past measurement was attributed to mechanical disturbance of previously contaminated road materials.

  The median annual gross alpha concentrations were typical of previous measurements. The maximum result is less than the DCS (DOE 2011) of 3.4×10^{-14} µCi/mL for $^{239/240}Pu$ (see Table A-2 of Appendix A), which is the most conservative specific radionuclide DCS that could, although unrealistically, be applied to gross alpha activity.

- ***Gross Beta.*** Weekly gross beta concentrations measured in air samples ranged from a low of $(1.8 \pm 5.3) \times 10^{-16}$ µCi/mL at Sugar City, collected by the INL contractor on September 27, 2017, to a high of $(6.7 \pm 0.11) \times 10^{-14}$ µCi/mL, collected by the ESER contractor at EFS on December 19, 2017 (Table 4-5).

Table 4-4. Median Gross Alpha Concentrations in Ambient Air Samples Collected in 2017.

Group	Location[a]	No. of Samples[b]	Range of Concentrations[c] ($\times 10^{-15}$ µCi/mL)	Annual Median Concentration ($\times 10^{-15}$ µCi/mL)
ESER Contractor				
Distant	Blackfoot	52	0.32 – 3.0	1.1
	Craters of the Moon	51	0.29 – 4.9	0.9
	Dubois	52	0.33 – 4.9	1.1
	Idaho Falls	52	0.36 – 4.9	1.5
	Jackson	52	0.37 – 3.4	1.0
	Sugar City	52	0.30 – 3.2	1.0
			Distant Median:	1.1
Boundary	Arco	52	0.39 – 4.6	1.1
	Atomic City	52	0.15 – 4.5	1.2
	Blue Dome	52	0.23 – 4.6	1.2
	FAA Tower	52	0.10 – 4.8	1.6
	Howe	52	0.48 – 5.7	1.8
	Monteview	50	0.43 – 5.0	2.3
	Mud Lake	52	0.46 – 4.0	1.2
			Boundary Median:	1.3
INL Site	EFS	52	0.21 – 5.0	1.0
	Main Gate	52	0.37 – 4.7	1.0
	Van Buren	52	0.33 – 4.3	1.1
			INL Site Median:	1.0
INL Contractor				
Distant	Blackfoot	51	-0.19 – 4.3	1.2
	Craters of the Moon	51	-0.35 – 7.5	1.0
	Idaho Falls	51	-0.12 – 6.7	1.0
	IRC[d]	51	-0.51 – 6.2	1.1
	Sugar City	50	-0.47 – 10.3	1.4
			Distant Median:	1.2
INL Site	ATR Complex (south side)	51	-0.40 – 9.2	1.2
	ATR Complex (NE corner)	51	-0.38 – 9.1	1.3
	Highway 26 Rest Area	51	-0.37 – 9.1	0.9
	CFA	51	-0.39 – 6.2	1.2
	EBR-I	48	-0.56 – 4.6	1.1
	EFS	49	-0.48 – 3.9	1.1
	Gate 4	51	-0.36 – 4.8	1.2
	INTEC (NE corner)	51	-0.42 – 8.5	1.2
	INTEC (west side)	50	-0.34 – 6.8	1.3
	MFC (North)	51	-0.48 – 7.9	1.3
	MFC (South)	51	0.39 – 4.9	1.2
	NRF	49	-0.22 – 8.8	1.1
	RWMC	51	-0.34 – 7.9	1.0
	RWMC (South)	49	-0.43 – 8.1	1.2

Table 4-4. Median Gross Alpha Concentrations in Ambient Air Samples Collected in 2017 (continued).

Group	Location[a]	No. of Samples[b]	Range of Concentrations[c] ($\times 10^{-15}$ µCi/mL)	Annual Median Concentration ($\times 10^{-15}$ µCi/mL)
	Van Buren Boulevard	50	-0.17 – 6.6	1.1
			INL Site Median:	1.2

a. ATR = Advanced Test Reactor Complex, CFA = Central Facilities Area, EBR-I = Experimental Breeder Reactor No. 1, EFS = Experimental Field Station, FAA = Federal Aviation Administration, INTEC = Idaho Nuclear Technology and Engineering Center, IRC = INL Research Center, MFC = Materials and Fuels Complex, NRF = Naval Reactors Facility, RWMC = Radioactive Waste Management Complex, SMC = Specific Manufacturing Capability. See Figure 4-2 for locations on INL Site.
b. Includes valid (i.e., sufficient volume) samples only. Does not include duplicate measurements which are made for quality assurance purposes.
c. All measurements made by INL and ESER contractors, with the exception of duplicate measurements made for quality assurance purposes, are included in this table and in computation of median annual values. A negative result indicates that the measurement was less than the laboratory background measurement. See Table 4-3.
d. IRC is an in-town (Idaho Falls) facility within the Research and Education Campus.

Table 4-5. Median Annual Gross Beta Concentrations in Ambient Air Samples Collected in 2017.

Group	Location[a]	No. of Samples[b]	Range of Concentrations[c] ($\times 10^{-14}$ µCi/mL)	Annual Median Concentration[c] ($\times 10^{-14}$ µCi/mL)
ESER Contractor				
Distant	Blackfoot	52	0.82 – 4.4	1.9
	Craters of the Moon	51	0.96 – 4.4	1.9
	Dubois	52	0.81 – 5.1	2.0
	Idaho Falls	52	0.91 – 4.6	1.9
	Jackson	52	0.89 – 4.0	1.9
	Sugar City	52	0.83 – 3.9	1.8
			Distant Median:	1.9
Boundary	Arco	52	0.86 – 5.3	2.0
	Atomic City	52	0.97 – 5.0	2.0
	Blue Dome	52	0.81 – 3.9	1.9
	FAA Tower	52	0.96 – 5.0	2.0
	Howe	52	0.88 – 6.0	2.0
	Monteview	50	0.77 – 5.1	2.0
	Mud Lake	52	0.87 – 5.7	2.1
			Boundary Median:	2.0
INL Site	EFS	52	0.74 – 6.7	2.0
	Main Gate	52	0.89 – 5.8	2.1
	Van Buren	52	1.2 – 5.6	2.1
			INL Site Median:	2.0
INL Contractor				
Distant	Blackfoot	51	1.10 – 4.9	2.1
	Craters of the Moon	51	0.86 – 4.3	2.1
	Idaho Falls	51	0.95 – 4.5	2.2
	IRC[d]	51	0.79 – 4.2	2.0
	Sugar City	50	0.018 – 5.1	2.1
			Distant Median:	2.1

Table 4-5. Median Annual Gross Beta Concentrations in Ambient Air Samples Collected in 2017 (continued).

Group	Location[a]	No. of Samples[b]	Range of Concentrations[c] ($\times 10^{-14}$ µCi/mL)	Annual Median Concentration[c] ($\times 10^{-14}$ µCi/mL)
INL Site	ATR Complex (south side)	51	1.2 – 6.6	2.3
	ATR Complex (NE corner)	51	0.92 – 5.9	2.3
	Highway 26 Rest Area	51	1.2 – 6.1	2.3
	CFA	51	1.1 – 5.5	2.3
	EBR-I	**48**	**0.96– 5.5**	**2.1**
	EFS	49	0.93 – 5.9	2.4
	Gate 4	51	0.79 – 5.9	2.2
	INTEC (NE corner)	51	0.98 – 5.5	2.2
	INTEC (west side)	50	0.86 – 5.1	2.2
	MFC (North)	51	0.67 – 4.9	2.1
	MFC (South)	51	0.82 – 4.3	2.1
	NRF	49	0.85 – 5.6	2.2
	RWMC	51	1.1 – 4.7	2.3
	RWMC (South)	49	0.98 – 5.3	2.2
	SMC	51	0.90 – 6.2	2.3
	Van Buren Boulevard	50	1.1 – 5.1	2.2
			INL Site Median:	2.2

a. ATR = Advanced Test Reactor Complex, CFA = Central Facilities Area, EBR-I = Experimental Breeder Reactor No. 1, EFS = Experimental Field Station, FAA= Federal Aviation Administration, INTEC = Idaho Nuclear Technology and Engineering Center, IRC = INL Research Center, MFC = Materials and Fuels Complex, NRF = Naval Reactors Facility, RWMC = Radioactive Waste Management Complex, SMC = Specific Manufacturing Capability

b. Includes valid (i.e., sufficient volume) samples only. Does not include duplicate measurements which are made for quality assurance purposes.

c. All measurements made by INL and ESER contractors, with the exception of duplicate measurements made for quality assurance purposes, are included in this table and in computation of median annual values. A negative result indicates that the measurement was less than the laboratory background measurement. See Table 4-3.

d. IRC is an in-town (Idaho Falls) facility within the Research and Education Campus.

All results were below the maximum concentration of 1.3×10^{-13} µCi/mL reported in previous Annual Site Environmental Reports (2007–2016). In general, median airborne radioactivity levels for the three groups (INL Site, boundary, and distant locations) tracked each other closely throughout the year. The typical temporal fluctuations for natural gross beta concentrations in air were observed, with higher values usually occurring at the beginning and end of the calendar year during winter inversion conditions (see sidebar). This pattern occurs over the entire sampling network, is representative of natural conditions, and is not caused by a localized source, such as a facility or activity at the INL Site. An inversion can lead to natural radionuclides being trapped close to the ground. In 2017, the most prominent inversion periods occurred in January, November, and December. The maximum weekly gross beta concentration is significantly below the DCS of 2.5×10^{-11} µCi/mL (see Table A-2 of Appendix A) for the most restrictive beta-emitting radionuclide in air, ^{90}Sr.

- ***Gross Activity Statistical Comparisons.*** Statistical comparisons were made using the gross alpha and gross beta radioactivity data collected by the ESER contractor from the INL Site, boundary, and distant locations (see the supplemental report, Statistical Methods Used in the Idaho National Laboratory Annual Site Environmental Report, for a description of methods used). If the INL Site were a significant source of offsite contamination, contaminant concentrations would be statistically greater at boundary locations than at distant locations. For these analyses, uncensored analytical results (i.e., values less than their analysis-specific minimum detectable concentrations) were included. There were no statistical differences between annual concentrations collected from the INL Site, boundary, and distant locations in 2017. There were a few statistical differences between weekly boundary and distant data sets collected by the ESER contractor during the 52 weeks of 2017 that can be attributed to expected statistical variation in the data and not to INL Site releases. Quarterly reports detailing these analyses are provided at www.idahoeser.com/Publications.htm#Quarterly.

The INL Contractor compared gross beta concentrations from samples collected at onsite and offsite locations. Statistical evaluation revealed no significant differences between onsite and offsite concentrations. Onsite and offsite mean concentrations ($2.4 \pm 0.3 \times 10^{-14}$ and $2.1 \pm 0.3 \times 10^{-14}$ µCi/mL, respectively) showed equivalence at one sigma uncertainty and are attributable to natural data variation.

Specific Radionuclides – The INL contractor reported no detections of any specific human-made radionuclide in any of the 84 quarterly composited air filters analyzed in 2017.

No human-made gamma-emitting radionuclide (e.g., ^{137}Cs) was detected in any of the 72 composited samples submitted by the ESER contractor for gamma analysis in 2017. The ESER contractor also reported no detections of ^{90}Sr in any of the 26 quarterly composited samples analyzed for ^{90}Sr in 2017.

Americium-241 was reported as detected in five of the 26 quarterly composites collected by the ESER contractor in 2017 (Table 4-6). Two of the samples were duplicates collected at Sugar City (second quarter) and Blackfoot (third quarter). Americium-241 was not detected in either of the primary samplers associated with these locations. The other detections at Idaho Falls (first quarter), Jackson (first quarter), and Mud Lake (third quarter) were approximately the same. The presence of this radionuclide in the environment may be attributed to historical global fallout, deposition on soil, and subsequent resuspension and may thus sometimes be detected, particularly if the detection level is low. The results were well below the DCS for ^{241}Am in air (4.1 x 10^{-14} µCi/mL). The maximum result (1.9 x 10^{-18} µCi/mL) is also less than the highest background concentration (35 x 10^{-18} µCi/mL) reported previously in the annual reports from 2007–2016.

Plutonium-239/240 was detected in one of 26 composite samples submitted to the laboratory for plutonium isotope analysis. The sample was a duplicate collected by the ESER contractor during the third quarter at Blackfoot. Plutonium-239/240 was not detected in the

Table 4-6. Human-Made Radionuclides Detected in Ambient Air Samples Collected in 2017.

Radionuclide	Result[a] (µCi/mL)	Location[b]	Group	Quarter Detected
Americium-241	$(1.9 \pm 0.58) \times 10^{-18}$	Idaho Falls	Distant	1st
	$(1.6 \pm 0.48) \times 10^{-18}$	Jackson	Distant	1st
	$(1.9 \pm 0.54) \times 10^{-18}$	Sugar City (duplicate)[c]	Distant	2nd
	$(1.3 \pm 0.42) \times 10^{-18}$	Blackfoot (duplicate)[c]	Distant	3rd
	$(1.9 \pm 0.50) \times 10^{-18}$	Mud Lake	Boundary	3rd
Plutonium-238	$(1.7 \pm 0.48) \times 10^{-18}$	Blackfoot (duplicate)	Distant	1st
	$(1.9 \pm 0.53) \times 10^{-18}$	Van Buren	INL Site	2nd
	$(2.1 \pm 0.59) \times 10^{-18}$	Blackfoot	Distant	3rd
	$(2.5 \pm 0.65) \times 10^{-18}$	Jackson	Distant	3rd
Plutonium-239/240	$(1.8 \pm 0.50) \times 10^{-18}$	Blackfoot (duplicate)[c]	Distant	3rd

a. Results $\pm 1\sigma$. Results shown are $\geq 3\sigma$.
b. Samples collected by ESER contractor. Radionuclides were not detected in any samples collected by the INL contractor.
c. Primary sample collected at same location had no detectable ^{241}Am or $^{239/240}$Pu on the filter.

primary filters collected at Blackfoot during the third quarter. Low levels of $^{239/240}Pu$ are present in soil (see Chapter 7) and thus particulates resuspended from soil into air is attributed to global fallout from past nuclear weapons testing. We can expect to occasionally detect this radionuclide, especially when detection levels are very low. The 2017 detections were all below the highest measurement (4.3 x 10^{-18} µCi/mL) reported in previous annual reports from 2007–2016 and well below the DCS for $^{239/240}Pu$ in air (3.4 x 10^{-14} µCi/mL).

Plutonium-238 was detected in four composited samples: Blackfoot (duplicate) in the first quarter, Van Buren in the second quarter, and Blackfoot and Jackson in the third quarter. All results were similar and well below the historical maximum value (33 × 10^{-18} µCi/mL) reported for the previous ten years (2007–2016). The results were also well below the DCS for ^{238}Pu in air (3.7 × 10^{-14} µCi/mL). The source of this radionuclide is most likely global fallout.

Natural ^{7}Be was detected in numerous ESER and INL contractor composite samples at concentrations consistent with past concentrations. Atmospheric ^{7}Be results from reactions of galactic cosmic rays and solar energetic particles with nitrogen and oxygen nuclei in earth's atmosphere.

4.3.4 Atmospheric Moisture Monitoring Results

During 2017, the ESER contractor collected 54 atmospheric moisture samples at six locations. Two stations (Blackfoot and Sugar City) were removed from the monitoring network after the first quarter and two other locations (EFS and Howe) were added at the end of the first quarter. The sampling design was changed to reflect modeled airborne deposition patterns (see Section 4.3.1).

Table 4-7 presents the percentage of samples that contained detectable tritium, the range of concentrations, and the mean concentration for each location. Tritium was detected in 38 ESER samples, with a high of 15.8 × 10^{-13} $\mu Ci/mL_{air}$ at Atomic City on July 5, 2017. The highest concentration of tritium detected in an atmospheric moisture sample collected since 2007 was 34 × 10^{-13} $\mu Ci/mL_{air}$ at Atomic City in 2009. The highest observed tritium concentration in a 2017 sample collected by the ESER contractor is far below the DCS for tritium in air (as hydrogen tritium oxygen) of 2.1 × 10^{-7} $\mu Ci/mL_{air}$ (see Table A-2 of Appendix A).

In 2017, the INL contractor collected 35 atmospheric moisture samples on the INL Site at EFS and Van Buren Boulevard and off the INL Site at Idaho Falls and Craters of the Moon (Table 4-7). The INL contractor results were similar to those measured in samples collected by the ESER contractor. Tritium was detected in 14 percent of the samples collected and the maximum concentration measured was 15.5 × 10^{-13} $\mu Ci/mL_{air}$ at Van Buren Boulevard on July 12, 2017. This is well below the DCS for tritium in air and below the maximum measured in 2010. Fewer detections were observed among INL samples than among ESER samples most likely because the samples were not counted as long as the ESER samples were, resulting in higher detection levels.

The source of tritium measured in atmospheric moisture samples collected on and around the INL Site is probably of cosmogenic origin (see Section 4.3.5). Tritium releases from non-fugitive sources, such as the ATR, are highly localized and although might be detected immediately adjacent to the facility are unlikely to be detected at current air monitoring stations due to atmospheric dispersion.

4.3.5 Precipitation Monitoring Results

Tritium exists in the global atmosphere primarily from nuclear weapons testing and from natural production in the upper atmosphere by the interaction of galactic cosmic rays with nitrogen and can be detected in precipitation. Since the Nuclear Test Ban Treaty in 1963, the level of tritium measured in precipitation has been steadily decreasing due to radioactive decay and dilution in the world oceans. The International Atomic Energy Agency has participated in surveying tritium composition in precipitation around the globe since 1961 (www-naweb.iaea.org/napc/ih/IHS_resources_gnip.html). Long-term data suggest that tritium levels in precipitation are close to their pre-nuclear test values (Cauquoin et al. 2015). The tritium measured in precipitation at the INL Site is thus most likely cosmogenic in origin and not from weapons testing.

The ESER contractor collects precipitation samples weekly, when available, at Atomic City, EFS, and Howe. Precipitation is collected monthly at Idaho Falls for the EPA RadNet monitoring (https://www.epa.gov/radnet) and a subsample is taken for the ESER contractor for analysis. Monthly samples were also collected at CFA during the first quarter of 2017 and then discontinued. In addition, stations were added at EFS and Howe after the

Table 4-7. Tritium Concentrations[a] in Atmospheric Moisture Samples Collected On and Off the INL Site in 2017.

ESER Contractor	Atomic City	Blackfoot[b]	EFS[c]	Howe[d]	Idaho Falls	Sugar City[e]
Number of samples	12	2	11	12	15	2
Number of detections	8	2	10	7	9	2
Detection percentage	73%	100%	91%	64%	64%	100%
Concentration range ($\times 10^{-13}$ µCi/mL$_{air}$)[f]	-5.7 ± 1.7 – 15.8 ± 2.1	4.0 ± 0.97 – 4.9 ± 0.93	1.4 ± 1.0 – 13 ± 1.3	-0.34 ± 0.58 – 5.3 ± 0.9	-23.0 ± 4.1 – 10.7 ± 2.2	2.6 ± 0.67 – 6.8 ± 0.90
Mean concentration ($\times 10^{-13}$ µCi/mL$_{air}$)[f]	5.7	4.4	8.4	2.2	3.2	4.7
Median concentration ($\times 10^{-13}$ µCi/mL$_{air}$)	5.2	4.4	9.4	2.3	5.5	4.7
Average detection level ($\times 10^{-13}$ µCi/mL$_{air}$)	5.1	3.5	3.9	2.4	5.9	2.8

INL Contractor	Craters of the Moon	EFS	Idaho Falls	Van Buren
Number of samples	7	9	8	11
Number of detections	0	3	0	2
Detection percentage	0%	33%	0%	18%
Concentration range ($\times 10^{-13}$ µCi/mL$_{air}$)[f]	-2.2 ± 1.8 – 5.6 ± 2.6	0.4 ± 3.0 – 15.4 ± 3.5	-1.6 ± 2.3 – 10.7 ± 5.5	-1.2 ± 2.8 – 15.5 ± 4.4
Mean concentration ($\times 10^{-13}$ µCi/mL$_{air}$)[f]	2.2	6.8	2.7	5.3
Median concentration ($\times 10^{-13}$ µCi/mL$_{air}$)	2.4	5.7	2.6	2.5
Average detection level ($\times 10^{-13}$ µCi/mL$_{air}$)	6.6	9.3	10.3	10.2

a. Results ± 1σ.
b. Sampling at Blackfoot was discontinued on 3/22/17.
c. Sampling at EFS by the ESER contractor began on 3/22/17.
d. Sampling at Howe began on 3/22/17
e. Sampling at Sugar City was discontinued on 3/22/17.

first quarter. The changes in stations were made to better reflect modeled airborne dispersion patterns (see Section 4.3.1).

A total of 74 precipitation samples were collected during 2017 from the five sites. Tritium was detected in 30 samples, and detectable results ranged from 72 pCi/L to 232 pCi/L at EFS during February. Most detections were near the approximate detection level of 89 pCi/L. Table 4-8 shows the percentage of detections, the concentration range, and the mean concentration for each location. The highest concentration is well below the DCS level for tritium in water of 1.9 x 10^6 pCi/L and within the historical range (-62.1 – 413 pCi/L) measured from 2007–2016, as reported in the previous annual reports.

The results were also comparable with tritium concentrations reported by EPA for precipitation during the 10-year period from 2002–2011 (measurements were

Table 4-8. Tritium Concentrations in Precipitation Samples Collected by ESER in 2017.[a,b]

	Atomic City[c]	Central Facilities Area[d]	Experimental Field Station	Howe[e]	Idaho Falls
Number of samples	17	4	22	20	11
Number of detections	8	3	13	3	3
Detection percentage	47%	75%	59%	15%	27%
Concentration range (pCi/L)	-11.4 ± 22.8 – 207 ± 25.5	50.7 ± 24.3 – 192 ± 26.7	-24.1 ± 22.9 – 232 ± 25.8	-34.1 ± 22.8 – 116 ± 23.9	-72.0 ± 23.9 – 126 ± 23.3
Mean concentration (pCi/L)	64.3	121.9	69.5	45.1	43.2
Median concentration (pCi/L)	52.7	122.5	87.5	54.7	60.5
Average detection level (pCi/L)	89	89	89	89	89

a. Results ± 1σ.
b. All measurements are included in this table and in computation of mean annual values. A negative result indicates that the measurement was less than the laboratory background measurement.
c. Sampling at Atomic City began on 4/5/17.
d. Sampling at Central Facilities Area was discontinued on 3/22/17.
e. Sampling at Howe began on 3/29/17.

discontinued after 2011), based on a query of available data (https://iaspub.epa.gov/enviro/erams_query_v2.simple_query). Concentrations reported by EPA for Idaho Falls during that period ranged from 0-1720 pCi/L and averaged 35.1 pCi/L.

Annual tritium concentrations in atmospheric moisture and precipitation have no discernable statistical distribution, so nonparametric statistical methods were used to assess both sets of data (see Statistical Methods Used in the Idaho National Laboratory Annual Site Environmental Report, a supplement to this annual report.) To summarize the results, box plots were constructed of annual tritium concentrations measured in atmospheric moisture (as water) and precipitation samples collected by the ESER Program for the past 10 years (Figure 4-4). The results appear to be similar for each year. A statistical comparison of both sets of data (using the nonparametric Wilcoxon Matched Pairs Test) shows that there are no differences between median annual tritium concentrations measured in atmospheric moisture and in precipitation samples. Because low levels of tritium exist in the environment at all times as a result of cosmic ray reactions with water molecules in the upper atmosphere and because tritium concentrations do not appear to differ between precipitation and atmospheric moisture samples, the source of tritium measured in precipitation and atmospheric moisture is most likely of natural origin and not from INL Site releases.

4.3.6 Suspended Particulates Monitoring Results

In 2017, the ESER contractor measured concentrations of suspended particulates using filters collected from the low-volume air samplers. The filters are 99 percent efficient for collection of particles greater than 0.3 μm in diameter. That is, they collect the total particulate load greater than 0.3 μm in diameter.

In general, particulate concentrations were highest during the period from the end of June through mid-September. This was most likely influenced by smoke from regional wildfires observed at all locations from the end of July through the first week of September, as well as from agricultural activities off the INL Site which resulted in increased dust loads.

The particulate concentrations of all locations (excluding Jackson, which was not affected by agricultural activities or wildfires near the INL Site) were determined to be log-normally distributed. The geometric mean of these measurements during 2017 was therefore calculated to be 10.7 $\mu g/m^3$.

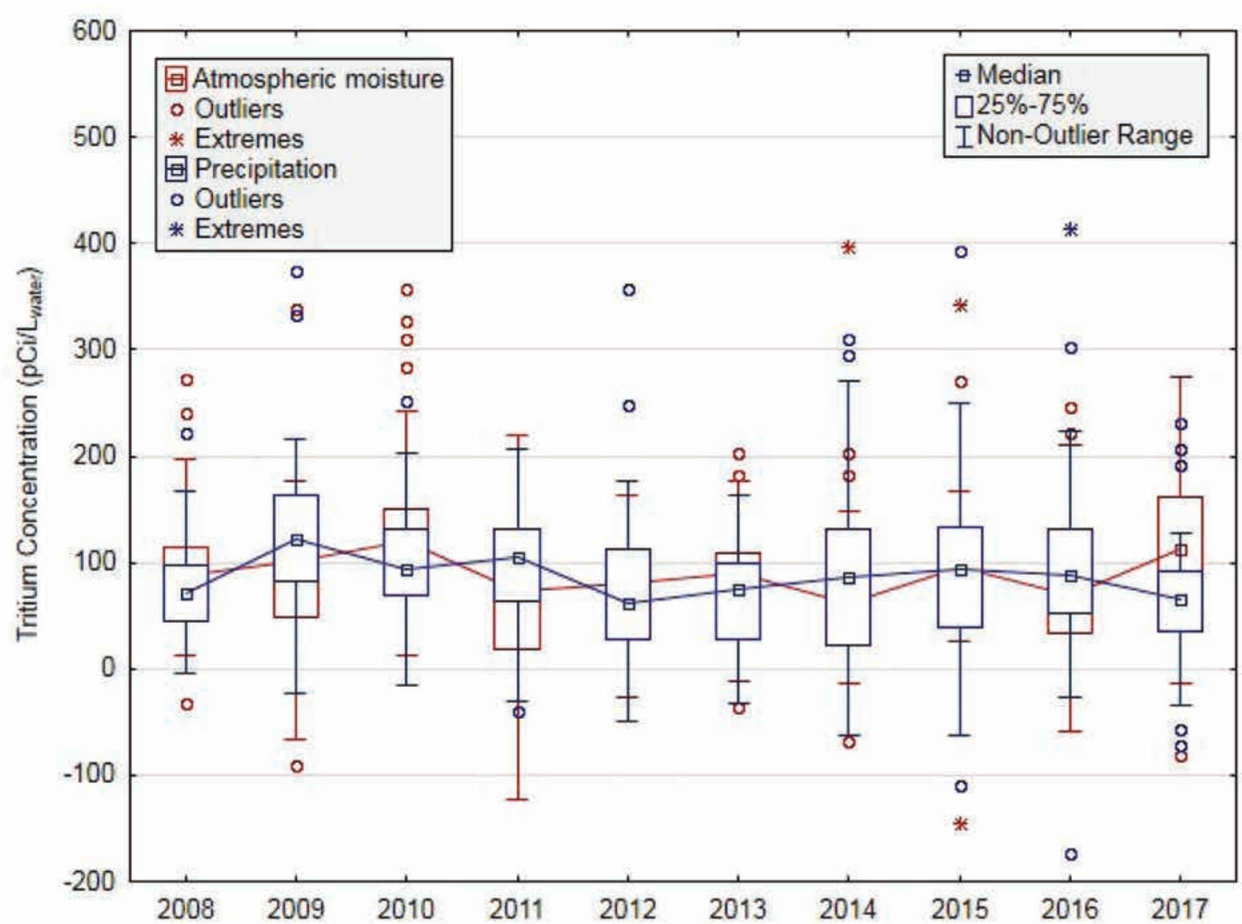


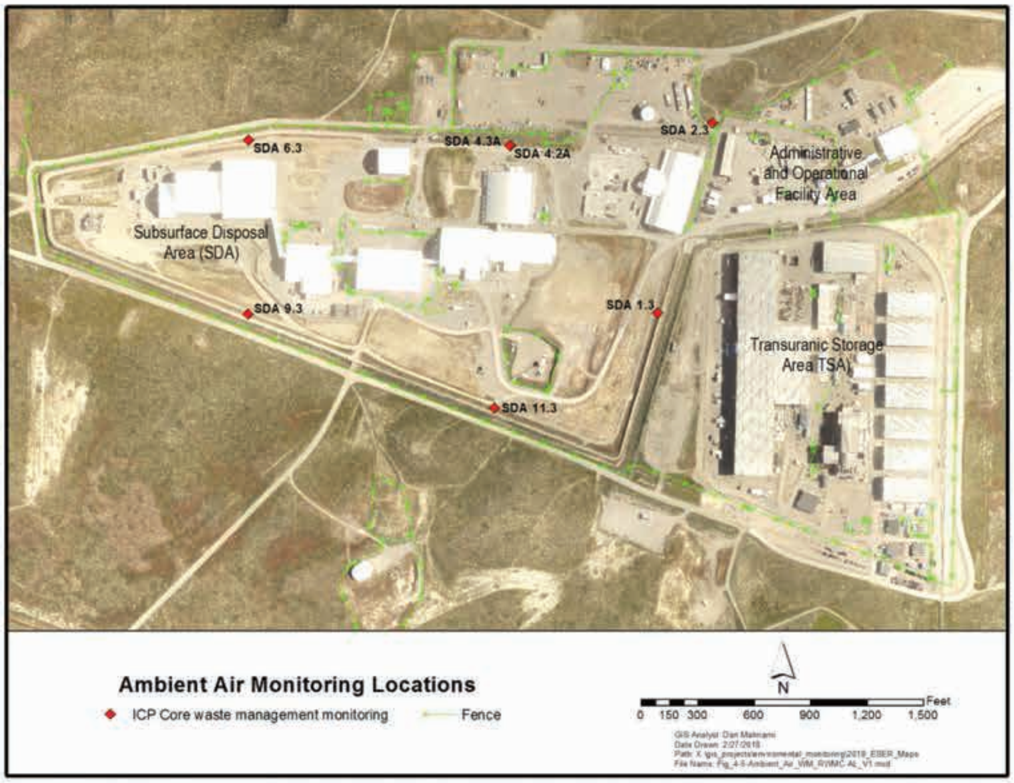
Figure 4-4. Box Plots of Tritium Concentrations Measured in Atmospheric Moisture and in Precipitation from 2008–2017.

4.4 Waste Management Environmental Surveillance Air Monitoring

4.4.1 Gross Activity

The ICP Core contractor conducts environmental surveillance in and around waste management facilities to comply with DOE Order 435.1, "Radioactive Waste Management." Currently, ICP Core waste management operations are performed at the SDA at RWMC and the ICDF at INTEC. These operations have the potential to emit radioactive airborne particulates. The ICP Core contractor collected samples of airborne particulate material from the perimeters of these waste management areas in 2017 (Figure 4-5). Samples were also collected at a control location at Howe, Idaho (Figure 4-2), to compare with the results of the SDA and ICDF.

Samples were obtained using suspended particulate monitors similar to those used by the INL and ESER contractors. The air filters are 4 in. in diameter and are changed out on the closest working day to the first and 15th of each month. Gross alpha and gross beta activity were determined on all suspended particulate samples. Table 4-9 shows the median annual and range of gross alpha concentrations at each location. Gross alpha concentrations ranged from a low of $(0.36 \pm 0.22) \times 10^{-15}$ µCi/mL collected at location SDA 6.3 on March 1, 2017, to a high of $(11.5 \pm 2.15) \times 10^{-15}$ µCi/mL at location SDA 4.3 on September 7, 2017. The September 7, 2017, sampling was an extra sampling event. Because of fires in the area and the amount of particulates in the air, the filters were becoming loaded and the monitors were shutting off, forcing samples to be collected earlier than anticipated.



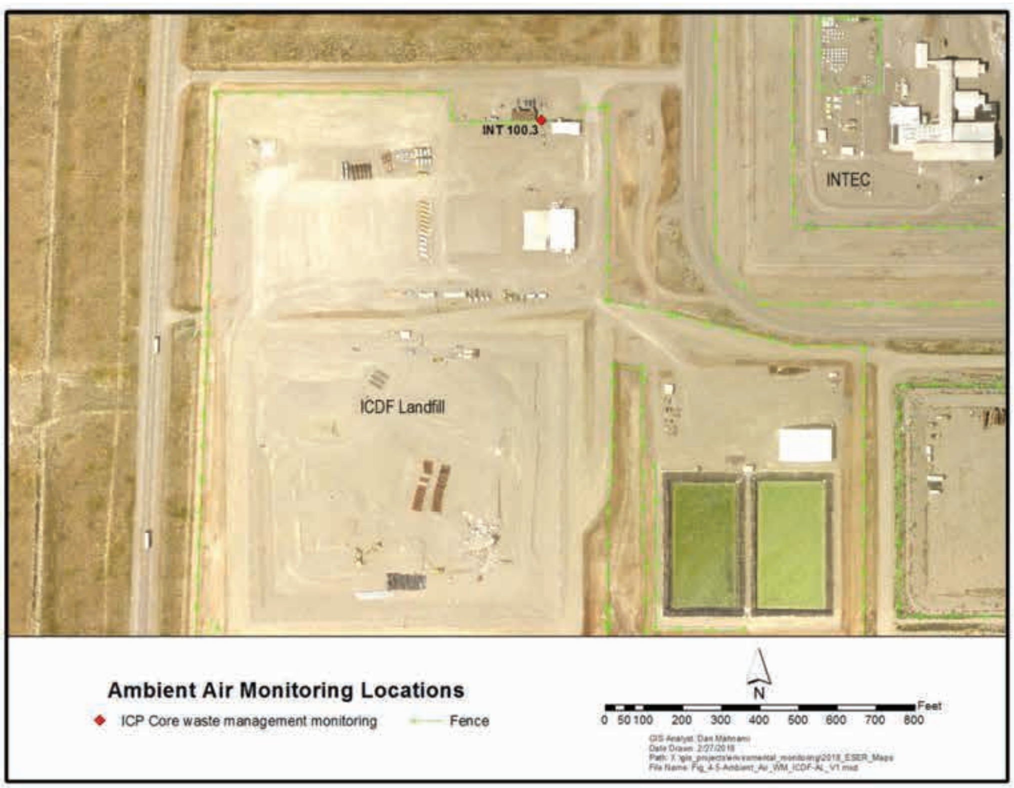


Figure 4-5. Locations of Low-volume Air Samplers at Waste Management Areas (SDA [top] and ICDF [bottom]).

Table 4-10 shows the annual median and range of gross beta concentrations at each location. Gross beta concentrations ranged from a low of (1.19 ± 0.12) x 10^{-14} µCi/mL at location HOWE 400.4 on May 1, 2017, to a high of (7.59 ± 1.05) x 10^{-14} µCi/mL also at location HOWE 400.4 during the extra sampling event on September 7, 2017.

Figure 4-6 compares gross alpha and gross beta sample results from 2012 through 2017 to the most restrictive DCS values ($^{239/240}Pu$ for gross alpha, ^{90}Sr for gross beta) established by DOE for inhaled air (DOE 2011). The results for the SDA and ICDF are well below their respective DCS values.

Table 4-9. Median Annual Gross Alpha Concentration in Air Samples Collected at Waste Management Sites in 2017.[a]

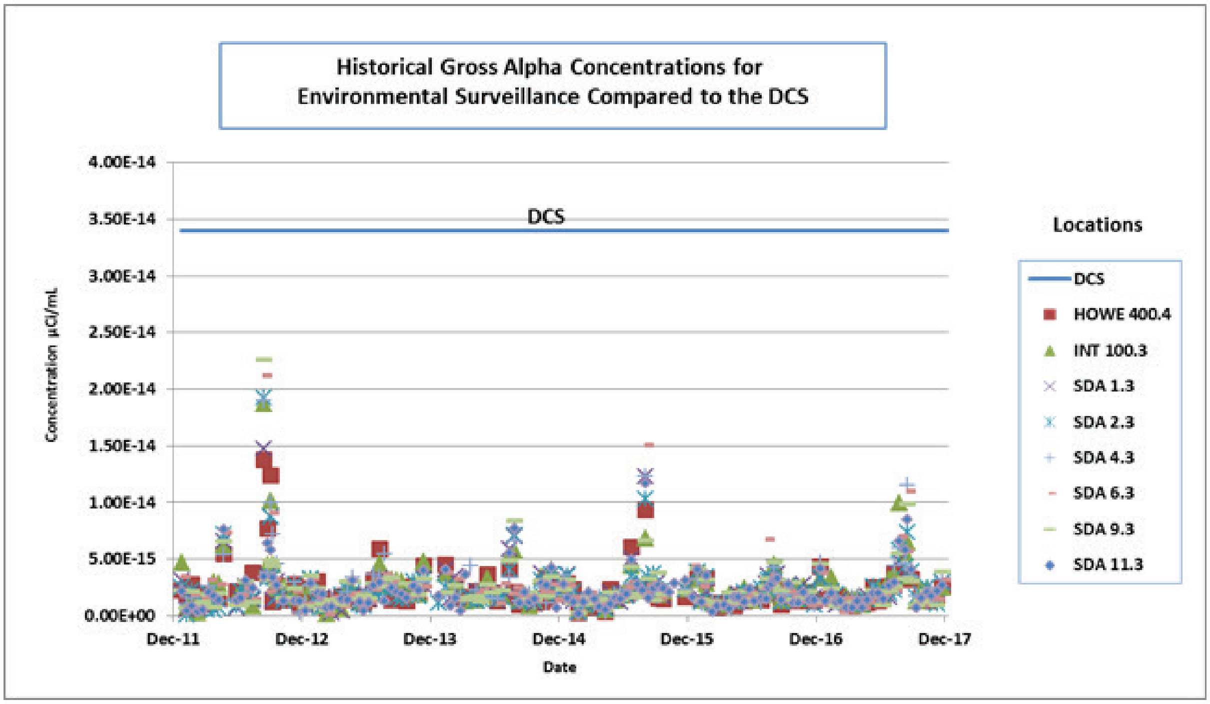
Group	Location	No. of Samples Collected	Range of Concentrations (× 10^{-15} µCi/mL)	Annual Median (× 10^{-15} µCi/mL)
Subsurface Disposal Area	SDA 1.3	19	0.97 – 4.82	1.78
	SDA 2.3	25	0.99 – 7.32	2.00
	SDA 4.3A	24	1.01 – 11.5	1.71
	SDA 6.3	25	0.36 – 11.0	1.52
	SDA 9.3	25	0.78 – 9.83	2.08
	SDA 11.3	25	0.67 – 8.45	1.97
Idaho CERCLA Disposal Facility	INT 100.3	25	0.91 – 9.94	2.34
Boundary	HOWE 400.4	24	0.90 – 3.83	1.73

a. Results ± 1σ.

Table 4-10. Median Annual Gross Beta Concentration in Air Samples Collected at Waste Management Sites in 2017.[a]

Group	Location	No. of Samples Collected	Range of Concentrations (× 10^{-14} µCi/mL)	Annual Median (× 10^{-14} µCi/mL)
Subsurface Disposal Area	SDA 1.3	19	1.49 – 5.49	3.11
	SDA 2.3	25	1.47 – 6.40	2.80
	SDA 4.3A	24	1.30 – 6.99	2.45
	SDA 6.3	25	1.31 – 6.94	2.40
	SDA 9.3	25	1.39 – 5.98	2.44
	SDA 11.3	25	1.59 – 6.78	2.72
Idaho CERCLA Disposal Facility	INT 100.3	25	1.52 – 6.54	2.93
Boundary	HOWE 400.4	24	1.19 – 7.59	2.50

a. Results ± 1σ.



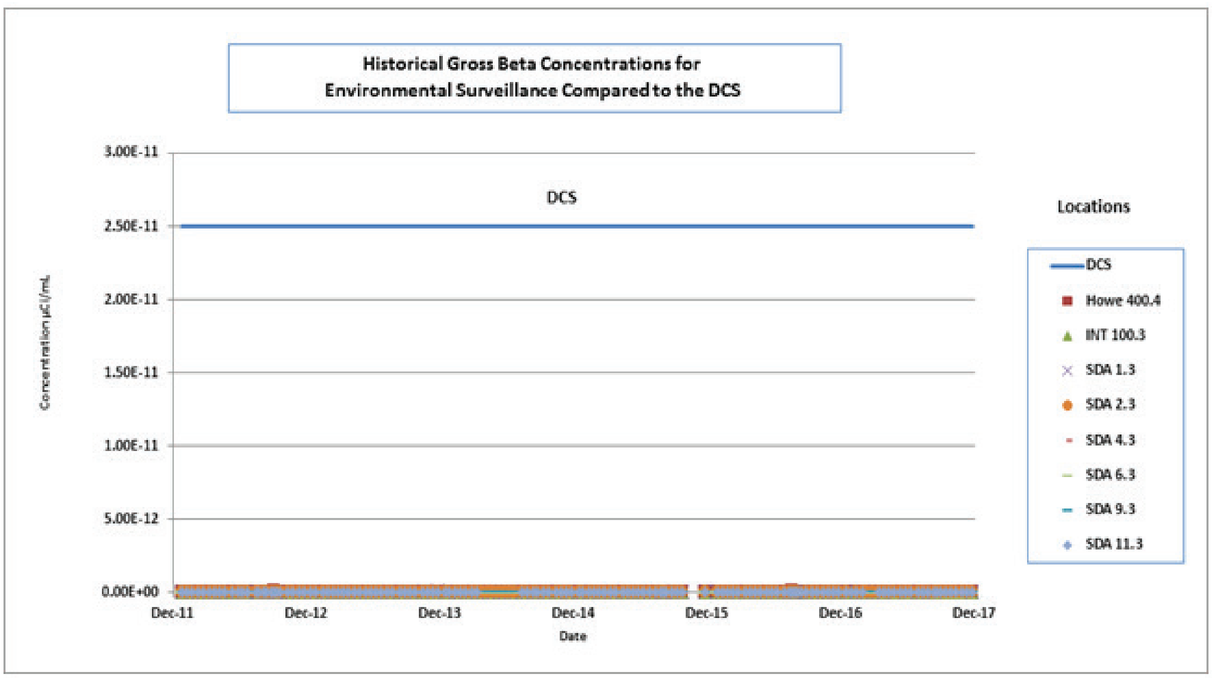


Figure 4-6. Gross Alpha and Gross Beta Results Compared to Their Respective Derived Concentration Standards.

4.4.2 Specific Radionuclides

Air filters collected by the ICP Core contractor are composited in a laboratory and analyzed for human-made, gamma-emitting radionuclides and specific alpha and beta emitting radionuclides. Gamma spectroscopy methods are performed monthly and radiochemical methods are performed quarterly.

In 2017, no human-made, gamma-emitting radionuclides were detected in air samples at the SDA at RWMC or at the ICDF at INTEC. However, human-made specific alpha- and beta-emitting radionuclides were detected at the SDA and at ICDF.

Table 4-11 shows human-made specific alpha- and beta-emitting radionuclides detected at the SDA and ICDF in 2017. These detections are consistent with levels measured in air at the SDA and ICDF in previous years. All detections were three to four orders of magnitude below the DCSs reported in DOE (2011), as shown in Figure 4-7, and statistically false positives at the 95 percent confidence error are possible. The ICP Core contractor will continue to closely monitor radionuclides to identify trends.

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Table 4-11. Human-made Radionuclides Detected in Air Samples Collected at Waste Management Sites in 2017.[a]

Radionuclide	Result (µCi/mL)	Location	Quarter Detected
Americium-241	2.23E-18	SDA 4.3A	1st
	6.41E-18	SDA 4.3	2nd
	2.89E-18	SDA 1.3	2nd
	6.56E-18	SDA 6.3	2nd
	2.22E-18	SDA 9.3	2nd
	2.89E-18	SDA 11.3	2nd
	3.43E-17	SDA 4.3A	3rd
	4.28E-18	SDA 2.3	3rd
	4.77E-18	SDA 6.3	3rd
	3.77E-18	SDA 9.3	3rd
	5.02E-18	SDA 11.3	3rd
	1.91E-18	SDA 2.3	4th
	8.42E-17	SDA 4.3A	4th
	2.42E-18	SDA 6.3	4th
	4.28E-18	INT 100.3	4th
Plutonium-239/240	1.58E-18	SDA 4.3A	1st
	2.19E-18	SDA 6.3	1st
	4.38E-18	SDA 4.3A	2nd
	3.85E-18	SDA 1.3	2nd
	2.41E-18	SDA 2.3	2nd
	7.43E-18	SDA 6.3	2nd
	1.99E-18	SDA 9.3	2nd
	4.04E-18	SDA 11.3	2nd
	7.35E-17	SDA 4.3A	3rd
	3.14E-18	SDA 1.3	3rd
	7.46E-18	SDA 6.3	3rd
	3.01E-18	SDA 9.3	3rd
	8.34E-18	SDA 11.3	3rd
	2.00E-18	SDA 2.3	4th
	7.46E-17	SDA 4.3A	4th
	4.35E-18	SDA 6.3	4th
	1.82E-18	SDA 9.3	4th
	4.36E-18	SDA 11.3	4th

a. Results $\pm 1\sigma$. Results shown are $\geq 3\sigma$.

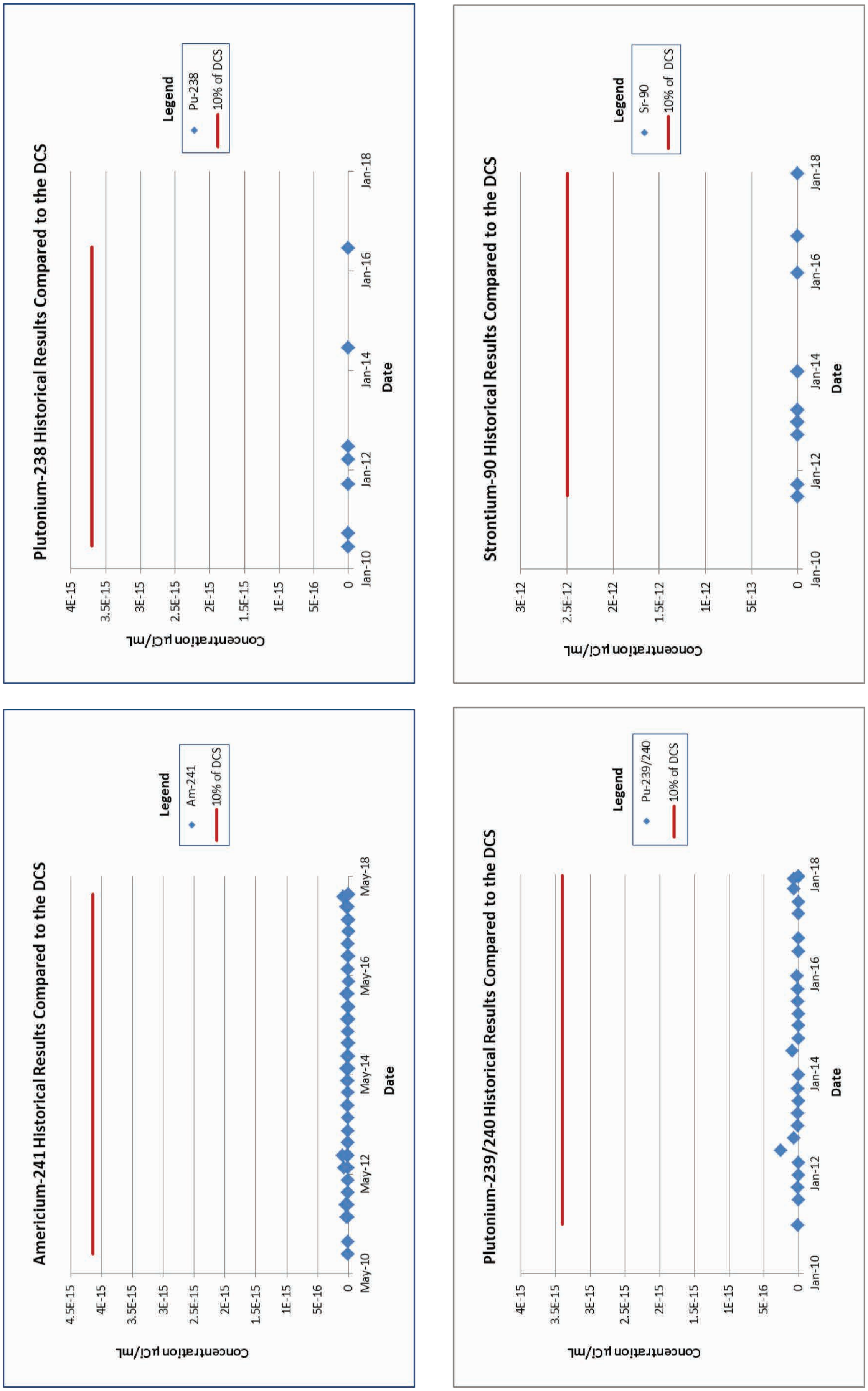

Figure 4-7. Specific Radionuclide Detections Compared to 10 Percent of Their Respective Derived Concentration Standards.

5. Environmental Monitoring Programs: Liquid Effluent Monitoring

Wastewater discharged to land surfaces and evaporation ponds at the INL Site is regulated by the state of Idaho groundwater quality and wastewater rules and requires a wastewater reuse permit. Liquid effluents and surface water runoff were monitored in 2017 by the Idaho National Laboratory (INL) contractor and the Idaho Cleanup Project (ICP) Core contractor for compliance with permit requirements and applicable regulatory standards established to protect human health and the environment.

During 2017, permitted facilities were: Advanced Test Reactor (ATR) Complex Cold Waste Pond; Central Facilities Area (CFA) Sewage Treatment Plant; Idaho Nuclear Technology and Engineering Center (INTEC) New Percolation Ponds; and Materials and Fuels Complex (MFC) Industrial Waste Ditch and Industrial Waste Pond. These facilities were sampled for parameters required by their facility-specific permits, except in the case of the CFA Sewage Treatment Plant because wastewater was not applied to the CFA land application area in 2017; therefore, no effluent monitoring was required there. The state of Idaho Department of Environmental Quality terminated the CFA Sewage Treatment Plant permit in December 2017. No permit requirements were exceeded in 2017.

Additional liquid effluent and groundwater monitoring was performed in 2017 at ATR, INTEC, and MFC to comply with environmental protection objectives of the U.S. Department of Energy (DOE). All parameters were below applicable health-based standards in 2017.

Surface water that runs off the Subsurface Disposal Area at the Radioactive Waste Management Complex during periods of rapid snowmelt or heavy precipitation is sampled and analyzed for radionuclides. The detected concentrations of americium-241, plutonium-239/240, and strontium-90 were approximately the same as those detected in previous years and did not exceed DOE Derived Concentration Standards.

5. ENVIRONMENTAL MONITORING PROGRAMS: LIQUID EFFLUENTS MONITORING

Operations at the Idaho National Laboratory (INL) Site may result in the release of liquid effluent discharges containing radioactive or nonradioactive contaminants. INL and Idaho Cleanup Project (ICP) Core personnel conduct liquid effluent monitoring through wastewater, liquid effluent, and surface water runoff sampling and surveillance programs. Groundwater sampling related to wastewater and direct discharges is also conducted as part of these programs.

Table 5-1 presents the requirements for liquid effluent monitoring performed at the INL Site. A comprehensive discussion and maps of environmental monitoring, including liquid effluent monitoring and surveillance programs performed by various organizations within and around the INL Site can be found in the *Idaho National Laboratory Site Environmental Monitoring Plan* (DOE-ID 2014). To improve the readability of this chapter, data tables are only included when monitoring results exceed specified discharge limits, permit limits, or maximum contaminant levels. Data tables for other monitoring results are provided in Appendix C.

5.1 Wastewater and Related Groundwater Compliance Monitoring

Discharge of wastewater to the land surface is regulated by wastewater rules (Idaho Administrative Procedures Act [IDAPA] 58.01.16 and .17). Wastewater reuse permits require monitoring of nonradioactive constituents in the influent waste, effluent waste, and groundwater in accordance with the Idaho groundwater quality standards stipulated in the "Ground Water Quality Rule" (IDAPA 58.01.11). Some facilities may have specified radiological constituents monitored for surveillance purposes (not required by regulations). The permits specify annual discharge volumes, application rates, and effluent quality limits. Annual reports (ICP 2018a, 2018b; INL

Table 5-1. Liquid Effluent Monitoring at the INL Site.

Area/Facility[a]	Monitoring Requirements: Idaho Wastewater Reuse Permit[b]	DOE Order 458.1[c] Liquid Effluent Monitoring	DOE Order 435.1[d] Surface Runoff Surveillance
INL Contractor			
ATR Complex Cold Waste Pond	•	•	
CFA Sewage Treatment Plant	•		
MFC Industrial Waste Pond and Industrial Waste Ditch	•	•	
ICP Core Contractor			
INTEC New Percolation Ponds and Sewage Treatment Plant	•	•	
RWMC SDA surface water runoff		•	•

a. ATR = Advanced Test Reactor, CFA = Central Facilities Area, MFC = Materials and Fuel Complex, INTEC = Idaho Nuclear Technology and Engineering Center, RWMC = Radioactive Waste Management Complex, SDA = Subsurface Disposal Area

b. Required by permits issued according to the Idaho Department of Environmental Quality Rules, Idaho Administrative Procedures Act 58.01.17, "Recycled Water Rules." This includes wastewater monitoring and related groundwater monitoring.

c. Paragraph 4(g) of U.S. Department of Energy (DOE) Order 458.1, "Radiation Protection of the Public and the Environment," establishes specific requirements related to control and management of radionuclides from DOE activities in liquid discharges. Radiological liquid effluent monitoring recommendations in *DOE Handbook – Environmental Radiological Effluent Monitoring and Environmental Surveillance* (DOE-HDBK-1216-2015) (DOE 2015) are followed to ensure quality. DOE Standard DOE-STD-1196-2011, "Derived Concentration Technical Standard," (DOE 2011) supports the implementation of DOE Order 458.1 and provides Derived Concentration Standards as reference values to control effluent releases from DOE facilities.

d. The objective of DOE Order 435.1, "Radioactive Waste Management," is to ensure that all DOE radioactive waste is managed in a manner that is protective of worker and public health and safety and the environment. This order requires that radioactive waste management facilities, operations, and activities meet the environmental monitoring requirements of DOE Order 458.1. The DOE Handbook suggests that potential impacts of storm-water runoff as a pathway to humans or biota should be evaluated.

2018a, 2018b, 2018c, 2018d) were prepared and submitted to the Idaho Department of Environmental Quality (DEQ).

During 2017, the INL contractor and ICP contractor monitored, as required by the permits, the following facilities (Table 5-2):

- Advanced Test Reactor (ATR) Complex Cold Waste Pond (Section 5.1.1)
- Central Facilities Area (CFA) Sewage Treatment Plant (STP) (Section 5.1.2)
- Idaho Nuclear Technology and Engineering Center (INTEC) New Percolation Ponds and STP (Section 5.1.3)
- Materials and Fuels Complex (MFC) Industrial Waste Ditch and Industrial Waste Pond (Section 5.1.4).

Additional effluent constituents are monitored at these facilities to comply with environmental protection objectives of DOE Order 458.1 and are discussed in Section 5.2. Surface water monitoring at the Radioactive Waste Management Complex is presented in Section 5.3.

5.1.1 Advanced Test Reactor Complex Cold Waste Pond

Description. The Cold Waste Pond (CWP) is located approximately 137 m (450 ft) from the southeast corner of the ATR Complex compound and approximately 1.2 km (0.75 mi) northwest of the Big Lost River channel (Figure 5-1). The CWP was excavated in 1982. It consists of two

Table 5-2. 2017 Status of Wastewater Reuse Permits.

Facility[a]	Permit Status at End of 2017	Explanation
ATR Complex Cold Waste Pond	Permit issued	DEQ[b] issued Permit I-161-02 on November 20, 2014, with a minor modification issued March 7, 2017. The permit expires on November 19, 2019.
CFA Sewage Treatment Plant	Permit cancelled	DEQ issued Permit LA-000141-03 on March 17, 2010. The permit expired on March 16, 2015. No wastewater was land applied since 2011. A closure report was submitted to DEQ on November 8, 2017. DEQ terminated the permit December 15, 2017.
INTEC New Percolation Ponds	Permit issued	DEQ issued Permit M-130-06 on June 1, 2017. The permit expires on June 1, 2024.
MFC Industrial Waste Pond and Industrial Waste Ditch	Permit issued	DEQ issued Permit LA-000160-01, effective May 1, 2010, to April 30, 2015. DEQ issued Permit WRU-I-0160-01 (formerly LA-000160-01), Modification 1 on June 21, 2012. A reuse permit renewal application was submitted to DEQ in October 2014. DEQ issued Permit I-160-02 on January 26, 2017, with a minor modification issued March 7, 2017.

a. ATR = Advanced Test Reactor, CFA = Central Facilities Area, INTEC = Idaho Nuclear Technology and Engineering Center, MFC = Materials and Fuels Complex

b. DEQ = Idaho Department of Environmental Quality

cells, each with dimensions of 55 × 131 m (180 × 430 ft) across the top of the berms and a depth of 3 m (10 ft). Total surface area for the two cells at the top of the berms is approximately 1.44 ha (3.55 acres). Maximum capacity is approximately 38.69 million liters (Ml) (10.22 million gallons [MG]).

Wastewater discharged to the CWP consists primarily of noncontact cooling tower blowdown, once-through cooling water for air conditioning units, coolant water from air compressors, and wastewater from secondary system drains and other nonradioactive drains throughout the ATR Complex. Chemicals used in the cooling tower and other effluent streams discharged to the CWP include commercial biocides and corrosion inhibitors.

DEQ issued a minor modification to the permit to clarify data delivery on March 7, 2017. The permit expires on November 19, 2019.

Wastewater Monitoring Results for the Wastewater Reuse Permit. The industrial wastewater reuse permit requires monthly sampling of the effluent to the CWP. The minimum, maximum, and median results of all constituents monitored are presented in Table C-1. The total dissolved solids concentration in the effluent to the CWP ranged from 223 mg/L in the July 2017 sample to 1,220 mg/L in the June 2017 sample. Sulfate ranged from a minimum of 20.2 mg/L in the July 2017 sample to a maximum of 644 mg/L in the June 2017 sample. There are no effluent permit limits for total dissolved solids or sulfate. Concentrations of sulfate and total dissolved solids are higher during reactor operation because of the evaporative concentration of the corrosion inhibitors and biocides added to the reactor cooling water.

Groundwater Monitoring Results for the Wastewater Reuse Permit. The industrial wastewater reuse permit requires groundwater monitoring, to measure potential impacts from the CWP, in April/May and September/October, at six groundwater wells (Figure 5-1). For 2017, none of the constituents exceeded their respective primary or secondary constituent standards and are presented in Table C-2 and Table C-2a. The metals concentrations continue to remain at low levels.

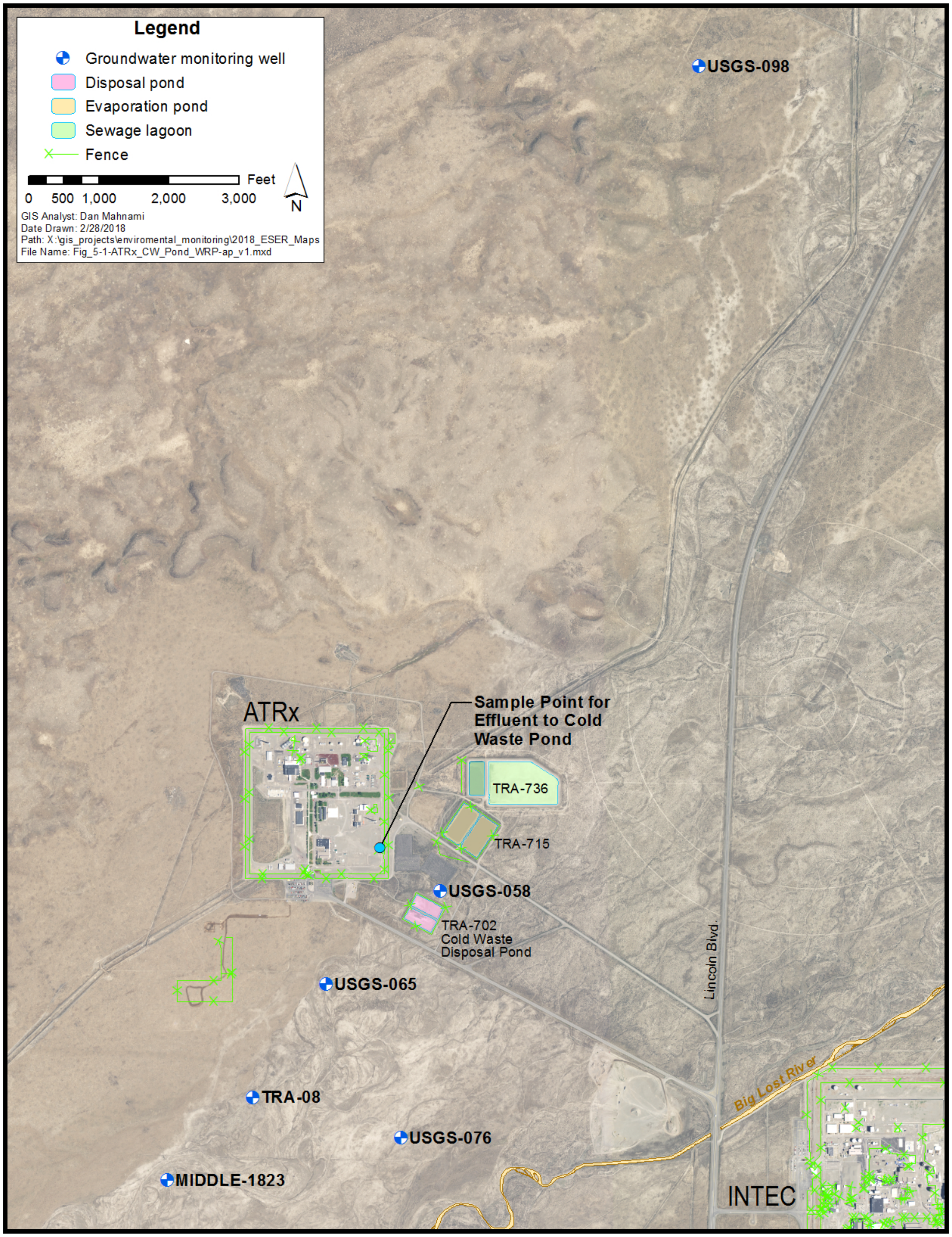

Figure 5-1. Permit Monitoring Locations for the ATR Complex Cold Waste Pond.

5.1.2 Central Facilities Area Sewage Treatment Plant

Description. The CFA STP serves all major buildings at CFA. The treatment facility is southeast of CFA, approximately 671 m (2,200 ft) downgradient of the nearest drinking water well (Figure 5-2).

A 1,500-L/min (400-gal/min) pump applies wastewater from a 0.2-ha (0.5-acre) lined polishing pond to approximately 30 ha (74 acres) of sagebrush steppe grassland through a computerized center pivot irrigation system; refer to Sections 5.2.2 and 7.2 for further information.

Wastewater Monitoring Results for the Wastewater Reuse Permit. DEQ issued a permit for the CFA STP on March 17, 2010. The permit requires effluent monitoring and soil sampling in the wastewater land application area (soil samples were required in 2010 and 2013). Effluent samples are collected from the pump pit (prior to the pivot irrigation system) monthly during land application. During the 2017 permit year, no wastewater was applied to the land application area; therefore, no effluent sampling was required by the permit. DEQ terminated the permit December 15, 2017, per the request of Battelle Energy Alliance.

Groundwater Monitoring Results for the Wastewater Reuse Permit. The wastewater reuse permit does not require groundwater monitoring at the CFA STP.

5.1.3 Idaho Nuclear Technology and Engineering Center New Percolation Ponds and Sewage Treatment Plant

Description. The INTEC New Percolation Ponds are composed of two unlined ponds excavated into the surficial alluvium and surrounded by bermed alluvial material (Figure 5-3). Each pond is 93 m x 93 m (305 ft x 305 ft) at the top of the berm and approximately 3 m (10 ft) deep. Each pond is designed to accommodate a continuous wastewater discharge rate of 11.36 Ml (3 MG) per day.

The INTEC New Percolation Ponds receive discharge of only industrial and municipal wastewater. Industrial wastewater (i.e., service waste) from INTEC operations consists of steam condensates, noncontact cooling water, water treatment effluent, boiler blowdown wastewater, storm water, and small volumes of other nonhazardous/nonradiological liquids. Municipal wastewater (i.e., sanitary waste) is treated at the INTEC STP.

The STP is located east of INTEC, outside the INTEC security fence, and treats and disposes of sewage, septage, and other nonhazardous industrial wastewater at INTEC. The sanitary waste in four lagoons of the STP is treated by natural biological and physical processes (digestion, oxidation, photosynthesis, respiration, aeration, and evaporation). After treatment in the lagoons, the effluent is combined with the service waste and discharged to the INTEC New Percolation Ponds.

During 2017, the INTEC New Percolation Ponds were permitted by DEQ to operate as a reuse facility under Wastewater Reuse Permit LA-000130-05 (DEQ 2016) and Reuse Permit M-130-06 (DEQ 2017). Reuse Permit M-130-06 became effective on June 1, 2017, and has an expiration date of June 1, 2024.

Wastewater Monitoring Results for the Wastewater Reuse Permit. Monthly samples were collected from CPP-769 (influent to STP), CPP-773 (effluent from STP), and CPP-797 (effluent to the INTEC New Percolation Ponds) (see Figure 5-4). As required by the permit, all samples are collected as 24-hour flow proportional composites, except pH, fecal coliform, and total coliform, which are collected as grab samples. The permit specifies the constituents that must be monitored at each location. The permit does not specify any wastewater discharge limits at these three locations. The 2017 reporting year monitoring results for CPP-769, CPP-773, and CPP-797 are provided in the 2017 Wastewater Reuse Report (ICP 2018a), and the 2017 calendar year monitoring results are summarized in Tables C-3, C-4, and C-5.

The permit specifies maximum daily and yearly hydraulic loading rates for the INTEC New Percolation Ponds. As shown in Table C-6, the maximum daily flow and the yearly total flow to the INTEC New Percolation Ponds were below the permit limits in 2017.

Groundwater Monitoring Results for the Wastewater Reuse Permit. To measure potential impacts to groundwater from wastewater discharges to the INTEC New Percolation Ponds, the permit requires that groundwater samples be collected from six monitoring wells as shown in Figure 5-3.

The permit requires that groundwater samples be collected semiannually during April/May and September/October and lists which constituents must be analyzed. Contaminant concentrations in the compliance wells are limited by primary constituent standards and second-

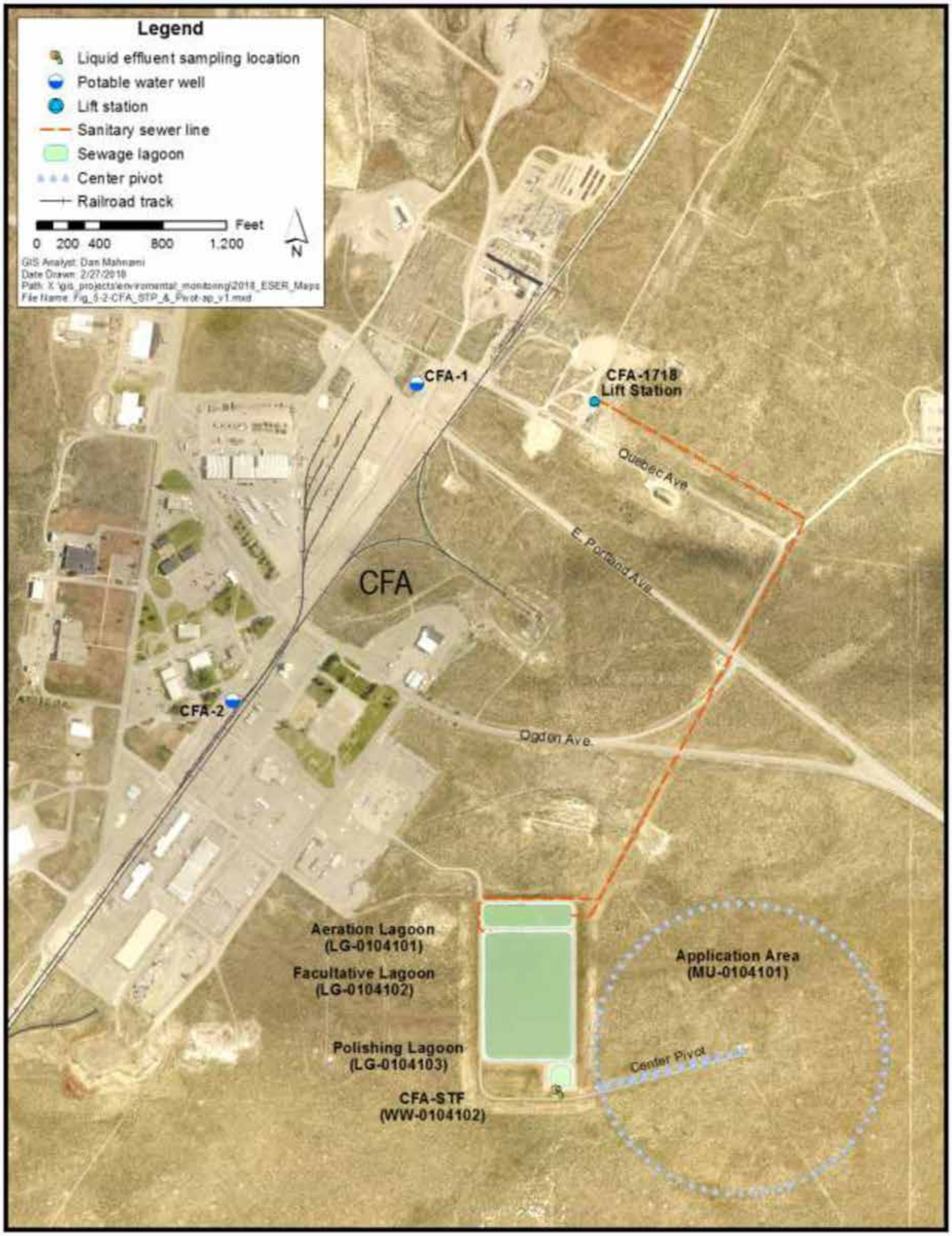

Figure 5-2. CFA Sewage Treatment Plant. Samples are collected at the irrigation pump pivot, sampling point CFA-STP.

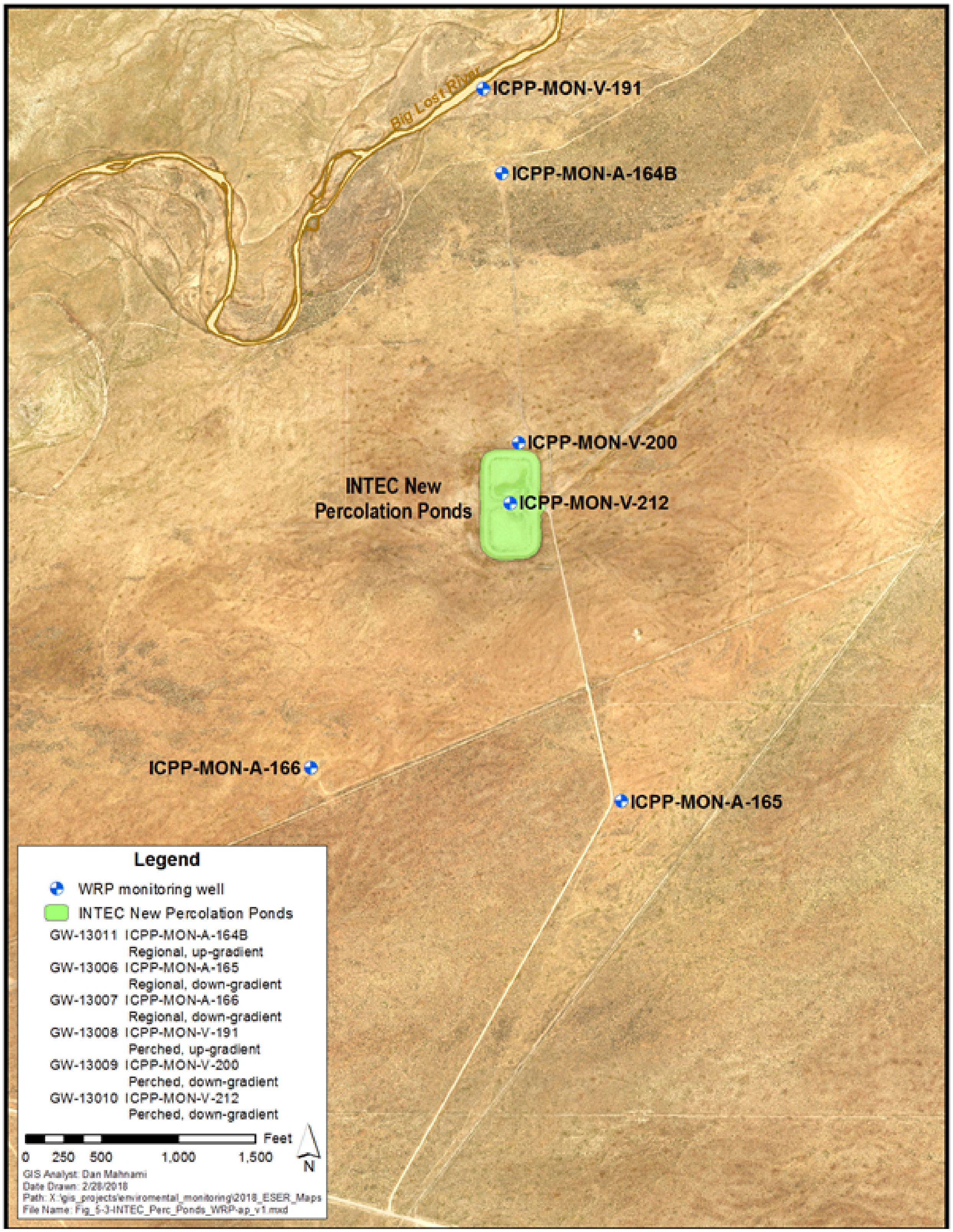

Figure 5-3. Permit Groundwater Monitoring Locations for INTEC New Percolation Ponds.

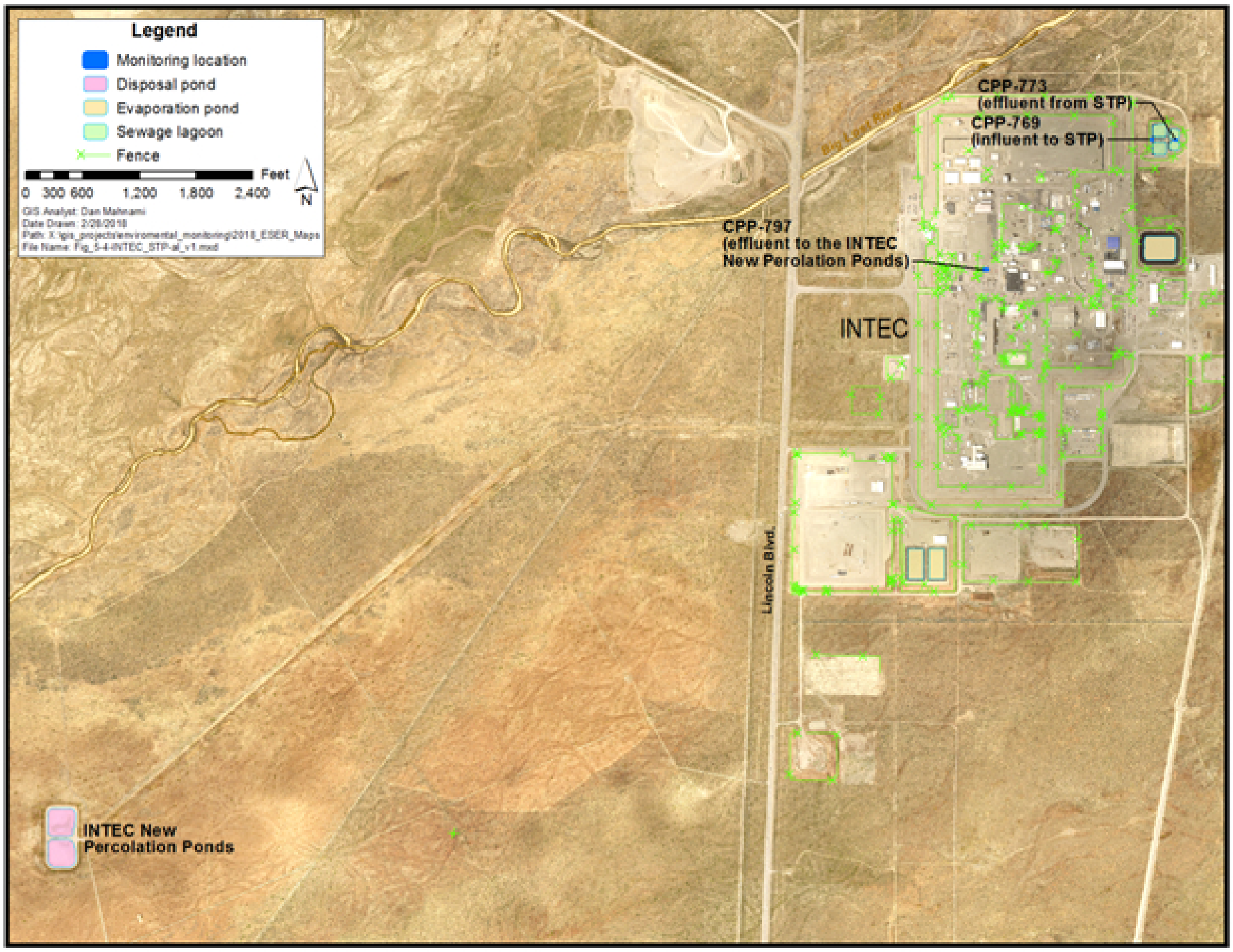

Figure 5-4. INTEC Wastewater Monitoring for Wastewater Reuse Permit.

ary constituent standards, specified in IDAPA 58.01.11, "Ground Water Quality Rule."

Table C-7 shows the 2017 water table elevations and depth to water table, determined prior to purging and sampling, and the analytical results for all constituents specified by the permit for the aquifer wells. Table C-8 presents similar information for the perched water wells.

Tables C-7 and C-8 show all permit-required constituents associated with the aquifer and perched water wells were below their respective primary constituent standards and secondary constituent standards in 2017.

5.1.4 Materials and Fuels Complex Industrial Waste Ditch and Industrial Waste Pond

Description. The MFC Industrial Waste Pond was first excavated in 1959 and has a design capacity of 1078.84 mL (285 MG) at a maximum water depth of 3.96 m (13 ft) (Figure 5-5). The pond receives industrial wastewater from the Industrial Waste Pipeline, storm water runoff from the nearby areas, and industrial wastewater from Ditch C. Industrial wastewater discharged to the pond via the Industrial Waste Pipeline consists primarily of noncontact cooling water, boiler blowdown, cooling tower blowdown and drain, air wash flows, and steam condensate. A small amount of wastewater discharged to the pond via Ditch C from the Industrial Waste Water Underground Pipe consists of intermittent reverse osmosis effluent and laboratory sink discharge from the MFC-768 Power Plant.

Reuse Permit I-160-02 issued January 26, 2017, with minor modification effective March 7, 2017, eliminated maximum concentration limits for total suspended solids and total nitrogen. The new permit also updated the constituents required for effluent and groundwater monitoring and frequency of recording flow data.

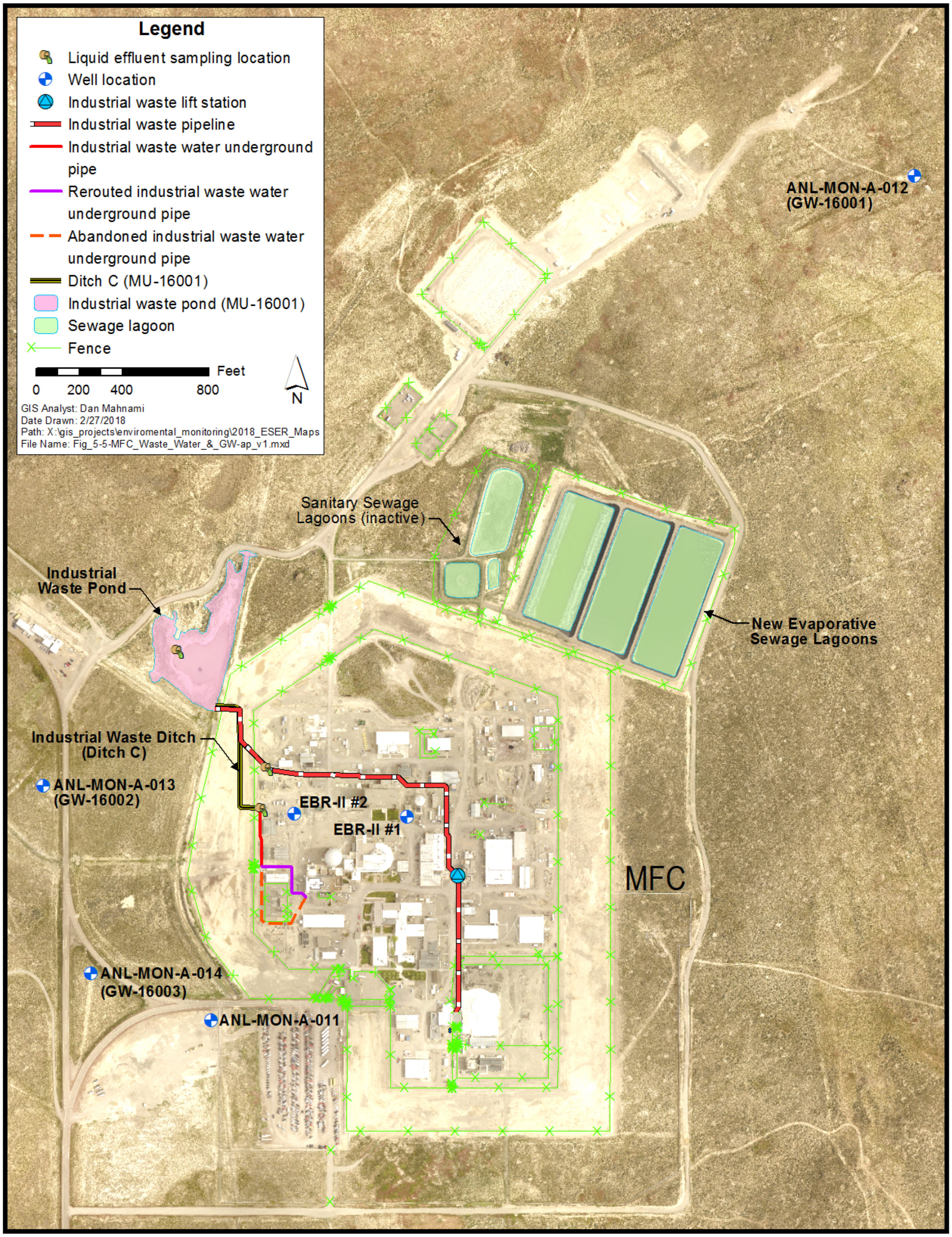

Figure 5-5. Wastewater and Groundwater Sampling Locations at the MFC.

Wastewater Monitoring Results for the Wastewater Reuse Permit. The new reuse permit requires monthly sampling of the effluent to the pond discharged to the Industrial Waste Pipeline and quarterly sampling of the discharge to Ditch C from the Industrial Waste Water Underground Pipe. As stated above, monthly concentration limits for total suspended solids and total nitrogen have been eliminated. The minimum, maximum, and median results of all constituents monitored are presented in Tables C-10 and C-10.

Groundwater Monitoring Results for the Wastewater Reuse Permit. The reuse permit requires groundwater monitoring in April/May and September/October at one upgradient well and two downgradient wells (Figure 5-5).

The analytical results are summarized in Table C-11. Analyte concentrations in the downgradient wells were consistent with background levels in the upgradient well.

5.2 Liquid Effluent Surveillance Monitoring

The following sections discuss results of liquid effluent surveillance monitoring performed at each wastewater reuse permitted facility.

5.2.1 Advanced Test Reactor Complex

The effluent to the CWP receives a combination of process water from various ATR Complex facilities. Table C-13 lists wastewater surveillance monitoring results for those constituents with at least one detected result. Radionuclides detected in groundwater samples are summarized in Table C-13. All detected constituents including tritium, gross alpha, and gross beta were below the Idaho groundwater primary constituent standards, IDAPA 58.01.11.

5.2.2 Central Facilities Area

The effluent from the CFA STP is monitored according to the wastewater reuse permit. No wastewater was land-applied in 2017; therefore, no effluent samples were collected at the treatment facility.

5.2.3 Idaho Nuclear Technology and Engineering Center

In addition to the permit-required monitoring summarized in Section 5.1.3, surveillance monitoring was conducted at CPP-773 (effluent from STP), CPP-797 (effluent to the INTEC New Percolation Ponds), and the groundwater at the INTEC New Percolation Ponds. Table C-14 summarizes the results of radiological monitoring at CPP-773 and CPP-797, and Table C-15 summarizes the results of radiological monitoring at groundwater Wells ICPP-MON-A-165, ICPP-MON-A-166, ICPP-MON-V-200, and ICPP-MON-V-212.

Twenty-four-hour flow proportional samples were collected from the CPP-773 effluent in March 2017 and September 2017 and analyzed for specific gamma-emitting radionuclides, gross alpha, gross beta, and total strontium activity. As shown in Table C-15, no gamma-emitting radionuclides, gross alpha, or total strontium was detected in any of these samples. Gross beta was detected in both the March 2017 sample (7.5 pCi/L) and the September 2017 sample (17.5 pCi/L). These detections were below the derived concentration standard for gross beta found in Table A-2.

Twenty-four-hour flow proportional samples were collected from the CPP-797 wastewater effluent and composited daily into a monthly sample. Each monthly composite sample was analyzed for specific gamma-emitting radionuclides, gross alpha, gross beta, and total strontium activity. As shown in Table C-15, no gamma-emitting radionuclides or total strontium activity was detected in any of the samples collected at CPP-797 in 2017. Gross alpha was detected in five of the 12 samples, and gross beta was detected in all 12 samples collected in 2017. These detections were below the derived concentration standards for gross alpha and gross beta found in Table A-2.

Groundwater samples were collected from aquifer Wells ICPP-MON-A-165 and ICPP-MON-A-166 and perched water Wells ICPP-MON-V-200 and ICPP-MON-V-212 in April 2017 and September 2017 and analyzed for gross alpha and gross beta. As shown in Table C-16, gross alpha was detected in aquifer Well ICPP-MON-A-165 (2.10 pCi/L) and perched water Well ICPP-MON-V-212 (1.76 pCi/L) in April 2017. Both detections were below the derived concentration standard for gross alpha found in Table A-2. Gross alpha was not detected in these two wells in September 2017. Gross alpha was not detected in the other two monitoring wells in 2017. Gross beta was detected in all four monitoring wells in April 2017 and three of the four monitoring wells in September 2017. These detections were below the derived concentration standard for gross beta found in Table A-2.

5.2.4 Materials and Fuels Complex

The Industrial Waste Pond is sampled quarterly for gross alpha, gross beta, gamma spectroscopy, and tritium (Figure 5-5). Annual samples are collected and analyzed for selected isotopes of americium, iron, strontium, plutonium, and uranium. Gross alpha, gross beta, potassium-40, and uranium isotopes were detected in 2017 (Table C-16) and are below applicable derived concentration standards found in Table A-2.

5.3 Waste Management Surveillance Surface Water Sampling

Radionuclides could be transported outside Radioactive Waste Management Complex (RWMC) boundaries via surface water runoff. Surface water runs off the Subsurface Disposal Area (SDA) only during periods of rapid snowmelt or heavy precipitation. At these times, water may be pumped out of the SDA retention basin into a drainage canal, which directs the flow outside RWMC. The canal also carries runoff from outside RWMC that has been diverted around the SDA.

In compliance with DOE Order 435.1, the ICP Core contractor collects surface water runoff samples at the RWMC SDA from the location shown in Figure 5-6. Surface water is collected to determine if radionuclide concentrations exceed administrative control levels or if concentrations have increased significantly, as compared to historical data. A field blank is also collected for comparison. Samples were collected quarterly during 2017.

Table 5-3 summarizes the specific alpha and beta results of human-made radionuclides. No human-made gamma-emitting radionuclides were detected. The americium-241, plutonium-239/240, and strontium-90 concentrations are approximately the same as those reported in previous years and are well below DOE Derived Concentration Standards (DOE 2011).

The ICP Core contractor will sample twice during 2018, when water is available, and evaluate the results to identify any potential abnormal trends or results that would warrant further investigation.

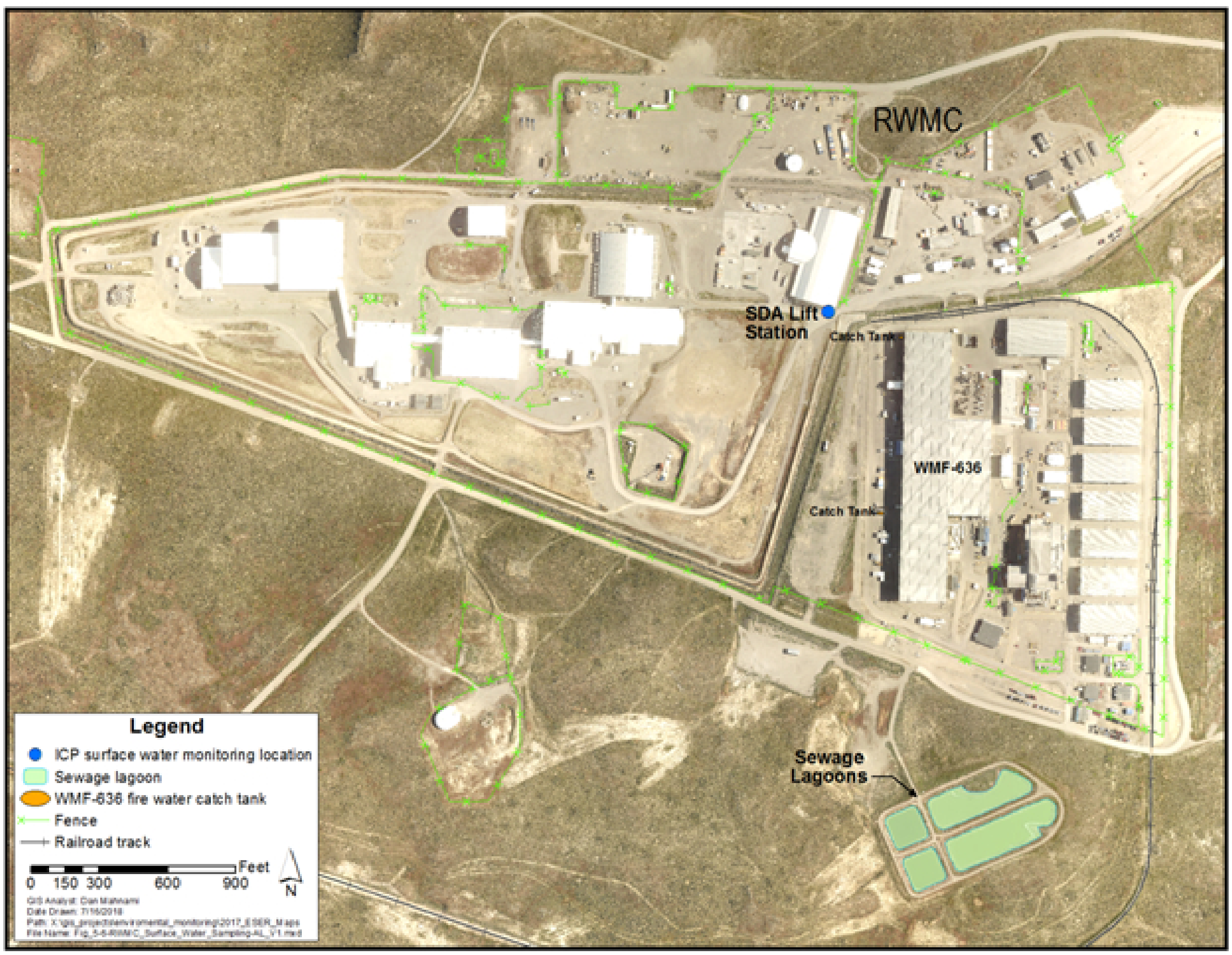

Figure 5-6. Surface Water Sampling Location at the RWMC SDA.

Table 5-3. Radionuclides Detected in Surface Water Runoff at the RWMC SDA (2017).

Parameter	Maximum Concentration[a] (pCi/L)	% Derived Concentration Standard[b]
Americium-241	0.689 ± 0.055	0.41
Plutonium-238	0.014 ± 0.004	0.01
Plutonium-239/240	0.44 ± 0.04	0.31
Strontium-90	0.081 ± 0.016	0.01

a. Result ±1s. Results shown are >3s.
b. See DOE-STD-1196-2011, Table A-2 (DOE 2011).

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DEQ, 2016, "Municipal and Industrial Wastewater Reuse Permit LA-000130-05, Idaho Nuclear Technology and Engineering Center New Percolation Ponds," ICP PER-143, Idaho Department of Environmental Quality, June 2016.

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DOE-ID, 2014, *Idaho National Laboratory Site Environmental Monitoring Plan*, DOE/ID-11088, Rev. 4, U.S. Department of Energy Idaho Operations Office, February 2014.

ICP, 2018a, *2017 Wastewater Reuse Site Performance Report for the Idaho Nuclear Technology and Engineering Center New Percolation Ponds (M-130-06)*, RPT-1600, Idaho Cleanup Project Core.

ICP, 2018b, *2017 Radiological Monitoring Results Associated with the Idaho Nuclear Technology and Engineering Center New Percolation Ponds*, RPT-1601, Idaho Cleanup Project Core.

IDAPA 58.01.11, 2016, "Ground Water Quality Rule," Idaho Administrative Procedures Act, Idaho Department of Environmental Quality.

IDAPA 58.01.16, 2016, "Wastewater Rules," Idaho Administrative Procedures Act, Idaho Department of Environmental Quality.

IDAPA 58.01.17, 2016, "Recycled Water Rule," Idaho Administrative Procedures Act, Idaho Department of Environmental Quality.

INL, 2018a, *2017 Groundwater Radiological Monitoring Results Associated with the Advanced Test Reactor Complex Cold Waste Pond*, INL/EXT-17-40908, Idaho National Laboratory.

INL, 2018b, *2017 Groundwater Radiological Monitoring Results Associated with the Materials and Fuels Complex Industrial Waste Ditch and Pond*, INL/EXT-17-44051, Idaho National Laboratory.

INL, 2018c, *2017 Annual Reuse Report for the Idaho National Laboratory Site's Advanced Test Reactor Complex Cold Waste Ponds*, INL/EXT-17-43969, Idaho National Laboratory.

INL, 2018d, *2017 Annual Industrial Wastewater Reuse Report for the Idaho National Laboratory Site's Materials and Fuels Complex Industrial Waste Ditch and Industrial Waste Pond*, INL/EXT-17-43968, Idaho National Laboratory.

6. Environmental Monitoring Programs: Eastern Snake River Plain Aquifer

One potential pathway for exposure to contaminants released at the Idaho National Laboratory (INL) Site is through the groundwater pathway. Historical waste disposal practices have produced localized areas of chemical and radiochemical contamination beneath the INL Site in the eastern Snake River Plain aquifer. These areas are regularly monitored by the U.S. Geological Survey (USGS), and reports are published showing the extent of contamination plumes. Results for most monitoring wells within the plumes show decreasing concentrations of tritium, strontium-90, and iodine-129 over the past 20 years. The decrease is likely the result of radioactive decay, discontinued disposal, dispersion, and dilution within the aquifer.

In 2017, the USGS sampled 26 groundwater monitoring wells and one perched water well at the INL Site for analysis of 61 purgeable (volatile) organic compounds (VOCs). Ten purgeable organic compounds were detected in at least one well. Most of the detected concentrations were less than maximum contaminant levels (MCLs) established by the Environmental Protection Agency (EPA) for public drinking water supplies. One exception was carbon tetrachloride, detected in the production well at the Radioactive Waste Management Complex. This compound has shown a decreasing trend since 2005 and is removed from the water prior to human consumption. Carbon tetrachloride was also detected in one other well at RWMC at its MCL in 2017. Trichloroethene was detected above the MCL at a well at Test Area North where there is a known groundwater plume containing this contaminant being treated.

Groundwater surveillance monitoring required in area-specific Records of Decision under the Comprehensive Environmental Response, Compensation, and Liability Act was performed at Waste Area Groups (WAGs) 1 – 4, WAG 7, and WAG 9 in 2017.

Twelve drinking water systems are in operation on the INL Site. All contaminant concentrations measured in drinking water systems in 2017 were below regulatory limits. Because of the potential impacts to workers at the Central Facilities Area (CFA) from an upgradient plume of radionuclides in the eastern Snake River Plain aquifer, the potential effective dose equivalent from ingesting radionuclides in water was calculated. The estimated annual effective dose equivalent to a worker from consuming all their drinking water at CFA during 2017 was 0.154 mrem (1.54 µSv). This value is below the EPA standard of 4 mrem/yr for public drinking water systems.

Drinking water and springs were sampled by the Environmental Surveillance, Education, and Research contractor downgradient of the INL Site and analyzed for gross alpha and gross beta activity and tritium. Some locations were co-sampled with the state of Idaho Department of Environmental Quality INL Oversight Program. Results were consistent with historical measurements and do not indicate any impact from historical INL Site releases.

The Big Lost River was sampled during the months of May, June, July, and October 2017 and analyzed for gross alpha and gross beta activity, tritium, and gamma-emitting radionuclides. Gamma-emitters were not detected. None of the other results exceeded EPA MCLs for drinking water.

6. ENVIRONMENTAL MONITORING PROGRAMS: EASTERN SNAKE RIVER PLAIN AQUIFER

The eastern Snake River Plain aquifer serves as the primary source of drinking water and crop irrigation in the upper Snake River Basin. This chapter presents the results of water monitoring conducted on and off the Idaho National Laboratory (INL) Site within the eastern Snake River Plain aquifer hydrogeologic system. This includes collection of water from the aquifer (including drinking water wells); downgradient springs along the Snake River where the aquifer discharges water (Figure 6-1); and an ephemeral stream (the Big Lost River), which flows through the INL Site and helps to recharge the aquifer. The purpose of the monitoring is to ensure that:

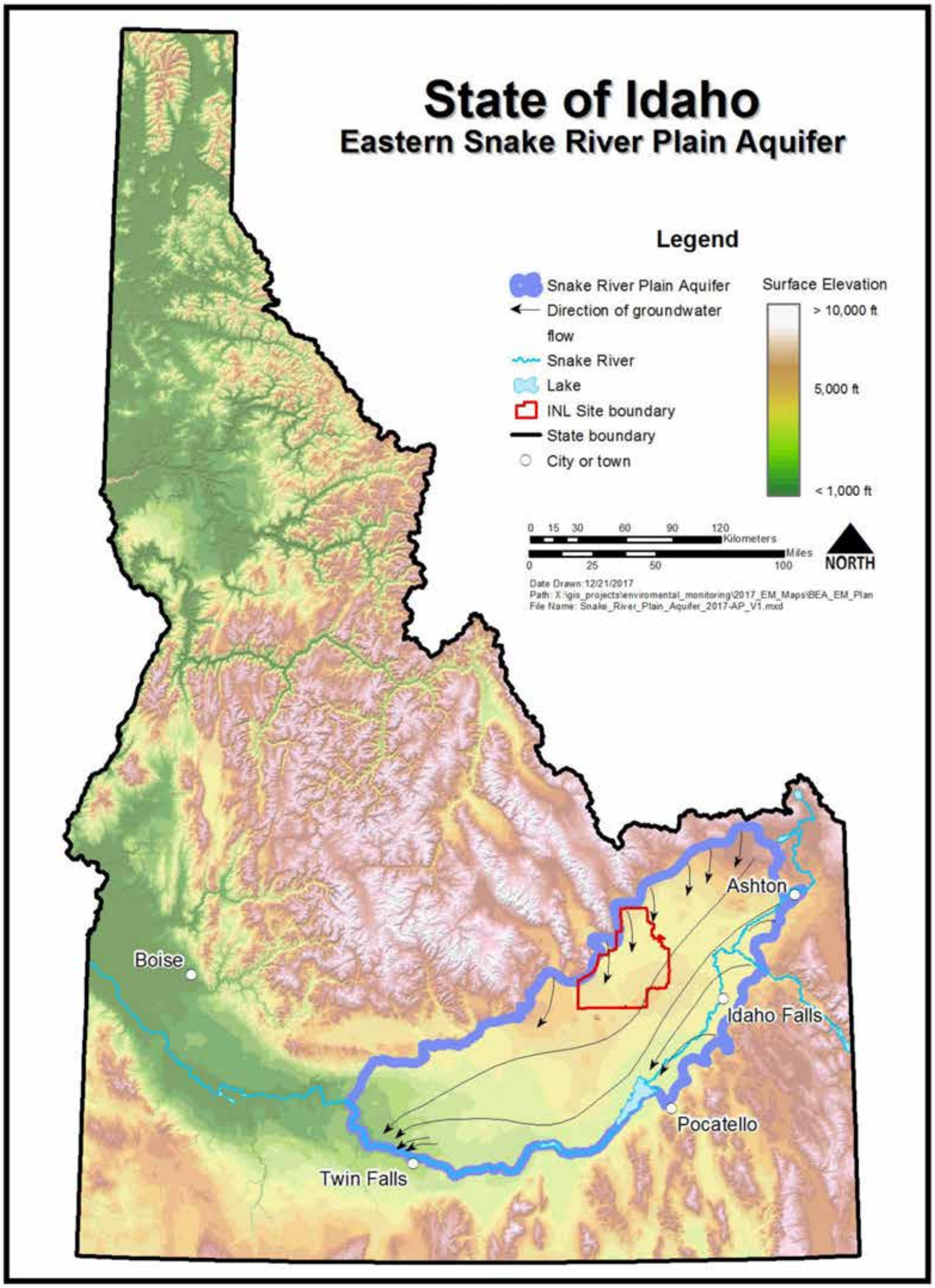


Figure 6-1. The Eastern Snake River Plain Aquifer and Direction of Groundwater Flow.

