DOE/ID-12082(15)
ISSN 1089-5469
WAI-ESER-203
September 2016

Idaho National Laboratory







Site Environmental Report

Calendar Year 2015

Environmental Surveillance, Education, and Research Program

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U.S. Department of Energy, Idaho Operations Office

September 2016

This report was prepared for the
U.S. Department of Energy, Idaho Operations Office
Under Contract DE-NE0008477
By Wastren Advantage Incorporated
Environmental Surveillance, Education, and Research Program
120 Technology Drive
Idaho Falls, ID 83401

Acknowledgments

The following people have provided primary authorship and review of this report:

- Marilyn Case, Russell Mitchell, Roger Blew, Quinn Shurtliff, Blane Teckmeyer, and Racquel Clark with Environmental Surveillance, Education, and Research Program, currently managed by Wastren Advantage Inc.
- Bradley Andersen, Kara Cafferty, Thomas Haney, Peggy Scherbinske, Jeffrey Sondrup, Christina Olson, and Brenda Pace with Battelle Energy Alliance
- Renee Bowser, David Eaton, John Espinosa, Jeffrey Forbes, Michael MacConnel, Kristina Alberico, Michael Roddy, and Valerie Kimbro with CH2M-WG Idaho
- Katherine Medellin, Betsy Holmes, Vanica Dugger, Nicole Hernandez, Tim Safford, Jason Sturm, Nicole Badrov, Greg Bass, Christian Natoni, Ron Ramsey, Richard Kauffman, Bill Harker, Nolan Jensen, Ben Roberts, Dan Shirley, Tauna Butler, Kevin O'Neill, and Benjamin Leake with the U.S. Department of Energy
- Kirk Clawson and Richard Eckman with the National Oceanic and Atmospheric Administration
- Roy Bartholomay with the U.S. Geological Survey
- Technical editing of this report was provided by Jacquine Dobbins, subcontractor to Wastren Advantage, Inc. Additional technical editing was performed by Pamela Lilburn with CH2M-WG Idaho and Kara Cafferty with Battelle Energy Alliance.
- Publishing layout was executed by Brande Hendricks with Stoller Newport News Nuclear and Alana Jensen with Wastren Advantage Inc.
- Web design was implemented by Alana Jensen of Wastren Advantage Inc.

The primary authors would like to thank all those who provided data for the completion of this document. In particular, we wish to thank the following people for their assistance:

- Amy Forman, Jackie Hafla, Doug Halford, and Jeremy Shive with Gonzales-Stoller Surveillance, LLC
- Lanelle Pokibro, David Hawley, Daniel Mahnami, Howard Johnson, Tracy Elder, and Kathleen Otter with CH2M-WG Idaho
- David Huber, Kathleen Lohse, Charles Peterson, Keith Reinhardt, and Kate McAbee with Idaho State University
- Marie-Anne deGraff, Kevin Feris, Patrick Sorensen, and Patricia Xochi Campos with Boise State University
- William H. Clark with the Orma J. Smith Museum of Natural History, College of Idaho
- Matthew Germino and Lar Svenson with U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center, Boise, ID
- Neil Maimer with U.S. Geological Survey, Idaho National Laboratory Project Office.

Lava Rock Outcrop

To Our Readers

The Idaho National Laboratory Site Environmental Report for Calendar Year 2015 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, 2015. 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 which may be of interest to the reader.

The report addresses three general levels of reader interest:

- The first 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 on this page or in the CD provided with the hard copy of this report.

The Environmental Surveillance, Education, and Research Program, which was managed by Gonzales-Stoller Surveillance, LLC, is responsible for contributing to and producing the annual INL Site Environmental Report (ASER). Other major contributors to the ASER include the INL contractor (Battelle Energy Alliance), the Idaho Cleanup Project contractor (CH2M-WG Idaho, LLC, or CWI), U.S. Department of Energy (Idaho Operations Office), National Oceanic and Atmospheric Administration (NOAA), and U.S. Geological Survey. Links to their websites may be found on this page or in the CD provided with the hard copy of this report.

- Idaho National Laboratory (https://www.inl.gov/)
- Idaho Cleanup Project (https://idahocleanupproject.com/)
- U.S. Department of Energy, Idaho Operations Office (http://www.id.doe.gov/)
- Field Research Division of NOAA's Air Resources Laboratory (http://www.noaa.inel.gov/)
- U.S. Geological Survey (http://id.water.usgs.gov/)

Sunrise on the INL Site.

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 ensure the nation's energy security with safe, competitive, and sustainable energy systems and unique national and homeland security capabilities. In order to clear the way for the facilities required for the new nuclear energy research mission, the Idaho Cleanup Project (ICP) 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, the public, and the environment and to protect the Snake River Plain aquifer. A great deal of this cleanup has occurred since the project began. Significantly, the ICP Decontamination and Decommissioning Project was officially closed out in 2012 with the safe decontamination and decommissioning of 223 buildings and structures for a total footprint reduction of over 1.6 million square feet.

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

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

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 all 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.

MAJOR INL SITE PROGRAMS AND FACILITIES

There are three primary programs at the INL Site: the INL, the ICP, and the Advanced Mixed Waste Treatment Project (AMWTP). DOE is committed to safely retrieve, characterize, treat, and package transuranic waste for shipment out of Idaho to permanent disposal at the Waste Isolation Pilot Plant in New Mexico. Characterized waste containers that need further treatment before they can be shipped are sent to the AMWTP Treatment Facility where the waste can be size-reduced, sorted, and repackaged. The prime contractors at the INL Site in 2015 were: Battelle Energy Alliance, the management and operations contractor for the INL; CWI, which managed ongoing cleanup operations under the ICP; and Idaho Treatment Group, LLC, which operated AMWTP. 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; 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 (SMC) (Figure ES-2). The Research and Education Campus (REC)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, CWI, and Idaho Treatment Group have each established and implemented an EMS and contribute 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.

The INL Site was far below all DOE public and biota dose limits for radiation protection in 2015.