- The eastern Snake River Plain groundwater is protected from contamination from current INL Site activities
- Areas of known underground contamination from past INL Site operations are monitored and trended
- Drinking water consumed by workers and visitors at the INL Site and by the public downgradient of the INL Site is safe
- The Big Lost River, which occasionally flows through the INL Site, is not contaminated by INL Site activities before entering the aquifer via playas on the north end of the INL Site.

Analytical results are compared to applicable regulatory guidelines for compliance and informational purposes. These include the following:

- State of Idaho groundwater primary and secondary constituent standards (Idaho Administrative Procedures Act [IDAPA] 58.01.11)
- U.S. Environmental Protection Agency (EPA) health-based maximum contaminant levels (MCLs) for drinking water (40 Code of Federal Regulations [CFR] 141)
- U.S. Department of Energy Derived Concentration Standards for ingestion of water (DOE Order 458.1).

6.1 Summary of Monitoring Programs

Four organizations monitor the eastern Snake River Plain aquifer hydrogeologic system:

- The United States Geological Survey (USGS) INL Project Office performs groundwater monitoring, analyses, and scientific studies to improve the understanding of the hydrogeological conditions that affect the movement of groundwater and contaminants in the eastern Snake River Plain aquifer underlying and adjacent to the INL Site. USGS utilizes an extensive network of strategically placed monitoring wells on the INL Site (Figure 6-2) and at locations throughout the eastern Snake River Plain. Table 6-1 summarizes the USGS routine groundwater surveillance program. In 2017, USGS personnel collected and analyzed over 1,000 samples for radionuclides and inorganic constituents, including trace elements, and 37 samples for purgeable organic compounds. USGS INL Project Office personnel also published four documents covering hydrogeologic conditions and monitoring at the INL Site. The abstracts to these reports are presented in Chapter 10.
- The Idaho Cleanup Project (ICP) Core contractor conducts groundwater monitoring at various Waste Area Groups (WAGs) delineated on the INL Site (Figure 6-3) for compliance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as well as drinking water monitoring at the Idaho Nuclear Technology and Engineering Center (INTEC) and Radioactive Waste Management Complex (RWMC). In 2017, the ICP Core contractor monitored groundwater at Test Area North (TAN), Advanced Test Reactor (ATR) Complex, INTEC, Central Facilities Area (CFA), and RWMC (WAGs 1, 2, 3, 4, and 7, respectively). Table 6-2 summarizes the routine monitoring for the ICP Core drinking water program. The ICP Core contractor collected and analyzed 167 drinking water samples for microbiological hazards, radionuclides, inorganic compounds, disinfection byproducts, and volatile organic compounds (VOCs) in 2017.
- The INL contractor monitors groundwater at the Materials and Fuels Complex (MFC) (WAG 9) and ATR Complex and drinking water at nine INL Site facilities: ATR Complex, CFA, Critical Infrastructure Test Range Complex (CITRC), Experimental Breeder Reactor-I (EBR-I), the Gun Range, Main Gate, MFC, TAN Contained Test Facility (CTF), and TAN/Technical Support Facility (TSF). Table 6-3 summarizes the routine groundwater and drinking water program. In 2017, the INL contractor sampled and analyzed 282 groundwater and 311 drinking water samples, which included 13 non routine and 17 performance samples for varying constituents including radionuclides, inorganic compounds, and VOCs.
- The Environmental Surveillance, Education and Research (ESER) contractor collects drinking water samples from around the INL Site, as well as samples from natural surface waters on and off the INL Site. This includes the Big Lost River, which occasionally flows through the INL Site, and springs along the Snake River that are downgradient from the INL Site. A summary of the program may be found in Table 6-4. In 2017, the ESER contractor sampled and analyzed 26 surface and drinking water samples. An additional 24 samples were collected on the Big Lost River.

Details of the aquifer, drinking water, and surface water programs may be found in the *Idaho National Laboratory Site Environmental Monitoring Plan* (DOE-ID 2017).

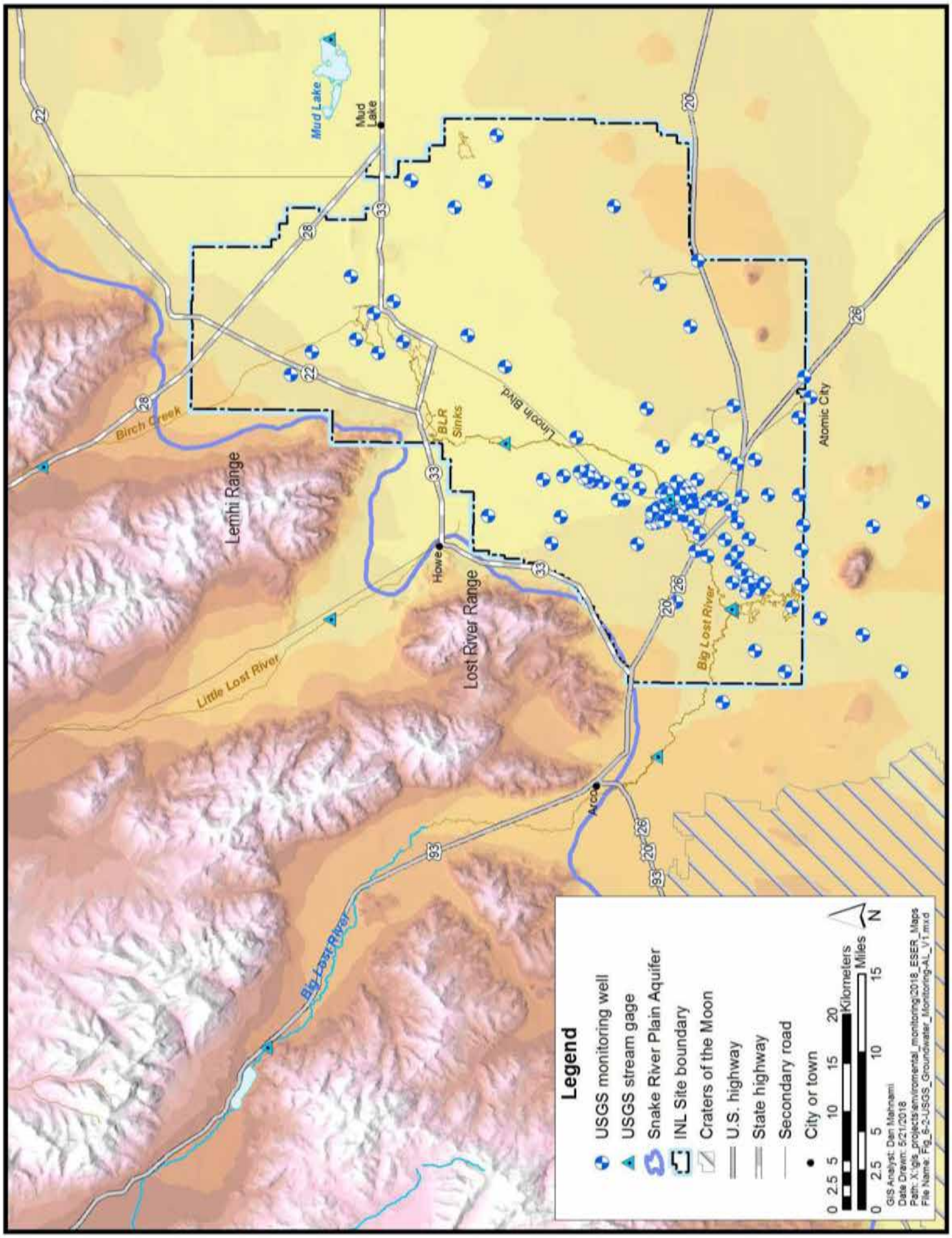


Figure 6-2. USGS Groundwater Monitoring Locations On and Off the INL Site.

Table 6-1. USGS Monitoring Program Summary (2017).

Constituent	Groundwater		Surface Water		Minimum Detectable Concentration or activity
	Number of Sites[a]	Number of Samples	Number of Sites	Number of Samples	
Gross alpha	51	50	4	4	8 pCi/L
Gross beta	51	50	4	4	3.5 pCi/L
Tritium	144	139	7	7	200 pCi/L
Gamma-ray spectroscopy	54	52	—[b]	—	—[c]
Strontium-90	83	80	—[b]	—	2 pCi/L
Americium-241	12	12	—[b]	—	0.03 pCi/L
Plutonium isotopes	12	12	—[b]	—	0.02 pCi/L
Iodine-129	16	16	—[b]	—	<1 pCi/L
Specific conductance	144	139	7	7	Not applicable
Sodium ion	138	133	—[b]	—	0.1 mg/L
Chloride ion	144	139	7	7	0.02 mg/L
Nitrates (as nitrogen)	117	114	—[b]	—	0.04 mg/L
Fluoride	4	4	—[b]	—	0.01 mg/L
Sulfate	127	122	—[b]	—	0.02 mg/L
Chromium (dissolved)	74	71	—[b]	—	0.6 mg/L
Purgeable organic compounds[d]	27	37	—[b]	—	Varies
Mercury	9	9	—[b]	—	0.005 µg/L
Trace elements	11	11	—[b]	—	Varies

a. Number of samples does not include 12 replicates, four blanks and one spike collected in 2017. Number of samples was different from the number of sites because one site for volatile organic compounds (VOCs) is sampled monthly, and two sites that had pump problems were not sampled. Number of sites does not include 30 zones from 11 wells sampled as part of the multi-level monitoring program.
b. No surface water samples collected for this constituent.
c. Minimum detectable concentration for gamma spectroscopic analyses varies depending on radionuclide.
d. Each purgeable organic compound water sample is analyzed for 61 purgeable organic compounds.

6.2 Hydrogeologic Data Management

Over time, hydrogeologic data at the INL Site have been collected by a number of organizations, including USGS, current and past contractors, and other groups. The following data management systems are used:

- The Environmental Data Warehouse is the official long-term management and storage location for INL programs. The Environmental Data Warehouse houses sampling and analytical data generated by site contractors and the USGS, and stores comprehensive information pertaining to wells, including construction, location, completion zone, type, and status.
- The ICP Core Site Sample and Analysis Management Program consolidates environmental sampling activities and analytical data management. The Sample and Analysis Management Program provides a single point of contact for obtaining analytical laboratory services and managing cradle-to-grave analytical data records.
- The USGS Data Management Program involves putting all data in the National Water Information System, which is available online at https://waterdata.usgs.gov/id/nwis/nwis.

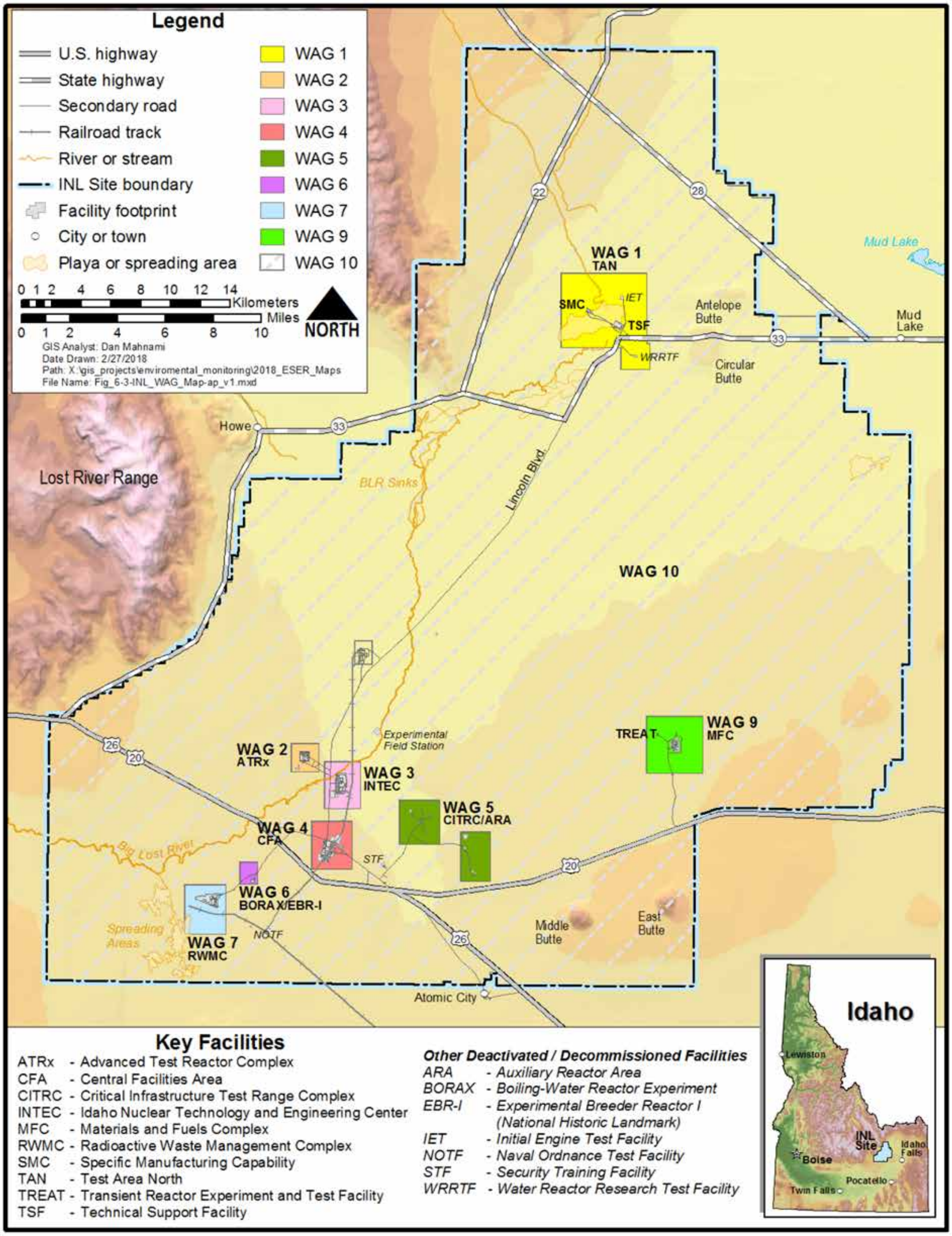


Figure 6-3. Map of the INL Site Showing Locations of Facilities and Corresponding WAGs.

Table 6-2. ICP Core Contractor Drinking Water Program Summary (2017).

Type of Analysis	Frequency (onsite)	Maximum Contaminant Level
Gross alpha	2 semiannually	15 pCi/L
Gross beta	2 semiannually	50 pCi/L screening level or 4 mrem/yr
Haloacetic acids	2 annually	0.06 mg/L
Total coliform	6 to 8 monthly	See 40 CFR 141.63(d)
E. coli	6 to 8 monthly	See 40 CFR 141.63(c)
Nitrate	2 annually	10 mg/L (as nitrogen)
Radium-226/-228	2 every 9 years	5 pCi/L
Strontium-90	2 annually	8 pCi/L
Total trihalomethanes	2 annually	0.08 mg/L
Tritium	2 annually	20,000 pCi/L
Uranium	2 every 9 years	30 µg/L
Volatile organic compounds	2 quarterly	Varies

Table 6-3. INL Contractor Drinking Water Program Summary (2017).

Type of Analysis	Frequency (onsite)	Maximum Contaminant Level
Gross alpha[a]	9 semiannually	15 pCi/L
Gross beta[a]	9 semiannually	4 mrem/yr
Tritium[a]	11 annually, 11 semiannually	20,000 pCi/L
Iodine-129[b]	1 semiannually	1 pCi/L
Parameters required by the state of Idaho under authority of the Safe Drinking Water Act	9 triennially	Varies
Nitrate[c]	11 annually	10 mg/L (as nitrogen)
Microbes	13 quarterly 12 monthly 1 monthly during summer	If <40 samples/ month, no more than one positive for total coliform
Volatile organic compounds[d]	2 semiannually	Varies
Total trihalomethanes[e]	1 annual	0.08 mg/L
Haloacetic acids[e]	1 annual	0.06 mg/L
Lead/Copper[e]	30 triennially	0.015/1.3 mg/L

a. Gross alpha, beta, and tritium are sampled at all INL water systems (i.e., TAN/TSF, TAN/CTF, ATR Complex raw/drinking water, CFA, Gun Range, EBR-1, CITRC, Main Gate, and MFC).
b. Iodine-129 is only sampled at the CFA water system.
c. Nitrate and microbes are sampled at all INL water systems.
d. Volatile organic compounds are only sampled at TAN/TSF water system.
e. Total trihalomethanes, haloacetic acids, and lead/copper are only sampled at ATR-Complex, CFA, MFC, and TAN/CTF water systems.

Table 6-4. Environmental Surveillance, Education, and Research Surface and Drinking Water Program Summary (2017).

Medium Sampled	Type of Analysis	Locations and Frequency		Minimum Detectable Concentration
		Onsite	Offsite	
Drinking Water[a]	Gross alpha	None	9-10 semiannually	3 pCi/L
	Gross beta	None	9-10 semiannually	2 pCi/L
	Tritium	None	9-10 semiannually	100 pCi/L
Surface Water[b,c]	Gross alpha	6, when available	3-4 semiannually	3 pCi/L
	Gross beta	6, when available	3-4 semiannually	2 pCi/L
	Tritium	6, when available	3-4 semiannually	100 pCi/L

a. Samples are co-located with the state of Idaho Department of Environmental Quality (DEQ) INL Oversight Program at Shoshone and Minidoka water supplies. An upgradient sample is collected at Mud Lake Well #2. The number of samples includes a duplicate sample.

b. Onsite locations are the Big Lost River (when flowing) at the public rest stop on Highway 20/26, at two locations along Lincoln Boulevard, at the Experimental Field Station, and at the Big Lost River Sinks. A duplicate sample is also collected on the Big Lost River. Offsite samples are co-located with the DEQ INL Oversight Program at Alpheus Spring, Clear Springs, and at a fish hatchery at Hagerman. A duplicate sample is also collected at one location.

c. One sample is also collected offsite at Birch Creek as a control for the Big Lost River, when it is flowing.

6.3 U.S. Geological Survey Radiological Groundwater Monitoring at the Idaho National Laboratory Site

Historic waste disposal practices have produced localized areas of radiochemical contamination in the eastern Snake River Plain aquifer beneath the INL Site.

Presently, strontium-90 (^{90}Sr) is the only radionuclide that continues to be detected by the ICP Core contractor and USGS above the primary constituent standard in some surveillance wells between INTEC and CFA and at TAN. Other radionuclides (e.g., gross alpha) have been detected above their primary constituent standard in wells monitored at individual WAGs.

Tritium – Because tritium is equivalent in chemical behavior to hydrogen—a key component of water—it has formed the largest plume of any of the radiochemical pollutants at the INL Site. The configuration and extent of the tritium contamination area, based on the most recent published USGS data (2015), are shown in Figure 6-4 (Bartholomay et al. 2017). The area of contamination within the 0.5-pCi/L contour line decreased from about 103 km^2 (40 mi^2) in 1991 to about 52 km^2 (20 mi^2) in 1998 (Bartholomay et al. 2000). The area of elevated tritium concentrations near CFA likely represents water originating at INTEC some years earlier when larger amounts of tritium were disposed. This source is further supported by the fact that there are no known sources of tritium contamination to groundwater at CFA.

Two monitoring wells downgradient of ATR Complex (USGS-065) and INTEC (USGS-114) have continually shown the highest tritium concentrations in the aquifer over the past 10 years (Figure 6-5). For this reason, these two wells are considered representative of maximum concentration trends in the rest of the aquifer. The tritium concentration in USGS-065 near ATR Complex decreased from 2,570 ± 90 pCi/L in 2016 to 2,150 ± 80 pCi/L in 2017; the tritium concentration in USGS-114, south of INTEC, decreased from 5,620 ± 120 pCi/L in 2016 to 5,410 ± 120 in 2017.

The Idaho primary constituent standard for tritium (20,000 pCi/L) in groundwater is the same as the EPA MCL for tritium in drinking water. The values in Wells USGS-065 and USGS-114 dropped below this limit in 1997 as a result of radioactive decay (tritium has a half-life of 12.33 years), ceased tritium disposal, advective dispersion, and dilution within the aquifer. A 2015 report by the USGS (Davis et al. 2015) indicated that water quality trends for tritium in all but one well at the INL Site showed decreasing or no trends, and the well that showed the increasing trend changed to a decreasing trend when data through 2015 were analyzed (Bartholomay et al. 2017, Figure 15).

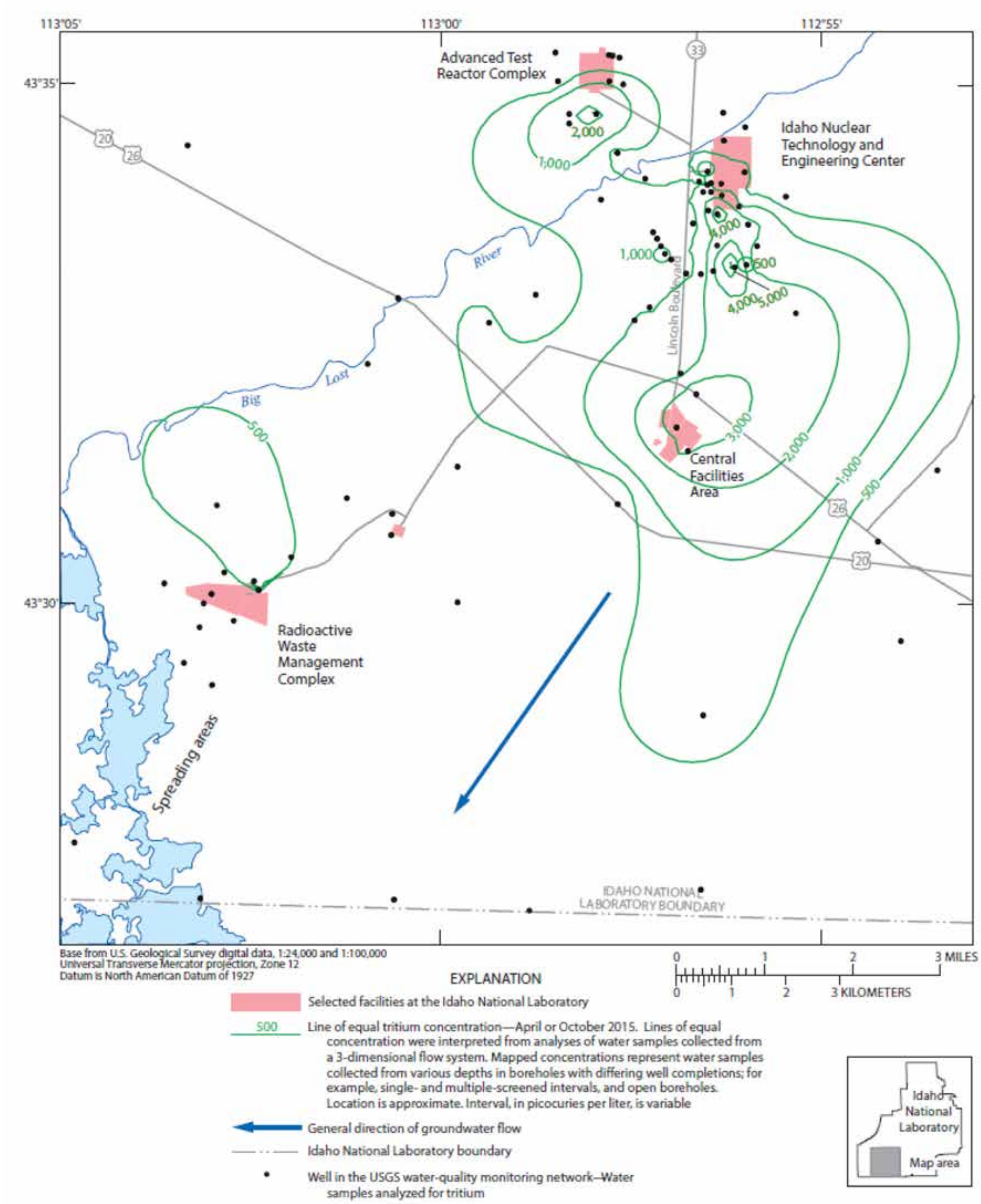


Figure 6-4. Distribution of Tritium (pCi/L) in the Eastern Snake River Plain Aquifer on the INL Site in 2015 (from Bartholomay et al. 2017).

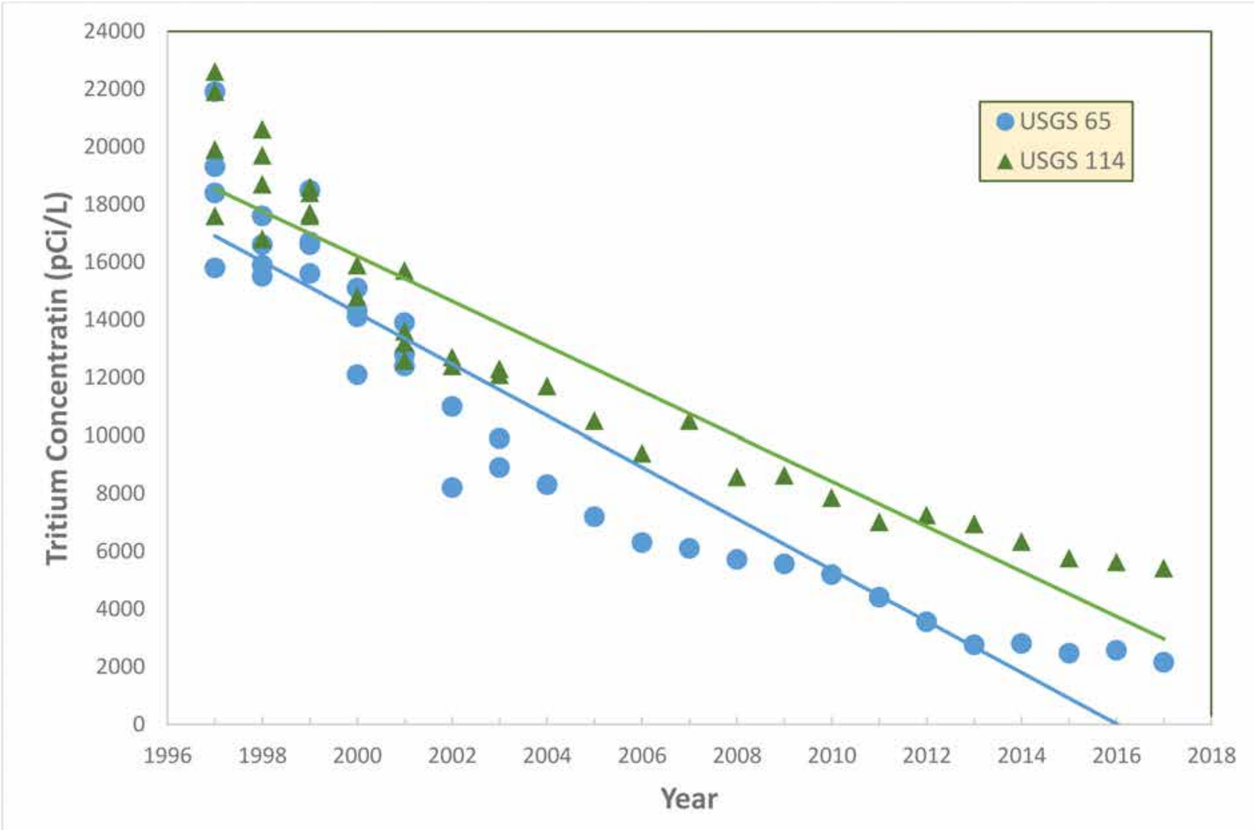


Figure 6-5. Long-term Trend of Tritium in Wells USGS-065 and -114 (1997–2017).

Strontium-90 – The configuration and extent of ^{90}Sr in groundwater, based on the latest published USGS data, are shown in Figure 6-6 (Bartholomay et al. 2017). The contamination originates at INTEC from historic injection of wastewater. No ^{90}Sr was detected by USGS in the eastern Snake River Plain aquifer near ATR Complex during 2017. All ^{90}Sr at ATR Complex was disposed to infiltration ponds in contrast to the direct injection that occurred at INTEC. At ATR Complex, ^{90}Sr is retained in surficial sedimentary deposits, interbeds, and perched groundwater zones. The area of ^{90}Sr contamination from INTEC is approximately the same as it was in 1991.

The ^{90}Sr trend over the past 20 years (1997–2017) in Wells USGS-047, USGS-057, and USGS-113 is shown in Figure 6-7. Concentrations in Well USGS-047 have varied through time but indicate a general decrease. Concentrations in Wells USGS-057 and USGS-113 also have generally decreased during this period. The variability of concentrations in some wells was thought to be due, in part, to a lack of recharge from the Big Lost River that would dilute the ^{90}Sr. Other reasons may include increased disposal of other chemicals into the INTEC percolation ponds, which may have changed the affinity of ^{90}Sr on soil and rock surfaces, causing it to become more mobile (Bartholomay et al. 2000). A 2015 report by the USGS (Davis et al. 2015) indicated that water quality trends for ^{90}Sr in all but two perched water wells at the INL Site showed decreasing or no trends.

Summary of other USGS Radiological Groundwater Monitoring – USGS collects samples annually from select wells at the INL Site for gross alpha, gross beta, gamma spectroscopy analyses, and plutonium and americium isotopes (Table 6-1). Results for wells sampled in 2017 are available at waterdata.usgs.gov/id/nwis/. Monitoring results for 2012–2015 are summarized in Bartholomay et al. (2017). During 2012–2015, concentrations of cesium-137 (^{137}Cs) were greater than or equal to the reporting level in eight wells, and concentrations of plutonium-238, plutonium-239/240, and americium-241 in all samples analyzed were less than the

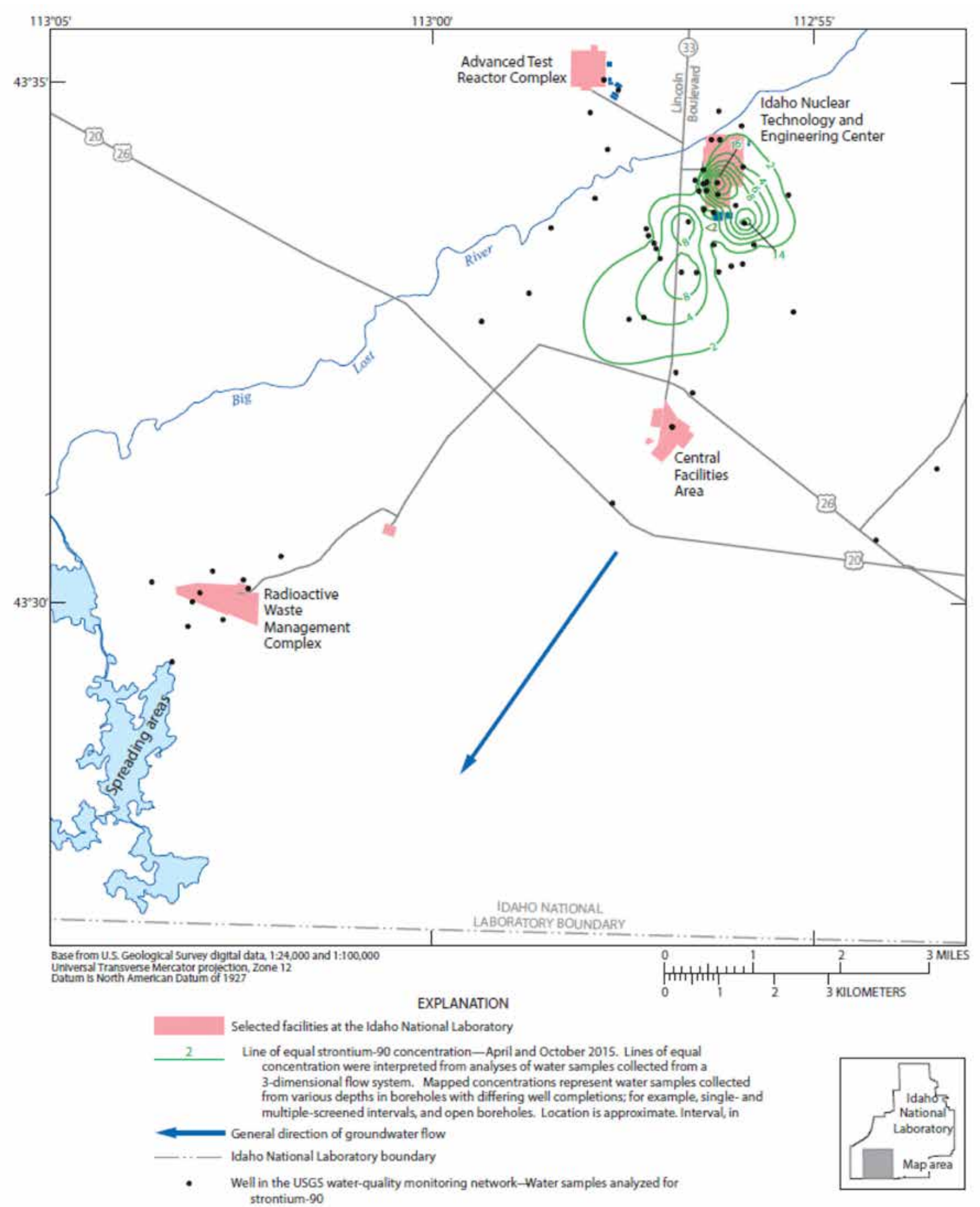


Figure 6-6. Distribution of ^{90}Sr (pCi/L) in the Eastern Snake River Plain Aquifer on the INL Site in 2015 (from Bartholomay et al. 2017).

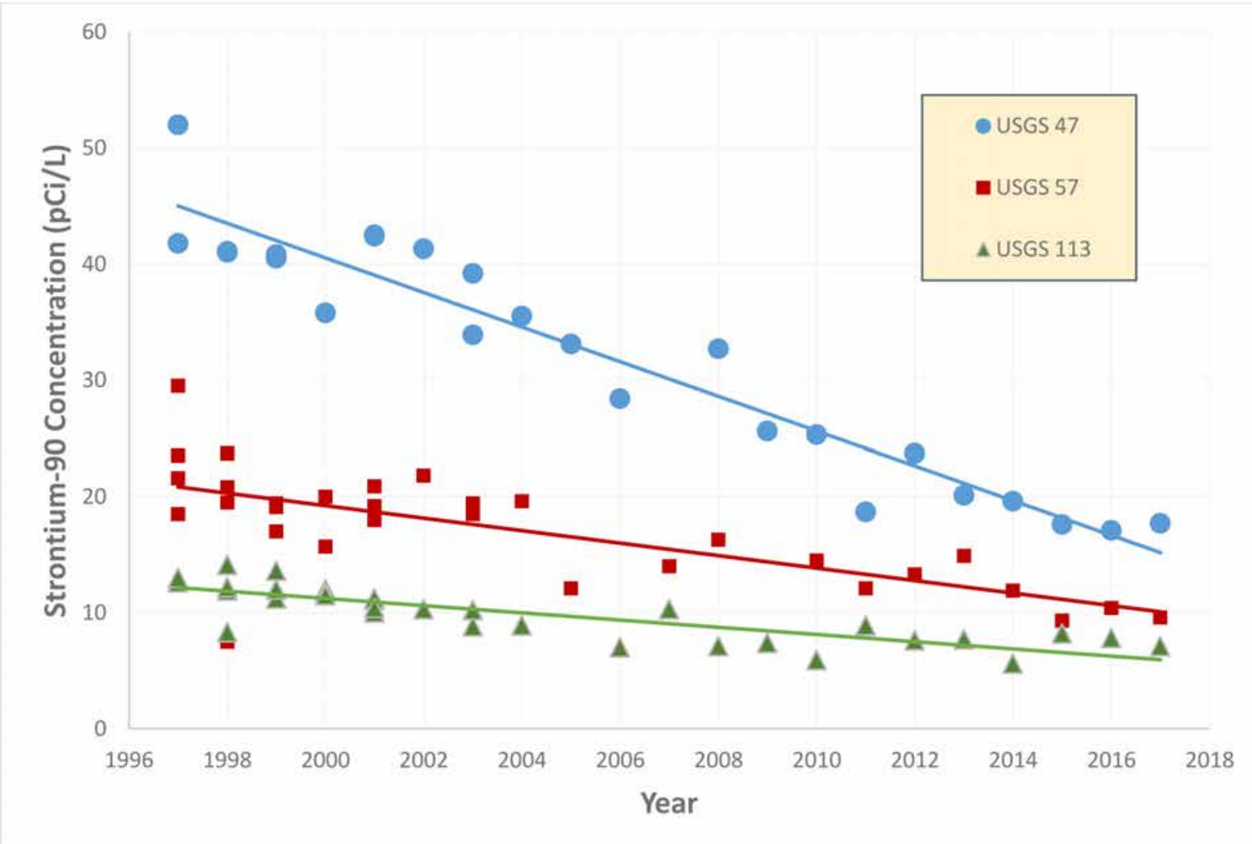


Figure 6-7. Long-term Trend of ^{90}Sr in Wells USGS-047, -057, and -113 (1997–2017).

reporting level. In 2012–2015, reportable concentrations of gross alpha radioactivity were observed in seven of the 59 wells and ranged from 6 ± 2 to 44 ± 9 pCi/L. Beta radioactivity exceeded the reporting level in most of the wells sampled, and concentrations ranged from 2.1 ± 0.7 to 1,010 ± 60 pCi/L (Bartholomay et al. 2017).

USGS periodically has sampled for iodine-129 (^{129}I) in the eastern Snake River Plain aquifer. Monitoring programs from 1977, 1981, 1986, 1990, 1991, 2003, 2007 and 2011-12 were summarized in Mann et al. (1988), Mann and Beasley (1994), and Bartholomay (2009, 2013). The USGS sampled for ^{129}I in wells at the INL Site in the fall of 2017 and will collect additional samples in the spring of 2018. Average concentrations of 15 wells sampled in 1990–1991, 2003, 2007, and 2011–2012 decreased from 1.15 pCi/L in 1990–1991 to 0.173 pCi/L in 2011–2012. The maximum concentration in 2011 was 1.02 ± 0.04 pCi/L in a monitoring well southeast of INTEC—the drinking water standard for ^{129}I is 1 pCi/L. Concentrations around INTEC showed slight decreases from samples collected in previous sample periods, and the decreases are attributed to discontinued disposal, as well as dilution and dispersion in the aquifer. The configuration and extent of ^{129}I in groundwater, based on the 2011–2012 USGS data (most current to date), are shown in Figure 6-8 (Bartholomay 2013).

6.4 U.S. Geological Survey Non-Radiological Groundwater Monitoring at the Idaho National Laboratory Site

USGS collects samples annually from select wells at the INL Site for chloride, sulfate, sodium, fluoride, nitrate, chromium, and selected other trace elements and purgeable organic compounds (Table 6-1). Bartholomay et al. (2017) provides a detailed discussion of results for samples collected during 2012–2015. Chromium had a concentration at the MCL of 100 µg/L in Well 65 in 2009 (Davis et al. 2013), but its concentration was below the MCL in 2016 at 75.5 µg/L and 76.1 µg/L in 2017; this well has shown a long-term decreasing trend (Davis et al. 2015, Appendix D).

Concentrations of chloride, nitrate, sodium, and sulfate historically have been above background concentrations in many wells at the INL Site, but concentrations were below established MCLs or secondary MCLs in all wells during 2015 (Bartholomay et al. 2017).

VOCs are present in water from the eastern Snake River Plain aquifer because of historical waste disposal practices at INL. Products containing VOCs were used for degreasing, decontamination, and other activities at INL Site facilities. The USGS sampled for purgeable (volatile) organic compounds in groundwater at the INL Site during 2017. Samples from 26 groundwater monitoring wells and one perched well were collected and submitted to the USGS National Water Quality Laboratory in Lakewood, Colorado, for analysis of 61 purgeable organic compounds. USGS reports describe the methods used to collect the water samples and ensure sampling and analytical quality (Mann 1996; Bartholomay et al. 2003; Knobel et al. 2008; Bartholomay et al. 2014). Ten purgeable organic compounds were detected above the

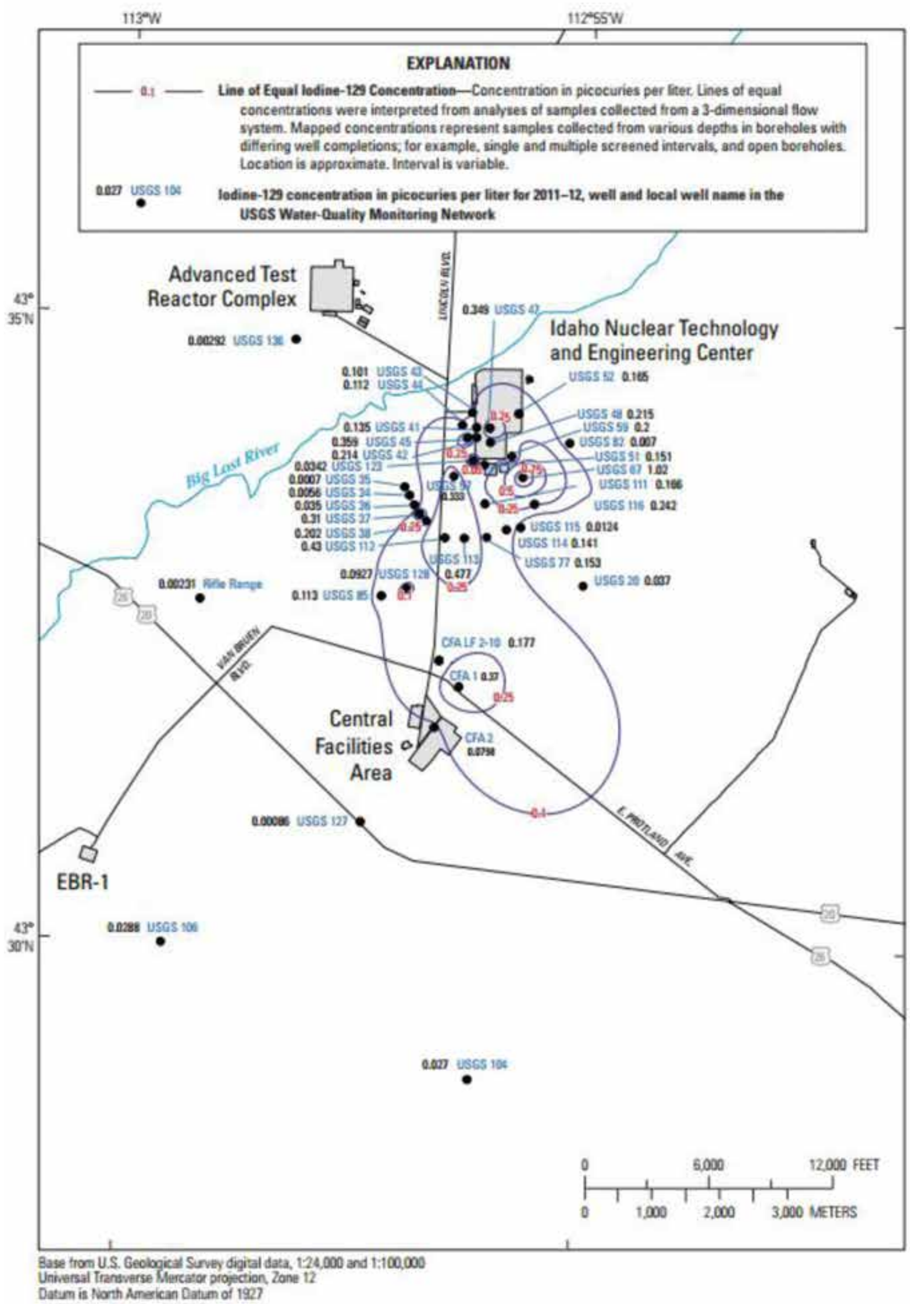


Figure 6-8. Distribution of ^{129}I in the Eastern Snake River Plain Aquifer on the INL Site in 2011–2012 (from Bartholomay 2013).

laboratory reporting level of 0.2 or 0.1 µg/L in at least one well on the INL Site (Table 6-5).

Historically, concentrations of VOCs in water samples from several wells at and near the RWMC exceeded the reporting levels (Bartholomay et al. 2000). However, concentrations for all VOCs except tetrachloromethane (also known as carbon tetrachloride) were less than the MCL for drinking water (40 CFR 141, Subpart G). The production well at the RWMC was monitored monthly for tetrachloromethane during 2017, and concentrations exceeded the MCL of 5 µg/L during all 12 months (Table 6-6). RWMC M7S also had a concentration at the MCL of 5 µg/L (Table 6-5).

Concentrations have routinely exceeded the MCL for carbon tetrachloride in drinking water (5 µg/L) at RWMC since 1998. (Note: VOCs are removed from the production well water prior to human consumption—see Section 6.6.4.) Trend test results for carbon tetrachloride concentrations in water from the RWMC production well indicate a statistically significant increase in concentrations has occurred since 1987; however, Bartholomay et al. (2017) indicated that more recent data collected since 2005 show a decreasing trend in the RWMC production well. The more recent decreasing trend indicates that engineering practices designed to reduce VOC movement to the aquifer are having a positive effect.

Concentrations of tetrachloromethane from USGS-87 and USGS-120, south of the RWMC, have had an increasing trend since 1987, but concentrations have decreased through time at USGS-88 (Davis et al. 2015).

Trichloroethene (TCE) exceeded the MCL of 5 µg/L from one sample collected from Well GIN 2 at TAN (Table 6-5). There is a known groundwater TCE plume being treated at TAN, as discussed in more detail in Section 6.5.1.

6.5 Comprehensive Environmental Response, Compensation, and Liability Act Groundwater Monitoring During 2017

CERCLA activities at the INL Site are divided into WAGs that roughly correspond to the major facilities, with the addition of the INL Site-wide WAG 10. Locations of the various WAGs are shown in Figure 6-3. The following subsections provide an overview of groundwater sampling results. More detailed discussions of CERCLA groundwater sampling can be found in the WAG-specific monitoring reports within the CERCLA Administrative Record at https://ar.icp.doe.gov. WAG 8 is managed by the Naval Reactors Facility and is not discussed in this report.

Table 6-5. Purgeable Organic Compounds in Annual USGS Groundwater Well Samples (2017).

Constituent[a]	GIN 2	RWMC-M7S	USGS-087	USGS-88	USGS-120
Tetrachloromethane (µg/L) (MCL=5)[b]	ND[c]	5.0	4.1	0.9	1.3
Trichloromethane (µg/L) (MCL=80)	0.1	1.0	0.3	0.4	0.193
1,1,1-Trichloroethane (µg/L) (PCS=200)[d]	ND	0.4	0.2	ND	ND
Tetrachloroethene (µg/L) (MCL=5)	2.7	0.4	0.2	ND	ND
Trichloroethene (µg/L) (PCS=5)	7.2	2.9	1.4	0.5	0.32

a. TAN-2271 contained 1.5 µg/L cis-1,2-Dichloroethene, 0.8 µg/L vinyl chloride, 69.2 µg/L trans-1,2-Dichloroethene, 0.2 µg/L 1,1-Dichloroethane, and 1.6 µg/L trichloroethene; USGS 77 contained 0.1 µg/L 1,1-Dichloroethane; RWMC M1SA contained 0.1 µg/L toluene; TAN-2312 contained 1.4 µg/L toluene, 0.2 µg/L tetrachloroethene, and 0.6 µg/L trichloroethene; and USGS 26 contained 2.7 µg/L toluene; 0.8 µg/L ethylbenzene; and 2.9 µg/L xylene.

b. MCL = maximum contaminant level from Environmental Protection Agency (40 CFR 141)

c. ND = not detected

d. PCS = primary constituent standard values from IDAPA 58.01.11

Table 6-6. Purgeable Organic Compounds in Monthly Production Well Samples at the RWMC (2017).

Constituent	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Tetrachloromethane (µg/L) (MCL = 5)[a]	6.5	5.6	6.6	6.3	5.7	5.9	5.5	5.5	5.9	5.4	6.7	6.4
Trichloromethane (µg/L) (MCL = 80)[b]	2.0	1.9	2.2	2.1	1.8	2.0	1.6	1.6	1.6	1.9	2.1	2.0
Tetrachloroethene (µg/L) (PCS = 5)[c]	0.5	0.4	0.4	0.4	0.4	0.3	0.4	0.4	0.4	0.3	0.4	0.4
1,1,1-Trichloroethane (µg/L) (PCS = 200)	0.3	0.3	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Trichloroethene (µg/L) (PCS = 5)	4.6	3.7	4.2	4.4	3.7	3.8	3.9	3.5	3.8	3.5	4.3	4.3

a. MCL = maximum contaminant level values from the Environmental Protection Agency (40 CFR 141)
b. The MCL for total trihalomethanes is 80 µg/L. This MCL is based on concentrations of bromodichloromethane, dibromochloromethane, tribromomethane, and trichloromethane.
c. PCS = primary constituent standard values from IDAPA 58.01.11

6.5.1 Summary of Waste Area Group 1 Groundwater Monitoring Results

Groundwater is monitored at WAG 1 to measure the progress of the remedial action at TAN. The groundwater plume at TAN has been divided into three zones for the three different remedy components. The three remedy components work together to remediate the entire plume. The monitoring program and results are summarized by plume zone in the following paragraphs.

Hot Spot Zone (historical TCE concentrations exceeding 20,000 µg/L) – In situ bioremediation (ISB) was used in the hot spot (TSF-05) to create conditions favorable for naturally occurring anaerobic bacteria in the aquifer to break down chlorinated ethene contaminants. The hot spot concentration was defined using data from 1997 (Figure 6-9) and is not reflective of current concentrations. With regulatory agency concurrence, an ISB rebound test began in July 2012 to determine if the residual TCE source in the aquifer had been sufficiently treated. Currently, the ISB rebound test has been split into two components: 1) an ISB rebound test for part of the area near the former injection Well TSF-05 and 2) ISB activities to treat the TCE source affecting TAN-28.

In 2017, an ISB rebound test was in progress for the area near the former injection Well TSF-05. Anaerobic conditions created by ISB were still present in the hot spot area, and TCE concentrations were near or below MCLs in the wells near the former injection Well TSF-05. After background aquifer conditions are re-established, the effectiveness of the ISB part of the remedy will be evaluated (DOE-ID 2018a).

Data from Wells TAN-28, TAN-30A, TAN-1860, and TAN-1861, located downgradient of the hot spot, are used to determine if ISB operations have reduced the downgradient flux of contaminants. Trends in TCE concentrations at Wells TAN-30A and TAN-1861 generally indicate that flux from the hot spot has been reduced at these wells, but the flux has not been reduced sufficiently at Wells TAN-28 and TAN-1860. Flow path analysis conducted after the first two years of the ISB rebound test determined that the cause of the higher TCE concentrations in TAN-28 and TAN-1860 was an untreated source area in the aquifer.

ISB injections continued during 2017 into Well TAN-2272 at a three-month interval throughout the year. The effect of the ISB injections into TAN-2272 on the TCE source impacting TAN-28 and TAN-1861 was marginal in 2017. A decision to continue the current ISB injections into TAN-2272 or switch to different injection wells will be made in 2018.

Medial Zone (historical TCE concentrations between 1,000 and 20,000 µg/L) – A pump and treat system has been used in the medial zone. The pump and treat system involves extracting contaminated groundwater, circulating the groundwater through air strippers to remove VOCs like TCE, and reinjecting treated groundwater into the aquifer. The New Pump and Treat Facility was generally operated Monday–Thursday, except for

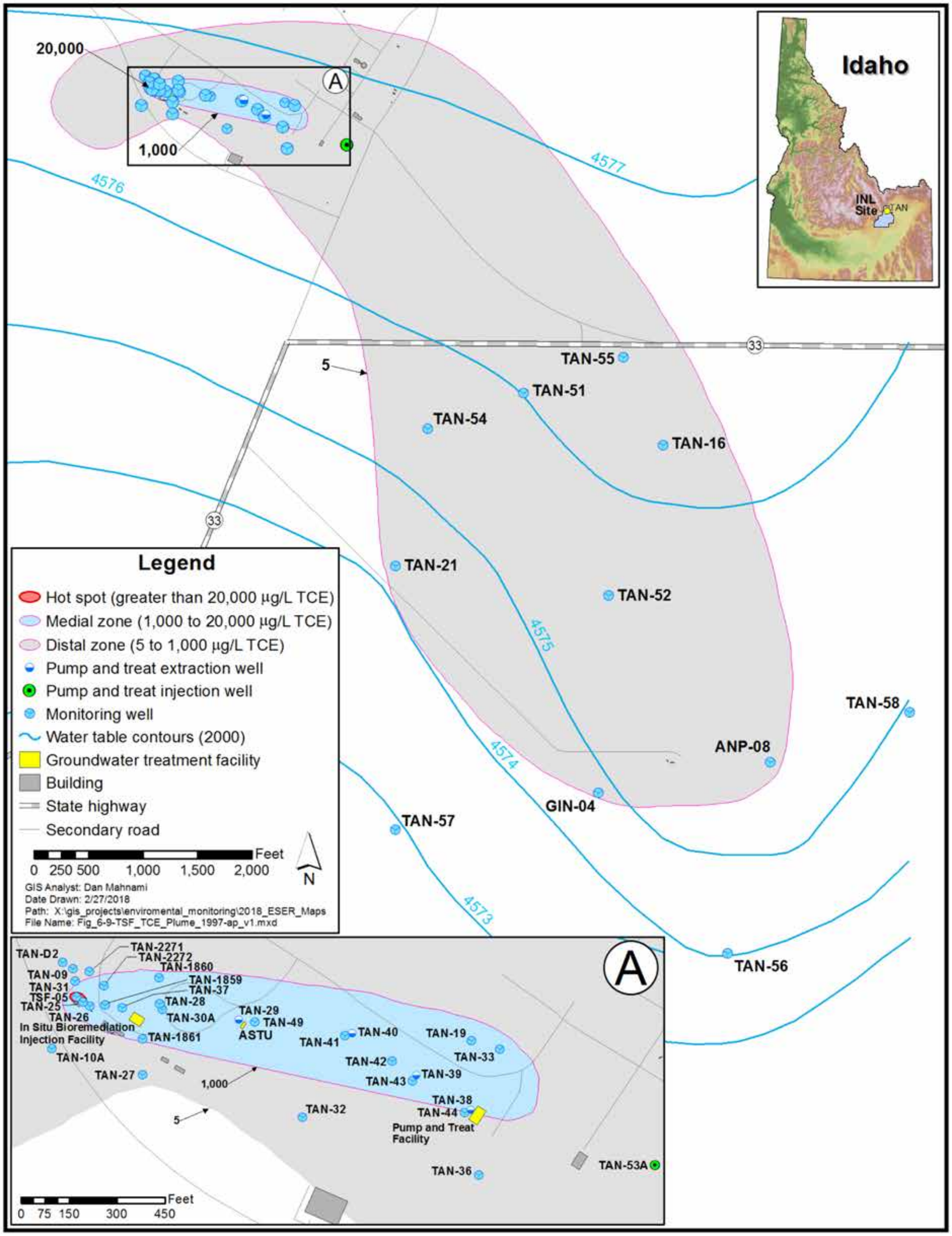


Figure 6-9. Trichloroethene Plume at TAN in 1997.

shutdowns due to maintenance. All 2017 New Pump and Treat Facility compliance samples were below the discharge limits. TCE concentrations used to define the medial zone (1,000–20,000 µg/L) are based on data collected in 1997, before remedial actions started (Figure 6-9), and do not reflect current concentrations. The TCE concentrations in Wells TAN-33, TAN-36, and TAN-44 are used as indicators of groundwater TCE concentrations that migrate past the New Pump and Treat Facility extraction wells and ranged from 22.3 to 72.4 µg/L in 2017.

Distal Zone (historical TCE concentrations between 5 and 1,000 µg/L) – Monitored natural attenuation is the remedial action for the distal zone of the plume, as defined by 1997 TCE concentrations (Figure 6-9). Monitored natural attenuation is the sum of physical, chemical, and biological processes that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in groundwater. Institutional controls are in place to protect current and future users from health risks associated with groundwater contamination until concentrations decline through natural attenuation to below the MCL.

TCE data collected in 2017 from the distal zone wells indicate that all wells are consistent with the model predictions, but additional data are needed to confirm that the monitored natural attenuation part of the remedy is on schedule for all wells in the distal portion of the plume to meet the remedial action objective of all wells below the MCL by 2095. The TCE data from the plume expansion wells suggest that plume expansion may have peaked within the limits allowed in the Record of Decision Amendment (DOE-ID 2001), but additional data are needed to confirm this.

Radionuclide Monitoring – Strontium-90 and ^{137}Cs are expected to decline below their respective MCLs before 2095. However, ^{90}Sr and ^{137}Cs concentrations for wells in the source area show elevated concentrations compared to those prior to starting ISB. The elevated ^{90}Sr and ^{137}Cs concentrations are due to elevated concentrations of competing cations (calcium, magnesium, sodium, and potassium) for adsorption sites in the aquifer leading to enhanced ^{90}Sr and ^{137}Cs mobility. The elevated cation concentrations are due to ISB activities. Strontium-90 and ^{137}Cs trends continued to be evaluated as competing cation concentrations declined toward background conditions to determine if they will meet the remedial action objective of declining below MCLs by 2095.

6.5.2 Summary of Waste Area Group 2 Groundwater Monitoring Results

Groundwater samples were collected from seven aquifer wells at WAG 2, ATR Complex, during 2017. The locations of the wells sampled for WAG 2 are shown in Figure 6-10. Aquifer samples were analyzed for ^{90}Sr, gamma-emitting radionuclides (target analyte is cobalt-60), tritium, and chromium (filtered). The data for the September 2017 sampling event will be included in the Fiscal Year 2018 Annual Report for WAG 2. The September 2017 sampling data are summarized in Table 6-7.

No analyte occurred above its MCL. The highest chromium concentration occurred in Well TRA-07 at 76.8 µg/L and was below the MCL of 100 µg/L. The chromium concentration in Well USGS-065 was also elevated at 75.8 µg/L. The chromium concentrations decreased in both TRA-07 and USGS-065 from the previous year and the chromium concentrations in both wells are in long-term decreasing trends.

Tritium was the only radionuclide analyte detected in the aquifer and was below the MCL of 20,000 pCi/L in all wells sampled. The highest tritium concentration was 5,020 pCi/L in Well TRA-07. In the past, Well TRA-08 had detections of ^{90}Sr, but since October 2010, ^{90}Sr has been below detection limits.

Chromium and tritium concentrations in the aquifer have declined faster than predicted by the WAG 2 models used for the Operable Unit 2-12 Record of Decision and the revised modeling performed after the first five-year review (DOE-NE-ID 2005).

The September 2017 eastern Snake River Plain aquifer water table map prepared for the vicinity of ATR Complex was consistent with previous maps showing general groundwater flow direction to the southwest. Water levels in the vicinity of ATR Complex rose approximately 0.34 m (1.12 ft) on average from October 2016 to September 2017.

6.5.3 Summary of Waste Area Group 3 Groundwater Monitoring Results

At INTEC, groundwater samples were collected from 18 eastern Snake River Plain aquifer monitoring wells during 2017 (Figure 6-11). Groundwater samples were analyzed for a suite of radionuclides and inorganic constituents, and the data are summarized in the 2017 Annual Report (DOE-ID 2018b). Table 6-8 summarizes the maximum concentrations observed, along with the

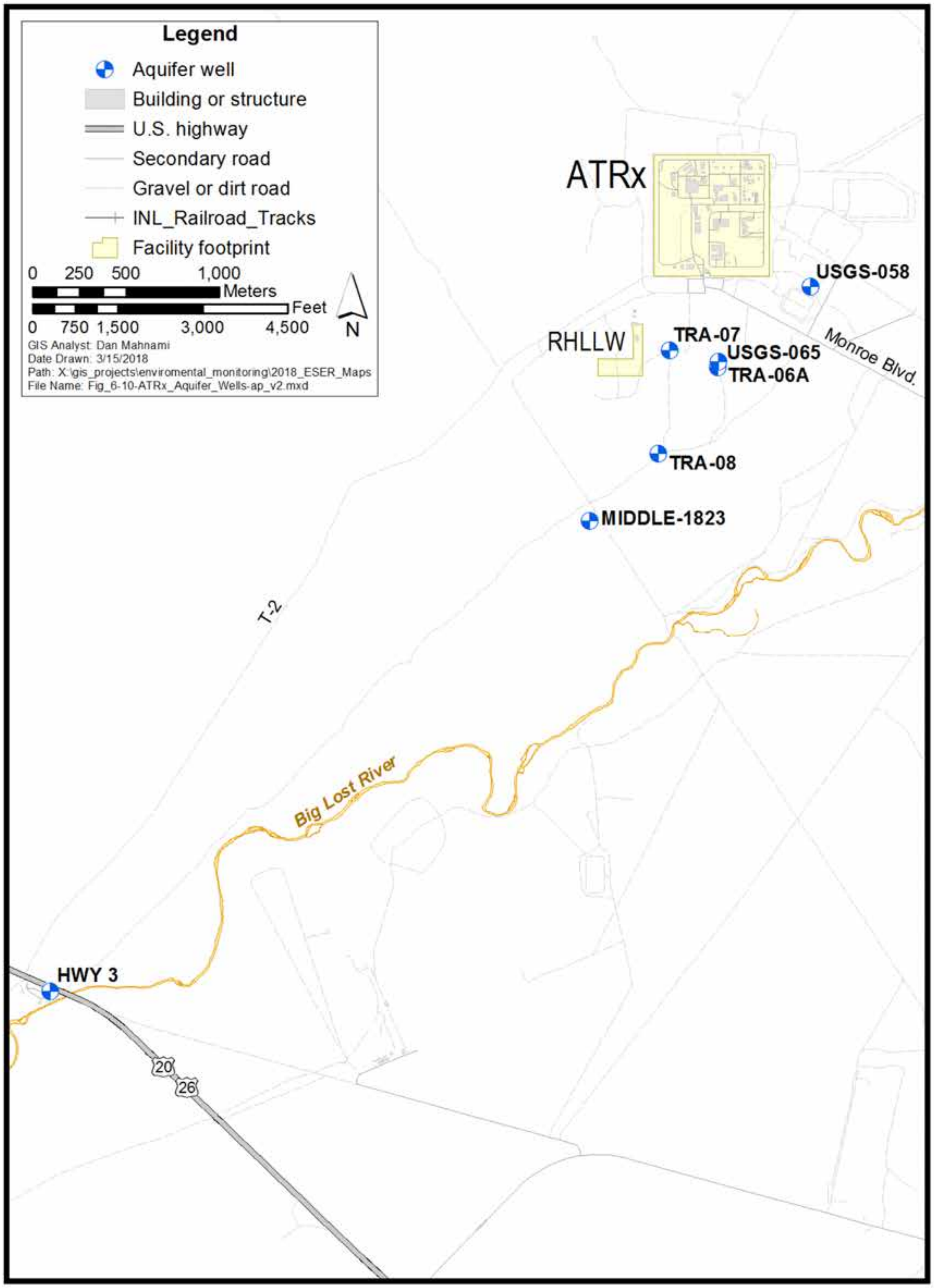


Figure 6-10. Locations of WAG 2 Aquifer Monitoring Wells.

Table 6-7. WAG 2 Aquifer Groundwater Quality Summary for 2017.

Analyte	MCL[a]	Background[b]	Maximum	Minimum	Number of Wells above MCL
Chromium (filtered) (µg/L)	100	4	76.8	ND	0
Cobalt-60 (pCi/L)	100	0	ND[c]	ND	0
Strontium-90 (pCi/L)	8	0	ND	ND	0
Tritium (pCi/L)	20,000	34	5,020	ND	0

a. MCL = maximum contaminant level
b. Background concentrations are for western tributary water for the eastern Snake River Plain aquifer from Bartholomay and Hall (2016).
c. ND = not detected

number of MCL exceedances reported for each constituent.

Strontium-90, technetium-99 (^{99}Tc), and nitrate exceeded their respective drinking water MCLs in one or more of the eastern Snake River Plain aquifer monitoring wells at or near INTEC, with ^{90}Sr exceeding its MCL by the greatest margin. Strontium-90 concentrations remained above the MCL (8 pCi/L) at seven of the well locations sampled. During 2017, the highest ^{90}Sr level in eastern Snake River Plain aquifer groundwater was at monitoring Well USGS-047 (15.3 ± 1.4 pCi/L), located south (downgradient) of the former INTEC injection well. All well locations showed similar or slightly lower ^{90}Sr levels compared to those reported during the previous sampling events.

As in the past, ^{99}Tc was detected above the MCL (900 pCi/L) in one monitoring well within INTEC, but concentrations were below the MCL at all other locations. During 2017, the highest ^{99}Tc level in eastern Snake River Plain aquifer groundwater was at monitoring Well ICPP-MON-A-230 (1,390 ± 79.7 pCi/L), located north of the INTEC Tank Farm. All wells sampled showed stable or declining trends from the previous reporting period.

Nitrate was detected in all wells sampled during this reporting period. The highest concentration was reported at Well ICPP-2021-AQ (11.6 mg/L as N). This was the only location where the nitrate concentration exceeded the MCL (10 mg/L as N). This well is located relatively close to the Tank Farm and shows groundwater quality impacts attributed to past releases of Tank Farm liquid waste. Nitrate concentrations were similar or slightly lower than observed in previous years.

Iodine-129 was below detection limits at all locations.

Tritium was detected in nearly all of the wells sampled, but none of the groundwater samples exceeded the tritium MCL (20,000 pCi/L). The highest tritium concentrations in groundwater were reported at Well ICPP-2021-AQ, southeast of the Tank Farm (2,670 ± 316 pCi/L), and Well USGS-51, near the former percolation ponds (2,370 ± 284 pCi/L). Tritium concentrations have declined at nearly all locations over the past few years.

During the reporting period, no plutonium isotopes were detected in any of the eastern Snake River Plain aquifer groundwater samples. Uranium-238 was detected at all eastern Snake River Plain aquifer well locations, with the highest concentration at Well LF3-08 (1.73 ± 0.297 pCi/L). Similarly, uranium-234 (^{234}U) also was detected in all groundwater samples, with the greatest concentrations of 2.98 ± 0.398 pCi/L at Well LF3-08. Uranium-234 is the daughter product of alpha decay of the long-lived, naturally occurring ^{238}U. Because the water table at this location declined to within 8 ft of the bottom of the well, sampling had to be performed with a bailer. The field notes indicate the groundwater sample from LF3-08 was very dark in color and contained a notable amount of sediment. The excessive turbidity likely explains the elevated uranium activities, since clay minerals may contain some natural uranium. Aside from Well LF3-08, uranium results for the other wells are consistent with background concentrations reported for Snake River Plain aquifer groundwater. Ratios of ^{234}U/^{238}U were simi-

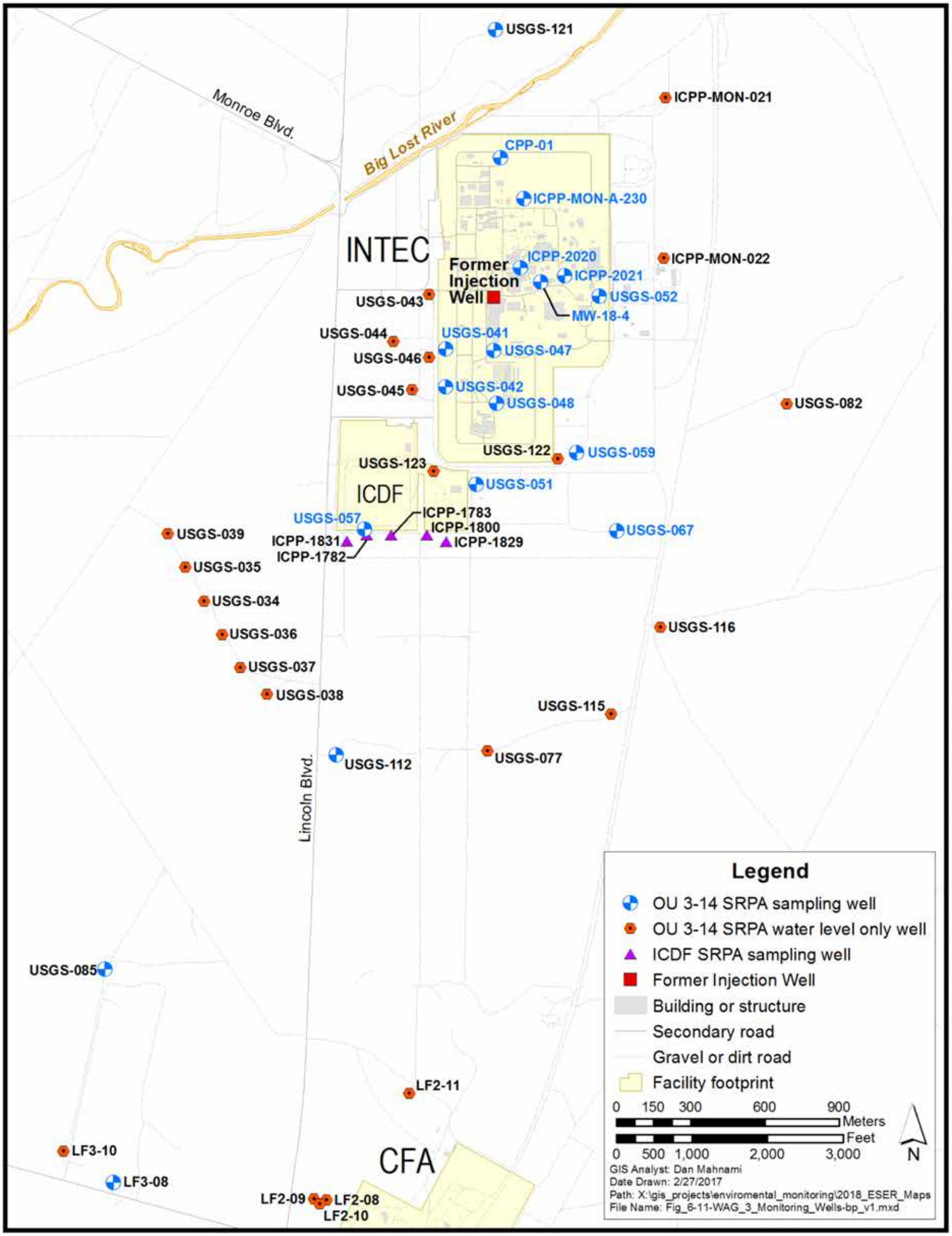


Figure 6-11. Locations of WAG 3 Monitoring Wells.

Table 6-8. Summary of Constituents Detected in WAG 3 Aquifer Monitoring Wells (Fiscal Year 2017).

Constituent	EPA MCL[a]	Units	Snake River Plain Aquifer Groundwater – May 2017		
			Maximum Reported Value	Number of Results[b]	Results >MCL[b]
Gross alpha	15	pCi/L	7.86 ± 1.29	18	0
Gross beta	NA[c]	pCi/L	739 ± 11.2	18	NA
Cesium-137	200	pCi/L	ND[d]	18	0
Strontium-90	8	pCi/L	**15.3 ± 1.4**[e]	18	7
Technetium-99	900	pCi/L	**1,390 ± 79.7**	18	1
Iodine-129	1	pCi/L	ND	18	0
Tritium	20,000	pCi/L	2,670 ± 316	18	0
Plutonium-238	15	pCi/L	ND	18	0
Plutonium-239/240	15	pCi/L	ND	18	0
Uranium-233/234	NA[f]	pCi/L	2.98 ± 0.398	18	0
Uranium-235	NA[f]	pCi/L	0.247 ± 0.0979	18	0
Uranium-238	NA[f]	pCi/L	1.73 ±0.297	18	0
Bicarbonate	NA	mg/L	162	18	NA
Calcium	NA	mg/L	60.2	18	NA
Chloride	250	mg/L	94.1	18	0
Magnesium	NA	mg/L	19.9	18	NA
Nitrate/Nitrite (as N)	10	mg/L	**11.6**	18	1
Potassium	NA	mg/L	4.43	18	NA
Sodium	NA	mg/L	27.9	18	NA
Sulfate	250	mg/L	40.8	18	0
Total dissolved solids	500	mg/L	391	18	0

a. EPA = Environmental Protection Agency; MCL = maximum contaminant level
b. Does not include field duplicates.
c. NA = not applicable
d. ND = constituent not detected in any sample
e. Bold values exceed MCL.
f. EPA MCL for total uranium is 30 µg/L.

lar to background $^{234}U/^{238}U$ activity ratios of 1.5 to 3.1 reported for the eastern Snake River Plain aquifer.

Uranium-235 was detected in nine groundwater samples. An evaluation of uranium in groundwater near RWMC indicates that eastern Snake River Plain aquifer background ^{235}U activities are generally less than 0.15 pCi/L (95 percent upper tolerance limit). Reported ^{235}U concentrations in groundwater at INTEC have historically been slightly above the background level, which is consistent with limited uranium impacts to groundwater from past operations at INTEC.

6.5.4 Summary of Waste Area Group 4 Groundwater Monitoring Results

The WAG 4 groundwater monitoring consists of two different components: 1) CFA landfill monitoring and 2) monitoring of a nitrate plume south of CFA. Groundwater monitoring for the CFA landfills consisted of sampling seven wells for metals (filtered), VOCs, and anions (nitrate, chloride, fluoride, and sulfate) and two wells for VOCs only, in accordance with the long-term monitoring plan (DOE-ID 2013). Four wells south of CFA were sampled for nitrate and other anions to monitor a nitrate plume downgradient of CFA. The CFA monitoring well locations are shown on Figure 6-12. Analytes detected in groundwater are compared to regulatory levels in Table 6-9. A complete list of the groundwater sampling results is contained in the *Central Facilities Area Landfills I, II, and III Annual Monitoring Report – Fiscal Year 2017* (DOE-ID 2018c).

In the CFA nitrate plume monitoring wells south of CFA, one well, CFA-MON-A-002, continued to exceed the groundwater MCL of 10 mg/L-N for nitrate. The nitrate concentration in CFA-MON-A-002 increased in 2017 to 15.8 mg/L-N. The nitrate concentration increase at CFA-MON-A-002 could indicate a change in the rate of decline, but the result is still consistent with a decreasing trend that has been in place since 2006.

The nitrate concentration of 8.43 mg/L-N in Well CFA-MON-A-003 is below the MCL and within its historic range of 8 to 11 mg/L-N. Except for a 2005 spike, nitrate concentrations in Well CFA-MON-A-003 have been relatively consistent since monitoring started in 1995.

In 2017, no analyte exceeded an EPA MCL for the CFA Landfill monitoring. The secondary maximum contaminant level (SMCL) for iron of 300 µg/L was exceeded in one well. However, the high iron concentration was inconsistent with the high dissolved oxygen level and slightly alkaline pH in this well. The elevated iron concentration is probably due to particles less than 0.45 microns that may have passed through the filter and interacted with the acid used to preserve the sample; or the filter may have experienced a minor breakthrough, despite precautions that were taken to guard against that occurring.

Water level measurements taken in the CFA in 2017 suggest that after the more than 10-ft drop in water levels from 2000–2005, water levels appear to be stabilizing, having declined only approximately 0.91 m (3 ft) since 2005. A water level contour map produced from water levels collected in August 2017 was consistent with previous maps in terms of gradients and groundwater flow directions (DOE-ID 2018c).

6.5.5 Summary of Waste Area Group 5 Groundwater Monitoring Results

Groundwater monitoring for WAG 5 was concluded in November 2006 in accordance with the recommendations from the first five-year review (DOE-NE-ID 2007).

6.5.6 Summary of Waste Area Group 6 Groundwater Monitoring Results

Independent groundwater monitoring is not performed for WAG 6. Groundwater monitoring in the vicinity of WAG 6 is conducted in accordance with the WAG 10 Site-wide monitoring requirements, as discussed in Section 6.5.9.

6.5.7 Summary of Waste Area Group 7 Groundwater Monitoring Results

Groundwater samples collected from monitoring wells near RWMC in November 2017 were analyzed for radionuclides, inorganic constituents, and VOCs. Of the 353 analyses performed, 13 met reportable criteria established in the Operable Unit 7-13/14 Field Sampling Plan (Forbes and Holdren 2014). Table 6-10 lists contaminants of concern that were detected above regional background concentrations, MCLs, or quantitation limits, and a discussion of those results follows.

- ***Carbon tetrachloride*** – Carbon tetrachloride was detected above the quantitation limit (1 µg/L) at six monitoring locations in November 2017 and in a field duplicate sample taken at Well M6S. The carbon tetrachloride concentrations appear to be trending downward in wells near the RWMC, thus approaching the quantitation limit (reporting threshold) (Figure 6-13).
- ***Gross alpha/Gross beta*** – In November 2017, gross beta activity was detected above the regional background concentration (7 pCi/L) in a sample collected from Well M16S. In addition, gross alpha activity was detected above its MCL at Well M16S (shown on Figure 6-14). Historically, gross beta activity has been detected above the regional background concentration in Well M16S twice, which occurred in September 2002 and November 2015. Gross alpha activity has never been detected above the MCL in M16S. The groundwater produced from M16S during purging and sampling was reported in the sampling logbook to be a "dirty orange/brown" and heavy in sediment. This suggests that the elevated gross alpha and gross beta activity may have been associated with naturally occurring radionuclides present in the suspended sediment.
- ***Trichloroethylene*** – Trichloroethylene reportable concentrations exhibited little change in November 2017, as compared with previous results (Figure 6-15).

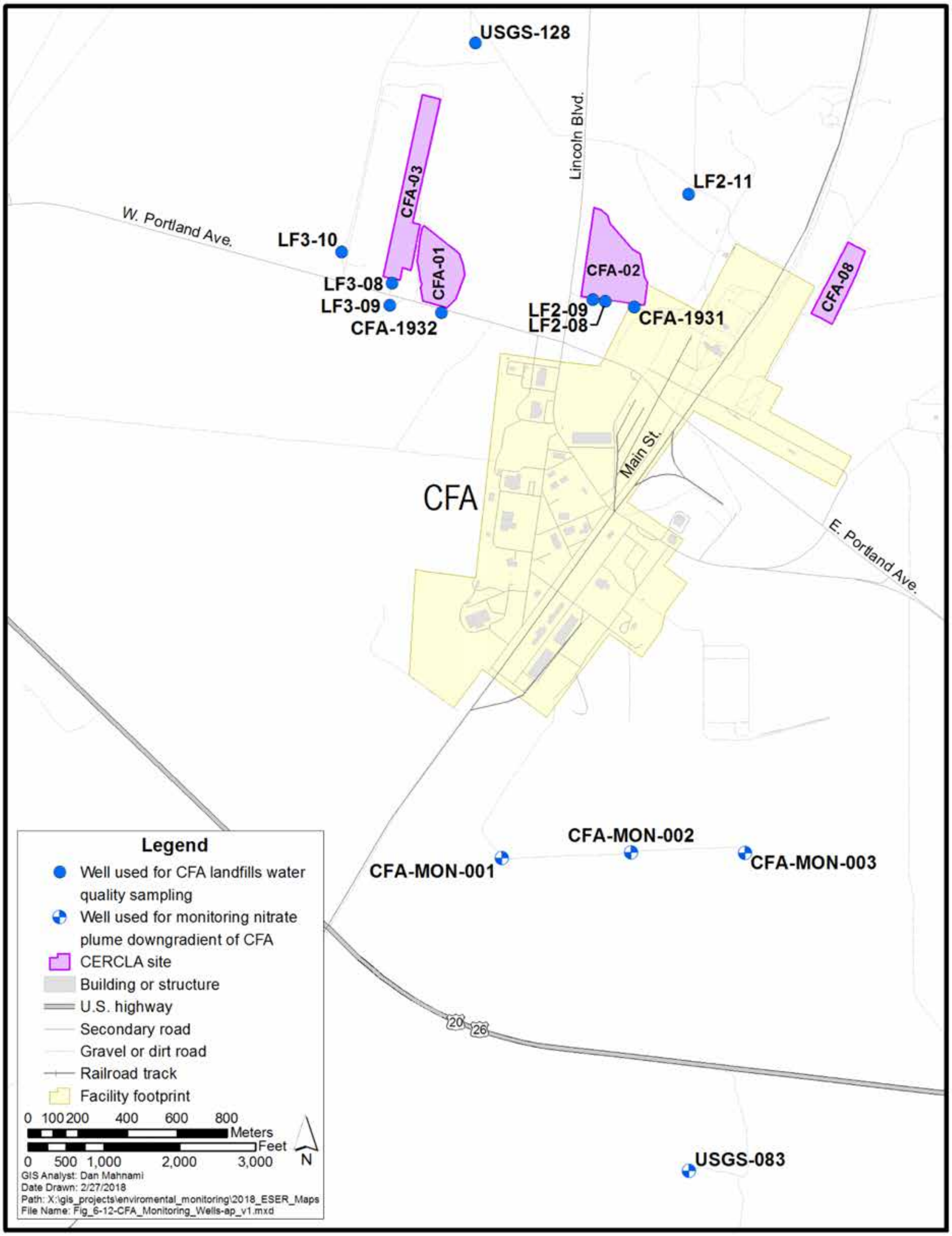


Figure 6-12. Locations of WAG 4/CFA Monitoring Wells.

Table 6-9. Comparison of WAG 4 Groundwater Sampling Results to Regulatory Levels (2017).

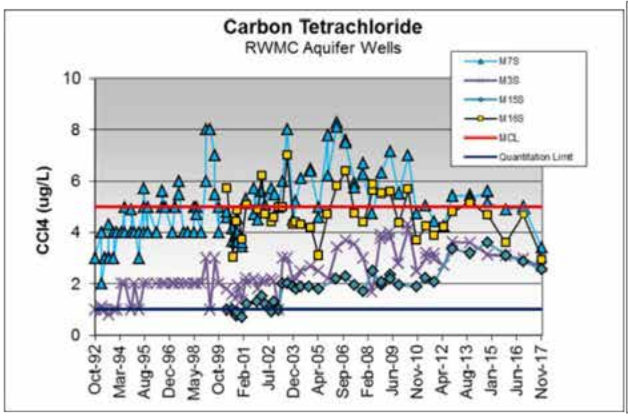
Compound	MCL[a] or SMCL[b]	Maximum Detected Value	Number of Wells above MCL or SMCL
Downgradient Central Facilities Area Wells			
Chloride (mg/L)	*250*[c]	67.1	0
Fluoride (mg/L)	2	0.17	0
Sulfate (mg/L)	*250*	31.1	0
Nitrate/nitrite (mg-N/L)	10	**15.8**[d]	1
Central Facilities Area Landfill Wells			
Anions			
Chloride (mg/L)	*250*	62.2	0
Fluoride (mg/L)	2	0.206	0
Sulfate (mg/L)	*250*	40.7	0
Nitrate/nitrite (mg-N/L)	10	1.61	0
Common Cations			
Calcium (µg/L)	None	60,600	NA[e]
Magnesium (µg/L)	None	19,200	NA
Potassium (µg/L)	None	5,200	NA
Sodium (µg/L)	None	29,400	NA
Inorganic Analytes			
Antimony (µg/L)	6	ND[f]	0
Aluminum (µg/L)	*50–200*	50.8	0
Arsenic (µg/L)	10	2.61	0
Barium (µg/L)	2,000	96.8	0
Beryllium (µg/L)	4	ND	0
Cadmium (µg/L)	5	ND	0
Chromium (µg/L)	100	49	0
Copper (µg/L)	*1,300/1,000*	1.86	0
Iron (µg/L)	*300*	**327**	1
Lead (µg/L)	15	0.512	0
Manganese (µg/L)	50	9.89	0
Mercury (µg/L)	2	ND	0
Nickel (µg/L)	None	62.9	NA
Selenium (µg/L)	50	2.38	0
Silver (µg/L)	100	ND	0
Thallium (µg/L)	2	ND	0
Vanadium (µg/L)	None	6.55	NA
Zinc (µg/L)	*5,000*	207	0
Detected Volatile Organic Compounds			
Chloroform (µg/L)	100	0.79	0
Toluene	1000	1.54	0
Acetone	–	2.74	0

a. MCL = maximum contaminant level
b. SMCL = secondary maximum contaminant level
c. Numbers in *italic* text are for the secondary MCL.
d. **Bold** values exceed an MCL or SMCL.
e. NA = not applicable
f. ND = not detected

Table 6-10. Summary of WAG 7 Aquifer Sampling and Analyses for Relevant Analytes in 2017.

Analyte	Number of Wells Sampled	Number of Analyses[a]	Number of Reportable Detections[a, b]	Concentration Maximum[a]	Location of Maximum Concentration	Number of Detections Greater than MCL[a]	MCL[c]
Carbon tetrachloride	12	15	7	3.40 µg/L	M7S	0	5 µg/L
Gross alpha	12	17	1	118 ± 9 pCi/L	M16S	1	15 pCi/L
Gross beta	12	18	1	172 ± 7 pCi/L	M16S	0	NA[d]
Trichloroethylene	12	15	4	2.08 µg/L	M7S	0	5 µg/L

a. Includes field duplicate samples collected for quality control purposes and reanalysis samples.
b. Reported results are contaminants of concern at concentrations greater than regional background concentrations or quantitation limits. Background concentrations of carbon tetrachloride and trichloroethylene in the Snake River Plain aquifer are essentially zero; therefore, laboratory quantitation limits are used as reporting limits.
c. MCL = maximum contaminant level. MCLs are from "National Primary Drinking Water Regulations" (40 CFR 141).
d. NA = not applicable



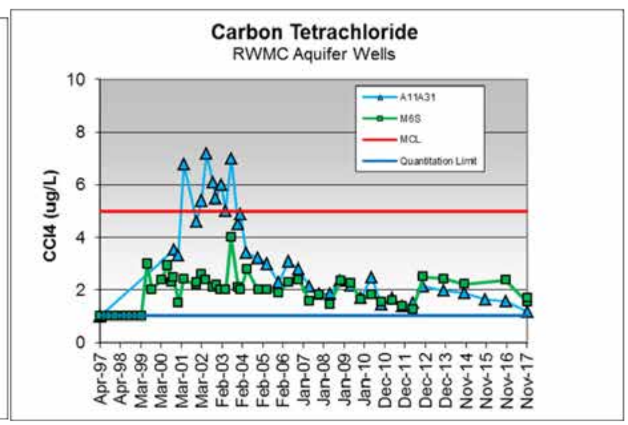


Figure 6-13. Concentration History of Carbon Tetrachloride for Wells Near the RWMC.

- ***Inorganic analytes*** – Inorganic analytes were not detected above reporting thresholds in groundwater samples in 2017.

As in previous years, groundwater level measurements in RWMC-area monitoring wells during 2017 indicate groundwater flow to the south-southwest (Figure 6-16).

6.5.8 Summary of Waste Area Group 9 Groundwater Monitoring Results

Five wells (four monitoring and one production) at the MFC are sampled twice a year by the INL contractor for selected radionuclides, metals, anions, cations, and other water quality parameters, as required under the WAG 9 Record of Decision (Figure 6-17; ANL-W 1998). The reported concentrations of analytes that were detected in at least one sample are summarized in Table 6-11. Overall, the data show no discernable impacts from activities at the MFC.

6.5.9 Summary of Waste Area Group 10 Groundwater Monitoring Results

In accordance with the Operable Unit 10-08 monitoring plan (DOE-ID 2016), groundwater samples are collected every two years at the locations shown on Figure

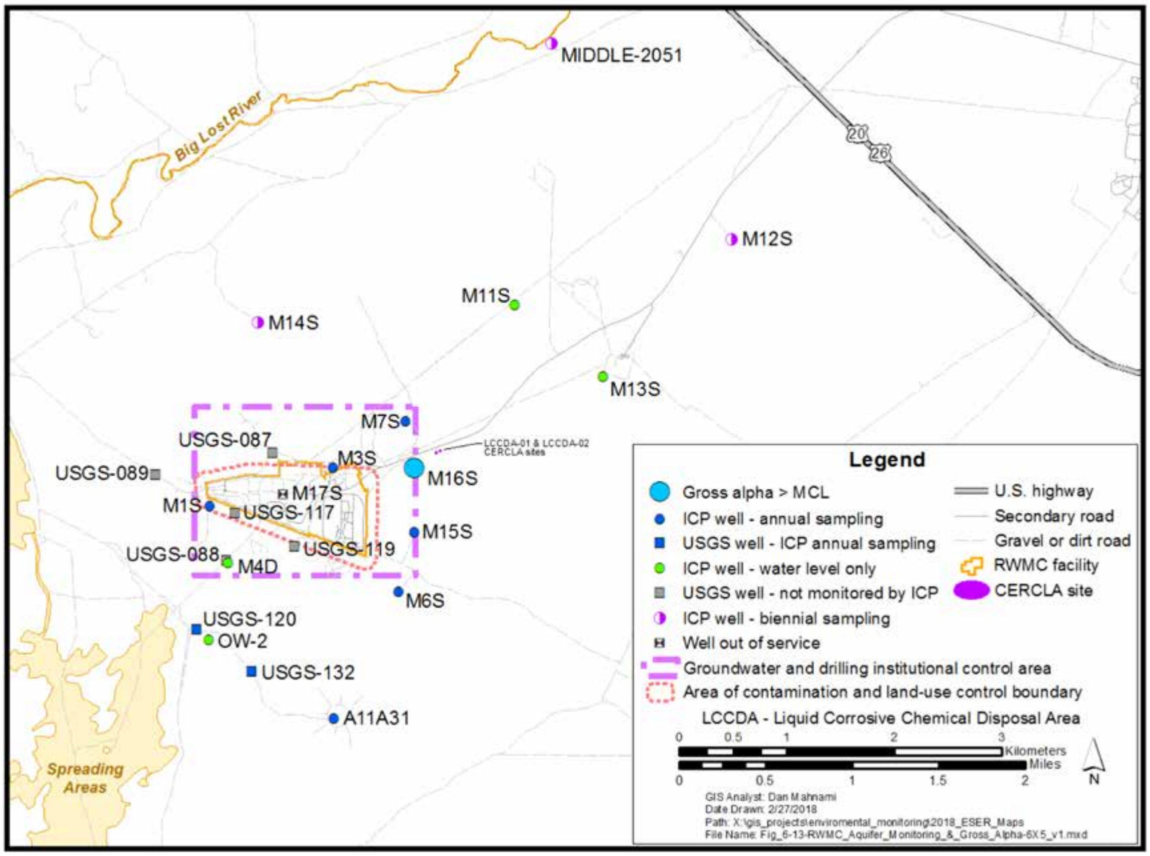


Figure 6-14. Aquifer Monitoring Wells Near the RWMC Where Gross Alpha Exceeded its MCL in November 2017.

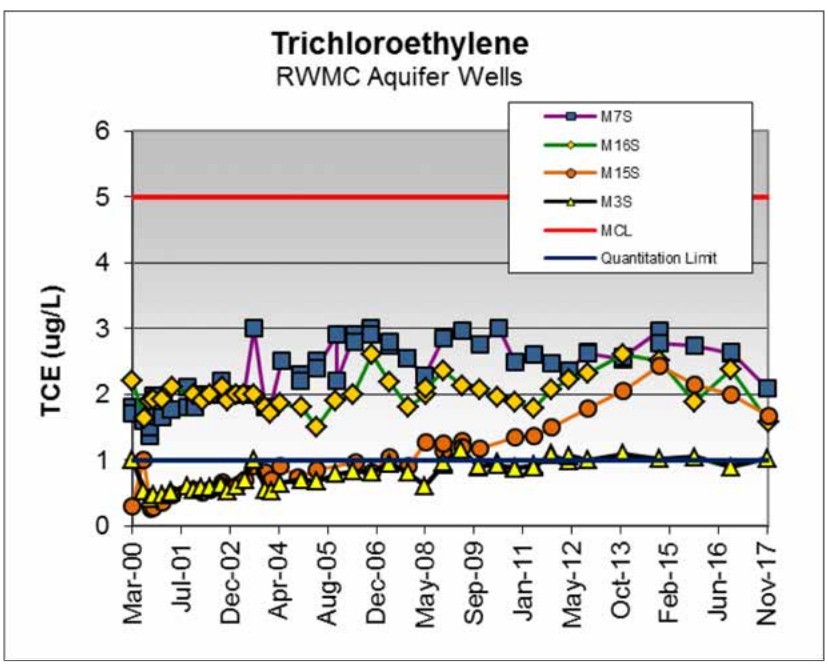


Figure 6-15. Concentration History of Trichloroethylene in Aquifer Wells near the RWMC.

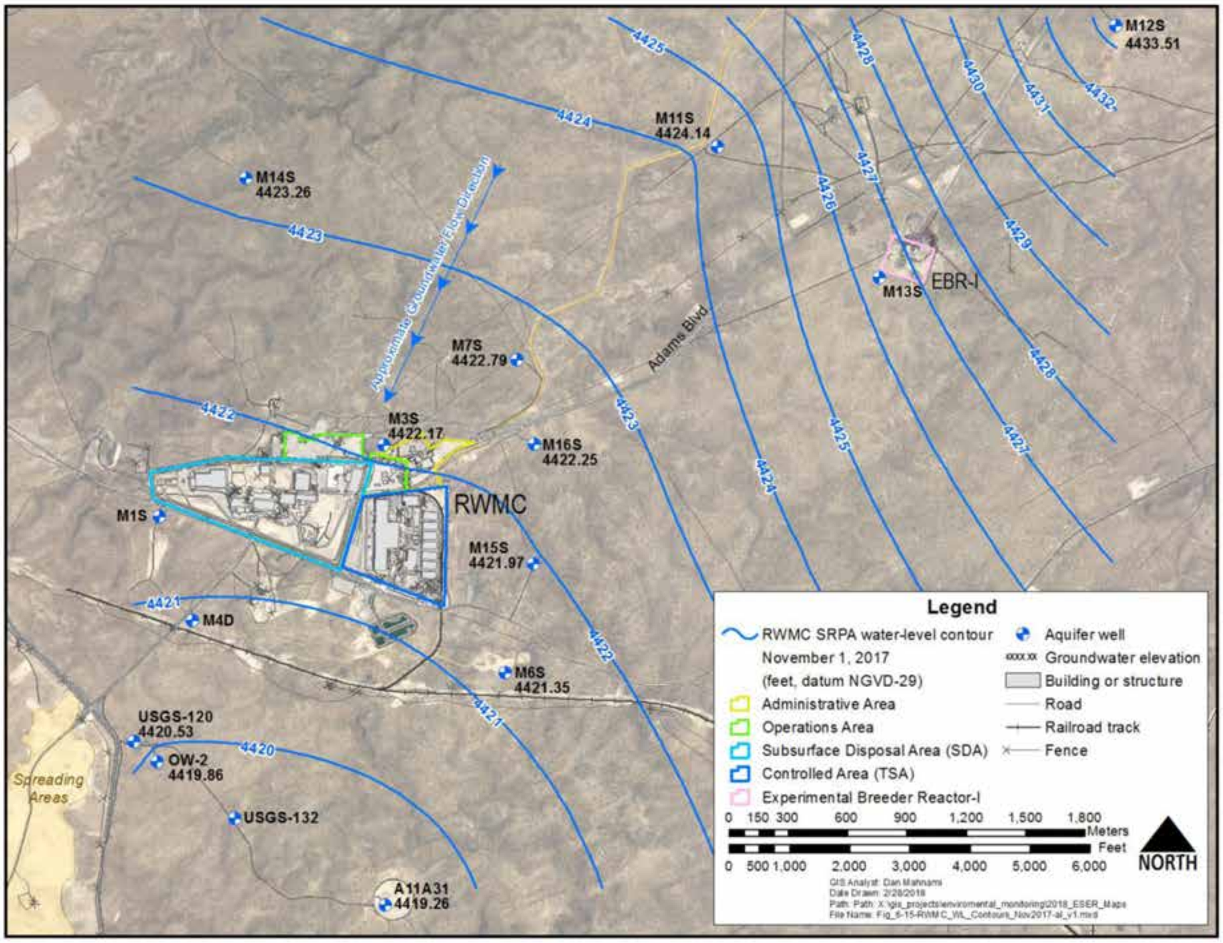


Figure 6-16. Groundwater-level Contours in the Aquifer Near the RWMC, Based on November 2017 Measurements.

6-18. Eight wells and six intervals from three Westbay wells were sampled. The wells sampled for WAG 10 were along the southern INL Site boundary or in the southern part of the INL Site (Figure 6-18). Groundwater samples from all wells were analyzed for chloride, nitrate/nitrite as nitrogen, gross alpha and gross beta, while sulfate, VOCs, and tritium were collected from a subset of the Operable Unit 10-08 monitoring wells (DOE-ID 2018d). None of the above analytes exceeded EPA MCLs or secondary MCLs (Table 6-12).

6.6 Onsite Drinking Water Sampling

The INL and ICP Core contractors monitor drinking water to ensure it is safe for consumption and to demonstrate that it meets federal and state regulations. Drinking water parameters are regulated by the state of Idaho under authority of the Safe Drinking Water Act (40 CFR 141, 142). Parameters with primary MCLs must be monitored at least once every three years. Parameters with SMCLs are monitored every three years based on a recommendation by the EPA (40 CFR 143). Many parameters require more frequent sampling during an initial period to establish a baseline, and subsequent monitoring frequency is determined from the baseline results.