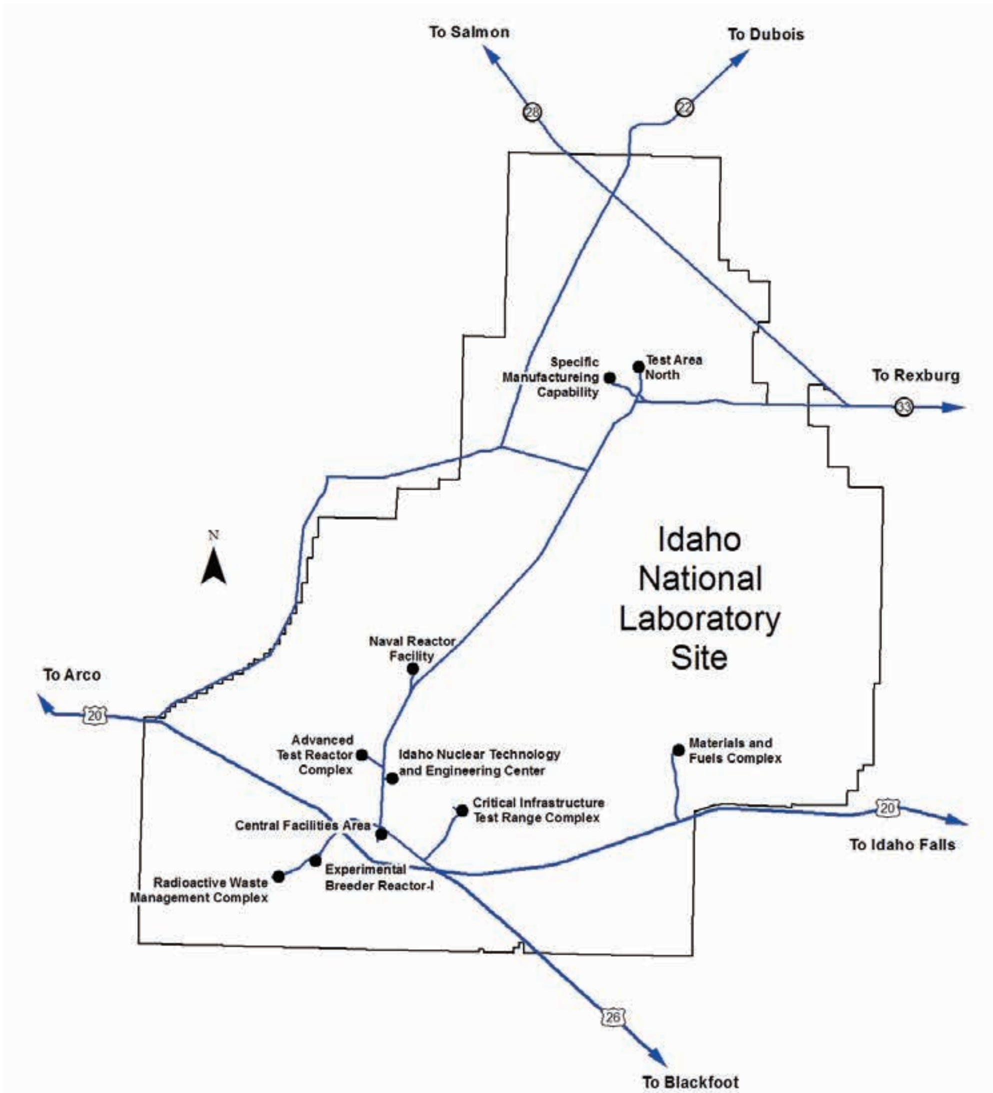


Figure ES-2. Idaho National Laboratory Site Facilities.

ENVIRONMENTAL RESTORATION

Environmental restoration at the INL Site is conducted under the Federal Facility Agreement 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 past release sites at the INL Site in compliance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). 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 2015, 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

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

Major INL Site Area[a]	Operated By	Mission
Advanced Test Reactor (ATR) Complex	INL	Research and development of nuclear reactor technologies. Home of the ATR, a DOE Nuclear Scientist User Facility and the world's most advanced nuclear test reactor.
Central Facilities Area (CFA)	INL	INL Support for the operation of other INL Site facilities.
Critical Infrastructure Test Range Complex (CITRC)	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 (INTEC)	ICP	Dry and wet storage of spent nuclear fuel, management of high-level waste calcine and sodium-bearing liquid waste, and operation of the Idaho CERCLA Disposal Facility including a landfill, evaporation ponds, and a staging and treatment facility.
Materials and Fuels Complex (MFC)	INL	Focuses on research and development of nuclear fuels. Pyroprocessing, which uses electricity to separate waste products in the recycling of nuclear fuel, is also researched here. Radioisotope-powered batteries for use on the nation's space missions are made at MFC.
Radioactive Waste Management Complex (RWMC)	ICP	Environmental remediation; and waste treatment, storage, and disposal for wastes generated at the INL Site and other DOE sites. Advanced Mixed Waste Treatment Project (AMWTP), operated by Idaho Treatment Group, LLC, and co-located with RWMC, characterizes, treats, and packages transuranic waste for shipment out of Idaho to permanent disposal facilities.
Research and Education Campus (REC)	INL	Located in Idaho Falls, is home to INL administration, the INL Research Center (IRC), the Center for Advanced Energy Studies (CAES), and other energy and security research programs. Research is conducted at IRC in robotics, genetics, biology, chemistry, metallurgy, computational science, and hydropower. CAES 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 (TAN)/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 SMC for the U.S. Department of Defense.

a. The Naval Reactors Facility (NRF) 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.

DOE sets dose limits for the public and biota to ensure 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 2015 was 0.0333 mrem (0.333 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 2015 to be 388 mrem (3,880 µSv) to an individual living on the Snake River Plain. The maximum potential population dose to the approximately 323,111 people residing within an 80-km (50-mi) radius of any INL Site facility was calculated as 0.614 person-rem (0.00614 person-Sv), below that expected from exposure to background radiation (125,367 person-rem or 1,254 person-Sv).