Currently, the INL Site has 12 drinking water systems. The INL contractor and ICP Core contractor monitor these systems to ensure a safe working environment. The INL contractor monitors nine of these drinking water systems, ICP Core contractor monitors two, and Naval Reactors Facility monitors one. According to the "Idaho Rules for Public Drinking Water Systems" (IDAPA 58.01.08), INL Site drinking water systems are classified as either non-transient or transient, non-community

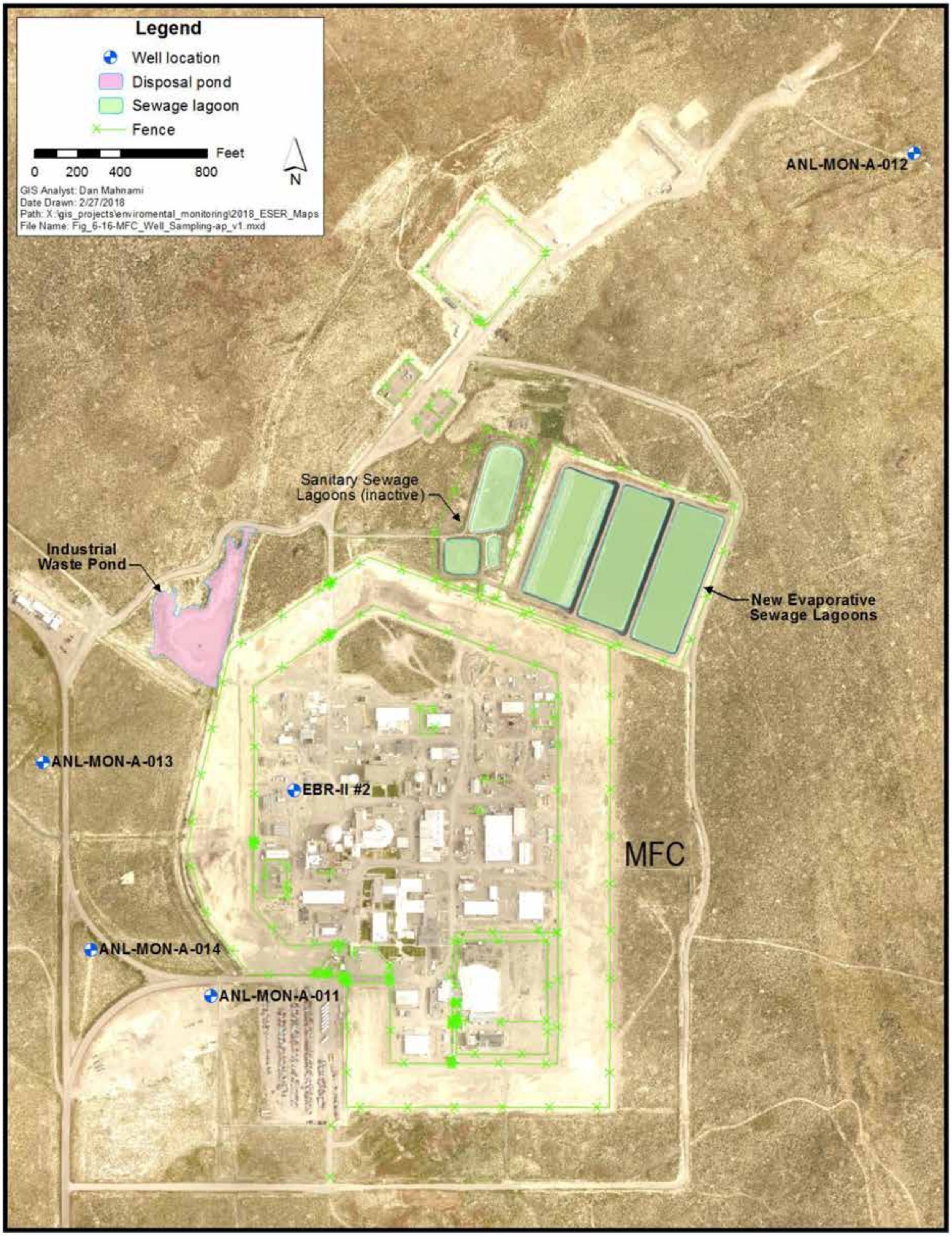


Figure 6-17. Locations of WAG 9 Wells Sampled in 2017.

Table 6-11. Comparisons of Detected Analytes to Drinking Water Standards at WAG 9 Monitoring Wells (2017).

Well:	ANL-MON-A-011		ANL-MON-A-012		ANL-MON-A-013		ANL-MON-A-014		EBR-II[a] No. 2		PCS/SCS[b]
Sample Date:	5/2/17	9/19/17	5/1/17	9/18/17	5/1/17	9/18/17	5/2/17	9/19/17	5/2/17	9/19/17	
Radionuclides[c]											
Gross beta (pCi/L)	ND[d] (3.36±0.772)[e]	3.41±0.88	4.19 ±0.778	3.46±0.748	4.33±0.749	2.79±0.507	2.72±0.755	1.95±0.627	3.05±0.734	3.78±0.821	4 mrem/yr
Uranium-233/234 (pCi/L)	1.13±0.16 (1.39±0.193)	1.59±0.183	1.26±0.188	1.48±0.178	1.34±0.198	1.65±0.188	1.6±0.205	1.51±0.169	1.55±0.195	1.57±0.18	186,000 pCi/L (30 µg/L)
Uranium-238 (pCi/L)	0.514±0.101 (0.836±0.142)	0.683±0.107	0.617±0.125	0.714±0.112	0.435±0.105	0.861±0.123	0.47±0.103	0.641±0.0991	0.644±0.115	0.895±0.125	9.9 pCi/L (30 µg/L)
Uranium-235 (pCi/L)	ND (ND)	0.241±0.0667	ND	ND	ND	0.196±0.0607	ND	ND	ND	0.335±0.0779	NE[f]
Metals[g]											
Arsenic (mg/L)	0.002U (0.002U)	0.002U	0.002U	0.002U	0.00201	0.002	0.002U	0.00211	0.002U	0.0021	0.05
Barium (mg/L)	0.0367 (0.0357)	0.0343	0.0402	0.039	0.0388	0.0363	0.0373	0.0357	0.0383	0.0364	2
Calcium (mg/L)	36.6J (35.6J)	36.4	36.3J	37.4	37.1J	37.9	34.7J	36.7	37.3J	37.6	NE[f]
Chromium (mg/L)	0.003U (0.003U)	0.003U	0.003U	0.003U	0.00347	0.00333	0.00327	0.00301	0.003U	0.003U	0.01
Copper (mg/L)	0.000362 (0.000396)	0.000668	0.000676	0.000786	0.000799	0.00115	0.000629	0.00088	0.0353	0.028	1.3
Iron (mg/L)	0.03U (0.03U)	0.0305	0.03U	0.03U	0.166	0.115	0.03U	0.03U	0.03U	0.03U	0.3
Lead (mg/L)	0.0005U (0.0005U)	0.0005U	0.0005U	0.0005U	0.0005U	0.000779	0.0005U	0.0005U	0.00257	0.00336	0.015
Magnesium (mg/L)	11.0J (10.8J)	12.6	10.7J	12.3	11.6J	13.5	10.5J	12.7	11.2J	13.0	NE
Manganese (mg/L)	0.001U (0.001U)	0.001U	0.00111	0.001U	0.00145	0.00377	0.001U	0.001U	0.001U	0.001U	0.05
Nickel (mg/L)	0.0006U (0.000693)	0.00175	0.000633	0.00143	0.00107	0.0022	0.0006U	0.00129	0.00893	0.0387	NE
Potassium (mg/L)	3.26 (3.18)	3.23	3.43	3.43	3.39	3.43	3.23	3.28	3.24	3.33	NE

Table 6-11. Comparisons of Detected Analytes to Drinking Water Standards at WAG 9 Monitoring Wells (2017) (continued).

Well:	ANL-MON-A-011		ANL-MON-A-012		ANL-MON-A-013		ANL-MON-A-014		EBR-II[a] No. 2		PCS/SCS[b]
Sodium (mg/L)	16.5J (16.1J)	18.9	16.2J	19.0	18.5J	21.0	15.9J	19.6	16.8J	20.3	NE
Vanadium (mg/L)	0.00373 (0.00382)	0.00399	0.0033U	0.00453	0.00423	0.00626	0.00352	0.00419	0.0033U	0.00472	NE
Zinc (mg/L)	0.0033U (0.0033U)	0.0033U	0.0033U	0.0033U	0.0033U	0.0033U	0.0033U	0.0033U	0.0228	0.0364	5
Anions											
Chloride (mg/L)	16.1J (15.9J)	16.2J	14.9J	15.1J	19.7J	19.4J	16.0J	15.8J	17.1J	17.1J	250
Nitrate-as nitrogen (mg/L)	2.29 (2.27)	2.37	2.06	2.13	2.08	2.24	2.15	2.16	2.16	2.23	10
Phosphorus (mg/L)	0.0803U (0.022J)	0.0415UJ	0.00938U	0.0259UJ	0.0202J	0.0369U	0.0105U	0.0379U	0.0239J	0.0387UJ	NE
Sulfate (mg/L)	17.8J (17.8J)	18.3J	17.2J	17.7J	20.5J	20.0J	18.7J	18.7J	18.8J	19.4J	250
Water Quality Parameters											
Alkalinity (mg/L)	136 (142)	136	141	137	144	139	140	138	147	137	NE
Bicarbonate alkalinity (mg/L)	136 (142)	136	141	137	144	139	140	138	147	137	NE
Total dissolved solids (mg/L)	229 (230)	177	216	211	236	217	223	217	220	214	500

a. EBR-II = Experimental Breeder Reactor II
b. PCS = primary constituent standard; SCS = secondary constituent standard
c. Result ± 1s.
d. ND = not detected; J = estimated concentration; U = not detected at the concentration shown
e. Results in parentheses are field duplicate.
f. NE = not established. A primary or secondary constituent standard has not been established for this constituent.
g. Metals reported as non-filtered unless noted.

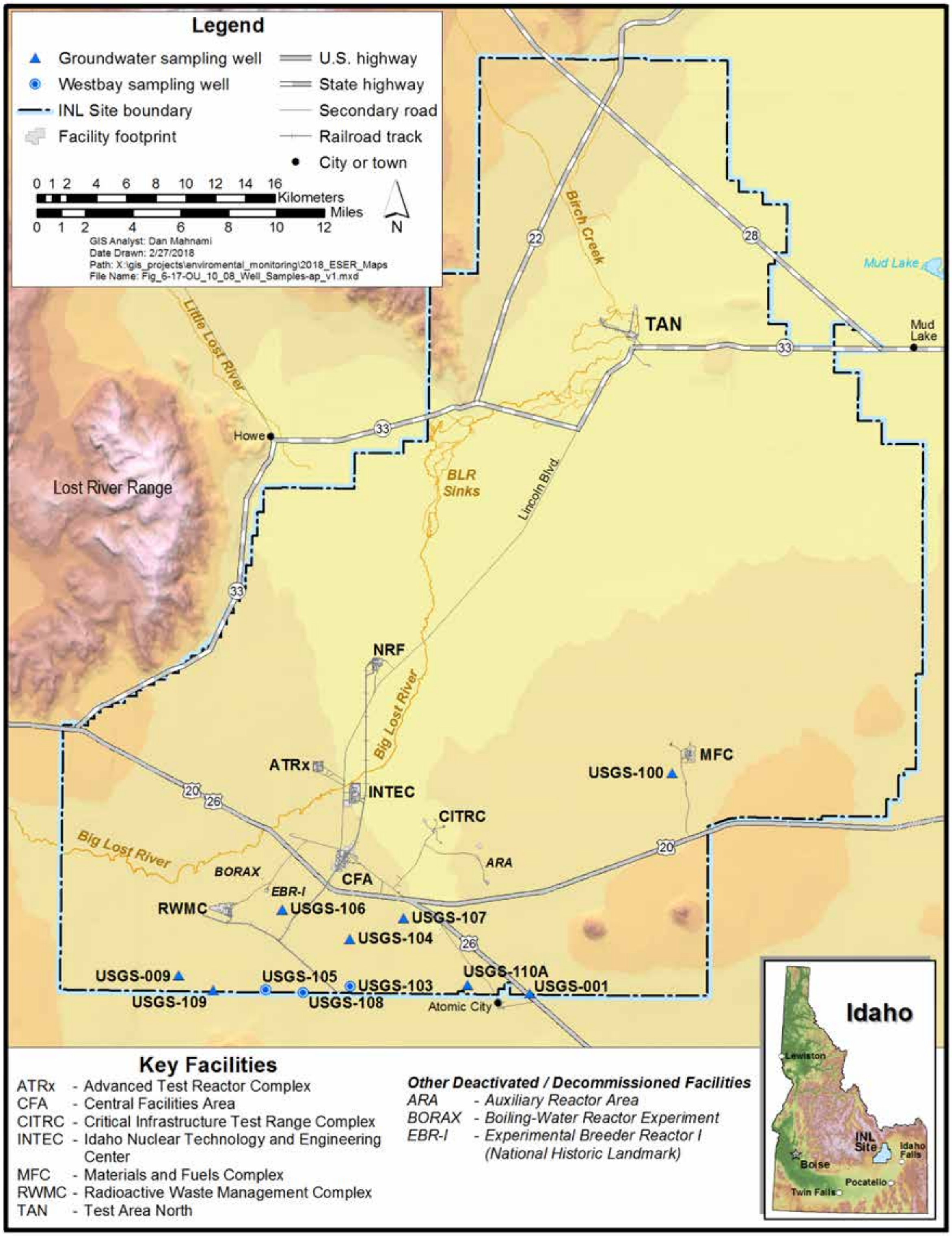


Figure 6-18. Well Locations Sampled for Operable Unit 10-08.

Table 6-12. Comparison of WAG 10 Groundwater Sampling Results to Regulatory Levels (2017).

Compound	MCL[a] or SMCL[b]	Maximum Detected Value	Number of Wells above MCL or SMCL
Anions			
Chloride (mg/L)	*250*	20.2	0
Sulfate (mg/L)	*250*	26.2	0
Nitrate/nitrite (mg-N/L)	10	2.11	0
Radionuclides			
Gross alpha (pCi/L)	15	6.81	0
Gross Beta (pCi/L)	4 mrem/yr	8.01	0
Tritium (pCi/L)	20,000	546	0
Detected Volatile Organic Compounds			
None detected	–	ND[c]	0

a. Numbers in *italic* text are for the secondary MCL. MCL = maximum contaminant level
b. SMCL = secondary maximum contaminant level
c. ND = not detected

water systems. The five INL contractor transient, non-community water systems are at the EBR-I, Gun Range (Live Fire Test Range), CITRC, TAN/TSF, and the Main Gate. The four remaining INL contractor water systems are classified as non-transient, non-community water systems. These systems are located at CFA, MFC, ATR Complex, and TAN/CTF. The two ICP Core contractor non-transient, non-community water systems are INTEC and the RWMC.

As required by the state of Idaho, the INL contractor and the ICP Core contractor Drinking Water Programs use EPA-approved (or equivalent) analytical methods to analyze drinking water in compliance with current editions of IDAPA 58.01.08 and 40 CFR Parts 141–143. State regulations also require that analytical laboratories be certified by the state or by another state whose certification is recognized by Idaho. DEQ oversees the certification program and maintains a list of approved laboratories.

Because of historic or problematic contaminants in the drinking water systems, the INL and ICP Core contractors monitor certain parameters more frequently than required by regulation. For example, bacterial analyses are conducted monthly rather than quarterly at all nine INL contractor drinking water systems and at the two ICP Core contractor drinking water systems during months of operation. Because of known groundwater plumes near two INL contractor drinking water wells and one ICP Core contractor drinking water well, additional sampling is conducted for tritium at CFA, for trichloroethylene at TAN/TSF, and for carbon tetrachloride at RWMC.

6.6.1 Idaho National Laboratory Site Drinking Water Monitoring Results

During 2017, the INL contractor collected 281 routine samples and 17 quality control samples from nine INL Site drinking water systems. In addition to routine samples, the INL contractor also collected 13 non-routine samples after a water main was repaired, a building was brought into service, and maintenance repairs were performed. The laboratories used to analyze the drinking water samples are shown in Table 11-1. Table 6-13 summarizes monitoring results for 2017. The quality control program associated with these data is discussed in Section 11.3.2.4.

Drinking water systems at EBR-I, CITRC, Gun Range, Main Gate, MFC, ATR Complex, and TAN/CTF were well below regulatory limits for drinking water; therefore, they are not discussed further in this report. In addition, all water systems were sampled for nitrates and all values were less than the MCL of 10 mg/L. The highest nitrate values were 2.59 mg/L at CFA and 2.327 mg/L at MFC. Samples for VOCs, total trihalomethanes (TTHMs), and haloacetic acids (HAA5) were collected at MFC, TAN/CTF, and TAN/TSF. There was no detection of regulatory VOCs, TTHMS, or HAA5.

Table 6-13. Summary of INL Site Drinking Water Results (2017).

Constituent	MCL	ATR-Complex	CFA	CITRC	EBR-I	GUN RANGE	MAIN GATE	MFC	TAN CTF	TAN TSF
Gross Alpha	15 pCi/L	ND-4.47	ND-4.07	ND-4.84	ND[a]	ND-3.87	ND	2.33-2.96	ND-5.71	ND
Gross Beta	50 pCi/L screening or 4 mrem	2.47-2.52	4.98-5.12	2.97-5.14	4.47-4.98	2.52-4.77	1.96-2.48	3.76-6.16	ND-4.84	ND-4.68
Tritium	20,000 pCi/L	ND	2,740-2,970	ND	ND	481-651	ND	ND	ND	ND
Iodine-129[b]	1 pCi/L	–	ND	–	–	–	–	–	–	–
Nitrate	10 mg/L	1.12	2.59	1.36	ND	1.14	ND	2.37	1.14	1.05
TTHMs	80 ppb	ND	2.2	NA[c]	NA	NA	NA	4.4	ND	NA
HAA5s	60 ppb	ND	ND	NA	NA	NA	NA	ND	ND	NA
VOCs	5 ppb for most VOCs	NA	NA	NA	NA	NA	NA	NA	NA	ND
Lead/Copper	0.015/1.3 mg/L	0.0025 /0.18	0.0063 /0.054	NA	NA	NA	NA	.0011 /.041	.0011 /.083	NA

a. ND = Not detected
b. Iodine-129 is only sampled at the CFA water system.
c. NA = Not applicable

6.6.2 Central Facilities Area

The CFA water system serves approximately 500 people daily. Since the early 1950s, wastewater containing tritium was disposed of to the eastern Snake River Plain aquifer through injection wells and infiltration ponds at INTEC and ATR Complex. This wastewater migrated south-southwest and is the suspected source of tritium contamination in the CFA water supply wells. Disposing of wastewater through injection wells was discontinued in the mid-1980s. In general, tritium concentrations in groundwater have been decreasing (Figure 6-19) because of changes in disposal techniques, diffusion, dispersion, recharge conditions, and radioactive decay. The laboratory used by the INL contractor for tritium analysis is shown in Table 11-1. Quality control is discussed in Section 11.3.2.4.

Prior to 2007, compliance samples for the CFA water distribution system were collected semiannually from Well CFA #1 at CFA-651 and Well CFA #2 at CFA-642 and quarterly from the distribution manifold at CFA-1603. Because the results were consistently below the MCL for tritium, the INL contractor decreased the tritium sampling frequency to semiannually at the CFA-1603 manifold and wells. During 2017, Well CFA #1 was used to supply approximately 58 percent of drinking water at CFA. Well CFA #2 was used to supply approximately 42 percent of the drinking water.

CFA Worker Dose. Because of the potential impacts to workers at CFA from an upgradient plume of radionuclides in the eastern Snake River Plain aquifer, the potential effective dose equivalent from radioactivity in water was calculated. For the 2017 dose calculation, it was assumed that each worker's total daily water intake would come from the CFA drinking water distribution system. The equation used to calculate the dose from water ingestion is:

$$Dose_{ingw} = TConc_{w} \times Ing_{w} \times EDC_{T}$$

where,

$Dose_{ingw}$ = effective dose from ingestion of water, mrem/yr (0.01 Sv/yr)

$TConc_{w}$ = average tritium concentration in drinking water, pCi/L

Ing_{w} = annual intake of water for an adult (L/yr)

EDC_{T} = effective dose coefficient for tritium ingested in water (mrem/pCi)

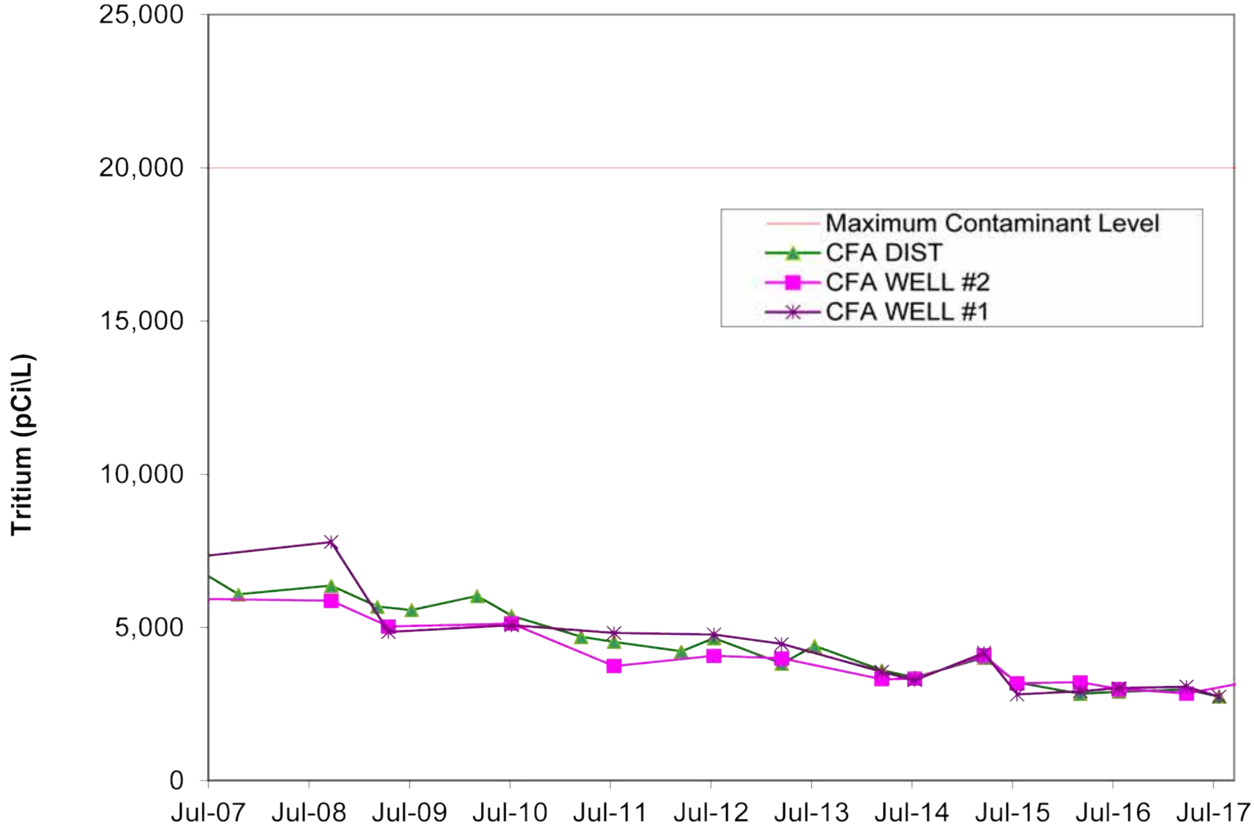


Figure 6-19. Tritium Concentrations in CFA Wells and Distribution System (2006–2017).

The values used for the variables used in the equation were:

$TConc_w$ = 2,953 pCi/L (average concentration in water in CFA distribution system for 2017)

Ing_w = 730 L/yr (calculated from Table 3 in DOE [2011])

$EDC_T = 7.14 \times 10^{-8}$ mrem/$pCi_{tritium}$ (calculated from Table A-1 of DOE [2011])

This calculation overestimates the actual dose since workers typically consume only about half their total intake during working hours and typically work only 240 days rather than 365 days per year. The estimated annual effective dose equivalent to a worker from consuming all their drinking water at CFA during 2017, as calculated from samples taken from the CFA distribution system, was 0.154 mrem (1.54 µSv). This value is below the EPA standard of 4 mrem/yr for public drinking water systems.

6.6.3 Idaho Nuclear Technology and Engineering Center

Drinking water for INTEC is supplied by two wells, CPP-04 and ICPP-POT-A-012, located north of the facility. A disinfectant residual (chlorine) is maintained throughout the distribution system. In 2017, drinking water samples were collected from the point of entry to the distribution system (CPP-614) and from various buildings throughout the distribution system. The analytical laboratories that analyzed the INTEC drinking water samples are presented in Table 11-1. Results are presented in Tables 6-14 and 6-15 and are discussed in the following paragraphs.

Four compliance samples and 38 surveillance samples were collected from various buildings throughout the distribution system at INTEC and analyzed for total coliform and E. coli per Standard Method 9223B. The results for all samples were reported as absent.

One compliance sample was collected at CPP-614 on April 26, 2017, and analyzed for VOCs by EPA Method 524.2. No VOCs were detected in the sample.

Table 6-14. 2017 Compliance Monitoring Results for the INTEC Drinking Water System – PWS#6120012.

Contaminant Sampled	# Samples Collected	Frequency	Average Result	Range Detected	MCL[a] or Action Level
Total coliform	4	1 per quarter	Absent	Absent	See 40 CFR 141.63(d)
E. coli	4	1 per quarter	Absent	Absent	See 40 CFR 141.63(c)
Copper	10	Every 3 years	0.067 mg/L	0.006 to 0.25 mg/L	1.3 mg/L
Lead	10	Every 3 years	0.00195 mg/L	ND[b] to 0.0028 mg/L	0.015 mg/L
Nitrate	1	1 per year	0.6 mg/L	NA[c]	10 mg/L (as nitrogen)
Total trihalomethanes	1	1 per year	0.0025 mg/L	NA	0.08 mg/L
Haloacetic acids	1	1 per year	< 0.002 mg/L	NA	0.06 mg/L
Volatile organic compounds	1	Every 6 years	ND	ND	0.002 – 10 mg/L[d]

a. MCL = maximum contaminant level
b. ND = not detected
c. NA = not applicable
d. This range of MCLs encompasses the 21 organic contaminants listed in 40 CFR 141.61(a).

Table 6-15. 2017 Surveillance Monitoring Results for the INTEC Drinking Water System – PWS #6120012.

Contaminant Sampled	# Samples Collected	Frequency	Average Result	Range Detected	MCL[a] or Action Level
Total coliform	40	3 per month	Absent	Absent	See 40 CFR 141.63(d)
E. coli	40	3 per month	Absent	Absent	See 40 CFR 141.63(c)
Gross alpha	2	2 per year	ND[b]	NA[c]	15 pCi/L
Gross beta	2	2 per year	5.42 pCi/L	ND – 5.42 pCi/L	50 pCi/L screening level or 4 mrem
Radium-226/228	1	Every 9 years	ND	NA	5 pCi/L
Strontium-90	1	1 per year	ND	NA	8 pCi/L
Tritium	1	1 per year	ND	NA	20,000 pCi/L
Uranium	1	Every 9 years	1.94 µg/L	NA	30 µg/L

a. MCL = maximum contaminant level
b. ND = not detected
c. NA = not applicable

On June 9, 2017, compliance samples were collected from CPP-626, CPP-652, CPP-659, CPP-663, CPP-666, CPP-684, CPP-698, CPP-1604, CPP-1606, and CPP-1631 and analyzed for lead and copper by EPA Method 200.8. None of the 10 samples exceeded the lead action level of 0.015 mg/L or the copper action level of 1.3 mg/L.

One compliance sample was collected at CPP-614 on June 28, 2017, and analyzed for nitrate by EPA Method 353.2. The result was 0.6 mg/L, which is below the nitrate MCL of 10 mg/L.

One compliance sample was collected at CPP-1666 on August 16, 2017, and analyzed for TTHM by EPA Method 524.2. The result was 0.0025 mg/L, which is below the TTHM MCL of 0.080 mg/L.

One compliance sample was collected at CPP-1666 on August 16, 2017, and analyzed for HAA5 by EPA Method 552.2. HAA5 were not detected (<0.0025 mg/L) in the sample. The MCL for HAA5 is 0.060 mg/L.

A surveillance sample was collected at CPP-614 on February 21, 2017, and analyzed for gross alpha, gross beta, tritium, ^{90}Sr, uranium, radium-226 (^{226}Ra), and radium-228 (^{228}Ra). Gross beta was detected at 5.42 pCi/L, below its screening level of 50 pCi/L. Uranium was detected at 1.94 µg/L, below its MCL of 30 µg/L. Gross alpha, tritium, ^{90}Sr, ^{226}Ra, and ^{228}Ra were reported as non-detects. Another surveillance sample was collected at CPP-614 on August 29, 2017, and analyzed for gross alpha and gross beta. Gross alpha and gross beta were not detected.

Seven quality control samples (four field duplicates and three performance evaluation samples) were collected in 2017. The results are summarized in Section 11.3.2.4.

6.6.4 Radioactive Waste Management Complex

The RWMC production well is located in Building WMF-603 and is the source of drinking water for RWMC. A disinfectant residual (chlorine) is maintained throughout the distribution system. Historically, carbon tetrachloride, total xylenes, and other VOCs had been detected in samples collected at the WMF-603 production well and at WMF-604, the point of entry into the RWMC drinking water distribution system. In July 2007, a packed tower air stripping treatment system was placed into operation to remove the VOCs from the groundwater prior to human consumption.

In 2017, drinking water samples were collected from:

- The source (WMF-603)
- Point of entry to the distribution system (WMF-604)
- Various buildings throughout the distribution system
- Comfort stations WMF-TR-12, WMF-TR-13, and WMF-TR-29
- Potable water transfer tank (PW-TK-RW01).

The analytical laboratories that analyzed the RWMC drinking water samples are presented in Table 11-1. Results are presented in Tables 6-16 and 6-17 and are discussed in the following paragraphs.

Four compliance samples and 27 surveillance samples were collected from various buildings at RWMC and analyzed for total coliform and E. coli per Standard Method 9223B. The results for all samples were reported as absent, except for total coliform, which was present in one sample collected at WMF-684 on November 6, 2017. WMF-684 was taken out-of-service, flushed, disinfected, and resampled on November 8, 2017. The results for the resampling were reported as absent for both total coliform and E. coli.

Sixteen surveillance samples were collected from the comfort stations and the potable water transfer tank and analyzed for total coliform and E. coli per Standard Method 9223B. The results for all 16 samples were reported as absent.

On June 9, 2017, compliance samples were collected from WMF-601, WMF-602, WMF-604, WMF-610, WMF-613, WMF-617, WMF-620, WMF-657, WMF-677, and WMF-678, and analyzed for lead and copper by EPA Method 200.8. None of the 10 samples exceeded the lead action level of 0.015 mg/L or the copper action level of 1.3 mg/L.

One compliance sample was collected at WMF-604 on June 28, 2017, and analyzed for nitrate by EPA Method 353.2. The result was 1 mg/L, below the nitrate MCL of 10 mg/L.

One compliance sample was collected at WMF-678 on August 16, 2017, and analyzed for TTHM by EPA Method 524.2. The result was 0.0043 mg/L, which is below the TTHM MCL of 0.080 mg/L.

Table 6-16. 2017 Compliance Monitoring Results for the RWMC Drinking Water System – PWS #6120018.

Contaminant Sampled	# Samples Collected	Frequency	Average Result	Range Detected	MCL[a] or Action Level
Total coliform	4	1 per quarter	Absent	Absent	See 40 CFR 141.63(d)
E. coli	4	1 per quarter	Absent	Absent	See 40 CFR 141.63(c)
Copper	10	Every 3 years	0.028 mg/L	0.005 to 0.078 mg/L	1.3 mg/L
Lead	10	Every 3 years	0.0064 mg/L	ND[b] to 0.0064 mg/L	0.015 mg/L
Nitrate	1	1 per year	1.0 mg/L	NA[c]	10 mg/L (as nitrogen)
Total trihalomethanes	1	1 per year	0.0043 mg/L	NA	0.08 mg/L
Haloacetic acids	1	1 per year	<0.002 mg/L	NA	0.06 mg/L
Xylenes (total)	4	1 per quarter	0.0006 mg/L	ND to 0.0007 mg/L[d]	10 mg/L
Volatile organic compounds	1	Every 3 years	0.0006 mg/L	ND to 0.0007 mg/L	0.002 – 10 mg/L[d]

a. MCL = maximum contaminant level
b. ND = not detected
c. NA = not applicable
d. This range of MCLs encompasses 21 organic contaminants listed in 40 CFR 141.61(a).

Table 6-17. 2017 Surveillance Monitoring Results for the RWMC Drinking Water System – PWS #6120018.

Contaminant Sampled	# Samples Collected	Frequency	Average Result	Range Detected	MCL[a] or Action Level
Total coliform	27	1 to 2 per month	Absent	26 samples: absent 1 sample: present	See 40 CFR 141.63(d)
E. coli	27	1 to 2 per month	Absent	27 samples: absent	See 40 CFR 141.63(c)
Volatile organic compounds	6	2 per quarter	0.0027 mg/L	ND[b] to 0.0054 mg/L	0.002 – 10 mg/L[c]
Gross alpha	2	2 per year	ND	NA[d]	15 pCi/L
Gross beta	2	2 per year	4.06 pCi/L	2.95 to 5.17 pCi/L	50 pCi/L screening level or 4 mrem
Radium-226/228	1	Every 9 years	ND	NA	5 pCi/L
Strontium-90	1	1 per year	ND	NA	8 pCi/L
Tritium	1	1 per year	705 pCi/L	NA	20,000 pCi/L
Uranium	1	Every 9 years	2.1 µg/L	NA	30 µg/L

a. MCL = maximum contaminant level
b. ND = not detected
c. This range of MCLs encompasses the 21 organic contaminants listed in 40 CFR 141.61(a). The 0.0054 mg/L result was for carbon tetrachloride and the sample was collected from the RWMC Production Well at WMF-603 on October 25, 2017. Although this result was above the MCL for carbon tetrachloride (0.005 mg/L), it was not a compliance issue because WMF-603 is not the point of entry into the RWMC drinking water system. No other MCLs were exceeded.
d. NA = not applicable

One compliance sample was collected at WMF-678 on August 16, 2017, and analyzed for HAA5 by EPA Method 552.2. HAA5 were not detected (<0.002 mg/L) in the sample. The MCL for HAA5 is 0.060 mg/L.

Four compliance samples were collected at WMF-604 and analyzed for total xylenes by EPA Method 524.2. Total xylenes were not detected (<0.0005 mg/L) in the July 26, 2017, sample. Total xylenes were detected in the January 25, 2017, sample (0.0006 mg/L), the April 26, 2017, sample (0.0005 mg/L), and the October 25, 2017, sample (0.0007 mg/L). All three of these samples were below the total xylenes MCL of 10 mg/L.

One compliance sample was collected at WMF-604 on July 26, 2017, and analyzed for VOCs by EPA Method 524.2. No VOCs were detected in the sample.

Three surveillance samples were collected at WMF-604 and analyzed for VOCs by EPA Method 524.2. Other than total xylenes, no other VOCs were detected in any of these samples.

Three surveillance samples were collected at the WMF-603 production well and analyzed for VOCs by EPA Method 524.2. Total xylenes were not detected (<0.0005 mg/L) in any of these three samples. Carbon tetrachloride was detected in all three samples and ranged in concentration from 0.0045 mg/L to 0.0054 mg/L. Trichloroethene was also detected in all three samples and ranged in concentration from 0.0023 mg/L to 0.0028 mg/L. No other VOCs were detected in any of the samples.

A surveillance sample was collected at WMF-604 on February 21, 2017, and analyzed for gross alpha, gross beta, tritium, ^{90}Sr, uranium, ^{226}Ra and ^{228}Ra. Gross beta was detected at 5.17 pCi/L, below its screening level of 50 pCi/L. Tritium was detected at 705 pCi/L, below its MCL of 20,000 pCi/L. Uranium was detected at 2.1 µg/L, below its MCL of 30 µg/L. Gross alpha, ^{90}Sr, ^{226}Ra, and ^{228}Ra were reported as non-detects. Another surveillance sample was collected on August 29, 2017, and analyzed for gross alpha and gross beta. Gross alpha was not detected. Gross beta was detected at 2.95 pCi/L, but below its screening level of 50 pCi/L.

Eight quality control samples (one field blank, two field duplicates, and five trip blanks) were collected. The results are summarized in Section 11.3.2.4.

6.7 Test Area North/Technical Support Facility

Well TSF #2 supplies drinking water to fewer than 25 employees at TSF. The facility is served by a chlorination system. TSF #2 is sampled for surveillance purposes only (not required by regulations).

In the past, trichloroethylene contamination has been a concern at TSF. The principal source of this contamination was inactive injection Well TSF-05. Although regulations do not require sampling Well TSF #2, samples are collected to monitor trichloroethylene concentrations due to the historical contamination. Since mid-2006, concentrations appear to be declining but will have to be confirmed with the collection of additional data.

Figure 6-20 illustrates the trichloroethylene concentrations in both Well TSF #2 and the distribution system. Table 6-18 summarizes the trichloroethylene concentrations at TSF #2 and the distribution system. The mean concentration at the distribution system for 2017 was ten times less than the reporting limit of 0.5 µg/L.

6.8 Offsite Drinking Water Sampling

As part of the offsite monitoring program performed by the ESER contractor, drinking water samples were collected off the INL Site for radiological analyses in 2017. Two locations, Shoshone and Minidoka, which are downgradient of the INL Site, were co-sampled with the state of Idaho DEQ-INL Oversight Program (DEQ-IOP) in May and November 2017. One upgradient location, Mud Lake, was also co-sampled with DEQ-IOP. ESER also collected samples at Atomic City, Craters of the Moon, Howe, Idaho Falls, and the public rest area at Highway 20/26. A control sample of bottled water was also obtained. The samples were analyzed for gross alpha and gross beta activities and for tritium. The ESER contractor results are shown in Table 6-19. DEQ-IOP results are reported quarterly and annually and can be accessed at www.deq.idaho.gov/inl-oversight.

Gross alpha activity was detected statistically (above 3σ) in seven of nine samples collected in May 2017 and in three of nine samples collected in November 2017 at just above the minimum detectable concentration. Neither of the bottled water (control) samples had detectable concentrations of gross alpha activity. The results are below the screening level of 15 pCi/L for gross alpha activity, with a maximum of 5.3 ± 0.71 pCi/L, measured at Minidoka in May.

Gross beta activity was detected statistically in all but five drinking water samples collected by the ESER

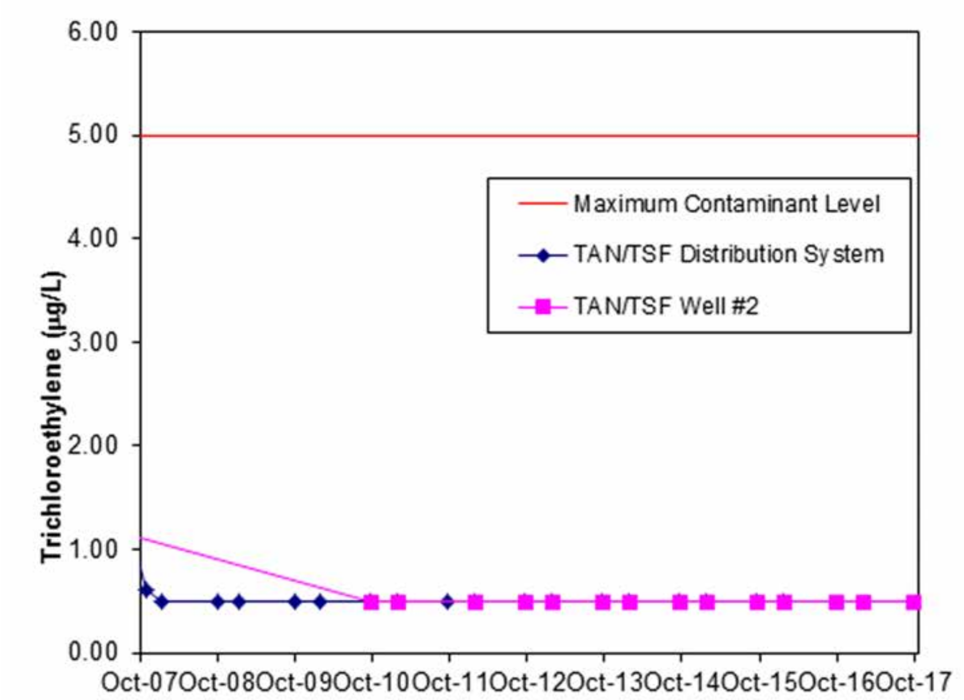


Figure 6-20. Trichloroethylene Concentrations in TSF Drinking Water Well and Distribution System (2007–2017).

Table 6-18. Trichloroethylene Concentrations at TAN/TSF Well #2 and Distribution System (2017).

Location	Number of Samples	Trichloroethylene Concentration (µg/L)			
		Minimum	Maximum	Mean	MCL[a]
TAN/TSF #2 (612)	2	<0.5	<0.5	<0.5	NA[b]
TAN/TSF Distribution (610)[c]	0	-	-	-	5.0

a. MCL = maximum contaminant level (see Table A-4)
b. NA = not applicable. Maximum contaminant level applies to the distribution system only.
c. TAN/TSF Distribution (610) is only sampled if there is a detection at TAN/TSF #2 (612).

contractor. Gross beta activity was not detected in the bottled water samples (controls). The results are below the screening level of 50 pCi/L for gross beta activity, with a maximum of 4.8 ± 0.47 pCi/L, measured at the Mud Lake well in May. If gross beta activity exceeds 50 pCi/L, an analysis of the sample must be performed to identify the major radionuclides present (40 CFR 141). Gross beta activity has been measured at these levels historically in offsite drinking water samples. For example, the maximum level reported since 2010 in the past Annual Site Environmental Reports was 7.83 ± 0.61 pCi/L (Atomic City in spring of 2011).

Tritium was statistically detected in eleven of the drinking water samples, including both of the bottled water control samples, collected in 2017. The maximum result measured was 169 ± 24.8 pCi/L. The results were within historical measurements and well below the EPA MCL of 20,000 pCi/L. For example, the maximum tritium level reported since 2010 was 193 ± 24 pCi/L (Rest Area in the fall of 2013).

6.9 Surface Water Sampling

Surface water was co-sampled with DEQ-IOP in May and November 2017 at three springs located downgradient of the INL Site: Alpheus Springs near Twin

Table 6-19. Gross Alpha, Gross Beta, and Tritium Concentrations in Offsite Drinking Water Samples Collected by the ESER Contractor in 2017.

Location	Sample Results (pCi/L)[a]		
Gross Alpha			
	Spring	***Fall***	***EPA MCL[b]***
Atomic City	2.4 ± 0.54	0.63 ± 0.46	15 pCi/L
Control (bottled water)[c]	0.67 ± 0.24	0.23 ± 0.23	15 pCi/L
Craters of the Moon	2.1 ± 0.48	2.2 ± 0.47	15 pCi/L
Howe	2.0 ± 0.54	1.5 ± 0.47	15 pCi/L
Idaho Falls	1.5 ± 0.69	1.0 ± 0.55	15 pCi/L
Minidoka	5.3 ± 0.71	0.47 ± 0.50	15 pCi/L
Mud Lake (Well #2)	1.1 ± 0.36	0.16 ± 0.33	15 pCi/L
Rest Area (Highway 20/26)	1.7 ± 0.52	1.7 ± 0.45	15 pCi/L
Shoshone	2.6 ± 0.60	1.3 ± 0.52	15 pCi/L
Gross Beta			
	Spring	***Fall***	***EPA MCL***
Atomic City	2.9 ± 0.48	2.8 ± 0.49	4 mrem/yr (50 pCi/L)[d]
Control (bottled water)	-0.01 ± 0.38	-0.99 ± 0.38	4 mrem/yr (50 pCi/L)
Craters of the Moon	2.1 ± 0.46	1.2 ± 0.46	4 mrem/yr (50 pCi/L)
Howe	1.2 ± 0.47	1.7 ± 0.46	4 mrem/yr (50 pCi/L)
Idaho Falls	3.1 ± 0.53	1.2 ± 0.49	4 mrem/yr (50 pCi/L)
Minidoka	2.7 ± 0.51	2.7 ± 0.51	4 mrem/yr (50 pCi/L)
Mud Lake (Well #2)	4.8 ± 0.47	3.3 ± 0.47	4 mrem/yr (50 pCi/L)
Rest Area (Highway 20/26)	2.2 ± 0.47	2.6 ± 0.48	4 mrem/yr (50 pCi/L)
Shoshone	3.7 ± 0.51	2.5 ± 0.49	4 mrem/yr (50 pCi/L)
Tritium			
	Spring	***Fall***	***EPA MCL***
Atomic City	62 ± 23	57 ± 23	20,000 pCi/L
Control (bottled water)	124 ± 24	93 ± 24	20,000 pCi/L
Craters of the Moon	64 ± 23	138 ± 24	20,000 pCi/L
Howe (duplicate in Spring)	88 ± 23	92 ± 23	20,000 pCi/L
Idaho Falls	57 ± 23	91 ± 23	20,000 pCi/L
Minidoka	34 ± 23	83 ± 23	20,000 pCi/L
Mud Lake (Well #2)	41 ± 23	91 ± 23	20,000 pCi/L
Rest Area (Highway 20/26)	169 ± 25	115 ± 24	20,000 pCi/L
Shoshone	117 ± 24	53 ± 23	20,000 pCi/L

a. Result ± 1σ. Results ≥ 3σ are considered to be statistically positive.
b. EPA = Environmental Protection Agency; MCL = maximum contaminant level
c. Water bottled in Ammon, Idaho.
d. The MCL for gross beta activity is not established. However, the EPA drinking water standard of 4 mrem/yr for public drinking water systems is applied and a screening level of 50 pCi/L is used. Samples with gross beta activity greater than 50 pCi/L must be analyzed to identify the major radionuclides present.

Falls, Clear Springs near Buhl, and a trout farm near Hagerman (see Figure 6-21). ESER contractor results are shown in Table 6-20.

Gross alpha activity was detected in all samples collected in May. There were no gross alpha detections in November samples. The highest result (3.7 ± 0.68 pCi/L) was measured at Clear Springs in May. This is the highest measurement made at this location since 2010. For comparison, the maximum concentration measured since 2010 in all locations was 2.76 ± 0.68 pCi/L at Minidoka in 2015.

Gross beta activity was detected in all surface water samples. The highest result (6.7 ± 0.58 pCi/L) was measured at Alpheus Springs. Alpheus Springs has historically shown higher results, and these values are most likely due to natural decay products of thorium and uranium that dissolve into water as it passes through the surrounding basalts of the eastern Snake River Plain aquifer. The maximum result measured since 2010 was 10.6 ± 0.56 pCi/L at Alpheus Springs in 2014.

Tritium was detected in five of the six surface water samples collected by the ESER contractor. Concentrations were similar to those found in the drinking water samples and in other liquid media, such as precipitation throughout the year.

The Big Lost River is an intermittent, ephemeral body of water that flows only during periods of high spring runoff and releases from the Mackay dam, which impounds the river upstream of the INL Site. The river flows through the INL Site and enters a depression, where the water flows into the ground, called Big Lost River Sinks (see Figure 6-21). The river then mixes with other water in the eastern Snake River Plain aquifer. Water in the aquifer then emerges about 160 km (100 miles) away at Thousand Springs near Hagerman and other springs downstream of Twin Falls.

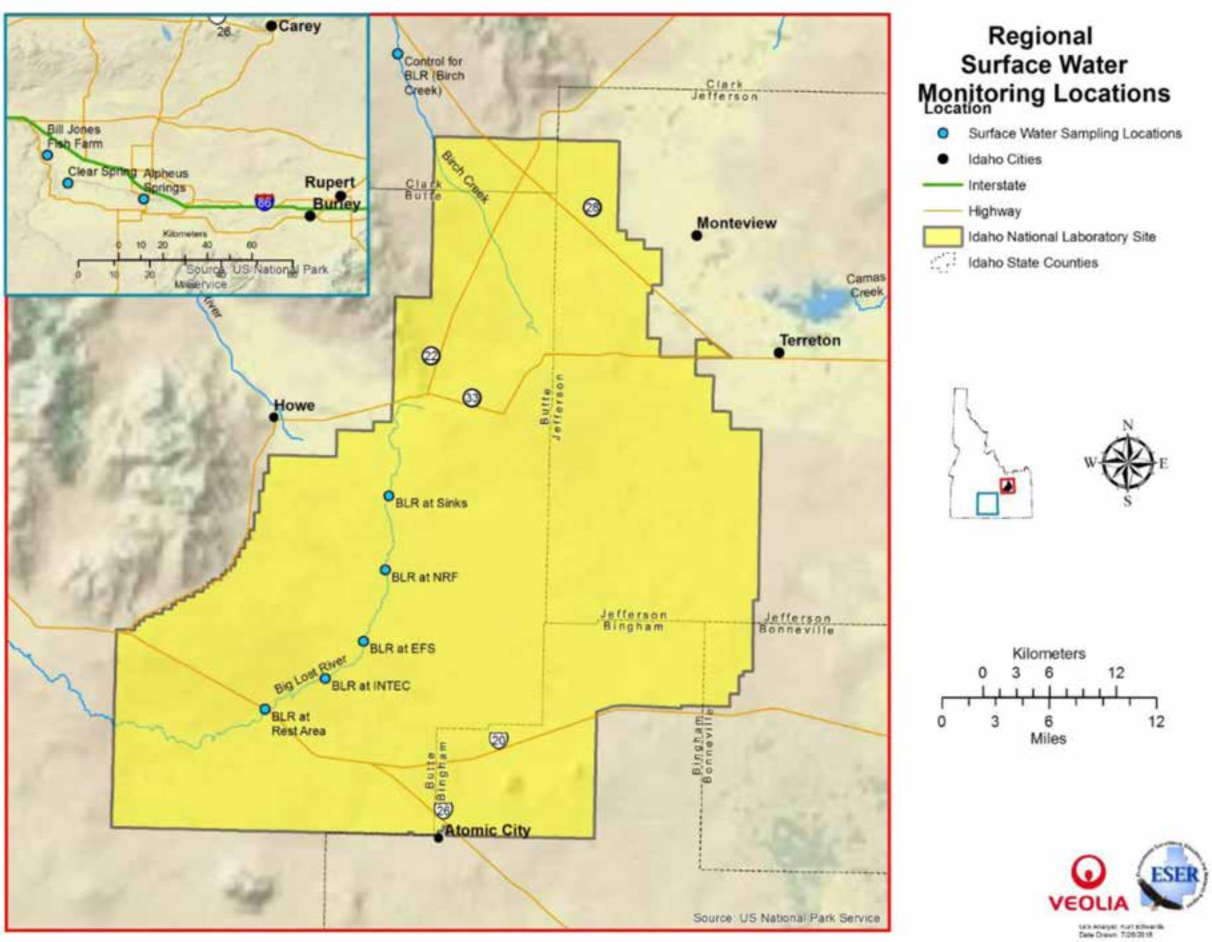


Figure 6-21. Detailed Map of ESER Program Surface Water Monitoring Locations.

Table 6-20. Gross Alpha, Gross Beta, and Tritium Concentrations in Surface Water Samples Collected by the ESER Contractor in 2017.

Location	Sample Results (pCi/L)[a]		
Gross Alpha			
	Spring[b]	***Fall***[b]	***EPA MCL***[c]
Alpheus Springs-Twin Falls	2.9 ± 0.68	1.3 ± 0.62	15 pCi/L
Clear Springs-Buhl	3.7 ± 0.68	0.24 ± 0.52	15 pCi/L
JW Bill Jones Jr Trout Farm-Hagerman	2.1 ± 0.53	0.94 ± 0.47	15 pCi/L
Gross Beta			
	Spring	***Fall***	***EPA MCL***
Alpheus Springs-Twin Falls	6.3 ± 0.57	6.7 ± 0.58	4 mrem/yr (50 pCi/L)[d]
Clear Springs-Buhl	5.2 ± 0.53	3.0 ± 0.51	4 mrem/yr (50 pCi/L)
JW Bill Jones Jr Trout Farm-Hagerman	3.7 ± 0.50	2.9 ± 0.49	4 mrem/yr (50 pCi/L)
Tritium			
	Spring	***Fall***	***EPA MCL***
Alpheus Springs-Twin Falls	93 ± 24	77 ± 23	20,000 pCi/L
Clear Springs-Buhl	22 ± 23	90 ± 23	20,000 pCi/L
JW Bill Jones Jr Trout Farm-Hagerman	204 ± 25	80 ± 23	20,000 pCi/L

a. Result ± 1s. Results ≥ 3s are considered to be statistically positive.
b. The springs and trout farm were sampled on May 16, 2017, and on November 13, 2017.
c. EPA = Environmental Protection Agency; MCL = Maximum Contaminant Level
d. The MCL for gross beta activity is not established. However, the EPA drinking water standard of 4 mrem/yr for public drinking water systems is applied and a screening level of 50 pCi/L is used. Samples with gross beta activity greater than 50 pCi/L must be analyzed to identify the major radionuclides present.

Normally the river bed is dry because of upstream irrigation and rapid infiltration into desert soil and underlying basalt. The river rarely flows onto the INL Site. The last time there was enough water in the river for ESER personnel to sample it on the INL Site was in 2012. However, in 2017 a wet fall season paired with a large snowpack and above-normal releases from the upstream Mackay reservoir resulted in a high-flowing river entering the sinks. Samples were collected during the months of May, June, July, and October and analyzed for gross alpha, gross beta, gamma-emitting radionuclides, and tritium. Samples were not collected during August and September because there was little or no flow due to upstream irrigation. There are no federal or state standards for surface water, so the results were compared with EPA MCLs (Table 6-21). None of the results exceeded these limits. No human-made gamma-emitting radionuclides were detected so they are not included in Table 6-21.

Table 6-21. Gross Alpha, Gross Beta, and Tritium Concentrations in Surface Water Samples Collected Along the Big Lost River by the ESER Contractor in 2017.

Location	Sample Results (pCi/L)[a]				
	Gross Alpha				
	May[b]	*June*[b]	*July*	*October*	*EPA MCL*[c]
Rest Area	1.3 ± 0.46	2.1 ± 0.48	1.5 ± 0.39	1.2 ± 0.44	15 pCi/L
INTEC	2.8 ± 0.58	2.0 ± 0.46	1.6 ± 0.41	0.88 ± 0.40	15 pCi/L
Experimental Field Station (EFS)	2.8 ± 0.57	1.9 ± 0.47	2.2 ± 0.45	0.81 ± 0.41	15 pCi/L
Naval Reactors Facility (NRF)	2.4 ± 0.57	2.4 ± 0.49	1.6 ± 0.42	1.6 ± 0.45	15 pCi/L
Big Lost River (BLR) Sinks	1.6 ± 0.48	3.3 ± 0.55	1.6 ± 0.44	1.6 ± 0.41	15 pCi/L
Birch Creek (control)	2.3 ± 0.56	3.3 ± 0.57	2.6 ± 0.49	2.5 ± 0.49	15 pCi/L
	Gross Beta				
	May[b]	*June*[b]	*July*	*October*	*EPA MCL*
Rest Area	3.5 ± 0.47	3.5 ± 0.48	1.6 ± 0.44	0.77 ± 0.45	4 mrem/yr (50 pCi/L)[d]
INTEC	6.4 ± 0.54	2.2 ± 0.47	1.3 ± 0.42	0.92 ± 0.45	4 mrem/yr (50 pCi/L)
EFS	3.8 ± 0.50	2.8 ± 0.45	2.5 ± 0.45	1.1 ± 0.45	4 mrem/yr (50 pCi/L)
NRF	4.0 ± 0.51	3.4 ± 0.49	1.7 ± 0.44	1.7 ± 0.46	4 mrem/yr (50 pCi/L)
BLR Sinks	4.1 ± 0.49	4.3 ± 0.48	3.5 ± 0.46	1.8 ± 0.45	4 mrem/yr (50 pCi/L)
Birch Creek (control)	2.3 ± 0.48	0.88 ± 0.47	0.9 ± 0.45	0.93 ± 0.46	4 mrem/yr (50 pCi/L)
	Tritium				
	May[b]	*June*[b]	*July*	*October*	*EPA MCL*
Rest Area	-61 ± 24	-40 ± 22	64 ± 23	86 ± 24	20,000 pCi/L
INTEC	-43 ± 24	13 ± 22	71 ± 23	62 ± 24	20,000 pCi/L
EFS	104 ± 26	-22 ± 22	69 ± 23	-8.2 ± 24	20,000 pCi/L
NRF	-80 ± 24	-30 ± 22	79 ± 23	163 ± 25	20,000 pCi/L
BLR Sinks	24 ± 24	6 ± 22	58 ± 23	65 ± 24	20,000 pCi/L
Birch Creek (control)	-3.5 ± 23	-11 ± 22	72 ± 23	79 ± 24	20,000 pCi/L

a. Result ± 1s. Results ≥ 3s are considered to be statistically positive.
b. Samples collected in May and June were very silty and were thus filtered prior to analysis.
c. EPA = Environmental Protection Agency; MCL = Maximum Contaminant Level
d. The MCL for gross beta activity is not established. However, the EPA drinking water standard of 4 mrem/yr for public drinking water systems is applied and a screening level of 50 pCi/L is used. Samples with gross beta activity greater than 50 pCi/L must be analyzed to identify the major radionuclides present.

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Gopher Snake
Pituophis catenifer

2017

7. Environmental Monitoring Programs: Agricultural Products, Wildlife, Soil, and Direct Radiation

Radionuclides released by Idaho National Laboratory (INL) Site operations and activities have the potential to be assimilated by agricultural products and game animals, which can then be consumed by humans. Thus, these media are sampled because of the potential transfer of radionuclides to people through food chains. Radionuclides may also be deposited on soils and can be detected through radioanalysis of soil samples. Some human-made radionuclides were detected at low levels in agricultural products (milk, lettuce, and alfalfa) collected in 2017. The results could not be directly linked to operations at the INL Site and are likely attributed to natural production in the atmosphere, in the case of tritium, or to the presence of fallout radionuclides in the environment, in the instances of strontium-90 (^{90}Sr) and cesium-137 (^{137}Cs). All measurements were well below standards (Derived Concentration Standards) established by the U.S. Department of Energy for protection of human health.

No human-made radionuclides were detected in tissue samples of five road-killed animals sampled in 2017. Six human-made radionuclides (cobalt-60 [^{60}Co], zinc-65 [^{65}Zn], ^{90}Sr, ^{137}Cs, plutonium-238, and plutonium-239/240) were detected in some tissue samples of waterfowl collected on ponds in the vicinity of the Advanced Test Reactor Complex at the INL Site. The source of these radionuclides was most likely the radioactive wastewater evaporation pond, which can be accessed by waterfowl, but not the public.

Bat carcasses have been collected on the INL Site since the summer of 2015. Bats collected during 2015 and 2016 were composited by area and analyzed for radionuclides in 2017. Three human-made radionuclides (^{60}Co, ^{65}Zn, and ^{137}Cs) were detected in at least half of the sample groups. While ^{137}Cs may be of fallout origin, ^{60}Co and ^{65}Zn may indicate that the bats have visited radioactive effluents ponds on the INL Site.

Soil samples were collected by the INL contractor on the INL Site in 2017 as part of a five-year rotational plan. Samples were collected at the RWMC, at the U.S. Highway 20/26 Rest Stop, and at the Experimental Field Station. The latter two locations are new, but the results are similar to Site-wide background measurements made in the past. Concentrations of radionuclides in RWMC soil were consistent with previous measurement. Strontium-90, plutonium-239/240, and americium-241 were detected at or below levels observed historically in the region and are likely due to deposition of fallout from aboveground nuclear weapons testing conducted prior to 1975.

Direct radiation measurements made at boundary and distant locations were consistent with background levels. The average annual dose equivalent from external exposure was estimated to be 115 mrem off the INL Site. The total background dose to an average individual living in southeastern Idaho was estimated to be approximately 383 mrem per year.

Radiation measurements taken in the vicinity of waste storage and soil contamination areas near INL Site facilities were consistent with previous measurements. Direct radiation measurements using a radiometric scanner system at the Radioactive Waste Management Complex and the Idaho CERCLA Disposal Facility were near background levels.

7. ENVIRONMENTAL MONITORING PROGRAMS: AGRICULTURAL PRODUCTS, WILDLIFE, SOIL, AND DIRECT RADIATION

This chapter summarizes results of environmental monitoring of agricultural products, wildlife, soil, and direct radiation on and around the Idaho National Laboratory (INL) Site during 2017. Details of these programs may be found in the *Idaho National Laboratory Site Environmental Monitoring Plan* (DOE-ID 2014a). The INL, Idaho Cleanup Project (ICP) Core, and Environmental Surveillance, Education, and Research Program (ESER) contractors monitor soil, vegetation, biota, and direct radiation on and off the

INL Site to comply with applicable U.S. Department of Energy (DOE) orders and other requirements. The focus of INL and ICP Core contractor monitoring is on the INL Site, particularly on and around facilities (Table 7-1). The ESER contractor's primary responsibility is to monitor the presence of contaminants in media off the INL Site, which may originate from INL Site releases (Table 7-1).

7.1 Agricultural Products and Biota Sampling

Agricultural products and game animals are sampled by the ESER contractor because of the potential transfer of radionuclides to people through food chains (Figure 4-1). Figure 7-1 shows the locations where agricultural products were collected in 2017.

7.1.1 Sampling Design for Agricultural Products

Agriculture products could become contaminated by radionuclides released from INL Site facilities which are transported offsite by wind and deposited in soil and on plant surfaces. This is important, since approximately 45 percent of the land surrounding the INL Site is used for agriculture (DOE-ID 1995). In addition, many residents maintain home gardens that could be impacted by INL Site releases. Animals could also eat contaminated crops and soil and in turn transfer radionuclides to humans through consumption of meat and milk.

Agricultural product sampling began in the vicinity of the INL Site in the 1960s with milk and wheat as part of the routine environmental surveillance program. Currently the program focuses on milk, lettuces, alfalfa, potatoes and grains.

As specified in the *DOE Handbook Environmental Radiological Effluent Monitoring and Environmental Surveillance* (DOE 2015), representative samples of the pathway-significant agricultural products grown within 10 miles (16 km) of the site should be collected and analyzed for radionuclides potentially present from site operations. These samples should be collected in at least two locations: the place of expected maximum radionuclide concentrations and a "background" location unlikely to be affected by radionuclides released from the site.

Table 7-1. Environmental Monitoring of Agricultural Products, Biota, Soil, and Direct Radiation at the INL Site.

	Media						
Area/Facility[a]	Agricultural Products (milk, lettuce, alfalfa, wheat, and potatoes)	Biota (waterfowl, large game animals)	Biota (vegetation)	CERCLA Ecological	Soil	Direct Radiation (global positioning radiometric scanner)	Direct Radiation
Environmental Surveillance, Education, and Research Program Contractor							
INL Site/Regional	•	•	•	•	•		•
Idaho National Laboratory Contractor							
INL Site					•		•
Regional							•
Idaho Cleanup Project Core Contractor							
ICDF[b]						•	
RWMC[c]			•			•	

a. INL Site = Idaho National Laboratory Site facility areas and areas between facilities
b. ICDF = Idaho CERCLA Disposal Facility
c. RWMC = Radioactive Waste Management Complex

Sample design was primarily guided by wind direction and frequencies and farming practices. Air dispersion modeling, using CALPUFF and INL Site meteorological data measured from 2006 through 2008, was performed to develop data quality objectives for radiological air surveillance for the INL Site using methodology documented in Rood and Sondrup (2014). The same methodology was used to discern deposition patterns. The dispersion and deposition patterns resulting from these sources reflect the southwest/northeast wind patterns typical of the INL Site. The maximum offsite deposition was modeled to be located between the southwest INL Site boundary and Big Southern Butte. Because there are no agricultural activities in this region,

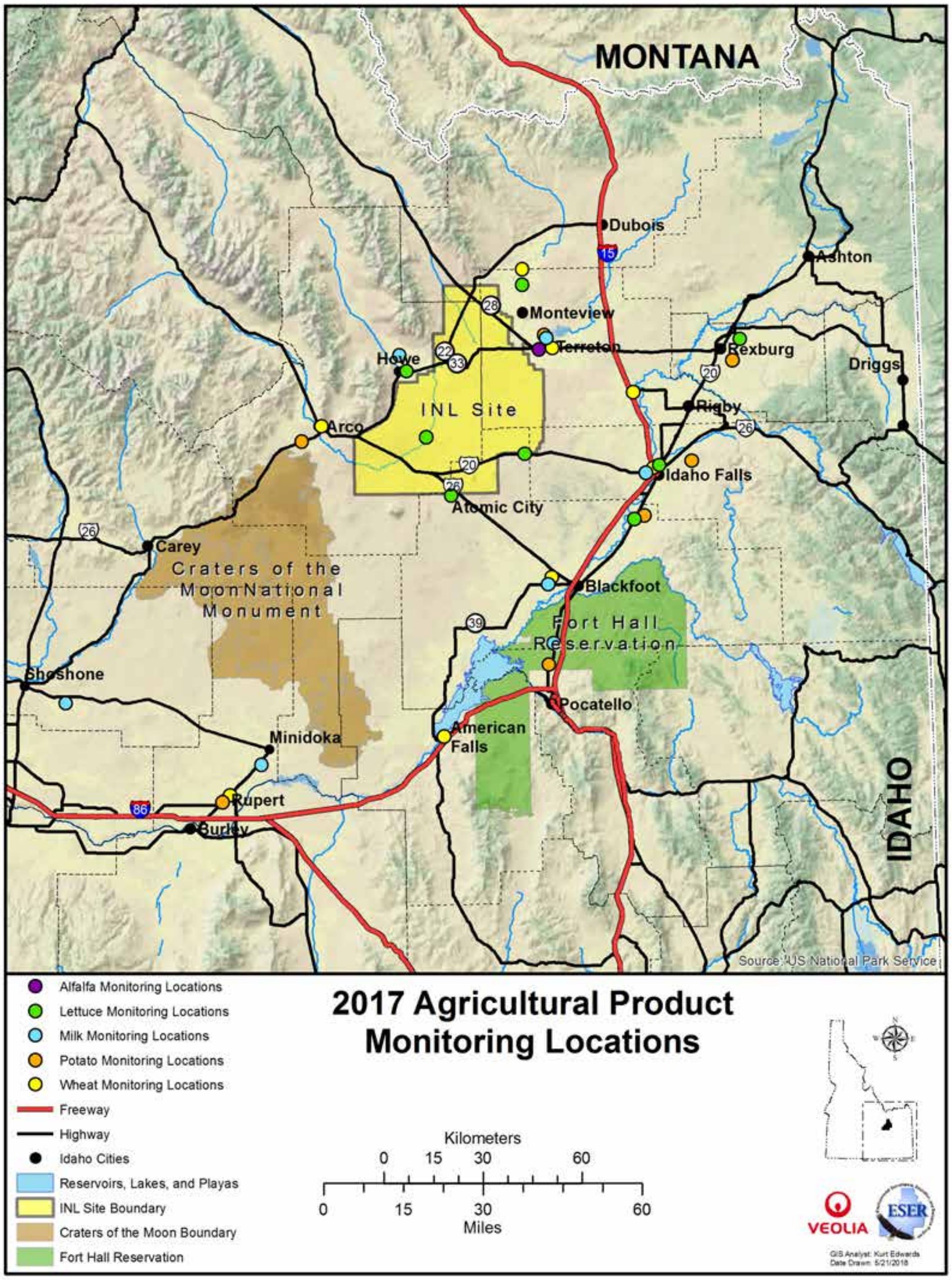

Figure 7-1. Locations of Agricultural Product Samples Collected (2017).

sampling is focused on other agricultural areas west and northeast of the INL Site. In addition, the sampling design considers locations of interest to the public, as well as those of historical interest, which is why some samples are collected at extended distances from the INL Site.

7.1.2 Methods

Fresh produce and milk are purchased from local farmers when available. In addition, lettuce is grown by the ESER program in areas that have no commercial or private producers.

7.1.3 Milk Results

Milk is sampled to monitor the pathway from potentially contaminated, regionally grown feed to cows, then to milk, which is then ingested by humans. During 2017, the ESER contractor collected 177 milk samples (including duplicates and controls) at various locations off the INL Site (Figure 7-1) and from commercially available milk from outside the state of Idaho. The number and location of the dairies can vary from year to year as farmers enter and leave the business. Milk samples were collected weekly in Idaho Falls and monthly at other locations around the INL Site. All samples were analyzed for gamma-emitting radionuclides, including iodine-131 (^{131}I) and cesium-137 (^{137}Cs). During the second and fourth quarters, samples from each of the seven locations (including the control) were analyzed for strontium-90 (^{90}Sr) and tritium, with the exception of Blackfoot during the fourth quarter. The family-run goat dairy at that location did not have enough sample for ^{90}Sr analysis at that time.

Iodine is an essential nutrient and is readily assimilated by cows that eat plants containing the element. Iodine-131 is of particular interest because it is produced by nuclear reactors or weapons, is readily detected, and, along with cesium-134 and ^{137}Cs, can dominate the ingestion dose regionally after a severe nuclear event such as the Chernobyl accident (Kirchner 1994) or the 2011 accident at Fukushima in Japan. Iodine-131 has a short half-life (eight days) and therefore does not persist in the environment. Past releases from experimental reactors at the INL Site and fallout from atmospheric nuclear weapons tests and Chernobyl are no longer present. Most of the ^{131}I released in 2017 was from the Materials and Fuels Complex (approximately 88.9 mCi). None was detected in air samples collected at or beyond the INL Site boundary (Chapter 4). Iodine-131 was also not detected in any milk sample collected during 2017.

Cesium-137 is chemically analogous to potassium in the environment and behaves similarly by accumulating in many types of tissue, most notably in muscle tissue. It has a half-life of about 30 years and tends to persist in soil. If in soluble form, it can readily enter the food chain through plants. It is widely distributed throughout the world from historic nuclear weapons detonations, which occurred between 1945 and 1980, and has been detected in all environmental media at the INL Site. Regional sources include releases from INL Site facilities and resuspension of previously contaminated soil particles. Cesium-137 was not detected in any milk samples collected in 2017.

Strontium-90 is an important radionuclide because it behaves like calcium and can deposit in bones. Strontium-90, like ^{137}Cs, is produced in high yields from nuclear reactors or detonations of nuclear weapons. It has a half-life of 28 years and can persist in the environment. Strontium tends to form compounds that are more soluble than ^{137}Cs, and is therefore comparatively mobile in ecosystems. Strontium-90 was detected in nine of the 13 milk samples analyzed, including the two control samples from outside the state. Detectable concentrations ranged from 0.22 pCi/L at Howe to 0.42 pCi/L at Blackfoot (Table 7-2). Overall, concentrations were fairly consistent in 2017 with those in 2014 and 2015 (but lower than 2012 and 2013). These levels were also consistent with levels reported by the U.S. Environmental Protection Agency (EPA) as resulting from worldwide fallout deposited on soil and taken up by cows through ingestion of grass. Results from EPA Region 10 (which includes Idaho) for a limited data set of seven samples collected from 2007 through 2016, ranged from 0 to 0.54 pCi/L (EPA 2017).

DOE has established Derived Concentration Standards (DCSs) (DOE 2011) for radionuclides in air and water. A DCS is the concentration of a radionuclide in air or water that would result in a dose of 100 mrem from ingestion, inhalation, or immersion in a gaseous cloud for one year. There are no established DCSs for foodstuffs such as milk. For reference purposes, the DCS for ^{90}Sr in water is 1,100 pCi/L. Therefore, the maximum observed value in milk samples (0.42 pCi/L) is approximately 0.04 percent of the DCS for drinking water.

Tritium, with a half-life of about 12 years, is an important radionuclide because it is a radioactive form of hydrogen, which combines with oxygen to form tritiated water. The environmental behavior of tritiated water is like that of water, and can be present in surface water, precipitation, and atmospheric moisture. Tritium is formed by natural processes, as well as by reactor operation and nuclear weapons testing. Tritium enters the food chain through surface water that people and animals drink, as well as from plants that contain water. Tritium was detected in four of 14 milk samples analyzed, including one of the samples of store-bought organic milk in May (Table 7-2). Detectable concentrations varied from 87 pCi/L in a sample from Terreton in November to 189 pCi/L in the control sample in May. These concentrations are similar to those of previous years and are consistent with those found in atmospheric moisture and precipitation samples. The DCS for tritium in water is 1,900,000 pCi/L. The maximum observed value in milk samples is approximately 0.01 percent of the DCS.

7.1.4 Lettuce

Lettuce was sampled because radionuclides in air can be deposited on soil and plants, which can then be ingested by people (Figure 4-1). Uptake of radionuclides by plants may occur through root uptake from soil and/or absorption of deposited material on leaves. For most radionuclides, uptake by foliage is the dominant process for contamination of plants (Amaral et al. 1994). For this reason, green, leafy vegetables, like lettuce, have higher concentration ratios of radionuclides to soil than

Table 7-2. Strontium and Tritium Concentrations[a] in Milk Samples Collected Off the INL Site in 2017.

Strontium-90 (pCi/L)		
Location	**May 2017**	**November 2017**
Blackfoot	0.42 ± 0.06	NS[c]
Dietrich	0.23 ± 0.06	0.15 ± 0.08
Howe	0.22 ± 0.05	-0.06[b] ± 0.09
Idaho Falls	0.36 ± 0.07	0.30 ± 0.08
Minidoka	0.22 ± 0.06	0.12 ± 0.08
Terreton	0.32 ± 0.05	0.08 ± 0.07
AVERAGE	0.29	0.12
Control (Colorado)	0.31 ± 0.07	0.38 ± 0.08
Tritium (pCi/L)		
Location	**May 2017**	**November 2017**
Blackfoot	107.0 ± 23.9	6.63 ± 23.5
Dietrich	-114.0 ± 23.6	16.2 ± 23.6
Howe	113.0 ± 26.3	43.8 ± 23.1
Idaho Falls	-46.9 ± 22.3	11.5 ± 23.6
Minidoka	-26.2 ± 24.7	29.9 ± 23.8
Terreton	28.7 ± 25.3	86.8 ± 23.7
AVERAGE	10.3	32.5
Control (Colorado)	189.0 ± 24.9	67.0 ± 23.5

a. Results ± 1σ. Results greater than 3σ uncertainty are considered statistically detected.
b. A negative result indicates that the measurement was less than the laboratory background measurement.
c. NS = no sample. The Blackfoot sample is collected from a small goat farm. There was insufficient sample collected in November for radiochemical analysis.

other kinds of plants. The ESER contractor collects lettuce samples every year from areas on and adjacent to the INL Site (Figure 7-1). The number and locations of gardens have changed from year to year depending on whether or not vegetables were available. Some home gardens were replaced with portable lettuce planters (Figure 7-2) because the availability of lettuce from home gardens was unreliable at some key locations. Also, the planters can be placed and lettuce collected at areas previously unavailable to the public, such as on the INL Site and near air samplers. The planters can allow radionuclides deposited from air to accumulate on the soil and plant surfaces throughout the growth cycle. The planters are placed in the spring, filled with soil, sown with lettuce seed, and self-watered through a reservoir.

Six lettuce samples were collected from portable planters at Atomic City, the Experimental Field Station (EFS), the Federal Aviation Administration Tower, Howe, Idaho Falls, and Monteview. In 2017, soil from the vicinity of the sampling locations was used in the planters. This soil was amended with potting soil as a gardener in the region would typically do when they grow their lettuce. A duplicate sample was collected at Monteview. In addition to the portable samplers, samples were obtained from gardens in Shelley and Sugar City. A control sample was obtained from an out-of-state location (Oregon).

The samples were analyzed for ^{90}Sr and gamma-emitting radionuclides. Strontium-90 was detected in all of the lettuce samples collected except for the one collected from Shelley. Figure 7-3 shows the average and range of all measurements (including those below detection levels) from 2013–2017. The maximum ^{90}Sr concentration of 112 pCi/kg, measured in the lettuce sample from Atomic City, is within the range of concentrations detected in the past five years. It is far lower than the 2015 maximum value (372 pCi/kg), when the sample was grown in a portable lettuce sampler using soil from the vicinity of the sampling location with no added potting soil. These results were most likely from fallout from past weapons testing and not INL Site operations. Strontium-90 is present in the environment as a residual of fallout from aboveground nuclear weapons testing, which occurred between 1945 and 1980.

No other human-made radionuclides were detected in any of the lettuce samples. Although ^{137}Cs from nuclear weapons testing fallout is measureable in soils, the ability of vegetation, such as lettuce, to incorporate cesium from soil in plant tissue is much lower than for strontium (Fuhrmann et al. 2003; Ng, Colsher, and Thompson 1982; Schulz 1965). In addition, the availability of ^{137}Cs to plants depends highly on soil properties, such as clay content or alkalinity, which can act to bind the radionuclide (Schulz 1965). Soils in southeast Idaho tend to be moderately to highly alkaline. Strontium, on the other hand, has a tendency to form compounds that are comparatively soluble. These factors could help explain why ^{90}Sr was detected in lettuce and ^{137}Cs was not.

Figure 7-2. Portable Lettuce Planter.

7.1.5 Grain

Grain (including wheat and barley) is sampled because it is a staple crop in the region. In 2017 the ESER contractor collected grain samples at nine locations from areas surrounding the INL Site (Figure 7-1), and an additional duplicate sample was collected from Arco. A control sample was purchased from outside the state of Idaho. The locations were selected because they are typically farmed for grain and are encompassed by the air surveillance network. Exact locations may change as growers rotate their crops. No human-made, gamma-emitting radionuclides were found in any samples.

Two of the 11 grain samples collected in 2017 contained a detectable concentration of ^{90}Sr. A lower detection limit was achieved in 2017 and both detectable results were close to this lower limit. The measured concentrations were 2.6 pCi/kg from American Falls and 2.0 pCi/kg from Moreland. The concentrations of ^{90}Sr sometimes measured in grain are generally much less than those measured in lettuce and the frequency of detections is lower. Agricultural products such as fruits and grains are naturally lower in radionuclides than green, leafy vegetables (Pinder et al. 1990). As discussed in Section 7.1.3, strontium in soil from fallout is more bioavailable to plants than cesium.

7.1.6 Potatoes

Potatoes are collected because they are one of the main crops grown in the region and are of special interest to the public. Because potatoes are not exposed to airborne contaminants, they are not typically considered a key part of the ingestion pathway. Potatoes were collected by the ESER contractor at eight locations in the vicinity of the INL Site (including a duplicate) and obtained from one location outside eastern Idaho. None of the nine potato samples collected during 2017 contained a detectable concentration of any human-made, gamma-emitting radionuclides. Strontium-90 was detected in the sample at Terreton at 2.7 pCi/kg. This radionuclide is present in the soil as a result of worldwide fallout from nuclear weapons testing, but it is only occasionally detected in potato samples. This is because potatoes, like grain, are generally less efficient at removing radioactive elements from soil than leafy vegetables such as lettuce.

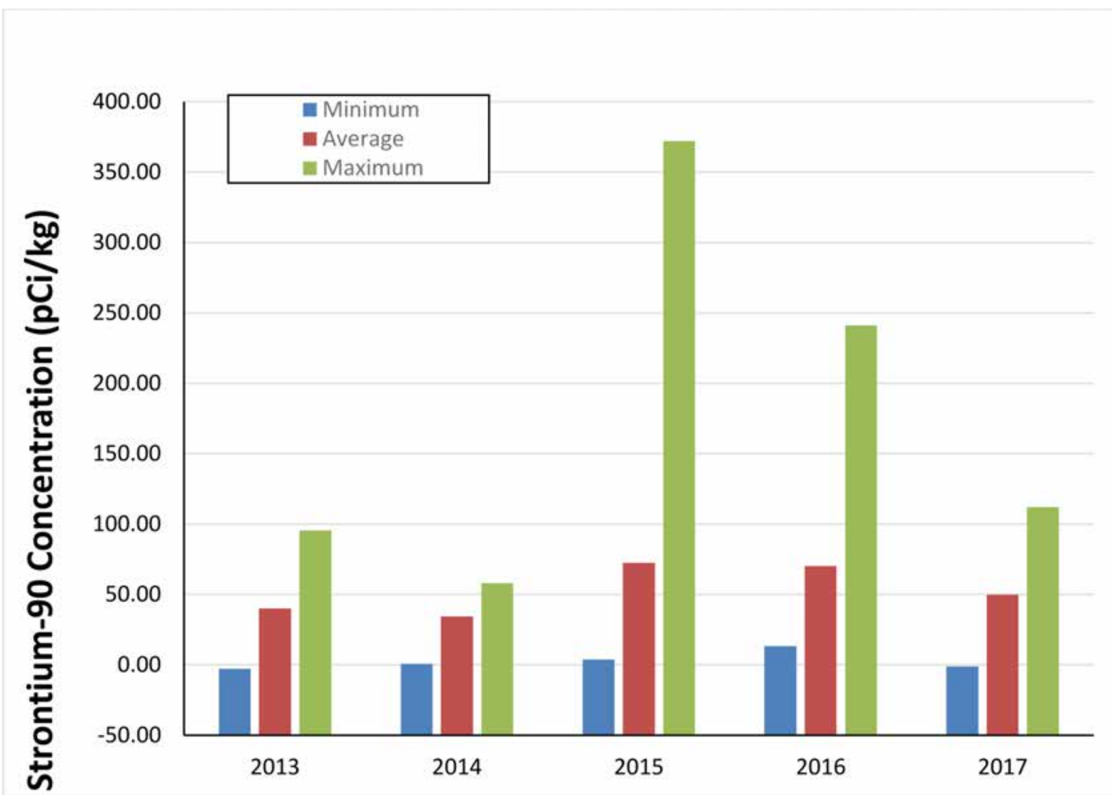

Figure 7-3. Strontium-90 Concentrations in Lettuce (2013–2017).

7.1.7 Alfalfa

In addition to analyzing milk, the ESER contractor began collecting data in 2010 on alfalfa consumed by milk cows. A sample of alfalfa was collected in June from a location in the Mud Lake/Terreton area, the agricultural area where the highest potential offsite air concentration was calculated by the National Oceanic and Atmospheric Administration Air Resources Laboratory–Field Research Division (see Figure 8-6). (Note: The highest offsite air concentration used for estimating doses was located south of the INL Site; however, there is no agriculture conducted at that location.) The sample was divided into three subsamples and analyzed for gamma-emitting radionuclides and ^{90}Sr. No human-made, gamma-emitting radionuclides were found, but ^{90}Sr was detected in all three subsamples. The concentrations found ranged from 7.9 to 13.5 pCi/kg. This is typical of the range found in alfalfa samples since collection began in 2010 and the concentrations are more similar to those found in lettuce than in wheat and potatoes.

7.1.8 Large Game Animals

Muscle samples were collected by the ESER contractor from five game animals (three pronghorn, one mule deer, and one elk). Five thyroid and three liver samples were also obtained. The muscle samples were analyzed for ^{137}Cs because it is an analog of potassium and is readily incorporated into muscle and organ tissues. Thyroids are analyzed for ^{131}I because, when assimilated by many animal species, it selectively concentrates in the thyroid gland and is, thus, an excellent bioindicator of atmospheric releases.

No ^{131}I was detected in the thyroid samples. No ^{137}Cs or other human-made, gamma-emitting radionuclides were found in any of the muscle or liver samples.

In 1998 and 1999, four pronghorn, five elk, and eight mule deer muscle samples were collected as background samples from hunters across the western United States, including three from central Idaho; three from Wyoming; three from Montana; four from Utah; and one each from New Mexico, Colorado, Nevada, and Oregon (DOE-ID 2002a). Each background sample had small, but detectable, ^{137}Cs concentrations in the muscle. These concentrations likely can be attributed to the ingestion of plants containing radionuclides from fallout associated with aboveground nuclear weapons testing. Allowing for radioactive decay since the time of the study, background measurements would be expected to range from approximately 3.5 to 10 pCi/kg in 2017. With the exception of an immature deer sampled in 2008 that had elevated ^{137}Cs concentrations, all detected values were within this range.

7.1.9 Waterfowl

Waterfowl are collected each year by the ESER contractor at ponds on the INL Site and at a location off the INL Site. Three waterfowl collected from wastewater ponds located at the Advanced Test Reactor (ATR) Complex plus four control waterfowl collected from American Falls Reservoir were analyzed for gamma-emitting radionuclides, ^{90}Sr, and actinides (americium-241 [^{241}Am], plutonium-238 [^{238}Pu], and plutonium-239/240 [$^{239/240}$Pu]). These radionuclides were selected because they have historically been measured in liquid effluents from some INL Site facilities. Each sample was divided into the following three sub-samples: 1) edible tissue (muscle, gizzard, heart, and liver), 2) external portion (feathers, feet, and head), and 3) all remaining tissue.

A total of six human-made radionuclides were detected in the samples from at least one of the ducks collected at the ATR Complex ponds. These were cobalt-60 (^{60}Co), zinc-65 (^{65}Zn), ^{90}Sr, ^{137}Cs, ^{238}Pu, and $^{239/240}$Pu. The Green-winged Teal, collected from the sewage lagoons at ATR Complex had four of these radionuclides in edible tissue (Table 7-3). In the control ducks, ^{90}Sr and $^{239/240}$Pu were detected in the external and remainder portions of some ducks, but were not found in the edible tissues.

Because more human-made radionuclides were found in ducks from the ATR Complex than other locations and at higher levels, it is assumed that the evaporation pond associated with this facility is the source of these radionuclides. The ducks were not taken directly from the two-celled hypalon-lined radioactive wastewater evaporation pond, but rather from an adjacent sewage lagoon. However, the ducks probably also spent time at the evaporation pond. Concentrations of the detected radionuclides in waterfowl collected at the ATR Complex were lower than those collected in 2015. In 2016, the hypalon liners in the wastewater ponds were replaced and waterfowl were not collected.

7.1.10 Bats

Bat carcasses have been collected on the INL Site since the summer of 2015. Bats are typically desiccated when received and generally weigh about a few grams

Table 7-3. Radionuclide Concentrations Detected in Waterfowl Collected in 2017.

Radionuclides Detected in Waterfowl Tissue (pCi/kg dry weight)				
Location	**Species**	**Portion**	**Radionuclide**	**Concentration**
ATR Complex Ponds	Green-winged Teal	Edible	^{60}Co	716 ± 42
			^{90}Sr	248 ± 4
			^{137}Cs	3,090 ± 152
			^{238}Pu	16 ± 4
		Exterior	^{60}Co	238 ± 26
			^{90}Sr	442 ± 9
			^{137}Cs	749 ± 62
		Remainder	^{60}Co	3,340 ± 144
			^{65}Zn	190 ± 20
			^{90}Sr	256 ± 3
			^{137}Cs	2,670 ± 124
			^{238}Pu	17 ± 4
			$^{239/240}$Pu	12 ± 4
	Northern Shoveler	Exterior	^{90}Sr	15 ± 3
		Remainder	^{90}Sr	17 ± 3
American Falls Reservoir	American Coot	Exterior	^{90}Sr	14 ± 3
			^{238}Pu	10 ± 3
	Bufflehead	Exterior	$^{239/240}$Pu	8 ± 3
		Remainder	^{90}Sr	4 ± 1
	Common Goldeneye	Remainder	^{238}Pu	13 ± 2

each. The samples collected in 2015–2016 were analyzed in 2017 for gamma-emitting radionuclides, for specific alpha-emitting radionuclides (plutonium isotopes and americium-241), and for ^{90}Sr (a beta-emitting radionuclide).

The laboratory performing the analyses (Oak Ridge Associated Universities) requested a minimum sample size so that, after ashing, the requested minimum detection limits could be met. For this reason, the bats were divided and composited into four groups from similar areas and weighed from 17–36 grams. The ashed weights ranged from 4–6 grams. Before reporting, results were converted from ashed weight concentrations to dry weight concentrations.

The following gamma-emitting radionuclides were detected in at least half of the sample groups: ^{60}Co, ^{65}Zn, and ^{137}Cs. Cesium-137 is fairly ubiquitous in the environment because of fallout from historical nuclear weapons tests. Cobalt-60 and ^{65}Zn may indicate that the bats visited radioactive effluent ponds on the INL Site. Strontium-90, another fallout radionuclide, was detected in all sample composites. Plutonium-239/240, which is present in radioactive waste as well as in the environment from past weapons testing, was detected in three sample groups. The results are summarized in Table 7-4. The potential doses received by bats are discussed in Section 8.7.2.

7.2 Soil Sampling

In the early 1970s, the DOE Radiological and Environmental Sciences Laboratory (RESL) established a routine program for collecting surface soils (0–5 and 5–10 cm deep) on and around the INL Site. At that time, RESL established extensive onsite soil sampling grids outside facilities. Offsite locations were also established by RESL during this process to serve as background sites. RESL analyzed all samples (onsite and offsite) for gamma-emitting radionuclides with a subset onsite analyzed for ^{90}Sr, ^{241}Am, and isotopes of plutonium. In addition, all soil from the surface component (0–5

Table 7-4. Radionuclide Concentrations Detected in Bats Collected in 2015 and 2016.

Bat Tissue Concentrations (pCi/g dry weight)			
Radionuclide	Minimum	Maximum	Number of detections
^{241}Am	ND[a]	ND	0
^{137}Cs	ND	(2.72 ± 0.12) E+01	3
^{60}Co	ND	(9.43 ± 0.29) E+01	2
^{238}Pu	ND	ND	0
^{239}Pu	ND	(1.54 ± 0.38) E-03	3
^{90}Sr	(3.00 ± 0.44) E-02	(4.05 ± 0.56) E+02	4
^{65}Zn	ND	(1.51 ± 0.07) E+01	2

a. ND = not detected

cm) of the offsite samples was analyzed for ^{90}Sr and alpha emitting-radionuclides (^{241}Am and isotopes of plutonium).

Between 1970 and 1978, RESL extensively sampled the onsite grids outside INL Site facilities and then reduced the onsite sampling frequency to a seven-year rotation that ended in 1990 with sampling at the Test Reactor Area (now known as the Advanced Test Reactor Complex). Surface soils were sampled at distant and boundary locations off the INL Site annually from 1970 to 1975, and the collection interval for offsite soils was extended to every two years starting in 1978.

The INL contractor currently completes soil sampling on a five year rotation at the INL site to evaluate long term accumulation trends and to estimate environmental radionuclide inventories. Data from previous years of soil sampling and analysis on the INL site show slowly declining concentrations of short lived manmade radionuclides (e.g., ^{137}Cs), with no evidence of detectable concentrations depositing onto surface soil from ongoing INL Site releases, as discussed in INL (2016).

The ESER contractor collects soil samples in offsite locations first established by RESL every two years (in even-numbered years). Results to date indicate that the source of detected radionuclides is not from INL Site operations and is most likely derived from worldwide fallout activity (DOE-ID 2014b). Soil was not sampled by the ESER contractor in 2017.

7.2.1 Soil Sampling Design

The basis for the current INL contractor soil sampling design is defined in the Data Quality Objectives Supporting the Environmental Soil Monitoring Program for the INL Site (INL 2016). The data quality objectives used historical data, current emissions data, and soil-deposition modeling for establishing the quality and quantity of data needed to support decision making for protecting human health and the environment. Figure 7-7 shows the 17 INL Site soil monitoring locations for 2017, most of which are near Radioactive Waste Management Complex (RWMC).

To determine the need for soil sampling, potential releases from each INL facility were modeled using CALPUFF, a non steady state Lagrangian puff dispersion model (Rood and Sondrup 2014), and estimated particulate deposition rates (INL 2016). The results showed that for the onsite facilities only the RWMC has the potential for soil accumulations to be detectable in less than a decade. Results for the other facilities (e.g., Idaho Nuclear Technology and Engineering Center and Materials and Fuels Complex) showed the potential for surface accumulations to be detectable only after hundreds to thousands of years (INL 2016). In addition, at best soil sampling is of questionable value in attempting to estimate small increments of deposition over a period of a few years or less because of the large uncertainties in sampling itself and the inherent variability in soil (EML 1997). Accordingly, the INL contractor uses a graded approach that takes into account extensive historical knowledge about soil conditions from past releases and current knowledge about facility emissions (INL 2016).

The INL contractor began performing near-facility monitoring at RWMC in 2017 on a five-year rotation focusing on radionuclides that could be detectable in the relative near term (i.e., plutonium isotopes, ^{90}Sr, and gamma emitters). The original sampling points established by RESL were selected as logical monitoring locations for data comparisons. Of the approximately 50 sampling points established by RESL, historical data were collected mostly southwest and northeast of the facility, with the highest radionuclide concentrations being in the prevalent wind direction to the northeast. For the current sampling, a systematic random sampling design was used to determine which of these points would be used as routine monitoring locations as shown in Figure 7-7.

Additional soil monitoring away from RWMC includes two INL Site ambient air-monitoring locations (U.S. Highway 20/26 Rest Stop [REST] and the EFS) that were chosen so that soil, ambient air, and direct radiation data can be compared. These locations were also chosen because they have higher modeled deposition potential from major facility emissions than other ambient air monitor locations. As at RWMC, soil will also be sampled there on a five-year rotation using the same methods and for the same radionuclides.

7.2.2 Methods

Soil is collected near each sampling post in an undisturbed area in a 100-m^2 area. Using techniques and equipment similar to those developed by RESL, each sample is a composite of five cores. Using a hammer, samplers force a metal ring that resembles a 10-cm-diameter and 5-cm-deep cookie cutter into the ground at the corners and center of the 100-m^2 area. Discreet samples are collected from each of the two depths: 0–5 cm and 5–10 cm. The soil inside each subsample is sieved through a 35-mesh screen, mixed in a pan, and composited into a single jar for that location.

7.2.3 Offsite Soil Sampling Results

Offsite soils were not collected in 2017.

7.2.4 Onsite Soil Sampling Results

Samples were collected from RWMC, EFS, and REST (Figure 7-4). No previous soil data is available from EFS and REST, so no site specific data can be compared to the current results. However, sitewide background values are available and the radionuclides and concentrations at EFS and REST are similar to those documented in Rood et al. (1996). Radionuclide concentrations for EFS and REST are shown in Figure 7-5 and 7-6, respectively. As more data are collected from these sites, background values will be computed and comparisons will be made. However, it will take several sampling events before there is enough data to do so. Results obtained from RWMC were consistent with previous results and all of the measured activities were less than the background values in INL 2016. The detections at RWMC are shown in the inset in Figure 7-4 and Figure 7-7.

7.2.5 Wastewater Reuse Permit Soil Sampling at Central Facilities Area

The Idaho Department of Environmental Quality issued a permit for the Central Facilities Area Sewage Treatment Plant on March 17, 2010. The permit required soil sampling in the wastewater land application area in 2010 and 2013. No soil samples were collected in 2017. The permit was terminated December 15, 2017, upon request of the INL contractor.

7.3 Direct Radiation

7.3.1 Sampling Design

Thermoluminescent dosimeters (TLDs) were historically used to measure cumulative exposures in air (in milliRoentgen or mR) to ambient ionizing radiation. The TLD packets contain four lithium fluoride chips and were placed approximately 1 m (about 3 ft) above the ground at specified locations. Beginning with the May 2010 distribution of dosimeters, the INL contractor began collocating optically stimulated luminescent dosimeters (OSLDs) with TLDs. The primary advantage of the OSLD technology over the traditional TLD is that the nondestructive reading of the OSLD allows for dose verification (i.e., the dosimeter can be read multiple times without destruction of the accumulated signal inside the aluminum oxide chips). TLDs, on the other hand, are heated, and once the energy is released, they cannot be reread. The last set of INL contractor TLD results were from November 2012. The ESER contractor began the use of OSLDs in November 2011 in addition to TLDs. In 2017, the ESER contractor TLDs were collected; however, results are not yet available. The ESER contractor and Idaho State University are working to resolve this issue and results will be reported when received. ESER and INL contractor OSLD data are shown in Table 7-5.

Dosimeter locations are shown in Figure 7-8. The sampling periods for 2017 were from November 2016–April 2017 and May 2017–October 2017.

Dosimeters on the INL Site are placed at facility perimeters, concentrated in areas likely to detect the highest gamma radiation readings. Other dosimeters on the INL Site are located near radioactive materials storage areas and along roads. For decades, the number

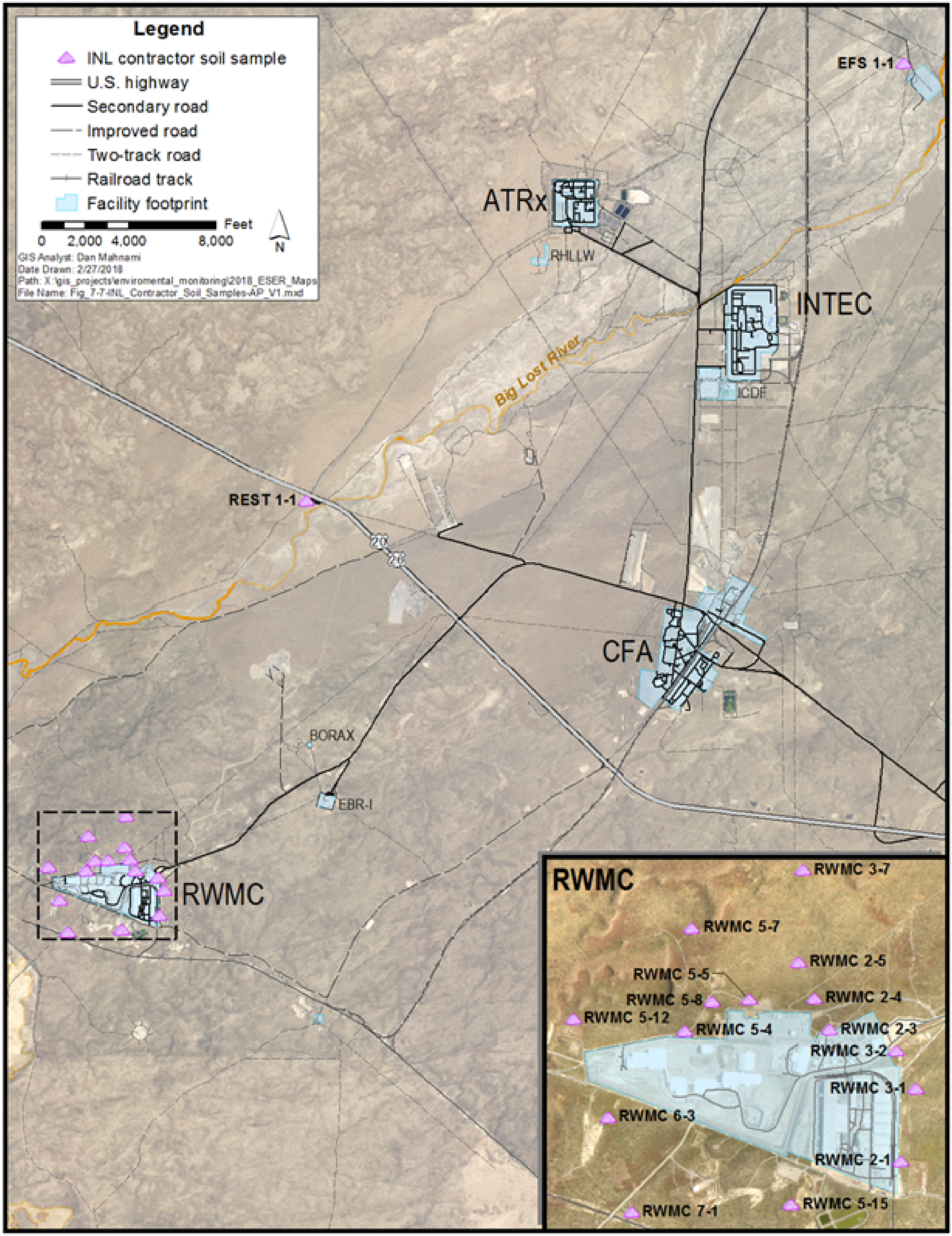

Figure 7-4. INL Site Soil Monitoring Locations.