The maximum potential individual dose from consuming waterfowl at the INL Site, based on the highest concentrations of radionuclides measured in samples of these animals, was estimated to be 0.492 mrem (0.492 µSv). There were no gamma-emitting radionuclides detected in big game animals sampled in 2015, 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 individual, the maximally exposed individual could potentially receive a total dose of 0.525 mrem (5.25 µSv) in 2015. This is 0.525 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).

Doses were also evaluated using a graded approach for nonhuman biota at the INL Site. Maximum concentrations of radionuclides measured in waterfowl

Table ES-2. Contribution to Estimated Dose to a Maximally Exposed Individual by Pathway (2015).

Pathway	Dose to Maximally Exposed Individual (mrem)	Dose to Maximally Exposed Individual (µSv)	Percent of DOE 100-mrem/yr Dose 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	0.0333	0.333	0.0333%	0.614	0.00614	323,111	125,367
Waterfowl ingestion	0.492	4.92	0.492%	NA[c]	NA	NA	NA
Big game animals	0	0	NA	NA	NA	NA	NA
Total pathways	**0.525**	**5.25**	**0.525%**	**NA**	**NA**	**NA**	**NA**

a. The DOE limit for all pathways is 100 mrem/yr total effective dose equivalent. For this analysis, it was assumed that the hunter who eats contaminated waterfowl lives at the same location (Frenchman's Cabin) as the maximally exposed individual. The EPA regulatory standard for the air pathway is 10 mrem/yr effective dose equivalent and does not include the waterfowl consumption pathway.

b. The individual dose from background was estimated to be 388 mrem (3.88 µSv) in 2015 (Table 7-5).

c. NA = Not applicable.

tissue were used to estimate doses to those wildlife accessing ATR Complex ponds. Ducks were estimated to receive less than the standard of 1 rad/d (1 mGy/d) established by DOE for aquatic biota. Based on the 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 established for the protection of human health and the environment is presented in Table ES-3. There were no reportable releases to the environment in 2015 per the Emergency Planning and Community Right-to-Know Act (EPCRA) requirements.

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 1,870 curies (6.92×10^{13} Bq) of radioactivity, primarily in the form of short-lived noble gas isotopes, were released as airborne effluents in 2015. The highest releases were from the ATR Complex (49.0 percent of total), INTEC (46.8 percent of total), and RWMC (4.07 percent of total.) In terms of the calculated dose to the maximally exposed individual, facility contributions were 44.4 percent from the RWMC, 29.9 percent from INTEC, and 24.9 percent from the ATR Complex. The major radionuclide contributors to dose were americium-241 (28.1 percent), tritium (33.7 percent), iodine-129 (11.2 percent), argon-41 (7.6 percent), plutonium isotopes (7.02 percent), strontium-90 (^{90}Sr) (6.6 percent), and cesium-137 (^{137}Cs) (3.2 percent).

The INL Site environmental surveillance programs, conducted by the INL, ICP, 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 2015, the INL contractor monitored ambient air outside 15 INL Site facilities and at five locations off the INL Site. The ICP 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 six locations distant from the INL Site (including Jackson, Wyoming).

Air particulate samples were collected weekly by the ESER and INL contractors and bimonthly by the ICP contractor. These samples were then analyzed for gross alpha and gross beta activity. Charcoal cartridges were also collected weekly and analyzed for radioiodine. The particulate samples were combined into monthly, or quarterly composite samples by the ICP contractors and ESER, and INL contractors, respectively, and were analyzed for gamma-emitting radionuclides, such as ^{137}Cs. Particulate filters were also composited quarterly by the ICP and ESER contractors and analyzed for specific alpha- and beta-emitting radionuclides, specifically ^{90}Sr, plutonium-238, plutonium-239/240, and americium-241.

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 no 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. The ESER contractor also collected atmospheric moisture at four offsite locations. In addition, the ESER contractor sampled precipitation at two stations on the INL Site and one location off the INL Site. These samples were all analyzed for tritium. The results were within measurements made historically and 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.

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 (CAA) 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 (NESHAPs), (40 CFR 61, Subpart H).	The INL Site is in compliance, as reported in *National Emission Standards for Hazardous Air Pollutants – Calendar Year 2015*.	2.1.1 4.2 8.2.1
DOE/Order 458.1, Change 2	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 the 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 INL Annual Site Environmental Report.	Chapter 4 Chapter 5 Chapter 6 Chapter 7 Chapter 8
EPA/40 CFR 300	The National Contingency Plan implements CERCLA and provides the regulatory framework for remediation of releases of hazardous substances and remediation (including decontamination and decommissioning [D&D]) 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 INL Site entered into a tri-party agreement, the Federal Facility Agreement and Consent Order, with EPA, the state of Idaho, and DOE-ID. INL Site remediation is conducted by the Idaho Cleanup Project (ICP) and the INL.	3.2
EPA/40 CFR 109-140	The Clean Water Act (CWA) establishes goals to control pollutants discharged to U.S. surface waters.	The INL Site complies with two CWA permits – the National Pollution Discharge Elimination System (NPDES) permits and Storm Water Discharge Permits for construction activity, as applicable.	2.4.1
EPA/40 CFR 141-143	The Safe Drinking Water Act (SDWA) establishes primary standards for public water supplies to ensure it is safe for consumption.	The INL Site has 12 active drinking water systems which are routinely sampled and analyzed as required by the state of Idaho and EPA.	5.4
EPA/40CFR 270.13	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 conducted an annual RCRA inspection of the INL Site in fiscal year 2015 and issued a Warning Letter to DOE and responsible INL Site contractors on March 12, 2015. There were three apparent violations: two at the Advanced Mixed Waste Treatment Project and one at the Idaho Nuclear Technology and Engineering Center.	

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 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. These effluents are regulated by the state of Idaho groundwater quality and wastewater rules through wastewater reuse permits, which require monitoring of the wastewater and, in some instances, groundwater in the area. During 2015, 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, CFA, 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 nine drinking water systems at the INL Site in 2015. Results were below limits for all relevant drinking water standards. The CFA distribution system serves 500 workers daily and is downgradient from an 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 2015. The dose, 0.186 mrem (1.86 µSv), is below the EPA standard of 4 mrem/yr (40 µSv/yr) for public drinking water systems.

Surface water flows off the 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-238, plutonium-239/240, and ^{90}Sr were detected 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 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. In 2015, 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 or no trends of tritium and ^{90}Sr concentrations over time.

Several purgeable (volatile) organic compounds were detected by USGS in 24 groundwater monitoring wells and one perched well sampled at the INL Site in 2015. Most concentrations of the 61 compounds analyzed were either below the laboratory reporting levels or their respective primary contaminant standards. An increasing trend for carbon tetrachloride for the Radioactive Waste Management Complex Production Well has been observed for the period 1987–2012; however, trend analyses of data collected since 2005 show no statistically significant trend indicating that engineering practices designed to reduce movement of volatile organic compounds to the aquifer may be having a positive effect on the aquifer. Trichloroethene (TCE) was measured in another well at TAN, which was expected as there is a known groundwater plume at this location.

Groundwater surveillance monitoring continued for the CERCLA WAGs on the INL Site in 2015. 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.

Data from groundwater in the vicinity of the ATR Complex (WAG 2) show no concentrations of chromium, ^{90}Sr, and tritium above their respective primary contaminant standards.

Groundwater samples were collected from eighteen aquifer monitoring wells at and near INTEC (WAG 3) during 2015. Stronium-90, technetium-99, total dissolved solids, 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 but at 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 2015 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. Nitrate continued to exceed the EPA maximum contaminant level in one well in the plume south of the CFA in 2015, but 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), gross beta, carbon tetrachloride, TCE and tetrachloroethylene were detected at several locations. Only tetrachloroethylene exceeded the EPA maximum contaminant level in one aquifer well northeast of the facility. This result is suspect because of the location of the well, which is upgradient of the RWMC. In general, constituents of concern in the aquifer at RWMC are relatively stable or trending slightly downward.