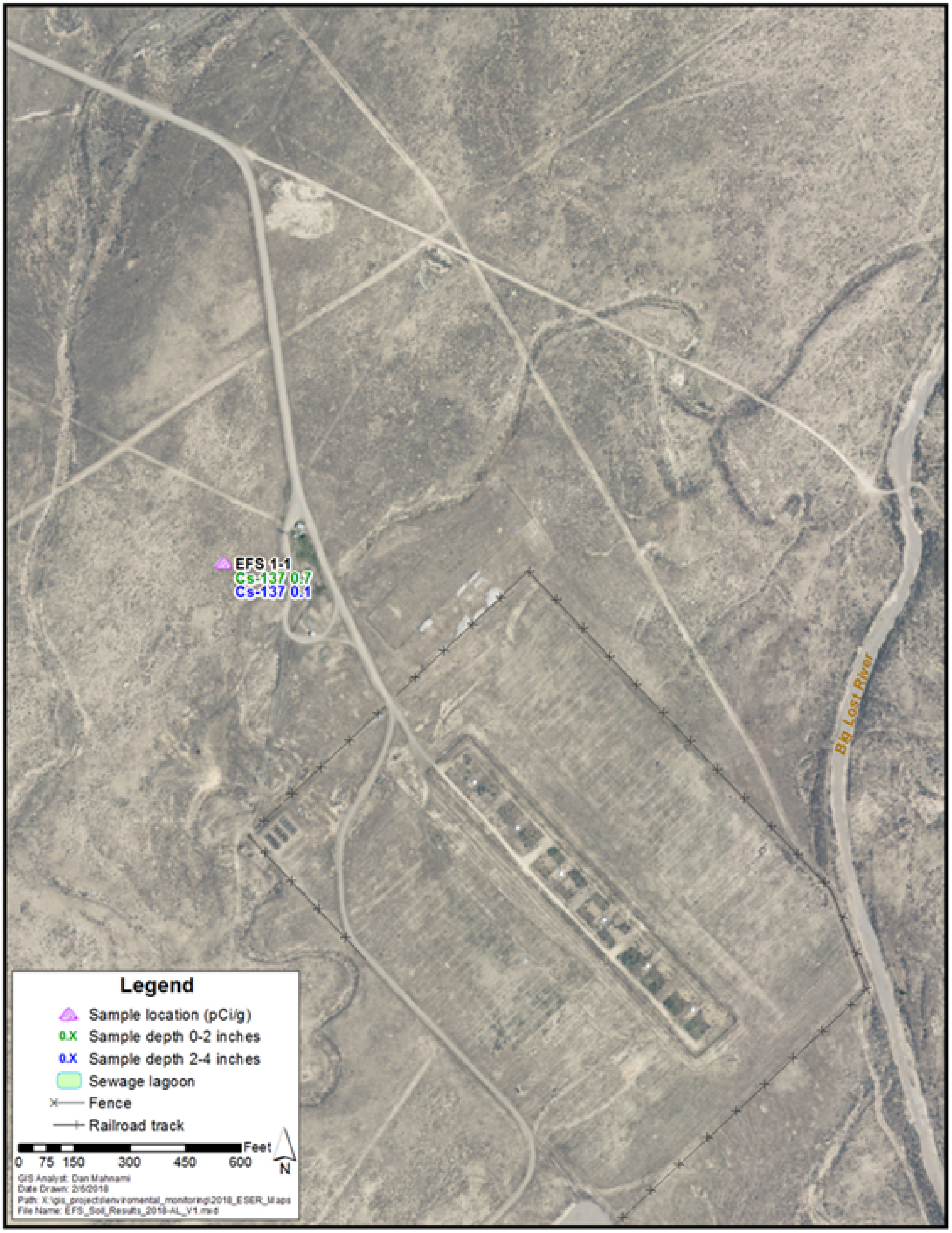

Figure 7-5. EFS Soil Concentrations.

Figure 7-6. REST Soil Concentrations.

Table 7-5. Annual Environmental Radiation Doses Using OSLDs at All Offsite Locations (2013–2017).

Location	2013		2014		2015		2016		2017	
	ESER[a]	INL[b] Contractor	ESER	INL Contractor	ESER	INL Contractor	ESER	INL Contractor	ESER	INL Contractor
	mrem									
Distant										
Aberdeen	113	125	112	NA[c]	119	NA	117	NA	120	NA
Blackfoot	107	NA	[d]	NA	114	NA	118	NA	112	NA
Craters of the Moon	100	118	109	124	115	125	113	118	116	125
Dubois	90	NA	95	NA	90	NA	103	NA	98	NA
Idaho Falls	113	111	103	119	113	124	122	113	110	119
IF-IDA	NA	NA	NA	NA	NA	109	NA	106	NA	106
Jackson	81	NA	89	NA	[e]	NA	[e]	NA	[e]	NA
Minidoka	99	111	104	NA	99	NA	99	NA	102	NA
Mountain View[f]	103	105	104	111	102	114	107	115	102	110
Rexburg/Sugar City[g]	140	114	147	121	134	NA	151	NA	141	NA
Roberts	125	128	118	140	117	135	132	122	119	124
Mean	108	116	109	123	109	116	118	115	113	117
Boundary										
Arco	112	112	117	127	113	125	114	121	111	122
Atomic City	112	116	113	123	119	117	122	128	117	122
Birch Creek Hydro	96	106	101	108	98	108	108	107	93	94
Blue Dome	86	NA	84	NA	95	NA	103	NA	94	NA
Howe	104	103	104	116	105	[h]	111	101	109	115
Monteview	100	106	102	117	106	117	115	124	110	133
Mud Lake	115	131	122	129	63	135	132	129	117	131
Mean	104	112	106	120	111	112	115	118	107	120

a. ESER = Environmental Surveillance, Education, and Research Program.
b. INL = Idaho National Laboratory.
c. NA = Not applicable. The ESER or INL contractor does not sample at this location.
d. The dosimeter was in an area with elevated natural radioactivity levels for part of the year and does not represent background values. See text for further explanation.
e. The Jackson location was not operating from May 2015 through January 2017 because a new location was identified and constructed during this period.
f. ESER has two locations at Blackfoot – one at Mountain View Middle School (MVMS) and one at Groveland, which is called "Blackfoot" by ESER. The INL has one OSL station at MVMS, which is called "Blackfoot." For the sake of consistency in this report, the MVMS site is called "MVMS" for both ESER and the INL.
g. Dosimeter was moved to Sugar City in July 2013. The INL contractor ended surveillance at Sugar City in May 2015.
h. Dosimeter missing at collection time in May.

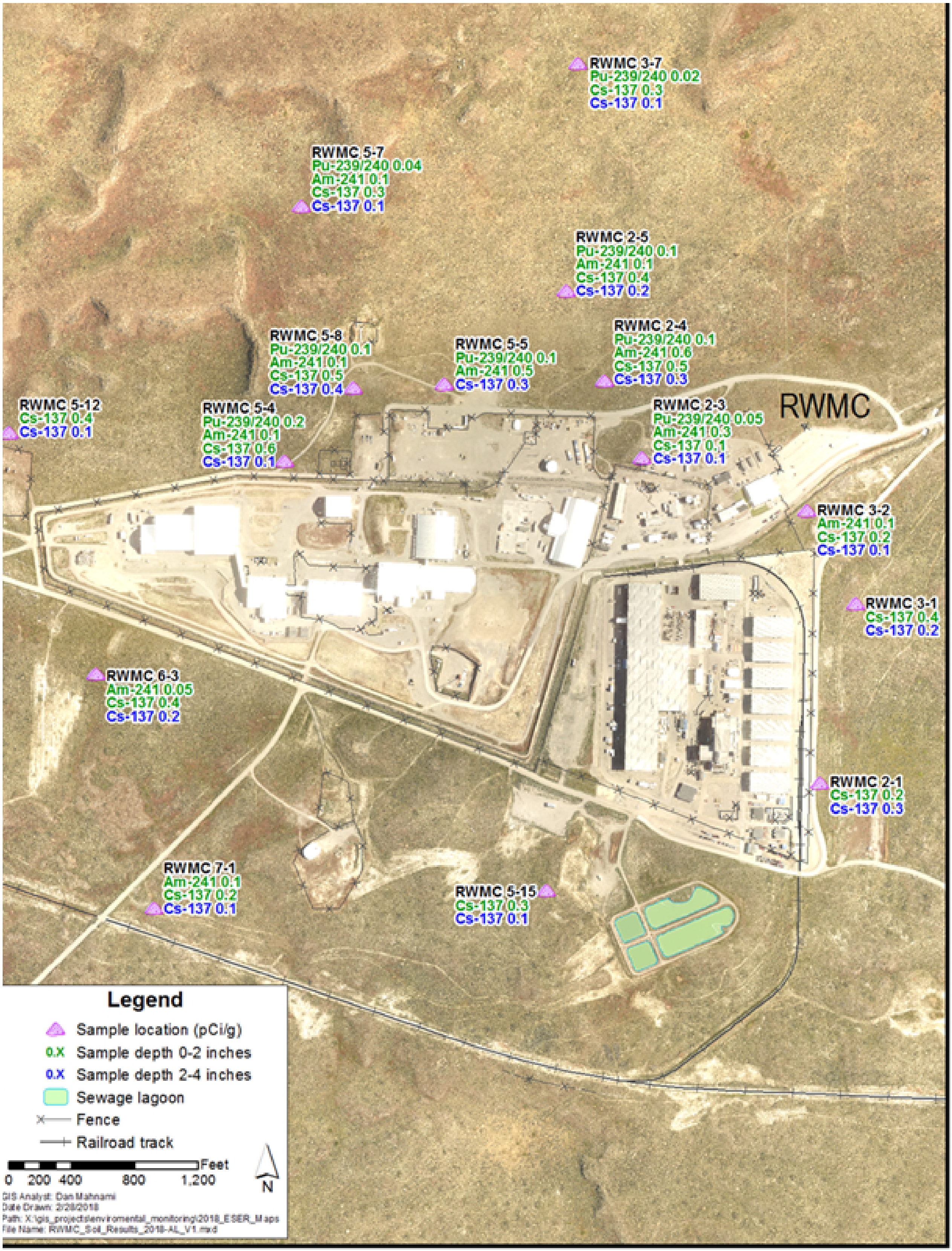

Figure 7-7. RWMC Soil Concentrations.

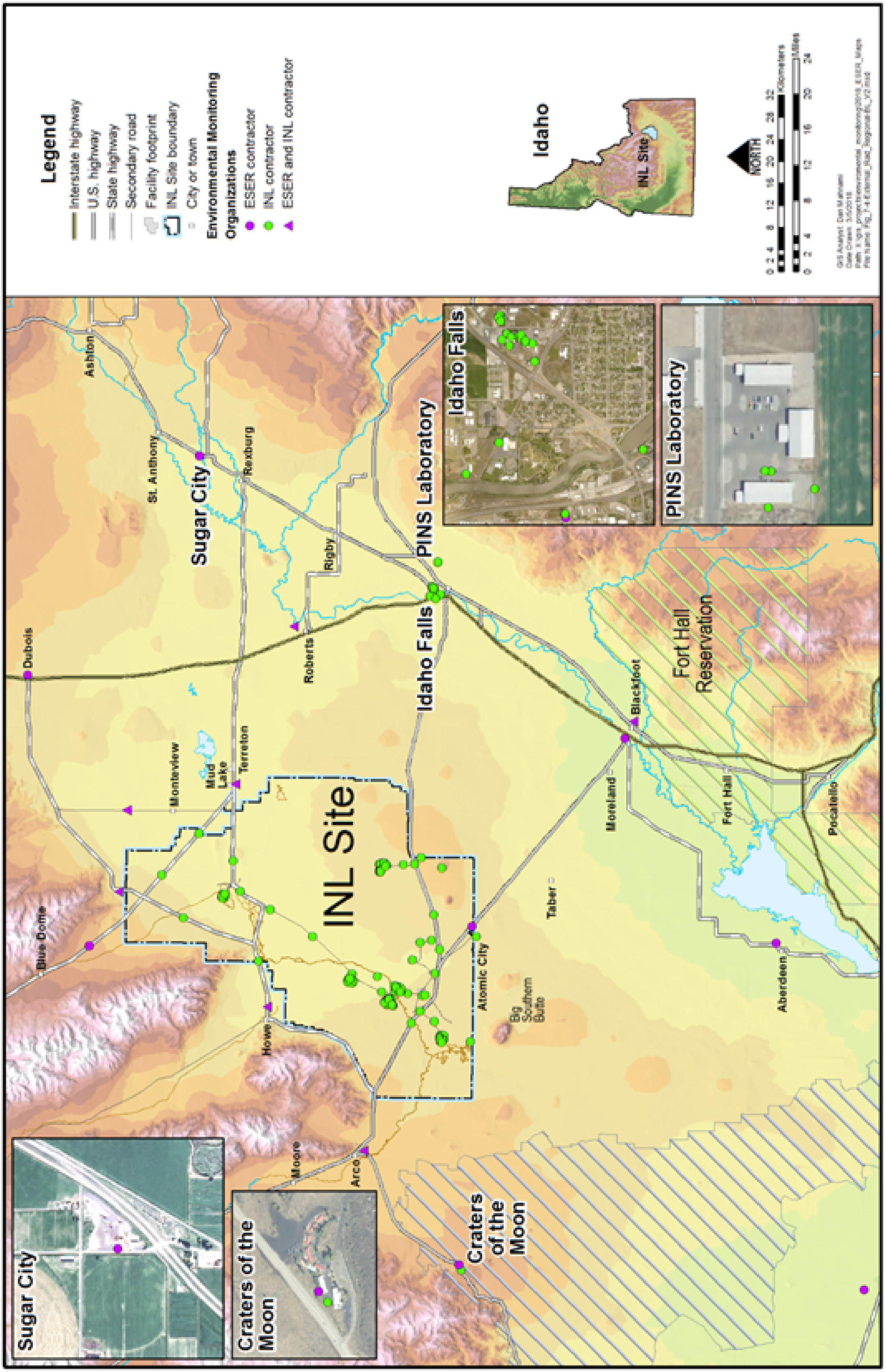

Figure 7-8. Regional Direct Radiation Monitoring Locations (2017).

and locations of the INL Site area dosimeters have been relatively constant; however, factors affecting potential exposures have changed. These changes include a reduced number of operating nuclear reactors, personnel, and waste shipments; decontamination and demolition of numerous buildings and facilities; and remediation of radionuclide-contaminated pond and soil areas. Additionally, new projects have been added. Because of these changes and because years of TLD exposures at many established locations were equivalent to natural background, the INL contractor reduced the number of INL Site dosimetry at some locations and added other locations.

7.3.2 Methods

OSLDs are placed in the field for six months, and then returned to the manufacturer for analysis. Transit control dosimeters are shipped with the field dosimeters to measure any dose received during shipment. Background radiation levels are highly variable; therefore, historical information establishes localized regional trends in order to identify variances. It is anticipated that five percent of the measurements will exceed the background dose. If a single measurement is greater than the background dose, it does not necessarily qualify that there is an unusually high amount of radiation in the area. When a measurement exceeds the background dose, the measurement is compared to other values in the area and to historical data to determine if the results may require further action as described in *Data Quality Objectives Supporting the Environmental Direct Radiation Monitoring Program for the Idaho National Laboratory* (INL 2015). The method for computing the background value as the upper tolerance limit (UTL) is described by EPA (2009) and EPA (2013). The ProUCL software has been used to compute UTLs, given all available data in the area, since 2007 (EPA 2013).

7.3.3 Results

Using OSLD data collected by both the ESER and INL contractors, the mean annual ambient dose was estimated at 111 mrem (1,110 uSv) for boundary and 115 mrem (1,150 uSv) for distant locations (Table 7-6). The mean annual ambient dose for all locations combined was also 113 mrem (1,130 uSv).

The 2017 direct radiation results and locations collected by the INL contractor are provided in Appendix D. Results are reported in gross units of ambient dose equivalent (mrem), rounded to the nearest mrem. The 2017 reported values for field locations were primarily below the historic background six-month UTL. Table 7-6 shows the locations that exceeded the facility specific six-month UTL.

Neutron monitoring is conducted around buildings in Idaho Falls with sources that may emit or generate neutron radiation. In Idaho Falls, these buildings include the IF-675 Portable Isotopic Neutron Spectroscopy facility, the IF-670 Bonneville County Technology Center, and the IF-638 Physics Laboratory. Additional neutron dosimeters are placed at INL Research Center along the south perimeter fence and at the Idaho Falls O-10 background location. The background level for neutron dose is zero and the current dosimeters have a detection limit of 10 mrem. The INL contractor follows the recommendations of the manufacturer to prevent environmental damage to the neutron dosimetry by wrapping each in aluminum foil. To keep the foil intact, the dosimeter is inserted into an ultraviolet protective cloth pouch when deployed. Any dose measured above the detection limit is considered present due to sources inside the building. Most neutron dosimeters collected in 2017 were reported as "M" (dose equivalents below the minimum measurable quantity of 10 mrem). One location, IF-638W O-4, located in the INL Research Complex, had a reading of 30 mrem. Neutron dosimetry is deployed at IF-638 because the building houses a sealed neutron source. It is likely that the 30-mrem reading is due to this source at that location.

Table 7-7 summarizes the calculated effective dose a hypothetical individual would receive on the Snake River Plain from various natural background radiation sources (cosmic and terrestrial). This table includes the latest recommendations of the National Council of Radiation Protection and Measurements (NCRP) in Ionizing Radiation Exposure of the Population of the United States (NCRP 2009).

The terrestrial natural background radiation exposure estimate is based on concentrations of naturally occurring radionuclides found in soil samples collected from 1976–1993, as summarized by Jessmore, Lopez, and Haney (1994). Concentrations of naturally occurring radionuclides in soil do not change significantly over this relatively short period. Data indicated the average concentrations of uranium-238 (^{238}U), thorium-232 (^{232}Th), and potassium-40 (^{40}K) were 1.5, 1.3, and 19 pCi/g, respectively. The calculated external dose equivalent received by a member of the public from

^{238}U plus decay products, ^{232}Th plus decay products, and ^{40}K based on the above-average area soil concentrations were 21, 28, and 27 mrem/yr, respectively, for a total of 76 mrem/yr (Mitchell et al. 1997). Because snow cover can reduce the effective dose that Idaho residents receive from soil, a correction factor must be made each year to the estimated 76 mrem/yr. In 2017, this resulted in a reduction in the effective dose from soil to a value of 69 mrem.

The cosmic component varies primarily with increasing altitude. Using Figure 3.4 in NCRP Report No. 160 (NCRP 2009), it was estimated that the annual cosmic radiation dose near the INL Site is approximately 57 mrem. Cosmic radiation may vary slightly because of solar cycle fluctuations and other factors.

Based on this information, the sum of the terrestrial and cosmic components of external radiation dose to a person residing on the Snake River Plain in 2017 was estimated to be 126 mrem/yr. This is slightly higher than the 113 mrem/yr measured at offsite locations using OSLD data. Measured values are typically within normal variability of the calculated background

Table 7-6. Dosimetry Locations Above the Six-month Background UTL (2017).

Location	Collect Date	Dose (mrem)	Background Level UTL[a] (mrem)
ANL O-21[b]	5/2017	81.4	80.42
ICPP O-20[b]	5/2017	171.3	102
ICPP O-28[b]	5/2017	104.2	102
ICPP O-30[b]	5/2017	124.9	102
ICPP Tree Farm O-4[b]	5/2017	102	102
RWMC O-13A	5/2017	88	85.78
TRA O-19[b]	5/2017	115.1	96.39
ANL O-21[b]	11/2017	88.9	80.42
ICPP O-15	11/2017	103.3	102
ICPP O-20[b]	11/2017	248.5	102
ICPP O-27[b]	11/2017	116.2	102
ICPP O-28[b]	11/2017	105.2	102
ICPP O-30[b]	11/2017	176.0	102
ICPP Tree Farm O-1[b]	11/2017	116.8	102
ICPP Tree Farm O-4[b]	11/2017	124.4	102
Lincoln Blvd O-5	11/2017	82.9	81.91
Monteview O-4	11/2017	70.7	65.74
RRL5 O-1[b]	11/2017	81.4	80.42
TRA O-10	11/2017	105.4	96.39
TRA O-19[b]	11/2017	101.8	96.39

a. The UTL is the value such that 95 percent of all the doses in the area are less than the UTL with 95 percent confidence. That is, only 5 percent of the doses should exceed the UTL.

b. Location has not been sampled long enough (years) to be included in the six month UTL calculation. The comparison value is from the facility UTL or other nearby locations.

doses. Therefore, it is unlikely that INL Site operations contributed to background radiation levels at distant locations in 2017.

The component of background dose that varies the most is inhaled radionuclides. According to the NCRP, the major contributor of effective dose received by a member of the public from ^{238}U plus decay products is short-lived decay products of radon (NCRP 2009). The amount of radon in buildings and groundwater depends, in part, upon the natural radionuclide content of soil and rock in the area. The amount of radon also varies among buildings of a given geographic area depending upon the materials each contains, the amount of ventilation and air movement, and other factors. The United States average of 212 mrem/yr was used in Table 7-7 for this component of the total background dose. The NCRP also reports that the average dose received from thoron, a decay product of ^{232}Th, is 16 mrem.

People also receive an internal dose from ingestion of ^{40}K and other naturally occurring radionuclides in environmental media. The average ingestion dose to an adult living in the United States was reported in NCRP Report No. 160 to be 29 mrem/yr (NCRP 2009).

With all of these contributions, the total background dose to an average individual living in southeast Idaho was estimated to be approximately 383 mrem/yr (Table 7-7). This value was used in Table 8-3 to calculate background radiation dose to the population living within 50 mi of INL Site facilities.

7.4 Waste Management Surveillance Sampling

For compliance with DOE Order 435.1, "Radioactive Waste Management" (2011), vegetation and soil are sampled at RWMC, and direct surface radiation is measured at RWMC and the Idaho Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Disposal Facility.

Table 7-7. Calculated Effective Dose from Natural Background Sources (2017).

Source of Radiation Dose	Total Average Annual Dose: Calculated (mrem)	Total Average Annual Dose: Measured[a] (mrem)
External irradiation		
Terrestrial	69[b]	NA[c]
Cosmic	57[d]	NA
Subtotal	126	113
Internal irradiation (primarily ingestion)[e]		
Potassium-40	15	NM[f]
Thorium-232 and uranium-238	13	NM
Others (carbon-14 and rubidium-87)	1	NM
Internal irradiation (primarily inhalation)[d]		
Radon-222 (radon) and its short-lived decay products	212	NM
Radon-220 (thoron) and its short-lived decay products	16	NM
Total	383	NM

a. Calculated from the average annual external exposure at all offsite locations measured using OSLDs (see Table 7-5).
b. Estimated using concentrations of naturally occurring radionuclide concentrations in soils in the Snake River Plain.
c. NA indicates terrestrial and cosmic radiation parameters were not measured individually but were measured collectively using dosimeters.
d. Estimated from Figure 3.4 of NCRP Report No. 160.
e. Values reported for average American adult in Table 3.14 of NCRP Report No. 160.
f. NM = not measured.

7.4.1 Vegetation Sampling at the Radioactive Waste Management Complex

At RWMC, if available, vegetation is collected from four major areas and a control location approximately seven miles south of the Subsurface Disposal Area (SDA) at the base of Big Southern Butte (Figure 7-9). Russian thistle is collected in even-numbered years. Crested wheat grass and rabbit brush are collected in odd numbered years. In 2017, both species of vegetation were available for sampling.

Radionuclide concentrations in vegetation samples from RWMC remained at low levels and within expected bounds (Table 7-8). A comparison of radionuclide concentration data for ^{90}Sr, ^{241}Am, and $^{239/240}$Pu from samples collected in 2017 to previous sampling events revealed little change.

7.4.2 Soil Sampling at the Radioactive Waste Management Complex

Waste Management surveillance soil sampling has been conducted triennially at the SDA at RWMC since 1994. The last triennial soil sampling event was conducted in 2015. In 2017, the results of soil sampling from 1994–2015 were reviewed for each constituent of interest and compared to their respective environmental concentration guide, which were established in 1986 in *Development of Criteria for the Release of Idaho National Engineering Laboratory Sites Following Decontamination and Decommissioning* (EGG-2400). All results were well below their environmental concentration guide.

The footprint at RWMC has changed drastically since this soil sampling began. The area where soil sampling has been performed at the SDA at RWMC is now a heavily disturbed area. Structures cover a majority

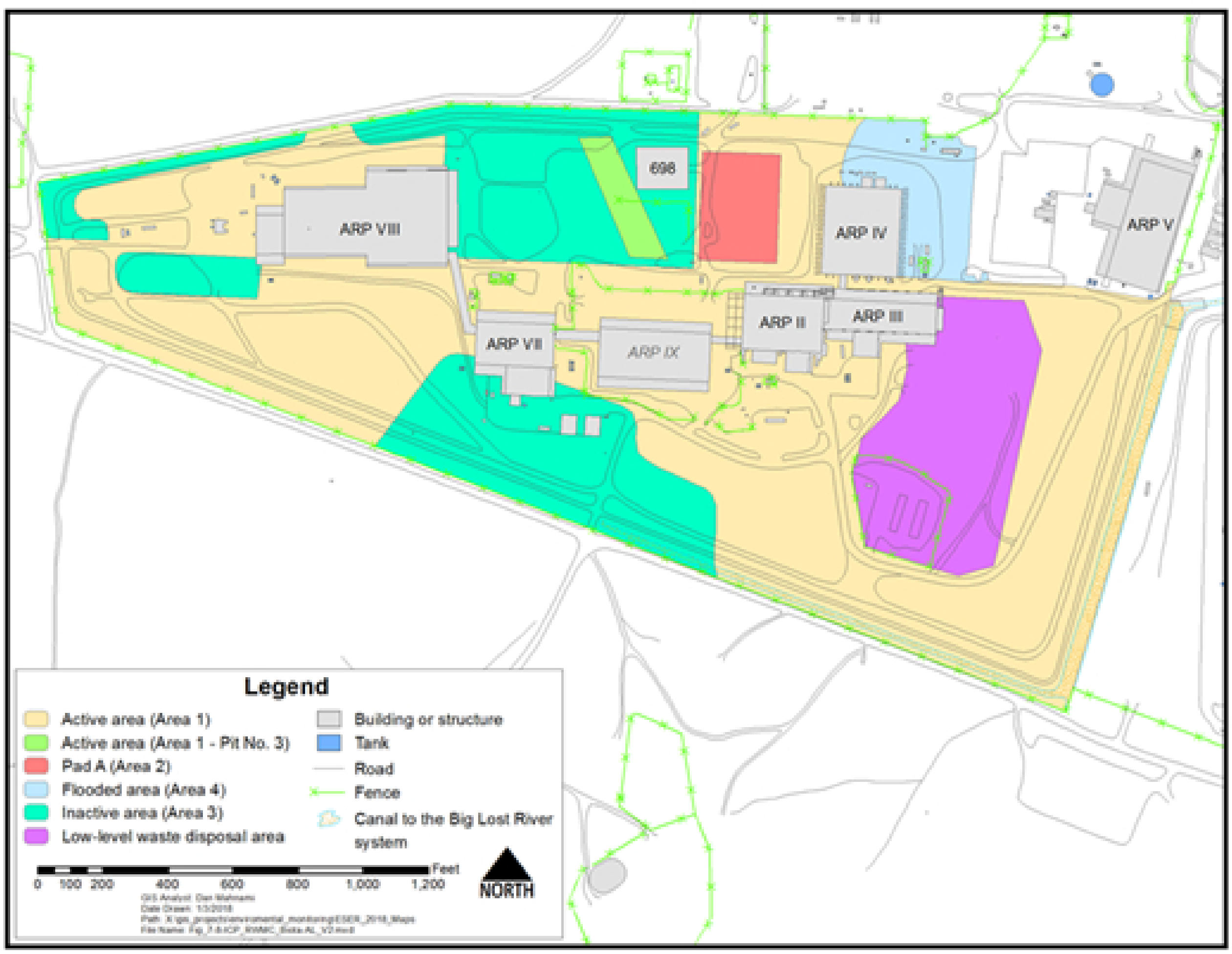

Figure 7-9. Four Vegetation Sampling Areas at the RWMC.

Table 7-8. Radionuclides Detected in RWMC Vegetation in 2017.

Radionuclide	Crested Wheatgrass Location	Result (pCi/g)[a]
Americum-241	Area 2 (Pad A)	(2.79 ± 1.51) E-04
Plutonium-239/240	Area 1 (Active Area)	(2.80 ± 0.86) E-04
	Area 2 (Pad A)	(7.92 ± 1.55) E-04
Strontium-90	Area 1 (Active Area)	(1.47 ± 0.17) E-01
	Area 2 (Pad A)	(1.07 ± 0.15) E-02
	Area 3 (Inactive Area)	(9.54 ± 1.42) E-03
	Area 4 (Flooded Area)	(4.64 ± 0.97) E-03
	Frenchman's Cabin (control area)	(1.60 ± 0.23) E-02
Radionuclide	**Rabbitbrush Location**	**Result (pCi/g)**
Americum-241	Area 1 (Active Area)	(1.16 ± 0.25) E-03
	Area 2 (Pad A)	(1.96 ± 0.30) E-03
Plutonium-239/240	Area 1 (Active Area)	(1.72 ± 0.28) E-03
Strontium-90	Area 1 (Active Area)	(5.43 ± 0.69) E-02
	Area 2 (Pad A)	(1.26 ± 0.25) E-02
	Area 3 (Inactive Area)	(2.91 ± 0.42) E-02
	Area 4 (Flooded Area)	(6.33 ± 1.69) E-03
	Frenchman's Cabin (control area)	(1.66 ± 0.30) E-02

a. Results ± 1s. Results shown are ≥ 3s.

of the area and fill has been brought in where subsidence has occurred. Gravel has been applied for road base. The DOE Handbook, *Environmental Radiological Effluent Monitoring and Environmental Surveillance* (DOE 2015) states, "Except where the purpose of soil sampling dictates otherwise, every effort should be made to avoid tilled or disturbed areas and locations near buildings when selecting soil sampling locations."

In 2017, a determination was made to discontinue soil monitoring based on several factors: 1) the limited availability of undisturbed soils; and 2) sufficient historical data had been collected to satisfy the characterization objectives, as well as the conclusion that planned activities in the SDA do not have a potential to change surface soil contaminant concentrations prior to installation of the surface cover over the entire SDA under the CERCLA program.

7.4.3 Surface Radiation Survey at the Radioactive Waste Management Complex and the Idaho CERCLA Disposal Facility

Surface radiation surveys are performed to characterize gamma radiation levels near the ground surface at waste management facilities. Comparing the data from these surveys year to year helps to determine whether radiological trends exist in specific areas. This type of survey is conducted at the RWMC SDA to complement air and soil sampling and at the Idaho CERCLA Disposal Facility (ICDF) to complement air sampling. The SDA contains legacy waste that is in the process of being removed for repackaging and shipment to an off-Site disposal facility. The ICDF consists of a landfill and evaporation ponds, which serve as the consolidation points for CERCLA-generated waste within the INL Site boundaries.

A vehicle-mounted Global Positioning Radiometric Scanner (GPRS) system (Rapiscan Model GPRS-1111) is used to conduct these soil surface radiation (gross gamma) surveys to detect trends in measured levels of surface radiation. The GPRS system consists of two scintillator gamma detectors, housed in two separate metal cabinets, and a Trimble global positioning system receiver, mounted on a rack located above the front bumper of a pickup truck. The detectors are approximately 36 in. above-ground. The detectors and the global positioning system receiver are connected to a system controller and to a laptop computer located inside the cabin of the truck. The GPRS system software displays the gamma counts per second from the detectors and the latitude and longitude of the system in real time on the laptop screen. The laptop computer also stores the data files collected for each radiometric survey. During radiometric surveys, the pickup truck is driven 5 mi/hr (7 ft/second), and the GPRS system collects latitude, longitude, and gamma counts per second from both detectors. Data files generated during the radiological surveys are saved and transferred to the ICP Core spatial analysis laboratory for mapping after the surveys are completed. The maps indicate areas where survey counts were at or near background levels, and areas where survey counts are above background levels. No radiological trends were identified in 2017, in comparison to previous years.

Figure 7-10 shows a map of the area that was surveyed at RWMC in 2017. Some areas that had been surveyed in previous years could not be accessed due to construction activities and subsidence restrictions. Although readings vary slightly from year to year, the 2017 results are comparable to previous years' measurements. The active low-level waste pit was covered during 2009, and, as a result of the reduced shine, elevated measurements from the buried waste in

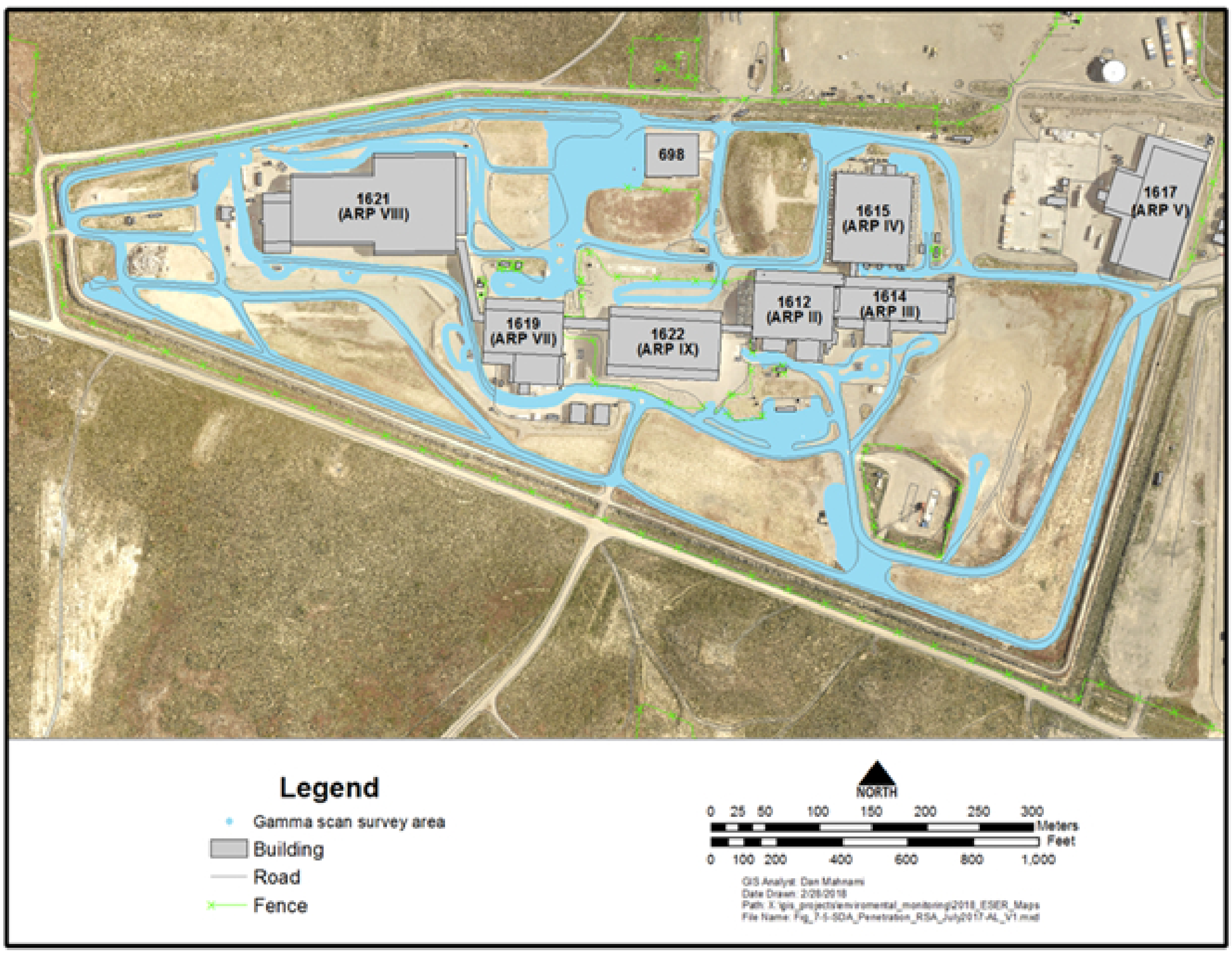

Figure 7-10. SDA Surface Radiation Survey Area (2017).

pits and trenches are more visible. Average background values near or around areas that were radiometrically scanned were generally below 750 counts per second. Most of the 2017 RWMC gross gamma radiation measurements were at background levels. The 2017 maximum gross gamma radiation measurement on the SDA was 11,706 counts per second, as compared to the 2016 measurement of 17,859 counts per second. As in previous years, the maximum readings were measured in a small area at the western end of the soil vault row SVR-7, and the size of that area has not increased.

The area that was surveyed at the ICDF is shown in Figure 7-11. The readings at the ICDF vary from year to year. These variations are related to the disposal and burial of new CERCLA remediation wastes in accordance with the ICDF waste placement plan (EDF-ER-286). In 2017, the readings were either at background levels or slightly above background levels (approximately 300 counts/second), which is expected until the facility is closed and capped.

7.5 CERCLA Ecological Monitoring

Ecological monitoring at the INL Site was conducted in accordance with the Record of Decision for Operable Unit 10-04 (DOE-ID 2002b) developed under CERCLA (42 USC § 9601 et seq.). The selected remedy was no action with long-term ecological monitoring to reduce uncertainties in the INL Site-wide ecological risk assessment.

After six years of data and observations from 2003 and 2008 to assess effects at the population level, it was determined that the no action decision is protective, and further ecological monitoring under CERCLA is not required (Holdren 2013). To validate the conclusion that further ecological monitoring under CERCLA is not required, the regulatory agencies requested additional

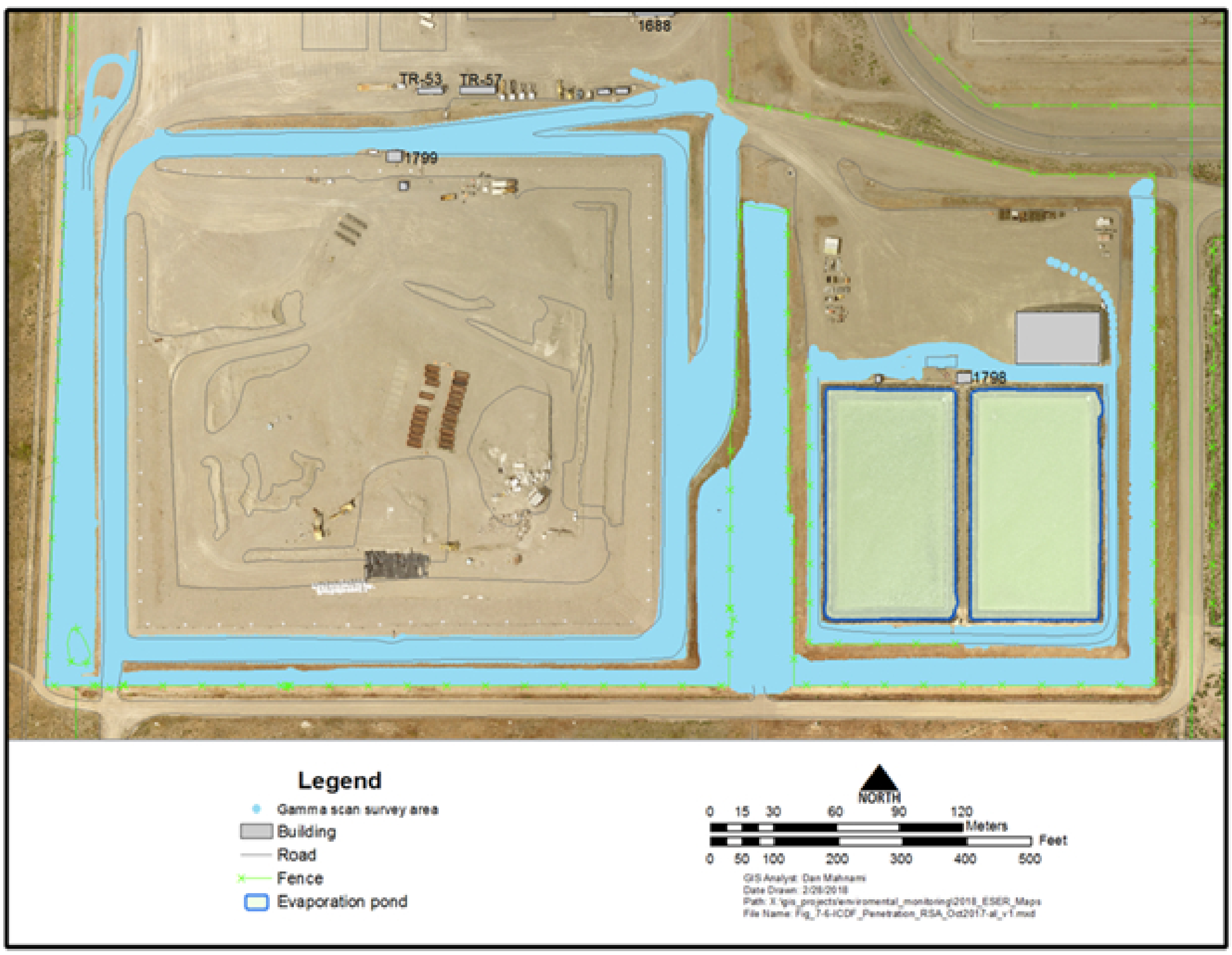

Figure 7-11. Idaho CERCLA Disposal Facility Surface Radiation Survey Area (2017).

analysis using the latest ecological risk assessments. Refined ecological risks were presented in a summary report (VanHorn 2013). Several individual release sites within the waste area groups were recommended for further evaluation in the next five-year review (planned to cover 2010–2014) to ensure the remedial action is protective of ecological receptors.

The five-year review, published in December 2015, considered toxicity, land-use projections, and endangered species listings and found no basis for further evaluation of potential ecological impacts. Individual sites tabulated by VanHorn (2013) offer limited habitat and considerable human activity, and they are not significant in the context of the INL Site-wide population effects conclusion. The five-year review concluded that the no-action decision (DOE-ID 2015):

- Is protective at the population level
- Eliminates further consideration of the INL Site-wide no-action decision in future five-year reviews
- Defers evaluation of ecological protectiveness at Idaho Nuclear Technology and Engineering Center and RWMC until after the planned surface barriers are operational and functional.

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8. Dose to the Public and Biota

The potential radiological dose to the public from Idaho National Laboratory (INL) Site operations was evaluated to determine compliance with pertinent regulations and limits. The Clean Air Act Assessment Package 88-PC computer program is required by the U.S. Environmental Protection Agency to demonstrate compliance with the Clean Air Act. The dose to the hypothetical, maximally exposed individual (MEI) in 2017, as determined by the CAP-88-PC program, was 0.008 mrem (0.08 µSv), well below the applicable standard of 10 mrem (100 µSv) per year. A maximum potential dose from ingestion was also estimated using the highest radionuclide concentrations in the edible tissue of waterfowl collected from ponds at the Advanced Test Reactor Complex. The maximum potential dose to an individual who consumes this waterfowl, for example a Green-winged Teal duck, was calculated to be 0.046 mrem (0.46 µSv). Therefore, the total dose (via air and ingestion) estimated to be received by the MEI during 2017 was 0.054 mrem (0.54 µSv). This dose is also far below the public dose limit of 100 mrem (1 mSv) established by the U.S. Department of Energy (DOE) for a member of the public.

The maximum potential population dose to the approximately 332,665 people residing within an 80-km (50-mi) radius of any INL Site facility was also evaluated. The population dose was calculated using reported releases, an air dispersion model (HYSPLIT) used by the National Oceanic and Atmospheric Administration Air Resources Laboratory-Field Research Division, and a dose calculation model (DOSEMM). For 2017, the estimated potential population dose was 1.06 x 10^{-2} person-rem (1.06 x 10^{-4} person-Sv). This dose is approximately 0.000008 percent of that expected from exposure to natural background radiation of 127,411 person-rem (1,274 person-Sv).

The potential doses to aquatic and terrestrial biota from contaminated soil and water were evaluated using a graded approach. Initially, the potential doses were screened using maximum concentrations of radionuclides detected in soil and effluents at the INL Site. Results of the screening calculations indicate that contaminants released from INL Site activities do not have an adverse impact on plants or animal populations. In addition, maximum concentrations of radionuclides measured in waterfowl accessing INL Site ponds and bats collected at or near INL Site facilities were used to estimate internal doses to thee animals. These calculations indicate that the potential doses to waterfowl and bats do not exceed the DOE limits for biota.

No unplanned releases occurred from the INL Site in 2017; therefore, no doses were associated with unplanned releases.

8. DOSE TO THE PUBLIC AND BIOTA

U.S. Department of Energy (DOE) Order 458.1, "Radiation Protection of the Public and the Environment," contains requirements for protecting the public and the environment against undue risk from radiation associated with radiological activities conducted under the control of the DOE. In addition to requiring environmental monitoring to ensure compliance with the order, DOE Order 458.1 establishes a public dose limit. DOE sites must perform dose evaluations using mathematical models that represent various environmental pathways to demonstrate compliance with the public dose limit and to assess collective (population) doses. In the interest of protection of the environment against ionizing radiation, DOE also developed the technical standard DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE 2002). The Standard provides a graded approach for evaluating radiation doses to aquatic and terrestrial biota.

40 Code of Federal Regulations (CFR) Part 61 Subpart H, "National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities," establishes federal radiation dose limits for the maximally exposed member of the public from all airborne emissions and pathways. It requires that doses to members of the public from airborne releases be calculated using U.S. Environmental Protection Agency (EPA) approved computer models.

This chapter describes the potential dose to members of the public and biota from operations at the Idaho National Laboratory (INL) Site, based on 2017 environmental monitoring measurements.

8.1 Possible Exposure Pathways to the Public

Air, soil, groundwater, agricultural products, and biota are routinely sampled to document the amount of radioactivity in these media and to determine if radioactive materials have been transported off the INL Site. The air pathway is the primary way people living beyond the INL Site boundary could be exposed to releases from INL Site operations (Figure 4-1).

Airborne radioactive materials are carried from the source and dispersed by winds. The concentrations from routine releases are too small to measure at locations around the INL Site, so atmospheric dispersion models were used to estimate the downwind concentration of air pollutants and the potential doses from these projected offsite concentrations. Conservative doses were also calculated from ingestion of meat from wild game animals that access the INL Site. Ingestion doses were calculated from concentrations of radionuclides measured in game animals killed by vehicles on roads at the INL Site that had detectable levels of human-made radionuclides. External exposure to radiation in the environment (primarily from naturally occurring radionuclides) was measured directly using thermoluminescent dosimeters and optically stimulated luminescence dosimeters.

Water pathways were not considered major contributors to dose, because no surface water flows off the INL Site and no radionuclides associated with INL Site releases have been measured in public drinking water wells.

8.2 Dose to the Public from INL Site Air Emissions

The potential doses from INL Site air emissions were estimated using the amounts reported to be released or could potentially be released by the facilities. The 2017 INL National Emission Standards for Hazardous Air Pollutants (NESHAP) evaluation (DOE-ID 2018) reported potential radionuclide releases from 68 source locations at the INL Site. However, many of the sources resulted in doses that were insignificant and many sources are located relatively close together such that the sampling network response from a release would be the same for all nearby sources. Therefore, insignificant sources were not explicitly modeled and some sources were consolidated with nearby sources. Four large operating stacks were modeled explicitly and included the Advanced Test Reactor (ATR) main stack (TRA-770), the Materials Test Reactor main stack (TRA-710), the Idaho Nuclear Technology and Engineering Center (INTEC) main stack (CPP-708), and the Experimental Breeder Reactor-II main stack (MFC-764). All other releases within a facility were assigned as ground-level releases from a single location within the facility. These other releases include other non-fugitive releases from ducts and vents and fugitive releases from ponds, soil, or other. Figure 8-1 shows the location of all sources modeled in the dose assessment. Releases from the Radiological Response Training Range–Northern Test Range (RRTR-NTR) and Test Area North–Technical Support Facility (TAN-TSF) were assumed collocated with releases from Specific Manufacturing Capability (SMC). Releases from the Transient Reactor Test (TREAT) Facility were assumed collocated with releases from Materials and Fuels Complex (MFC).

The radionuclides and source terms used in the dose calculations are presented in Table 4-2 and summarized in Table 8-1. Tritium (^{3}H) accounted for the largest percentage of the activity released and cumulative dose. Although noble gases were the radionuclides released in the largest quantities, with the exception of argon-41 (^{41}Ar) they contributed very little to the cumulative dose (affecting immersion only) largely because of their short half-lives and the fact that they are not incorporated into the food supply. Other radionuclides that contributed the most to the overall estimated dose (carbon-14 [^{14}C], cobalt-60 [^{60}Co], strontium-90 [^{90}Sr], iodine-129 [^{129}I], cesium-137 [^{137}Cs], americium-241 [^{241}Am], and plutonium [Pu] isotopes) are typically associated with airborne particulates and were a very small fraction of the total amount of radionuclides reported.

The following two kinds of dose estimates were made using the release data:

- ***The effective dose to the hypothetical maximally exposed individual (MEI)***, as defined by the NESHAP regulations. The Clean Air Act Assessment Package-1988 computer model, PC Version 4 (CAP88-PC V4) (EPA 2013), was used to predict the maximum downwind concentration at an offsite receptor location and estimate the dose to the MEI.
- ***The collective effective dose (population dose) for the population within 80 km (50 mi) of any INL Site facility.*** For this calculation, the HYSPLIT model (Stein et al. 2015) was used to model atmospheric transport, dispersion, and deposition of radionuclides

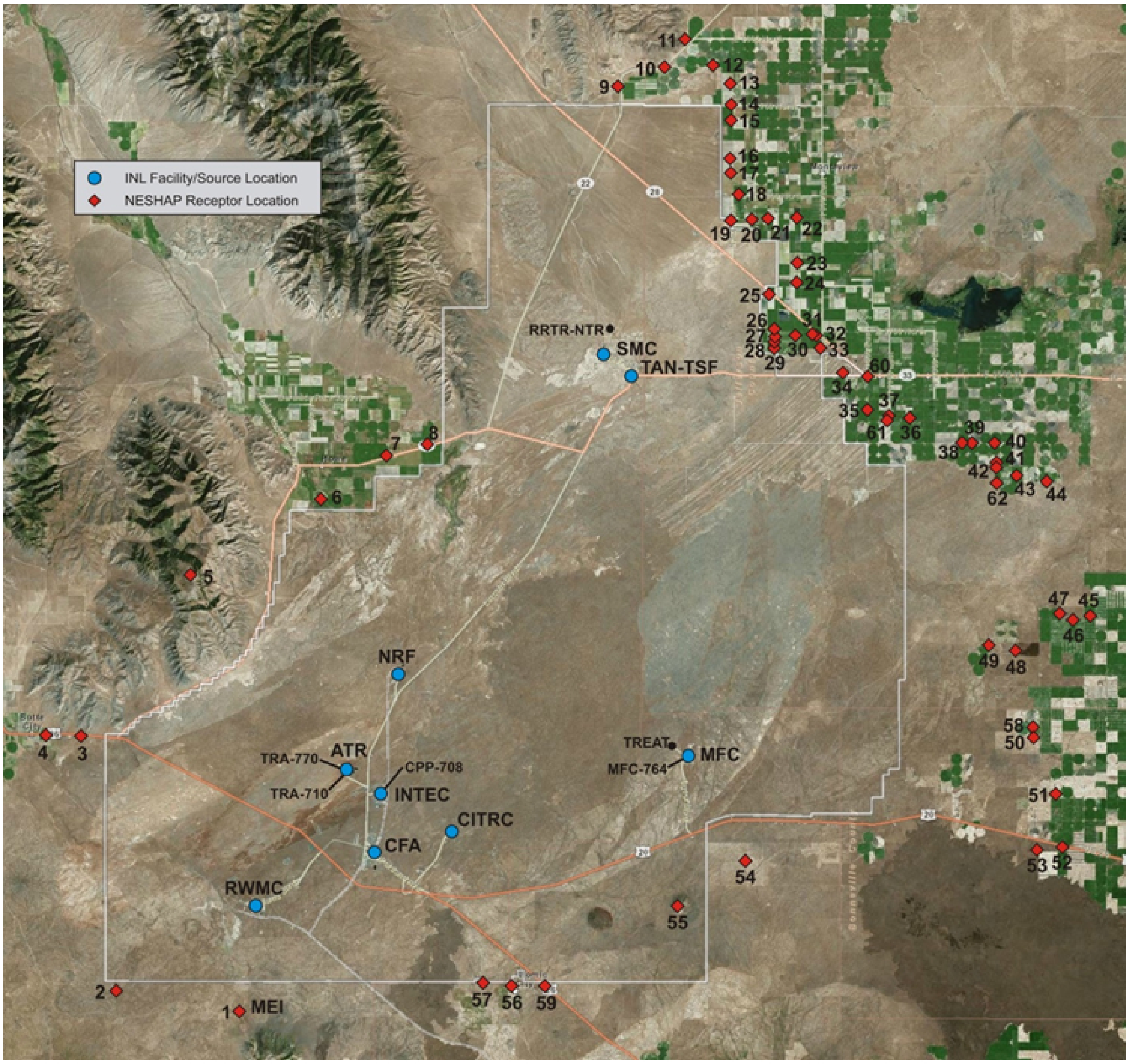

Figure 8-1. INL Site Major Facility Airborne Source Locations. *TRA-770, TRA-710, CPP-708, and MFC-764 were modeled as stack releases. The remaining sources were modeled as ground-level releases. Releases from RRTR-NTR and TAN-TSF were assumed collocated with releases from SMC. Releases from TREAT were assumed collocated with releases from MFC. Specific receptor locations, including the MEI, modelled by CAP88-PC are also shown.*

released to the air from the INL Site. The population dose was estimated using the DOSEMM model (Rood 2017), using dispersion and deposition factors calculated by HYSPLIT in order to comply with DOE Order 458.1.

The dose estimates considered air immersion dose from gamma-emitting radionuclides, internal dose from inhalation of airborne radionuclides, internal dose from ingestion of radionuclides in plants and animals, and external dose from gamma-emitting radionuclides deposited on soil (see Figure 8-1). The CAP88-PC computer model uses dose and risk tables developed by the EPA. Population dose calculations were made using: 1) the HYSPLIT to calculate dispersion and deposition factors, the methods described in Rood (2017), 2) DOE effective dose coefficients for inhaled radionuclides (DOE 2011), 3) EPA dose conversion factors for ingested radionuclides (EPA 2002), and 4) EPA dose conversion factors for external exposure to radionuclides in the air and deposited on the ground surface (EPA 2002).

Table 8-1. Summary of Radionuclide Composition of INL Site Airborne Effluents (2017).

	Total Curies[a] Released										
Facility[b]	Tritium	Noble Gases[c] ($T_{1/2} > 40$ days)	Noble Gases[d] ($T_{1/2} < 40$ days)	Fission and Activation Products[e] ($T_{1/2} < 3$ hours)	Fission and Activation Products[f] ($T_{1/2} > 3$ hours)	Total Radioiodine[g]	Total Radiostrontium[h]	Total Uranium[i]	Plutonium[j]	Other Actinides[k]	Other[l]
ATR Complex	3.01E+02	1.48E-19	9.19E+02	1.87E-01	1.80E-02	2.90E-02	2.04E-02	1.21E-08	8.46E-06	3.18E-05	3.12E-10
CFA	5.70E-01	4.28E-09	2.00E-05	1.34E-10	6.34E-07	—	4.59E-10	1.50E-08	2.54E-10	1.71E-08	6.76E-15
CITRC	—	—	—	—	1.52E-05	—	—	—	—	—	—
INTEC	2.58E+01	3.83E+00	—	—	1.03E-02	1.59E-03	1.23E-04	3.77E-07	4.79E-06	1.01E-05	—
MFC	2.03E-01	3.11E-02	1.03E+01	7.01E-02	2.06E-03	8.90E-02	1.15E-06	7.68E-06	9.76E-07	6.52E-06	1.68E-11
NRF	1.20E-02	1.20E-02	—	—	5.30E-01	2.98E-05	4.80E-05	—	2.30E-06	2.30E-06	—
RWMC	6.76E+01	9.57E-04	—	1.03E-10	8.30E-02	—	1.03E-06	2.95E-09	1.96E-04	4.93E-04	1.39E-10
TAN	3.26E-02	8.56E-06	1.25E-05	1.44E-03	4.31E-03	—	1.02E-06	1.69E-10	—	—	6.85E-12
Total	**3.95E+02**	**3.87E+00**	**9.30E+02**	**2.59E-01**	**6.48E-01**	**1.20E-01**	**2.06E-02**	**8.08E-06**	**2.12E-04**	**5.44E-04**	**4.75E-10**

a. One curie (Ci) = 3.7×10^{10} becquerels (Bq).

b. ATR Complex = Advanced Test Reactor Complex; CFA = Central Facilities Area; CITRC = Critical Infrastructure Test Range Complex; INTEC = Idaho Nuclear Technology and Engineering Center; MFC = Materials and Fuels Complex; NRF = Naval Reactors Facility; RWMC = Radioactive Waste Management Complex (including AMWTP = Advanced Mixed Waste Treatment Project and Radiological Response Training Range-Southern Test Range); TAN = Test Area North (including SMC = Specific Manufacturing Capability and Radiological Response Training Range-Northern Test Range).

c. Noble gases ($T_{1/2} > 40$ days) released in 2017 = ^{39}Ar and ^{85}Kr (^{39}Ar release is negligible).

d. Noble gases ($T_{1/2} < 40$ days) released in 2017 = ^{41}Ar, ^{79}Kr, ^{83m}Kr, ^{85m}Kr, ^{87}Kr, ^{88}Kr, ^{133}Xe, ^{135}Xe, ^{135m}Xe and ^{138}Xe.

e. Fission products and activation products ($T_{1/2} < 3$ hours) released in 2017 = ^{110}Ag, ^{137m}Ba, ^{139}Ba, ^{141}Ba, ^{80}Br, ^{83}Br, ^{38}Cl, ^{60m}Co, ^{138}Cs, ^{178m}Hf, ^{142}La, ^{56}Mn, ^{144}Pr, ^{88}Rb, ^{89}Rb, ^{103m}Rh, ^{106}Rh, ^{106m}Rh, ^{81}Se, ^{81m}Se, ^{129}Te, and ^{208}Tl.

f. Fission products and activation products ($T_{1/2} > 3$ hours) released in 2017 = ^{108m}Ag, ^{110m}Ag, ^{133}Ba, ^{140}Ba, ^{7}Be, ^{10}Be, ^{207}Bi, ^{210m}Bi, ^{80m}Br, ^{82}Br, ^{14}C, ^{45}Ca, ^{109}Cd, ^{139}Ce, ^{141}Ce, ^{144}Ce, ^{36}Cl, ^{57}Co, ^{58}Co, ^{60}Co, ^{51}Cr, ^{134}Cs, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{155}Eu, ^{156}Eu, ^{55}Fe, ^{59}Fe, ^{60}Fe, ^{153}Gd, ^{68}Ge, ^{71}Ge, ^{175}Hf, ^{179m}Hf, ^{181}Hf, ^{182}Hf, ^{203}Hg, ^{192}Ir, ^{40}K, ^{42}K, ^{43}K, ^{53}Mn, ^{54}Mn, ^{93}Mo, ^{99}Mo, ^{22}Na, ^{24}Na, ^{93m}Nb, ^{94}Nb, ^{95}Nb, ^{95m}Nb, ^{147}Nd, ^{59}Ni, ^{63}Ni, ^{185}Os, ^{191}Os, ^{32}P, ^{33}P, ^{205}Pb, ^{147}Pm, ^{143}Pr, ^{184}Re, ^{184m}Re, ^{186}Re, ^{186m}Re, ^{187}Re, ^{188}Re, ^{103}Ru, ^{106}Ru, ^{122}Sb, ^{124}Sb, ^{125}Sb, ^{46}Sc, ^{32}Si, ^{145}Sm, ^{151}Sm, ^{113}Sn, ^{179}Ta, ^{182}Ta, ^{183}Ta, ^{99}Tc, ^{99m}Tc, ^{127}Te, ^{129m}Te, ^{132}Te, ^{204}Tl, ^{49}V, ^{181}W, ^{185}W, ^{187}W, ^{188}W, ^{88}Y, ^{90}Y, ^{91}Y, ^{92}Y, ^{65}Zn, ^{95}Zr and ^{97}Zr.

g. Radioiodine released in 2017 = ^{125}I, ^{128}I, ^{129}I, ^{131}I, ^{132}I, ^{133}I, ^{134}I and ^{135}I.

h. Radiostrontium released in 2017 = ^{80}Sr, ^{85}Sr, ^{89}Sr, ^{90}Sr, ^{91}Sr and ^{92}Sr.

i. Uranium isotopes released in 2017 = ^{232}U, ^{233}U, ^{234}U, ^{235}U, ^{236}U and ^{238}U.

j. Plutonium isotopes released in 2017 = ^{236}Pu, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu and ^{242}Pu.

k. Other actinides released in 2017 = ^{227}Ac, ^{241}Am, ^{243}Am, ^{242}Cm, ^{243}Cm, ^{244}Cm, ^{237}Np, ^{239}Np, ^{231}Pa, ^{233}Pa, ^{229}Th, ^{230}Th and ^{232}Th.

l. Other = radioisotopes of elements that are not noble gases, activation or fission products, radioiodine, radiostrontium, or actinides released in 2017. These are typically heavy elements that are decay chain members of actinides.

8.2.1 Maximally Exposed Individual Dose

The EPA NESHAP regulation requires demonstrating that radionuclides other than radon released to air from any DOE nuclear facility do not result in a dose to the public of greater than 10 mrem/yr (0.1 mSv/yr) (40 CFR 61, Subpart H). This includes releases from stacks and diffuse sources, such as resuspension of contaminated soil particles. EPA requires the use of an approved computer model such as CAP88-PC to demonstrate compliance with 40 CFR 61, Subpart H. CAP88-PC uses a modified Gaussian plume model to estimate the average dispersion of radionuclides released from up to six sources. It uses average annual wind files based on data collected at multiple locations on the INL Site by National Oceanic and Atmospheric Administration (NOAA). Assessments are conducted for a circular grid of distances and directions from each source up to a radius of 80 km (50 mi) around the facility. The program computes radionuclide concentrations in air, rates of deposition on ground surfaces, concentrations in food, and intake rates to people from ingestion of food produced in the assessment area. Estimates of the radionuclide concentrations in produce, leafy vegetables, milk, and meat consumed by humans are made by coupling the output of the atmospheric transport models with the Nuclear Regulatory Commission Regulatory Guide 1.109 (NRC 1977) terrestrial food chain models.

The dose to the MEI from INL Site airborne releases of radionuclides was calculated to demonstrate compliance with NESHAP and is published in the *National Emissions Standards for Hazardous Air Pollutants – Calendar Year 2017 INL Report for Radionuclides* (DOE-ID 2018). In order to identify the MEI, the doses at 62 offsite locations were calculated and then screened for the maximum potential dose to an individual who might live at one of these locations. The highest potential dose was determined to be to a hypothetical person living at Frenchman's Cabin, located 2.26 km (1.4 mi) south of the INL Site southern boundary. This location is inhabited only during portions of the year, but it must be considered as a potential MEI location according to NESHAP. An effective dose of 0.008 mrem (0.08 µSv) was calculated for a hypothetical person living at Frenchman's Cabin during 2017.

Figure 8-2 compares the maximum individual doses calculated for 2007–2017. All of the doses are well below the whole body dose limit of 10 mrem/yr (0.1 mSv/yr) for airborne releases of radionuclides established by 40 CFR 61, Subpart H. The highest dose was estimated in 2008 and was attributed primarily to plutonium-241 (^{241}Pu), which was reported to be released during the dismantling of facilities at Test Area North.

Although noble gases were the radionuclides released in the largest quantities (~70 percent of the total Ci released in 2017), they represented relatively smaller fractions of the cumulative dose from all pathways (affecting immersion only) largely because of their short half-lives and the fact that they are not incorporated into the food supply. For example, 65 percent of the total activity released was ^{41}Ar (Table 4-2), yet ^{41}Ar resulted in approximately 21 percent of the estimated MEI dose. On the other hand, radionuclides typically associated with airborne particulates (^{241}Am, ^{60}Co, ^{137}Cs, ^{129}I, ^{90}Sr and plutonium-238 [^{238}Pu], plutonium-239 [^{239}Pu], and plutonium-240 [^{240}Pu] isotopes) were a tiny fraction (less than 0.01 percent) of the total amount of radionuclides reported to be released (Table 4-2) yet resulted in approximately 46 percent of the estimated dose (Figure 8-3). The potential dose from ingesting or inhaling ^{90}Sr is higher than that for other particulate radionuclides because it is long-lived (half-life = 29 years) and in the body it acts very much like calcium, getting into the bones where it can remain for many years. While in the body, ^{90}Sr continues to expose the surrounding tissues to beta radiation. Tritium represented about 30 percent of the total activity released and contributed approximately 30 percent of the calculated dose to the MEI in 2017. Tritium interacts with the environment in a unique fashion because it may exchange with hydrogen atoms in water molecules in air. Therefore, tritium can follow water almost precisely through the environment. The dose calculations in CAP88-PC assume that doses from ingestion of food and water are directly proportional to modeled tritium concentrations in air.

Primary sources of the major radionuclides used to estimate the dose to the MEI (Figure 8-4) were identified during preparation of the annual NESHAP report (DOE-ID 2018) as follows:

- The dose from tritium emissions, which accounted for approximately 30 percent of the total dose to the MEI, results mainly from non-fugitive (i.e., point source) releases from the ATR main stack (TRA-770) and the INTEC main stack (CPP-708); and fugitive (i.e., nonpoint source) releases from beryllium blocks at the Radioactive Waste Management Complex (RWMC) and the Warm Waste Evaporation Pond (TRA-715-001) at the ATR Complex.

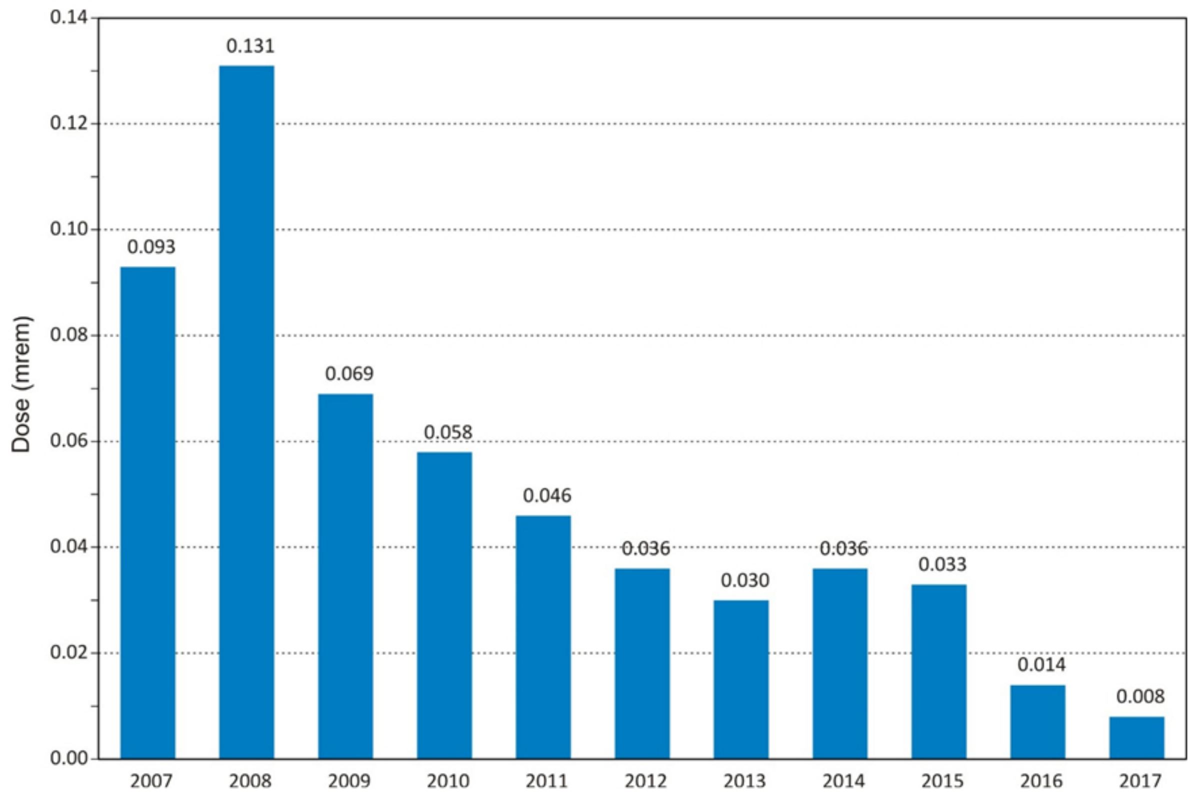

Figure 8-2. Maximum Individual Doses from INL Site Airborne Releases Estimated for 2007–2017.

- Emissions of ^{241}Am, ^{238}Pu, ^{239}Pu, and ^{240}Pu were primarily from Accelerated Retrieval Projects, at RWMC, the Warm Waste Evaporation Pond (TRA-715-001) at the ATR Complex, and the Idaho CERCLA Disposal Facility (ICDF) landfill near INTEC. These nuclides accounted for 9.7 percent of the total MEI dose.
- The major source of ^{90}Sr and ^{137}Cs resulting in dose to the MEI was from the Warm Waste Evaporation Pond at the ATR Complex, ICDF landfill and ICDF evaporation ponds near INTEC, the ATR main stack (TRA-770) and sources at Naval Reactors Facility. These nuclides accounted for 20.4 percent of the total MEI dose.
- Iodine-129 releases accounted for 8.7 percent of the total MEI dose and were primarily from the INTEC main stack (CPP-708).
- Airborne emissions of ^{41}Ar were primarily the result of operation of the Advanced Test Reactor at the ATR Complex and accounted for 21.4 percent of the total MEI dose.

8.2.2 Eighty Kilometer (50 Mile) Population Dose

The NOAA Air Resources Laboratory – Field Research Division adapted the widely used HYbrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) transport and dispersion model for use at the INL Site. The model, in conjunction with meteorological data collected by NOAA, was used to estimate the dispersion and deposition of radionuclides estimated to be released from the INL Site activities during 2017 (see Table 4-2). The model and its capabilities are described on the NOAA Air Resources Laboratory website (https://www.arl.noaa.gov/hysplit/hysplit/).

During 2017, the NOAA Air Resources Laboratory – Field Research Division continuously gathered meteorological data at 34 meteorological stations on and around the INL Site (see *Meteorological Monitoring*, a supplement to this Annual Site Environmental Report).

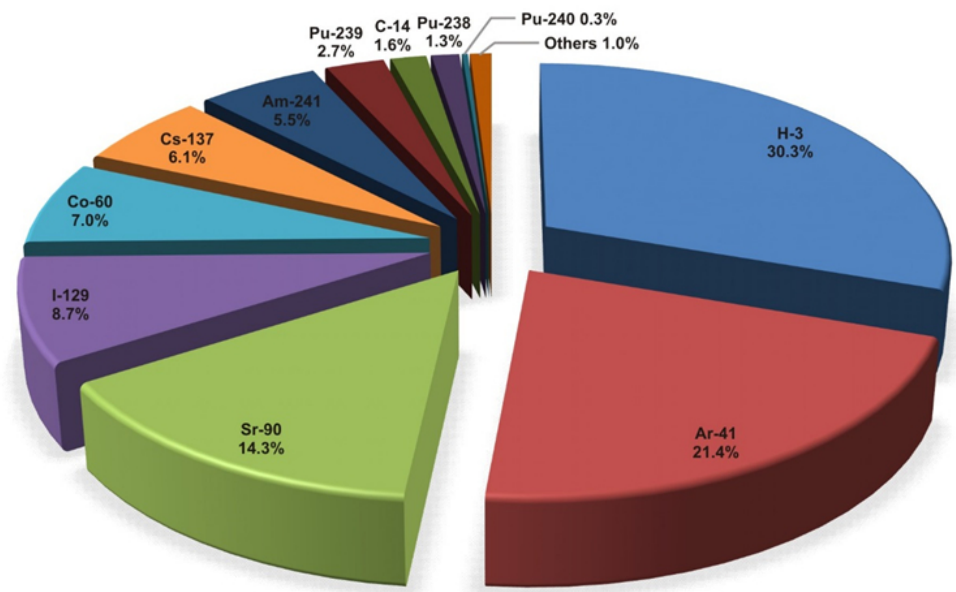

Figure 8-3. Radionuclides Contributing to Dose to MEI from INL Site Airborne Effluents as Calculated Using the CAP88-PC Model (2017).

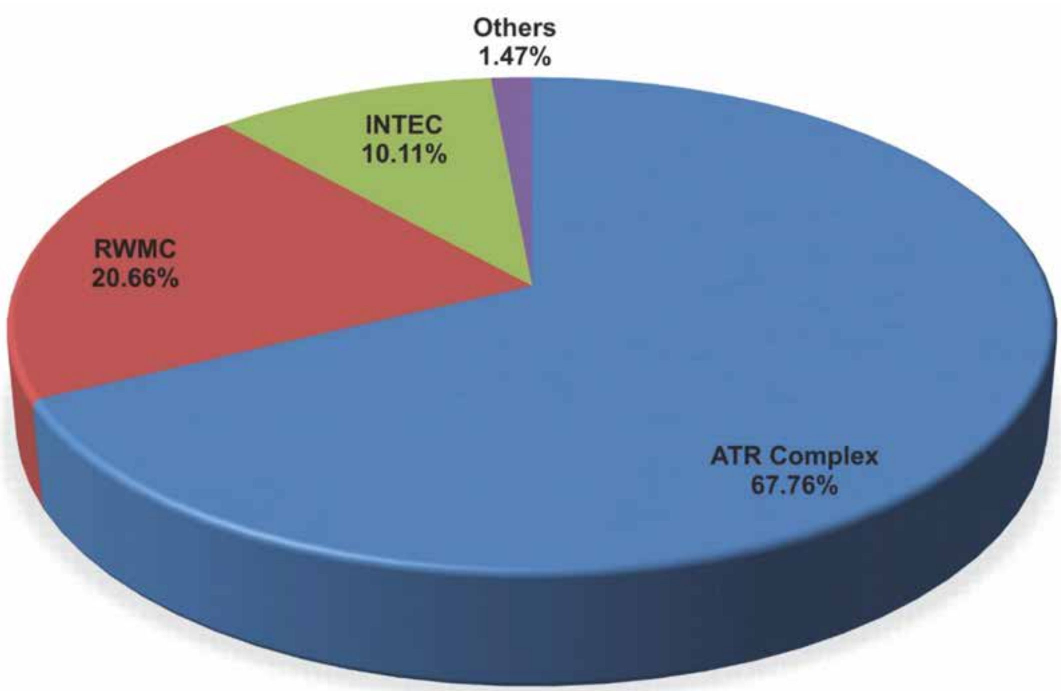

Figure 8-4. Percent Contributions, by Facility, to Dose to MEI from INL Site Airborne Effluents as Calculated Using the CAP88-PC Model (2017).

The transport and dispersion of contaminants by winds and deposition onto the ground was projected by the HYSPLIT model using hourly averaged observations from the meteorological stations throughout 2017 together with regional topography. The model predicted dispersion and deposition resulting from releases from each facility at each of 17,877 grid points projected on and around the INL Site. The Cartesian grid was designed to encompass the region within 80 km (50 mi) of INL Site facilities (Figure 8-5). In addition, 27 boundary receptor locations, representing actual residences around the INL Site, were included in the modeling.

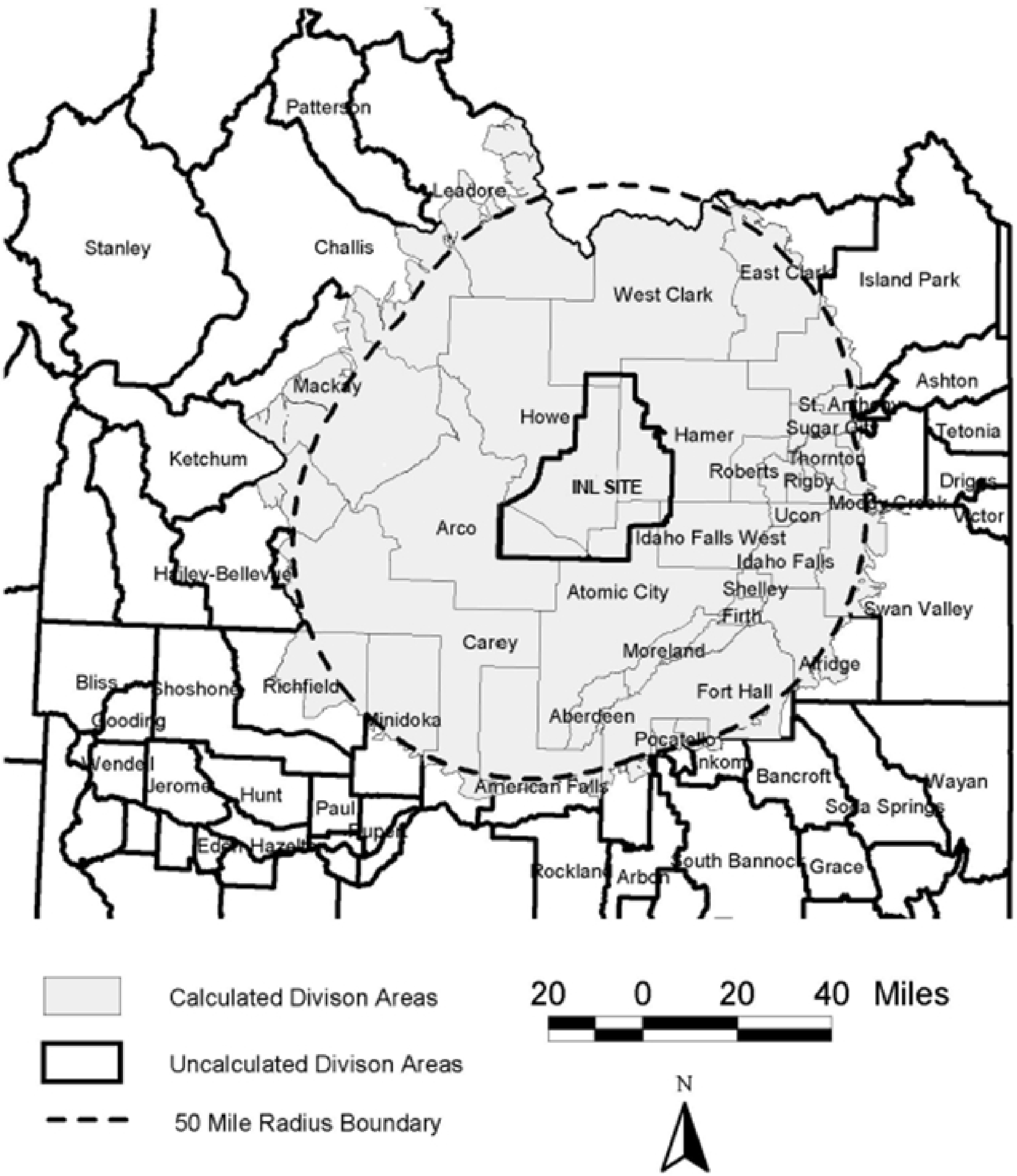

Figure 8-5. Region within 50 miles of INL Site Facilities.
Census Divisions used in the 50-mile population dose calculation are shown.

Outputs from the NOAA HYSPLIT model were radionuclide concentrations and deposition amounts for a unit release (1 Ci/s) for each significant INL Site source calculated at 17,877 grid nodes across the model domain. These values were converted to dispersion and deposition factors for use in DOSEMM (Rood 2017). The dispersion factor, often referred to as the X/Q value (concentration divided by source), was calculated by dividing the concentration (Ci/m^3) by the unit release rate (1 Ci/s) resulting in dispersion factor units of s/m^3. The deposition factor was calculated by dividing the total deposition (Ci/m^2) by the release time (seconds) and then by the unit release rate (1 Ci/s) to yield deposition factors in units in 1/m^2. Dispersion and deposition factors were calculated for each month of the year and were read into DOSEMM along with the annual radionuclide release rates from each source. Although annual release quantities were provided, monthly release quantities could have been used if available to account for seasonal variations in atmospheric dispersion.

The following radionuclides were modeled because each contributed to ≥ 0.1 percent of the total MEI dose calculated by CAP88-PC (see Figure 8-3): ^{241}Am, ^{41}Ar, ^{14}C, ^{60}Co, ^{137}Cs, ^{3}H, ^{129}I, iodine-131, krypton-87, krypton-88, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{90}Sr, xenon-135, and xenon-138. Using DOSEMM, the actual estimated radionuclide emission rate (Ci/s) for each radionuclide and each facility was multiplied by the air dispersion and deposition factors that were calculated by HYSPLIT to yield an air concentration (Ci/m^3) and deposition (Ci/m^2) at each of the grid points over the time of interest (in this case, one year). The products were then used to calculate the effective dose (mrem) via inhalation, ingestion, and external exposure pathways at each grid point and at each boundary receptor location using the methodology described in Rood (2017).

Figure 8-6 displays the summation of all doses calculated from the modeling of all releases from all facilities as isopleths, ranging in value from 0.0001 to 0.03 mrem. The highest dose to an INL Site boundary receptor was estimated to be 0.01 mrem at Frenchman's Cabin (Receptor location #1). Frenchman's Cabin is also the location of the MEI used for the NESHAP dose assessment in 2017, which reported an estimated dose of 0.008 mrem to the MEI (see Section 8.2.1). The lowest dose (0.00007 mrem) was estimated at Receptor location #7.

To calculate the 80 km (50 mi) population dose, the number of people living in each census division was first estimated with data from the 2010 census extrapolated to 2017. The next step involved the use of the Geographic Information System. The grid and dose values from DOSEMM were imported into the Geographic Information System project established and maintained by Environmental Surveillance, Education and Research program. The doses within each census division were averaged and multiplied by the population within each of the divisions or portion of divisions within the 80-km (50-mi) area defined in Figure 8-5. These doses were then summed over all census divisions to result in the 80-km (50-mi) population dose (Table 8-2). The estimated potential population dose was 1.06 x 10^{-2} person-rem (1.02 x 10^{-4} person-Sv) to a population of approximately 332,665. When compared with the approximate population dose of 127,411 person-rem (1,274 person-Sv) estimated to be received from natural background radiation, this represents an increase of about 0.000008 percent. The largest collective dose was in the Arco census division due its proximity to the INL Site (see Figure 8-6).

The estimated population dose for 2017 is about four times less than that calculated for 2016 (4.42 x 10^{-2} person-rem).

8.3 Dose to the Public from Ingestion of Wild Game from the INL Site

The potential dose an individual may receive from occasionally ingesting meat from game animals continues to be studied at the INL Site. These studies estimate the potential dose to individuals who may eat waterfowl that briefly reside at wastewater disposal ponds at the ATR Complex and MFC, and game animals that may reside on or migrate through the INL Site.

8.3.1 Waterfowl

Seven waterfowl were collected during 2017: three from the ATR Complex wastewater ponds and four from a control location on American Falls Reservoir. The maximum potential dose from eating 225 g (8 oz) of duck meat collected in 2017 is presented in Table 8-3. Radionuclide concentrations used to determine these doses are reported in Table 7-3. Doses from consuming waterfowl are conservatively based on the assumption that ducks are eaten immediately after leaving the pond and no radioactive decay occurs.

The maximum potential dose of 0.046 mrem (0.46 µSv) calculated for an individual consuming contaminated waterfowl is much lower than the dose estimated for 2015 (0.49 mrem [4.9 µSv]). The 2017 samples were not collected directly from the wastewater disposal ponds

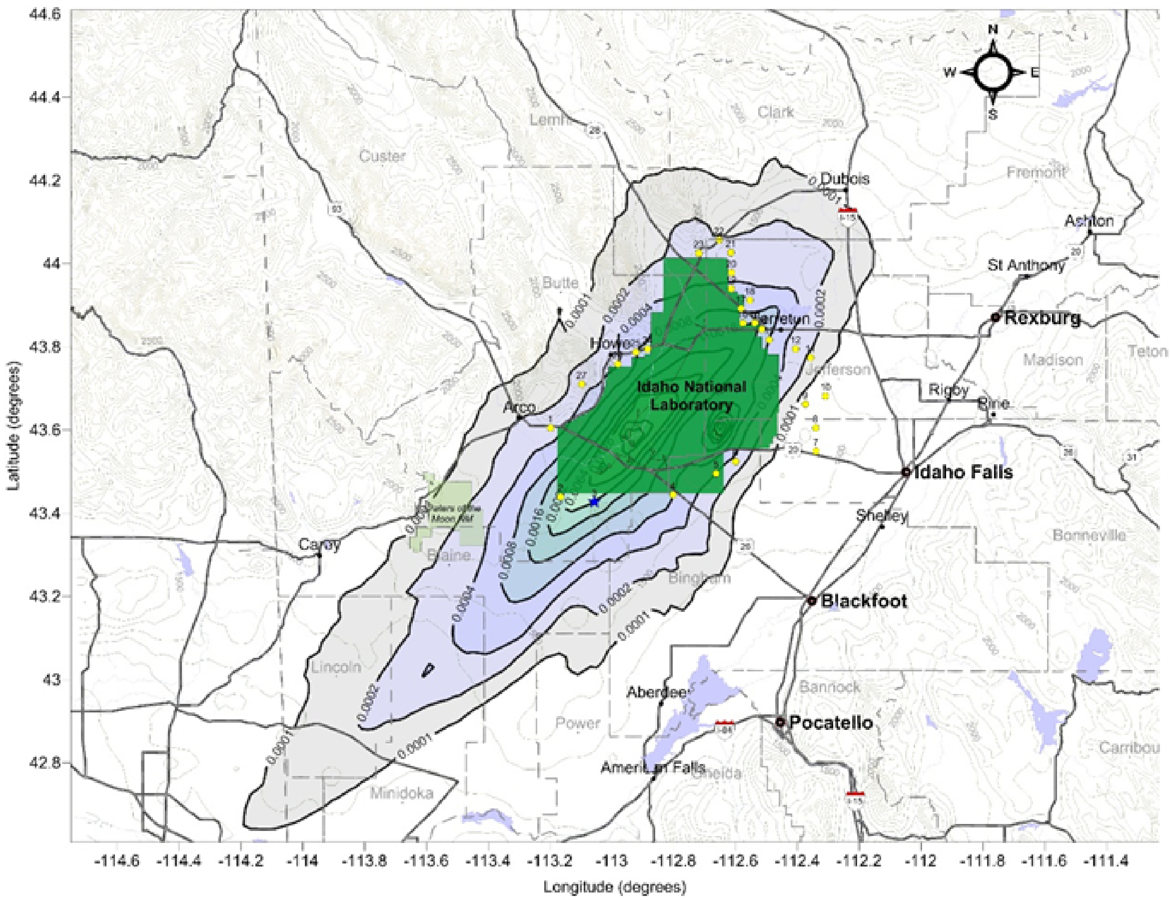

Figure 8-6. Effective Dose (mrem) Isopleth Map with Boundary Receptor Locations Displayed (2017). ***The 27 boundary receptor locations are depicted as yellow circles. The maximum receptor dose is projected at Frenchman's Cabin (depicted as a blue star south of the INL southern boundary.)***

at the ATR Complex but from sewage lagoons adjacent to them. However, the waterfowl probably resided at all the ponds while they were in the area. The decrease in dose in 2017 may be attributed to the fact that in 2016 the hypalon liner was replaced in the west disposal pond and any associated contaminated debris was removed with the old liner. Waterfowl were not collected in 2016 during this activity. The east disposal pond liner has not been replaced yet.

8.3.2 Big Game Animals

A study on the INL Site from 1972–1976 conservatively estimated the potential whole-body dose that could be received from an individual eating the entire muscle (27,000 g [952 oz]) and liver mass (500 g [17.6 oz]) of an antelope with the highest levels of radioactivity found in these animals. This dose was 2.7 mrem (27 µSv) (Markham et al. 1982). Game animals collected at the INL Site during the past few years have generally shown much lower concentrations of radionuclides. In 2017, none of the five game animals collected (three pronghorn, one mule deer, and one elk) had a detectable concentration of ^{137}Cs or other human-made radionuclides. Therefore, no dose would be associated with the consumption of these animals.

The contribution of game animal consumption to the population dose has not been calculated because only a limited percentage of the population hunts game, few of the animals killed have spent time on the INL Site, and most of the animals that do migrate from the INL Site would have reduced concentrations of radionuclides in their tissues by the time they were harvested (Halford, Markham, and White 1983). The total population dose

Table 8-2. Dose to Population within 80 km (50 miles) of INL Site Facilities (2017).

Census County Division[a,b]	Population[c]	Population Dose Person-rem	Person-Sv
Aberdeen	3,583	1.45×10^{-4}	8.01×10^{-6}
Alridge	581	7.16×10^{-7}	7.16×10^{-9}
American Falls	8,926	5.58×10^{-4}	5.58×10^{-6}
Arbon (part)	30	1.78×10^{-7}	1.78×10^{-9}
Arco	2,644	3.84×10^{-3}	3.84×10^{-5}
Atomic City (division)	2,690	1.09×10^{-3}	1.09×10^{-5}
Blackfoot	15,808	6.09×10^{-5}	6.09×10^{-7}
Carey (part)	1,082	2.42×10^{-4}	2.42×10^{-6}
East Clark	82	5.14×10^{-6}	5.14×10^{-8}
East Madison (part)	296	2.91×10^{-6}	2.91×10^{-8}
Firth	3,279	1.13×10^{-5}	1.13×10^{-7}
Fort Hall (part)	4,545	2.69×10^{-5}	2.69×10^{-7}
Hailey-Bellevue (part)	6	1.39×10^{-7}	4.06×10^{-9}
Hamer	2,358	1.27×10^{-3}	1.27×10^{-5}
Howe	386	1.33×10^{-3}	1.33×10^{-5}
Idaho Falls	107,744	4.74×10^{-4}	4.74×10^{-6}
Idaho Falls, west	1,694	6.64×10^{-5}	6.64×10^{-7}
Inkom (part)	653	1.37×10^{-6}	1.37×10^{-8}
Island Park (part)	97	3.25×10^{-6}	3.25×10^{-8}
Leadore (part)	6	2.53×10^{-7}	2.53×10^{-9}
Lewisville-Menan	4,341	6.80×10^{-5}	6.80×10^{-7}
Mackay (part)	1,266	3.02×10^{-5}	3.02×10^{-87}
Moreland	10,734	1.16×10^{-4}	1.14×10^{-6}
Pocatello	69,159	2.88×10^{-4}	2.88×10^{-6}
Rexburg	30,159	3.64×10^{-4}	3.64×10^{-6}
Rigby	20,926	1.80×10^{-4}	1.80×10^{-6}
Ririe	2,044	1.37×10^{-5}	1.37×10^{-7}
Roberts	1,655	4.40×10^{-5}	4.40×10^{-7}
Shelley	8,985	4.22×10^{-5}	4.22×10^{-7}
South Bannock (part)	331	1.44×10^{-6}	1.44×10^{-8}
St. Anthony (part)	2,661	3.29×10^{-5}	3.29×10^{-7}
Sugar City	7,553	1.22×10^{-4}	1.22×10^{-6}
Swan Valley (part)	6,769	1.93×10^{-5}	1.93×10^{-7}
Ucon	6,740	4.91×10^{-5}	4.91×10^{-7}
West Clark	851	8.83×10^{-5}	8.83×10^{-7}
Total	**332,665**	$\mathbf{1.06 \times 10^{-2}}$	$\mathbf{1.06 \times 10^{-4}}$

a. The U.S. Census Bureau divides the country into four census regions and nine census divisions. The bureau also divides counties (or county equivalents) into census county divisions.

b. (Part) means only a part of the county census division lies within the 80-km (50-mi) radius of a major INL Site facility.

c. Population extrapolated to estimated 2017 values based on 2010 Census Report for Idaho.

Table 8-3. Contribution to Estimated Annual Dose to a Maximally Exposed Individual by Pathway (2017).

Pathway	Annual Dose to Maximally Exposed Individual (mrem)	Annual Dose to Maximally Exposed Individual (µSv)	Percent of DOE 100 mrem/yr Limit[a]	Estimated Population Dose (person-rem)	Estimated Population Dose (person-Sv)	Population within 80 km	Estimated Background Radiation Population Dose (person-rem)[b]
Air	0.008	0.08	0.008	0.01	0.0001	332,665	127,411
Waterfowl	0.046	0.46	NA[c]	NA	NA	NA	NA
Big game animals	0	0	NA	0	0	NA	NA
Total pathways	**0.054**	**0.54**	**0.054**	**0.01**	**0.0001**	**NA**	**NA**

a. The DOE public dose limit from all sources of ionizing radiation and exposure pathways that could contribute significantly to the total dose is 100 mrem/yr (1 mSv/yr) total effective dose equivalent. It does not include dose from background radiation.
b. The individual dose from background was estimated to be 383 mrem (3.8 mSv) in 2017 (Table 7-7).
c. NA = Not applicable

contribution from these pathways would, realistically, be less than the sum of the population doses from inhalation of air, submersion in air, ingestion of vegetables, and deposition on soil.

8.4 Dose to the Public from Drinking Contaminated Groundwater from the INL Site

Tritium has previously been detected in three U.S. Geological Survey monitoring wells located along the southern boundary of the INL Site (Mann and Cecil 1990; Bartholomay, Hopkins, and Maimer 2015). These wells, located in an uninhabited area, have shown a historical downward trend in tritium detections. The maximum concentration from all wells on the INL Site (5,410 ± 120 pCi/L) in 2017 is considerably less than the maximum contaminant level established by EPA for drinking water (20,000 pCi/L). The maximum contaminant level corresponds to a dose from the drinking water ingestion pathway of 4 mrem/yr. An individual drinking water from these wells would hypothetically receive a dose of less than 0.2 mrem (2.0 µSv) in one year. Because these wells are not used for drinking water, this is an unrealistic scenario and the groundwater ingestion pathway is not included in the total dose estimate to the MEI.

8.5 Dose to the Public from Direct Radiation Exposure along INL Site Borders

The direct radiation exposure pathway from gamma radiation to the public is monitored annually using thermoluminescent dosimeters and optically stimulated luminescence dosimeters (Figure 7-7). In 2017, the external radiation measured along the INL Site boundary was statistically equivalent to that of background radiation and, therefore, does not represent a dose resulting from INL Site operations.

8.6 Dose to the Public from All Pathways

DOE Order 458.1 establishes a radiation dose limit to a member of the general public from all possible pathways as a result of DOE facility operations. This limit is 100 mrem/yr (1 mSv/yr) above the dose from background radiation and includes the air transport, ingestion, and direct exposure pathways. For 2017, the only probable pathways from INL Site activities to a realistic MEI include the air transport pathway and ingestion of game animals.

The hypothetical individual, assumed to live at Frenchman's Cabin (see Figure 8-6), would receive a calculated dose from INL Site airborne releases reported for 2017 (Section 8.2.1) and from consuming a duck contaminated at the ATR Complex wastewater ponds. No dose was calculated from eating game animals in 2017 (see Sections 8.3.1 and 8.3.2).

The dose estimate for an offsite MEI is presented in Table 8-3. The total dose was conservatively estimated to be 0.054 mrem (0.54 µSv) for 2017. The total dose calculated to be received by the hypothetical MEI for 2017 represents about 0.01 percent of the dose expected to be received from background radiation (383 mrem [3.8 mSv], as shown in Table 7.5) and is well below the 100 mrem/yr (1 mSv/yr) public dose limit above background established by DOE. As discussed in the Helpful Information section of this report, the 100 mrem/yr limit is far below the exposure levels that cause acute health effects.

The dose received by the entire population within 80 km (50 mi) of INL Site facilities was calculated to be 1.06 x 10^{-2} person-rem (1.06 x 10^{-4} person-Sv) (Table 8-2). This is approximately 0.000008 percent of the dose (127,411 person-rem, [1,274 person-Sv]) expected from exposure to natural background radiation in the region.

8.7 Dose to the Public from Operations on the INL Research and Education Campus (REC)

The INL Research Center (IRC) and DOE Radiological and Environmental Sciences Laboratory (RESL) facilities are located contiguously at the Research and Education Campus (REC) on the north side of the City of Idaho Falls. Though programs and operations at the IRC/RESL are affiliated with the INL, the IRC/RESL is located within the city limits of Idaho Falls and is not contiguous with the INL Site, the nearest boundary of which is approximately 22 mi west of Idaho Falls. For this reason, the 2017 INL NESHAP evaluation (DOE-ID 2018) includes a dose calculation to a member of the public that is separate from the INL Site MEI. The IRC/RESL MEI for CY 2017 is 100 meters south of the IRC/RESL. The EDE to the MEI was conservatively calculated, using CAP88-PC, to be 0.01 mrem/yr (0.1 µSv/yr), which is 0.10 percent of the 10-mrem/yr federal standard.

8.8 Dose to Biota

8.8.1 Introduction

The impact of environmental radioactivity at the INL Site on nonhuman biota was assessed using *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE 2002) and the associated software, RESRAD-Biota (DOE 2004). The graded approach includes a screening method and three more detailed levels of analysis for demonstrating compliance with standards for protection of biota. The threshold of protection is assumed at the following absorbed doses: 1 rad/d (10 mGy/d) for aquatic animals, 0.1 rad/d (1 mGy/d) for terrestrial animals, and 1 rad/d (10 mGy/d) for terrestrial plants.

The first step in the graded approach uses conservative default assumptions and maximum values for all currently available data. This general screening level (Level 1 in RESRAD-Biota) provides generic limiting concentrations of radionuclides in environmental media, termed “Biota Concentration Guides.” Each biota concentration guide is the environmental concentration of a given radionuclide in soil or water that, under the assumptions of the model, would result in a dose rate less than 1 rad/d (10 mGy/d) to aquatic animals or terrestrial plants or 0.1 rad/d (1 mGy/d) to terrestrial animals. If the sum of the measured maximum environmental concentrations divided by the biota concentration guides (the combined sum of fractions) is less than one, no negative impact to plant or animal populations is expected. No doses are calculated unless the screening process indicates a more detailed analysis is necessary. Failure at this initial screening step does not necessarily imply harm to organism populations. Instead, it is an indication that more realistic model assumptions may be necessary.

If the screening process indicates the need for a more site-specific analysis, an analysis is performed using site-representative parameters (e.g., distribution coefficients, bioconcentration factors) instead of the more conservative default parameters. This is Level 2 in RESRAD-Biota.

The next step in the graded approach methodology involves a site-specific analysis employing a kinetic modeling tool provided in RESRAD-Biota (Level 3). Multiple parameters that represent contributions to the organism internal dose (e.g., body mass, consumption rate of food/soil, inhalation rate, lifespan, and biological elimination rates) can be modified to represent site- and organism-specific characteristics. The kinetic model employs equations relating body mass to internal dose parameters. At Level 3, bioaccumulation (the process by which biota concentrate contaminants from the surrounding environment) can be modeled to estimate the dose to a plant or animal. Alternatively, concentrations of radionuclides measured in the tissue of an organism can be input into RESRAD-Biota to estimate the dose to the organism.

The final step in the graded approach involves an actual site-specific biota dose assessment. This would include a problem formulation, analysis, and risk characterization protocol similar to that recommended by EPA (1998). RESRAD-Biota cannot perform these calculations.

8.8.2 Terrestrial Evaluation

The division of the INL Site into evaluation areas based on potential soil contamination and habitat types is of particular importance for the terrestrial evaluation portion of the 2017 biota dose assessment. For the INL Site, it is appropriate to consider specific areas that have been historically contaminated above background levels. Most of these areas have been monitored for radionuclides in soil since the early 1970s (Jessmore, Lopez, and Haney 1994). In some of these areas, structures have been removed and areas cleaned to a prescribed, safe contamination level, but the soil may still have residual, measurable concentrations of radionuclides. These areas are associated with facilities shown in Figure 1-4 and include:

- Auxiliary Reactor Area
- ATR Complex
- Critical Infrastructure Test Range Complex
- INTEC
- Large Grid, a 24-mile radius around INTEC
- MFC
- Naval Reactors Facility
- RWMC
- Test Area North.

For the initial terrestrial evaluation, the most recently measured maximum concentrations of radionuclides in INL Site soil were used (Table 8-4). The table includes laboratory analyses of soil samples collected in 2005, 2006, 2012, 2015, and 2017 (soil samples were not collected on the INL Site in 2016).

Using the maximum radionuclide concentrations for all locations in Table 8-4, a screening level analysis was made of the potential terrestrial biota dose. The soil concentrations are conservative because background concentrations were not subtracted. The analysis also assumed that animals have access to water in facility effluents and ponds. The maximum radionuclide concentrations reported in ponds at the INL Site were for the MFC Industrial Waste Pond (Table C-17). The results for uranium-233/234 ($^{233/234}U$) and uranium-238 in Table C-17, 0.87 pCi/L and 0.58 pCi/ respectively, were thus used to represent surface water concentrations. When $^{233/234}U$ was reported, it was assumed that the radionuclide present was ^{233}U.

The combined sum of fractions was less than one for both terrestrial animals (0.211) and plants (0.00201) and passed the general screening test (Table 8-5). Based on the results of the graded approach, there is no evidence that INL Site-related radioactivity in soil is harming terrestrial plant or animal populations.

Tissue data from bats collected at or near INL facilities were also available (Table 7-4). Concentrations of radionuclides in tissue were input into the RESRAD-Biota code at the Level 3 step to calculate the internal dose to bats. The results of the dose evaluation to bats using radionuclide concentrations measured in tissue are shown in Table 8-6. The maximum dose received by bats at the INL Site was estimated to be 0.02 rad/d (0.2 mGy/d). The calculated dose is below the standard of 1 rad/d (10 mGy/d).