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

Drinking water and surface water samples were sampled downgradient of the INL Site and analyzed for gross alpha and beta activity, and tritium. 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. The data appear to show no discernible impacts from activities at the MFC.

MONITORING OF AGRICULTURAL PRODUCTS, WILDLIFE, 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 2015. The agricultural products were collected on, around and distant from the INL Site by the ESER contractor.

Wildlife sampling included collection of ducks from wastewater ponds in the vicinity of the ATR Complex and the MFC, as well as big game animals killed by vehicles on roads within the INL Site. In addition, direct radiation was measured on and off the INL Site in 2015.

Some human-made radionuclides were detected in agricultural products and waterfowl samples. However, measurements were consistent with those made historically.

Strontium-90, a radionuclide measured in fallout, was detected at low levels in most lettuce samples collected locally. No gamma-emitting radionuclides were detected in the five big game animals sampled in 2015. Cesium-134, cesium-137, chromium-51, cobalt-58, cobalt-60, selenium-75, ^{90}Sr, and zinc-65 were measured in the edible tissue of waterfowl accessing ATR Complex wastewater ponds.

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 2015 included the midwinter eagle survey, sage-grouse lek surveys, and a breeding bird survey. During 2015 permanent bat monitoring stations continued to be monitored at the INL Site.

Notable results from the 2015 surveys were discovery of a new sage-grouse lek, the fifth-lowest count of raptors in the past 15 years, a continuing upward trend in the number of raven nests, and that INL Site caves may be used as stop-over habitat during fall migration of previously undocumented forest bats.

ENVIRONMENTAL RESEARCH AT THE IDAHO NATIONAL ENVIRONMENTAL RESEARCH PARK AT THE INL SITE

Forty years ago, 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 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 2015, four major ecological research projects took place on the Idaho National Environmental Research Park. The researchers were from Idaho State University; Boise State University; College of Idaho; Environmental Surveillance, Education, and Research Program; and U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center, Boise, ID.

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 2015, the USGS published six 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 2015. Data reported in this document were obtained from several commercial, university, government, and government contractor laboratories. To assure quality results, these laboratories participated in a number of laboratory quality check programs. Quality issues that arose with laboratories used by the INL, ICP, and ESER contractors during 2015 were addressed with the laboratories and have been or are being resolved.

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 radiowaves, 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 plus 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.

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).