Based on these results, members of the bat population at the INL Site receive an absorbed dose that is within the DOE standard established for protection of terrestrial animals.

8.8.3 Aquatic Evaluation

Maximum radionuclide concentrations reported in Table C-17 (results for the MFC Industrial Waste Pond) were also used for aquatic evaluation. Potassium-40 reported in ponds was assumed to be of natural origin and was not included in the 2016 calculations. The results shown in Table 8-7 indicate that INL Site-related radioactivity in ponds and liquid effluents is not harming aquatic biota. The combined sum of fractions was less than one for both aquatic animals (8.76E-03) and riparian animals (2.45E-03).

Tissue data from waterfowl collected on the ATR Complex ponds in 2017 were also available (Table 7-3). Concentrations of radionuclides in tissue can be input into the RESRAD-Biota code at the Level 3 step to calculate the internal dose to biota. To confirm that doses to waterfowl from exposure to radionuclides in the vicinity of the ATR Complex are not harmful, a Level 3 analysis was performed using the maximum tissue concentrations shown in Table 7-3. The waterfowl were assumed in the model to be riparian animals, accessing both aquatic and terrestrial environments in the area. External dose was calculated using the maximum radionuclide concentrations measured in soils around the ATR Complex.

Results of the dose evaluation to waterfowl using radionuclide concentrations measured in tissue are shown in Table 8-8. The estimated dose to waterfowl was calculated by RESRAD-Biota 1.5 to be 4.86 E-04 rad/d (4.86 E-03 mGy/d). This dose is less than the standard of

Table 8-4. Concentrations of Radionuclides in INL Site Soils, by Area.

Location[a]	Radionuclide	Detected Concentration (pCi/g)[b] Minimum	Maximum
ATR Complex	Cesium-137	2.0×10^{-1}	6.1×10^{-1}
	Strontium-90	------[c]	5.8×10^{-2}
	Plutonium-238	5.9×10^{-3}	4.3×10^{-2}
	Plutonium-239/240	1.7×10^{-2}	2.2×10^{-2}
ARA/CITRC	Cesium-134	4.0×10^{-2}	6.0×10^{-2}
	Cesium-137	1.3×10^{-1}	3.0
	Strontium-90	2.1×10^{-1}	3.7×10^{-1}
	Plutonium-238	------	3.9×10^{-3}
	Plutonium-239/240	1.3×10^{-2}	1.8×10^{-2}
	Americium-241	5.5×10^{-3}	8.5×10^{-3}
EFS	Cesium-137	1.5×10^{-1}	6.8×10^{-1}
MFC	Cesium-134	4.0×10^{-2}	6.0×10^{-2}
	Cesium-137	1.3×10^{-1}	4.9×10^{-1}
	Cobalt-60	------	5.0×10^{-2}
	Plutonium-239/240	1.5×10^{-2}	2.9×10^{-2}
	Americium-241	4.3×10^{-3}	1.2×10^{-2}
INTEC	Cesium-134	------	8.0×10^{-2}
	Cesium-137	3.0×10^{-2}	3.5
	Strontium-90	4.9×10^{-1}	7.1×10^{-1}
	Plutonium-238	2.5×10^{-2}	4.3×10^{-2}
	Plutonium-239/240	1.1×10^{-2}	2.9×10^{-2}
	Americium-241	6.1×10^{-3}	8.1×10^{-3}
Rest Area	Cesium-137	1.4×10^{-2}	4.5×10^{-2}
	Plutonium 239/240	------	2.4×10^{-2}
NRF	Cesium-134	------	6.0×10^{-2}
	Cesium-137	------	3.3×10^{-1}
	Plutonium-239/240	5.7×10^{-3}	1.6×10^{-2}
	Americium-241	4.3×10^{-3}	9.7×10^{-3}
RWMC	Cesium-134	3.0×10^{-2}	9.0×10^{-2}
	Cesium-137	6.5×10^{-2}	6.0×10^{-1}
	Srontium-90	1.0×10^{-1}	3.5×10^{-1}
	Plutonium-238	2.2×10^{-3}	1.5×10^{-2}
	Plutonium-239/240	1.9×10^{-2}	9.5×10^{-1}
	Americium-241[d]	4.7×10^{-2}	6.2×10^{-1}
TAN/SMC	Cesium-134	4.0×10^{-2}	6.0×10^{-2}
	Cesium-137	1.1×10^{-1}	3.1
	Plutonium-239/240	1.3×10^{-2}	1.7×10^{-2}
	Americium-241	3.2×10^{-3}	5.7×10^{-3}
All	**Cesium-134**	3.0×10^{-2}	9.0×10^{-2}
	Cesium-137	1.4×10^{-2}	3.5
	Cobalt-60	------	5.0×10^{-2}
	Strontium-90	1.0×10^{-2}	7.1×10^{-1}
	Plutonium-238	2.2×10^{-3}	4.3×10^{-2}
	Plutonium-239/240	5.7×10^{-3}	9.5×10^{-1}
	Americium-241[d]	3.2×10^{-3}	6.2×10^{-1}

a. ARA = Auxiliary Reactor Area; ATR = Advanced Test Reactor; CITRC = Critical Infrastructure Test Range Complex; MFC = Materials and Fuels Complex; INTEC = Idaho Nuclear Technology and Engineering Center; NRF = Naval Reactors Facility; RWMC = Radioactive Waste Management Complex; TAN/SMC = Test Area North/Specific Manufacturing Capability. See Figure 8-1.

b. Legend:

a.	Results measured in 2013-2014 using in situ gamma spectroscopy.
b.	Results measured by laboratory analyses of soil samples collected in 2005.
c.	Results measured by laboratory analyses of soil samples collected in 2006.
d.	Results measured by laboratory analyses of soil samples collected in 2012.
e.	Result measured by laboratory analyses of soil samples collected in 2015.
f.	Results measured by laboratory analyses of soil samples collected in 2017.

c. '-----' indicates that only one measurement was taken and is reported as the maximum result.

d. The data were the results of laboratory analysis for Americium-241 in soil samples.

Table 8-5. RESRAD-Biota 1.5 Assessment (Screening Level) of Terrestrial Ecosystems on the INL Site (2017).

Terrestrial Animal						
	Water			Soil		
Nuclide	Concentration (pCi/L)	BCG[a] (pCi/L)	Ratio	Concentration (pCi/g)	BCG (pCi/g)	Ratio
Americium-241	0	2.02E+05	0.00E+00	0.62	3.89E+03	1.59E-04
Cobalt-60	0	1.19E+06	0.00E+00	0.05	6.92E+02	7.23E-05
Cesium-134	0	3.26E+05	0.00E+00	0.09	1.13E+01	7.97E-03
Cesium-137	0	5.99E+05	0.00E+00	3.5	2.08E+01	1.69E-01
Plutonium-238	0	1.89E+05	0.00E+00	0.043	5.27E+03	8.16E-06
Plutonium-239	0	2.00E+05	0.00E+00	0.946	6.11E+03	1.55E-04
Strontium-90	0	5.45E+04	0.00E+00	0.71	2.25E+01	3.16E-02
Uranium-233	0.868	4.01E+05	2.17E-06	0	4.83E+03	0.00E+00
Uranium-238	0.58	4.06E+05	1.43E-06	0	1.58E+03	0.00E+00
Summed	–	–	**3.59E-06**	–	–	**2.09E-01**
Terrestrial Plant						
	Water			Soil		
Nuclide	Concentration (pCi/L)	BCG (pCi/L)	Ratio	Concentration (pCi/g)	BCG (pCi/g)	Ratio
Americium-241	0	7.04E+08	0.00E+00	0.62	2.15E+04	2.88E-05
Cobalt-60	0	1.49E+07	0.00E+00	0.05	6.13E+03	8.16E-06
Cesium-134	0	2.28E+07	0.00E+00	0.09	1.09E+03	8.28E-05
Cesium-137	0	4.93E+07	0.00E+00	3.5	2.21E+03	1.59E-03
Plutonium-238	0	3.95E+09	0.00E+00	0.043	1.75E+04	2.46E-06
Plutonium-239	0	7.04E+09	0.00E+00	0.946	1.27E+04	7.46E-05
Strontium-90	0	3.52E+07	0.00E+00	0.71	3.58E+03	1.98E-04
Uranium-233	0.868	1.06E+10	8.19E-11	0	5.23E+04	0.00E+00
Uranium-238	0.58	4.28E+07	1.35E-08	0	1.57E+04	0.00E+00
Summed	–	–	**1.36E-08**	–	–	**1.98E-03**

a. BCG = Biota Concentration Guide. Each radionuclide-specific BCG represents the limiting radionuclide concentration in an environmental medium which would not result in recommended dose standards for biota to be exceeded.

Table 8-6. RESRAD Biota Assessment (Level 3 Analysis) of Terrestrial Ecosystems on the INL Site Using Measured Bat Tissue Data (2017[a]).

	Bat Dose (rad/d)				
Nuclide	Water[b]	Soil[b]	Sediment	Tissue[c]	Summed
Cobalt-60	0.00E+00	0.00E+00	0.00E+00	8.26E-04	8.26E-04
Cesium-137	0.00E+00	0.00E+00	0.00E+00	3.58E-04	3.58E-04
Plutonium-239	0.00E+00	0.00E+00	0.00E+00	8.23E-06	8.23E-06
Strontium-90	0.00E+00	0.00E+00	0.00E+00	2.09E-02	2.09E-02
Zinc-65	0.00E+00	0.00E+00	0.00E+00	2.03E-05	2.03E-05
Total	0.00E+00	0.00E+00	0.00E+00	**2.03E-02**	**2.03E-02**

a. Bat carcasses collected during 2015 and 2016 were composited into four samples and analyzed in 2017.
b. External doses to bats from radionuclides in soil and water were assumed to be negligible.

Table 8-7. RESRAD-Biota 1.5 Assessment (Screening Level) of Aquatic Ecosystems on the INL Site (2017).

	Aquatic Animal					
	Water			Sediment		
Nuclide	Concentration (pCi/L)	BCG[a] (pCi/L)	Ratio	Concentration (pCi/g)	BCG (pCi/g)	Ratio
Uranium-233	0.868	2.00E+02	4.35E-03	0.0434	1.06E+07	4.10E-09
Uranium-238	0.58	2.23E+02	2.60E-03	0.029	4.28E+04	6.77E-07
Summed	–	–	**6.94E-03**	–	–	**6.81E-07**
	Riparian Animal					
	Water			**Sediment**		
Nuclide	**Concentration (pCi/L)**	**BCG (pCi/L)**	**Ratio**	**Concentration (pCi/g)**	**BCG (pCi/g)**	**Ratio**
Uranium-233	0.868	6.76E+02	1.23E-03	0.0434	5.28E+03	8.22E-06
Uranium-238	0.58	7.56E+02	7.67E-04	0.029	2.49E+03	1.17E-05
Summed	–	–	**2.05E-03**	–	–	**1.99E-05**

a. BCG = Biota Concentration Guide. Each radionuclide-specific BCG represents the limiting radionuclide concentration in an environmental medium which would not result in recommended dose standards for biota to be exceeded.

Table 8-8. RESRAD Biota Assessment (Level 3 Analysis) of Aquatic Ecosystems on the INL Site Using Measured Waterfowl Tissue Data (2017).

Waterfowl Dose (rad/d)					
Nuclide	**Water[a]**	**Soil[b]**	**Sediment**	**Tissue[c]**	**Summed**
Americium-241	0.00E+00	4.37E-06	0.00E+00	0.00E+00	4.37E-06
Cesium-134	0.00E+00	4.97E-06	0.00E+00	2.40E-05	2.90E-05
Cesium-137	0.00E+00	5.37E-06	0.00E+00	0.00E+00	5.37E-06
Cobalt-60	0.00E+00	1.76E-10	0.00E+00	9.11E-05	9.11E-05
Plutonium-238	0.00E+00	1.94E-09	0.00E+00	0.00E+00	1.94E-09
Plutonium-239	0.00E+00	5.14E-07	0.00E+00	1.41E-05	1.46E-05
Strontium-90	0.00E+00	4.97E-06	0.00E+00	0.00E+00	7.59E-05
Uranium-233	1.28E-04	0.00E+00	8.17E-07	0.00E+00	4.37E-06
Uranium-238	7.54E-05	0.00E+00	5.24E-07	2.40E-05	2.90E-05
Total	2.03E-04	9.10E-05	1.34E-06	1.90E-04	4.86E-04

a. Only uranium isotopes were measured in the Material and Fuels Complex Industrial Waste Pond. Hence, there doses were not calculated for other radionuclides in water and sediment.

b. External doses to waterfowl were calculated using soil concentrations. Maximum concentrations of radionuclides measured in soil at the INL Site were used (Table 8-4).

c. Internal doses to waterfowl were calculated using maximum concentrations in edible tissue shown in Table 7-3.

Note: uranium isotopes were not measured in soil.

1 rad/d (10 mGy/d). Based on these results, there is no evidence that impounded water at the INL Site is harming aquatic biota.

8.9 Doses from Unplanned Releases

No unplanned radioactive releases from the INL site were reported in 2017. As such, there are no doses associated with unplanned releases during 2017.

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9. Monitoring Wildlife Populations

Sagebrush Lizard
Sceloporus graciosus

Field data are routinely collected on several key groups of wildlife at the Idaho National Laboratory (INL) Site for information that can be used to prepare National Environmental Policy Act documents and to enable the U.S. Department of Energy, Idaho Operations Office (DOE-ID) to make informed decisions, based on species use of the INL Site and historical trends, for planning projects and complying with state and federal regulations, environmental policies, and executive orders related to protection of wildlife. During 2017, sage-grouse, raven, midwinter eagle, breeding bird, and bat surveys were conducted on the INL Site and are highlighted as follows:

Sage-grouse research has been conducted on the INL Site for over 30 years and shown that the populations are decreasing. When sage-grouse were petitioned for listing under the Endangered Species Act, DOE-ID recognized the need to reduce impacts to existing and future mission activities. In 2014, DOE-ID entered into a Candidate Conservation Agreement (CCA) with the U.S. Fish and Wildlife Service (USFWS) to identify threats to the species and its habitat and develop conservation measures and objectives to avoid or minimize threats to sage-grouse. The CCA established a monitoring program based on a population trigger that, if tripped by declining male lek attendance, would initiate a response by USFWS and DOE-ID. Since 2010, Environmental Surveillance, Education, and Research (ESER) biologists have conducted surveys of sage-grouse leks along routes established by the Idaho Department of Fish and Game (IDFG) in the mid-1990s, as well as at other leks on the INL Site.

Ravens are known to prey on sage-grouse eggs and chicks. Raven and raven-nest observations have had a positive trend over the past 30 years. Because of this, DOE-ID has committed in the CCA to support research aimed at developing methods for deterring raven nesting on utility structures.

The midwinter eagle survey has been conducted every January, as part of the national Midwinter Bald Eagle Survey, since 1983. Along with identifying and documenting bald eagles, researchers also identify all raptors, golden eagles, ravens, and other selected bird species.

The North American Breeding Bird Survey was developed in the 1960s by the U.S. Fish and Wildlife Service along with the Canadian Wildlife Service to document trends in bird populations. The U.S. Geological Survey manages the program in North America, which currently consists of over 4,100 routes with approximately 3,000 of these sampled annually. The INL Site has five permanent official Breeding Bird Survey routes, established in 1985, and eight additional routes which border INL Site facilities.

Bats have been researched at the INL Site for several decades. Recently, white-nose syndrome (WNS) has been identified as a major threat to many bats that hibernate in caves. To assess bat activity and species occurrence at critical features, a program of passive acoustic monitoring of bat calls was initiated in by ESER in 2012. In addition, monitoring of hibernating bat populations is conducted biennially.

9. MONITORING WILDLIFE POPULATIONS

The Environmental Surveillance, Education, and Research Program (ESER) contractor has historically collected data on several key groups of wildlife that occupy the Idaho National Laboratory (INL) Site, including greater sage-grouse, raptors, rabbits/hares, breeding birds, and bats. These surveys provide the U.S. Department of Energy, Idaho Operations Office (DOE-ID) with an understanding of how these species use the INL Site, and context for analyzing historical trends. This information is often used in National Environmental Policy Act (NEPA 1970) documents and enables DOE-ID officials to make informed decisions for project planning and to maintain up-to-date information on potentially sensitive species on the INL Site. These surveys also support DOE-ID's compliance with several regulations, agreements, policies and executive orders including:

- Migratory Bird Treaty Act (1918)
- Bald and Golden Eagle Protection Act (1940)
- Executive Order 11514 (1970); Protection and Enhancement of Environmental Quality—(Created in furtherance of the purpose and policy of National Environmental Policy Act, directs federal agencies to monitor, evaluate, and control—on a continuing basis—their activities to protect and enhance the quality of the environment)
- Idaho National Laboratory Comprehensive Land Use and Environmental Stewardship Report (INL 2011)
- Memorandum of Understanding between the U.S. Department of Energy and the U.S. Fish and Wildlife Service (FWS) regarding implementation of Executive Order 13186, responsibilities of federal agencies to protect migratory birds (Federal Register 2013)
- Candidate Conservation Agreement (CCA) for greater sage-grouse on the INL Site (DOE-ID and FWS 2014)
- Migratory Bird Treaty Act Special Purpose Permit with FWS.

In the following sections, we summarize results from wildlife surveys conducted by the ESER contractor on the INL Site during 2017.

9.1 Sage-grouse

Populations of greater sage-grouse (hereafter, sage-grouse) have declined in recent decades (Connelly et al. 2004), and the species' range-wide distribution across western North America has been reduced to nearly half of its historic distribution (Schroeder et al. 2004, Connelly et al. 2011a). Although the rate of decline of this species has slowed over the past two decades (Connelly et al. 2004, Garton et al. 2011), there is concern for the future of sage-grouse because of its reliance on broad expanses of sagebrush (*Artemisia spp.*). The sagebrush ecosystem has been greatly altered during the past 150 years and is currently at risk from a variety of threats (Knick et al. 2003, Connelly et al. 2004). Not only are healthy stands of sagebrush necessary year-round for sage-grouse to survive, but, during summer, young sage-grouse also require a diverse understory of native forbs and grasses. This vegetation provides protection from predators and supplies high-protein insects necessary for rapidly growing chicks (Connelly et al. 2011b).

In 2014, DOE-ID entered into a CCA with the FWS to conserve sage-grouse and the habitats upon which it depends across the INL Site (DOE-ID and FWS 2014). This voluntary agreement established a Sage-Grouse Conservation Area (SGCA) where infrastructure development and human disturbance would be limited (Figure 9-1). To guard against sage-grouse declines, the CCA includes a population trigger that, if tripped by declining male lek attendance, would initiate an automatic response by both the FWS and DOE-ID. The population trigger is set to trip if there is a 20 percent or greater reduction in the three-year average peak male attendance on a set of 27 baseline leks within the SGCA.

The CCA established a monitoring program based on this trigger threshold and other criteria (Shurtliff et al. 2016). Part of the program includes annual surveys of sage-grouse leks on the INL Site. A lek is a traditional breeding site, located near nesting habitat, where sage-grouse return each spring to display and mate (Jenni and Hartzler 1978). Counting males annually at lek sites is the best way to document trends in sage-grouse abundance (Jenni and Hartzler 1978, Connelly et al. 2003, Garton et al. 2011). Because sage-grouse abundance varies naturally from year to year, biologists use a three-year running average of the peak male attendance across 27 baseline leks to calculate trends relative to the population trigger. In addition, other active and non-active leks on the INL Site are surveyed each year for the purpose of understanding population dynamics.

In 2013, DOE-ID formalized the following three monitoring tasks designed to track the number of male sage-grouse at active leks and document additional active leks on the INL Site (DOE-ID and FWS 2014). The general tasks and their purposes are:

1) ***Lek Census and Route Surveys*** – Surveys of all active leks on the INL Site, including leks on three Idaho Department of Fish and Game (IDFG) survey routes and three new lek routes established after the 2016 field season. A subset of these leks comprise the baseline set to which the CCA population trigger is linked. Inactive leks that are included on IDFG routes or the baseline set are also surveyed under this task.
2) ***Historical Lek Surveys*** – Surveys of sites where sage-grouse have been observed displaying in the past. The purpose is to determine if grouse still use those areas.
3) ***Systematic Lek Discovery Surveys*** – Surveys of poorly sampled regions of the INL Site. The purpose is

to discover additional active leks, especially within the SGCA.

Task 1—Lek Census and Route Surveys

Summary of Results: The three-year average peak male attendance (2014–2017) across the 27 baseline leks in the SGCA was 5 percent higher than last year and is now 160 percent of the population trigger threshold. Lek route data suggest that the sage-grouse breeding population on the INL Site was stable or increasing from 1999–2006, after which it declined, perhaps until 2012. The three-year average of male lek attendance has increased steadily during the past three years.

In 2017, ESER biologists surveyed all 45 leks classified as active on or near the INL Site from four to seven

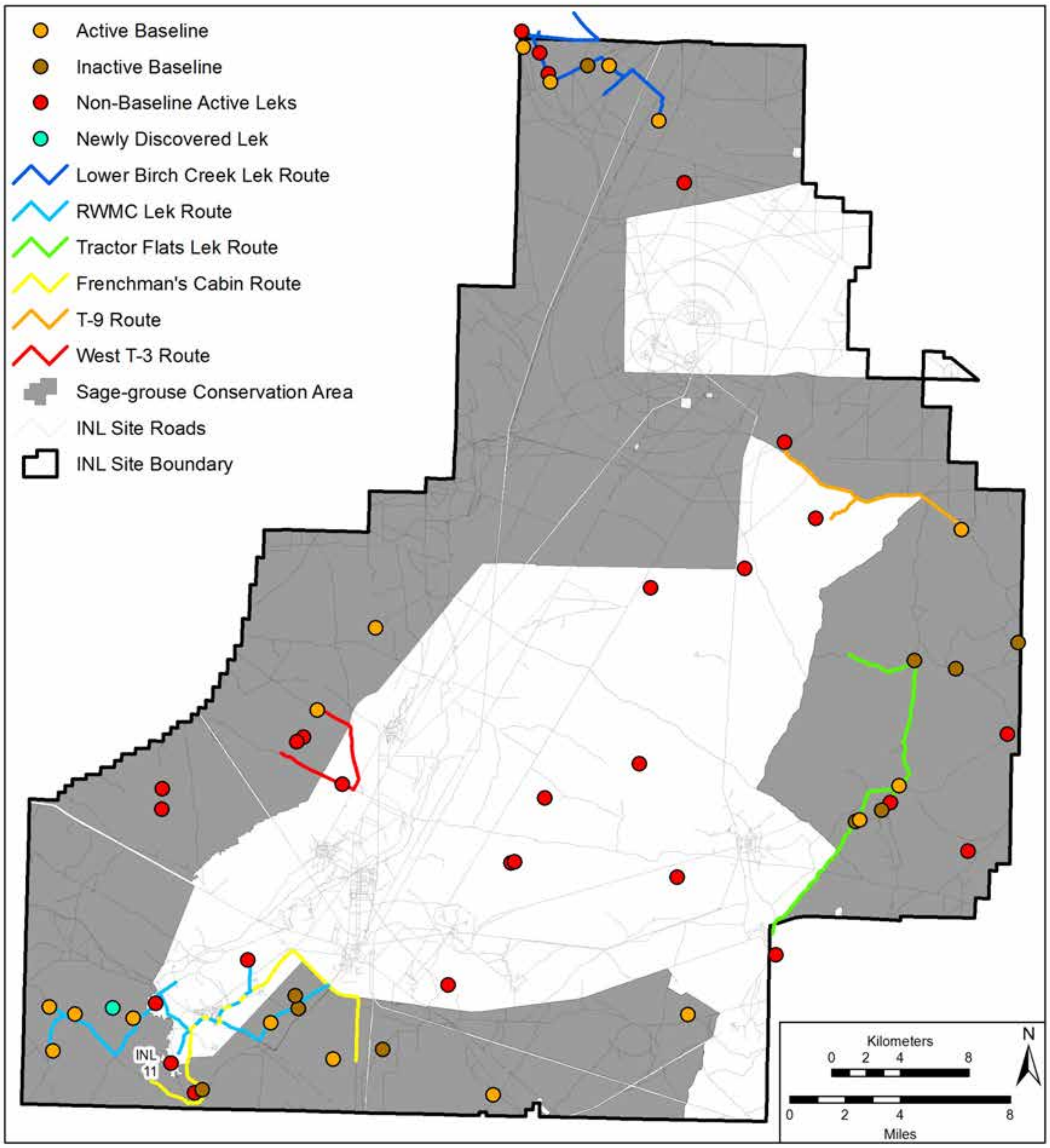


Figure 9-1. An Overview of 2017 Lek Surveys and Lek Route Efforts in Support of Task 1. *All leks surveyed by ESER are displayed, and lek activity designations are based on results from the 2016 season. Following the 2017 survey, two baseline leks were reclassified as inactive. Lek INL 11, surveyed as part of the RWMC route, was elevated to active status at the end of the field season.*

times each (Shurtliff et al. 2018). These leks were partitioned into three different categories for analysis, with some leks occurring in more than one category.

SGCA Baseline Leks: With regard to the CCA population trigger, the most important category consists of the 27 leks that were used to establish the original value upon which the trigger is based. The sum of peak male attendance counts across the 27 leks in 2017 was 412, a 13 percent decrease from 2016. The three-year mean (2014–2016) is now 406 males, which is 5 percent higher than last year's 2014–2016 mean (Figure 9-2), and 160 percent of the threshold (253 males) that would trigger prescribed action by DOE-ID and the FWS (DOE-ID and FWS 2014). The three-year mean has been stable or has increased each of the past three years.

Following the 2017 field season, 17 baseline leks remain classified as active (two were reclassified as inactive). In each of the past five years, at least one baseline lek per year has been reclassified as inactive. These results should not be interpreted as evidence that ten leks have been abandoned in the past five years but rather that at least five years of data have accumulated for most leks, allowing for more precise lek classifications (Whiting et al. 2014). As noted above, the three-year average of male sage-grouse attending active leks continues to increase and is higher than it has been since the baseline was established.

Other Non-route Leks: All other known active leks, whether in or out of the SGCA, which are not part of the baseline set described above, fall into a second analysis category. In 2017, an additional 27 active leks were surveyed (i.e., non-baseline) a mean of 4.8 times each (range: 4–7, SD: 1.3; see Figure 9-1). Average peak male attendance was 12.1 males per lek (range: 0–36, SD: 10.7), down from 10.1 males per lek in 2016 and 10.6 males per lek in 2015.

In addition, 19 inactive leks were surveyed that had not been visited since 2012 and one inactive lek that had not been visited since 2013. The 20 leks were visited twice and one was visited three times between March 27 and May 1, 2017. We did not record observations of male sage-grouse at any of the leks.

Lek Routes: The third category includes all leks, both active and inactive, that are part of three IDFG lek routes and three additional routes established at the end of the 2016 field effort. IDFG routes, Lower Birch Creek, Tractor Flats, and Radioactive Waste Management Complex (RWMC), have been monitored annually since 1999 and they provide historical context for interpreting abundance trends on the INL Site (Shurtliff et al. 2016).

The average number of males per lek surveyed (MPLS) decreased on the Tractor Flats route from a three-year mean of 39.1 (1999–2001) to a low of 7.6 in

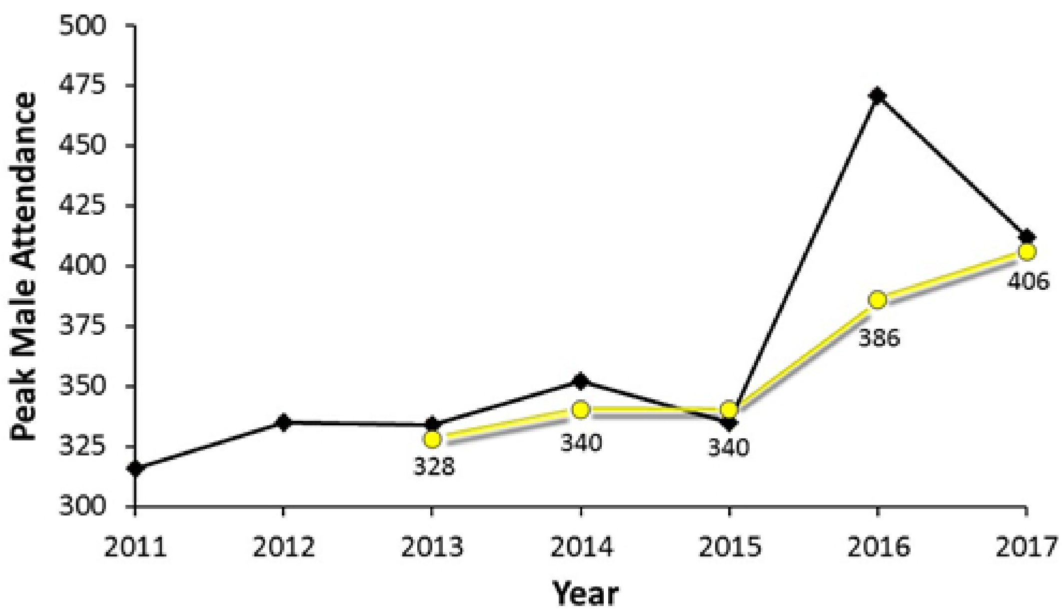


Figure 9-2. Peak Male Attendance on 27 Leks in the SGCA Used to Calculate the Original Baseline Value. *Black diamonds represent annual counts, and yellow dots represent the three-year running average.*

2013 (Figure 9-3). Compared to 2016, the Tractor Flats route was 27 percent lower (2016 = 14.4 MPLS). The RWMC lek route, which has been stable since 2008, was 16 percent lower (2016 = 14.8 MPLS), and the Lower Birch Creek route was <1 percent lower (2016 = 13.2 MPLS) than 2016 MPLS counts. The Lower Birch Creek route has exhibited low variability between consecutive years during the past ten years, and after declining from 8.4–6.0 MPLS between 2008 and 2013, the route has steadily increased each of the past three years, reaching 13.3 MPLS in 2016. A <1 percent decrease is within the variability displayed over the past ten years.

The downward trend on the Tractor Flats route since 1999 likely reflects local impacts of wildland fire on sage-grouse nesting habitat near the lek route. A 164 km^2 (40,539 acres) fire burned over a lek that was at the northern end of the route in 1999. By 2004, this lek, which was one of five on the route, was vacated. In 2010, the Jefferson fire burned 52 percent of the lek route (9.7 km [6.0 miles]) and one more of the six leks that were surveyed annually at that time. Therefore, by 2011, a third of the leks that were part of the official route were within a large burned area. No other lek routes had fires that burned over any leks or any part of the lek route.

Taken together, lek route data on the INL Site suggest that the sage-grouse breeding population was stable to increasing from 1999–2006, with a peak occurring from 2005–2007. By 2008, male attendance (and presumably abundance) was substantially lower and may have continued to decline through 2012.

Task 2—Historical Lek Surveys

Summary of Results: No sage-grouse were observed on any of the five remaining historical lek sites surveyed in 2017 (Figure 9-4). No historical leks remain to have their status evaluated. 2017 marks the completion of this task.

During the past several decades, many leks have been documented on the INL Site as a result of surveys and opportunistic observations of displaying sage-grouse (Whiting and Bybee 2011). Prior to 2009, many of these

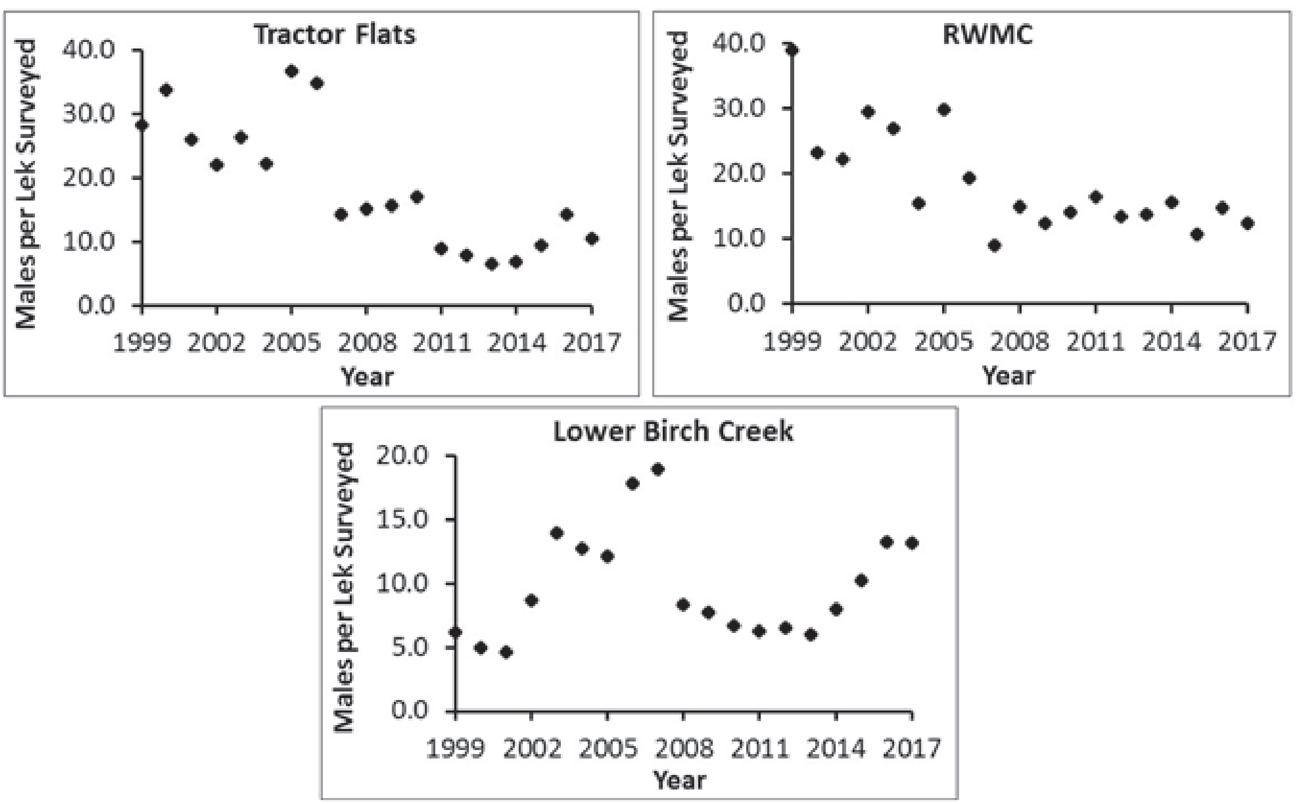


Figure 9-3. Mean Number of Males Per Lek Surveyed at Peak Male Attendance on Three IDFG Lek Routes from 1999–2017 on the INL Site. ***The number of leks surveyed each year increased over the displayed time period as follows: Tractor Flats (4-8 leks), RWMC (2-9 leks), and Lower Birch Creek (6-10 leks). Note that the Y-axis is at a different scale in the Lower Birch Creek panel.***

historical lek sites had not been surveyed for nearly 30 years. Since 2009, ESER biologists have revisited a subset of historical leks each spring to determine if the leks remain active based on current criteria (DOE-ID and FWS 2014). The objective of Task 2 was to determine which historical leks are active before establishing new lek routes (DOE-ID and FWS 2014).

Five historical leks were surveyed five two times each. No sage-grouse were observed on any of these potential lek sites. Following the 2017 surveys, this task is considered complete.

Task 3—Systematic Lek Discovery Surveys

Summary of Results: One active lek was discovered in 2017. Seven leks have been documented on the INL Site under Task 3 since 2013. No areas of the INL Site remain unexplored; this task is considered complete.

Known lek sites are few or absent across large portions of the SGCA (Figure 9-1), even though habitat in these areas often appears to be adequate to support sage-grouse breeding and nesting activities (DOE-ID and FWS 2014). The objective of Task 3 is to survey suitable sage-grouse habitat within and near the SGCA where no leks are known to exist. Since 2013, ESER has systematically searched for unknown leks each spring. If a lek is discovered, it is included thereafter in ESER's annual monitoring program.

Between March 27 and May 8, 2017, 68 surveys were completed (52 road, 16 remote) within the southern sections of the INL Site. One active sage-grouse lek was discovered (INL164, Figure 9-5). Since surveys began in 2013, seven leks have been discovered through Task 3.

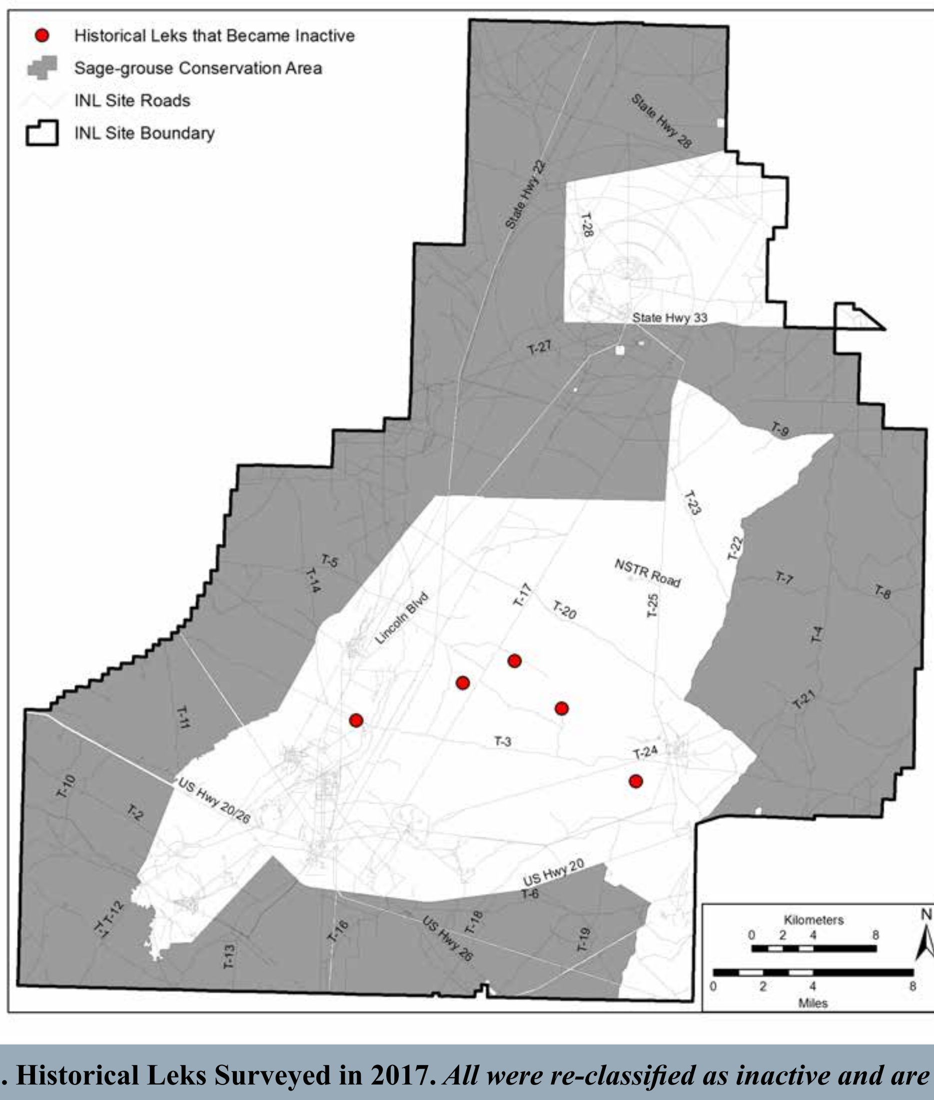


Figure 9-4. Historical Leks Surveyed in 2017. ***All were re-classified as inactive and are shown in red.***

9.1.1 Summary of Known Active Leks and of Changes in Lek Classification

Before the 2017 field season, 49 leks were designated active on or near the INL Site, including two just outside the Site boundaries that are part of the IDFG survey routes. After the field season, six leks were downgraded from an active to inactive status. One new lek was discovered in 2017 and one inactive lek was upgraded to active status (Figure 9-1).

With the discovery of one lek and the upgrade of an inactive lek to active status, the total number of known active leks on or near the INL Site is currently 45 (Figure 9-6).

9.2 Raven Nest Surveys

Summary of Results: Over the period 2014–2017, raven nesting on INL Site infrastructure increased 41 percent, at an average rate of 4 nests per year. Power line nesting increased over the same period at an even higher rate—43 percent. Despite a minor downturn during 2017, it was predicted that two or three times the current number of raven nesting pairs could occupy INL Site infrastructure in the future. The 2017 results are consistent with natural variable within a long term positive trend. It is unclear if this substantial increase in nest predators would impact sage-grouse reproductive success, but ravens have been found to be effective nest predators elsewhere.

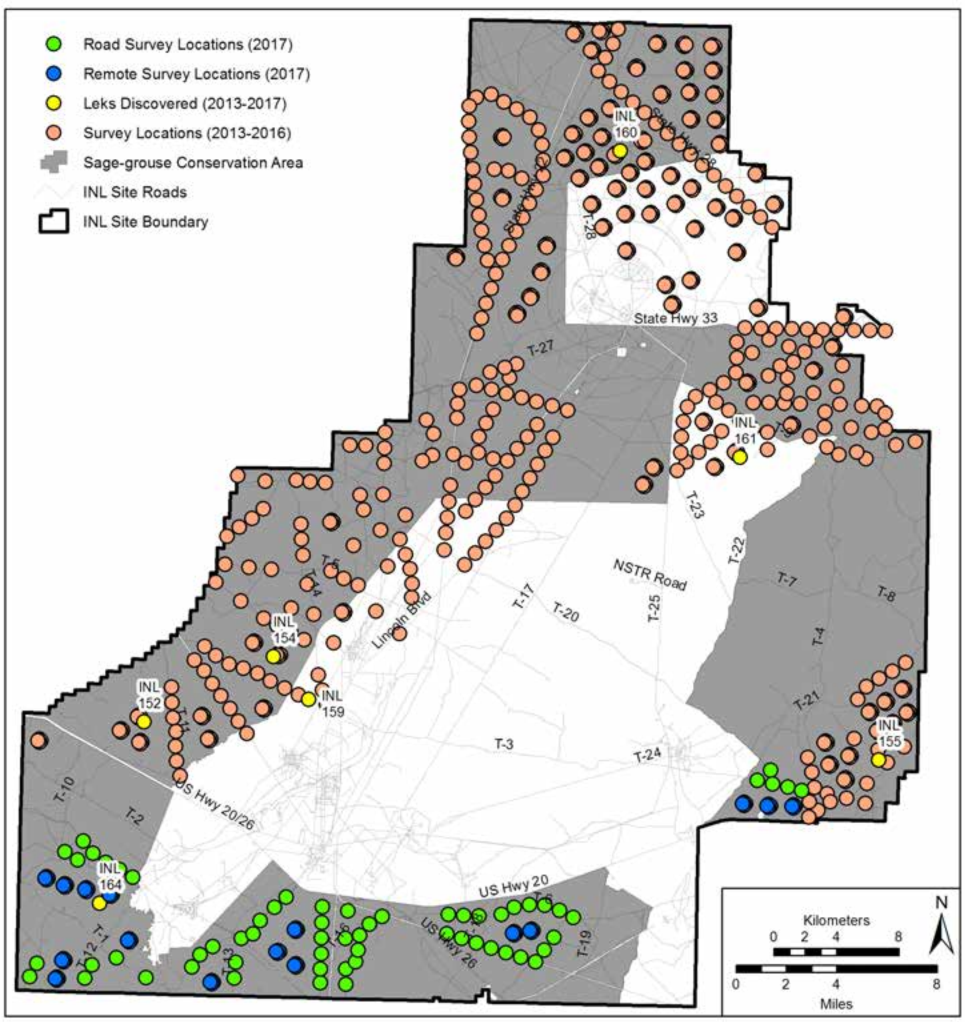


Figure 9-5. Locations of Task 3 Surveys Conducted since 2013. ***All active leks discovered as a result of these surveys are indicated by yellow dots.***

Background

The common raven is a native bird that adapts well to human disturbance and habitat fragmentation. Ravens prey on sage-grouse eggs and chicks, and consequently may directly impact a species that DOE-ID is striving to conserve in partnership with other federal and state agencies. Raven observations made during annual breeding bird surveys have been steadily increasing over the past 30 years, mirroring trends across western North America (Sauer et al. 2014).

In the CCA, DOE-ID committed to support research aimed at developing methods for deterring raven nesting on utility structures (*Conservation Measure 10*; DOE-ID and FWS 2014). The objective of this task is to annually survey all man-made structures on the INL Site that could potentially be used by ravens as nesting substrates and document the number and location of active nest sites. These data will allow DOE-ID to determine the trend of raven nesting and decide how and when to begin testing nest deterrent designs.

Results and Discussion

Survey Results: Forty-three active raven nests were observed on man-made structures (Table 9-1), 29 of which (67 percent) were on power line structures. During analysis, two pairs of nests, N294/N247 and N227/N154 were merged, reducing the total number of active raven nests (i.e. adjusted total) to 41, with 27 (66 percent) of those on power lines. The two nests in each merged set

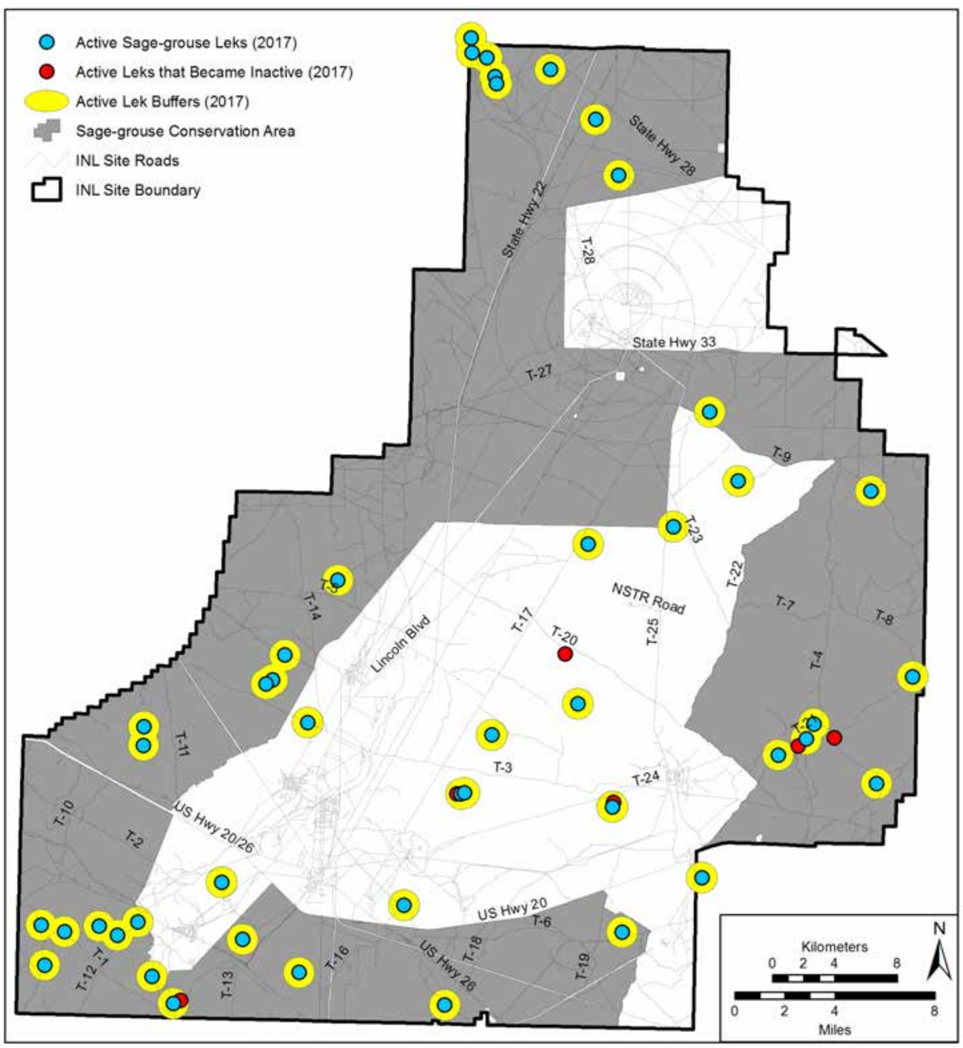


Figure 9-6. Locations of 45 Active Leks and Six That Were Reclassified as Inactive on or near the INL Site.

were likely tended by the same raven pairs. All power line nests were on transmission structures, including one on a large lattice structure next to a transmission line that is used for power grid tests. Eight active nests were at facilities (Table 9-2) and three were on towers (two meteorological towers and one cellular tower; Figure 9-7). Ravens nested on the same three towers that they occupied last year. Two of these towers are operated by the National Oceanic and Atmospheric Administration.

Table 9-1. Summary of Raven Nest Data Collected during Surveys of INL Site Infrastructure. *"Adjusted" data (columns 3–4, 6–7) are indexes of breeding pairs of ravens after accounting for nests t hat blew down and were likely rebuilt by the same nesting pair. The distance between the two closest active raven nests is listed in the penultimate column.*

Year	Total Active Nests Observed	Adjusted Active Nests	Change from past year (Adjusted)	Total Power Line Nests Observed	Adjusted Power Line Nests	Change from past year (Power lines)	Nearest Nests (m)	Mean (SD) nest distance (m)
2014	35	29	N/A	29	23	N/A	1,525	3,366 (1,440)
2015	39	38	31%	31	30	23%	1,525	2,803 (1,282)
2016	46	44	16%	35	33	10%	1,216	3,220 (2,200)
2017	43	41	–7%	28	26	–21%	378	not calculated
Mean/ Increase	**41**	**38**	***41%**	**31**	**28**	***13%**	****1,161**	

*Percent increase from 2014 to 2017.
**Mean from 2014 to 2017.

Table 9-2. Facilities Surveyed for Raven Nests in 2017. *The number of days between surveys is indicated, though individual nests with unconfirmed activity statuses were sometimes revisited more frequently.*

Facility	# Times Surveyed	Days Between Surveys	Active Raven Nest Confirmed	Substrate Supporting Active Nest
Advanced Mixed Waste Treatment Project	2	22	Yes	Building Platform
Central Facilities Area Main Gate	2	15	Yes	Building Platform
Critical Infrastructure Test Range Complex (CITRC)	2	16**	Yes	Light Fixture
Experimental Breeder Reactor I	2	15	Yes	Building Platform
U.S. Sheep Experiment Station	2	16	Yes (3 nests)	Ornamental Trees
Idaho Nuclear Technology and Engineering Center	2	16	Yes	Effluent Stack
Materials & Fuel Complex /Transient Reactor Test Facility	2	21	Yes	Building Platform
Naval Reactors Facility (NRF)	2*	18	Yes	Building Platform
Specific Manufacturing Capability/Test Area North	2	20	Yes	Ornamental Tree
Advanced Test Reactor Complex	2	14	No	N/A
Central Facilities Area	2	13	No	N/A
Highway Department	2	23	No	N/A
RWMC	2	23	No	N/A

* ESER personnel are restricted from entering the NRF. Therefore, we initially trained, and then interviewed an NRF representative in the parking lot of the facility and he pointed out where he has seen active raven or owl nests.
**During the second survey, one part of CITRC was unavailable, so we returned to survey that section four days later.

Trend Analysis: To analyze raven nesting trends on infrastructure from 2014–2017, the total nest count for each year is first reduced by disqualifying from analysis active nests that blew down during the nesting season, but for which there was evidence that the nest occupants rebuilt a second or third nest during the same season (Shurtliff et al. 2018). This adjusted value more precisely approximates the actual number of breeding pairs, compared to a simple count of active nests.

One to six nests were removed per year (all power-line nests) from the four-year dataset prior to analysis (Table 9-1). The number of active raven nests (adjusted) on the INL Site was 7 percent lower in 2017 than in 2016, the first time since surveys began that fewer raven nests were recorded than the previous year. The greatest decreases were on power lines (-18 percent from 2016, -9 percent from 2015). Although slightly lower than in 2016, the adjusted raven nest count in 2017 is 41 percent higher than in 2014, and nests on power lines are 30 percent higher than 2014.

Nearest-Nest Distances: Using data from 2014–2017, it was determined the straight-line distance from each active raven nest on the INL Site to the nearest active raven nest from the same year. The aim was to learn how close territory-holding raven pairs would nest to each other so that an estimation could be made on how many pairs could potentially occupy the INL Site. A cluster of three active raven nests were recorded within the U.S. Experiment Sheep Station on the northeast portion of the INL Site near Mud Lake. The nearest pair

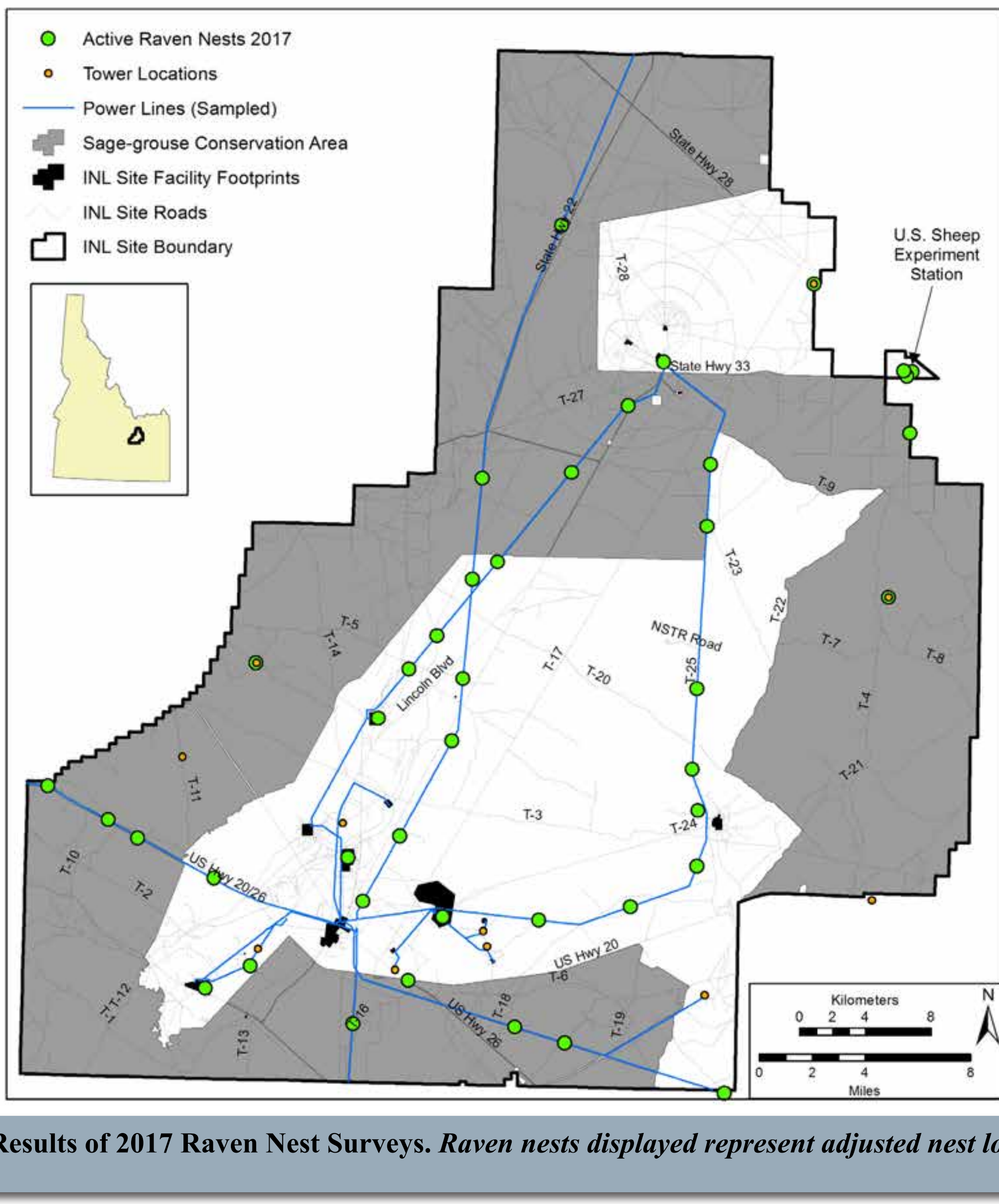


Figure 9-7. Results of 2017 Raven Nest Surveys. ***Raven nests displayed represent adjusted nest locations (n = 41).***

were 377 m (1,237 ft) apart and the other pair were 421 m (1,381 ft) apart. Elsewhere on the INL Site, the closest two raven nests with evidence of simultaneous activity, were on transmission structures and were separated by 1,841 m (6,040 ft). No other raven nests in the final dataset were within 2 km (1.2 mi) of each other.

Discussion

During the period 2014–2017, raven use of infrastructure for nesting on the INL Site increased substantially (41 percent), and use of power lines increased by 13 percent. The number of active raven nests recorded on INL Site infrastructure was lower in 2017 than in 2016, but the current-year levels are still substantially higher than when surveys began in 2014. Results may reflect a slight decline in raven nesting on INL Site infrastructure in 2017, but this decline does not necessarily signal a reversal of the upward trend that has been observed during the previous three years. Observations of ravens during annual Breeding Bird Surveys (BBS) on the INL Site often fluctuate greatly between years, but looking back across over 30 years of data, there is an apparent positive trend. Most ravens that nest on the INL Site occupy infrastructure rather than natural substrates (Howe et al. 2014), and although natural substrates were not surveyed, it is probable that the patterns documented on infrastructure reflect general raven nesting trends on the INL Site (for more details, see Shurtliff et al. 2018).

Howe (2012) used methods similar to ours to monitor raven nests on INL Site infrastructure. Howe recorded 21, 26, and 29 active raven nests on man-made structures in 2007, 2008, and 2009, respectively. Beginning five years later, 35, 39, 46, and 43 nests on infrastructure were recorded (unadjusted counts, 2014–2017; Table 9-2). Although it would be inappropriate statistically to combine the results from the two studies into a single analysis (Shurtliff et al. 2017), together, they suggest that increasing use of INL Site infrastructure by ravens for nesting is probably a long-term trend.

Looking to the future, it is expected that the number of raven nests on INL Site infrastructure will continue to increase. Analysis following the 2016 field season suggested that raven nesting pairs may not tolerate another raven nest within 1,200 m (3,937 ft) of their own nest on the INL Site (Shurtliff et al. 2017). This conclusion was based on data from the first three years of raven nest surveys, during which time no two raven nests closer than 1,216 m (3,990 ft) (Table 9-1) were observed. Nevertheless, during 2017 three simultaneously-active raven nests separated by only 377 m (1,237 ft) and 421 m (1,381 ft) were observed at the U.S. Sheep Experiment Station. The U.S. Sheep Experiment Station is located near the interface between sagebrush steppe and agricultural lands, and it is near two main highways and the town of Mud Lake. It is surmised that resources were abundant near the U.S. Sheep Experiment Station in 2017. Elsewhere on the INL Site, the closest distance between two raven nests (adjusted) was 1,841 m (6,040 ft) in 2017, the greatest minimum distance recorded in the past four years (Table 9-1).

Across the sage-grouse range, predation by ravens is not believed to limit population growth. However, evidence is mounting that at a local scale, raven predation may negatively affect sage-grouse reproductive success and population growth (Bui et al. 2010; Coates and Delehanty 2010; Lockyer et al. 2013). The raven nest monitoring task on the INL Site does not directly address impacts of raven predation on sage-grouse reproduction. However, ravens are opportunistic foragers, and we know they depredate sage-grouse nests on the INL Site (Howe and Coates 2015). It is unclear if increasing occupancy of the INL Site by ravens will reach a point where it substantially limits sage-grouse reproductive success. Measures to address threats posed by raven predation are discussed in Section 5 of the CCA, *Implementation of Conservation Measures*.

9.3 Midwinter Raptor, Corvid, and Shrike Surveys

Each January, hundreds of volunteers and wildlife professionals throughout the United States count eagles along standardized, non-overlapping survey routes as part of the Midwinter Bald Eagle Survey (Steenhof et al. 2008). These annual surveys commenced in 1979 and today are managed by the U.S. Geological Survey (USGS). The Midwinter Bald Eagle Surveys were originally established to develop a population index of wintering bald eagles in the lower 48 states, determine bald eagle distribution, and identify previously unrecognized areas of important winter habitat (Steenhof et al. 2008).

On the INL Site, Midwinter Bald Eagle Surveys have taken place since 1983. In early January of each year, two teams drive along established routes across the north and south of the INL Site and record the number and locations of all bald and golden eagles seen. Observers also record the same information for other raptors, common ravens, shrikes, and black-billed magpies they see along each route. Data are submitted to the regional coordinator of the USGS Biological Resource Division to be added to the nationwide database.

On January 11, 2017, ESER biologists completed two surveys along the traditional driving routes on the INL Site. Observers recorded a total of 444 target birds (Figure 9-8) on both routes. This is the third highest count in the past 17 years and is 3.5 times the 16-year median of 128 birds. More common ravens were recorded (n = 294) than any time during past surveys dating back to 2001. Rough-legged hawk observations were up for a second year (n = 128 in 2016; n = 76 in 2017) after four years of counts ranging from 15 to 22 (mean of 18.8 over period 2012–2015). Golden eagle observations (n = 36) were higher than any previous year.

The importance of the mid-winter eagle count on the INL Site is that it contributes to a continent-wide effort to monitor trends in raptors and other species. The species highlighted above are wide-ranging (e.g., rough-legged hawks summer in the arctic), and habitat conditions on the INL Site may not influence species abundance, or may only have a minor impact. Perhaps the most useful information for DOE-ID that can be gleaned from these surveys is a clear picture that many species' populations are cyclic. Understanding this ecological truism provides context for year-to-year observations.

9.4 Breeding Bird Surveys

The North American Breeding Bird Survey (BBS) was developed by the FWS along with the Canadian Wildlife Service to document trends in bird populations. Pilot surveys began in 1965 and immediately expanded to cover the United States east of the Mississippi and Canada, and by 1968 the surveys included all of North America (Sauer and Link 2011). The BBS program in North America is managed by the USGS and currently consists of over 4,100 routes, with approximately 3,000 of these being sampled each year. BBS data provide long-term species abundance and distribution trends across a broad geographic scale. These data have been used to estimate population changes for hundreds of bird species, and they are the primary source for regional conservation programs and modeling efforts (Sauer and Link 2011). Because of the broad spatial extent of the surveys, BBS data is the foundation for broad conservation assessments extending beyond local jurisdictional boundaries.

In 1985, five official BBS routes were established on the INL Site (i.e., remote routes) and eight additional survey routes were established near INL Site facilities (i.e., facility routes; Figure 9-9). Data from remote routes contribute to the USGS continent-wide analyses of bird trends, and they also provide information that local biologists can use to track and understand population trends. Data from facility routes may be useful in detecting whether INL Site activities cause measurable impacts on abundance and diversity of native birds.

We conducted surveys along the 13 remote and facility routes in June of 2017 and documented a total

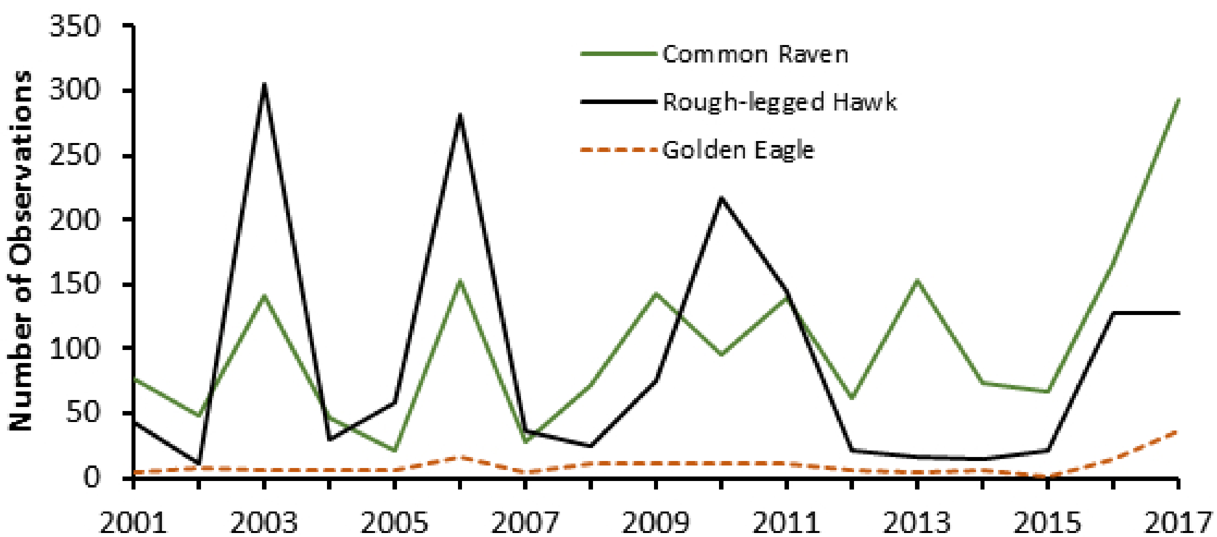


Figure 9-8. Trends of the Three Species Most Commonly Observed During Annual Midwinter Eagle Surveys. ***Data were pooled from the northern and southern routes.***

of 3,314 individuals from 50 bird species (Bybee and Shurtliff 2018). The six most abundant birds across all routes were horned lark (*Eremophila alpestris, n* = 936), western meadowlark (*Sturnella neglecta, n* = 660), sage thrasher (*Oreoscoptes montanus, n* = 455), Brewer's sparrow (*Spizella breweri, n* = 292), Franklin's gulls (*Larus pipixcan, n* = 213), and sagebrush sparrow (*Artemisiospiza nevadensis, n* = 205). These six species comprised >83 percent of all observations, and with the exception of Franklin's gull, each was observed on every remote route. Horned lark, western meadowlark, sage thrasher, sagebrush sparrow, and Brewer's sparrow have been the five most abundant species in 24 of the 31 years of INL Site BBS (in the other years they were among the seven most abundant species).

Observers saw three species that were previously not recorded during the INL surveys: one Dark-eyed Junco (unidentified race) (*Junco hyemalis*), one long-eared owl (*Asio otus*), and two western bluebirds (*Sialia mexicana*). One species was observed during the surveys that had been recorded in two of the past 31 years. This species was the Eurasian collared-dove (*Streptopelia decaocto, n* = 1), it was also observed in 2016 and is considered an invasive species.

Species observed during the 2017 BBS that are considered by the IDFG as "Species of Greatest Conservation Need" included the sage thrasher (*Oreoscoptes montanus, n* = 455), sagebrush sparrow (*Artemisiospiza nevadensis, n* = 205), Franklin's gull (*Larus pipixcan, n* = 213), common nighthawk (*Chordeiles minor, n* = 23), ferruginous hawk (*Buteo regalis, n* = 16), grasshopper sparrow (*Ammodramus savannarum, n* = 6), burrowing owl (*Athene cunicularia, n* = 4), and long-billed curlew (*Numenius americanus, n* = 1).

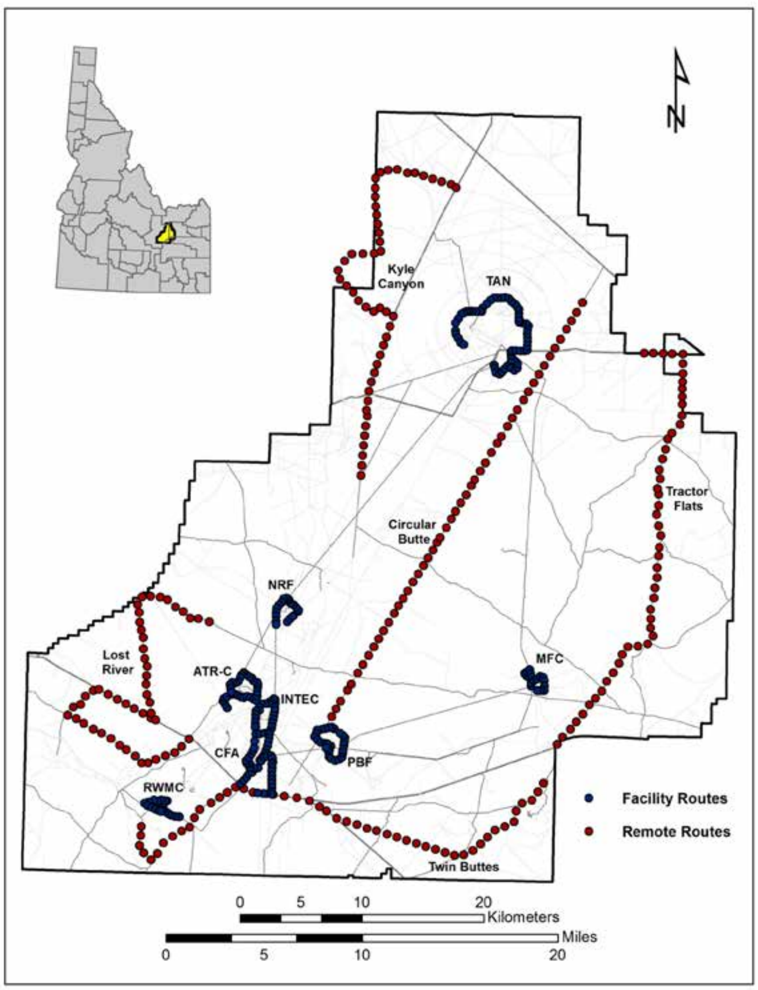


Figure 9-9. Breeding Bird Survey Routes on the INL Site. ***Blue dots represent survey points along facility routes and red dots represent the same for remote routes.***

The number of common ravens observed in 2017 was higher than any other year except 2010 (*n* = 115; Figure 9-10) (for clarity of presentation, data from 2010 were excluded as an outlier in the figure because 280 ravens were observed, mostly in a single, large flock). The common raven is an effective nest predator of sage-grouse, and DOE-ID is concerned about the potential impact common ravens may have on nesting sage-grouse (DOE-ID and FWS 2014). There is some evidence that territory-holding mated pairs may be primarily responsible for sage-grouse nest predation, rather than non-territorial juvenile flocks (Bui et al. 2010). It is unclear how many common ravens observed during the BBS are mated pairs and how many are unmated, but the trend reported here may not be a good indicator of the level of nest predation risk to sage-grouse.

Two sagebrush-obligate species (sagebrush sparrow and Brewer's sparrow) are at historically low levels on the INL Site, which is probably a consequence of losing large amounts of sagebrush-dominated communities during recent wildfires. Conversely, common raven observations continue to increase (which also may be driven by wildfires). The combination of loss of sagebrush-dominated communities and increased predators that raid nests of sagebrush obligates may affect the growth potential of some species, especially sage-grouse, which is a conservation concern for DOE-ID.

Three songbirds are sagebrush obligates, meaning that they specialize on and require sagebrush-dominated lands for survival. These are sage thrasher, sagebrush sparrow, and Brewer's sparrow. Sage thrasher was the most abundant sagebrush obligate (*n* = 455), followed by Brewer's sparrow (*n* = 292) and sagebrush sparrow (*n* = 205). Since 1985, sage thrasher counts have fluctuated, but appear to be stable.

Sagebrush and Brewer's sparrows, however, are at historically low levels (Figure 9-11). For the past seven years (since 2011), sagebrush sparrow observations ranged from 161–237, all of which were lower than the previous low count of 241 individuals recorded in 1987. Brewer's sparrow observations in 2017 were 51 percent higher than in 2016, this was the first year since 2012 that it has been above 200 birds. It is attributed that the decline in sagebrush and Brewer's sparrow is to the loss of sagebrush habitats during large fires on the INL Site in 2010 and 2011.

9.5 Bats

Temperate insectivorous bats serve important roles in many ecosystems, providing concomitant ecosystem services of benefit to humans (Kunz and Reichard 2010, Cryan 2011). For example, insectivorous bats are very effective at suppressing populations of nocturnal insects, and some authors estimate the value of bats to the agricultural industry in the United States at roughly $22.9 billion each year through the suppression of insect pest species (Boyles et al. 2011). Moreover, insectivorous bats are effective top-down predators of forest insects (Boyles et al. 2011). In nutrient-poor environments bats

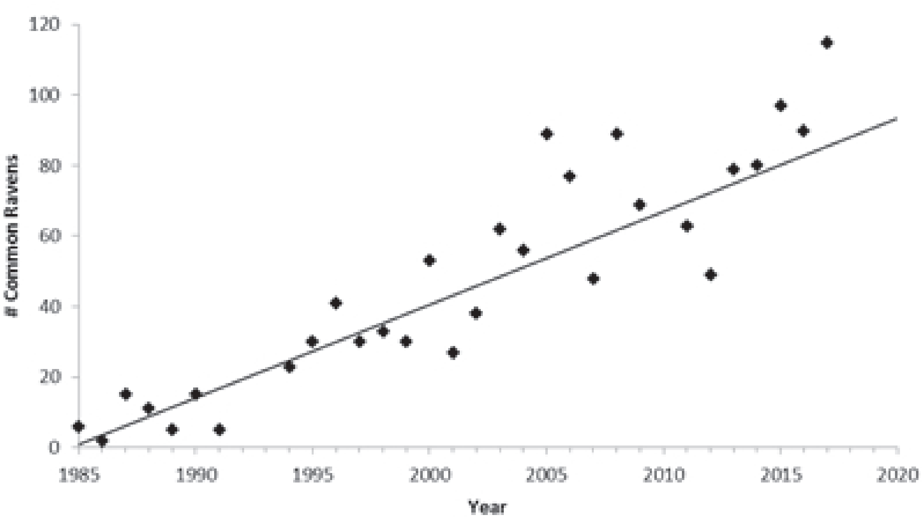


Figure 9-10. Common Raven Observations during Breeding Bird Surveys on the INL Site 1985−2017. ***No surveys were conducted in 1992 and 1993, and the data point in 2010 was removed because it represented an outlier (n = 280) caused by a single large flock flying overhead during one survey.***

can serve as nutrient "resets," feeding intensely on aerial insects in nutrient-richer areas (e.g., riparian corridors, ponds, agricultural fields, etc.) and then transporting and depositing nutrient-rich material, in the form of guano in nutrient-poorer upland roost sites or in caves (Kunz et al. 2011). In some cases bat guano may be the sole source of nutrient input for entire cave ecosystems (Kunz et al. 2011). Potential declines in populations of bats could have far-reaching consequences across ecosystems and biological communities (Miller 2001, Adams 2003, Blehert et al. 2009).

Established threats to bats have traditionally included human destruction and modification of hibernacula and other roost sites as well as pesticide use and loss of important foraging habitats through human development and habitat conversion. However, recent emerging threats (white-nose syndrome [WNS] and wind-energy development) have impacted populations of bats at levels without precedent, eclipsing these traditional threats in at least the eastern United States. WNS, first observed in a hibernation cave near Albany, New York in 2006, has been identified as a major threat to multiple bat species (Blehert et al. 2009; Foley et al. 2011; Kunz and Reichard 2010). The disease has swept northeast into Canada and south and west first along the Appalachian Mountains and then into the Midwest, affecting most major bat hibernation sites east of the Mississippi River and killing an estimated 5.5 to 6.7 million bats in seven species (Blehert et al. 2009; Foley et al. 2011). Documented declines of heavily impacted populations in the Northeast exceed 80 percent. How the disease will affect western bat species is uncertain. In March of 2016, a grounded little brown bat (*Myotis lucifugus*) found by some hikers near Seattle, Washington tested positive for the WNS organism and later was confirmed to have died from the disease. Shortly after this event, the WNS organism was identified in a silver-haired bat (*Lasionycteris noctivagans*) from the same area. In 2017 an infected little brown bat was identified in southern Washington State. WNS is considered one of the greatest wildlife crises of the past century with many once common bat species at risk of significant declines or even extinction (Kunz and Reichard 2010).

Wind-energy development is expanding rapidly across the western United States, and unprecedented mortality rates of bats have occurred recently at many of these facilities (Arnett et al. 2008; Cryan 2011; Cryan and Barclay 2009). Upper-end annual estimates for bat mortality from wind generation plants are approximately 900,000 individuals of mainly tree-roosting bat species (Smallwood 2013); however, widely accepted estimates remain elusive (Huso and Dalthorp 2014). Despite recent focus on emerging threats, direct impacts to hibernacula by humans' remains the single most important conservation concern for bat populations in many areas (Adams 2003).

Over the past several decades, research and monitoring of bats have been conducted on the INL Site by contractors of DOE-ID in a somewhat ad hoc fashion. During that time, four theses, three reports, and one publication have been produced by contractors, university researchers, and graduate students. The majority of that research and monitoring occurred in the late 1980s and early 1990s. Of the 14 confirmed species of bats that

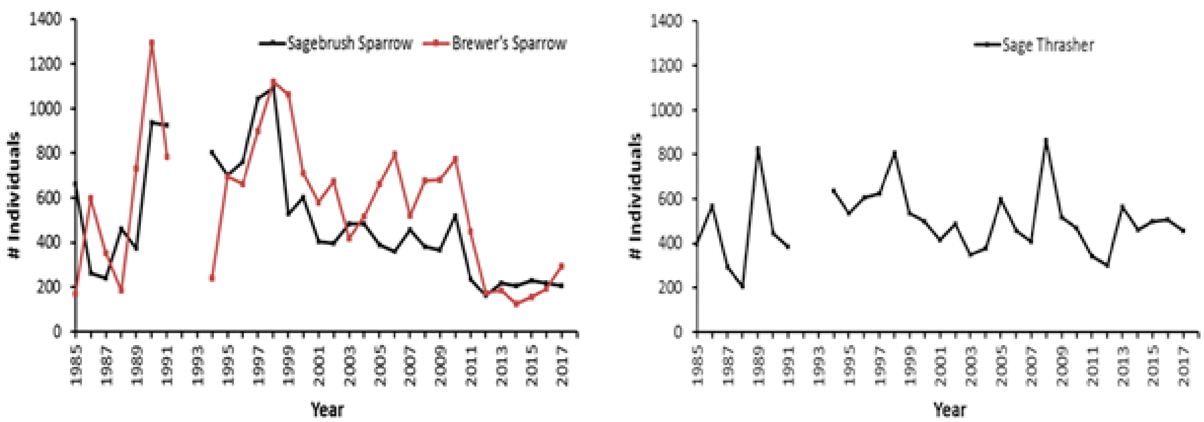


Figure 9-11. Trends of Three Sagebrush Obligates Recorded during Breeding Bird Surveys since 1985. ***Surveys were not conducted in 1992 and 1993.***

reside in the state in Idaho, eleven of those species are confirmed to occupy the INL Site during some part of the year (Table 9-3). All eleven of these species may be detected at the INL Site in appropriate habitats throughout the summer season. Three of them are year-round residents and have been documented hibernating in INL Site caves; two of the species are long-distance migrants with increased numbers detectable during fall migration (Table 9-3). An additional two species (western red bat [*Lasiurus blossevillii*] and Brazilian free-tailed bat [*Tadarida brasiliensis*]) are not listed as occurring in the state of Idaho and are possible vagrants at the INL Site (Table 9-3). To date, Brazilian free-tailed bats have not been detected acoustically at the INL Site. Several bat species detected at the INL Site are considered for different levels of protection by the FWS, Bureau of Land Management, Western Bat Working Group, and other conservation organizations (Table 9-3).

To assess bat activity and species occurrence at critical features, a program of passive acoustic monitoring of bat calls was initiated by ESER in 2012. In 2017, ESER continued monitoring bat activity using acoustical detectors set at hibernacula and other important habitat

Table 9-3. Bat Species and the Seasons and Areas They Occupy on the INL Site, as Well as Emerging Threats to These Mammals.

Common and Scientific Name	Distribution, Habitat, and Seasonal Occurrence	Affected by WNS	Affected by Wind Energy
Big Brown Bat[a] (*Eptesicus fuscus*)[b]	Site-wide; buildings, caves, and lava tubes; year-round	Yes	Yes
Hoary Bat[a] (*Lasiurus cinereus*)[c]	Patchy; riparian and junipers; summer resident at facilities and autumn migrant	No	Yes
Little Brown Myotis[a] (*Myotis lucifugus*)	Site-wide; roosts in buildings; summer resident and autumn transient	Yes	Yes
Long-legged Myotis (*Myotis volans*)	Site-wide; roosts in buildings; summer resident and autumn transient	Potentially	Potentially
Red Bat (*Lasiurus blossevillii* or *L. borealis*)[d]	Unknown; possible autumn migrant or vagrant; not considered Idaho state species [e]	No	Yes
Silver-haired Bat[a] (*Lasionycteris noctivagans*)[c]	Patchy; riparian and junipers; summer resident at facilities and autumn migrant	No	Yes
Townsend's Big-eared Bat[a] (*Corynorhinus townsendii*)[b]	Caves, lava tubes and rocky areas; year-round	No	Potentially
Fringed myotis (*Myotis thysanodes*)	Unknown; caves and lava tubes; single high-certainty acoustic detection only	No	Yes
Brazilian free-tailed bat (*Tadarida brasiliensis*)[d]	Unknown; single dead specimen found at TAN; not considered Idaho state species	No	Yes
California Myotis (*Myotis californicus*)	Site-wide; buildings, caves, and lava tubes; summer resident	Potentially	Potentially
Yuma myotis (*Myotis yumanensis*)	Site-wide; buildings, caves, and lava tubes; summer resident	Yes	Potentially
Western Long-eared Myotis[a] (*Myotis evotis*)	Site-wide; caves and junipers; summer and autumn	Potentially	Potentially
Western Small-footed Myotis[a] (*Myotis ciliolabrum*)[b]	Site-wide; buildings, caves, and lava tubes; year-round	Potentially	Potentially

a. These species are designated as Type 2 Idaho Special Status Species by the BLM.
b. Year-round resident species
c. Migratory tree species
d. Possible vagrant
e. Detected acoustically only, possible vagrant

features (caves and facility waste water ponds) used by these mammals (Figure 9-12). Preliminary analysis of a pilot data set was initiated in 2015 and continued in 2017 (Figure 9-13). Over 2.15 million ultrasonic files were collected during the 2017 monitoring season; more than 600,000 of these files were recorded at facilities, the rest

Figure 9-12. Typical Passive-acoustical Monitoring Station for Bats with a Microphone Mounted at the Top. ***(These devices record the echolocation calls of bats and were installed at cave openings and f acility waste-water ponds.)***

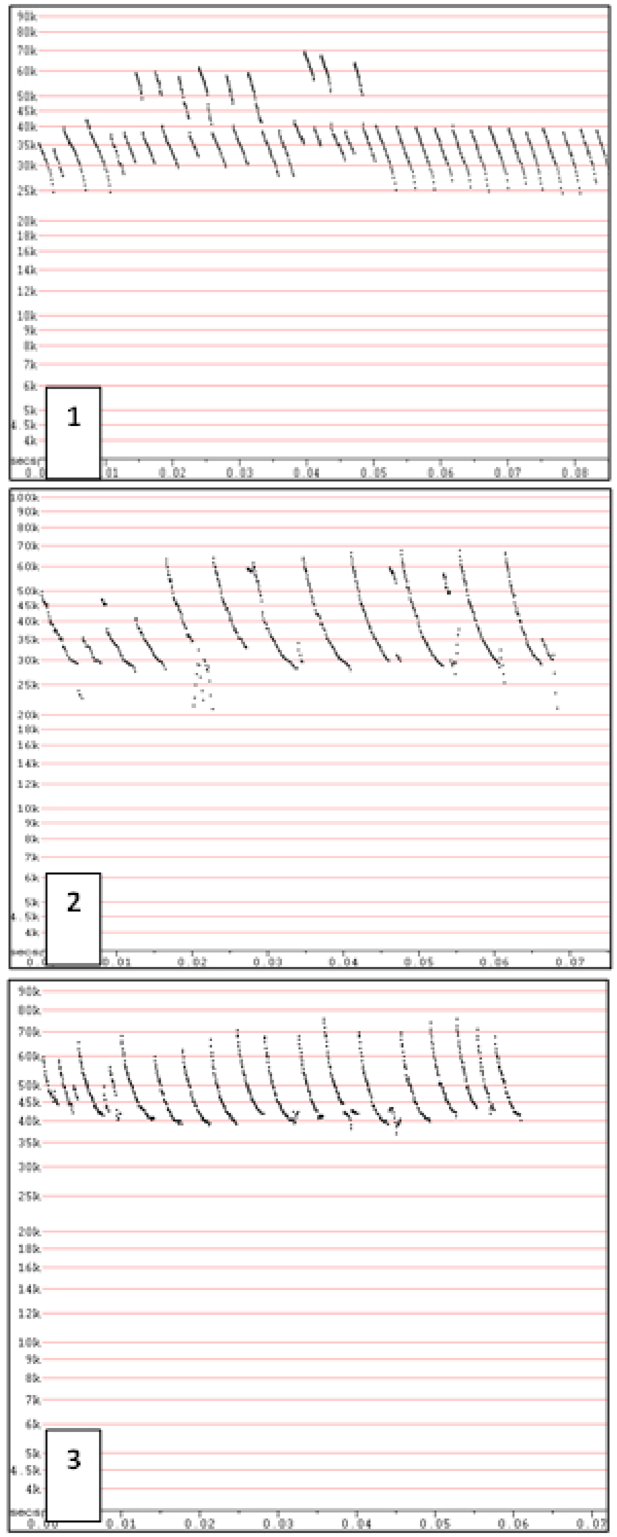


Figure 9-13. Sonograms (Frequency Versus Time Plots) of Bat Echolocation Calls of Three Species of Bats Recorded by AnaBat Detectors (1 = Townsend's big-eared bat, 2 = big brown bat, 3 = western small-footed myotis) from Caves on the INL Site.

at caves and other remote sites. Initial species review of these data are consistent with on-going ESER monitoring efforts. Summer resident bat community appears to consist predominantly of western small-footed myotis (*Myotis ciliolabrum*), Townsend's big-eared bat (*Corynorhinus townsendii*), big brown bat (*Eptesicus fuscus*), and western long-eared myotis (*Myotis evotis*) with some little brown myotis (*Myotis lucifugus*) and silver-haired bat (*Lasionycteris noctivagans*) detected at moderate levels at a few locations. Low levels of summer activity of hoary bat (*Lasiurus cinereus*) were detected through the summer at many features. Western small-footed myotis was the most commonly detected bat at all surveyed features. Little brown bats are more commonly detected at facilities than at cave sites.

Most identified bat species were detected at all features (both facilities and caves). One exception, Townsend's big-eared bat, appears to have a somewhat restricted distribution on the INL Site and, to date, has only been detected at two facilities despite being detected at all caves. Small numbers of Townsend's big-eared bat files have been recorded every survey year at two facilities (Materials and Fuels Complex and RWMC). These facilities are nearer to areas of the INL Site where typical Townsend's big-eared bat roost habitat (e.g., exposed rock outcrops, caves and cave-like features) is most common. Tree bats (hoary bats and silver-haired bats) were detected more frequently at facilities than caves. Patterns suggest both resident and migrant tree bats occur at INL Site facilities. The results of our passive monitoring program are providing critical information regarding bat distribution, ecology and conservation on the INL Site.

In conjunction with the IDFG, Bureau of Land Management (BLM), U.S. Forest Service (USFS), and FWS; the ESER program developed two preliminary active acoustic driving survey transects in 2014 for bats on the INL Site. Survey transects were developed consistent with the North American Bat Monitoring Program, a multi-agency, multi-national effort that is designed to standardize monitoring and management of bat species. Feasibility was assessed and preliminary data were collected on these transects during 2015. Survey were conducted for two years, but because so few bats were recorded (0-2 bats each two hour survey conducted twice monthly), it was felt these surveys did not produce useful information for DOE and were discontinued for the 2017 season.

At least 17 out of 23 caves that are known to exist on the INL Site are used by several species of bats for winter hibernacula, as well as for summer day and night roosts. Lava caves are also an essential habitat during most of the year for three resident species. Much of the historic information concerning bats on the INL Site comes from research that has centered on counting and trapping at caves (Genter 1986, Wackenhut 1990, Bosworth 1994, Doering 1996). In addition to being used as roost and hibernation areas, caves also provide habitat for concentrated patches of insect prey for these mammals. Indeed, in a number of cases, cold-trap crater caves that are too cool during summer to serve as day roosts will have high levels of evening activity as bats focus foraging at these sites. Beyond their use as roosts, caves at the INL Site serve as important habitat features for summer resident bats. Additionally, preliminary surveys indicate that caves may be used as stop-over habitat during fall migrations by previously undocumented forest bats, such as the hoary bat. Very little is known about the use of caves by migrating forest bats (Cryan 2011), and these areas may provide vital resources as bats traverse atypical habitats.

Currently, monitoring of hibernating bat populations is conducted biennially by ESER wildlife biologists at nine known INL Site hibernacula. Surveys are conducted in coordination with BLM and IDFG surveys conducted across the region. The winter of 2014–2015 was a scheduled survey year with surveys conducted mid-winter during early 2015 when numbers of hibernating bats are presumed highest and most stable. Caves were scheduled to be counted again during the winter of 2016–2017; however, numerous instance of severe winter weather and impassible travel conditions resulted in a decision to cancel 2016–2017 surveys. Hibernaculum surveys will be conducted during the 2017–2018 season and reported in the 2018 ASER. Current National Wildlife Health Center guidance for WNS surveillance recommends that hibernation counts be conducted as late as possible to increase the chances of detecting WNS infected bats. For this reason bat counts are typically counted during February and early March of survey winters.

To date, Townsend's big-eared bat is the most commonly counted over-wintering bat species, with western small-footed myotis being the second most common, but with far fewer numbers. Trends and numbers of those species have been stable over the past two counts in all nine hibernacula on the INL Site (Figure 9-14). Historically over-wintering big brown bats have been encountered, but not during the most recent surveys.

Passive acoustic monitoring at long-term stations operating at caves and facilities are revealing patterns of bat activity across the INL Site. An analysis of passive acoustic data collected at remote site (caves) and facility ponds indicated high variability and distinct patterns of activity across seasons with clear differences between developed and natural areas (Figure 9-15). Developed areas with anthropogenic structures (facilities, bridges, and culverts) are used as habitat by bats on the INL Site as well as natural areas. Developed areas, and their associated lands, occupy about 0.38 percent of the INL Site. Some of these facilities were constructed in the 1950s, and are surrounded by mature landscaping trees and wastewater ponds, which provide bats with vertical-structure habitat, water, and foraging areas. Patterns shown in Figure 9-15 reveal good levels of summer activity at both developed and natural sites. May and August peaks at facilities reveal transient use at facilities as bats move back and forth between summer and winter habitats. Many of these transient bats are migrating tree bat species, likely using facility resources (landscaping trees and surface water) as stopover habitat. High levels of activity from July through September at caves indicate these area are important activity centers for resident bats and also serve as pre-hibernation gather sites (swarming sites).

9.6 Rabbits and Hares

Introduction

Rabbits and hares (*Lepardae*) are ecologically important species in sagebrush landscapes. They are hunted by many avian and mammalian predators, and the abundance of some species, such as the golden eagle, is closely associated with the abundance of jackrabbit populations (Marzluff et al. 1997). Local research has confirmed that the abundance of coyotes and wintering raptors on the INL Site is strongly correlated with fluctuations in black-tailed jackrabbit abundance (Craig et al. 1984; Stoddart et al. 2001). Additionally, researchers found in Wyoming that sage-grouse and cottontail rabbit abundances demonstrated highly synchronized cycles over 26 years (Fedy and Doherty 2011). DOE-ID's interested in knowing when jackrabbit abundance peaks, because increased numbers of predators could result in increased predation on sage-grouse, especially after the jackrabbit population crashes. Furthermore, it is possible that the abundance of sage-grouse, jackrabbits, and other species respond to similar environmental cues (e.g., annual precipitation).

Methods

Night-time rabbit and hare surveys were initiated in 1980 on the INL Site in response to a population explosion of black-tailed jackrabbits (Lepus californicus) that became a costly nuisance for landowners in southeastern

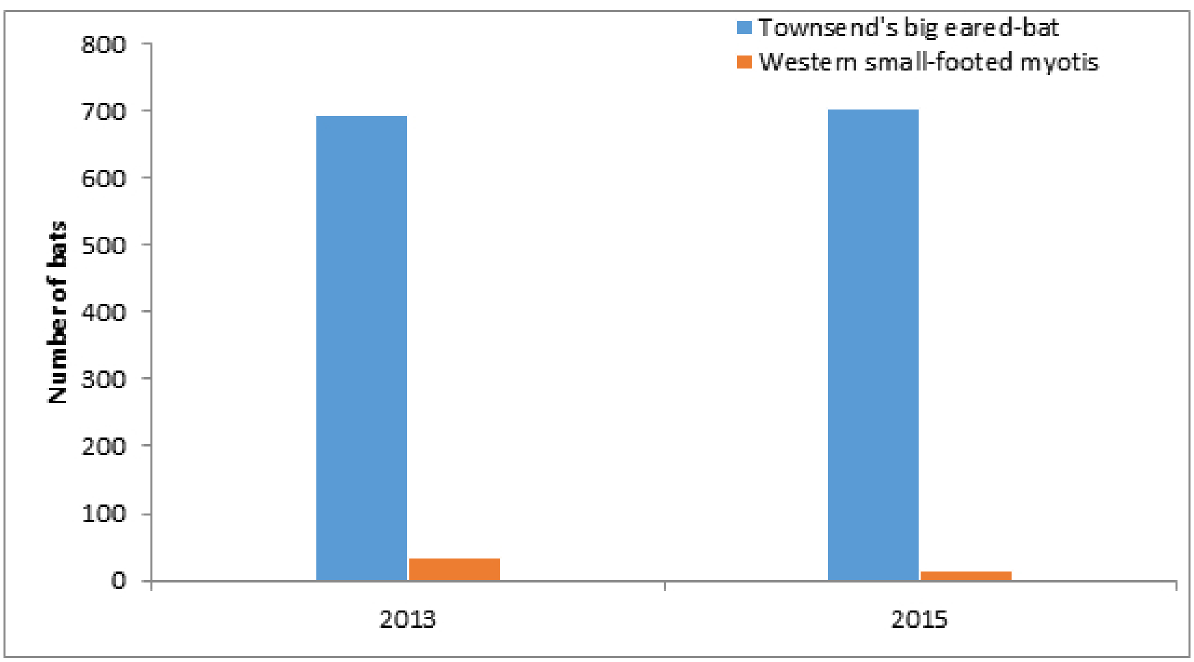
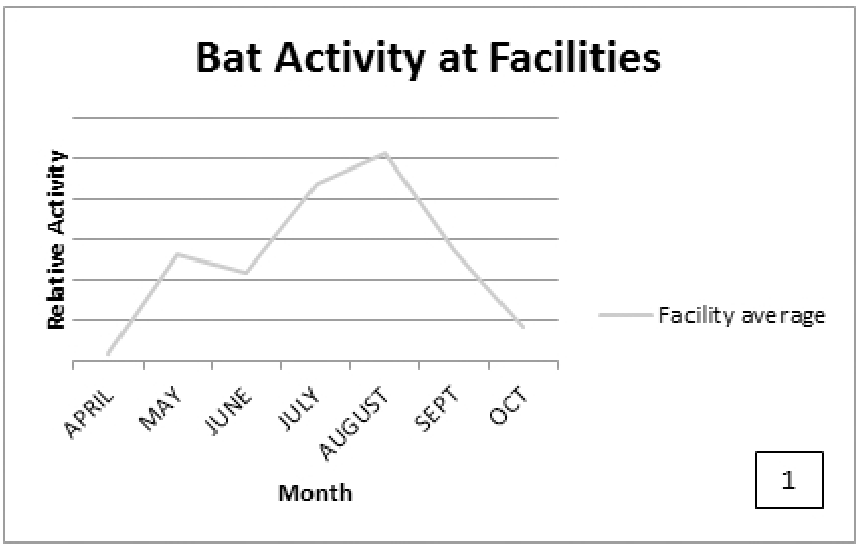


Figure 9-14. Number of Two Bat Species Counted at Known Hibernacula on the INL Site during the Past Two Biennial Survey Periods (Counts Appear Stable).

Idaho. Jackrabbit populations tend to be cyclic, and the purpose of the surveys was to devise an early-warning system that farmers could use should jackrabbit abundance approach that experienced from 1980–1982. Nearly every spring from 1980–2007, biologists drove slowly along a 30-mi (48-km) two-track route on the east side of the INL Site using spotlights to search for rabbits and hares of all species. Black-tailed jackrabbits made up nearly 100 percent of observations across all years. During a population peak in May 1981, 1,193 black-tailed jackrabbits were counted along the route. The population declined precipitously from 1981–1984, and the average number of black-tailed jackrabbits seen along the route from 1985–1989 was 1.8 individuals per year. Jackrabbit observations remained relatively low throughout the remaining years the survey was conducted (median of five jackrabbit observations per night between 1984 and 2007 [range: 0-142]), though there were small peaks in 1992 (n = 53), 2000 (n = 26), and 2007 (n = 142). The survey was discontinued after 2007 since DOE-ID determined it was not providing useful data, as jackrabbit numbers had remained low for over 20 years.

During winter of 2016, INL Site contractors and ESER field crews began reporting that jackrabbit abundance on the INL Site was once again high. For example, security personnel at several INL Site facilities reported that security alarms were frequently triggered by the



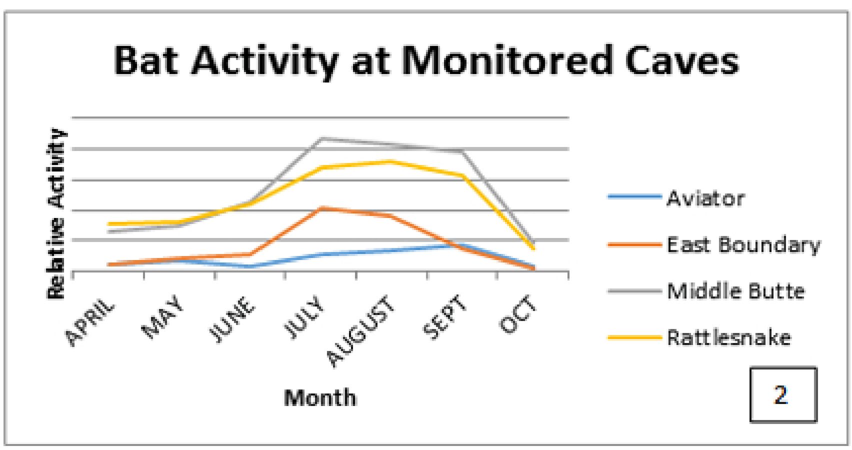


Figure 9-15. Average Relative Levels of Bat Activity across the Summer Activity Season (April–October) for Acoustic Monitors deployed at Facilities (1) and Caves (2). ***May and August activity peaks at facilities indicate a good deal of transient use as bats migrate back and forth between summer and winter habitats. High activity throughout summer months at caves indicate these areas are important summer activity centers for resident bats.***

numerous jackrabbits that managed to get inside facility fences. After consulting with DOE-ID, ESER reinitiated rabbit and hare surveys in 2016. The primary uses of the rabbit and hare data will be 1) to assist ESER in collecting more comprehensive data on cyclic population patterns that may trend with sage-grouse populations at the INL Site, and 2) to advise facility personnel when jackrabbit abundance begins to increase in the future so they can ensure that facility fences are in good repair before jackrabbit abundance reaches the point where they impact the work of facility forces.

Results and Discussion

During 2017 surveys we counted a mean of 11.3 jackrabbits during three spotlight surveys (range: 6-16). In contrast, we counted a mean of 520 jackrabbits during three spotlight surveys conducted during the initiation year of 2016 (Figure 9-16). The 2016 number was higher than any other year surveyed between 1980 and 2007, except 1981. Since we appear to have entered another cyclic decline phase, these surveys have been discontinued until reports indicate otherwise.

A large section of the survey route and surrounding sagebrush-dominated habitat burned in 2010 during the Jefferson fire—the largest wildfire in the history of the INL Site. Prior to the Jefferson fire, 31 km (19.0 mi) of the 48-km (30-mi) survey route cut through sagebrush-dominated habitat. After the fire, only 13.8 mi (22 km) of the route remained within sagebrush habitat (mainly in the northern and southern-most portions of the route). Jackrabbits are strongly associated with sagebrush since they feed on the shrub and seek cover in sagebrush stands during the day. During the 2016 surveys (see DOE-ID 2016 for further discussion and details) most jackrabbits were detected in sagebrush dominated habitats and nearly absent from graminoid-dominated habitats. Despite the paucity of data collected during 2017, the same pattern is suggested.

Both jackrabbits and sage-grouse tend to cycle approximately every 10 years. Consequently, only long-term datasets could have the power to elucidate potential correlations between population trends. Although we do not yet have sufficient data to make a robust comparison between sage-grouse and jackrabbit datasets (primarily since jackrabbits have not been surveyed since 2007), it is interesting to note that in 2016, counts of male sage-grouse on the INL Site were higher than any other year since the last peak in 2006. When ESER ceased the jackrabbit surveys in 2007, total jackrabbit observations were higher than they had been at any other time since 1983 (Figure 9-16). Nine years later, we have documented a peak in jackrabbit abundance (though previous years could also have been higher). Therefore, initial comparisons support the hypothesis that jackrabbits and sage-grouse follow a similar cyclic pattern on the INL Site.

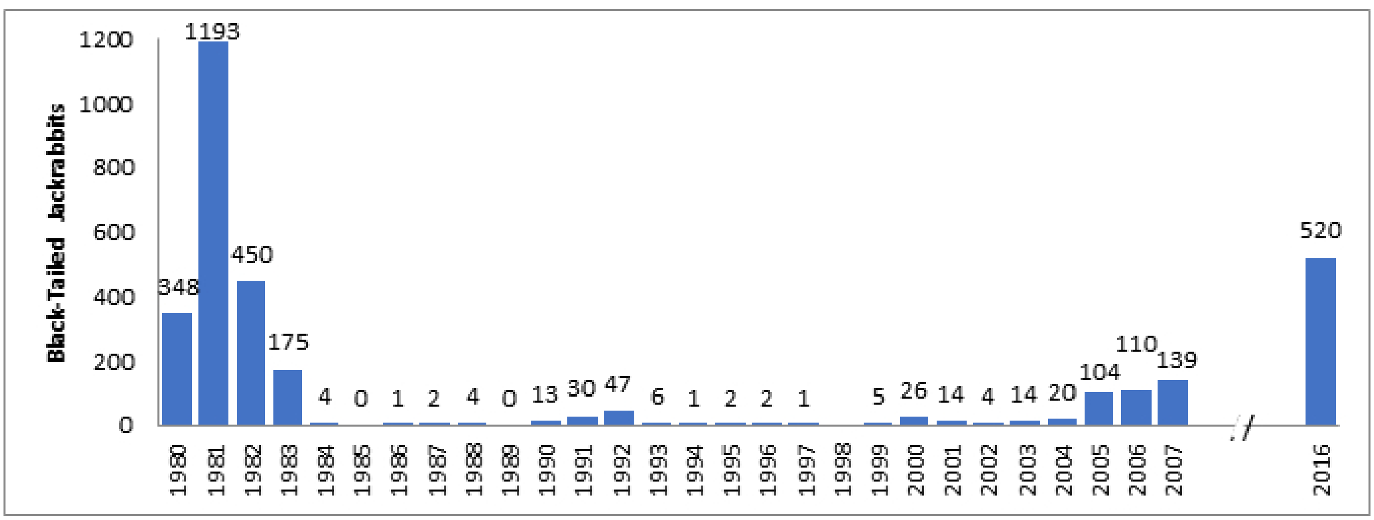


Figure 9-16. Jackrabbits Observed along a Rabbit and Hare Spotlight Survey Route on the East Side of the INL Site. ***Surveys completed prior to 2008 consisted of a single survey each year, typically in May. For recent surveys (2016), the bar is the mean of three surveys completed in June. No survey was conducted in 1998.***

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Great Basin
Spadefoot Toad
Spea intermontana

10. Environmental Research at the Idaho National Laboratory Site

Ecological monitoring and research at the Idaho National Laboratory Site in 2017 was focused on: 1) monitoring the condition and conservation status of vegetation communities and sensitive plant species; 2) annual assessment of sagebrush habitat and restoration-based conservation efforts to support the Candidate Conservation Agreement (CCA) for Greater Sage-grouse; and 3) research supported through the National Environmental Research Park (NERP).

The monitoring of vegetation communities and sensitive plants species continued in 2017 through analysis of data collected across the INL Site using the Long-Term Vegetation (LTV) transects and associated permanent plots from 1950 through 2016. The LTV project allows researchers to observe long-term vegetation changes and the potential impacts of these changes across the INL Site.

Sagebrush habitat monitoring and conservation measures to support the CCA were addressed by three tasks in 2017. The first entails resampling 75 plots, which have been sampled annually since 2013, to assess habitat condition. Absolute cover, height, and density of sagebrush and perennial grass/forbs were measured for this task. Inventory and monitoring of cheatgrass, a threat to sagebrush habitat, continued with field-based assessment of several potential restoration areas. Sagebrush habitat restoration continued in 2017 and seedling survivorship assessments of shrubs planted in 2016 were completed.

During 2017, one ecological research project was conducted on the Idaho National Environmental Research Park; continued studies of ants and ant guests at the INL Site. The INL Site was designated as a NERP in 1975. The National Environmental Research Parks provide rich environments for training researchers and introducing the public to ecological sciences. NERPs have been used to educate grade school and high school students and the general public about ecosystem interactions at U.S. Department of Energy (DOE) sites; train graduate and undergraduate students in research related to site-specific, regional, national, and global issues; and promote collaboration and coordination among local, regional, and national public organizations, schools, universities, and federal and state agencies.

The United States Geological Survey (USGS) has been studying the hydrology and geology of the eastern Snake River Plain and eastern Snake River Plain aquifer since 1949. The USGS INL Project Office collects data from research and monitoring wells to create and refine hydrologic and geologic models of the aquifer, to track contaminant plumes in the aquifer and improve understanding of the complex relationships between the rocks, sediments and water that compose the aquifer. Four reports were published in 2016 by the Idaho National Laboratory Project Office.

10. ENVIRONMENTAL RESEARCH AT THE IDAHO NATIONAL LABORATORY SITE

This chapter summarizes ecological monitoring and research performed at the Idaho National Laboratory (INL) (Sections 10.1 through 10.4) and research conducted on the eastern Snake River Plain and eastern Snake River Plain aquifer by the United States Geological Survey (Section 10.5) during 2017.

10.1 Ecological Monitoring and Research at the Idaho National Laboratory

Ecological monitoring and research on the INL Site generally falls into three categories; 1) Monitoring the condition and conservation status of vegetation communities and sensitive plant species, 2) Annual assessment of sagebrush habitat and restoration-based conservation measures to support the Candidate Conservation Agreement (CCA) for Greater Sage-grouse (*Centrocercus urophasianus*); DOE-ID and FWS

2014), and 3) Research supported through the National Environmental Research Park (NERP).

Monitoring tasks in the first category are conducted to provide information to U.S. Department of Energy (DOE) about the abundance, distribution, condition, and conservation status of vegetation communities and sensitive plant species known or expected to occur on the INL Site. Results from these tasks are used to monitor overall health and condition of the sagebrush steppe ecosystem locally, to understand the potential causes and consequences of vegetation change over time and within a greater regional context, to make quantitative data available for land use planning, and to support environmental regulatory compliance (i.e., National Environmental Policy Act [NEPA]). Component tasks include the long-term vegetation (LTV) survey, major vegetation classification and map updates, sensitive species reports, and any other monitoring necessary to address current concerns. Many of these tasks are completed on a rotational schedule, once every several years. Vegetation surveys to support the LTV were conducted in 2016.

The second set of ecologically-based tasks and activities include sagebrush habitat assessments, evaluation of risks to habitat, and conservation measures to improve habitat. These activities support the voluntary agreement U.S. Department of Energy, Idaho Operations Office (DOE-ID) entered into with the U.S. Fish and Wildlife Service (FWS) to conserve sage-grouse and the habitat they depend on across the INL Site (DOE-ID and FWS 2014). There are two habitat monitoring tasks, one to assess annual habitat condition and one to document habitat distribution across the INL Site. The habitat distribution task is completed periodically and was not conducted in 2017. There are also two tasks associated with threats to habitat and habitat restoration. Because cheatgrass (*Bromus tectorum*) poses one of the greatest biological risks to sagebrush habitat, there is a task designed to target, inventory, and explore possible restoration options to areas with the potential to become vectors for cheatgrass spread. The final ecological monitoring task to support the CCA is a conservation measure that includes planting sagebrush seedlings to hasten the return of viable habitat in burned areas.

The INL Site was designated as a NERP in 1975. According to the Charter for the National Environmental Research Parks, NERPs are intended to be outdoor laboratories where research can be carried out to achieve agency and national environmental goals. Those environmental goals are stated in the NEPA, the Energy Reorganization Act, and the Non-nuclear Energy Research and Development Act. These goals dictate that the task is to understand our environment sufficiently that we may enjoy its bounty without detracting from its value and eventually to evolve an equilibrium use of our natural resources. The desirability of conducting research on the NERP is enhanced by having access to relatively undisturbed sagebrush steppe habitat and no public access. Universities typically provide their own funding and the Environmental Surveillance, Education, and Research (ESER) Program facilitates researcher access to the INL Site. There is one ecological research project ongoing through the Idaho NERP, it includes documenting ants and associated arthropods on the INL Site.

10.2 Vegetation Communities and Sensitive Plant Species

10.2.1 The Long-term Vegetation Transects

The LTV transects and associated permanent plots were established on what is now the INL Site in 1950 for the purposes of assessing impacts of nuclear energy research and production on surrounding ecosystems (Singlevich et al. 1951). Initial sampling efforts focused on potential fallout from nuclear reactors and the effects of radionuclides on the flora and fauna of the Upper Snake River Plain. After several years of sampling, however, the concentrations and any related effects of radionuclides on the sagebrush steppe ecosystem of the INL Site were determined to be negligible (Harniss 1968).

Because the LTV plots were widely distributed across two transects that bisect the INL Site (Figure 10-1) and vegetation abundance data had been collected periodically since their establishment, their utility as a basis for monitoring vegetation trends in terms of species composition, abundance, and distribution was eventually recognized. Vegetation data collection has continued on the LTV plots on a semi-regular basis, about once every five years. Eighty-nine LTV plots are still accessible and most have now been sampled regularly between 1950–2016, making the resulting dataset one of the oldest, largest, and most comprehensive for sagebrush steppe ecosystems in North America.

As the mission of the INL Site has grown and changed over the past 67 years, so too has the purpose and utility of the LTV project. Although the LTV project was initiated to address energy development at the INL Site, it is unique in its capacity to allow investigators to observe long-term

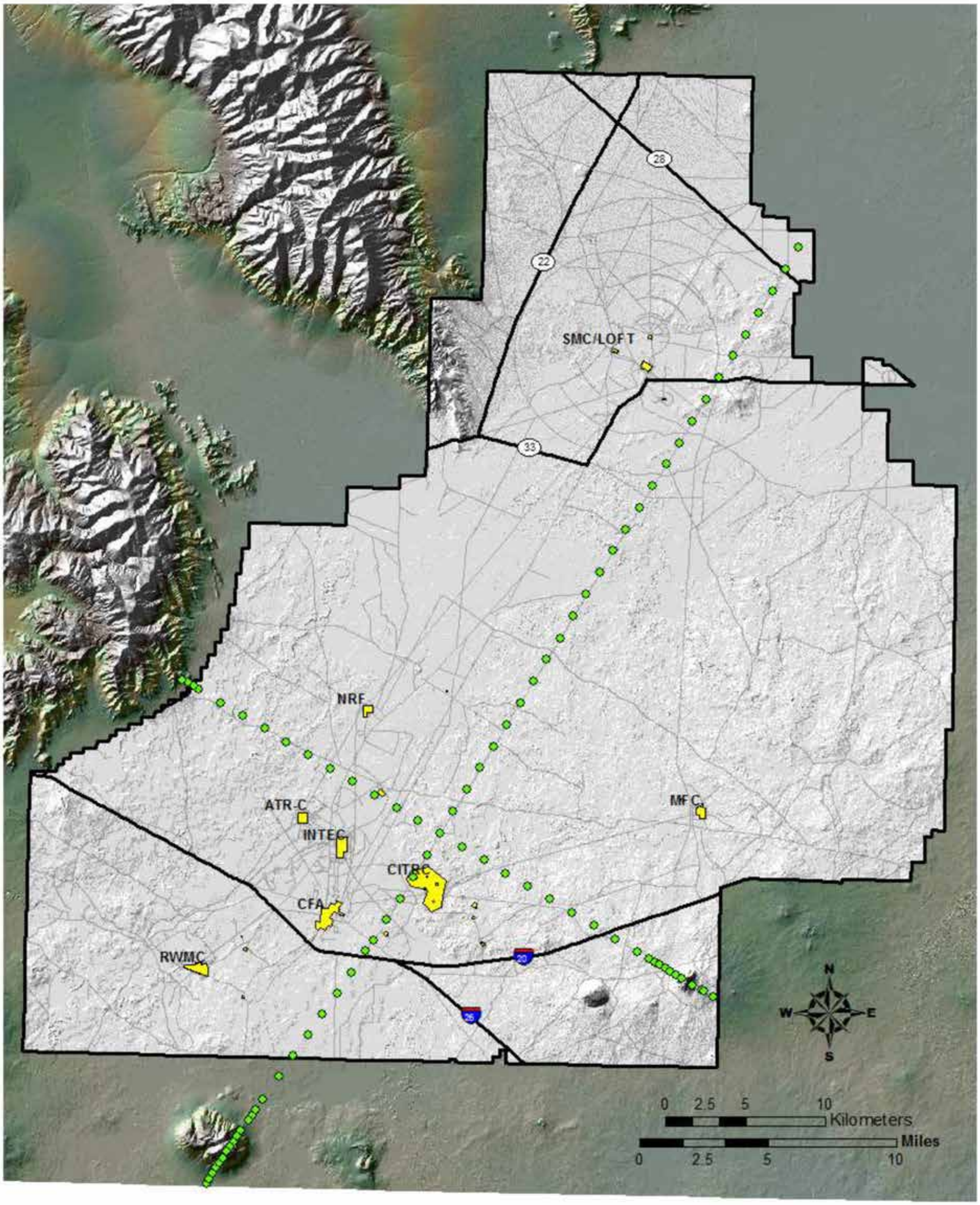

Figure 10-1. Long-term Vegetation Transects and Permanent Plot Locations on the INL Site.

vegetation change and the potential impacts of that change at the INL Site and across the region. Abiotic and biotic conditions (conditions created by the physical environment and by other living organisms) have been characterized by rapid change over the past few decades. These changes include shifts in land cover, land use, and weather. Several large wildland fires have removed sagebrush from a large portion of the Upper Snake River Plain over the past twenty years; nearly 60,000 hectares (148,263 acres) have burned on the INL Site in the past seven years. Soil disturbance associated with fighting wildland fires and disturbance associated with general increases in the use of remote backcountry areas are notable throughout the Intermountain West. Concurrently, many of the hottest and driest years during the 60-year weather record occurred during the past decade. All of these factors contribute to increasing stress on native plant communities and potentially set the stage for a period of dramatic change in vegetation across the region. The LTV project is documenting this change and may provide some context for understanding resistance and resilience in local sagebrush steppe.

Data were collected across the 89 active LTV plots for the 13th time between June–August of 2016. Plots were sampled for cover and density by species according to methodologies developed in 1950, with supplemental sampling protocols added in 1985. See Forman et al. (2010) for details of the project sample design. In addition, data have been collected for six consecutive years (2011–2016) on 11 LTV plots that were burned on August 25, 2011, in the T-17 fire (Figure 10-2), providing a rare opportunity to monitor fire recovery on a number of plots that were recently sampled and had been well-characterized for more than half a century prior to the fire.

There are three specific objectives for LTV data analysis following the most recent data collection efforts. The first is to provide an update to the standard long-term trend analyses that are reported subsequent to all comprehensive LTV sampling efforts (e.g., Forman et al. 2013, Chapter 2). These analyses provide a useful indicator of overall ecosystem health for sagebrush steppe at the INL Site, as well as benchmark values for specific vegetation characteristics that can be used for NEPA analyses and habitat assessments. The second objective is to summarize results from the pre- and post-fire cover data on the LTV plots burned in the T-17 fire; results will facilitate developing a framework for assessing post-fire vegetation condition and recovery trajectory. The third objective will address the spread and distribution of non-native plants across the INL Site. Data will be analyzed with the intent of characterizing non-native species abundance and distribution patterns and understanding how those patterns relate to changing weather patterns and land uses. A report detailing these objectives and all analytical results addressing these objectives will be finalized in 2018.

10.2.2 INL Site Vegetation Map Update

The most recent vegetation map for the Idaho National Laboratory (INL) Site was based on vegetation classification data sampled across the Site and a time-series of digital imagery used to produce manual map delineations (Shive et al. 2011). This dataset represented a substantial improvement over previous maps of the INL Site in terms of resolution, accuracy, and statistical rigor. Since its completion, the vegetation map has been used extensively to support inventory and monitoring of ecological resources on the INL Site. Several of the monitoring and adaptive management tasks outlined in the CCA for Greater Sage-grouse (DOE-ID and FWS 2014), including assessment of the status of habitat distribution, require an accurate vegetation map. The vegetation map is also instrumental for identifying and prioritizing potential habitat for other sensitive species, identifying restoration and/or weed control opportunities, and characterizing affected environments for NEPA analyses. Over the past decade, the vegetation map has become one of ESER's most important datasets and is used to support nearly every other ecologically-based task.

Because the vegetation map is integral to the ESER Program, it is important to update the map periodically to ensure that both the vegetation classes identified on the INL Site and the mapped boundaries of those classes remain accurate. There have been many changes in vegetation distribution and composition since the map was completed. The most discrete changes were caused by four relatively large wildland fires that burned approximately 52,820 ha (130,521 acres), representing about 23 percent of the INL Site from 2010–2012. More gradual changes in plant community composition, like increases in the abundance and distribution of non-native annual grasses and forbs, have also been occurring over the past decade. These changes will affect the way vegetation classes are defined and mapped across the INL Site and will be an important consideration for all ESER tasks that utilize the vegetation map.

A comprehensive update to the current map was initiated in 2017 and involves three steps 1) plant community classification to define vegetation classes, 2) map delineations of those classes, and an 3) accuracy assessment of the map. Data were collected to support the plant community classification, those data were analyzed, and a draft vegetation class list was compiled in 2017. Map delineations also began in 2017.

The field sampling site selection process for plant community classification consisted of calculating a landscape filter for potential sampling area and assigning

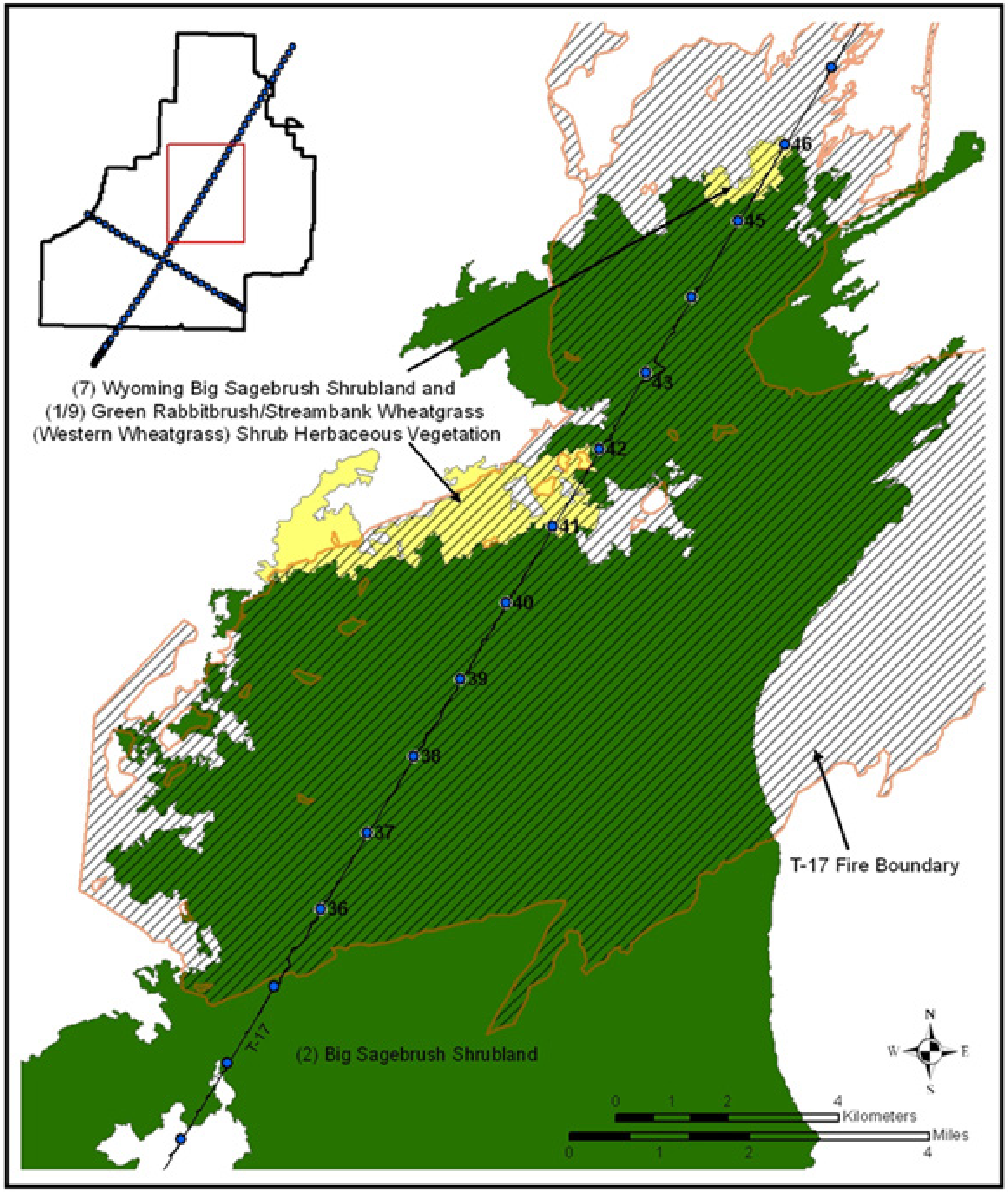

Figure 10-2. Location of 11 Long-term Vegetation Transect Plots that Burned During the 2011 T-17 Fire.
Vegetation classes listed were characterized prior to the fire and are from Shive et al. (2011).

stratified random samples to each vegetation class based on the current map. The purpose of the landscape filter is to remove all non-vegetated areas (e.g., facilities, landfills, etc.) and also to limit that area sampling teams have to travel from roads that provide access. We applied a 100 m buffer and 1100 m buffer on all roads. The 100 m buffer is designed to remove any road effects or influences on native vegetation, and the 1100 m buffer defines the outer extent of the potential sampling area resulting in 1 km swaths adjacent to each access road. Sampling plot locations were randomly stratified among mapped vegetation classes from the previous map and randomly selected within the recently burned area discussed above (Figure 10-3).

At 333 of the locations resulting from the site selection process, field data were collected along 50 m transects which were oriented along a 20 degree compass bearing. Quantitative cover data were recorded using five consecutively placed point interception frames randomly located within in each 10 m segment of the transect. Point interception frame data were collected according to methods described by Floyd and Anderson (1982). Plot photos were also taken for general reference.

We used a multivariate statistical approach to analyze the vegetation cover data from each plot. We compared eight classification methods to determine the best method given the general cluster structure of the data. Additionally, seven classification evaluators were used to compare classification methods and optimal number of clustering solutions for each method. The optimal statistical clustering solution organized the 333 sampled plant communities into 16 different vegetation classes. The new vegetation classes included seven shrubland classes, two shrub grassland classes, six grassland classes, and one woodland class (Table 10-1). There were two pairs of vegetation classes that are nearly indistinguishable in aerial imagery, and were consequently combined to create 14 total map classes that will be assigned to new map polygons.

While the plant community classification analysis was being conducted, we also started updating the

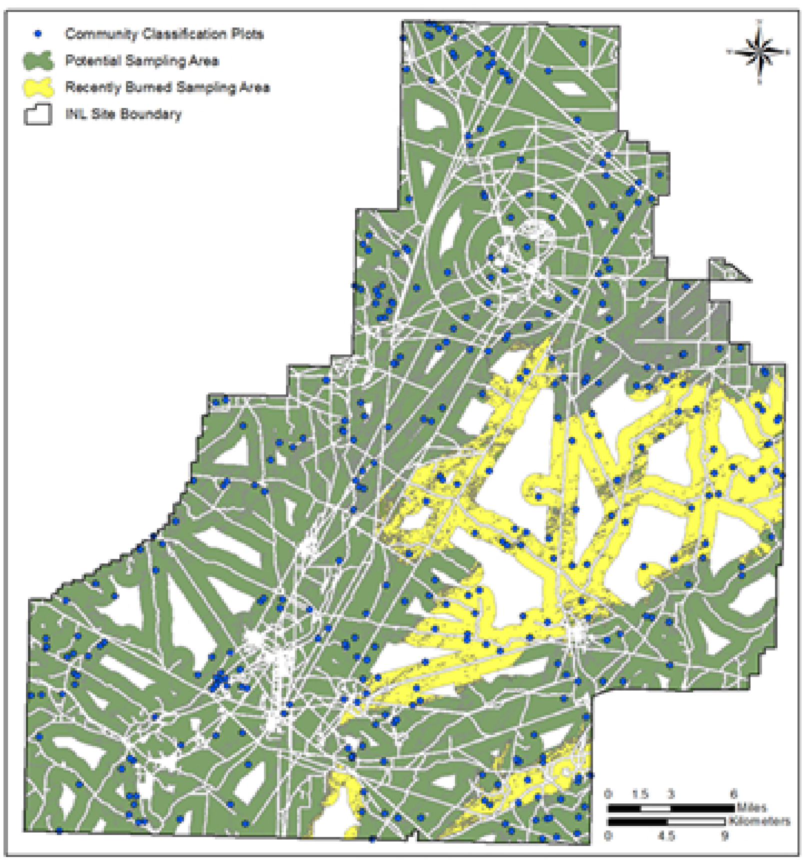

Figure 10-3. Plant Community Classification Plots on the INL Site to Support the Update of the INL Site Vegetation Map.

Table 10-1. Sixteen Vegetation Classes Resulting Multivariate Classification of 333 Plots Sampled on the INL Site in 2017.

Cluster #	Vegetation Classes – Colloquial Name
1	Green Rabbitbrush / Sandberg Bluegrass – Bluebunch Wheatgrass Shrub Grassland
2	Cheatgrass Ruderal Grassland
3	Green Rabbitbrush / Thickspike Wheatgrass Shrub Grassland
4	Green Rabbitbrush / Desert Alyssum (Cheatgrass) Ruderal Shrubland
5	Needle and Thread Grassland
6	Big Sagebrush – Green Rabbitbrush (Threetip Sagebrush) Shrubland
7	Crested Wheatgrass Ruderal Grassland
8	Big Sagebrush Shrubland
9	Western Wheatgrass Grassland
10	(Basin Wildrye) – Mixed Mustards Infrequently Inundated Playa/Streambed
11	Juniper Woodland
12	Indian Ricegrass Grassland
13	Shadscale Saltbush – Winterfat Shrubland
14	Sickle Saltbush (Winterfat) Shrubland
15	Black Sagebrush Shrubland
16	Low Sagebrush Shrubland

spatial boundaries of vegetation classes across the INL Site using more recent high resolution aerial imagery. The previous vegetation map was produced through manual delineations at a 1:12,000 mapping scale and the last plant community classification was driven by data collected at plots with a 20 m x 20 m dimension. Consequently, the finer scale used to define the vegetation classes was most commonly mixed at the broader mapping scale. This resulted in many of the map polygons assigned as two-class complexes to denote that either class was likely present within a polygon boundary. In some cases, the two-class complex was a combination of a shrubland and grassland vegetation class and the difference between those two classes can be seen at finer spatial scales in the imagery but not observable at the 1:12,000 scale. The new vegetation map polygon boundaries are still being updated to reflect current distribution and extent on the ground. Once that step is complete, we will further separate the previous two-class complexes into stand-alone polygons assigned to a single vegetation class.

Over the next year a dichotomous field key will be developed based on the statistical results of the community classification, and used to assign plant community classes to plots during the accuracy assessment phase of the project in summer 2018. The accuracy assessment field data will be used to statistically evaluate the accuracy of individual map classes and overall map accuracy.

10.3 Sagebrush Habitat Monitoring and Restoration

10.3.1 Sagebrush Habitat Condition

Sage-grouse cannot survive without healthy sagebrush stands that meet certain criteria related to the condition and distribution of their habitat (Connelly et al. 2000). Sage-grouse use sagebrush dominated lands year-round and rely on sagebrush for food, nesting, and concealment from predators. Not only are healthy stands of sagebrush necessary for sage-grouse to survive, during summer young sage-grouse also require a diverse understory of native forbs and grasses. Vegetation cover provides protection from predators and supplies high-protein insects necessary for rapidly growing chicks (Connelly et al. 2011).

This monitoring task, outlined in the sage-grouse CCA between the FWS and DOE-ID (DOE-ID and FWS 2014), provides ongoing assessment of habitat condition, allowing for comparisons of sagebrush habitat indicators on the INL Site with general sage-grouse habitat guidelines (e.g., Connelly et al. 2000). Habitat condition monitoring may also be used to track trends in the quality of habitat available to sage-grouse on the INL Site through time, as well as to identify the effects of threats that may impact habitat condition (e.g., increases in nonnative weeds). Although these surveys weren't designed to address specific interactions between birds and their environment (i.e., nest site selection or foraging behaviors related to brood-rearing) they do provide an excellent index of the overall condition and composition of the plant communities considered to be appropriate habitat for sage-grouse on the INL Site.

Seventy-five habitat condition monitoring plots have been sampled annually since 2013. Forty-eight plots are located in areas currently mapped as sagebrush habitat and 27 are located in previously burned areas that are recovering to sagebrush habitat (Figure 10-4). Plots are sampled for vegetation cover and height by species and also for sagebrush density and juvenile frequency. In 2017, data were collected on all 75 annual plots between June and August. Data were summarized and results were compared to data values from previous years and to general recommended habitat guidelines (Connelly et al. 2000).

Mean sagebrush cover from annual sagebrush habitat plots (Table 10-2), and for the sagebrush habitat polygons they represent, is near the upper end of the range suggested for optimal breeding (15-25 percent) and brood-rearing habitat (10-25 percent) in arid sites (Connelly et al. 2000). Mean sagebrush height is also within the optimal range (40-80 cm; Table 10-2). Perennial grass/forb mean height values were above the minimum value recommended (18 cm) in current sage-grouse habitat guidelines (Connelly et al. 2000). Average perennial grass/forb cover on sagebrush habitat plots was about 18 percent in 2017, which is above the minimum specified for breeding and brood-rearing habitat (15 percent), but it was higher in 2017 than in any of the four previous years and was likely at the upper end of the

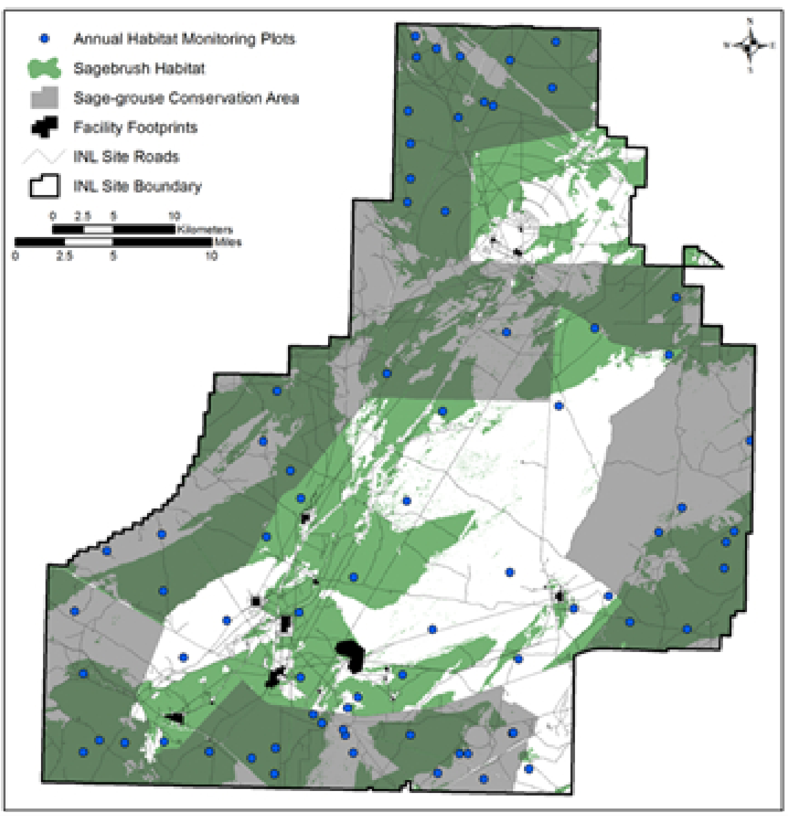

Figure 10-4. Sage-grouse Habitat Condition Monitoring Plots Sampled in 2017 on the INL Site.

Table 10-2. Summary of Selected Vegetation Measurements for Characterization of Condition of Sagebrush Habitat Monitoring Plots and Non-sagebrush Monitoring Plots on the INL Site in 2017.
***The number marked by an asterisk (*) includes five plots with notable sagebrush seedling germination events. Most seedlings in these plots will fail due to self-thinning; the adjusted mean sagebrush density (without the five high-germination plots) is 4.21 individuals/m²*.**

	Mean Cover (%)	Mean Height (cm)	Mean Density (individuals/m²)
Sagebrush Habitat Plots (n = 48)			
Sagebrush	22.14	50.38	7.02*
Perennial Grass/Forbs	18.29	32.55	
Non-sagebrush Plots (n = 27)			
Sagebrush	0.32	35.43	0.12
Perennial Grass/Forbs	23.88	38.57	

range of variability for this functional group on the INL Site.

Herbaceous functional groups are highly influenced by precipitation. Total annual precipitation for 2017 was above average. Comparatively, the first year of data collection for this monitoring task, 2013, was the driest year on record with only about ¼ of average annual precipitation. Much of the sampling in 2014 was completed prior to August precipitation. Almost half of the total precipitation from 2014 fell in August. Mean August precipitation, is about 13 mm; total August precipitation from 2014 was 102 mm. In 2015, May was abnormally wet, with a total of nearly 60 mm, which is twice the historical monthly average. September and October of 2016 had more than three times average historical precipitation for the same time period and more than half of the annual precipitation fell after the summer growing season. Snowpack through the winter of 2016/2017 was much higher than average and is reflected in the December 2016–February 2017 precipitation data.

These short-term precipitation patterns, which deviate from historical patterns of seasonality, would certainly favor some plant species and functional groups over others. Cover from perennial herbaceous species, as well as cover from cheatgrass and all annual forbs was probably uncharacteristically low in 2013 and 2014 (Shurtliff et al. 2015) and was probably much higher than normal in 2015–2017 due to the anomalous precipitation patterns in those years.

10.3.2 Identifying Non-Native Annual Grass Priority Restoration Areas

When firefighters construct wildland fire containment lines, they scrape away all vegetation, leaving swaths of disturbed bare ground that are susceptible to non-native annual grass domination. Many containment lines on the INL Site have not had any post-fire rehabilitation to stabilize the soil and restore native vegetation communities. Consequently, those areas, are often adjacent to relatively intact sagebrush and other native plant communities, and have the potential to become a vector for the spread of non-native annual grasses and thereby reduce sagebrush habitat value for sage-grouse.

Habitat loss due to dominance by non-native grasses, primarily cheatgrass, is a threat to sage-grouse across its range and on the INL Site (DOE and USFWS 2014). Cheatgrass domination generally follows the loss of native herbaceous species, resulting in an altered landscape in poor ecological condition and function for indefinite periods of time. This monitoring task was developed to reduce the threat of annual grasslands (DOE-ID and USFWS 2014). This task is currently outlined in three phases (Shurtliff et al. 2018) that ultimately address the goal of restoring healthy sagebrush communities in areas known to have been impacted by soil disturbance and cheatgrass invasion. The phases are to 1) delineate wildfire containment lines, 2) survey and prioritize potential cheatgrass treatment areas along a subset of mapped containment lines, and 3) propose a treatment plan to reduce the abundance of non-native annual grasses.

In Phase 1 (completed in 2016), we delineated a total of 847.4 km (526.5 mi) of bladed wildfire containment lines across the INL Site. For Phase 2, completed in 2017, we surveyed non-native annual grass occurrence and relative abundance within a subset of delineated wildfire containment lines and developed a prioritized list of potential cheatgrass treatment areas. Potential cheatgrass treatment areas were selected based on several criteria related to implementation logistics and likelihood of success. Ideally, plant communities selected for treatment would have abundant cheatgrass cover with a co-dominant native assemblage that could provide some residual native seed bank. Logistical characteristics important to the proposed restoration areas included travel time, road condition, and accessibility.

We surveyed 74 point locations across the southern portion of the INL Site. Of those locations, 34 (46 percent) were visually estimated to be abundant with cheatgrass. From point locations that had abundant cheatgrass cover, 23 (68 percent) had an associated native assemblage. The sites with abundant cheatgrass and a co-dominant native plant community were organized into two potential cheatgrass treatment areas (Figure 10-5) and these two potential treatment areas were prioritized based on access and logistics.

ESER will stay abreast of treatment options that are currently being tested region-wide (Phase 3) to reduce cheatgrass and improve native perennial cover. A proposed cheatgrass treatment(s) should be effective at decreasing cheatgrass cover, pose little risk to native plant communities, and be economical so that the project can be scaled to a meaningful level. Because cheatgrass control research is still primarily exploratory, there is no currently accepted standard restoration approach. This monitoring task will be suspended for the near-term, but as viable restoration approaches become available, the potential treatment areas identified in 2017 may be used to test new cheatgrass control techniques.

10.3.3 Sagebrush Habitat Restoration

In the CCA for the INL Site (DOE-ID and FWS 2014), DOE committed to minimize the impact of habitat loss due to wildland fire and firefighting activities by taking steps to hasten sagebrush reestablishment whenever a fire burns >40 hectares (>99 acres). Although no wildfires >40 hectares have burned on the INL Site since 2012, DOE has voluntarily initiated an annually recurring task to plant at least 5,000 sagebrush seedlings each fall in priority habitat restoration areas (DOE and FWS 2014, Section 9.4.4).

In 2014, sagebrush seeds were collected from a representative sample of stands across the INL Site. In 2015 and 2016, seeds were germinated and grown in greenhouses in 10-in3 conetainers, and each fall the seedlings were planted into the selected priority restoration area (Figure 10-6). Approximately 5,000 seedlings were planted in 2015 and nearly 6,000 seedlings were planted in 2016. Seedlings were planted at a rate of about 198 sagebrush/hectare (80 sagebrush/acre). The goal of planting at this rate isn't necessarily to replace sagebrush at natural densities across a few acres, but rather to establish a seed source to hasten sagebrush reestablishment across larger restoration areas. We moved the planting area in 2017 to a location within the Jefferson Fire burned area (Figure 10-6).

In order to monitor the survivorship of sagebrush using this rehabilitation approach, a subset of at least 10 percent of the planted seedlings are selected for monitoring one and five years after planting. Seedlings are relocated, if possible, and are ranked as healthy, stressed, or dead (Figure 10-7). To assess 2016 seedling survivorship and condition, we revisited 497 sagebrush seedlings in September 2017. We relocated 332 seedlings, of which 240 (48 percent) were healthy, 66 (13 percent) were stressed, and 26 (5 percent) were dead (Figure 10-7). Assuming that the 165 (33 percent) plants that we were unable to locate did not survive, a total of 62 percent of the seedlings survived the first year. For comparison, in 2016 we revisited 501 seedlings that had been planted the previous year and recorded 129 (26 percent) healthy, 238 (48 percent) stressed, 61 (12 percent) dead, and 73 (15 percent) missing (Figure 10-7). Assuming missing seedlings were dead, we concluded that one-year survivorship was 73 percent (Shurtliff et al. 2017).

The number of seedlings missed during the relocation survey increased dramatically from 2015 to 2016. Given the accuracy of our GPS units, it is likely that many of these missing seedlings did not survive, though we may have missed some live seedlings, especially if they were stressed and in areas with relatively high grass and forb cover. A conservative assessment would assume these 165 seedlings did not survive, increasing our estimate of seedling death from 5 percent to 38 percent. However, based on the fact that most of the relocated seedlings that were found were labeled healthy, it's possible that some were simply

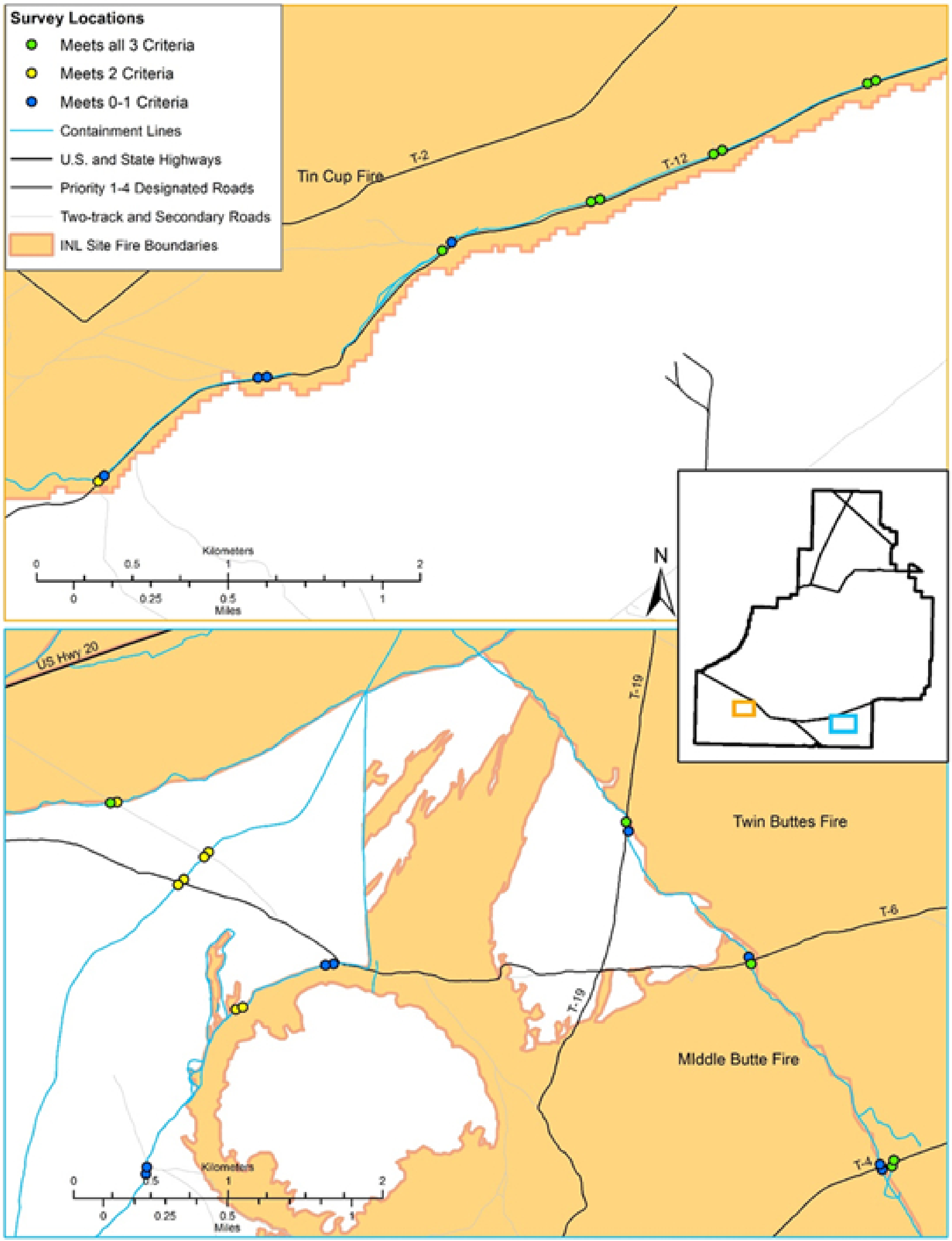

Figure 10-5. Two Potential Cheatgrass Treatment Areas are Displayed South of Highway 20/26 on INL Site with Wildfire Boundaries Shown in Light Orange. *The orange box is the primary potential treatment area. The blue box is the secondary potential treatment area. The green symbols reflect that three criteria, cheatgrass abundance, native species assemblage, and accessibility, have been met. The yellow symbols have two out of three criteria met and blue has one or none of the criteria met.*

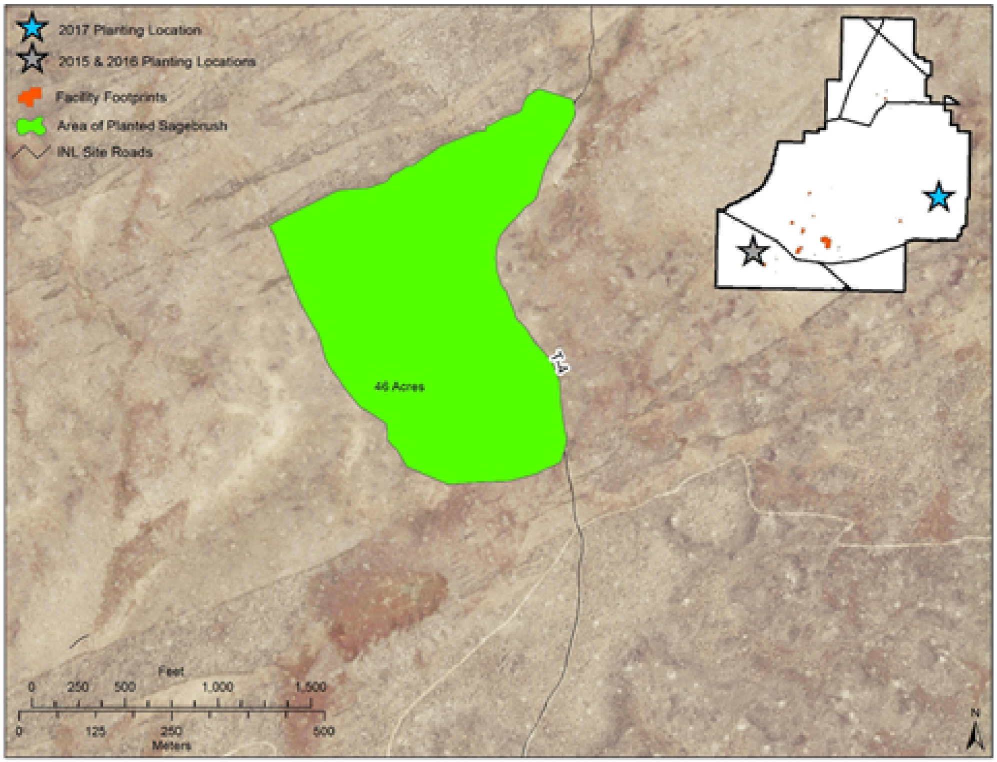

Figure 10-6. Areas Planted with Big Sagebrush Seedlings in 2017.
The star on the inset map shows the general location of the plantings.

Figure 10-7. Examples of Sagebrush Seedling Conditions. *From left to right: healthy, stressed, and dead.*

missed. ESER will revisit all locations again five years post-planting to refine estimates of survivorship and to evaluate the success of this project in hastening the return of sagebrush to the landscape.

In a review of 24 projects where containerized sagebrush seedlings were planted and survivorship was measured after one year, researchers reported first year survival of stock ranged from 14 percent to 94 percent (median = 59 percent, weighted average = 57 percent). Thus, sagebrush establishment following the 2016 planting on the INL Site was higher than average even when the missing plants were considered dead.

Young sagebrush plants experience the highest mortality during the first year (Dettweiler-Robinson et al. 2013), but favorable precipitation may have reduced first-year mortality of the 2016 planting. Precipitation patterns from fall 2016–fall 2017 were characteristic of a good recruitment year. From the fall of 2016–spring of 2017, most months had above average precipitation. The summer growing season was also above average.

10.4 Ecological Research at the Idaho National Environmental Research Park

10.4.1 Studies of Ants and Ant Guests at the INL Site

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Clark and Blom (2007) gave a list of ants found at the INL Site. This has given us a base to study some ecological relationships between some of the ant taxa at the INL Site and a variety of ant guests.

One such ant guest taxa, a desert beetle (Coleoptera: Tenebrionidae, *Philolithus elatus*) was collected in *Pogonomyrmex salinus* nests and is the subject of study and description (Clark et al. in prep). We have now taken photographs with light and scanning electron microscope, and we have observed a *Philolithus elatus* female ovipositing on a *Pogonomyrmex salinus* nest. The results will be published in Clark et al. (in prep) and have been presented in Clark et al. (2015). We are also working on a publication relating to past research at the INL Site involving cicadas and *Pogonomyrmex salinus* nests (Blom and Clark, in prep).

An undescribed species of Jerusalem cricket (Orthoptera: Stenopelmatidae, *Stenopelmatus* sp.) has been found at the INL Site. The *Stenopelmatus* was found in the ant nests during previous fieldwork. A series of live individuals, including both males and females, were needed for a proper species description. Live specimens were collected in July 2013, and additional specimens were collected during September 2014. In addition, one specimen was found in one of the excavated ant nests. They have been shipped to the specialist in the group for rearing and description. This relationship will require more study during future visits to the INL Site.

In addition, during 2015, we made field observations of predation on *Pogonomyrmex salinus*, and this turns out to be a different spider species as predator of the ant from what we have previously reported for the site (Clark and Blom 1992). The spider has since been identified as Xysticus, a member of the family Thomisidae (crab spiders). This family and genus are likely new records for the INL Site and are predators on *Pogonomyrmex salinus*.

During the 2016 field season, we continued research relating to the projects listed above. We observed many (most) nests of *Pogonomyrmex salinus* with small holes dug into them, presumably by heteromyid rodents (Figure 10-8). This interaction has been reported in the literature by Clark and Comanor (1973) for *Pogonomyrmex occidentalis*, but not yet reported for *Pogonomyrmex salinus*. These stores in ant nests may represent a significant food source for the rodents at INL.

Weather and logistical constraints precluded fieldwork in 2017; however, field research will continue into the foreseeable future.

Acknowledgments

Mary Clark assisted with the field work. Jim Berrian provided the spider identification. Bill Doering provided field access and other logistical assistance.

10.5 U.S. Geological Survey 2017 Publication Abstracts

In 1949, the USGS was asked to characterize water resources prior to the building of nuclear-reactor testing facilities at the INL Site. Since that time, USGS hydrologists and geologists have been studying the hydrology and geology of the ESRP and the ESRP aquifer.

At the INL Site and in the surrounding area, the USGS INL Project Office:

- Monitors and maintains a network of existing wells
- Drills new research and monitoring wells, providing information about subsurface water, rock, and sediment
- Performs geophysical and video logging of new and existing wells
- Maintains the Lithologic Core Storage Library.

Data gathered from these activities are used to create and refine hydrologic and geologic models of the aquifer, to track contaminant plumes in the aquifer, and

Figure 10-8. Typical Nest of the Harvester Ant, *Pogonomyrmex salinus* Olsen, at the Circular Butte Site at the Idaho National Laboratory Site, Showing Digging, Presumably by Heteromyid Rodents for Plant Seed Caches. ***W.H. Clark Photo. September 12, 2016.***

to improve understanding of the complex relationships between the rocks, sediments, and water that compose the aquifer. The USGS INL Project Office publishes reports about their studies, available through the USGS Publications Warehouse: http://id.water.usgs.gov/projects/INL/Pubs/index.html.

Four reports were published by the USGS INL Project Office in 2017. The abstracts of these studies and the publication information associated with each study are presented below.

10.5.1 An update of hydrologic conditions and distribution of selected constituents in water, eastern Snake River Plain aquifer and perched groundwater zones, Idaho National Laboratory, Idaho, emphasis 2012-15 (Bartholomay, R. C. et al., 2017)

Since 1952, wastewater discharged to infiltration ponds (also called percolation ponds) and disposal wells at the Idaho National Laboratory (INL) has affected water quality in the eastern Snake River Plain (ESRP) aquifer and perched groundwater zones underlying the INL. The U.S. Geological Survey (USGS), in cooperation with the U.S. Department of Energy, maintains groundwater-monitoring networks at the INL to determine hydrologic trends and to delineate the movement of radiochemical and chemical wastes in the aquifer and in perched groundwater zones. This report presents an analysis of water-level and water-quality data collected from the ESRP aquifer, multilevel monitoring system (MLMS) wells in the ESRP aquifer, and perched groundwater wells in the USGS groundwater monitoring networks during 2012–15.

From March–May 2011 to March–May 2015, water levels in wells completed in the ESRP aquifer declined in all wells at the INL. Water-level declines were largest in the northern part of the INL and smallest in the southwestern part.

Detectable concentrations of radiochemical constituents in water samples from wells or MLMS equipped wells in the ESRP aquifer at the INL generally decreased or remained constant during 2012–15. Decreases in concentrations were attributed to radioactive decay, changes in waste-disposal methods, and dilution from recharge and underflow.

In 2015, concentrations of tritium in groundwater from 49 of 118 ESRP aquifer wells were greater than or equal to the reporting level and ranged from 230±50 to 5,760±120 picocuries per liter. Tritium concentrations from one or more discrete zones from nine wells equipped with MLMS were greater than or equal to reporting levels in water samples collected at various depths. Tritium concentrations in deep perched groundwater at the Advanced Test Reactor Complex (ATR Complex) equaled or exceeded the reporting level in 13 wells during at least one sampling event during 2012–15, and concentrations ranged from 210±60 to 28,100±900 pCi/L.

Concentrations of strontium-90 in water from 18 of 67 ESRP aquifer wells sampled during April or October 2015 exceeded the reporting level. Strontium-90 was not detected in the ESRP aquifer beneath the ATR Complex. During at least one sampling event during 2012–15, concentrations of strontium-90 in water from 12 wells completed in deep perched groundwater at the ATR Complex equaled or exceeded the reporting levels and concentrations ranged from 1.8±0.6 to 73.6±2 pCi/L.

During 2012–15, concentrations of cesium-137 were less than the reporting level in all but eight ESRP aquifer wells, and concentrations of plutonium-238, plutonium-239, -240 (undivided), and americium-241 were less than the reporting level in water samples from all ESRP aquifer wells and all zones in wells equipped with MLMS.

In April 2009, the dissolved chromium concentration in water from one ESRP aquifer well, USGS 65, south of ATR Complex equaled the maximum contaminant level (MCL) of 100 μg/L. In April 2015, the concentration of chromium in water from that well had decreased to 72.8 μg/L, much less than the MCL. Concentrations in water samples from 62 other ESRP aquifer wells sampled ranged from <0.6 to 25.4 μg/L. During 2012–15, dissolved chromium was detected in water from all wells completed in deep perched groundwater at the ATR Complex, and concentrations ranged from 4.41 to 37 μg/L.

In 2015, concentrations of sodium in water from most ESRP aquifer wells in the southern part of the INL were greater than the western tributary background concentration of 8.3 milligrams per liter (mg/L). After the new percolation ponds were put into service in 2002 southwest of the Idaho Nuclear Technology and Engineering Center (INTEC), concentrations of sodium in water samples from the Rifle Range well increased steadily until 2008, when concentrations generally began decreasing. The increases and decreases were attributed to disposal variability in the new percolation ponds.

Concentrations of sodium in most wells equipped with MLMS generally varied little with depth. During 2012–15, dissolved sodium concentrations in water from 18 wells completed in deep perched groundwater at the ATR Complex ranged from 7.09 to 33.4 mg/L.

In 2015, concentrations of chloride in most water samples from ESRP aquifer wells south of the INTEC and at the Central Facilities Area exceeded the background concentrations. Chloride concentrations in water from wells south of the INTEC have generally decreased because of discontinued chloride disposal to the old percolation ponds since 2002 when discharge of wastewater was discontinued. After the new percolation ponds were put into service in 2002 southwest of the INTEC, concentrations of chloride in water samples from one well rose steadily until 2008 then began decreasing. Most of the concentrations in 11 MLMS wells are less than or near background concentrations for western tributary water at the INL. The zones from wells with greater than background concentrations represent influence from wastewater disposal. During 2012–15, dissolved chloride concentrations in deep perched groundwater from 18 wells at the ATR Complex ranged from 4.16 to 78.1 mg/L.

In 2015, sulfate concentrations in water samples from ESRP aquifer wells in the south-central part of the INL that exceeded the background concentration of sulfate ranged from 22 to 162 mg/L. The greater-than-background concentrations in water from these wells probably resulted from sulfate disposal at the ATR Complex infiltration ponds or the old INTEC percolation ponds. In 2015, sulfate concentrations in water samples from wells near the Radioactive Waste Management Complex (RWMC) were mostly greater than background concentrations and could have resulted from well construction techniques and (or) waste disposal at the RWMC or the ATR Complex. The vertical distribution of sulfate concentrations in multilevel monitoring wells near the southern boundary of the INL was generally consistent with depth and ranged between 17 and 28 mg/L. The maximum dissolved sulfate concentration in shallow perched groundwater near the ATR Complex was 175 mg/L in well CWP 3 in April 2012. During 2012–15, dissolved sulfate concentrations in water from 18 wells completed in deep perched groundwater at the ATR Complex ranged from 18.8 to 638 mg/L.

In 2015, concentrations of nitrate in water from most ESRP aquifer wells at and near the INTEC exceeded the western tributary background concentration of 0.655 mg/L. Concentrations of nitrate in wells southwest of INTEC and farther away from the influence of disposal areas and the Big Lost River show a general decrease in nitrate concentration through time. Two wells south of INTEC show increasing trends that could be the result of wastewater beneath the INTEC tank farm being mobilized to the aquifer.

During 2012–15, water samples from several ESRP aquifer wells were collected and analyzed for volatile organic compounds (VOCs). Eighteen VOCs were detected. At least 1 and up to 7 VOCs were detected in water samples from 14 wells. The primary VOCs detected include carbon tetrachloride, trichloromethane, tetrachloroethene, 1,1,1-trichloroethane, and trichloroethene. In 2015, concentrations for all VOCs were less than their respective MCL for drinking water, except carbon tetrachloride in water from two wells, trichloroethene in three wells and vinyl chloride in one well.

During 2012–15, variability and bias were evaluated from 54 replicate and 33 blank quality-assurance samples. Results from replicate analyses were investigated to evaluate sample variability. Constituents with acceptable reproducibility were major ions, nutrients, and VOCs. All radiochemical constituents and trace metals had acceptable reproducibility except for gross alpha- and beta-particle radioactivity, cesium-137, antimony, cobalt, iron and manganese. The samples that did not meet reproducibility criteria all had very small concentrations. Bias from sample contamination was evaluated from equipment, field, container, and source-solution blanks. Some of the constituents were found at small concentrations near reporting levels, but analyses indicate that no sample bias was likely for any of the sample periods.

10.5.2 Drilling, construction, geophysical log data, and lithologic log boreholes USGS 142 and USGS 142A, Idaho National Laboratory, Idaho (Twining, B. V. et al. 2017)

Starting in 2014, the U.S. Geological Survey in cooperation with the U.S. Department of Energy, drilled and constructed boreholes USGS 142 and USGS 142A for stratigraphic framework analyses and long-term groundwater monitoring of the eastern Snake River Plain aquifer at the Idaho National Laboratory in southeast Idaho. Borehole USGS 142 initially was cored to collect rock and sediment core, then re-drilled to complete construction as a screened water-level monitoring well. Borehole USGS 142A was drilled and constructed as a monitoring well after construction problems with borehole USGS 142 prevented access to upper 100 feet (ft) of the aquifer. Boreholes USGS 142 and USGS 142A are separated by about 30 ft and have similar geology and hydrologic characteristics. Groundwater was first measured near 530 feet below land surface (ft BLS) at both borehole locations. Water levels measured through piezometers, separated by almost 1,200 ft, in borehole USGS 142 indicate upward hydraulic gradients at this location. Following construction and data collection, screened water-level access lines were placed in boreholes USGS 142 and USGS 142A to allow for recurring water level measurements.

Borehole USGS 142 was cored continuously, starting at the first basalt contact (about 4.9 ft BLS) to a depth of 1,880 ft BLS. Excluding surface sediment, recovery of basalt, rhyolite, and sediment core at borehole USGS 142 was approximately 89 percent or 1,666 ft of total core recovered. Based on visual inspection of core and geophysical data, material examined from 4.9 to 1,880 ft BLS in borehole USGS 142 consists of approximately 45 basalt flows, 16 significant sediment and (or) sedimentary rock layers, and rhyolite welded tuff. Rhyolite was encountered at approximately 1,396 ft BLS. Sediment layers comprise a large percentage of the borehole between 739 and 1,396 ft BLS with grain sizes ranging from clay and silt to cobble size. Sedimentary rock layers had calcite cement. Basalt flows ranged in thickness from about 2 to 100 ft and varied from highly fractured to dense, and ranged from massive to diktytaxitic to scoriaceous, in texture.

Geophysical logs were collected on completion of drilling at boreholes USGS 142 and USGS 142A. Geophysical logs were examined with available core material to describe basalt, sediment and sedimentary rock layers, and rhyolite. Natural gamma logs were used to confirm sediment layer thickness and location; neutron logs were used to examine basalt flow units and changes in hydrogen content; gamma-gamma density logs were used to describe general changes in rock properties; and temperature logs were used to understand hydraulic gradients for deeper sections of borehole USGS 142. Gyroscopic deviation was measured to record deviation from true vertical at all depths in boreholes USGS 142 and USGS 142A.

10.5.3 U.S. Geological Survey geohydrologic studies and monitoring at the Idaho National Laboratory, southeastern Idaho (Bartholomay, R. C., 2017)

The U.S. Geological Survey (USGS) geohydrologic studies and monitoring at the Idaho National Laboratory (INL) is an ongoing, long-term program. This program, which began in 1949, includes hydrologic monitoring networks and investigative studies that describe the effects of waste disposal on water contained in the eastern Snake River Plain (ESRP) aquifer and the availability of water for long-term consumptive and industrial use. Interpretive reports documenting study findings are available to the U.S. Department of Energy (DOE) and its contractors; other Federal, State, and local agencies; private firms; and the public at https://id.water.usgs.gov/INL/Pubs/index.html. Information contained within these reports is crucial to the management and use of the aquifer by the INL and the State of Idaho. USGS geohydrologic studies and monitoring are done in cooperation with the DOE Idaho Operations Office.

10.5.4 Correlation between basalt flows and radiochemical and chemical constituents in selected wells in the southwestern part of the Idaho National Laboratory, Idaho (Bartholomay, R. C. et al., 2017)

Wastewater discharged to wells and ponds and wastes buried in shallow pits and trenches at facilities at the Idaho National Laboratory (INL) have contributed contaminants to the eastern Snake River Plain (ESRP) aquifer in the southwestern part of the INL. This report describes the correlation between subsurface stratigraphy in the southwestern part of the INL with information on the presence or absence of wastewater constituents to better understand how flow pathways in the aquifer control the movement of wastewater discharged at INL facilities. Paleomagnetic inclination was used to identify subsurface basalt flows based on similar inclination measurements, polarity, and stratigraphic position. Tritium concentrations, along with other chemical information for wells where tritium concentrations were lacking, were used as an indicator of which wells were influenced by wastewater disposal.

The basalt lava flows in the upper 150 feet of the ESRP aquifer where wastewater was discharged at the Idaho Nuclear Technology and Engineering Center (INTEC) consisted of the Central Facilities Area (CFA) Buried Vent flow and the AEC Butte flow. At the Advanced Test Reactor (ATR) Complex, where wastewater would presumably pond on the surface of the water table, the CFA Buried Vent flow probably occurs as the primary stratigraphic unit present; however, AEC Butte flow also could be present at some of the locations. At the Radioactive Waste Management Complex (RWMC), where contamination from buried wastes would presumably move down through the unsaturated zone and pond on the surface of the water table, the CFA Buried Vent; Late Basal Brunhes; or Early Basal Brunhes basalt flows are the flow unit at or near the water table in different cores.

In the wells closer to where wastewater disposal occurred at INTEC and the ATR-Complex, almost all the wells show wastewater influence in the upper part of the ESRP aquifer and wastewater is present in both the CFA Buried Vent flow and AEC Butte flow. The CFA Buried Vent flow and AEC Butte flow are also present in wells at and north of CFA and are all influenced by wastewater contamination. All wells with the AEC Butte flow present have wastewater influence and 83 percent of the wells with the more prevalent CFA Buried Vent flow have wastewater influence. South and southeast of CFA, most wells are not influenced by wastewater disposal and are completed in the Big Lost Flow and the CFA Buried Vent flow. Wells southwest of CFA are influenced by wastewater disposal and are completed in the Big Lost flow and CFA Buried Vent flow at the top of the aquifer. Basalt stratigraphy indicates that the CFA Buried Vent flow is the predominant flow in the upper part of the ESRP aquifer at and near the RWMC as it is present in all the wells in this area. The Late Basal Brunhes flow, Middle Basal Brunhes flow, Early Basal Brunhes flow, South Late Matuyama flow, and Matuyama flow are also present in various wells influenced by waste disposal.

Some wells south of RWMC do not show wastewater influence, and the lack of wastewater influence could be due to low hydraulic conductivities. Several wells south and southeast of CFA also do not show wastewater influence. Low hydraulic conductivities or ESRP subsidence are possible causes for lack of wastewater south of CFA.

Multilevel monitoring wells completed much deeper in the aquifer show influence of wastewater in numerous basalt flows. Well Middle 2051 (northwest of RWMC) does not show wastewater influence in its upper three basalt flows (CFA Buried Vent, Late Basal Brunhes, and Middle Basal Brunhes); however, wastewater is present in two deeper flows (the Matuyama and Jaramillo flows). Well USGS 131A (southwest of CFA) and USGS 132 (south of RWMC) both show wastewater influence in all the basalt flows sampled in the upper 600 feet of the aquifer. Wells USGS 137A, 105, 108, and 103 completed along the southern boundary of the INL all show wastewater influence in several basalt flows including the G flow, Middle and Early Basal Brunhes flows, the South Late Matuyama flow and the Matuyama flow; however, the strongest wastewater influence appears to be in the South Late Matuyama flow. The concentrations of wastewater constituents in deeper parts of these wells support the concept of groundwater flow deepening in the southwestern part of the INL.

Sego Lily

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11. Quality Assurance of Environmental Monitoring Programs

11. QUALITY ASSURANCE OF ENVIRONMENTAL MONITORING PROGRAMS

Quality assurance (QA) consists of planned and systematic activities that give confidence in effluent monitoring and environmental surveillance program results (NCRP 2012). Environmental monitoring programs should provide data of known quality for the assessments and decisions being made. This chapter describes specific measures taken to ensure adequate data quality and summarizes performance.

11.1 Quality Assurance Policy and Requirements

The primary policy, requirements, and responsibilities for ensuring QA in U.S. Department of Energy (DOE) activities are provided in:

- DOE Order 414.1D, "Quality Assurance"
- 10 Code of Federal Regulations (CFR) 830, Subpart A, "Quality Assurance Requirements"
- American Society of Mechanical Engineers NQA-1-2012, "Quality Assurance Requirement for Nuclear Facility Applications."

These regulations specify 10 criteria of a quality program, shown in the box to the right. Additional QA program requirements in 40 CFR 61, Appendix B, must be met for all radiological air emission sources continuously monitored for compliance with 40 CFR 61, Subpart H.

Each Idaho National Laboratory (INL) Site environmental monitoring organization incorporates QA requirements appropriate to its program to ensure that environmental samples are representative and complete and that data are reliable and defensible.

11.2 Program Elements and Supporting QA Processes

According to the National Council on Radiation Protection and Measurements (NCRP 2012), QA is an integral part of every aspect of an environmental monitoring program, from the reliability of sample collection through sample transport, storage, processing, and measurement, to calculating results and formulating the report. Uncertainties in the environmental monitoring process can lead to misinterpretation of data and/or errors in decisions based on these data. Every step in radiological effluent monitoring and environmental surveillance should be evaluated for integrity, and actions should be taken to evaluate and manage data uncertainty. These actions include proper planning, sampling and measurement, application of quality control (QC) procedures, and careful analysis of data used for decision making.

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

What is the difference between Quality Assurance and Quality Control in an environmental program?

- Quality Assurance (QA) is an integrated system of management activities designed to ensure quality in the processes used to produce environmental data. The goal of QA is to improve processes so that results are within acceptable ranges.
- Quality Control (QC) is a set of activities that provide program oversight (i.e., a means to review and control the performance of various aspects of the QA program). QC provides assurance that the results are what is expected.

11.2 INL Site Environmental Report

The main elements of environmental monitoring programs implemented at the INL Site, as well as the QA processes/activities that support them, are shown in Figure 11-1 and are discussed below. Summaries of program-specific QC data are presented in Section 11.3. Documentation of the QA programs is provided in Section 11.4.

11.2.1 Planning

Environmental monitoring activities are conducted by a variety of organizations including:

- Idaho National Laboratory (INL)
- Idaho Cleanup Project (ICP) Core
- Environmental Surveillance, Education, and Research (ESER) Program
- U.S. Geological Survey (USGS)
- National Oceanic and Atmospheric Administration.

Each INL Site monitoring organization determines sampling requirements using the U.S. Environmental Protection Agency (EPA) Data Quality Objective (DQO) process (EPA 2006) or its equivalent. During this process, the project manager determines the type, amount, and quality of data needed to meet regulatory requirements, support decision making, and address stakeholder concerns.

Environmental Monitoring Plan. The *Idaho National Laboratory Site Environmental Monitoring Plan* (DOE-ID 2014) summarizes the various programs at the INL Site. It describes routine compliance monitoring of airborne and liquid effluents; environmental surveillance of air, water (surface, drinking, and ground), soil, biota, agricultural products, and external radiation; and ecological and meteorological monitoring on and near the INL Site. The plan includes the rationale for monitoring, the types of media monitored, where the monitoring is conducted, and information regarding access to analytical results.

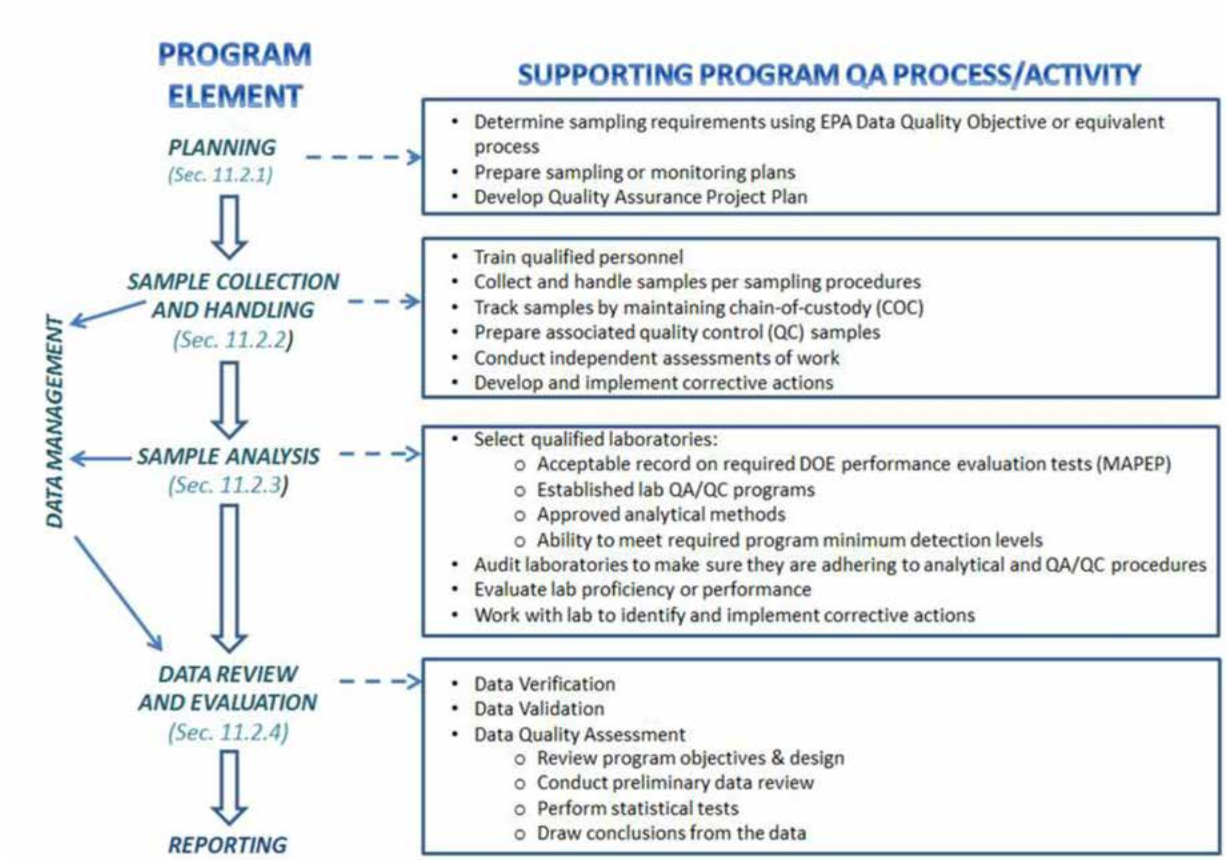

Figure 11-1. Flow of Environmental Monitoring Program Elements and Associated QA Processes and Activities.

Quality Assurance Project Plan. Implementation of QA elements for sample collection and data assessment activities are documented by each monitoring contractor using the approach recommended by the EPA. The EPA policy on QA plans is based on the national consensus standard ANSI/ASQC E4-1994, "Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs." The EPA approach to data quality centers on the DQO process. DQOs are project dependent and are determined on the basis of the data users' needs and the purpose for which data are generated. Quality elements applicable to environmental monitoring and decision making are specifically addressed in *EPA Requirements for Quality Assurance Project Plans* (EPA QA/R-5) (EPA 2001). These elements are categorized as follows:

- Project management
- Data generation and acquisition
- Assessment and oversight
- Data validation and usability.

A QA Project Plan documents the planning, implementation, and assessment procedures for a particular project, as well as any specific QA and QC activities. It integrates all the technical and quality aspects of the project in order to provide a "blueprint" for obtaining the type and quality of environmental data and information needed for a specific decision or use. Each environmental monitoring and surveillance program at the INL Site prepares a QA Project Plan.

11.2.2 Sample Collection and Handling

Strict adherence to program procedures is an implicit foundation of QA. In 2017, samples were collected and handled according to documented program procedures. Samples were collected by personnel trained to collect and properly process samples. Sample integrity was maintained through a system of sample custody records. Assessments of work execution were routinely conducted by personnel independent of the work activity, and deficiencies were addressed by corrective actions, which are tracked in contractor-maintained corrective action tracking systems.

QC samples were also collected or prepared to check the quality of sampling processes. They included the collection of trip blanks, field blanks, split samples, and field duplicates, which are defined as follows:

Trip Blank. A sample of analyte-free media taken from the sample preparation area to the sampling site and returned to the analytical 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.

Field Blank. A clean, analyte-free sample that is carried to the sampling site and then exposed to sampling conditions, returned to the laboratory, and treated as an environmental sample. A field blank is collected to assess the potential introduction of contaminants during sampling, storage, and transport.

Split Sample. A sample collected and later divided from the same container into two portions that are analyzed separately. Split samples are used to assess precision.

Field Replicates (duplicates or collocated samples). Two samples collected from a single location at the same time, stored in separate containers, and analyzed independently. In the case of air sampling, two air samplers are placed side by side and each filter is analyzed separately. Duplicates are useful in documenting the precision (defined in the box on the right) of the sampling process. Field duplicates also provide information on analytical variability caused by sample heterogeneity, collection methods, and laboratory procedures (see Section 11.2.3).

11.2.3 Sample Analysis

Analytical laboratories used to analyze environmental samples collected on and off the INL Site are presented in Table 11-1.

Laboratories used for routine analyses of radionuclides in environmental media were selected by each monitoring program based on each laboratory's capabilities to meet program objectives (such as ability

Precision

Precision is a measure of mutual agreement among individual measurements of the same property.

Results obtained from analyses of split or duplicate samples are compared and precision is expressed as standard deviation, variance, or range.

Table 11-1. Analytical Laboratories Used by INL Site Contractors and USGS Environmental Monitoring Programs.

Contractor and Program	Laboratory	Type of Analysis
ICP Core Drinking Water Program	GEL Laboratories, LLC	Radiological
	Intermountain Analytical Service – EnviroChem	Microbiological
	Eurofins Eaton Analytical, Inc.	Inorganic and organic
ICP Core Environmental Program	ALS Laboratory Group – Fort Collins	Radiological
ICP Core Liquid Effluent Monitoring Program	Intermountain Analytical Service – EnviroChem	Microbiological
	GEL Laboratories, LLC	Inorganic and radiological
ICP Core Groundwater Monitoring Program	Intermountain Analytical Service – EnviroChem	Microbiological
	GEL Laboratories, LLC	Inorganic, organic, and radiological
	Southwest Research Institute	Inorganic, organic, and radiological
INL Drinking Water Program	GEL Laboratories, LLC	Radiological
	Intermountain Analytical Service – EnviroChem	Inorganic
	Teton Microbiology Laboratory of Idaho Falls	Bacterial
	Eurofins Eaton Analytical, Inc.	Organic
INL Liquid Effluent and Groundwater Program	GEL Laboratories, LLC	Radiological and inorganic
INL Environmental Surveillance Program	ALS Laboratory Group – Fort Collins	Radiological
	Environmental Services In Situ Gamma Laboratory	^{131}I
	Landauer, Inc.	Penetrating radiation (OSL and neutron dosimeters)
Environmental Surveillance, Education, and Research Program	Environmental Assessments Laboratory (EAL) at Idaho State University (ISU) – Pocatello, ID	Gross radionuclide analyses (gross alpha and gross beta), OSL dosimetry, liquid scintillation counting (tritium), and gamma spectrometry
	Oak Ridge Associated Universities (ORAU) – Radiological and Environmental Analytical Laboratory (REAL) – Oak Ridge, TN	Specific radionuclides (e.g. ^{90}Sr, ^{241}Am, ^{238}Pu, and $^{239/240}Pu$)
	GEL Laboratories, LLC – Charleston, SC	Specific radionuclides (e.g. ^{90}Sr, ^{241}Am, ^{238}Pu, and $^{239/240}Pu$) and gamma spectrometry.
U.S. Geological Survey	DOE's Radiological and Environmental Sciences Laboratory	Radiological
	USGS National Water Quality Laboratory	Nonradiological and low-level tritium and stable isotopes
	Purdue Rare Isotope Measurement Laboratory	Low-level ^{129}I
	GEL Laboratories	Radiological and nonradiological for the USGS Naval Reactors Facility sample program
	Test America Laboratories	Semi-volatile and volatile organic compounds for the USGS Naval Reactors Facility sample program

to meet required detection limits) and past results in performance evaluation programs, such as the Mixed Analyte Performance Evaluation Program (MAPEP) described in Section 11.3.1. Continued acceptable performance in programs such as MAPEP is required to remain as the contracted laboratory.

Each laboratory is audited as follows:

- Contracting environmental monitoring program personnel check adherence to laboratory and QA procedures
- DOE Consolidated Audit Program (DOECAP) audits laboratories used by the INL and ICP contractors.

DOECAP uses trained and certified personnel to perform in-depth audits of subcontract laboratories to review the following:

- Personnel training and qualification
- Detailed analytical procedures
- Calibration of instrumentation
- Participation in an inter-comparison program
- Use of blind controls
- Analysis of calibration standards.

Laboratories are required to provide corrective action plans for audit findings and are closed when DOECAP approves the corrective action plan.

Laboratory data quality is continually verified by internal laboratory QA/QC programs, participation in inter-laboratory crosschecks, replicate sampling and analysis, submittal of blind standard samples and blanks, and splitting samples with other laboratories.

Performance evaluation samples and blind spikes are used to measure accuracy (defined in box at right) and are described as follows:

Performance Evaluation Sample or Blind spike used to assess the accuracy of the analytical laboratory. A known quantity of material, radionuclides, or nonradioactive substances are incorporated into a sample in order to evaluate the laboratory's ability to detect. These samples are typically traceable to National Institute of Standards and Technology (NIST) requirements. Samples are submitted to the laboratory with regular field samples using the same labeling and sample numbering system, or they can be submitted by a third party directly to evaluate the performance of the laboratory. The MAPEP is an example of this (see Section 11.3.1). The analytical results are expected to compare to the known value within a set of performance limits. Blind spikes are generally used to establish intra-laboratory or analyst-specific precision and accuracy or to assess the performance of all or a portion of the measurement system. A double blind spike is a sample with concentration and identity unknown to both the submitter and the analyst.

Accuracy

Accuracy refers to the degree of agreement between a measured value and an accepted reference or true value. Two principal attributes of accuracy are precision and systematic error (bias). An accurate measurement is achieved with high precision and low systematic error (bias). Accuracy is monitored by performing measurements and evaluating results of control samples containing known quantities of the analytes of interest (performance evaluation sample or blind spike).

11.2.4 Data Review and Evaluation

Data generated from environmental monitoring or surveillance programs are evaluated in order to understand and sustain the quality of data. This allows the program to determine if the monitoring objectives established in the planning phase were achieved and determine if the laboratory is performing within QA/QC requirements.

An essential component of data evaluation is the availability of reliable, accurate, and defensible records for all phases of the program, including sampling, analysis, and data management.

Environmental data are subject to data verification, data validation, and data quality assessment. These terms are discussed below:

Data Verification. The act of reviewing, inspecting, testing, checking, auditing, or otherwise determining and documenting whether items, processes, services, or documents conform to specified requirements. The data verification process involves checking for common errors associated with analytical data. A review is first conducted to ensure all data and sample documentation are present and complete. In addition, the following may be reviewed: sample preservation and temperature, defensible chain-of-custody documentation and integrity, analytical hold-time compliance, correct test method, adequate analytical recovery, correct minimum detection limit, possible cross-contamination, and matrix interference (i.e., analyses affected by dissolved inorganic/organic materials in the matrix).

Data Validation. Confirmation by examination and provision of objective evidence that the particular requirements for a specified intended use are fulfilled. Validation involves a more extensive process than data verification, according to the *DOE Handbook – Environmental Radiological Monitoring and Environmental Surveillance* (DOE 2015).

Validation confirms that the required number of samples and types of data were collected in accordance with the sampling/monitoring plan; confirms the usability of the data for the intended end use via validation of analyses performed and data reduction and reporting; and ensures requirements were met such as detection limits, QC measurements, impacts of qualifiers, etc.

Data Quality Assessment. Data quality assessment includes reviewing data for accuracy, representativeness, and fit with historical measurements to ensure that the data support their intended uses. A preliminary data assessment is also performed to determine the structure of the data (i.e., distribution of data [normal, lognormal, exponential, or nonparametric]); identify relationships/associations, trends, or patterns between sample points/variables or over time; identify anomalies; and select the appropriate statistical tests for decision making.

11.3 Quality Control Results for 2017

Results of the QC measurements for specific DOE contracted environmental programs in 2017 are summarized in the following sections. The programs include results of the MAPEP proficiency tests as well as individual program QC sample data, including the use of duplicates, split samples, spiked samples, and blank analyses.

11.3.1 Mixed Analyte Performance Evaluation Program Proficiency Tests

The MAPEP is administered by DOE's Radiological and Environmental Sciences Laboratory (RESL). RESL conducts the MAPEP using a performance-based performance evaluation program that tests the ability of the laboratories to correctly analyze for radiological, nonradiological, stable organic, and inorganic constituents representative of those at DOE sites. RESL maintains the following accreditation certifications through the American Association for Laboratory Accreditation:

- International Organization for Standardization (ISO) 17043 (2377.02) as a Performance Testing Provider
- ISO 17025 (2377.01) as a Chemical Testing Laboratory
- ISO G34 (2377.03) as a Reference Material Producer by the American Association for Laboratory Accreditation.

The DOE RESL participates in a Radiological Traceability Program administered through NIST. The RESL prepares requested samples for analysis by NIST to confirm their ability to adequately prepare sample material to be classified as NIST traceable. NIST also prepares several alpha-, beta-, and gamma-emitting standards in all matrix types for analysis by the RESL to confirm their analytical capabilities. The RESL maintains NIST certifications in both preparation of performance evaluation material and analysis of performance evaluation samples on an annual basis. For further information on the RESL participation in the Radiological Traceability Program, visit www.id.energy.gov/resl/rtp/rtp.html.

MAPEP distributes samples of air filter, water, vegetation, and soil for radiological analysis during the first and third quarters. Series 36 was distributed in February 2017, and Series 37 was distributed in August 2017. Both radiological and nonradiological constituents are included in MAPEP. Results can be found at www.id.energy.gov/resl/mapep/mapepreports.html.

MAPEP laboratory results may include the following flags:

- A = Result acceptable, bias ≤ 20 percent
- W = Result acceptable with warning, 20 percent < bias < 30 percent
- N = Result not acceptable, bias > 30 percent
- L = Uncertainty potentially too low (for information purposes only)
- H = Uncertainty potentially too high (for information purposes only)
- QL = Quantitation limit

- RW = Report warning
- NR = Not reported.

MAPEP issues a letter of concern to a laboratory for sequential unresolved failures to help the laboratory identify, investigate, and resolve potential quality issues (www.id.energy.gov/resl/mapep/MAPEP-HB-1 Rev 1.pdf). A letter of concern is issued to any participating laboratory that demonstrates:

- "Not Acceptable" performance for a targeted analyte in a given sample matrix for the two most recent test sessions (e.g., plutonium-238 [^{238}Pu] in soil test 13 "+N" [+36 percent bias], ^{238}Pu in soil test 14 "-N" [-43 percent bias])

  "Not Acceptable" performance for a targeted analyte in two or more sample matrices for the current test session (e.g., cesium-137 [^{137}Cs] in water test 14 "+N" [+38 percent], ^{137}Cs in soil test 14 "+N" [+45 percent])
- Consistent bias, either positive or negative, at the "Warning" level (greater than ± 20 percent bias) for a targeted analyte in a given sample matrix for the two most recent test sessions (e.g., strontium-90 [^{90}Sr] in air filter test 13 "+W" [+26 percent], ^{90}Sr in air filter test 14 "+W" [+28 percent])
- Quality issues (flags other than "Acceptable") that were not identified by the above criteria for a targeted analyte in a given sample matrix over the last three test sessions (e.g., americum-241 [^{241}Am] in soil test 12 "-N" [-47 percent], ^{241}Am in soil test 13 "+W" [+24 percent], ^{241}Am in soil test 14 "-N" [-38 percent])
- Any other performance indicator and/or historical trending that demonstrate an obvious quality concern (e.g., consistent "false positive" results for ^{238}Pu in all tested matrices over the last three test sessions). NOTE: The above are examples for information purposes.

A more detailed explanation on MAPEP's quality concerns criteria can be found at www.id.energy.gov/resl/mapep/data/mapep_loc_final_4.pdf.

In 2017, each radiological laboratory used by the INL, ICP Core, and ESER contractors participated in the 2017 MAPEP Series 36 (February 2017) and 37 (August 2017). The laboratories evaluated were ALS-Fort Collins (ALS-FC), Oak Ridge Associated Universities – Radiological and Environmental Analytical Laboratory (ORAU-REAL), Idaho State University-Environmental Assessment Laboratory (ISU-EAL), GEL Laboratories, LLC (GEL), and Test America, Inc. St Louis. The results of the MAPEP tests, as they pertain to the INL Site environmental programs, are presented below by laboratory.

ALS-Fort Collins. ALS is located in Fort Collins, Colorado. The INL and ICP Core contractors used ALS-FC for their surveillance programs. The isotopic analytes of common interest to the INL and ICP Core surveillance programs include: ^{90}Sr, ^{241}Am, ^{238}Pu, and plutonium-239/240 ($^{239/240}$Pu). Ambient air samples collected by the INL and ICP Core contractors were also analyzed by ALS-FC for gross alpha/beta and for gamma-emitting radionuclides, such as ^{241}Am, cobalt-60 (^{60}Co), cesium-134 (^{134}Cs), cesium-137 (^{137}Cs), europium-152 (^{152}Eu), and antimony-125 (^{125}Sb). The same isotopic analytes and gamma-emitting radionuclides were analyzed for surface water and vegetation samples collected by the ICP Core.

For MAPEP Series 36 and 37, all analytes of interest in air filters were acceptable. All analytes of interest in vegetation were acceptable except for ^{238}Pu, which received a "W" flag in Series 36, but in Series 37 an "A" flag was received. All analytes of interest in water were acceptable for both Series 36 and 37. The MAPEP results for these INL and ICP Core programs reported by ALS-FC do not demonstrate any issues of concern for the 2017 data. The programs will continue to monitor the MAPEP results to determine if any trends warrant further action.

Oak Ridge Associated Universities – Radiological and Environmental Analytical Laboratory (ORAU-REAL). The ORAU-REAL is located in Oak Ridge, Tennessee. The ESER contractor used ORAU-REAL for all sample medias including: ambient air samples, milk (^{90}Sr only), and agricultural (^{90}Sr only) samples. ESER analytes of interest include: ^{90}Sr, ^{241}Am, ^{238}Pu, and $^{239/240}$Pu. The ORAU-REALwas closed in March 2018 and did not analyze the fourth quarter air samples or waterfowl samples. These samples were analyzed by GEL Laboratories, LLC.

All analytes of interest were acceptable for MAPEP Series 36 and 37. The MAPEP results do not demonstrate any issues of concern for the 2017 data reported by ORAU-REAL. The laboratory has ceased operations and will no longer be monitored.

Idaho State University Environmental Assessment Laboratory (ISU-EAL). The ISU-EAL is located in Pocatello, Idaho. The ESER contractor uses ISU-EAL to analyze samples for the following analytes of interest: tritium (^{3}H), gross alpha and gross beta, and multiple gamma spectroscopy radioisotopes.

All analytes of interest were acceptable for MAPEP Series 36 and 37. The MAPEP results do not demonstrate any issues of concern for the 2017 data reported by ISU-EAL. The ESER contractor will continue to monitor the MAPEP results to determine if any trends warrant further action.

GEL Laboratories, LLC. The INL and ICP Core drinking water, liquid effluent, soil, and groundwater monitoring programs used GEL in Charleston, South Carolina, for inorganic, organic, and radiological analysis of samples.

The MAPEP Series 36 and 37 flag results for GEL were:

- MAPEP Series 37 – Air Filter – "W" (Acceptable with Warning) for ^{90}Sr
- MAPEP Series 37 – Vegetation –"W" (Acceptable with Warning) for ^{90}Sr
- All other analytes of interest were "A" (Acceptable) for both Series 36 and 37.

The MAPEP results for these INL and ICP Core programs reported by GEL do not demonstrate any issues of concern for the 2017 data.

Southwest Research Institute. The ICP Core groundwater monitoring programs used Southwest Research Institute in San Antonio, Texas, for inorganic, organic, and radiological analysis of samples. All analytes of interest were acceptable for MAPEP Series 36 and 37 for Southwest Research Institute, except for the following:

- MAPEP Series 36 – "N" for ^{134}Cs which resulted in a false positive
- MAPEP Series 37 – "W" for radium-226 (^{226}Ra).

For all results reported by Southwest Research Institute, no issues of concern for the 2017 data were demonstrated.

11.3.2 Environmental Program Sample QC Results

Each INL Site contractor evaluates the overall effectiveness of its QA program through management and independent assessments. These assessments include measurement of data quality, including:

- ***Field duplicate analysis (precision)*** – Precision, as determined by analyses of field duplicate sample, is estimated using the relative percent difference (RPD) between the field duplicate result and the corresponding field sample result and 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). An RPD of zero indicates a perfect duplication of results.
- ***Performance evaluation (PE) analysis (accuracy)*** – Accuracy is calculated by dividing the measured value by the known concentration in the spiked sample. A ratio of one indicates a completely accurate measure of a PE sample.
- ***Blank sample analysis*** – Field blank sample analyses are essentially the opposite of PE analyses. Results of these analyses are expected to be "zero" or more accurately below the minimum detectable concentration of a specific procedure. Any positive measurement may indicate the introduction of contamination.

The following sections provide brief discussions and summary tables of the 2017 QC results for field duplicates, PE samples, and blank analyses. Each discussion also addresses program completeness—the number of samples collected and analyzed expressed as a percentage of that required. Ideally, all (i.e., 100 percent) samples should be collected and analyzed.

11.3.2.1 Liquid Effluent and Groundwater Monitoring Program Quality Control Data

INL Contractor

The INL contractor Liquid Effluent Monitoring (LEMP) and Groundwater Monitoring Programs have specific QA/QC objectives for analytical data. Table 11-2 presents a summary of 2017 LEMP Groundwater Monitoring Programs QC criteria and performance results.

Table 11-2. 2017 INL LEMP, Groundwater Monitoring Program, and Drinking Water Program QA/QC Criteria and Performance.

Liquid Effluent Monitoring Program	Criterion	2017 Performance
Completeness		
Compliance Samples Successfully Collected	100 percent	100 percent
Compliance Samples Successfully Analyzed	100 percent	100 percent
Surveillance Samples Collected and Successfully Analyzed	100 percent	100 percent
Precision		
Field Duplicates	Performed at each facility location	
Field Blanks	Engineering and administrative controls applied to mitigate contamination	
Accuracy		
Performance Evaluation Samples		
Groundwater Monitoring Program	**Criterion**	**2017 Performance**
Completeness		
Compliance Samples Successfully Collected	100 percent	100 percent
Compliance Samples Successfully Analyzed	100 percent	100 percent
Surveillance Samples Collected and Successfully Analyzed	100 percent	100 percent
Precision		
Field Duplicates	Performed at each facility location	
Field Blanks	Engineering and administrative controls applied to mitigate contamination	
Accuracy		
Performance Evaluation Samples		
INL Drinking Water Monitoring Program	**Criterion**	**2017 Performance**
Completeness		
Compliance Samples Successfully Collected	100 percent	100 percent
Compliance Samples Successfully Analyzed	100 percent	100 percent
Surveillance Samples Collected and Successfully Analyzed	90 percent	99 percent
Precision		
Field Duplicates	90 percent	100 percent
Field Blanks	90 percent	100 percent
Accuracy		
Performance Evaluation Samples Note: 17 out of 176 samples were QA/QC.	90 percent	100 percent

Completeness – Collection and Analysis. The goal for completeness is to collect 100 percent of all required compliance samples. This goal was met in 2017.

Precision – Field Duplicates. Field duplicates are collected annually at each sample location, or 10 percent of the total samples collected, in order to assess measurement uncertainty and variability caused by sample heterogeneity and collection methods. In 2017, field duplicates were collected at the Advanced Test Reactor Complex Cold Waste Pond, Middle-1823, Materials and Fuels Complex Industrial Waste Pipeline, Ditch C, and the Industrial Waste Water Pond, and Well ANL-MON-A-11 at the Materials and Fuels Complex.

The INL contractor LEMP and Groundwater Monitoring Program (GWMP) requires that the RPD from field duplicates be less than or equal to 35 percent for 90 percent of the analyses. In 2017, these goals were met.

Accuracy – Performance Evaluation Samples. Accuracy of results was assessed using the laboratory's control samples, initial and continuing calibration samples, and matrix spikes. Additional performance evaluation samples (prepared by RESL) were submitted to the laboratory and analyzed for radiological constituents. The results for the spiked constituents were mostly in agreement with the known spiked concentrations.

Precision – Field Blank Samples. Engineering and administrative controls, including dedicated equipment and administrative scheduling, were implemented to control introduced contamination into the samples.

ICP Core Contractor

The ICP Core contractor has QA/QC objectives for analytical data. Goals are established for completeness, precision, and accuracy, and all analytical results are validated following standard EPA protocols. Three types of LEMP QC samples are submitted for analysis: field duplicates, equipment rinsates, and performance evaluation samples. Table 11-3 presents a summary of 2017 QC criteria and performance results.

Completeness – Collection and Analysis. The ICP Core LEMP goal for completeness was to collect and successfully analyze 100 percent of all permit-required compliance samples. This goal was not met in 2017. The permit required a total of 331 parameters to be collected and analyzed during the year. However, the CPP-773 biochemical oxygen demand sample was not collected in January 2017 due to weather conditions and sample shipment issues. The other 330 sample parameters were collected, submitted for analysis, and successfully analyzed. The results are provided in the 2017 Wastewater Reuse Report (ICP 2018) and summarized in Tables C-3, C-4, and C-5.

The goal for completeness was to collect and successfully analyze 90 percent of the LEMP surveillance samples. This goal was exceeded in 2017, because 100 percent of the samples were collected and analyzed. A total of 350 sample parameters were collected, and 350 parameters were successfully analyzed. The results are provided in Table C-15.

Precision – Field Duplicate Samples. To quantify measurement uncertainty from field activities, a nonradiological field duplicate sample is collected annually at CPP-769, CPP-773, and CPP-797 and analyzed for the permit-specific parameters. The RPD between the sample result and the field duplicate sample result (using only parameters with two detectable quantities) should be 35 percent or less for 90 percent of the parameters analyzed. Field duplicate samples were collected at CPP-769, CPP-773, and CPP-797 on March 15, 2017. Eighty-eight percent of the results had an RPD of less than or equal to 35 percent. This is a marked improvement from last year's value and ICP Core will continue to implement improvements in this area of the sampling program. This precision value had no negative impact to data usability.

A radiological field duplicate sample is collected annually at CPP-773 and CPP-797 and analyzed for gross alpha, gross beta, total strontium activity, and gamma spectrometry. The mean difference determined from the sample result and the field duplicate sample result (using two statistically positive results) should be less than or equal to three for 90 percent of the parameters. A radiological field duplicate sample was collected from CPP-773 on March 23, 2017. Of the 24 parameters analyzed, only gross beta had two statistically positive results. The mean difference was calculated to be 0.28, which was less than 3. A radiological field duplicate sample was collected from CPP-797 on November 1, 2017. Of the 25 parameters analyzed, only gross beta had two statistically positive results. The mean difference was calculated to be 0.28, which was less than 3.

Table 11-3. 2017 ICP Core LEMP, Wastewater Reuse Permit Groundwater Monitoring Program, and Drinking Water Program QA/QC Goals and Performance.

ICP Core Liquid Effluent Monitoring Program	Criterion	2017 Performance
Completeness		
Compliance samples successfully collected	100 percent	99.7 percent
Compliance samples successfully analyzed	100 percent	99.7 percent
Surveillance samples collected and successfully analyzed	90 percent	100 percent
Precision		
Field duplicates	90 percent	88 percent
Equipment rinsates	90 percent	63 percent
Field blanks	90 percent	83 percent
Accuracy		
Performance evaluation samples	90 percent	80 percent
ICP Core WRP Groundwater Monitoring Program	**Criterion**	**2017 Performance**
Completeness		
Compliance samples successfully collected	100 percent	100 percent
Compliance samples successfully analyzed	100 percent	100 percent
Surveillance samples collected and successfully analyzed	90 percent	100 percent
Precision		
Field duplicates	90 percent	89 percent
Equipment rinsates	90 percent	85 percent
Field blanks	90 percent	83 percent
Accuracy		
Performance evaluation samples	90 percent	90 percent
ICP Core Drinking Water Monitoring Program	**Criterion**	**2017 Performance**
Completeness		
Compliance samples successfully collected	100 percent	100 percent
Compliance samples successfully analyzed	100 percent	100 percent
Surveillance samples collected and successfully analyzed	90 percent	100 percent
Precision		
Field duplicates	90 percent	71 percent
Field blanks	90 percent	100 percent
Trip blanks	90 percent	100 percent
Accuracy		
Performance evaluation samples	90 percent	94 percent

WRP = Wastewater Reuse Permit

Accuracy – Performance Evaluation Samples. During 2017, performance evaluation samples were submitted to the laboratory with routine wastewater monitoring samples on December 13, 2017. Eighty percent of the results were within their QC performance acceptance limits, which was less than the program goal of 90 percent. ICP Core will continue to work with the analytical laboratories to improve this value.

Introduction of Contamination – Field Blank Samples. A field blank was collected on September 27, 2017. A total of 12 parameters were analyzed, and 10 of these parameters were not detected. Chloride and total phosphorus were detected. Since chlorides and total phosphorus are not typical site contaminants that would be introduced during sample collection, storage, or transportation activities, these analytical detections do not negatively impact data usability.

Decontamination – Equipment Rinsate Samples. Equipment rinsate samples are collected annually and are used to evaluate the effectiveness of equipment decontamination. On June 14, 2017, a sample carboy associated with CPP-797 was decontaminated by the Idaho Nuclear Technology and Engineering Center licensed wastewater operators. After decontamination, deionized water was added to the carboy, and the rinsate samples were collected by LEMP personnel. A total of eight parameters were analyzed, and five of those parameters were not detected. However, three parameters, chloride (0.0679 mg/L), total phosphorus (0.0304 mg/L), and total dissolved solids (14.3 mg/L), were detected. ICP Core will investigate the use of engineering and administrative controls, including dedicated and disposable equipment, to control introduction of contamination into the wastewater samples.

11.3.2.2 Idaho Cleanup Project Contractor Wastewater Reuse Permit Groundwater Monitoring Quality Control Data

The ICP Core contractor Wastewater Reuse Permit (WRP) GWMP has specific QA/QC objectives for analytical data. Goals are established for completeness, precision, and accuracy, and all analytical results are validated following standard EPA protocols. Four types of QC samples are submitted for analysis: field duplicates, field blanks, equipment rinsates, and performance evaluation samples. Table 11-3 presents a summary of 2017 WRP GWMP QC criteria and performance results.

Completeness – Collection and Analysis. The goal for completeness was to collect and successfully analyze 100 percent of all required compliance samples. This goal was met in 2017. A total of 240 sample parameters were collected and submitted for analysis, and 240 parameters were successfully analyzed. The results are provided in Tables C-7 and C-8 and summarized in the 2017 Wastewater Reuse Report (ICP 2018).

The goal for completeness was to collect and successfully analyze 90 percent of the WRP GWMP surveillance samples. This goal was exceeded in 2017. Sixteen parameters, or 100 percent, were collected and successfully analyzed. The results are provided in Table C-16.

Precision-Field Duplicate Samples. To quantify measurement uncertainty from field activities, nonradiological field duplicate samples are collected semiannually and analyzed for the permit-specific parameters. The RPD between the sample result and the field duplicate sample result (using only parameters with two detectable quantities) should be 35 percent or less for 90 percent of the parameters analyzed. Field duplicate samples were collected from Well ICPP-MON-A-165 on April 4, 2017, and from Well ICPP-MON-A-166 on September 13, 2017. Eighty-nine percent of the results had an RPD of less than or equal to 35 percent. This is an improvement from last year's value and ICP Core will continue to implement improvements in this area of the sampling program. This precision value had no negative impact to data usability.

Radiological field duplicate samples are collected semiannually and analyzed for gross alpha and gross beta. Duplicate samples were collected from Well ICPP-MON-A-165 on April 4, 2017, and from Well ICPP-MON-A-166 on September 13, 2017. The mean difference determined from the sample result and the field duplicate sample result (using two statistically positive results) should be less than or equal to three for 90 percent of the parameters. Two of the four samples collected had statistically positive results, and both of these results had a mean difference of less than three.

Accuracy – Performance Evaluation Samples. Performance evaluation samples were submitted to the laboratory on April 13, 2017. Ninety percent of the performance evaluation sample results were within their QC performance acceptance limits.

Introduction of Contaminants – Field Blank Samples. Field blanks were collected on April 6, 2017, and September 13, 2017, and analyzed for the permit-specific parameters. A total of 18 parameters were analyzed, and 15 of these parameters were not detected. Gross beta, copper, and silver were detected. Since the positive detections from copper, silver, and gross beta were reported at such low concentrations, these analytical detections do not negatively impact data usability.

Introduction of Contaminants – Equipment Rinsate Samples. Equipment rinsates were collected on April

5, 2017 and September 14, 2017, and analyzed for the permit-specific parameters. A total of 47 parameters were analyzed, and 40 of these parameters were not detected in the samples. Copper, silver, total dissolved solids, and total phosphorus were detected above their respective detection/reporting limits in the April 5, 2017 sample, and total dissolved solids, chloride, and electrical conductivity were detected above their respective detection/reporting limits in the September 14, 2017 sample, indicating that proper decontamination procedures may not have been followed. Since the positive detected values were reported at such low concentrations, these analytical detections do not negatively impact data usability.

11.3.2.3 Idaho Cleanup Project Contractor Groundwater Monitoring Quality Control Data

QA/QC samples and results for Waste Area Groups (WAG) 1, WAG 3, and WAG 4 are discussed in the annual reports for Fiscal Year 2017 (DOE-ID 2018a, 2018b, 2018c) and for WAG 2 in the Fiscal Year 2018 report (DOE-ID 2018d). QA/QC samples and results for WAG 7 are discussed in the following paragraphs.

Completeness, Precision, Representativeness, Comparability – Field Sampling Plan. For the WAG 7 November 2017 groundwater monitoring sampling event at Radioactive Waste Management Complex, the QA parameters of completeness, precision, representativeness, and comparability met the project goals and DQOs as specified in the Field Sampling Plan (Forbes and Holdren 2014).

11.3.2.4 Drinking Water Program Quality Control Data

INL Contractor

The INL contractor Drinking Water Program (DWP) has specific QA/QC objectives for analytical data.

Completeness – Collection and Analysis. The DQOs address completeness for laboratory and field operations. The criteria for completeness by laboratories is that at least 90 percent of the surveillance and 100 percent of the compliance samples submitted annually must be successfully analyzed and reported according to specified procedures. Similarly, the criteria for field data collection under the INL Environmental Support and Monitoring Services is that at least 90 percent of the surveillance, and 100 percent of the compliance samples must be successfully collected on an annual basis and reported according to the specified procedures. These criteria were met. If a completeness criterion is not met, the problem will be evaluated, and it will be determined whether the quality of the remaining data is suspect and whether a corrective action is needed either in the field collection or laboratory analysis.

Precision – Field Duplicates. DWP goals are established for precision of less than or equal to 35 percent for 90 percent of the analyses. The DWP submits field duplicates to provide information on analytical variability caused by sample heterogeneity, collection methods, and laboratory procedures.

Precision for radiological data is evaluated by calculating the RPD with a goal of less than 35 percent. Results reported as nondetect are not used in the RPD calculation. For 2017, the DWP reported 32 samples with detectable radiological quantities, which all met the RPD goal. For nonradiological data, precision is evaluated by calculating the RPD if the result in the first sample and the duplicate exceeded the detection limit by a factor of five or more.

Accuracy – Performance Evaluation Samples. Blind spike samples are used to determine the accuracy of laboratory analyses for concentrations of parameters in drinking water. Within each calendar year, the program lead determines the percentage of the samples collected (excluding bacteria samples) that are QA/QC samples, which include blind spikes. All blind spike percent recoveries must fall within the standards range.

Representativeness. Representativeness is ensured through use of established sampling locations, schedules, and procedures for field sample collections, preservation, and handling.

Comparability. Comparability is ensured through the use of 1) laboratory instructions for sample collection, preparation, and handling; 2) approved analytical methods for laboratory analyses; and 3) consistency in reporting procedures.

ICP Contractor

The ICP Core DWP has specific QA/QC objectives for analytical data. Goals are established for completeness, precision, and accuracy, and all analytical results are validated or verified following standard EPA protocols. Four types of DWP QC samples are submitted for analysis: field duplicates, field blanks, trip blanks, and performance evaluation samples. Table 11-3 presents a summary of 2017 DWP QC criteria and performance results.

Completeness – Collection and Analysis. The goal for completeness was to collect and successfully analyze 100 percent of all required compliance samples. This goal was met in 2017. A total of 60 parameters were collected and submitted for analysis, and 60 parameters were successfully analyzed. For the DWP surveillance samples, the goal for completeness was to collect and successfully analyze 90 percent of the samples. This goal was exceeded in 2017. A total of 107 parameters were collected and 100 percent of these parameters were successfully analyzed.

Precision – Field Duplicates. Field duplicate samples were collected on June 9, 2017, and June 23, 2017 (lead and copper); August 16, 2017 (disinfection byproducts); and October 25, 2017 (volatile organic compounds). The RPD determined from field duplicate samples should be 35 percent or less for 90 percent of the parameters analyzed. Seventy-one percent of the results had an RPD of less than or equal to 35 percent. The positive detects were associated with lead and copper. Since these constituents are not typical site contaminants that would be introduced during sample collection, storage, or transportation activities, these analytical detections do not negatively impact data usability.

A radiological field duplicate sample was collected from WMF-604 on February 21, 2017, and analyzed for ^{3}H. The mean difference was calculated to be 0.5, which was less than three. On August 29, 2017, a radiological field duplicate sample was collected from CPP-614 and analyzed for gross alpha and gross beta. Neither parameter had two statistically positive results.

Accuracy – Performance Evaluation Samples. Performance evaluation samples were submitted to the laboratory with routine drinking water samples on June 23, 2017 (lead and copper); July 26, 2017 (volatile organic compounds); and August 16, 2017 (disinfection byproducts). Ninety-four percent of the performance evaluation sample results were within their QC performance acceptance limits, exceeding the program goal of 90 percent.

Introduction of Contaminants – Field Blank Samples. A field blank was prepared as part of the January 25, 2017, (volatile organic compounds) sampling event. One hundred percent of the analytical results were below their respective detection/reporting limits, exceeding the program goal of 90 percent.

Introduction of Contaminants – Trip Blank Samples. Trip blanks were prepared as part of the following sampling events: January 25, 2017 (volatile organic compounds); April 26, 2017 (volatile organic compounds); July 26, 2017 (volatile organic compounds); August 16, 2017 (total trihalomethanes); and October 25, 2017 (volatile organic compounds). One hundred percent of the analytical results were below their respective detection/reporting limits, exceeding the program goal of 90 percent.

11.3.2.5 Environmental Surveillance, Education, and Research Program Quality Control Data

Table 11-4 presents a summary of 2017 ESER QC analysis results.

Completeness – Collection and Analysis. The ESER contractor met its completeness goals of greater than 98 percent in 2017. Six air samples were considered invalid because insufficient volumes were collected due to power interruptions (i.e., blown fuse and/or tripped breaker). Two optically stimulated luminescent dosimeters (OSLD) and one thermoluminescent dosimeter (TLD) samples were considered invalid because the full six months were not completed before sampling. All other samples were collected and analyzed as planned.

Precision – Field Duplicate Samples. Field duplicate samples were collected for air, milk, lettuce, potatoes, grain, soil, and water to assess data precision and sampling bias. Most duplicate data were associated with the air sampling program. Duplicate air samplers were operated at two locations (Blackfoot and Sugar City) adjacent to regular air samplers. The objective was to have data close enough to conclude that there was minor sampling bias between the samplers and acceptable laboratory precision. The ESER QA program establishes that sample results should agree within three standard deviations. Any variation outside the predetermined criterion could be due to one of the samplers not operating correctly (e.g., a leak in one sampling system) or not operating within the same operating parameters (e.g., flow rate, sampling time). In addition, any variation outside the predetermined criterion could be attributed to inhomogeneous distribution of a contaminant in the sample medium so that true replication is not possible. The ISU-EAL sample and duplicate results agreed with each other in 99.4

Table 11-4. 2017 ESER Surveillance Program Quality Assurance Elements.

QC Program Element - 2017	Criterion	Performance[a]
Completeness		
Surveillance Samples Successfully Completed	100 percent	99.9 percent
Submitted Surveillance Samples Successfully Analyzed	100 percent	100 percent
Accuracy		
Blind Spike Program[b]		
Idaho State University - Environmental Assessment Lab (EAL)	90 percent	100 percent
Oak Ridge Associated Universities - (ORAU)	90 percent	100 percent
Precision		
Field Duplicates		
EAL	Differences within 3 standard deviations (3σ) or within ± 20 percent RPD	99.4 percent
ORAU		100.0 percent
Field Blanks		
EAL	± 3σ of Zero	95.3 percent
ORAU		83.3 percent

a. Sample matrices include: water (drinking, surface, and precipitation), air filter, milk, soil, TLD/OSLD, vegetation (wheat, alfalfa, potato, lettuce), and waterfowl. Big game (deer, elk, antelope) are also sampled on an as notified case-by-case basis; these samples are not included in sample percent completeness.

b. ISU-EAL - ESER requested analysis: gamma spec (i.e. ^{137}Cs, and ^{131}I), tritium, gross alpha, and gross beta. ORAU - ESER requested analysis: ^{90}Sr, ^{241}Am, ^{238}Pu, and $^{239/240}Pu$.

percent and the ORAU-REAL in 100.0 percent of all environmental samples collected during 2017, indicating acceptable precision.

Accuracy – Performance Evaluation Samples. Accuracy is measured through the successful analysis of samples spiked with a known standard traceable to the NIST. Each analytical laboratory conducted an internal spike sample program using NIST standards to confirm analytical results.

As a check on accuracy, the ESER contractor provided blind spiked samples prepared by personnel at RESL, as described in Section 11.3.1, for soil, wheat, air particulate filter, milk, and water samples. All the acceptance criteria are for three-sigma limits and ± 30 percent of the known values for respective sample matrices. This is a double blind "spiked" sample, meaning that neither the ESER Program nor the laboratories know the value of the radioisotope that is in the sample submitted to the laboratories for sample analysis.

The ESER Program sent eight double blind spike sample sets to the ISU-EAL laboratory during the 2017 calendar year for gamma spectroscopy and liquid scintillation analysis. The following matrices were spiked for the 2017 year: water, air particulate filters, milk, and wheat. The ISU-EAL submitted sample results for 30 individual analytes that had recovery analysis completed by the RESL; 30 had an Agreement of "YES". This was a 100.0 percent (i.e., 30/30 x 100) performance in the ESER double blind spike program.

The ESER Program sent five double blind spike sample sets to the ORAU-REAL laboratory during the 2017 calendar year for radiochemical analysis. The following matrices were spiked for the 2017 year: water, air particulate filters, milk, and wheat. The ORAU-REAL submitted sample results for seven individual analytes that had recovery analysis completed by the RESL; seven had an Agreement of "YES." This was a 100 percent (i.e., 7/7 x 100) performance in the ESER double blind spike program.

Introduction of Contamination – Field Blanks. Field blank samples were submitted with each set of samples to test for the introduction of contamination during the process of field collection, laboratory preparation, and laboratory analysis. Ideally, blank results should be within two standard deviations of zero and preferably within one standard deviation. In 2017, the ISU-EAL attained over 95.3 percent performance of blanks within one to three standard deviations of zero; the ORAU-REAL had an 83.3 percent performance of blanks with the above stated criterion.

Invalid Sample Results. In 2017, five "J" flags were received for tracer recoveries exceeding 110 percent of known value, reported for an AP Filter Composite analyzed by the ORAU Laboratory. Per ORAU-REAL procedures these values are estimated values. The samples could not be re-analyzed as the air filter samples are single set samples and cannot be re-prepped and re-analyzed.

ISU-EAL Review of air filter gross beta results (Per ISU-EAL Quarterly Quality Assurance Report for Third Quarter 2017). A review of the gross beta results for low-volume air filters was conducted due to an expressed concern by Wastren Advantage, Inc., (WAI), the previous ESER contractor, about a downward trend in the gross beta results of low-volume air filter samples over the past few years. The EAL investigated five areas of concern:

1) Trends in relation to the calibration source
2) Dust build up on the surface of the detector
3) Radon progeny buildup on background filters
4) Changes in the mechanical sample positioning system of the detector and
5) The reason for the relatively sudden drop in the number of counts observed from January 2016–May of 2016 on the plot received from WAI.

The following paragraphs present the findings of the investigation:

1) Review of calibration data for each proportional counter revealed counting efficiencies and crosstalk values were consistent for each calibration performed during 2013–2017. Therefore, no unusual trends were observed in relation to the calibration sources.
2) Review of control charts for daily background performance checks does not suggest any evidence that dust has built up on either of the detectors (i.e., increase in background counts). Background counts were performed on the Tennelec 5100B using clean, blank, stainless steel planchets, which were analyzed in conjunction with the prepared water samples. The count times varied from 300 to 510 minutes with an average beta background count rate of 1.6 ± 0.15 counts per minute (cpm). This average value coincides with typical beta background values of 1.7 ± 0.13 cpm; therefore, it is not likely that dust has built up on the window of this instrument.
3) The low-volume air filter used as a background sample was examined for build-up of radon progeny by examining the background count rates over the past five years. A single filter has been designated for use as a background sample. The number of samples requiring gross alpha/gross beta analysis often determines which of the two gas flow proportional counters (Canberra 2404 and Tennelec 5100) will be used on a weekly basis. Every week, one of the two counters is dedicated to analyzing the weekly low-volume air filters. Since each detector has a different counting efficiency, separate plots of the background count rates were made to see if any trends were evident. The plots show beta background count rates for both detectors increased during 2016 (beginning of April 2016 for the Canberra 2404 and the middle of August 2016 for the Tennelec 5100). The average beta background (bkg) count rate obtained for the Canberra 2404 was 1.06 ± 0.09 cpm prior to April 2016. The average beta bkg count rate increased to 1.34 ± 0.6 cpm. In addition, the average bkg count rate obtained using the Tennelec 5100 was 1.61 ± 0.25 cpm prior to August 2016 and increased to an average count rate of 2.24 ± 0.12 cpm from August 16, 2016, to January 2, 2017. As a result, the ISU-EAL has implemented a policy to discard and replace the background filter once every month. The background count rates for the Canberra 2404 and the Tennelec 5100 decreased to an average count rate of 1.17 ± 0.11 cpm and 1.43 ± 0.14 cpm respectively, following replacement of the background filter.
4) The sample changing mechanisms on both proportional counters were observed for several cycles as samples were moved through the counter. Sample position for analysis seemed consistent for both detectors. Low-volume air filter recount data for the last five years has been within specification. As a result, there is no indication that an issue has

occurred due to the sample changing mechanism on either proportional counter.

5) The plot of gross beta counts over time, received from WAI, showed a decreasing trend from January 2015–May 2017. In addition, a sudden drop in counts was observed between January–May 2016. The plot includes gross beta counts from two proportional counters (Canberra 2404A and Tennelec 5100B). Each proportional counter has characteristics that are unique (e.g., counting efficiencies, crosstalk values and required count times). Since the counting efficiencies and crosstalk values vary between counters, each counter has a specific count time (Canberra: 190 minutes, Tennelec: 150 minutes) in order to reach the data quality objective. As a result, a sample counted on each detector would show different gross counts. A better comparison would be a plot that takes into account the counter characteristics and count times. The plot still indicates a decrease in the beta concentration at the end of February 2016 through the beginning of March 2016. The decrease was believed to be due to a buildup of radon progeny on the background filter, thus lowering the beta concentration value. However, a buildup of radon progeny on the background filter was observed from August 16, 2016–January 2, 2017, which occurs after the decrease in beta concentration. Since the buildup of radon progeny on the background filter was not the cause of the sudden decrease, further review of the plot indicates gross beta results from the Tennelec 5100B proportional counter trending lower than those from the Canberra 2404A proportional counter. Previous discussion ruled out any unusual trends with regard to calibration sources and changes in mechanical positioning of the samples. This lead to a review of filter sample preparation for counting on the 5100B proportional counter. Filter paper samples, to be analyzed on the 5100B, are prepared for counting by placing the filter in a plastic planchet with a plastic “snap” ring to hold the filter in place. Calibration of the proportional counters are performed with filter paper standards mounted in a stainless steel planchet. Prior to analysis of any filter paper samples, the initial setup of the Tennelec 5100B included a comparison of the stainless steel planchet and plastic planchet. These items were examined to identify differences that would affect analysis results. At that time, no differences were identified. A reexamination of the plastic planchet and stainless steel planchet was performed. Each planchet was placed in a planchet carrier and several measurements were taken in order to estimate the height of each planchet. The plastic planchet places the filter approximately 0.75-mm lower than a filter placed in a stainless steel planchet. As a result, the filter paper standards were placed in a plastic planchet and counted on December 11, 2017. The results were used to calculate counting efficiencies and crosstalk values. The alpha counting efficiencies decreased from 36.13 percent to 28.02 percent, whereas the beta counting efficiency decreased from 41.89 percent to 32.65 percent. In addition, the alpha crosstalk decreased from 18.19 percent to 18.91 percent, and the beta crosstalk decreased from 1.89 percent to 1.84 percent. When a correction factor, to account for the decrease, is applied to data obtained using the Tennelec 5100B, the gross alpha concentrations increase by 29 percent, and gross beta activity concentrations increase by 28 percent. This increase seems to follow the trend observed from year to year.

11.3.2.6 INL Environmental Surveillance Program Quality Assurance/Quality Control Data

The INL contractor analytical laboratories analyzed all Surveillance Monitoring Program samples as specified in the statements of work. These laboratories participate in a variety of inter-comparison QA programs, including the DOE MAPEP and the EPA National Center for Environmental Research QA Program. These programs verify all the methods used to analyze environmental samples (see Table 11-5).

Completeness – Collection and Analysis. The INL Surveillance Monitoring Program met its completeness and precision goals. Samples were collected and analyzed from all available media as planned. Of approximately 1,100 air samples, 12 were invalid because of power interruptions (i.e., blown fuses and/or tripped breakers), inaccessibility due to weather, and insufficient volumes.

Precision – Collocated Samples. To allow for data comparisons, the Environmental Surveillance Program rotates two replicate air samplers that are placed adjacent to regular samplers and that are currently at Radioactive Waste Management Complex and Chemical Processing Plant locations. The collocated samples are collected at the same time, stored in separate containers, and

Table 11-5. 2017 BEA Environmental Surveillance Program QA Elements.

QC Program Element - 2017	Criterion	Performance
Completeness		
Samples Collected		
Air	90 percent	99 percent
Samples Analyzed		
Air	90 percent	100 percent
Accuracy		
Performance Evaluation Samples		
Air[a]	Ideally 100 percent	99 percent
Precision		
Field Replicates/Duplicates		
Air	MD[b] < 3	
Gross Beta (weekly)	Ideally 100 percent	99 percent
Gamma Spec[c] (Quarterly)	Ideally 100 percent	100 percent
Laboratory Control Sample		
Air	LCS percent Recovery ± 25 percent	100 percent
Media Blanks		
Air	Ideally 100 percent within 2σ of zero	99 percent

a. Includes all results for gamma spectrometry and isotopic analysis.
b. Mean difference.
c. As ^{7}Be.

analyzed independently. A mean difference calculation can be used to compare two radiological measurements that are reported with an associated uncertainty. For ambient air, because all the gross beta and beryllium-7 (^{7}Be) results were positive for the regular and replicate samples, these data are ideal as indicators of precision, and 99 percent of the mean difference values were less than the goal of three.

Introduction of Contaminants – Media Blanks. In 2017, the majority of the media blanks were within two standard deviations of zero for air. See Table 11-5 for details.

Accuracy – Performance Evaluation Samples. As an additional check on accuracy, the INL contractor provided blind spiked samples prepared by personnel at the RESL for air filter samples, which are composited by location quarterly and analyzed by gamma spectroscopy and radiochemistry. During 2017 for the four samples spiked with gamma emitters (i.e., ^{60}Co, ^{134}Cs, ^{137}Cs, manganese-54 [^{54}Mn], zinc-65 [^{65}Zn]) and radionuclides requiring radiochemistry (i.e., ^{241}Am, ^{90}Sr, ^{238}Pu, and $^{239/240}Pu$), the results were in agreement with the known activity, until the fourth quarter. In the fourth quarter the gamma spectroscopy results were in agreement, but the radiochemistry results (^{241}Am, ^{90}Sr, ^{238}Pu) were biased low and not in agreement with the known activities.

11.3.2.7 ICP Core Environmental Surveillance for Waste Management Quality Control Data

Table 11-6 summarizes the 2016 ICP Core Environmental Surveillance Program for Waste Management QC analysis results.

Completeness. The ICP Core Environmental Surveillance Program for Waste Management completeness goal, which includes samples collected and samples analyzed, is 90 percent. The collection of air samples was 98.7 percent in 2017. For gross alpha and gross beta analysis, 11 days of sampling in a two-week period is required. During the time period from mid-July through September, high temperatures and smoke from wildfires caused the air monitors to shut down

Table 11-6. 2017 ICP Core Environmental Surveillance Program QA Elements.

QC Program Element - 2017	Criterion	Performance[a]
Completeness		
Surveillance samples successfully completed	90 percent	98.7 percent
Surveillance samples successfully analyzed	90 percent	100 percent
Accuracy		
Blind Spike Program[b]		
ALS Environmental Laboratory – Fort Collins (ALS)	90 percent	98.7 percent
Precision		
Field Replicates/Duplicates		
Differences within 3 standard deviations (3σ)	MD[b] > 3	85 percent
Laboratory Control Sample		
All media	Laboratory control sample percent recovery ±25 percent	100 percent
Field Blanks		
Air and surface water	Ideally 100 percent within 2s	98 percent

a. Sample matrices include: air filter and surface water.
b. Requested analyses—Gamma spectrometry and isotopic.

periodically. Therefore, the 11-day collection period was not met for several air monitors. The samples were still collected and used for gamma spectrometry and isotopic analysis. Also, a few monitors were out for repairs during several collection periods. Surface water samples collected was 100 percent. Biota samples collected was 100 percent. Overall sample collection for all media was 98 percent.

For air and surface water samples, 100 percent were analyzed, although the laboratory was not able to analyze surface water samples for ^{90}Sr on the fourth quarter sample. During sample preparation, a rinse solution is collected for ^{90}Sr analysis. Because of an analyst's oversight, the rinse solution was not collected and no original sample remained. A Non-Conformance Report was filed and the laboratory re-emphasized the importance of following procedure for sequential preparation for non-recoverable matrices.

Precision – Field Duplicate/Replicate Samples. To measure precision of duplicates/replicates, results are compared using the RPD or the standard deviation criterion (Equation 1); the RPD is acceptable if it is within 20 percent. For air sampling, a replicate air sampler is set adjacent to a regular sampler. For ambient air, an overall average performance rate of 96.8 percent was achieved.

$$|R_1 - R_2| \leq 3(s_1^2 + s_2^2)^{1/2} \quad (1)$$

Where:

R_1 = concentration of analyte in the first sample

R_2 = concentration of analyte in the duplicate sample

s_1 = uncertainty (one standard deviation) associated with the laboratory measurement of the first sample

s_2 = uncertainty (one standard deviation) associated with the laboratory measurement of the duplicate sample.

Surface water samples are collected quarterly. In 2017, a field duplicate was taken during the third quarter sampling. When comparing results of the regular sample and the duplicate sample, precision was 78.5 percent. When the samples were taken, it was noted that the duplicate sample contained more sediments than the regular sample. When the results were received and reviewed, changes were made to the sampling procedure to ensure samples are of similar consistency. ICP Core will continue to monitor this situation.

A biota sample was split and analyzed for gamma-emitting radionuclides. The overall precision was 60 percent. Although this precision was lower than the ideal criterion, all samples were nondetect.

The overall precision result for all media sampled was 85 percent.

Accuracy. The ICP Core contractor submitted air, surface water, and biota blind spike samples to ALS Laboratory Group for analysis in 2017 to check laboratory accuracy. These samples were prepared at the RESL as described in Section 11.3.1. All air blind spike samples showed 100 percent satisfactory agreement (within ± 30 percent of the known value and within three-sigma) for all constituents of concern. For water, all blind spike samples showed satisfactory agreement for all constituents of concern except for $^{239/240}$Pu, which received an "Acceptable with Warning" showing a low bias.

The biota blind spike samples showed satisfactory agreement for all constituents of concern except for ^{137}Cs, which received an "Acceptable with Warning." As a best management practice, the laboratory has been asked to investigate this, although no further action is required. For ^{90}Sr a "Not Acceptable – False Positive" was received. The laboratory recounted the sample and the results were comparable. No sample was available to re-prep. This blank sample was prepped next to another sample that had ^{90}Sr in it. The laboratory stated that cross contamination might have occurred. The lab emphasized with their staff the potential for cross-contamination, especially in dealing with trace level analytical work.

Laboratory Inter-comparison QA Programs. ALS Laboratory Group participated in a variety of inter-comparison QA programs, which verified all the methods used to analyze environmental samples. The programs include the DOE MAPEP and the National Environmental Laboratory Accreditation Program. The laboratory met the performance objectives specified by these two inter-comparison QA programs.

Laboratory Control Samples. All laboratory control sample recoveries were within their acceptance range of ± 25 percent recovery, indicating that the laboratory's radiochemical procedure is capable of recovering the radionuclide of interest.

Introduction of Contaminants – Field Blanks and Batch Blanks. In 2017, 95.8 percent of the field blanks were within two standard deviations of zero for both air and water.

For the first quarter isotopic air results, the laboratory reported that ^{238}Pu and ^{234}U were detected in the batch blank. In the third quarter, ^{238}Pu was detected. Positive sample results were reported, even though there is a potential positive bias. The results were comparable to past results. The batch blanks for both the second and fourth quarters were nondetects.

Representativeness and Comparability. Representativeness is the degree to which data accurately and precisely represent characteristics of a population, parameter variations at a sampling point, a process condition, or an environmental condition. Comparability expresses the confidence with which one data set can be compared to another data set measuring the same property. Both of these are ensured through the use of technical procedures and sampling procedures for sample collection and preparation, approved analytical methods for laboratory analyses, and consistency in reporting procedures.

Various QC processes designed to evaluate precision, accuracy, representativeness, completeness, and comparability of data are implemented in detailed procedures. All sampling procedures were reviewed in 2017 and updated as needed, to clarify procedures and training qualifications.

Surveillances. Periodic surveillances of procedures and field operations are conducted to assess the representativeness and comparability of data. In August 2015, the ICP Core QA program performed a triennial surveillance on the air sampling program. No findings were noted. Strengths were noted in sample collection and sample preparation for shipment to the offsite laboratory.

11.3.2.8 U.S. Geological Survey Water Sampling Quality Control Data

Water samples are collected in accordance with a QA plan for quality-of-water activities by personnel assigned to the USGS INL project office; the plan was revised in 2014 (Bartholomay, Maimer, and Wehnke 2014). Additional QA is assessed with QA/QC duplicates, blind replicates, replicates, source solution blanks, equipment blanks, field blanks, splits, trip blanks, and spikes (Bartholomay, Maimer, and Wehnke 2014). Evaluations of QA/QC data collected by USGS can be found in Wegner (1989), Williams (1996), Williams (1997), Williams, Bartholomay, and Campbell (1998), Bartholomay and Twining (2010), Rattray (2012), Davis, Bartholomay, and Rattray (2013), Rattray (2014); and Bartholomay, Maimer, Rattray, and Fisher (2017). During 2017, the USGS collected 16 replicate samples, five field blank samples, two equipment blank samples, two spike samples, one source solution blank, and one trip blank sample. Evaluation of results will be summarized in future USGS reports.

11.4 Environmental Monitoring Program Quality Assurance Program Documentation

The following sections summarize how each monitoring organization at the INL Site implements QA requirements. An overview of the INL contractor environmental monitoring program, the ICP Core contractor, and ESER contractor documentation is presented in Table 11-7, Table 11-8, and Table 11-9, respectively.

11.4.1 Idaho National Laboratory Contractor

The INL contractor integrates applicable requirements from *Manual 13A—Quality Assurance Laboratory Requirements Documents* (INL 2014) into the implementing monitoring program plans and procedures for non-Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) monitoring activities. The program plans address the QA elements as stated in *EPA Requirements for Quality Assurance Project Plans* (EPA QA/R-5) (EPA 2001) to ensure that the required standards of data quality are met.

In addition, the INL contractor uses a documented approach for collecting, assessing, and reporting environmental data. To ensure that analytical work supports DQOs, environmental and effluent monitoring is conducted in accordance with PLN-8510, PLN-8515, and PLN-8540 (Table 11-7).

11.4.2 Idaho Cleanup Project Core Contractor

All CERCLA monitoring activities at the INL Site are conducted in accordance with the *Quality Assurance Project Plan for Waste Area Groups 1, 2, 3, 4, 5, 6, 7, 10* (DOE-ID 2016), written in accordance with Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA 1988).

In addition, the ICP Core contractor uses the following program plans for environmental monitoring and surveillance: PLN-720, PLN-729, PLN-730, and PLN-1305 (Table 11-8).

11.4.3 Advanced Mixed Waste Treatment Project

The Advanced Mixed Waste Treatment Project maintains a QA program in accordance with 40 CFR 61, Appendix B, as required of all radiological air emission sources continuously monitored for compliance with 40 CFR 61, Subpart H. The QA requirements are documented in PLN-5231, "Quality Assurance Project Plan for the WMF 676 NESHAPs Stack Monitoring System," and AMWTP-PD-EC&P-03, *Quality Assurance Project Plan for the RCE/ICE NESHAPs Stack Monitoring System*.

11.4.4 Environmental Surveillance, Education, and Research Program

The ESER Program QA documentation (Table 11-9) consists of:

- *ESER Quality Management Plan for the Environmental Surveillance, Education, and Research Program*, which implements and is consistent with the requirements of 10 CFR 830, Subpart A, and DOE Order 414.1D
- *ESER Quality Assurance Project Plan for the INL Offsite Environmental Surveillance Program*, which provides additional QA requirements for monitoring activities.
- *ESER Quality Assurance Implementation Plan for the Environmental Surveillance, Education, and Research Program*. This Quality Assurance Implementation Plan provides requirements, responsibilities, and authority for implementing the ESER Quality Assurance Project Plan under a graded and tailored approach to all work activities for the ESER Program.

Table 11-7. INL Environmental Program Documentation.

Document/Media Type	Document No.[a] and Title
Program Documents	PLN-8510, Planning and Management of Environmental Support and Services Monitoring Services Activities
Data Management and Validation Documents	PLN-8101, Records Management Plan for Environmental Records PLN-8550, Environmental Support and Services Monitoring Services Surveillance Plan PLN-8515, Data Management Plan for the INL Environmental Support and Services Monitoring Services Program PLN-8520, INL Sampling and Analysis Plan Table Entry Database, Software Management Plan GDE-8511, Inorganic Analyses Data Validation for INL GDE-8512, Radioanalytical Data Validation GDE-8513, Validation of Gas and Liquid Chromatographic Organic Data GDE-8514, Validation of Semivolatile Organic Compounds Data Analyzed Using Gas Chromatography/Mass Spectrometry GDE-8516, Validation of Volatile Organic Compounds Data Analyzed Using Gas Chromatography/Mass Spectrometry
Field Sampling Documents	GDE-9103, Conduct of Operations Guidance for Communications MCP-8523, Managing Hazardous and Non-Hazardous Samples LI-355, Working in Environmental Monitoring Services Sample Preparation Areas (SPA) LI-359, Cleaning of Environmental Monitoring Services Sampling Equipment
Groundwater Documents	LI-156, Groundwater Monitoring at the Materials and Fuels Complex LI-330, Groundwater Monitoring at the Advanced Test Reactor Complex LI-148, Accument Model AP85 Portable PH/Conductivity Meter Operating Instructions
Liquid Effluent Documents	PLN-8540, Idaho National Laboratory Liquid Effluent Monitoring Plan MCP-8540, Reporting Requirements for Liquid Effluent and Wastewater Reuse Permit Monitoring LI-8540, Liquid Effluent Sampling GDE-8544 , Collecting Samples Using a Peristaltic Pump GDE-8545, Collection of Soil Samples for the Central Facilities Area Sewage Treatment Plant Wastewater Reuse Permit
Drinking Water Documents	PLN-8530, Idaho National Laboratory Drinking Water Monitoring Plan LI-361, Sampling of INL Public Water Systems LI-370, Cross Connection Inspections and Backflow Prevention Device Testing PLN-8532, Cross Connect Database
Surveillance Documents	MCP-8550, Ambient Air Surveillance Instrumentation Calibration LI-351, Sampling Atmospheric Tritium LI-352, Low Volume Air Sampling Using DL-22 LI-321, In Situ Gamma Radiation Measurements LI-357, Collecting and Preparing Environmental Dosimetry LI-459, Surface Radiation Surveys Using GPRS LI-776, Soil Sampling
Other Documents	LI-458, Establishing Revegetation Performance Measures LI-353, Event Air Monitoring LI-14602, Asbestos Building Material Inspections and Sampling

Table 11-7. INL Environmental Program Documentation (continued).

Document/Media Type	Document No.[a] and Title
	PLN-8560, BEA Asbestos Database Software Management Plan PLN-3059, Quality Assurance Project Plan for Environmental Monitoring Program Sampling LI-328, Idaho National Laboratory Miscellaneous Media Umbrella Sampling
Statement of Work Documents	SOW-4785, Validating Organic Analyses Data SOW-4786, Validating Inorganic Analyses Data SOW-4787, Validating Radioanalytical Analyses Data SOW-8500 Rev. 5, Battelle Energy Alliance Statement of Work for Analytical Services
Reference Documents	LRD-8000, Environmental Requirements for Facilities, Processes, Materials and Equipment LWP-8000, Environmental Instructions for Facilities, Processes, Materials, and Equipment

a. GDE = Guide
LI = Laboratory Instruction
LRD = Laboratory Requirements Document
LWP = Laboratory Wide Procedure
MCP = Management Control Procedure
PLN = Plan
PRD = Program Requirements Documents
SOW = Statement of Work

Analytical laboratories used by the ESER Program maintain their own QA programs consistent with DOE requirements.

11.4.5 U.S. Geological Survey

Field Methods and Quality-Assurance Plan for Water-Quality Activities and Water-Level Measurements, (Bartholomay, Maimer, and Wehnke 2014) defines procedures and tasks performed by USGS project office personnel that ensure the reliability of water quality and water level data. The plan addresses all elements needed to ensure:

- Reliability of the water-quality and water-level data
- Compatibility of the data with data collected by other organizations at the INL Site
- That data meet the programmatic needs of DOE and its contractors and the scientific and regulatory communities.

The USGS conducts performance audits on field personnel collecting samples and on the analytical laboratories that analyze their environmental monitoring samples, with the exception of the DOE RESL. The RESL is assessed by the American Association of Laboratory Accreditation as an ISO 17025 Chemical Testing Laboratory. In addition, the USGS routinely evaluates its QC data and publishes analyses in USGS reports. Analyses of QA data collected from 2012–2015 are found in Bartholomay, Maimer, Rattray, and Fisher (2017).

11.4.6 National Oceanic and Atmospheric Administration

The National Oceanic and Atmospheric Administration *Quality Program Plan, NOAA Air Resources Laboratory Field Research Division* (NOAA-ARLFRD 1993) addresses the requirements of DOE Order 414.1D, and is consistent with American Society of Mechanical Engineers. Implementing procedures include regular independent system and performance audits, written procedures and checklists, follow-up actions, and continuous automated and visual data checks to ensure representativeness and accuracy. The plan and implementing procedures ensure that the INL Meteorological Monitoring Network meets the elements of *DOE Handbook – Environmental Radiological Effluent Monitoring and Environmental Surveillance* (DOE 2015).

All the meteorological sensors in the Air Resources Laboratory Field Research Division tower network are inspected, serviced, and calibrated semiannually as recommended by American Nuclear Society guidelines of ANSI/ANS 3.11 2005. Unscheduled service also is performed promptly whenever a sensor malfunctions.

Table 11-8. ICP Core Environmental Program Documentation.

Document/Media Type	Document No.[a] and Title
Requirement Documents	PRD-5030, Environmental Requirements for Facilities, Processes, Materials, and Equipment MCP-3480, Environmental Instructions for Facilities, Processes, Materials, and Equipment
Data and Validation Documents	PLN-491, Laboratory Performance Evaluation Program PLN-1401, Transferring Integrated Environmental Data Management System Revised Data to the Environmental Data Warehouse GDE-201, Inorganic Analyses Data Validation for Sample and Analysis Management GDE-204, Guide to Assessment of Radionuclide Analysis of Performance Evaluation Samples GDE-205, Radioanalytical Data Validation GDE-206, Obtaining Laboratory Services for Sample Analysis GDE-239, Validation of Volatile Organic Compounds Data Analyzed Using Gas Chromatography/Mass Spectrometry GDE-240, Validation of Gas and Liquid Chromatographic Organic Data GDE-241, Validation of Semivolatile Organic Compounds Data Analyzed Using Gas Chromatography/Mass Spectrometry GDE-7003, Levels of Analytical Method Data Validation MCP-1298, Sample and Analytical Data Management Process for the Sample and Analysis Management Program
Sampling Documents	MCP-9439, Environmental Sampling Activities at the INL
Groundwater Documents	PLN, 1305, Wastewater Reuse Permit Groundwater Monitoring Program Plan SPR-162, Measuring Groundwater Levels and Sampling Groundwater TPR-6539, Calibrating and Using the Hydrolab Quanta Water Quality Multiprobe TPR-7582, Well Inspection/Logging Using Down-Hole Cameras
Liquid Effluent Documents	PLN-729, Idaho Cleanup Project Liquid Effluent Monitoring Program Plan SPR-101, Liquid Effluent Sampling TPR-6539, Calibrating and Using the Hydolab Quanta Water Quality Multiprobe
Drinking Water Documents	PLN-730, Idaho Cleanup Project Drinking Water Program Plan SPR-188, Collecting Water Samples for Radiological Analysis SPR-189, Routine Collection of Samples for Coliform Bacteriological Analysis SPR-190, Sampling of Public Water Systems TPR-6555, Cross Connection Inspections and Backflow Prevention Assembly Testing
Surveillance Documents	PLN-720, Environmental Surveillance Program Plan SPR-106, Biotic Monitoring SPR-107, Waste Management Low-Volume Suspended Particulate Air Monitoring SPR-193, NESHAP Ambient Air Sampling for Accelerated Retrieval Project and RCRA Processing Operations SPR-213, Surface Water Sampling at Radioactive Waste Management Complex TPR-6525, Surface Radiation Surveys Using the Global Positioning Radiometric Scanner
Gamma Documents	TPR-7485, Filling Gamma Detectors with Liquid Nitrogen TPR-7859, Shipping Screen Gamma Scan TPR-7860, Germanium Detector Calibration and Performance Testing Using Gamma Vision
Documentation Documents	MCP-9227, Environmental Log Keeping Practices MCP-9235, Reporting Requirements for the INTEC Wastewater Reuse Permit Monitoring Program
Sample Management Documents	MCP-9228, Managing Nonhazardous Samples MCP-1394, Managing Hazardous Samples

a. GDE = guide
MCP = management control procedure
PLN = plan
PRD = program requirements document
SPR = sampling procedure
TPR = technical procedure.

Table 11-9. ESER Program Documentation.

Document/ Media Type	Document No.[a] and Title
Program Description	DOE/ID-11088 Revision 4, Idaho National Laboratory Site Environmental Monitoring Plan
Document Management	QAP-1 Preparation, Review, and Approval of ESER Procedures QAP-2 Document Control QAP-3 Information Management
Quality Procedures	QAP-4 Assessments QAP-7 Measuring and Test Equipment QAPP, Environmental Surveillance Task – Quality Assurance Project Plan QMP, Quality Management Plan for the Environmental Surveillance, Education, and Research Program QIP, Quality Assurance Implementation Plan for the Environmental Surveillance, Education, and Research Program
Field Sampling Procedures	ESP-1.1, Low-Volume Air Sampler ESP-1.2, EPA High-Volume Air Sampling ESP-1.4, Precipitation Sampling ESP-1.5, Atmospheric Moisture Sampling ESP-1.6, Environmental Radiation Measurement ESP-1.9, Jackson WY Low-Volume Air Sampler ESP 2.1, Drinking Water Sampling ESP 2.2, Soil Sampling ESP 3.1, Milk Sampling ESP 3.2, Lettuce Sampling ESP 3.3, Wheat Sampling ESP 3.4, Potato Sampling ESP 3.5, Large Game Animal ESP 3.7, Bird Collection for Scientific Purposes ESP 3.8, Alfalfa Sampling ESP 4.1, Use of Lab Balances ESP 4.2, Sample Handling and Custody ESP 4.3, Sample Delivery for Analysis ESP 4.6, R-275 Series Gas Flowmeter Equipment ESP 4.8, Sample Retention
Data Analysis and Reporting	Statistical Methods Used in the Idaho National Laboratory Site Environmental Report, http://www.idahoeser.com/Annuals/2016/Supplements/Statistical_Methods_Supplement_Final.pdf Dose Calculation Methodology, http://www.idahoeser.com/Annuals/2013/PDFS/AppendixB.pdf

a. ESP = Environmental Surveillance Program
QAP = Quality Assurance Procedure
QIP = Quality Implementation Plan
QMP = Quality Management Plan

11.5 Duplicate Sampling among Organizations

The ESER contractor, INL contractor, and the Department of Environmental Quality-INL Oversight Program (DEQ-INL OP) collects air samples at four common sampling locations: 1) the distant locations of Craters of the Moon National Monument, 2) Idaho Falls, 3) on the INL Site at the Experimental Field Station, and 4) Van Buren Boulevard Gate. The DEQ-INL OP Annual Report for 2017 has not been issued at this time. Results for 2016 are compared in the DEQ-INL OP Annual Report (www.deq.idaho.gov/media/60181000/inl-oversightprogram-annual-report-2016.pdf).

DEQ-INL OP also uses a network of passive electret ionization chambers on and around INL to cumulatively measure radiation exposure. These measurements are then used to calculate an average exposure rate for the quarterly monitoring period. Radiation monitoring results obtained by DEQ-INL OP are compared with radiation monitoring results reported by the DOE and its INL contractors for these same locations to determine whether the data are comparable. DEQ-INL OP has placed several electret ionization chambers at locations monitored by DOE contractors, using TLDs and OSLDs. Comparisons of results may be found in the 2016 DEQ-INL OP Annual Report.

The DEQ-INL OP also collects surface water and drinking water samples at select downgradient locations in conjunction with the ESER contractor. Samples are collected at the same place and time, using similar methods. Sample-by-sample comparisons are provided in the DEQ-INL OP Annual Report for 2016.

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Appendix A. Environmental Statutes and Regulations

The following environmental statutes and regulations apply, in whole or in part, to the Idaho National Laboratory (INL) or at the INL Site boundary:

- 36 CFR 79, 2014, "Curation of Federally-Owned and Administered Archeological Collections," U.S. Department of the Interior, National Park Service, *Code of Federal Regulations*, Office of the Federal Register
- 36 CFR 800, "Protection of Historic Properties," U.S. Department of the Interior, National Park Service, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 50, 2014, "National Primary and Secondary Ambient Air Quality Standards," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 61, 2014, "National Emission Standards for Hazardous Air Pollutants," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 61, Subpart H, 2014, "National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities," *Code of Federal Regulations*, Office of the Federal Register.
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- 40 CFR 143, 2014, "National Secondary Drinking Water Regulations," *Code of Federal Regulations*, Office of the Federal Register.
- 40 CFR 260, 2014, "Hazardous Waste Management System: General," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 261, 2014, "Identification and Listing of Hazardous Waste," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 262, 2014, "Standards Applicable to Generators of Hazardous Waste," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 263, 2014, "Standards Applicable to Transporters of Hazardous Waste," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 264, 2014, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 265, 2014, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 267, 2014, "Standards for Owners and Operators of Hazardous Waste Facilities Operating under a Standardized Permit," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 43 CFR 7, 2014, "Protection of Archeological Resources," U.S. Department of the Interior, National Park Service, *Code of Federal Regulations*, Office of the Federal Register
- 50 CFR 17, 2014, "Endangered and Threatened Wildlife and Plants," U.S. Department of the Interior, Fish and Wildlife Service, *Code of Federal Regulations*, Office of the Federal Register

- 50 CFR 226, 2014, "Designated Critical Habitat," U.S. Department of Commerce, National Marine Fisheries Service, *Code of Federal Regulations*, Office of the Federal Register
- 50 CFR 402, 2014, "Interagency Cooperation – Endangered Species Act of 1973, as Amended," U.S. Department of the Interior, Fish and Wildlife Service, *Code of Federal Regulations*, Office of the Federal Register
- 50 CFR 424, 2014, "Listing Endangered and Threatened Species and Designating Critical Habitat," U.S. Department of the Interior, Fish and Wildlife Service, *Code of Federal Regulations*, Office of the Federal Register
- 50 CFR 450–453, 2014, "Endangered Species Exemption Process," U.S. Department of the Interior, Fish and Wildlife Service, *Code of Federal Regulations*, Office of the Federal Register
- 42 USC § 9601 et seq., 1980, "Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA/Superfund)," United States Code.
- DOE Order 231.1B, 2011, "Environment, Safety, and Health Reporting," Change 1, U.S. Department of Energy
- DOE Order 435.1, 2001, "Radioactive Waste Management," Change 1, U.S. Department of Energy
- DOE Order 436.1, 2011, "Departmental Sustainability," U.S. Department of Energy
- DOE Order 458.1, 2011, "Radiation Protection of the Public and the Environment," Change 3, U.S. Department of Energy
- DOE Standard 1196-2011, 2011, "Derived Concentration Technical Standard," U.S. Department of Energy
- Executive Order 11514, 1970, "Protection and Enhancement of Environmental Quality"
- Executive Order 11988, 1977, "Floodplain Management"
- Executive Order 11990, 1977, "Protection of Wetlands"
- Executive Order 12344, 1982, "Naval Nuclear Propulsion Program."
- Executive Order 12580, 1987, "Superfund Implementation"
- Executive Order 12856, 1993, "Federal Compliance With Right-to-Know Laws and Pollution Prevention Requirements"
- Executive Order 12873, 1993, "Federal Acquisition, Recycling, and Waste Prevention"
- Executive Order 13101, 1998, "Greening the Government Through Waste Prevention, Recycling, and Federal Acquisition"
- Executive Order 13423, 2007, "Strengthening Federal Environmental, Energy, and Transportation Management"
- Executive Order 13514, 2009, "Federal Leadership in Environmental, Energy, and Economic Performance"
- Executive Order 13693, 2015, "Planning for Federal Sustainability in the Next Decade"
- IDAPA 58.01.01, 2014, "Rules for the Control of Air Pollution in Idaho," Idaho Administrative Procedures Act, Idaho Department of Environmental Quality
- IDAPA 58.01.02, 2014, "Water Quality Standards," Idaho Administrative Procedures Act, Idaho Department of Environmental Quality
- IDAPA 58.01.03, 2014, "Individual/Subsurface Sewage Disposal Rules," Idaho Administrative Procedures Act, Idaho Department of Environmental Quality
- IDAPA 58.01.05, 2014, "Rules and Standards for Hazardous Waste," Idaho Administrative Procedures Act, Idaho Department of Environmental Quality
- IDAPA 58.01.06, 2014, "Solid Waste Management Rules," Idaho Administrative Procedures Act, Idaho Department of Environmental Quality
- IDAPA 58.01.08, 2014, "Idaho Rules for Public Drinking Water Systems," Idaho Administrative Procedures Act, Idaho Department of Environmental Quality
- IDAPA 58.01.11, 2014, "Ground Water Quality Rule," Idaho Administrative Procedures Act, Idaho Department of Environmental Quality
- IDAPA 58.01.15, 2014, "Rules Governing the Cleaning of Septic Tanks," Idaho Administrative Procedures Act, Idaho Department of Environmental Quality

- IDAPA 58.01.16, 2014, "Wastewater Rules," Idaho Administrative Procedures Act, Idaho Department of Environmental Quality.
- IDAPA 58.01.17, 2014, "Recycled Water Rules," Idaho Administrative Procedures Act, Idaho Department of Environmental Quality

U.S. Department of Energy (DOE) Order 458.1 Ch. 3 provides the principal requirements for protection of the public and environment at the INL Site. The DOE public dose limit is shown in Table A-1, along with the Environmental Protection Agency statute for protection of the public, for the airborne pathway only.

Derived Concentration Standards are established to support DOE Order 458.1 in DOE Standard 1196-2011 (DOE-STD-1196-2011), "Derived Concentration Technical Standard." These quantities represent the concentration of a given radionuclide in either water or air that results in a member of the public receiving 100 mrem (1 mSv) effective dose following continuous exposure for one year for each of the following pathways: ingestion of water, submersion in air, and inhalation. The Derived Concentration Standards used by the environmental surveillance programs at the INL Site are shown in Table A-2. The most restrictive Derived Concentration Standard is listed when the soluble and insoluble chemical forms differ. The Derived Concentration Standards consider only inhalation of air, ingestion of water, and submersion in air.

The Environmental Protection Agency National Ambient Air Quality Standards may be found at https://www.epa.gov/criteria-air-pollutants/naaqs-table.

Water quality standards are dependent on the type of drinking water system sampled. Tables A-4 through A-6 list maximum contaminant levels set by the Environmental Protection Agency for public drinking water systems in 40 Code of Federal Regulations 141 (2014) and the Idaho groundwater quality values from IDAPA 58.01.11 (2012).

Table A-1. Radiation Standards for Protection of the Public in the Vicinity of DOE Facilities.

Radiation Standard	Effective Dose Equivalent (mrem/yr)	Effective Dose Equivalent (mSv/yr)
DOE standard for routine DOE activities (all pathways)	100[a]	1
EPA standard for site operations (airborne pathway only)	10	0.1

a. The effective dose equivalent for any member of the public from all routine DOE operations, including remedial activities, and release of naturally occurring radionuclides shall not exceed this value. Routine operations refer to normal, planned operations and do not include accidental or unplanned releases.

Table A-2. Derived Concentration Standards for Radiation Protection.

Derived Concentration Standard[a]			Derived Concentration Standard		
Radionuclide	**In Air (µCi/ml)**	**In Water (µCi/ml)**	**Radionuclide**	**In Air (µCi/ml)**	**In Water (µCi/ml)**
Gross Alpha[b]	3.4 x 10^{-14}	1.7 x 10^{-7}	Antimony-125	3.1 x 10^{-10}	2.7 x 10^{-5}
Gross Beta[c]	2.5 x 10^{-11}	1.1 x 10^{-6}	Iodine-129[f]	1.0 x 10^{-10}	3.3 x 10^{-7}
Tritium (tritiated water)	2.1 x 10^{-7}	1.9 x 10^{-3}	Iodine-131[f]	4.1 x 10^{-10}	1.3 x 10^{-6}
Carbon-14	6.6 x 10^{-10}	6.2 x 10^{-5}	Iodine-132[f]	3.0 x 10^{-8}	9.8 x 10^{-5}
Sodium-24	7.0 x 10^{-9}	7.2 x 10^{-5}	Iodine-133[f]	2.0 x 10^{-9}	6.0 x 10^{-6}
Argon-41[d]	1.4 x 10^{-8}	__	Iodine-135[f]	9.7 x 10^{-9}	3.0 x 10^{-5}
Chromium-51	9.4 x 10^{-8}	7.9 x 10^{-4}	Xenon-131m[d]	2.4 x 10^{-6}	__
Manganese-54	1.1 x 10^{-9}	4.4 x 10^{-5}	Xenon-133[d]	6.3 x 10^{-7}	__
Cobalt-58	1.7 x 10^{-9}	3.9 x 10^{-5}	Xenon-133m[d]	6.6 x 10^{-7}	__
Cobalt-60	1.2 x 10^{-10}	7.2 x 10^{-6}	Xenon-135[d]	7.8 x 10^{-8}	__
Zinc-65	1.6 x 10^{-9}	8.3 x 10^{-6}	Xenon-135m[d]	4.5 x 10^{-8}	__
Krypton-85[d]	3.6 x 10^{-6}	__	Xenon-138[d]	1.6 x 10^{-8}	__
Krypton-85m[d,e]	1.3 x 10^{-7}	__	Cesium-134	1.8 x 10^{-10}	2.1 x 10^{-6}
Krypton-87[d]	2.2 x 10^{-8}	__	Cesium-137	9.8 x 10^{-11}	3.0 x 10^{-6}
Krypton-88[d]	8.8 x 10^{-9}	__	Cesium-138	7.5 x 10^{-8}	3.1 x 10^{-4}
Rubidium-88	1.2 x 10^{-7}	3.2 x 10^{-4}	Barium-139	5.8 x 10^{-8}	2.4 x 10^{-4}
Rubidium-89	1.5 x 10^{-7}	6.6 x 10^{-4}	Barium-140	6.2 x 10^{-10}	1.1 x 10^{-5}
Strontium-89	4.6 x 10^{-10}	1.1 x 10^{-5}	Cerium-141	9.9 x 10^{-10}	4 x 10^{-5}
Strontium-90	2.5 x 10^{-11}	1.1 x 10^{-6}	Cerium-144	7.1 x 10^{-11}	5.5 x 10^{-6}
Yttrium-91m	3.1 x 10^{-7}	2.7 x 10^{-3}	Plutonium-238	3.7 x 10^{-14}	1.5 x 10^{-7}
Zirconium-95	6.3 x 10^{-10}	3.1 x 10^{-5}	Plutonium-239	3.4 x 10^{-14}	1.4 x 10^{-7}
Technetium-99m	1.7 x 10^{-7}	1.4 x 10^{-3}	Plutonium-240	3.4 x 10^{-14}	1.4 x 10^{-7}
Ruthenium-103	1.3 x 10^{-9}	4.2 x 10^{-5}	Plutonium-241	1.8 x 10^{-12}	7.6 x 10^{-6}
Ruthenium-106	5.6 x 10^{-11}	4.1 x 10^{-6}	Americium-241	4.1 x 10^{-14}	1.7 x 10^{-7}

a. Derived concentration standards are from DOE-STD-1196-2011 (*Derived Concentration Technical Standard)* and support the implementation of DOE Order 458.1. They are based on a committed effective dose equivalent of 100 mrem/yr (1 mSv) for ingestion or inhalation of a radionuclide during one year. Inhalation values shown represent the most restrictive lung retention class.

b. Based on the most restrictive human-made alpha emitter ($^{239/240}Pu$).

c. Based on the most restrictive human-made beta emitter (^{90}Sr).

d. The DCS for air immersion is used because there is no inhaled air DCS established for the radionuclide.

e. An "m" after the number refers to a metastable form of the radionuclide.

f. Particulate aerosol form in air.

Table A-3. Environmental Protection Agency Maximum Contaminant Levels for Public Drinking Water Systems and State of Idaho Groundwater Quality Standards for Radionuclides and Inorganic Contaminants.

Constituent	Maximum Contaminant Level	Groundwater Quality Standard
Gross alpha (pCi/L)	15	15
Gross beta (mrem/yr)	4	4
Beta/gamma emitters	Concentrations resulting in 4 mrem total body or organ dose equivalent	4 mrem/yr effective dose equivalent
Radium-226 plus -228 (pCi/L)	5	5
Strontium-90 (pCi/L)	8	8
Tritium (pCi/L)	20,000	20,000
Uranium (µg/L)	30	30
Arsenic (mg/L)	0.01	0.05
Antimony (mg/L)	0.006	0.006
Asbestos (fibers/L)	7 million	7 million
Barium (mg/L)	2	2
Beryllium (mg/L)	0.004	0.004
Cadmium (mg/L)	0.005	0.005
Chromium (mg/L)	0.1	0.1
Copper (mg/L)	1.3	1.3
Cyanide (mg/L)	0.2	0.2
Fluoride (mg/L)	4	4
Lead[a] (mg/L)	0.015	0.015
Mercury (mg/L)	0.002	0.002
Nitrate (as N) (mg/L)	10	10
Nitrite (as N) (mg/L)	1	1
Nitrate and Nitrite (both as N) (mg/L)	--[b]	10
Selenium (mg/L)	0.05	0.05
Thallium (mg/L)	0.002	0.002

a. Treatment technique action level, the concentration of a contaminant which, if exceeded, triggers treatment or other requirements that a water system must follow.
b. No maximum contaminant level for this constituent.

Table A-4. Environmental Protection Agency Maximum Contaminant Levels for Public Drinking Water Systems and State of Idaho Groundwater Quality Standards for Organic Contaminants.

Constituent	Maximum Contaminant Level (mg/L)	Groundwater Quality Standard (mg/L)
Benzene	0.005	0.005
Carbon tetrachloride	0.005	0.005
m-Dichlorobenzene	__	0.6
o-Dichlorobenzene	0.6	0.6
p-Dichlorobenzene	0.075	0.075
1,2-Dichloroethane	0.005	0.005
1,1-Dichloroethylene	0.007	0.007
cis-1,2-Dichloroethylene	0.07	0.07
trans-1,2-Dichloroethylene	0.1	0.1
Dichloromethane	0.005	0.005
1,2-Dichloropropane	0.005	0.005
Ethylbenzene	0.7	0.7
Monochlorobenzene	0.1	0.1
Styrene	0.1	0.1
Tetrachloroethylene	0.005	0.005
Toluene	1.0	1.0
1,2,4-Trichlorobenzene	0.07	0.07
1,1,1-Trichloroethane	0.2	0.2
1,1,2-Trichloroethane	0.005	0.005
Trichloroethylene	0.005	0.005
Vinyl chloride	0.002	0.002
Xylenes (total)	10.0	10.0
Bromate	0.01	__
Bromodichloromethane	__	0.1
Bromoform	__	0.1
Chlorodibromomethane	__	0.1
Chloroform	__	0.002
Chlorite	1.0	__
Haloacetic acids (HAA5)	0.06	__
Total Trihalomethanes (TTHMs)	0.08	0.1

Table A-5. Environmental Protection Agency Maximum Contaminant Levels for Public Drinking Water Systems and State of Idaho Groundwater Quality Standards for Synthetic Organic Contaminants.

Constituent	Maximum Contaminant Level (mg/L)	Groundwater Quality Standard (mg/L)
Alachlor	0.002	0.002
Atrazine	0.003	0.003
Carbofuran	0.04	0.04
Chlordane	0.002	0.002
Dibromochloropropane	0.0002	0.0002
2,4-Dichlorophenoxyacetic acid	0.07	0.07
Ethylene dibromide	0.00005	0.00005
Heptachlor	0.0004	0.0004
Heptachlor epoxide	0.0002	0.0002
Lindane	0.0002	0.0002
Methoxychlor	0.04	0.04
Polychlorinated biphenyls	0.0005	0.0005
Pentachlorophenol	0.001	0.001
Toxaphene	0.003	0.003
2,4,5-TP (silvex)	0.05	0.05
Benzo(a)pyrene	0.0002	0.0002
Dalapon	0.2	0.2
Di(2-ethylhexyl) adipate	0.4	0.4
Di(2-ethylhexyl) phthalate	0.006	0.006
Dinoseb	0.007	0.007
Diquat	0.02	0.02
Endothall	0.1	0.1
Endrin	0.002	0.002
Glyphosate	0.7	0.7
Hexachlorobenzene	0.001	0.001
Hexachlorocyclopentadiene	0.05	0.05
Oxamyl (vydate)	0.2	0.2
Picloram	0.5	0.5
Simazine	0.004	0.004
2,3,7,8-TCDD (dioxin)	3×10^{-8}	3×10^{-8}

Table A-6. Environmental Protection Agency National Secondary Drinking Water Regulations and State of Idaho Groundwater Quality Standards for Secondary Contaminants.

Constituent	Secondary Standard[a]	Groundwater Quality Standard
Aluminum (mg/L)	0.05 to 0.2	0.2
Chloride (mg/L)	250	250
Color (color units)	15	15
Foaming agents (mg/L)	0.5	0.5
Iron (mg/L)	0.3	0.3
Manganese (mg/L)	0.05	0.05
Odor (threshold odor number)	3	3
pH	6.5 to 8.5	6.5 to 8.5
Silver (mg/L)	0.1	0.1
Sulfate (mg/L)	250	250
Total dissolved solids (mg/L)	500	500
Zinc (mg/L)	5	5

a. The Environmental Protection Agency (EPA) has not established National Primary Drinking Water Regulations that set mandatory water quality standards (maximum contaminant levels) for these constituents because these contaminants are not considered a risk to human health. EPA has established National Secondary Drinking Water Regulations that set secondary maximal contaminant levels as guidelines to assist public water systems in managing their drinking water for aesthetic considerations, such as taste, color, and odor.

Appendix B. Cultural Resource Reviews Performed at the INL Site

The Idaho National Laboratory (INL) Cultural Resource Management Office (CRMO) resides within U.S. Department of Energy - Idaho Operations Office's (DOE-ID) INL Management and Operations Contractor, Battelle Energy Alliance. Cultural resource professionals within the INL CRMO coordinate cultural resource-related activities at the INL Site and implement the *INL Cultural Resource Management Plan* (DOE-ID 2016) with oversight by DOE-ID's Cultural Resource Coordinator. Provisions to protect the unique cultural resources of the lands and facilities at the INL Site are included in Environmental Policies issued by Battelle Energy Alliance and other INL Site contractors and in company procedures that guide work completion.

B.1 INL Section 106 Project Reviews

Cultural resource identification and evaluation studies in fiscal year (FY) 2017 included archaeological field surveys related to INL Site project activities as well as broader research goals, archival and historic research, routine monitoring of sensitive resources and ground disturbance associated with active INL Site projects, and meaningful interaction with members of the Shoshone-Bannock Tribes and public stakeholders who value the largely undisturbed legacy of human history and prehistory that is preserved at the INL Site. The totals reported in this section are derived from surveys related to INL Site project reviews.

In FY 2017, 33 INL Site project reviews were completed to assess potential impacts to archaeological resources per the general requirements of Section 106 of the National Historic Preservation Act. Field investigations were completed for 14 of these proposed projects and 203 acres were intensively surveyed for cultural resources. Nearly all of the proposed projects were small in size (½ to 20 acres) and included activities like parking lot improvements, fiber optic line installations, monitoring wells, gravel pit expansion, and road maintenance. Project-related surveys in FY 2017 resulted in the documentation of seven previously unknown archaeological resources and reassessment of 32 previously recorded resources. Table B-1 provides a summary of the cultural resource reviews performed in 2017.

Reporting for FY 2017 INL Site Cultural Resource Management (CRM) projects consisted largely of recommendations tailored to specific projects and any archaeological resources that required consideration, all delivered in official e-mail notes that became part of the projects' National

Environmental Policy Act-driven Environmental Checklists and permanent records. Several project-specific reports or plans were also prepared.

The INL Cultural Resource Management Plan defines architectural historic properties as buildings, structures, and objects that are eligible for listing on the National Register of Historic Places (NRHP). The historic property management approach includes property categories under which architectural properties are defined as eligible for listing on the NRHP. The four architectural property categories are (INL Cultural Resource Management Plan 2016: pg. 160):

- ***Signature Properties:*** A term used by U.S. Department of Energy-Headquarters, Signature Properties represent the most historically important properties across the complex and/or properties that are viewed as having tourism potential. These properties are documented through Historic American Buildings Survey (HABS), Historic American Engineering Record (HAER), or Historic American Landscape Survey reports, or NRHP nomination packets, regardless of their ultimate disposition.
- ***Category 1 Properties:*** Key individual INL properties (generally reactor buildings) that, through periodic reviews, may be reclassified as Signature Properties.
- ***Category 2 Properties:*** INL properties, which are contributing to the historic context and landscape, and which are directly associated with Signature or Category 1 properties.
- ***Category 3 Properties:*** INL properties, which are contributing to the historic context and landscape, but which are not directly associated with Signature or Category 1 properties.

Table B-1. FY 2017 Projects for Archaeological Properties.

CRMO Project Number	Project Title	Associated Documentation	Survey Required	Project Area (acres)	Number of Historic Properties	Recommendations/ Mitigation	SHPO Consult
BEA-17-01	Annual Section 110 Research	INL/EXT-17-41959	n/a	n/a	n/a	No Effect	n/a
BEA-17-02	Annual Monitoring	CDRL F.46	n/a/	n/a	n/a	n/a	n/a
BEA-17-03	USGS Well 145	EC INL-16-140	Yes	4	0	No Effect	n/a
BEA-17-04	MFC Gun Range	EC INL-16-122	Yes	5	1	No Effect	Pending
BEA-17-05	Monroe Gravel Pit Expansion	EC INL-14-045	Yes	17	1	No Effect	Pending
BEA-17-06	MFC Rabbit Fence	EC INL-16-165	Yes	8	0	No Effect	n/a
BEA-17-07	REC Campus Expansion	EC INL-17-037	No	0	0	No Effect	n/a
BEA-17-08	Power Management	EC INL-16-152	Yes	5	0	No Effect	n/a
BEA-17-09	Taylor Creek Road Curve	EC INL-16-171	Yes	1	0	No Effect	n/a
BEA-17-10	Box Canyon Bonfire Point	EC INL-17-029	No *BLM	0	0	No Effect	n/a
BEA-17-11	Environmental Monitoring	EC INL-16-153	No	0	0	No Effect	n/a
BEA-17-12	First Responder Jamming Exercise	EC INL-17-020	No	0	0	No Effect	n/a
BEA-17-13	Fluor ICP Routine Maintenance	ICP-17-001EC	No	0	0	No Effect	n/a
BEA-17-14	INTEC CERCLA Site	ICP-17-007EC	No	0	0	No Effect	n/a
BEA-17-15	MFC Drainage and Paving	EC INL-17-013	No	0	0	No Effect	n/a
BEA-17-16	MFC Road Widening	EC INL-16-147	No	0	0	No Effect	n/a
BEA-17-17	Overarching Critical Infrastructure Protection Program	EC INL-16-150	No	0	0	No Effect	n/a
BEA-17-18	REC Generator and Tank Removal	EC INL-16-167	No	0	0	No Effect	n/a

Table B-1. FY 2017 Projects for Archaeological Properties (continued).

CRMO Project Number	Project Title	Associated Documentation	Survey Required	Project Area (acres)	Number of Historic Properties	Recommendations/ Mitigation	SHPO Consult
BEA-17-19	Road Improvements	EC INL-17-030	No	0	0	No Effect	n/a
BEA-17-20	Safety Improvements	EC INL-16-160	No	0	0	No Effect	n/a
BEA-17-21	SMC Paving	EC INL-16-159	No	0	0	No Effect	n/a
BEA-17-22	Unmanned Aerial Vehicles	EC INL-16-149	No	0	0	No Effect	n/a
BEA-17-23	Wilson Blvd Parking Areas	EC INL-17-051	Yes	2	0	No Effect	n/a
BEA-17-24	NRF North Fence Relocation	INL/LTD-12-27685	No	0	0	No Effect	n/a
BEA-17-25	SMC Pavement Repair	EC INL-16-159	No	0	0	No Effect	n/a
BEA-17-26	Iona Hill Relay Station	EC INL-17-002	No	0	0	No Effect	n/a
BEA-17-27	MFC Fire Station Stormwater Control	EC INL-17-042	No	0	0	No Effect	n/a
BEA-17-28	MFC, CFA Underground Tanks	EC IN-17-043	No	0	0	No Effect	n/a
BEA-17-29	CITRC Rock Disposal	EC INL-16-010	Yes	3	0	No Effect	n/a
BEA-17-30	RRTR Expansion	EC INL-17-046	Yes	69	0	No Effect	Pending
BEA-17-31	INTEC Interim Storage Upgrade	ICP-17-010EC	No	0	0	No Effect	n/a
BEA-17-32	INL Boundary Signs	n/a	Yes	1	0	No Effect	n/a
BEA-17-33	Wigwam Fence	EA ID-074-02-067	Yes	160	16	No Effect/Avoidance	Pending
BEA-17-34	Weather Tower	EC INL-17-108	Yes	TBD	TBD	No Effect	n/a
BEA-17-35	Injection Well Decommission	EC INL-17-091	No	0	0	No Effect	n/a
BEA-17-36	T-25 Sand Removal	EC INL-17-095	Yes	TBD	TBD	Pending	Pending
BEA-17-37	CFA Live Fire Shoot House	EC INL-17-077	Yes	2	0	No Effect	n/a

When an effect on a historic architectural property will be adverse and avoidance or reuse is infeasible, mitigation to minimize the adverse effect is necessary. Based on the relative importance of the affected property, as defined by the property category, mitigation includes varying types of documentation and potentially other activities (INL Cultural Resource Management Plan 2016, pg. 165).

Fifty projects were identified for cultural resource review for potential effects to historic architectural properties in FY 2017 (Table B-2). Most of these projects (forty-two) involved exempt activities including routine maintenance, replacement-in-kind, safety systems, and internal reconfiguration of active laboratories.

Two of these projects completed required mitigation:

- ***BEA-17-H001*** - Deactivation, Decontamination, and Decommissioning of Atomic Energy Commission era additions to CF-633, the Arco Naval Proving Ground Concussion Wall, a DOE Signature Property; an Historic American Landscape Survey was completed in FY 2015;
- ***BEA-17-H002*** - Deactivation, Decontamination, and Decommissioning of CF-690, the Radiological and Environmental Sciences Laboratory; Category 3 property mitigation, in the form of digital photography and completion of an Idaho Historic Sites Inventory form.

Two of these projects are ongoing:

- ***BEA-17-H007*** - INL Site Characterization and Environmental Monitoring (overarching EC);
- ***BEA-17-H009*** - INL Installation of Relocation of Machinery and Equipment B1.31 (overarching EC).

Four of these projects are awaiting implementation and have not yet completed cultural resource review:

- ***BEA-17-H012*** - HFEF/IMCL Shielded Container Material Transfer Station (MFC-785);
- ***BEA-17-H014*** - PBF-612 Maintenance and Modifications;
- ***BEA-17-H016*** - MFC-752 AL Sodium Stack Monitoring System Redesign;
- ***BEA-17-H045*** - TRA-621 (NMIS) Facility Upgrades (TRA-605).

B.2 INL Section 110 Research

In 2017, INL cultural resource investigations were also conducted to further DOE-ID obligations under Section 110 of the National Historic Preservation Act. These efforts were designed to develop a broad understanding of regional Native American and Euroamerican land use patterns, as well as assist in formulating historic contexts as per the *INL Cultural Resource Management Plan* (DOE-ID 2016). In 2017, implementation began on two Section 110 research proposals, including: *Pluvial Lake Terreton: Building a Multidisciplinary Dataset to Understand Human Land Use During the Terminal Pleistocene* (INL/EXT-17041959) and *Decoding the Southern Idaho Cultural Landscape Through Volcanic Glass Source Analysis* (INL/MIS-17-41305). DOE-ID and the CRM staff are currently developing a Memorandum of Understanding to outline coordination of these research efforts with the Shoshone-Bannock Tribes, the United States Forest Service and the Bureau of Land Management.

During 2017, the CRM staff generated a predictive model using existing terminal Pleistocene archaeological data from the Pioneer Basin of southeastern Idaho. These data not only imply that Lake Terreton experienced fluctuations between 13,000 and 8,000 years ago, but that human reliance on lake shore resources may have been previously overemphasized. Figure B-1 highlights the frequency of terminal Pleistocene sites across the open plain, especially in the vicinity of the Big Lost River. During this time frame, surface water would not have been limited to Lake Terreton, thus providing rich riparian habitats in the form of rivers, washes and what would have been highly productive ephemeral ponds. The multi-agency Memorandum of Understanding will allow an examination of land use patterns spanning the initial Clovis occupation of the Pioneer Basin through the late terminal Pleistocene/early Holocene, as people learned to adapt to a warmer, drier climate and significant loss of surface water and a reduction in available megafauna.

B.3 Cultural Resource Monitoring

The INL CRMO conducts yearly cultural resource monitoring that includes many sensitive archaeological, historic architectural and tribal resources. Results of all monitoring and formal impact investigations are summarized annually in a year-end report to DOE-ID that is completed at the end of October. For 2017, the following report provides documentation:

Table B-2. FY 2017 Cultural Resource Review for Historic Architectural Properties.

Project Number	Project Title	Associated Documentation	Property Type(s)
BEA-17-H001	DD&D of AEC Additions to CF-633/Arco NPG Concussion Wall	EC INL-13-081; HALS No. ID-1	Signature
BEA-17-H002	DD&D of CF-690/Radiological and Environmental Sciences Laboratory	EC-INL-13-075; INL/EXT-10-17663	Category 3
BEA-17-H003	ATR Complex - installation of jacking bolts	correspondence in CRMO project file BEA-17-H003	various
BEA-17-H004	Install PCM12 at TRA-605	WO 228309	Category 2
BEA-17-H005	Replace Hydrogen Detection System at ATR/TRA-670	WO 228888	Category 1
BEA-17-H006	MFC-785/HFEF Spray Chamber Water Conditioner Removal	EC INL-16-143	Category 2
BEA-17-H007	INL Site Characterization and Environmental Monitoring (overarching EC)	EC INL-16-153	various
BEA-17-H008	Spark Plasma Sintering at MFC-784	INL EC-16-155	Category 2
BEA-17-H009	INL Installation of Relocation of Machinery and Equipment B1.31 (overarching EC)	EC INL-16-156	various
BEA-17-H010	EBR-II Blanket Sodium Melt Drain Evaporator (MEDE) Test at MFC-765/FCF	EC INL-16-164	Category 2
BEA-17-H011	Eyewash Station Replacement in TRA-670/ATR	correspondence in CRMO project file BEA-17-H011	Category 1
BEA-17-H012	HFEF/IMCL Shielded Container Material Transfer Station (MFC-785)	EC INL-16-173	Category 2
BEA-17-H013	Iona Relay Station Decommissioning	EC INL-17-002	exempt property
BEA-17-H014	PBF-612 Maintenance and Modifications	EC INL-17-004	Category 1
BEA-17-H015	Remove Steam Kettle System and Install Respirator Mask Washer in MFC-752	EC INL-17-009	Category 3
BEA-17-H016	MFC-752 AL Sodium Stack Monitoring System Redesign	EC INL-17-012	Category 3
BEA-17-H017	Install Face Velocity Monitors on ATR Fume Hoods (TRA-670/ATR)	EC INL-17-014	Category 1
BEA-17-H018	EBR-I Sustainability	N/A	Signature
BEA-17-H019	MFC-752 AL Special Projects Glovebox Modification for Laser Flash Diffusivity Instrument Removal (AL-1700, AL-1730)	EC INL-17-018	Category 3
BEA-17-H020	Equipment Installation for ATR Pumps (TRA-670/ATR)	EC INL-17-015	Category 1

Table B-2. FY 2017 Cultural Resource Review for Historic Architectural Properties (continued).

Project Number	Project Title	Associated Documentation	Property Type(s)
BEA-17-H021	ATR Loop 1C-W, Relief Valve Discharge Piping Modifications for SF-135, -137, and -535 (TRA-670/ATR)	EC INL-17-023	Category 1
BEA-17-H022	ATR 670-C-8 Crane System Modification (TRA-670/ATR)	EC INL-17-024	Category 1
BEA-17-H023	ATR 670-C-1, Crane End Modification (TRA-670/ATR)	EC INL-17-026	Category 1
BEA-17-H024	MFC Complex – 2017 Expand Wireless Data Infrastructure	EC INL-17-027	Various
BEA-17-H025	MFC-752 L&O Conference Room Remodel	correspondence in CRMO project file BEA-17-H025	Category 3
BEA-17-H026	Install Resin Hose Inlet and Valve on Experiment Loop 1D-N (TRA-670/ATR)	EC INL-17-028	Category 1
BEA-17-H027	Install and Operate Inductively Coupled Plasma-Mass Spectrometer in MFC AL (MFC-752)	EC INL-17-025	Category 3
BEA-17-H028	ATF-2 Sensor Qualification Test Equipment Installation ATR/ TRA-670)	WO 239405	Category 1
BEA-17-H029	Remove Buss Tie between 670-E-1 and 670-E-2 (ATR / TRA-670)	WO 242572	Category 1
BEA-17-H030	Repair of North Radiography Station (NRS) Gamma Shield (MFC-785 / HFEF)	EC INL-17-047	Category 2
BEA-17-H031	ZPPR Criticality Detector Modification (MFC-776)	EC INL-17-050	Category 2
BEA-17-H032	INTEC – Process Evaporator Waste Process Condensate Surge Tank System (VES-WL-131) Modifications (CPP-604)	EC ICP-17-012	Category 2
BEA-17-H033	Removal and repair of weather stripping along front bay door (EBR-I)	correspondence in CRMO project file BEA-17-H033	Signature; Listed NHL
BEA-17-H034	INTEC / CPP-603 Large Cask Adaptability	EC ICP-17-013	Category 2
BEA-17-H035	Energy Efficient Upgrades for MFC-791	correspondence in CRMO project file BEA-17-H035	Not Eligible
BEA-17-H036	ATR/ATRC Security Upgrades (ATR/TRA-670)	EC INL-17-063	Category 1
BEA-17-H037	INTEC – Acid Recycle Tank (VES-NCR-171) to Valve Box Leak Detection Modifications (CPP-659)	EC ICP-17-015	Not eligible
BEA-17-H038	Installation of Cell Phone Booster Antennas (MFC-781)	correspondence in CRMO project file BEA-17-H038	Category 3
BEA-17-H039	Replace/Install Air Dryer and Mill in MFC-782 Machine Shop	EC INL-17-083 (QA 27)	Category 3

Table B-2. FY 2017 Cultural Resource Review for Historic Architectural Properties (continued).

Project Number	Project Title	Associated Documentation	Property Type(s)
BEA-17-H040	Removal of TRA-670 (ATR) RadCon Hood TRA H-31	EC INL-17-079	Category 1
BEA-17-H041	Installation of Network Data Cables (TRA-670/ATR)	EC INL-17-081	Category 1
BEA-17-H042	Install/replace drinking water dispensers with ice machines and/or upgraded water dispensers (TRA-670/ATR, TRA-649, TRA-653, TRA-662, TRA-667, TRA-670)	correspondence in CRMO project file BEA-17-H042	Category 1; Category 3
BEA-17-H043	Installation of flag in ATR (TRA-670)	WO 247101	Category 1
BEA-17-H044	Upgrade ATR Complex Fire Alarm System (TRA-670/ATR)	EC INL-17-089	Category 1
BEA-17-H045	TRA-621 (NMIS) Facility Upgrades (TRA-605)	EC INL-17-090	Category 2
BEA-17-H046	ATR Portable Fire Extinguisher Relocation and Signage (TRA-670/ATR)	WO 232601	Category 1
BEA-17-H047	EBR-I Brick and Drainage Repair	EC INL-17-099; SOW-14291; Contract 192563	Signature; Listed NHL
BEA-17-H048	Research and Education Campus (REC) Fiscal Year (FY) 2018 Interior Updates	EC INL-17-101	Not eligible
BEA-17-H049	ATR Maintenance Support Building Design and Construction (TRA-653)	EC INL-17-109	Category 3
BEA-17-H050	MFC-752 Analytical Laboratory (AL) Hot Cell 5 Gamma Spectrometer Installation (MFC-752/AL-3100)	EC INL-17-113	Category 3

- INL/LDT-17-43938: Idaho National Laboratory Cultural Resource Monitoring Report for Fiscal Year 2017.

This report is available through the DOE-ID Cultural Resource Coordinator or the INL Cultural Resource Management Office. Reports containing restricted data on site locations are not available to the public.

B.4 Stakeholder, Tribal, Public, and Professional Outreach

Outreach and education are important elements in the INL CRMO program and efforts are routinely oriented toward the general public, INL employees, and stakeholders such as the Idaho State Historic Preservation Office, Shoshone-Bannock Tribes, and cultural resource professionals. Tools that facilitate communication include activity reports, presentations, newspaper articles and interviews, periodic tours, regular meetings with Tribal representatives, and various INL-specific internal and external media outlets. Educational exhibits at the Experimental Breeder Reactor-I Visitor's Center (a National Historic Landmark) and the Big Lost River Rest Area on U.S. Highway 20/26 are also important public outreach tools.

In 2017, INL CRMO staff members spoke on a wide variety of general topics, including regional prehistory and history, World War II, nuclear history, historic preservation, careers, cultural resource management, archaeological resource protection, and Native American resources and sensitivities. Audiences ranged from the general public, students, and INL employees to civic groups, and cultural resource management professionals. Archaeological awareness and protection training is also routinely conducted on an as needed basis to various project personnel.

The INL Site is located on the aboriginal territory of the Shoshone and Bannock people. The Shoshone-

Bannock Tribes have a government-to-government relationship with DOE-ID that is strengthened and maintained through an Agreement-in-Principle (AIP) between the Tribes and the DOE-ID (DOE-ID 2017). The AIP defines working relationships between the Shoshone-Bannock Tribes and DOE-ID and fosters a mutual understanding and commitment to addressing a variety of tribal concerns regarding protection of health, safety, and environment, including cultural resources of importance to the Tribes. To aid with implementing cultural resource aspects of the AIP, a Cultural Resources Working Group comprised of representatives from the Shoshone-Bannock's Heritage Tribal Office, DOE-ID, and the INL CRMO meets on a bi-monthly basis.

REFERENCES

DOE-ID, 2016, *Idaho National Laboratory Cultural Resource Management Plan*, DOE/ID-10997, Rev 6, February 2016.

DOE-ID, 2017, *Agreement-in-Principle (between the Shoshone-Bannock Tribes and the U.S. Department of Energy)*, September, 2017.

DOE-ID, 2017, *INL Cultural Resource Monitoring Report for Fiscal Year 2017,* INL/LDT-43938, December 2017.

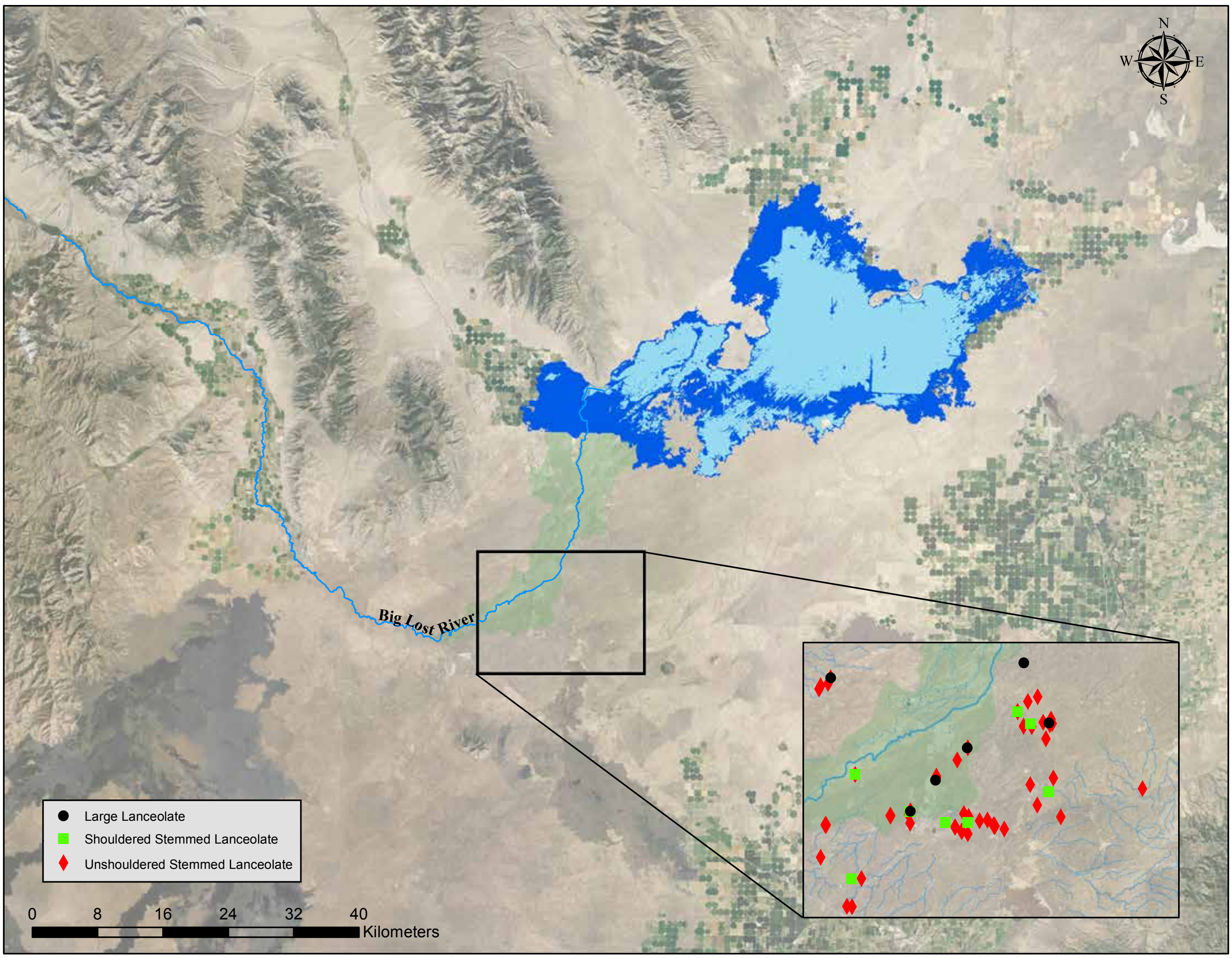

Figure B-1. Density of Terminal Pleistocene Sites Located a Significant Distance from Lake Terreton.

Appendix C. Chapter 5 Addendum

Table C-1. Advanced Test Reactor Complex Cold Waste Pond Effluent Permit-Required Monitoring Results (2017).[a]

Parameter	Minimum	Maximum	Median
pH (standard units)	6.59	7.50	6.90
Conductivity (µS/cm)	397	1,324	458
Aluminum, filtered (mg/L)	0.015U[b]	0.034	0.0193U
Chloride (mg/L)	9.20	44.5	11.9
Chromium, filtered (mg/L)	0.0335	0.0152	0.0047
Chromium, total (mg/L)	0.00353	0.0158	0.00455
Iron, filtered (mg/L)	0.033U	0.265	0.0452
Manganese, filtered (mg/L)	0.001U	0.0049	0.001U
Nitrate + Nitrite as Nitrogen (mg/L)	0.87	3.68	1.03
Nitrogen, Total Kjeldahl Nitrogen (TKN) (mg/L)	-0.0209	1.19	0.0957
Nitrogen, Total (mg/L)[c]	0.87	4.87	1.12
Solids, Total Dissolved (mg/L)	223	1,220	239
Sulfate (mg/L)	20.2	644	34.7

a. Duplicate samples were collected in July and the results for the duplicate samples are included in the summary.

b. U qualifier indicates the result was below the detection limit.

c. Total nitrogen is calculated as the sum of total Kjeldahl nitrogen and nitrate + nitrite, as nitrogen. For results reported below the laboratory instrument detection limit and with a negative value, the sample results are considered zero when used in the calculation.

Table C-2. Advanced Test Reactor Complex Cold Waste Pond Industrial Wastewater Reuse Permit Monitoring Well Results (2017).

Well Name	USGS-098 (GW-016101)		USGS-065 (GW-016102)		USGS-076 (GW-016104)		TRA-08 (GW-016105)		Middle-1823 (GW-016106)		Standard PCS/SCS[a]
Sample Date:	*5/4/17*	*9/12/17*	*5/9/17*	*9/13/17*	*5/8/17*	*9/13/17*	*5/8/17*	*9/13/17*	*5/4/17*	*9/12/17*	
Water table depth (ft below ground surface)	429.36	429.64	476.97	476.74	484.95	484.67	490.18	489.84	494.56	494.56	NA[b]
Water table elevation (above mean sea level in ft)[c]	4459.85	4459.57	4451.60	4451.83	4448.26	4448.54	4448.88	4449.22	4448.31	4448.31	NA
Borehole correction factor (ft)[d]	2.53	2.53	NA	NA	NA	NA	0.63	0.63	NA	NA	NA
pH	7.24	6.75	7.59	7.20	7.90	6.83	7.84	7.26	7.61	7.09	6.5 to 8.5 (SCS)
Electrical Conductivity (µS/cm)	393	386	567	553	419	380	417	388	404	420	NA
Nitrite +Nitrite as Nitrogen (mg/L)	1.07	0.825	1.41	1.24	1.04	0.93	0.975	0.822	0.985	0.855 (0.865)[e]	NA
Total Kjeldahl nitrogen (mg/L)	0.0398U[f]	0.0325U	0.132U	0.0817U	-0.0032U	-0.00857U	0.0362U	0.0793U	0.146U	-0.0097U (0.314U)	NA
Total nitrogen[g] (mg/L)	1.11	0.86	1.54	1.32	<1.07	<0.96	1.01	0.90	1.13	0.89 (1.18)	NA
Total dissolved solids (mg/L)	221	196	394	417	243	267	231	280	243	260 (247)	500 (SCS)
Aluminum (mg/L) filtered	0.0193U	0.0193U	0.0193U	0.0193U	0.0193U	0.0193U	0.0953	0.0235	0.0193U	0.0193U (0.0193U)	0.2 (SCS)
Chloride (mg/L)	13.4	13.7	17.1	17.5J[h]	11.8	11.8	10.4	10.3	10.4	10.3 (10.4)	250 (SCS)
Chromium filtered (mg/L) total	0.00677	0.00689	0.0112	0.00769	0.0115	0.0112	0.0209	0.0195	0.0108	0.0102 (0.0107)	NA
Iron filtered(mg/L)	0.03U	0.03U	0.03U	0.03U	0.03U	0.03U	0.0324	0.03U	0.03U	0.03U (0.03U)	0.3 (SCS)
Manganese (mg/L) filtered	0.001U	0.001U	0.001U	0.001U	0.001U	0.001U	0.00124J	0.001U	0.00167J	0.00118 (0.00115)	0.05 (SCS)
Sulfate (mg/L)	21.5	21.6	150	143	34.8	34.3	44.5	43.7	34.3	33.6	250

Table C-2. Advanced Test Reactor Complex Cold Waste Pond Industrial Wastewater Reuse Permit Monitoring Well Results (2017) (continued).

Well Name	USGS-098 (GW-016101)		USGS-065 (GW-016102)		USGS-076 (GW-016104)		TRA-08 (GW-016105)		Middle-1823 (GW-016106)		Standard
Sample Date:	*5/4/17*	*9/12/17*	*5/9/17*	*9/13/17*	*5/8/17*	*9/13/17*	*5/8/17*	*9/13/17*	*5/4/17*	*9/12/17*	PCS/SCS[a]
										(33.5)	(SCS)

a. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in the State of Idaho Ground Water Quality Rule, IDAPA 58.01.11.200.01.a and b. In accordance with Reuse Permit I-161-02, Section 5.2.2, footnote a., compliance with the PCS for chromium, under the Reuse Permit, shall not apply.

b. NA = Not applicable

c. Elevation data provided using the North American Vertical Datum of 1988 (NAVD 88).

d. The United States Geological Survey performed gyroscopic surveys on wells TRA-08 and USGS-098 circa 2002 to 2005. The surveys revealed these two wells were not perfectly straight or vertical which can cause the water level measurements to be greater than the true distance from the measuring point on the well to the water table. The water table elevations for these two wells have been adjusted using the borehole correction factors that were determined from the gyroscopic surveys.

e. Results shown in parenthesis are from the field duplicate samples.

f. U qualification indicates the analyte was not detected above the instrument detection limit or the analyte was detected at or above the applicable detection limit but the value is not more than 5 times the highest positive amount in any laboratory blank and is U qualified as a result of data validation.

g. Total nitrogen is calculated as the sum of the total Kjeldahl nitrogen (TKN) and nitrite +nitrate as nitrogen. For results reported as a negative value, the method detection limit (MDL) of 0.033 mg/L replaced the result for calculation purpose and the product was reported as a less than (<) number. For positive results reported below the instrument detection limit, the MDL was used in the total nitrogen calculation and the product was reported as a less than (<). Results were rounded to the nearest hundredth.

h. J flag indicates the associated value is an estimate and may be inaccurate or imprecise.

Table C-2a. Advanced Test Reactor Complex Cold Waste Pond Industrial Wastewater Reuse Permit Monitoring Well Results (2017).

Well Name	USGS-058 (GW-016107)		Standard (PCS/SCS)[a]
Sample Date:	***5/4/17***	***9/14/17***	
Water table depth (ft below land surface)	472.93	472.66	NA[b]
Water table elevation (ft above mean sea level)[c]	4448.96	4449.23	NA
Borehole correction factor (ft)	NA	NA	NA
pH	NR[d]	NR	6.5 to 8.5 (SCS)
Electrical Conductivity (µS/cm)	NR	NR	NA
Total dissolved solids (mg/L)	216	236	500 (SCS)
Sulfate (mg/L)	35.9	34.3	250 (SCS)

a. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in the State of Idaho Ground Water Quality Rule, IDAPA 58.01.11.200.01.a and b.
b. NA = Not applicable
c. Elevation data provided using the North American Vertical Datum of 1988 (NAVD 88).
d. NR indicates the parameter is not required by the Reuse Permit.

Table C-3. Idaho Nuclear Technology and Engineering Center Sewage Treatment Plant Influent Monitoring Results at CPP-769 (2017).

Parameter	Minimum	Maximum	Mean
Biochemical oxygen demand (5-day) (mg/L)	120	583	233
Nitrate + nitrite, as nitrogen (mg/L)	-0.0262 U[a]	3.9	0.372
Total Kjeldahl nitrogen (mg/L)	4.68	156	72
Total phosphorus (mg/L)	4.04	9.76	6.13
Total suspended solids (mg/L)	45.6	220	122

a. U flag indicates the analyte was analyzed for but not detected above the method detection limit.

Table C-4. Idaho Nuclear Technology and Engineering Center Sewage Treatment Plant Effluent Monitoring Results at CPP-773 (2017).

Parameter	Minimum	Maximum	Mean
Biochemical oxygen demand (5-day) (mg/L)	5.35	32	14.4
Nitrate + nitrite, as nitrogen (mg/L)	0.0086 U[a]	4.34	1.2
pH (standard units)[b]	6.72	9.30	8.14
Total coliform (MPN/100 mL)[b]	156.5	>2,419	1,178.2
Total Kjeldahl nitrogen (mg/L)	5.35	68	20.5
Total phosphorus (mg/L)	2.09	10.3	4.34
Total suspended solids (mg/L)	1.9	163	23

a. U flag indicates the analyte was analyzed for but not detected above the method detection limit.
b. As required by the permit, the results for this parameter were obtained from a grab sample.
MPN = most probable number

Table C-5. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Effluent Monitoring Results at CPP-797 (2017).

Parameter	Minimum	Maximum	Mean
Aluminum (mg/L)[a]	0.068 U[b]	0.068 U	0.068 U
Arsenic (mg/L)[a]	0.005 U	0.005 U	0.005 U
Biochemical oxygen demand (5-day) (mg/L)[a]	3.53 U	9.72	6.46
Cadmium (mg/L)[a]	0.001 U	0.001 U	0.001 U
Chloride (mg/L)	11.4	143	25.5
Chromium (mg/L)	0.0051	0.006	0.0055
Coliform, fecal (MPN/100 mL)[c, d]	<1	<1	<1
Coliform, total (MPN/100 mL)[d]	4.1	1299.7	216.5
Conductivity (µS/cm)[a]	370	405	392
Copper (mg/L)[a]	0.0050	0.0089	0.0068
Fluoride (mg/L)	0.172	0.313	0.229
Iron (mg/L)[a]	0.03 U	0.03 U	0.03 U
Manganese (mg/L)	0.002 U	0.002 U	0.002 U
Mercury (mg/L)[a]	0.000067 U	0.000067 U	0.000067 U
Nitrate + nitrite, as nitrogen (mg/L)	0.757	2.48	1.33
pH (standard units)[d]	7.66	8.69	8.18
Selenium (mg/L)	0.002 U	0.003	0.002
Silver (mg/L)[a]	0.001 U	0.001 U	0.001 U
Sodium (mg/L)[a]	9.21	15.9	13.52
Total dissolved solids (mg/L)	203	467	246
Total Kjeldahl nitrogen (mg/L)[a]	0.209	1.01	0.553
Total phosphorus (mg/L)	0.596	1.42	0.882
Total suspended solids (mg/L)[a]	0.200 U	3.80	2.18

a. Monitoring for this parameter ceased when Reuse Permit M-130-06 was issued in June 2017.
b. U flag indicates the analyte was analyzed for but not detected above the method detection limit.
c. As required by the permit, the results for this parameter were obtained from a grab sample.
d. Monitoring for this parameter began when Reuse Permit M-130-06 was issued in June 2017.

Table C-6. Hydraulic Loading Rates for the INTEC New Percolation Ponds.

	Maximum Daily Flow	Yearly Total Flow
2017 flow	817,100 gallons	193 MG[a]
Permit limit	3,000,000 gallons	1,095 MG

a. MG = million gallons

Table C-7. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Aquifer Monitoring Well Groundwater Results (2017).

Parameter	ICPP-MON-A-165 (GW-13006)		ICPP-MON-A-166 (GW-13007)		ICPP-MON-A-164B (GW-13011)		Standard PCS/SCS[a]
Sample Date:	*4/4/2017*	*9/13/2017*	*4/4/2017*	*9/13/2017*	*4/4/2017*	*9/13/2017*	
Water table depth (ft below land surface)	505.40	504.77	512.64	511.94	504.48	503.85	NA[b]
Water table elevation (ft above mean sea level)[c]	4,447.51	4,448.14	4,446.90	4,447.60	4,447.69	4,448.32	NA
Aluminum (mg/L)[d]	0.068 U[e]	NR[f]	0.068 U	NR	0.068 U	NR	0.2
Arsenic (mg/L)	0.002 U	NR	0.002 U	NR	0.002 U	NR	0.05
Biochemical oxygen demand (mg/L)	17	NR	8.15	NR	21	NR	NA
Cadmium (mg/L)	0.001 U	NR	0.001 U	NR	0.001 U	NR	0.005
Chloride (mg/L)	35	33.8	12.4	12.7	9.78	9.77	250
Chromium (mg/L)	0.00973	0.0098	0.00477	0.00452	0.0114	0.00792	0.1
Coliform, fecal (MPN[g]/100 mL)	<1	<1	<1	<1	<1	<1	<1 CFU[h]/100 ml
Coliform, total (MPN/100 mL)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1 CFU/100 ml[i]
Copper (mg/L)	0.003 U	NR	0.003 U	NR	0.003 U	NR	1.3
Dissolved oxygen (mg/L)	NR	8.29	NR	6.12	NR	7.10	NA
Electrical conductivity (µmhos/cm)	NR	593	NR	410	NR	526	NA
Fluoride (mg/L)	0.227	0.180	0.307	0.214	0.205	0.148	4
Iron (mg/L)[d]	0.030 U	NR	0.0736	NR	0.030 U	NR	0.3
Manganese (mg/L)[d]	0.002 U	NR	0.0116	NR	0.002 U	NR	0.05
Manganese, total (mg/L)	NR	0.001 U	NR	0.0148	NR		0.05
Mercury (mg/L)	0.000067 U	NR	0.000067 U	NR	0.000067 U	NR	0.002
Nitrate, as nitrogen (mg/L)	1.07	NR	0.277	NR	0.843	NR	10
Nitrite, as nitrogen (mg/L)	0 U	NR	0 U	NR	0 U	NR	1
Nitrate/Nitrite, as nitrogen (mg/L)	NR	1.08	NR	0.271	NR	0.905	10

Table C-7. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Aquifer Monitoring Well Groundwater Results (2017) (continued).

Parameter	ICPP-MON-A-165 (GW-13006)		ICPP-MON-A-166 (GW-13007)		ICPP-MON-A-164B (GW-13011)		Standard PCS/SCS[a]
Sample Date:	*4/4/2017*	*9/13/2017*	*4/4/2017*	*9/13/2017*	*4/4/2017*	*9/13/2017*	
pH (standard units)	7.88	8.26	7.83	7.91	7.81	7.88	6.5–8.5
Selenium (mg/L)	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U	0.05
Silver (mg/L)[d]	0.00108 U	NR	0.00124	NR	0.001 U	NR	0.1
Sodium (mg/L)	17.1	NR	9.91	NR	10.7	NR	NA
Temperature (°F)	NR	55.83	NR	54.59	NR	57.74	NA
Total dissolved solids (mg/L)	276	267	197	183	253	237	500
Total Kjeldahl nitrogen (mg/L)	-0.0346 U	NR	-0.0854 U	NR	0.0274 U	NR	NA
Total phosphorus (mg/L)	0.0485	0.0264	0.0943	0.0296	0.0123	0.0273	NA

a. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in IDAPA 58.01.11.200.01.a and b.
b. NA = Not Applicable.
c. Water table elevations referenced to North American Vertical Datum of 1988 (NAVD 88).
d. The results of dissolved concentrations of this parameter are used for secondary constituent standard compliance determinations.
e. U flag indicates the result was reported as below the detection/reporting limit.
f. NR = monitoring for this parameter was "not required" per the permit.
g. MPN = most probable number.
h. CFU = colony forming unit.
i. An exceedance of the PCS for total coliform is not a violation. If the PCS for total coliform is exceeded, analysis for fecal coliform is conducted. An exceedance of the PCS for fecal coliform is a violation.

Table C-8. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Perched Water Monitoring Well Groundwater Results (2017).

Parameter	ICPP-MON-V-191 (GW-13008)		ICPP-MON-V-200 (GW-13009)		ICPP-MON-V-212 (GW-13010)		Standard PCS/SCS[a]
Sample date:	*5/31/2017*	*10/26/2017*	*4/5/2017*	*9/13/2017*	*4/5/2017*	*9/13/2017*	
Depth to water (ft below land surface)	107.89	107.90	110.22	114.25	236.22	235.82	NA[b]
Water table elevation (ft above mean sea level)[c]	4,840.07	4,840.06	4,842.75	4,838.72	4,722.28	4,722.68	NA
Aluminum (mg/L)[d]	0.0683	NR[e]	0.068 U[f]	NR	0.068 U	NR	0.2
Arsenic (mg/L)	0.00203	NR	0.00956	NR	0.002 U	NR	0.05
Biochemical oxygen demand (mg/L)	0.942	NR	0.209 U	NR	1.35	NR	NA
Cadmium (mg/L)	0.001 U	NR	0.001 U	NR	0.001 U	NR	0.005
Chloride (mg/L)	3.12	2.99	26.5	18.7	33.6	31.5	250
Chromium (mg/L)	0.00636	0.00456	0.00608	0.0116	0.00609	0.00623	0.1
Coliform, fecal (MPN[g]/100 mL)	<1	<1	<1	<1	<1	<1[h]	<1 CFU[i]/100 mL
Coliform, total (MPN/100 mL)	65.0	<1.0	<1.0	4.1	<1.0	517.2[h]	1 CFU/100 mL[j]
Copper (mg/L)	0.00334	NR	0.003 U	NR	0.003 U	NR	1.3
Dissolved oxygen (mg/L)	NR	5.37	NR	6.99	NR	8.39	NA
Electrical conductivity (µmhos/cm)	NR	363	NR	509	NR	566	NA
Fluoride (mg/L)	0.278	0.273	0.245	0.184	0.293	0.226	4
Iron (mg/L)[d]	0.0544	NR	0.030 U	NR	0.030 U	NR	0.3
Manganese (mg/L)[d]	0.00325	NR	0.002 U	NR	0.002 U	NR	0.05
Manganese, total (mg/L)	NR	0.00973	NR	0.001U	NR	0.00495	0.05
Mercury (mg/L)	0.000067 U	NR	0.000067 U	NR	0.000067 U	NR	0.002
Nitrate, as nitrogen (mg/L)	0.444	NR	1.61	NR	1.37	NR	10
Nitrite, as nitrogen (mg/L)	0 U	NR	0 U	NR	0 U	NR	1

Table C-8. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Perched Water Monitoring Well Groundwater Results (2017) (continued).

Parameter	ICPP-MON-V-191 (GW-13008)		ICPP-MON-V-200 (GW-13009)		ICPP-MON-V-212 (GW-13010)		Standard PCS/SCS[a]
Sample date:	*5/31/2017*	*10/26/2017*	*4/5/2017*	*9/13/2017*	*4/5/2017*	*9/13/2017*	
Nitrate/Nitrite, as nitrogen (mg/L)	NR	0.252	NR	0.898	NR	1.23	10
pH (standard units)	8.03	7.87	7.62	7.60	7.76	7.64	6.5–8.5
Selenium (mg/L)	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U	0.05
Silver (mg/L)[d]	0.00158 U	NR	0.00169	NR	0.001 U	NR	0.1
Sodium (mg/L)	7.07	NR	17.7	NR	35.1	NR	NA
Temperature (°F)	NR	55.49	NR	62.26	NR	65.82	NA
Total dissolved solids (mg/L)	146	206	236	223	259	230	500
Total Kjeldahl nitrogen (mg/L)	-0.029 U	NR	-0.0713 U	NR	-0.0925 U	NR	NA
Total phosphorus (mg/L)	0.0832 U	0.0526	0.385	0.216	0.121	0.0409	NA

a. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in IDAPA 58.01.11.200.01.a and b.

b. NA = not applicable.

c. Water table elevations referenced to North American Vertical Datum of 1988 (NAVD 88).

d. The results of dissolved concentrations of this parameter are used for secondary constituent standard compliance determinations.

e. NR = monitoring for this parameter was "not required" per the permit.

f. U flag indicates the result was reported as below the detection/reporting limit.

g. MPN = most probable number.

h. Samples exceeded the SM 9060B transport hold time of 6 hours.

i. CFU = colony forming units.

j. An exceedance of the PCS for total coliform is not a violation. If the PCS for total coliform is exceeded, analysis for fecal coliform is conducted. An exceedance of the PCS for fecal coliform is a violation.

Table C-9. Materials and Fuels Complex Industrial Waste Pipeline Monitoring Results (2017).[a]

Parameter	Minimum	Maximum	Median
pH (standard units)	6.60	8.22	7.44
Conductivity ((µS/cm)	338	712	469
Nitrate + Nitrite as Nitrogen (mg-N/L)	1.88	3.43	2.48
Iron (mg/L)	0.033U[b]	0.171	0.065
Iron, filtered(mg/L)	0.03U	0.0487	0.03U
Manganese (mg/L)	0.00103	0.00345	0.002U
Manganese, filtered(mg/L)	0.001	0.00259	0.002U
Total Dissolved Solids (mg/L)	227	369	244

a. Duplicate samples were collected in September and the results for the duplicate samples are included in the data summary.
b. U qualifier indicates the result was below the detection limit.

Table C-10. Materials and Fuels Complex Industrial Waste Water Underground Pipe Monitoring Results (2017).[a]

Parameter	Minimum	Maximum	Median
pH (standard units)	6.80	7.48	7.20
Conductivity ((µS/cm)	684	927	865
Nitrate + Nitrite as Nitrogen (mg-N/L)	3.5	5.53	5.3
Iron (mg/L)	0.03U[b]	0.0734	0.03U
Iron, filtered (mg/L)	0.03U	0.033	0.03U
Manganese (mg/L)	0.002U	0.00222	0.002U
Manganese, filtered (mg/L)	0.00159	0.002U	0.002U
Total Dissolved Solids (mg/L)	379	596	567

a. Duplicate samples were collected in May and the results for the duplicate samples are included in the data summary.
b. U qualifier indicates the result was below the detection limit.

Table C-11. Summary of Groundwater Quality Data Collected for the Wastewater Reuse Permit for the MFC Industrial Waste Ditch and Pond (2017).

Well Name	ANL-MON-A-012 (GW-16001)		ANL-MON-A-013 (GW-16002)		ANL-MON-A-014 (GW-16003)		PCS/SCS[a]
Sample Date:	*5/1/17*	*9/18/17*	*5/1/17*	*9/18/17*	*5/2/17*	*9/19/17*	
Water table depth (ft below land surface)	659.64	661.07	647.94	649.36	647.14	648.59	NA[b]
Water table elevation (ft above mean sea level)[c]	4473.06	4471.63	4472.43	4471.01	4470.94	4469.49	NA
pH (standard units)	6.86	6.67	7.16	7.08	7.22	7.18	6.5 to 8.5 (SCS)
Temperature (°F)	56.8	56.5	56.5	59.3	55.6	54.5	None
Electrical Conductivity (µS/cm)[d]	400	420	405	436	381	418	None
Nitrite + nitrate as nitrogen (mg/L)	2.24	2.40	2.25	2.39	2.28	2.38	None
Nitrate as nitrogen (mg/L)	2.06	2.13	2.08	2.24	2.15	2.16	10 (PCS)
Total Phosphorus (mg/L)	0.00938U[e]	0.0259U	0.0202J[f]	0.0369U	0.0105U	0.0379U	NA
Total dissolved solids (mg/L)	216	211	236	217	223	217	500 (SCS)
Calcium (mg/L)	36.3J	37.4	37.1J	37.9	34.7J	36.7	NA
Iron, total (mg/L)	0.03U	0.03U	0.166	0.115	0.03U	0.03U	0.3 (SCS)
Iron, filtered (mg/L)	0.033U	0.03U	0.03U	0.03U	0.03U	0.03U	0.3 (SCS)
Potassium (mg/L)	3.43	3.43	3.39	3.43	3.23	3.28	NA
Magnesium (mg/L)	10.7J	12.3	11.6J	13.5	10.5J	12.7	NA
Manganese, total (mg/L)	0.00111	0.001U	0.00145	0.00377	0.001U	0.001U	0.05 (SCS)
Manganese, filtered(mg/L)	0.001U	0.001U	0.001U	0.001U	0.001U	0.001U	0.05 (PCS)
Sodium (mg/L)	16.2J	19.0	18.5J	21.0	15.9J	19.6	NA

Table C-11. Summary of Groundwater Quality Data Collected for the Wastewater Reuse Permit for the MFC Industrial Waste Ditch and Pond (2017) (continued).

Well Name	ANL-MON-A-012 (GW-16001)		ANL-MON-A-013 (GW-16002)		ANL-MON-A-014 (GW-16003)		
Sample Date:	*5/1/17*	*9/18/17*	*5/1/17*	*9/18/17*	*5/2/17*	*9/19/17*	PCS/SCS[a]
Sulfate (mg/L)	17.2J	17.7J	20.5J	20.0J	18.7J	18.7J	250 (SCS)
Chloride (mg/L)	14.9J	15.1J	19.7J	19.4J	16.0J	15.8J	250(SCS)
Total Alkalinity as $CaCO_3$ (mg/L)	141	137	144	139	140	138	NA
Bicarbonate Alkalinity as $CaCO_3$ (mg/L)	141	137	144	139	140	138	NA

a. Primary Constituent Standard (PCS) or Secondary Constituent Standard (SCS) from IDAPA 58.01.11 (Ground Water Quality Rule).
b. NA = Not applicable
c. Elevations are given in the National Geodetic Vertical Datum of 1929.
d. Conductivity (or specific conductance) is a measure of the ability to conduct electricity. One unit of measurement is Siemens (S) per m.
e. U flag indicates the result was reported as below the instrument detection limit by the analytical laboratory.
f. J flag indicates the associated value is an estimate and may be inaccurate or imprecise. See Section 4.4 for additional discussion.

Table C-12. Advanced Test Reactor Complex Cold Waste Pond Surveillance Monitoring Results (2017).

Parameter	Minimum	Maximum
Gross alpha (pCi/L ± 1σ)	-0.189 ± 0.715U[a]	3.64 ± 1.13
Gross beta (pCi/L ± 1σ)	-1.81 ± 0.743	5.39 ± 1.02
pH (standard units)[b]	6.59	7.50
Potassium-40 (pCi/L ± 1σ)	-26.6 ± 11.9	15.0 ± 14.5

a. U qualifier indicates the result was below the detection limit.
b. Median pH was 6.90.

Table C-13. Radioactivity Detected in Surveillance Groundwater Samples Collected at the Advanced Test Reactor Complex (2017).

Monitoring Well	Sample Date	Parameter	Sample Result (pCi/L)
USGS-098	5/4/17	Gross Alpha	ND[a]
		Gross Beta	2.36 (± 0.725)[b]
		Tritium	ND
	9/12/17	Gross Alpha	ND
		Gross Beta	2.30 (± 0.675)
		Tritium	ND
		Strontium-90	0.71 (± 0.178)
USGS-065	5/9/17	Gross Alpha	ND
		Gross Beta	4 (± 0.687)
		Tritium	2,570 (± 290)
	9/13/17	Gross Alpha	ND
		Gross Beta	3.30 (± 0.711)
		Tritium	2,530 (± 299)
		Strontium-90	2.3 (± 0.353)
TRA-08	5/8/17	Gross Alpha	5.16 (± 1.2)
		Gross Beta	9.29 (± 1.01)
		Tritium	1,170 (± 162)
		Ra-226	0.775 (± 0.19)
	9/13/17	Gross Alpha	5.25 (±1.45)
		Gross Beta	5.09 (± 1.01)
		Tritium	978 (±157)
		Strontium-90	1.88 (± 0.285)
USGS-076	05/11/16	Gross Alpha	ND
		Gross Beta	2.4 (± 0.71)
		Tritium	384 (± 105)
	09/20/16	Gross Alpha	ND
		Gross Beta	ND
		Tritium	466 (± 118)
		Strontium-90	1.33 (± 0.267)
Middle-1823	5/4/17	Gross Alpha	ND
		Gross Beta	ND
		Tritium	770 (± 131)
	9/12/17	Gross Alpha	ND [ND][c]
		Gross Beta	ND [ND]
		Tritium	935 (± 157) [834 (± 148]
		Strontium-90	1.03 (±221) [ND]
USGS-058	5/9/17	Gross Alpha	ND
		Gross Beta	ND
		Tritium	588 (± 119)
	9/14/17	Gross Alpha	ND
		Gross Beta	2.91 (±0.745)
		Tritium	814 (± 146)

a. ND = Not detected
b. One sigma uncertainty shown in parentheses.
c. Analytical result from field duplicate sample collected on September 12, 2017, from well Middle-1823 in brackets.

Table C-14. Liquid Effluent Radiological Monitoring Results for the Idaho Nuclear Technology and Engineering Center (2017).

Sample Date	Gamma Emitters[a] (pCi/L)	Gross Alpha[b] (pCi/L)	Gross Beta[b] (pCi/L)	Total Strontium (pCi/L)
Effluent from INTEC Sewage Treatment Plant (CPP-773)				
March 2017	ND[c]	ND	7.5 (±0.45)	ND
September 2017	ND	ND	17.5 (±1.12)	ND
Effluent to INTEC New Percolation Ponds (CPP-797)				
January 2017	ND	4.14 (±0.84)	8.42 (±0.77)	ND
February 2017	ND	ND	5.10 (±1.03)	ND
March 2017	ND	ND	3.89 (±0.34)	ND
April 2017	ND	ND	4.65 (±0.80)	ND
May 2017	ND	3.03 (±0.94)	6.85 (±0.95)	ND
June 2017	ND	ND	7.02 (±0.61)	ND
July 2017	ND	ND	3.94 (±0.86)	ND
August 2017	ND	3.79 (±1.15)	6.75 (±1.02)	ND
September 2017	ND	3.28 (±1.11)	6.20 (±0.91)	ND
October 2017	ND	2.94 (±0.96)	4.34 (±0.86)	ND
November 2017	ND	ND	6.10 (±0.70)	ND
December 2017	ND	ND	6.79 (±0.77)	ND

a. Gamma-emitting radionuclides include americium-241, antimony-125, cerium-144, cesium-134, cesium-137, cobalt-58, cobalt-60, europium-152, europium-154, europium-155, manganese-54, niobium-95, potassium-40, radium-226, ruthenium-103, ruthenium-106, silver-108m, silver-110m, uranium-235, zinc-65, and zirconium-95.

b. Detected results are shown along with the reported 1-sigma uncertainty.

c. ND = no radioactivity was detected. The result was not statistically positive at the 95% confidence interval and was below its minimum detectable activity.

Table C-15. Groundwater Radiological Monitoring Results for the Idaho Nuclear Technology and Engineering Center (2017).

Monitoring Well	Sample Date	Gross Alpha[a] (pCi/L)	Gross Beta[a] (pCi/L)
ICPP-MON-A-165	4/4/2017	2.10 (±0.45)	3.36 (±0.31)
	9/13/2017	ND[b]	3.30 (±0.76)
ICPP-MON-A-166	4/4/2017	ND	3.12 (±0.38)
	9/13/2017	ND	ND
ICPP-MON-V-200	4/5/2017	ND	3.20 (±0.47)
	9/13/2017	ND	7.69 (±1.38)
ICPP-MON-V-212	4/5/2017	1.76 (±0.41)	5.73 (±0.47)
	9/13/2017	ND	4.41 (±0.84)

a. Detected results are shown along with the reported 1-sigma uncertainty.

b. ND = no radioactivity was detected. The result was not statistically positive at the 95% confidence interval and was below its minimum detectable activity.

Table C-16. Radioactivity Monitoring Results for Material and Fuels Complex Industrial Waste Pond (2017).[a]

Parameter[b] (pCi/L)	Minimum	Maximum
Gross alpha	0.329 ± 0.705U[c]	2.36 ± 0.981U
Gross beta	4.11 ± 0.616	8.87 ± 1.36
Uranium-238[d]	0.58 ± 0.118	0.58 ± 0.118
Uranium-233/234[d]	0.868 ± 0.15	0.868 ± 0.15
Potassium-40	-26.3 ± 14.3	0 ± 9.94

a. Detected results are shown along with the reported 1 σ uncertainty.
b. Only parameters with at least one detected result are shown.
c. U qualifier indicates the result was below the detection limit
d. Parameter was analyzed in August only; therefore, the minimum and maximum are the same.

Horned Lark

	mrem[a]	
Location	Nov. 2016 – April 2017	May 2017 – Oct. 2017
ARA O-1	58	72
PBF SPERT O-1	70	76

a. Ambient dose equivalent.

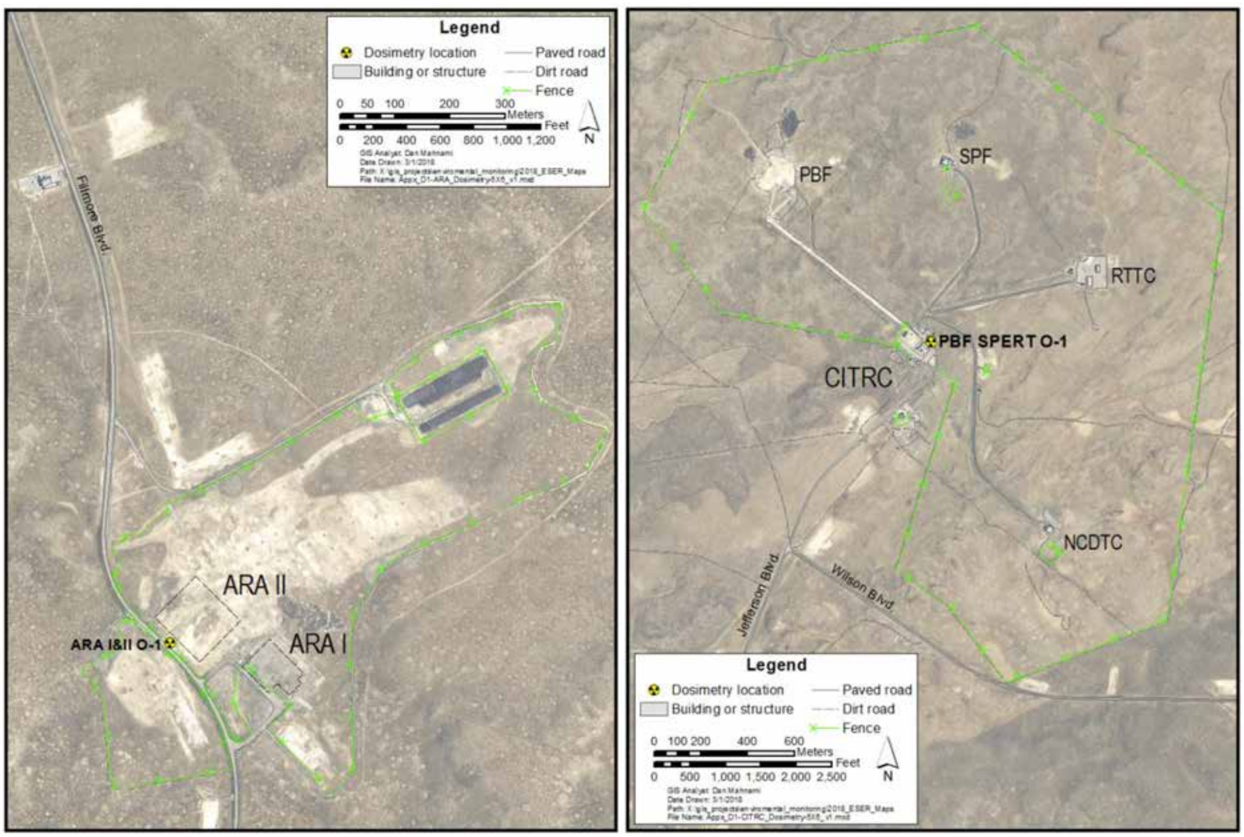

Figure D-1. Environmental Radiation Measurements at Auxiliary Reactor Area (ARA) and Critical Infrastructure Test Range Complex (CITRC) (2017).

Location	mrem[a] Nov. 2016 – April 2017	mrem[a] May 2017– Oct. 2017	Location	mrem[a] Nov. 2016– April 2017	mrem[a] May 2017 – Oct. 2017
RHLLW O-1	60	76	TRA O-14	59	69
RHLLW O-2	61	62	TRA O-15	63	63
RHLLW O-3	67	71	TRA O-16	61	72
RHLLW O-4	55	73	TRA O-17	79	69
RHLLW O-5	63	71	TRA O-18	78	63
RHLLW O-6	65	70	TRA O-19	115	102
TRA O-1	64	78	TRA O-20	61	73
TRA O-6	62	70	TRA O-21	65	79
TRA O-7	69	70	TRA O-22	70	72
TRA O-8	67	89	TRA O-23	59	69
TRA O-9	69	76	TRA O-24	72	73
TRA O-10	91	105	TRA O-25	63	67
TRA O-11	79	89	TRA O-26	67	70
TRA O-12	69	77	TRA O-27	71	73
TRA O-13	67	69	TRA O-28	67	66

a. Ambient dose equivalent.

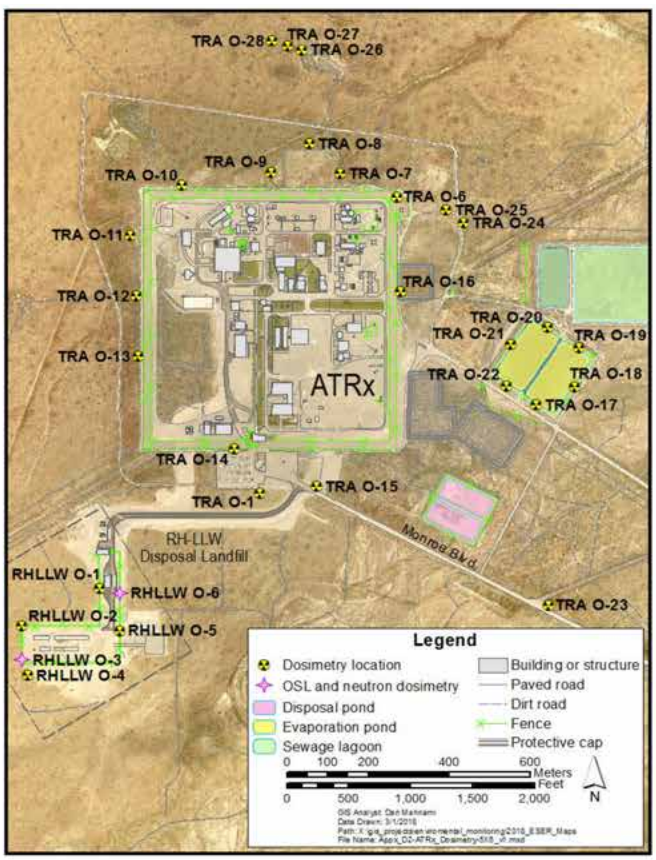

Figure D-2. Environmental Radiation Measurements at Advanced Test Reactor Complex (TRA) and Remote-Handled Low Level Waste Disposal Facility (RHLLW) (2017).

Location	mrem[a]	
	Nov. 2016 – April 2017	May 2017 – Oct. 2017
CFA O-1	64	70
LincolnBlvd O-1	66	67

a. Ambient dose equivalent.

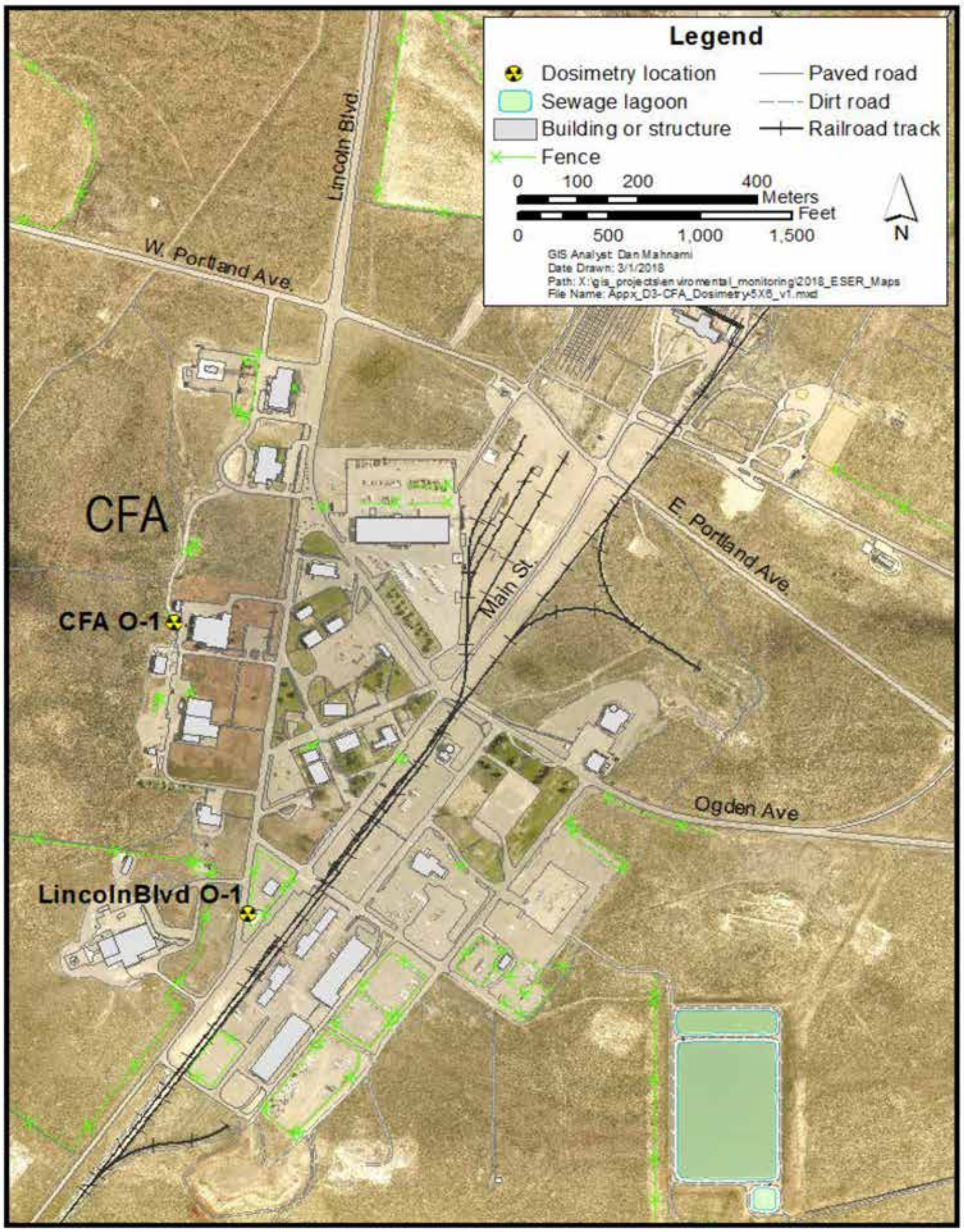

Figure D-3. Environmental Radiation Measurements at Central Facilities Area (CFA) (2017).

	mrem[a]			mrem[a]	
Location	Nov. 2016 – April 2017	May 2017 – Oct. 2017	Location	Nov. 2016 – April 2017	May 2017– Oct. 2017
ICPP O-9	73	86	ICPP O-26	62	73
ICPP O-14	82	97	ICPP O-27	92	116
ICPP O-15	81	103	ICPP O-28	104	105
ICPP O-17	63	70	ICPP O-30	125	176
ICPP O-19	67	85	TreeFarm O-1	93	117
ICPP O-20	171	249	TreeFarm O-2	67	88
ICPP O-21	73	85	TreeFarm O-3	75	77
ICPP O-22	75	87	TreeFarm O-4	102	124
ICPP O-25	61	76			

a. Ambient dose equivalent.

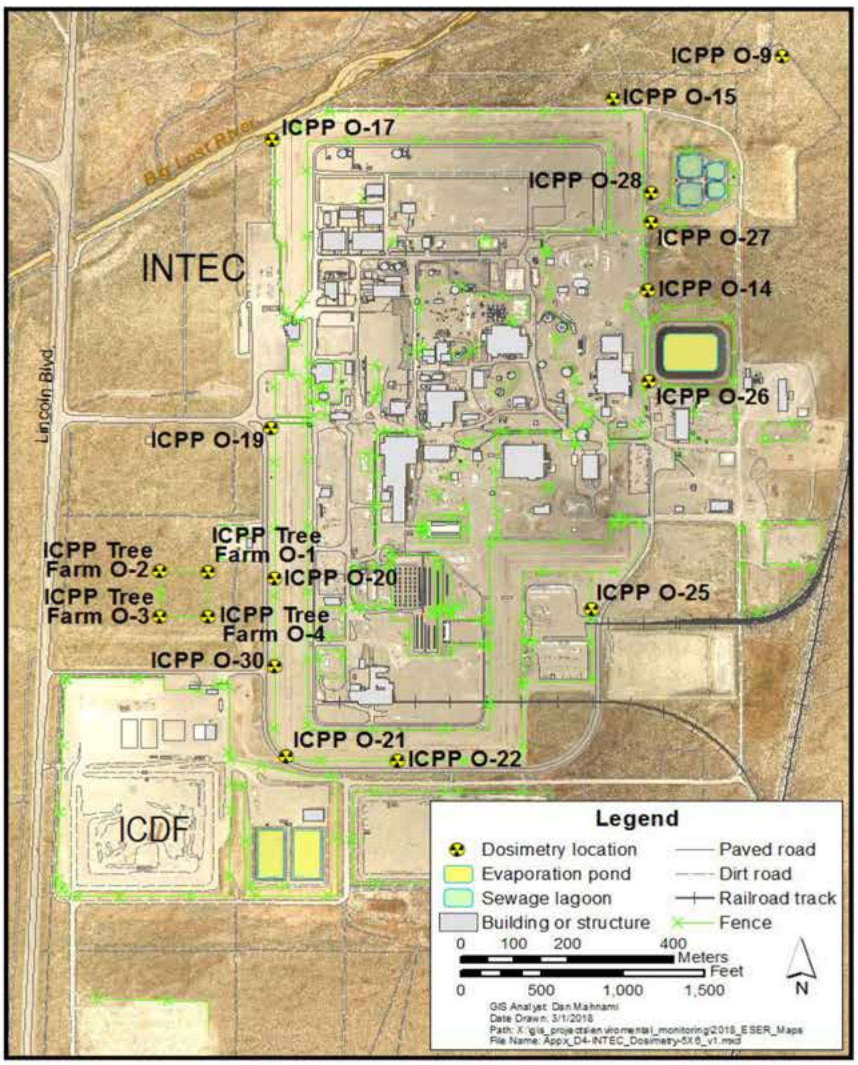

Figure D-4. Environmental Radiation Measurements at Idaho Nuclear Technology and Engineering Center (INTEC) (2017).

	mrem[a]			mrem[a]	
Location	Nov. 2016 – April 2017	May 2017– Oct. 2017	Location	Nov. 2016 – April 2017	May 2017 – Oct. 2017
IF-603N O-1	55	51	IF-670N O-31	57	56
IF-603E O-2	49	52	IF-670E O-32	51	53
IF-603S O-3	49	55	IF-670S O-33	56	56
IF-603W O-4	49	57	IF-670D O-34	57	53
IF-627 O-30	51	58	IF-670W O-35	65	61
IF-638N O-1	55	55	IF-689 O-7	56	58
IF-638E O-2	53	54	IF-689 O-8	55	58
IF-638S O-3	59	59	IRC O-39	53	60
IF-638W O-4	65	64			

a. Ambient dose equivalent.

Figure D-5. Environmental Radiation Measurements at INL Research Center Complex (IRC) (2017).

Location	mrem[a] Nov. 2016 – April 2017	mrem[a] May 2017 – Oct. 2017	Location	mrem[a] Nov. 2016 – April 2017	mrem[a] May 2017 – Oct. 2017
ANL O-7	63	69	ANL O-24	58	60
ANL O-8	57	63	ANL O-25	64	67
ANL O-12	63	50	ANL O-26	60	60
ANL O-14	58	65	TREAT O-1	65	61
ANL O-15	66	65	TREAT O-2	57	65
ANL O-16	65	80	TREAT O-3	65	69
ANL O-18	57	75	TREAT O-4	58	74
ANL O-19	59	69	TREAT O-5	57	62
ANL O-20	67	80	TREAT O-6	60	61
ANL O-21	81	89	TREAT O-7	61	69
ANL O-22	75	79	TREAT O-8	63	63
ANL O-23	62	63			

a. Ambient dose equivalent.

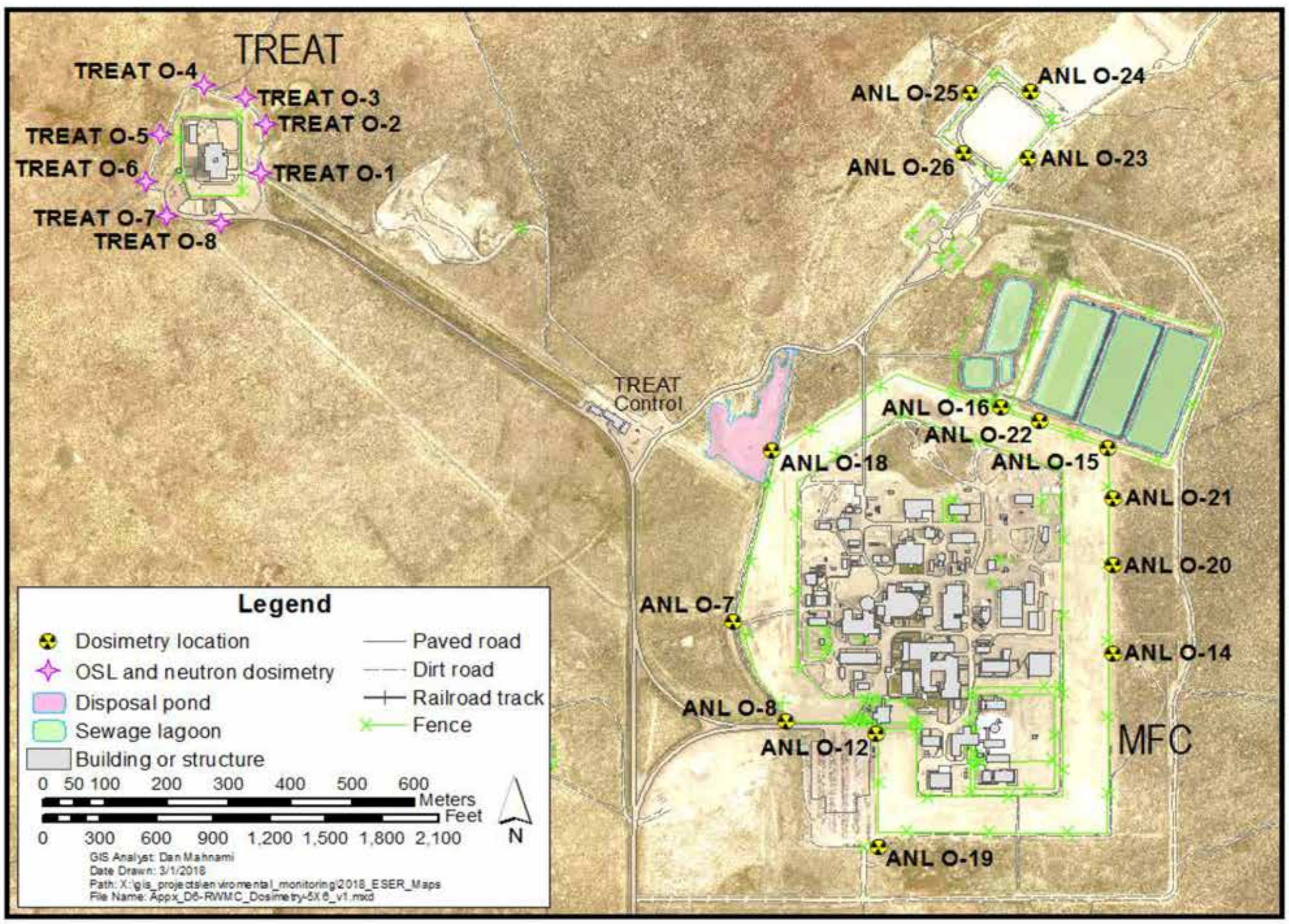

Figure D-6. Environmental Radiation Measurements at Materials and Fuels Complex (MFC) (2017).

Location	Exposure[a]		Location	Exposure[a]	
	Nov. 2016 – April 2017	May 2017 – Oct. 2017		Nov. 2016 – April 2017	May 2017 – Oct. 2017
NRF O-4	61	61	NRF O-16	61	66
NRF O-5	63	70	NRF O-18	59	68
NRF O-11	59	61	NRF O-19	62	68
NRF O-12	63	72	NRF O-20	62	68
NRF O-13	65	71			

a. Ambient dose equivalent.

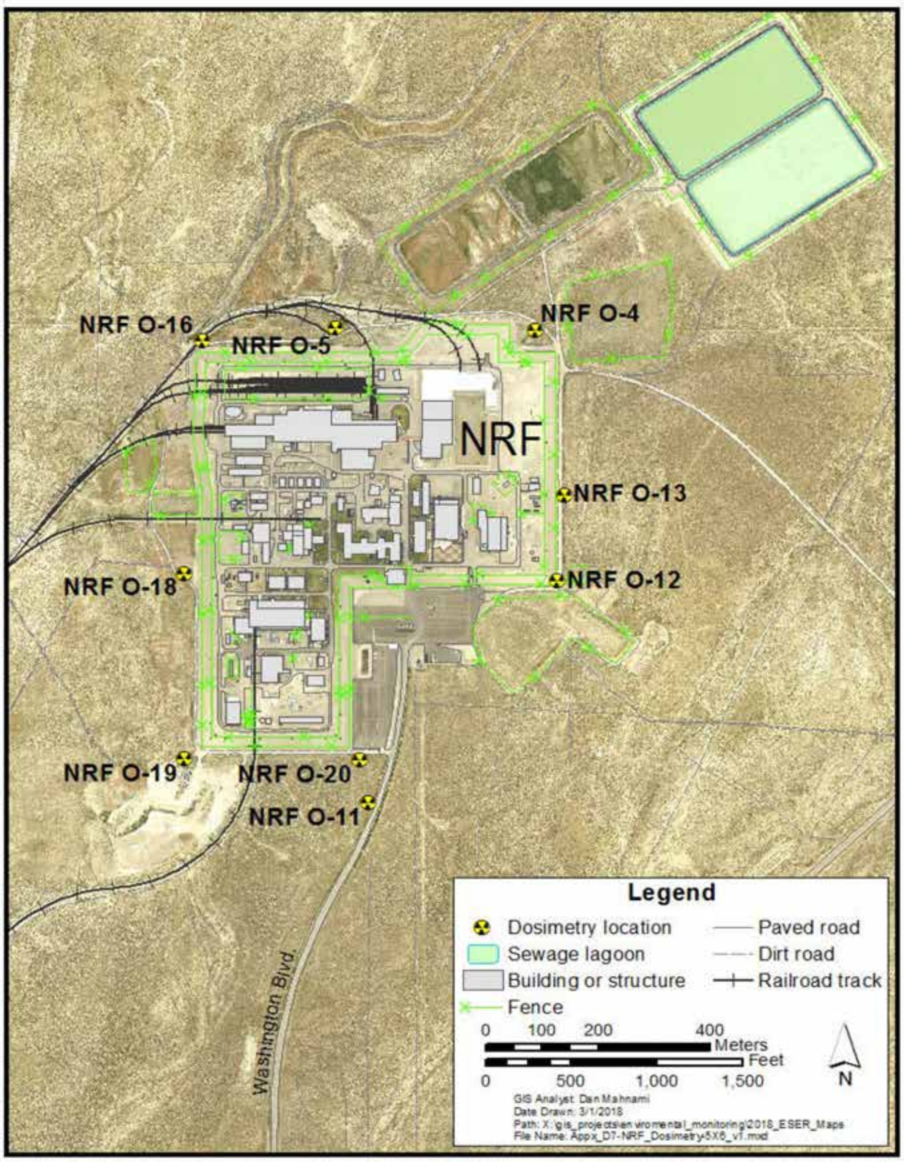

Figure D-7. Environmental Radiation Measurements at Naval Reactors Facility (NRF) (2017).

	mrem[a]	
Location	Nov. 2016 – April 2017	May 2017 – Oct. 2017
IF-675E O-31	51	55
IF-675D O-33	48	52
IF-675S O-34	56	55
IF-675W O-35	55	50

a. Ambient dose equivalent.

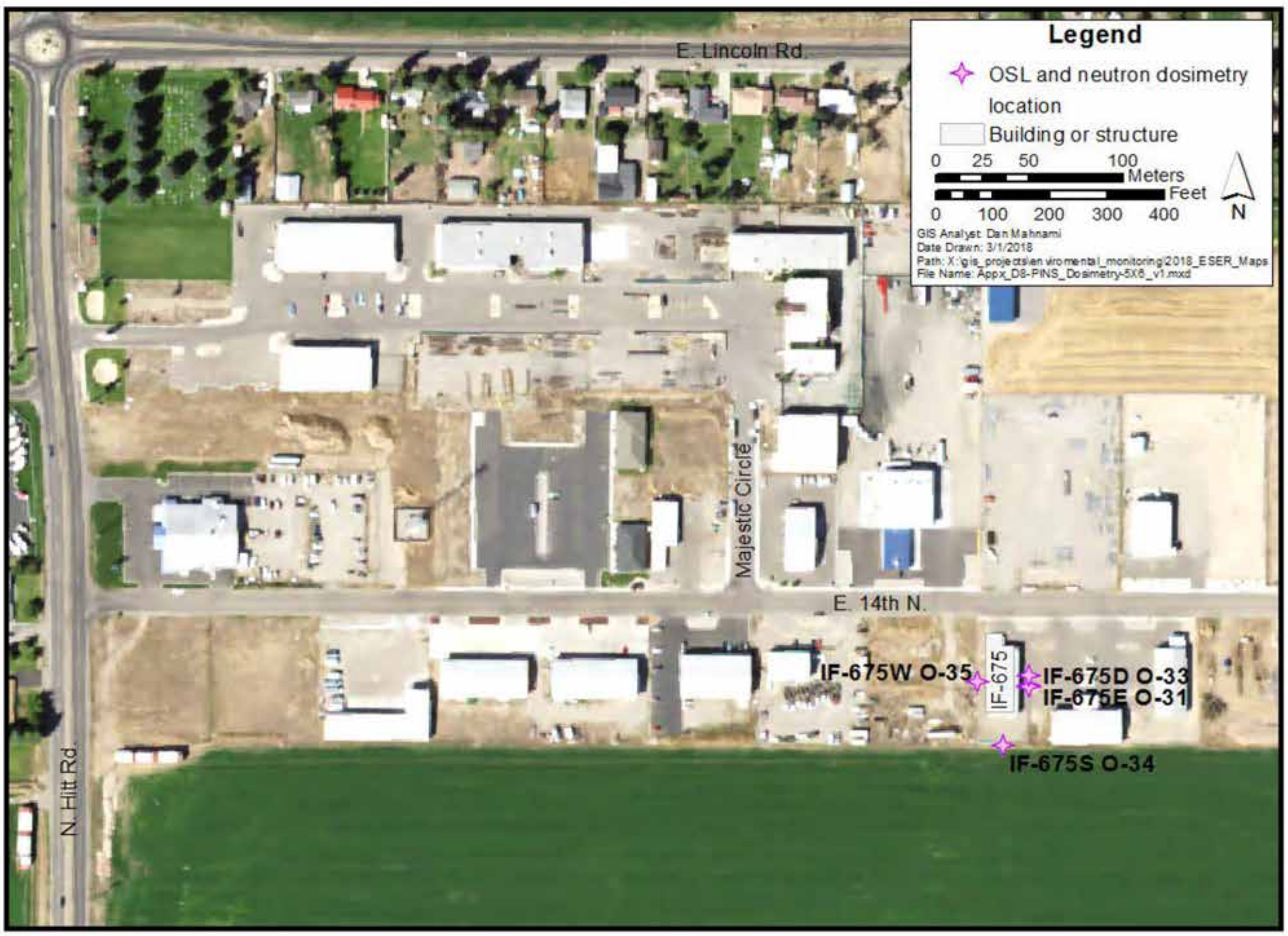

Figure D-8. Environmental Radiation Measurements at IF-675 PINS Facility (2017).

Location	mrem[a] Nov. 2016 – April 2017	mrem[a] May 2017 – Oct. 2017	Location	mrem[a] Nov. 2016 – April 2017	mrem[a] May 2017 – Oct. 2017
RWMC O-3A	62	68	RWMC O-25A	56	65
RWMC O-5A	58	63	RWMC O-27A	55	69
RWMC O-7A	51	57	RWMC O-29A	58	71
RWMC O-9A	74	81	RWMC O-39	61	74
RWMC O-11A	67	69	RWMC O-41	112	118
RWMC O-13A	88	75	RWMC O-43	57	68
RWMC O-19A	59	62	RWMC O-46	56	69
RWMC O-21A	60	74	RWMC O-47	64	65
RWMC O-23A	60	67			

a. Ambient dose equivalent.

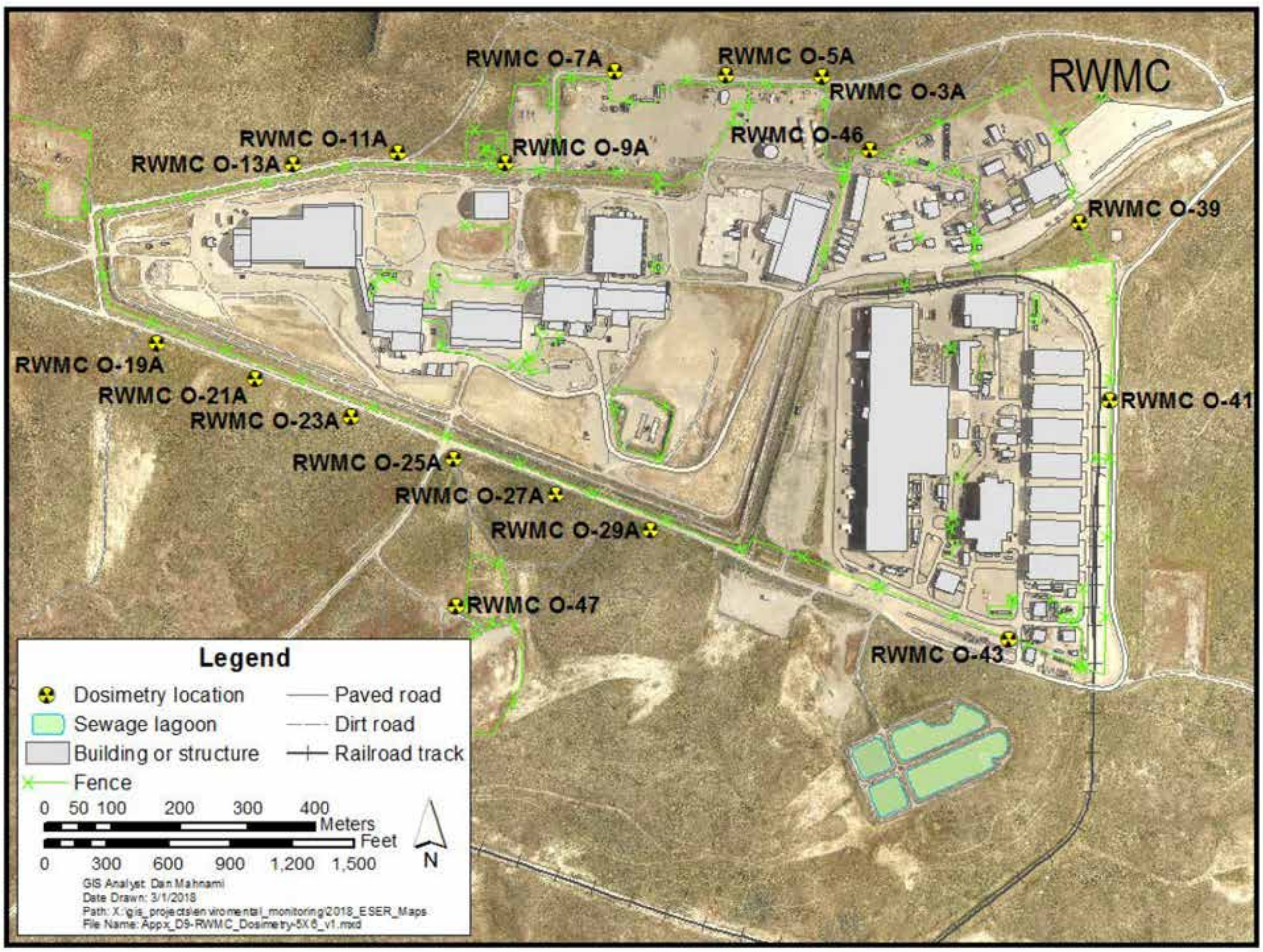

Figure D-9. Environmental Radiation Measurements at Radioactive Waste Management Complex (RWMC) (2017).

Location	mrem[a] Nov. 2016 – April 2017	mrem[a] May 2017 – Oct. 2017	Location	mrem[a] Nov. 2016 – April 2017	mrem[a] May 2017 – Oct. 2017
TAN LOFT O-6	63	58	TAN LOFT O-10	63	67
TAN LOFT O-7	65	67	TAN LOFT O-11	62	65
TAN LOFT O-8	59	56	TAN LOFT O-12	58	67
TAN LOFT O-9	55	57	TAN LOFT O-13	68	70

a. Ambient dose equivalent.

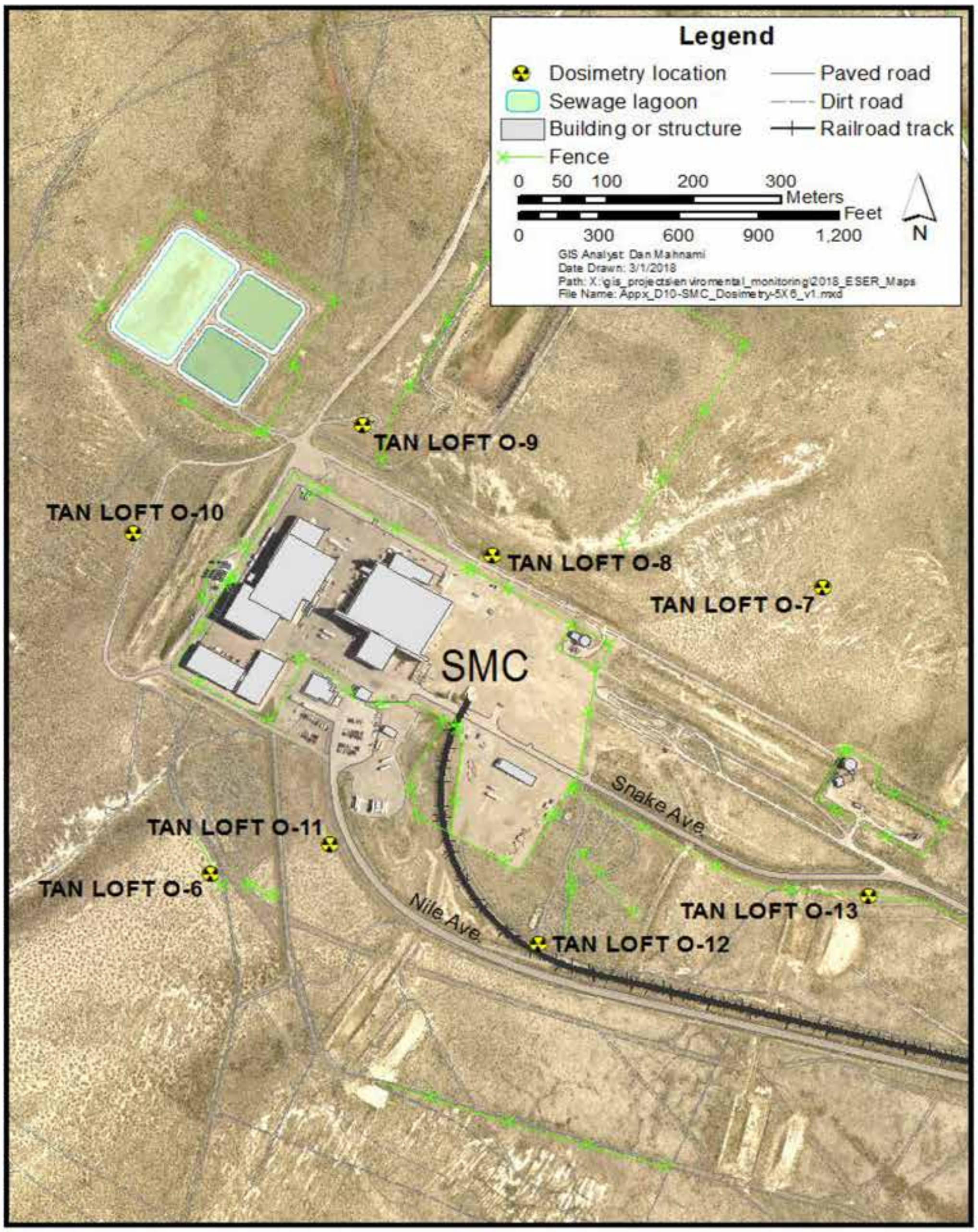

Figure D-10. Environmental Radiation Measurements at Test Area North (TAN) (2017).

Location	mrem[a]		Location	mrem[a]	
	Nov. 2016 – April 2017	May 2017 – Oct. 2017		Nov. 2016 – April 2017	May 2017 – Oct. 2017
EBR1 O-1	57	63	Hwy33 T17 O-3	50	55
EFS O-1	61	68	LincolnBlvd O-3	70	71
Gate4 O-1	63	60	LincolnBlvd O-5	65	83
Haul E O-1	57	65	LincolnBlvd O-9	61	70
Haul W O-2	62	65	LincolnBlvd O-15	64	62
Hwy20 Mile O-266	57	65	LincolnBlvd O-25	62	70
Hwy20 Mile O-270	Lost	71	Main Gate O-1	58	70
Hwy20 Mile O-276	54	66	Rest O-1	58	65
Hwy22 T28 O-1	56	52	VANB O-1	67	70
Hwy28 N2300 O-2	49	57			

a. Ambient dose equivalent.

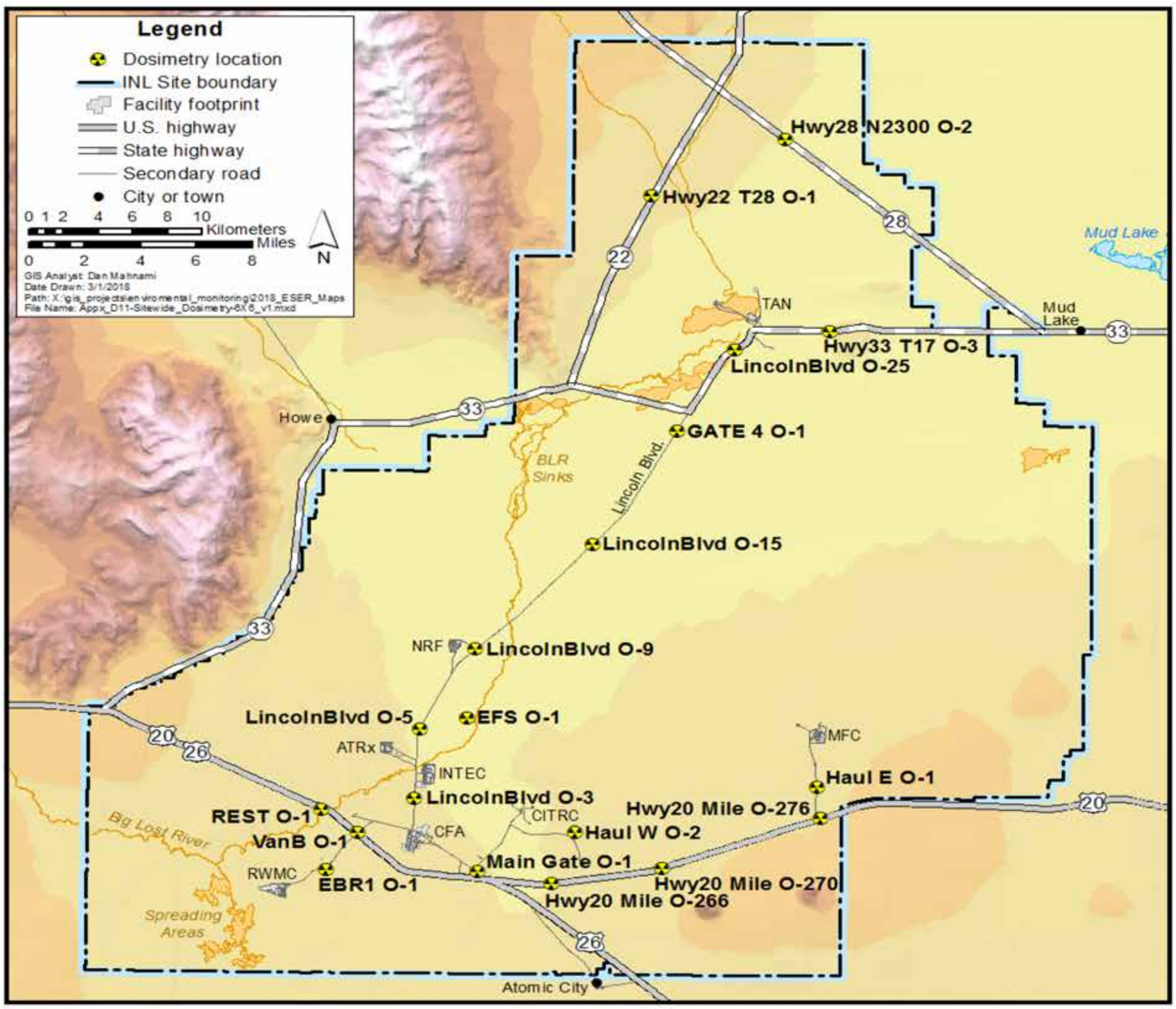

Figure D-11. Environmental Radiation Measurements at Sitewide Locations (2017).

	mrem[a]			mrem[a]	
Location	Nov. 2016–April 2017	May 2017 – Oct. 2017	Location	Nov. 2016–April 2017	May 2017 – Oct. 2017
Arco O-1	55	67	Mud Lake O-5	64	67
Atomic City O-2	57	66	Reno Ranch O-6	40	54
Blackfoot O-9	55	55	RobNOAA	61	63
Craters O-7	56	69	RRL3 O-1	56	65
Howe O-3	59	66	RRL5 0-1	69	81
Idaho Falls O-10	54	65	RRL6 O-1	55	65
IF-IDA O-38	50	56	RRL17 O-1	53	62
Monteview O-4	63	71	RRL24 O-1	52	56

a. Ambient dose equivalent.

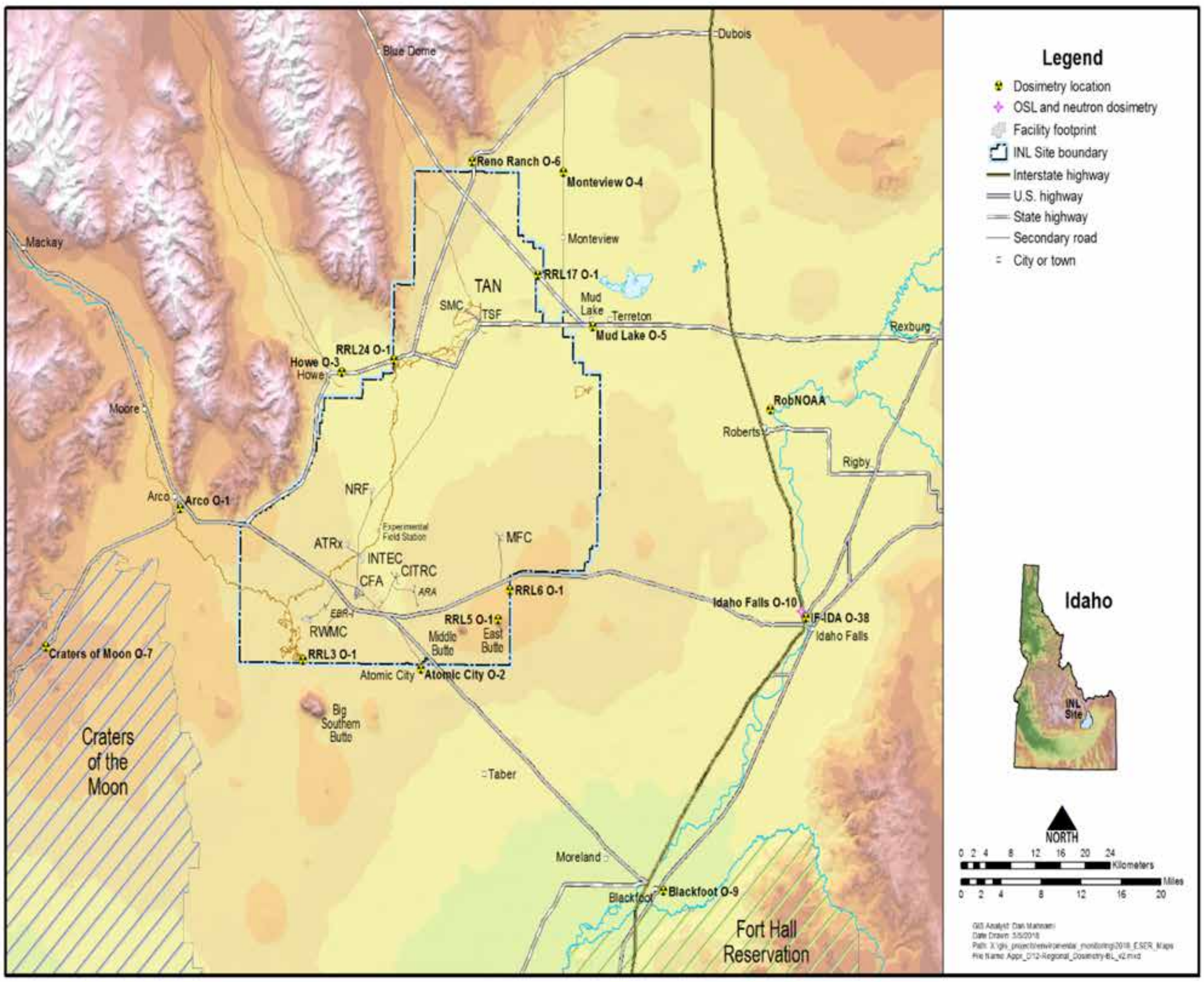

Figure D-12. Environmental Radiation Measurements at Regional Locations (2017).

	mrem[a]	
Location	Nov. 2016 – April 2017	May 2017 – Oct. 2017
IF-616N O-36	52	59
IF-665W O-37	59	54

a. Ambient dose equivalent.

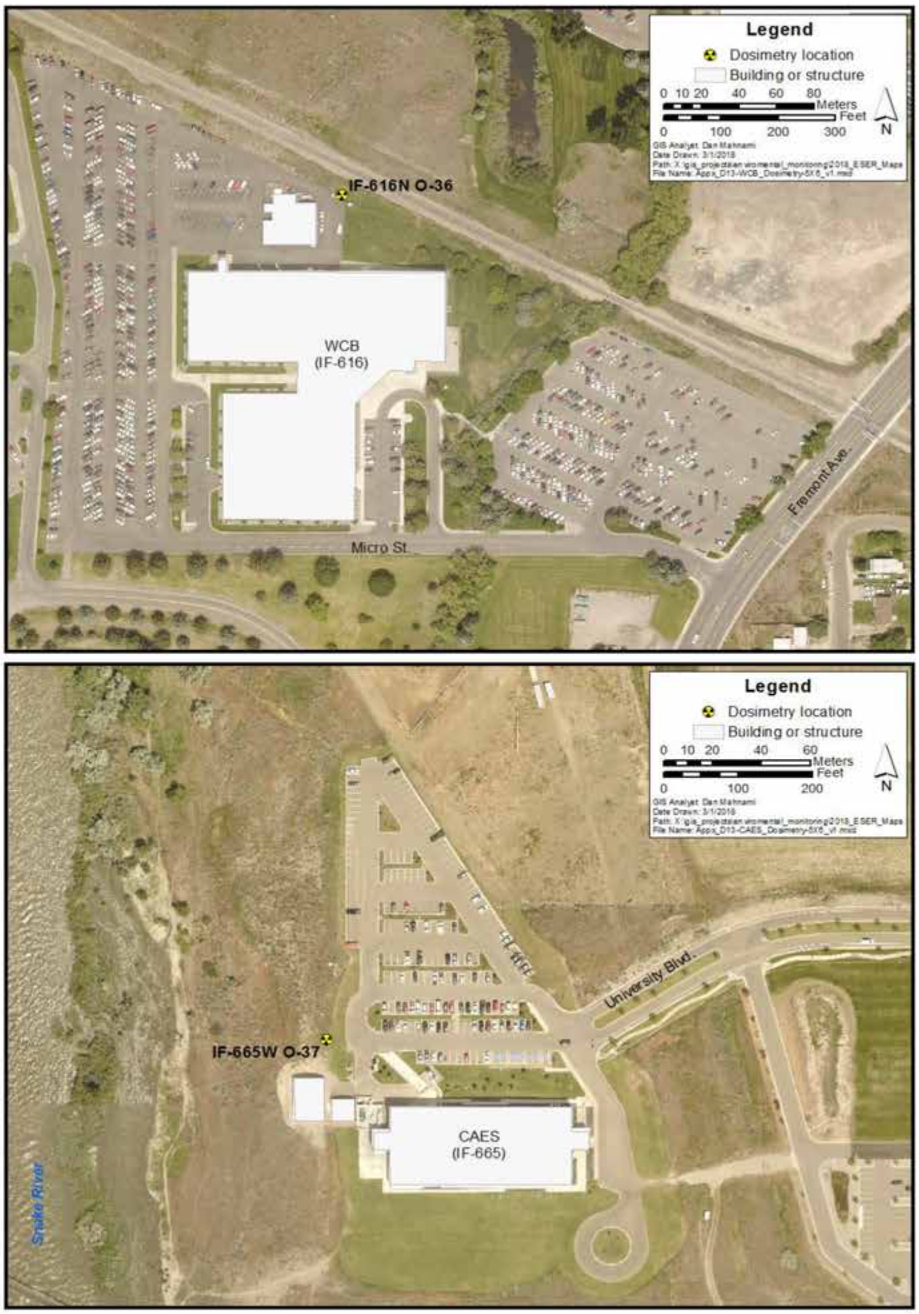

Figure D-13. Environmental Radiation Measurements at Willow Creek Building (WCB) and Center for Advanced Energy Studies (CAES) (2017).

Pronghorn ***(Antilocapra americana)***

Appendix E. Glossary

A

accuracy: A measure of the degree to which a measured value or the average of a number of measured values agrees with the "true" value for a given parameter; accuracy includes elements of both bias and precision.

actinides: The elements of the periodic table from actinium to lawrencium, including the naturally occurring radionuclides thorium and uranium, and the human-made radionuclides plutonium and americium.

alpha radiation: The emission of alpha particles during radioactive decay. Alpha particles are identical in makeup to the nucleus of a helium atom and have a positive charge. Alpha radiation is easily stopped by materials as thin as a sheet of paper and has a range in air of approximately an inch. Despite its low penetration ability, alpha radiation is densely ionizing and, therefore, very damaging when ingested or inhaled.

ambient dose equivalent: Since the effective dose cannot be measured directly with a typical survey instrument or a dosimeter, approved simulation quantities are used to approximate the effective dose (see **dose, effective**). The ambient dose equivalent is the quantity recommended by the International Commission on Radiation Units and Measurements to approximate the effective dose received by a human from external exposure to ambient ionizing radiation.

anthropogenic radionuclide: Radionuclide produced as a result of human activity (human-made).

aquifer: A geologic formation, group of formations, or part of a formation capable of yielding a significant amount of groundwater to wells or springs.

aquifer well: A well that obtains its water from below the water table.

B

background radiation: Radiation from cosmic sources; naturally occurring radioactive materials, including radon (except as a decay product of source or special nuclear material), and global fallout as it exists in the environment from the testing of nuclear explosive devices. It does not include radiation from source, byproduct, or special nuclear materials regulated by the Nuclear Regulatory Commission. The typically quoted average individual exposure from background radiation in southeastern Idaho is 360 millirems per year.

basalt: The most common type of solidified lava; a dense, dark grey, fine-grained, igneous rock that is composed chiefly of plagioclase, pyroxene, and olivine, often displaying a columnar structure.

becquerel (Bq): A quantitative measure of radioactivity. This is an alternate measure of activity used internationally. One becquerel of activity is equal to one nuclear decay per second. There are 3.7 x 10_{10} Bq in 1 Curie (Ci).

beta radiation: Radiation comprised of charged particles emitted from a nucleus during radioactive decay. A negatively charged beta particle is identical to an electron. A positively charged beta particle is called a positron. Beta radiation is slightly more penetrating than alpha, and it may be stopped by materials such as aluminum or Lucite panels. Naturally occurring radioactive elements, such as potassium-40, emit beta radiation.

bias: The tendency for an estimate to deviate from an actual or real event. Bias may be the tendency for a model to over- or under-predict.

bioremediation: The process of using various natural or introduced microbes or both to degrade, destroy, or otherwise permanently bond contaminants contained in soil or water or both.

biota concentration guide: The limiting concentration of a radionuclide in soil, sediment, or water that would not cause dose limits for protection of populations of aquatic and terrestrial biota to be exceeded.

blank: Used to demonstrate that cross contamination has not occurred. See **field blank, laboratory blank, equipment blank,** and **reagent blank.**

blind sample: Contains a known quantity of some of the analytes of interest added to a sample media being collected. A blind sample is used to test for the presence of compounds in the sample media that interfere with the analysis of certain analytes.

butte: A steep-sided and flat-topped hill.

C

calibration: The adjustment of a system and the determination of system accuracy using known sources and instrument measurements of higher accuracy.

chain of custody: A method for documenting the history and possession of a sample from the time of collection, through analysis and data reporting, to its final disposition. An item is considered to be in a person's custody if the item is 1) in the physical possession of that person, 2) within direct view of that person, or 3) placed in a secured area or container by that person.

comparability: A measure of the confidence with which one data set or method can be compared to another.

composite sample: A sample of environmental media that contains a certain number of sample portions collected over a time period. The samples may be collected from the same location or different locations. They may or may not be collected at equal intervals over a predefined period (e.g., quarterly).

completeness: A measure of the amount of valid data obtained from a measurement system compared to the amount that was expected under optimum conditions.

confidence interval: A statistical range with a specified probability that a given parameter lies within the range.

contaminant: Any physical, chemical, biological, radiological substance, matter, or concentration that is in an unwanted location.

contaminant of concern: Contaminant in a given media (usually soil or water) above a risk level that may result in harm to the public or the environment. At the INL Site, a contaminant that is above a 10^{-6} (1 in 1 million) risk value.

control sample: A sample collected from an uncontaminated area that is used to compare INL Site analytical results to those in areas that could not have been impacted by INL Site operations.

cosmic radiation: Penetrating ionizing radiation, both particulate and electromagnetic, that originates in outer space. Secondary cosmic rays, formed by interactions in the earth's atmosphere, account for about 45 to 50 millirem of the 300 millirem of natural background radiation that an average member of the U.S. public receives in a year.

curie (Ci): The original unit used to express the decay rate of a sample of radioactive material. The curie is a unit of activity of radioactive substances equivalent to 3.70×10^{10} disintegrations per second: it is approximately the amount of activity produced by 1 gram of radium-226. It is named for Marie and Pierre Curie who discovered radium in 1898. The curie is the basic unit of radioactivity used in the system of radiation units in the United States, referred to as "traditional" units. (See also **becquerel**).

D

data gap: A lack or inability to obtain information despite good faith efforts to gather desired information.

data validation: A systematic review of a data set to identify outliers or suspect values. More specifically, data validation refers to the systematic process of independently reviewing a body of analytical data against established criteria to provide assurance that the data are acceptable for their intended use. This process may use appropriate statistical techniques to screen out impossible or highly unlikely values.

data verification: The scientific and statistical evaluation of data to determine if data obtained from environmental operations are of the right type, quality, and quantity to support their intended use. Data verification also includes documenting those operations and the outcome of those operations (e.g., data do or do not meet specified requirements). Data verification is not synonymous with data validation.

decay products: Decay products are also called "daughter products." They are radionuclides that are formed by the radioactive decay of parent radionuclides. In the case of radium-226, for example, nine successive different radioactive decay products are formed in what is called a "decay chain." The chain ends with the formation of lead-206, which is a stable nuclide.

derived concentration standard (DCS): The concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by a single pathway (e.g., air inhalation or immersion, water ingestion), would result in an effective dose of 100 mrem (1 mSv). U.S. Department of Energy Order 458.1 "Radiation Protection of the Public and the Environment" establishes this limit and DOE Standard DOE-STD-1196-2011, "Derived Concentration Technical Standard," provides the numerical values of DCSs.

deterministic effect: A health effect, the severity of which varies with the dose and for which a threshold is believed to exist. Deterministic effects generally result from the receipt of a relatively high dose over a short time period. Skin erythema (reddening) and radiation-induced cataract formation is an example of a deterministic effect (formerly called a nonstochastic effect).

diffuse source: A source or potential source of pollutants that is not constrained to a single stack or pipe. A pollutant source with a large areal dimension.

diffusion: The process of molecular movement from an area of high concentration to one of lower concentration.

direct radiation: External radiation from radioactive plumes or from radionuclides deposited on the ground or other surfaces.

dispersion: The process of molecular movement by physical processes.

dispersion coefficient: An empirical concentration, normalized to a unit release rate, used to estimate the concentration of radionuclides in a plume at some distance downwind of the source. The National Oceanic and Atmospheric Administration, using data gathered continuously at meteorological stations on and around the INL Site and the HYSPLIT transport and dispersion model, prepared the dispersion coefficients for this report.

dose: A general term used to refer to the effect on a material that is exposed to radiation. It is used to refer either to the amount of energy absorbed by a material exposed to radiation (see **dose, absorbed**) or to the potential biological effect in tissue exposed to radiation (see **dose, equivalent** and **dose, effective**). See also: **dose, population.**

dose, absorbed: The amount of energy deposited in any substance by ionizing radiation per unit mass of the substance. It is expressed in units of rad or gray (Gy) (1 rad = 0.01 gray).

dose, effective (E): The summation of the products of the equivalent dose received by specified tissues and organs of the body, and tissue weighting factors for the specified tissues and organs, and is given by the expression:

$$E = \sum_T w_T \sum_R w_R D_{T,R} \quad or \quad E = \sum_T w_T H_T$$

where H_T or $W_R D_{T,R}$ is the equivalent dose in a tissue or organ, T, and w_T is the tissue weighting factor. The effective dose is expressed in the SI unit Sievert (Sv) or conventional unit rem (1 rem = 0.01 Sv). (See **dose, equivalent** and **weighting factor.**)

dose, equivalent (HT): The product of absorbed dose in tissue multiplied by a quality factor, and then sometimes multiplied by other necessary modifying factors, to account for the potential for a biological effect resulting from the absorbed dose. For external dose, the equivalent dose to the whole body is assessed at a depth of 1 cm in tissue; the equivalent dose to the lens of the eye is assessed at a depth of 0.3 cm in tissue, and the equivalent dose to the extremity and skin is assessed at a depth of 0.007 cm in tissue. Equivalent dose is expressed in units of rems (or sieverts). It is expressed numerically in rems (traditional units) or sieverts (SI units). (See **dose, absorbed** and **quality factor.**)

dose, population or collective: The sum of the individual effective doses received in a given time period by a specified population from exposure to a specified source of radiation. Population dose is expressed in the SI unit person-sievert (person-Sv) or conventional unit person-rem. (1 person-Sv = 100 person-rem.) (See **dose, effective.**)

dosimeter: Portable detection device for measuring the total accumulated exposure to ionizing radiation.

dosimetry: The theory and application of the principles and techniques involved in the measurement and recording of radiation doses.

drinking water: Water for the primary purpose of consumption by humans.

duplicate sample: A sample collected from the same sampling location using the same equipment and sampling technique and placed into an identically prepared and preserved container. Duplicate samples are analyzed independently as an indication of gross errors in sampling techniques.

E

eastern Snake River Plain aquifer: One of the largest groundwater "sole source" resources in the United States. It lies beneath a rolling topography extending some 308 km (191 mi) from Ashton to King Hill, Idaho, and ranges in width from 64 to 130 km (40 to 80 mi). The plain and aquifer were formed by repeated volcanic eruptions that were the result of a geologic hot spot beneath the earth's crust.

ecosystem: The interacting system of a biologic community and its nonliving environment.

effluent: Any liquid discharged to the environment, including storm water runoff at a site or facility.

effluent waste: Treated wastewater leaving a treatment facility.

electrometallurgical treatment: The process of treating spent nuclear fuel using metallurgical techniques.

environment: Includes water, air, and land and the interrelationship that exists among and between water, air, and land and all living things.

environmental indicators: Animal and plant species that are particularly susceptible to decline related to changes, either physical or chemical, in their environment.

environmental media: Includes air, groundwater, surface water, soil, flora, and fauna.

environmental monitoring: Sampling for contaminants in air, water, sediments, soils, agricultural products, plants, and animals, either by direct measurement or by collection and analysis of samples. It is a combination of two distinct activities (effluent monitoring and environmental surveillance) that together provide information on the health of an environment.

equipment blank: Sample prepared by collecting uncontaminated water passed over or through the sampling equipment. This type of blank sample is normally collected after the sampling equipment has been used and subsequently cleaned. An equipment blank is used to detect contamination introduced by the sampling equipment either directly or through improper cleaning.

exposure: The interaction of an organism with a physical or chemical agent of interest. Examples of such agents are radiation (physical) and carbon tetrachloride (chemical).

exposure pathway: The mechanism through which an organism may be exposed to a contaminant. An example is the surface water pathway, whereby an organism may be exposed to a contaminant through the consumption of surface water containing that contaminant.

external dose or exposure: That portion of the dose received from radiation sources outside the body (i.e., external sources).

extremely hazardous chemical: A substance listed in the appendices to 40 CFR 355, "Emergency Planning and Notification."

F

fallout: Radioactive material made airborne as a result of aboveground nuclear weapons testing and deposited on the earth's surface.

field blank: A blank used to provide information about contamination that may be introduced during sample collection, storage, and transport. A known uncontaminated sample, usually deionized water, is exposed to ambient conditions at the sampling site and subjected to the same analytical or measurement process as other samples.

fissile material: Although sometimes used as a synonym for fissionable material, this term has acquired a more restricted meaning. Namely, any material that is fissionable by thermal (slow) neutrons. The three primary fissile materials are uranium-233, uranium-235, and plutonium-239.

fission: The splitting of the nucleus of an atom (generally of a heavy element) into at least two other nuclei and the release of a relatively large amount of energy. Two or three neutrons are usually released during this type of transformation.

fission products: The nuclei (fission fragments) formed by the fission of heavy elements, plus the nuclides formed by the subsequent decay products of the radioactive fission fragments.

fissionable material: Commonly used as a synonym for fissile material, the meaning of this term has been extended to include material that can be fissioned by fast neutrons, such as uranium-238.

flood plain: Lowlands that border a river and are subject to flooding. A flood plain is comprised of sediments carried by rivers and deposited on land during flooding.

G

gamma radiation: A form of electromagnetic radiation, like radio waves or visible light, but with a much shorter wavelength. It is more penetrating than alpha or beta radiation, and capable of passing through dense materials such as concrete.

gamma spectroscopy: An analysis technique that identifies specific radionuclides that emit gamma radiation. It measures the particular energy of a radionuclide's gamma radiation emissions. The energy of these emissions is unique for each radionuclide, acting as a fingerprint to identify a specific radionuclide.

gross alpha activity: The total radioactivity due to alpha particle emission as inferred from measurements on a dry sample. See **alpha radiation.**

gross beta activity: The total radioactivity due to beta particle emission as inferred from measurements on a dry sample. See **beta radiation.**

groundwater: Water located beneath the surface of the ground (subsurface water). Groundwater usually refers to a zone of complete saturation containing no air.

H

half-life: The time in which one-half of the activity of a particular radioactive substance is lost due to radioactive decay. Measured half-lives vary from millionths of a second to billions of years. Also called physical or radiological half-life.

hazardous air pollutant: See **hazardous substance,**

hazardous chemical: Any hazardous chemical as defined under 29 CFR 1910.1200 ("Hazard Communication") and 40 CFR 370.2 ("Definitions").

hazardous material: Material considered dangerous to people or the environment.

hazardous substance: Any substance, including any isomers and hydrates, as well as any solutions and mixtures containing these substances, designated as such under Section 311 (b) (2)(A) of the *Clean Water Act*; any toxic pollutant listed under Section 307 (a) of the Clean Water Act; any element, compound, mixture, solution, or substance designated pursuant to Section 102 of the *Comprehensive Environmental Response, Compensation and Liability Act*; any hazardous waste having the characteristics identified under or listed pursuant to Section 3001 of the *Solid Waste Disposal Act*; any hazardous air pollutant listed under Section 112 of the *Clean Air Act*; and any imminently hazardous chemical substance or mixture to which the U.S. Environmental Protection Agency Administrator has taken action pursuant to Section 7 of the *Toxic Substances Control Act*. The term does not include petroleum, including crude oil or any fraction thereof that is not otherwise specifically listed or designated in the first paragraph, and it does not include natural gas, natural gas liquids, liquefied natural gas, or synthetic gas usable for fuel (or mixtures of natural gas and such synthetic gas).

hazardous waste: A waste that is listed in the tables of 40 CFR 261 ("Identification and Listing Hazardous Waste") or that exhibits one or more of four characteristics (corrosiveness, reactivity, flammability, and toxicity) above a predefined value.

high-level radioactive waste: Waste material resulting from the reprocessing of spent nuclear fuel, including both liquid and solid materials containing enough radioactivity to require permanent isolation from the environment.

hot spot: 1) In environmental surveillance, a localized area of contamination or higher contamination in an otherwise uncontaminated area. 2) In geology, a stationary, long-lived source of magma coming up through the mantle to the earth's surface. The hot spot does not move, but remains in a fixed position. As the crust of the earth moves over a hot spot, volcanic eruptions occur on the surface.

I

infiltration: The process by which water on the ground surface enters the soil or rock.

influent waste: Raw or untreated wastewater entering a treatment facility.

inorganic: Relating to or belonging to the class of compounds not having a carbon basis; hydrochloric and sulfuric acids are called inorganic substances.

ionizing radiation: Any radiation capable of displacing electrons from atoms or molecules, thereby producing ions. Some examples are alpha, beta, gamma, x-rays, neutrons, and light. High doses of ionizing radiation may produce severe skin or tissue damage.

isopleth: A line on a map connecting points having the same numerical value of some variable.

isotope: Two or more forms of an element having the same number of protons in the nucleus (or the same atomic number), but having different numbers of neutrons in the nucleus (or different atomic weights). Isotopes of a single element possess almost identical chemical properties. Examples of isotopes are plutonium-238, plutomium-239, and plutonium-241; each acts chemically like plutonium but have 144, 145, and 147 neutrons, respectively.

L

laboratory blank: A sample, usually deionized water, that is intended to contain none of the analytes of interest and is subjected to the same analytical or measurement process as other samples to establish a zero baseline or laboratory background value. Laboratory blanks are run before and after regular samples are analyzed to measure contamination that may have been introduced during sample handling, preparation, or analysis. A laboratory blank is sometimes used to adjust or correct routine analytical results.

liquid effluent: A liquid discharged from a treatment facility.

M

matrices/matrix/media: Refers to the physical form (solid, liquid, or gas) or composition (soil, filter, groundwater, or air) of a sample.

maximally exposed individual (MEI): A hypothetical member of the public whose location and living habits tend to maximize his or her radiation dose, resulting in a dose higher than that received by other individuals in the general population.

millirem (mrem): A unit of radiation dose that is equivalent to one one-thousandth of a rem.

millisievert (mSv): The International System of Units (SI) for radiation dose and effective dose equivalent. The SI equivalent of the millirem (1 millisievert = 100 millirem).

minimum detection concentration (MDC): The lowest concentration to which an analytical parameter can be measured with certainty by the analytical laboratory performing the measurement. While results below the MDC are sometimes measurable, they represent values that have a reduced statistical confidence associated with them (less than 95 percent confidence).

multi-media: Covering more than one environmental media (e.g., an inspection that reviews groundwater, surface water, liquid effluent, and airborne effluent data).

N

natural background radiation: Radiation from natural sources to which people are exposed throughout their lives. It does not include fallout radiation. Natural background radiation is comprised of several sources, the most important of which are:

- ***Cosmic radiation:*** Radiation from outer space (primarily the sun)
- ***Terrestrial radiation:*** Radiation from radioactive materials in the crust of the earth
- ***Inhaled radionuclides:*** Radiation from radioactive gases in the atmosphere, primarily radon-222.

natural resources: Land, fish, wildlife, biota, air, water, groundwater, drinking water supplies, and other such resources belonging to, managed by, held in trust by, appertaining to, otherwise controlled by the United States, any state or local government, any foreign government, or Native American tribe.

noble gas: Any of the chemically inert gaseous elements of the helium group in the periodic table.

noncommunity water system: A public water system that is not a community water system. A noncommunity water system is either a transient noncommunity water system or a nontransient noncommunity water system.

nontransient noncommunity water system: A public water system that is not a community water system and that regularly serves at least 25 of the same persons over six months per year. These systems are typically schools, offices, churches, factories, etc.

O

organic: Relating or belonging to the class of chemical compounds having a carbon basis; hydrocarbons are organic compounds.

optically stimulated luminescence dosimeter (OSLD): Used to measure direct penetrating gamma radiation through the absorption of energy from ionizing radiation by trapping electrons that are excited to a higher energy band. The trapped electrons in the OSLD are released by exposure to green light from a laser.

P

perched water well: A well that obtains its water from a water body above the water table.

performance evaluation sample: Sample prepared by adding a known amount of a reference compound to reagent water and submitting it to the analytical laboratory as a field duplicate or field blank sample. A performance evaluation sample is used to test the accuracy and precision of the laboratory's analytical method.

person-rem: Sum of the doses received by all individuals in a population.

pH: A measure of hydrogen ion activity. A low pH (0 – 6) indicates an acid condition; a high pH (8 – 14) indicates a basic condition. A pH of 7 indicates neutrality.

playa: A depression that is periodically inundated with water and will retain such water over time. An intermittent or seasonal water body.

plume: A body of contaminated groundwater or polluted air flowing from a specific source. The movement of a groundwater plume is influenced by such factors as local groundwater flow patterns, the character of the aquifer in which groundwater is contained, and the density of contaminants. The movement of an air contaminant plume is influenced by the ambient air motion, the temperatures of the ambient air and of the plume, and the density of the contaminants.

PM_{10}: Particle with an aerodynamic diameter less than or equal to 10 microns.

pollutant: 1) Pollutant or contaminant as defined by Section 101(33) of the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA), shall include, but not be limited to, any element, substance, compound, or mixture, including disease causing agents, which after release into the environment and upon exposure, ingesting, inhalation, or assimilation into an organism, either directly from the environment or indirectly by ingestion through food chains, will or may reasonably be anticipated to cause death, disease, behavioral abnormalities, cancer, genetic mutation, physiological malfunctions (including malfunctions in reproduction), or physical deformation, in such organisms or their offspring. The term does not include petroleum, including crude oil or any fraction thereof which is not otherwise specifically listed or designated as a hazardous substance under Section 101(14) (A) through (F) of CERCLA, nor does it include natural gas, liquefied natural gas, or synthetic gas of pipeline quality (or mixtures of natural gas and such synthetic gas). For purposes of the National Oil and Hazardous Substances Pollution Contingency Plan, the term pollutant or contaminant means any pollutant or contaminant that may present an imminent and substantial danger to public health or welfare of the United States. 2) Any hazardous or radioactive material naturally occurring or added to an environmental media, such as air, soil, water, or vegetation.

polychlorinated biphenyl: Any chemical substance that is limited to the biphenyl molecule that has been chlorinated to varying degrees or any combination of substances that contain such substance.

precision: A measure of mutual agreement among individual measurements of the same property. Precision is most often seen as a standard deviation of a group of measurements.

public water system: A system for the provision to the public of water for human consumption through pipes or other constructed conveyances, if such system has at least 15 service connections or regularly serves an average of at least 25 individuals daily at least 60 days out of the year. Includes any collection, treatment, storage, and distribution facilities under control of the operator of such system and used primarily in connection with such system and any collection or pretreatment storage facilities not under such control that are used primarily in connection with such system. Does not include any special irrigation district. A public water system is either a community water system or a noncommunity water system.

purgeable organic compound: An organic compound that has a low vaporization point (volatile).

Q

quality assurance (QA): Those planned and systematic actions necessary to provide adequate confidence that a facility, structure, system, or component will perform satisfactorily and safely in service. Quality assurance includes quality control. If quality is the degree to which an item or process meets or exceeds the user's requirements, then quality assurance is those actions that provide the confidence that quality was in fact achieved.

quality control (QC): Those actions necessary to control and verify the features and characteristics of a material, process, product, service, or activity to specified requirements. The aim of quality control is to provide quality that is satisfactory, adequate, dependable, and economic.

quality factor: The factor by which the absorbed dose (rad or gray) must be multiplied to obtain a quantity that expresses, on a common scale for all ionizing radiation, the biological damage (rem or sievert) to the exposed tissue. It is used because some types of radiation, such as alpha particles, are more biologically damaging to live tissue than other types of radiation when the absorbed dose from both is equal. The term, quality factor, has now been replaced by "radiation weighting factor" in the latest system of recommendations for radiation protection.

R

rad: Short for radiation absorbed dose; a measure of the energy absorbed by any material.

radioactivity: The spontaneous transition of an atomic nucleus from a higher energy to a lower energy state. This transition is accompanied by the release of a charged particle or electromagnetic waves from the atom. Also known as activity.

radioactive decay: The decrease in the amount of any radioactive material with the passage of time due to the spontaneous emission from the atomic nuclei of either alpha or beta particles, often accompanied by gamma radiation.

radioecology: The study of the behavior and the effects of radioactive materials on the environment. Also includes the use of radioisotopes to study the structure and function of ecosystems and their component parts.

radionuclide: A type of atom that emits energy in the form of photons or particles (radiation) during transformation.

radiotelemetry: The tracking of animal movements through the use of a radio transmitter attached to the animal of interest.

reagent blank: A sample of any reagent used for sample preparation subjected to the same analytical or measurement process as a normal sample. A reagent blank is used to show that the reagent used in sample preparation does not contain any of the analytes of interest.

rehabilitation: The planting of a variety of plants in an effort to restore an area's plant community diversity after a loss (e.g., after a fire).

relative percent difference: A measure of variability adjusted for the size of the measured values. It is used only when the sample contains two observations, and it is calculated by the equation:

$$RPD = \frac{|R1 - R2|}{(R1 + R2)/2} \times 100$$

where R1 and R2 are the duplicate sample measurement results.

release: Spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing of a hazardous substance, pollutant, or contaminant into the environment.

rem (Roentgen Equivalent Man): A unit in the traditional system of units that measures the effects of ionizing radiation on humans.

reportable quantity: Any *Comprehensive Environmental Response, Compensation, and Liability Act* hazardous substance, the reportable quantity for which is established in Table 302.4 of 40 CFR 302 ("Designation, Reportable Quantities, and Notification"), the discharge of which is a violation of federal statutes and requires notification of the regional U.S. Environmental Protection Agency administrator.

representativeness: A measure of a laboratory's ability to produce data that accurately and precisely represent a characteristic of a population, a parameter variation at a sampling point, a process condition, or an environmental condition.

reprocessing: The process of treating spent nuclear fuel for the purpose of recovering fissile material.

resuspension: Windblown reintroduction to the atmosphere of material originally deposited onto surfaces from a particular source.

rhyolite: A usually light-colored, fine-grained, extrusive igneous rock that is compositionally similar to granite.

risk: In many health fields, risk means the probability of incurring injury, disease, or death. Risk can be expressed as a value that ranges from zero (no injury or harm will occur) to one (harm or injury will definitely occur).

risk assessment: The identification and quantification of the risk resulting from a specific use or occurrence of a chemical, taking into account the possible harmful effects on individuals or society of using the chemical in the amount and manner proposed and all the possible routes of exposure. Quantification ideally requires the establishment of dose-effect and dose-response relationships in likely target individuals and populations.

roentgen (R): The amount of ionization produced by gamma radiation in air. The unit of roentgen is approximately numerically equal to the unit of rem.

S

shielding: The material or process used for protecting workers, the public, and the environment from exposure to radiation.

sievert (Sv): A unit for assessing the risk of human radiation dose, used internationally. One sievert is equal to 100 rem.

sigma uncertainty: The uncertainty or margin of error of a measurement is stated by giving a range of values likely to enclose the true value. These values follow from the properties of the normal distribution, and they apply only if the measurement process produces normally distributed errors, e.g., the quoted standard errors are easily converted to 68.3 percent (one sigma), 95.4 percent (two sigma), or 99.7 percent (three sigma) confidence intervals; which are usually denoted by error bars on a graph or by the following notations:

- measured value ± uncertainty
- measured value (uncertainty).

sink: Similar to a playa with the exception that it rapidly infiltrates any collected water.

spent nuclear fuel: Uranium metal or oxide and its metal container that have been used to power a nuclear reactor. It is highly radioactive and typically contains fission products, plutonium, and residual uranium.

split sample: A single sample, usually divided by the analytical laboratory, split into two separate samples. Each sample is prepared and analyzed independently as an indication of analytical variability and comparability.

spreading areas: At the INL Site, a series of interconnected low areas used for flood control by dispersing and evaporating or infiltrating water from the Big Lost River.

stabilization: The planting of rapidly growing plants for the purpose of holding bare soil in place.

standard: A sample containing a known quantity of various analytes. A standard may be prepared and certified by commercial vendors, but it must be traceable to the National Institute of Standards and Technology.

standard deviation: In statistics, the standard deviation (SD), also represented by the Greek letter sigma σ, is a measure of the dispersion of a set of data from its mean.

stochastic effect: An effect that occurs by chance and which may occur without a threshold level of dose, whose probability is proportional to the dose and whose severity is independent of the dose. In the context of radiation protection, the main stochastic effect is cancer.

storm water: Water produced by the interaction of precipitation events and the physical environment (buildings, pavement, ground surface).

surface radiation: See **direct radiation.** Surface radiation is monitored at the INL Site at or near waste management facilities and at the perimeter of Site facilities.

surface water: Water exposed at the ground surface, usually constrained by a natural or human-made channel (stream, river, lake, ocean).

surveillance: Monitoring of parameters to observe trends but which is not required by a permit or regulation.

T

thermoluminescent dosimeter (TLD): A device used to measure radiation dose to occupational workers or radiation levels in the environment. A dosimeter is made of one or more lithium fluoride chips that measure cumulative exposure to ionizing radiation. Lithium fluoride absorbs the energy of radiation and releases it as light when heated.

total effective dose (TED): The sum of the effective dose (for external exposures) and the committed effective dose.

total organic carbon: A measure of the total organic carbon molecules present in a sample. It will not identify a specific constituent (e.g., benzene), but will detect the presence of a carbon-bearing molecule.

toxic chemical: Chemical that can have toxic effects on the public or environment above listed quantities. See also hazardous chemical.

traceability: The ability to trace history, application, or location of a sample standard and like items or activities by means of recorded identification.

transient noncommmunity water system: A water system that is not a community water system, and serves 25 nonresident persons per day for six months or less per year. These systems are typically restaurants, hotels, large stores, etc.

transuranic (TRU): Elements on the periodic table with an atomic number greater than uranium (>92). Common isotopes of transuranic elements are neptunium-239 and plutonium-238.

transuranic waste: Waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes (radionuclide isotopes with atomic numbers greater than uranium [92]) per gram of waste with half-lives greater than 20 years.

tritium: A radioactive isotope of hydrogen, having three times the mass of ordinary hydrogen.

V

vadose zone: That part of the subsurface between the ground surface and the water table.

W

water quality parameter: Parameter commonly measured to determine the quality of a water body or sample (i.e., specific conductivity, pH, temperature, dissolved oxygen content).

weighting factor (w_T): A multiplier that is used for converting the equivalent dose to a specific organ or tissue (T) into what is called the effective dose. The goal of this process is to develop a method for expressing the dose to a portion of the body in terms of an equivalent dose to the whole body that would carry with it an equivalent risk in terms of the associated fatal cancer probability. The equivalent dose to tissue (H_T) is multiplied by the appropriate tissue weighting factor to obtain the effective dose (E) contribution from that tissue. (See **dose, equivalent** and **dose, effective.**)

wetland: An area inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include playa lakes, swamps, marshes, bogs, and similar areas as sloughs, prairie potholes, wet meadows, prairie river overflows, mudflats, and natural ponds.

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