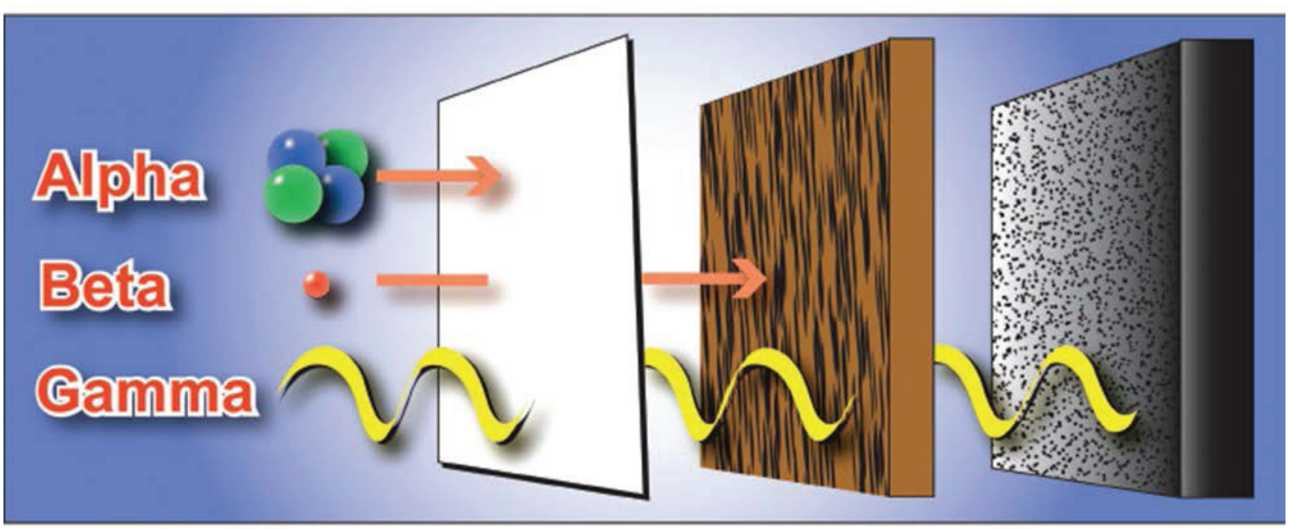


Figure HI-1. Comparison of Penetrating Ability of Alpha, Beta, and Gamma Radiation.

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 man-made 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 (G-M) counter. However, detection of specific beta-emitting radionuclides, such as tritium-3 (^{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.

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

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	312.5 d
^{243}Am	Americium-243	7,380 yr	^{59}Ni	Nickel-59	7.5 x 10^4 yr
^{125}Sb	Antimony-125	2.77 yr	^{63}Ni	Nickel-63	96 yr
^{41}Ar	Argon-41	1.827 hr	^{238}Pu	Plutonium-238	87.74 yr
^{137m}Ba	Barium-137m	2.552 min	^{239}Pu	Plutonium-239	2.4065 x 10^4 yr
^{140}Ba	Barium-140	12.74 d	^{240}Pu	Plutonium-240	6.537 x 10^3 yr
^{7}Be	Beryllium-7	53.3 d	^{241}Pu	Plutonium-241	14.4 yr
^{14}C	Carbon-14	5,730 yr	^{242}Pu	Plutonium-242	3.763 x 10^5 yr
^{141}Ce	Cerium-141	32.5 d	^{40}K	Potassium-40	1.28 x 10^9 yr
^{144}Ce	Cerium-144	284.3 d	^{226}Ra	Radium-226	1.62 x 10^3 yr
^{134}Cs	Cesium-134	2.062 yr	^{228}Ra	Radium-228	5.75 yr
^{137}Cs	Cesium-137	30.0 yr	^{220}Rn	Radon-220	55.6 s
^{51}Cr	Chromium-51	27.704 d	^{222}Rn	Radon-222	3.8235 d
^{60}Co	Cobalt-60	5.271 yr	^{103}Ru	Ruthenium-103	39.28 d
^{152}Eu	Europium-152	13.33 yr	^{106}Ru	Ruthenium-106	368.2 d
^{154}Eu	Europium-154	8.8 yr	^{90}Sr	Strontium-90	29.12 yr
^{3}H	Tritium	12.35 yr	^{99}Tc	Technetium-99	2.13 x 10^5 yr
^{129}I	Iodine-129	1.57 x 10^7 yr	^{232}Th	Thorium-232	1.405 x 10^{10} yr
^{131}I	Iodine-131	8.04 d	^{233}U	Uranium-233	1.585 x 10^5 yr
^{55}Fe	Iron-55	2.7 yr	^{234}U	Uranium-234	2.445 x 10^5 yr
^{59}Fe	Iron-59	44.529 d	^{235}U	Uranium-235	7.038 x 10^8 yr
^{85}Kr	Krypton-85	10.72 yr	^{238}U	Uranium-238	4.468 x 10^9 yr
^{87}Kr	Krypton-87	1.27 hr	^{90}Y	Yttrium-90	64.0 hr
^{88}Kr	Krypton-88	2.84 hr	^{65}Zn	Zinc-65	243.9 d
^{212}Pb	Lead-212	10.64 hr	^{95}Zr	Zirconium-95	63.98 d

a. From EPA (1999).

b. d = days; hr = hours; min = minutes; s = seconds; yr = years.

exponent. In this case, 1.0 x 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 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

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

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)

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.

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 3.7×10^{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 and sievert (Sv) for effective dose, where 1 Sv equals 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 illustrates the minimum, maximum, and median of a set of air measurements. The vertical lines drawn above and below the median represent the range of values between the minimum and maximum results.

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.

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 7-5 of this report.

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

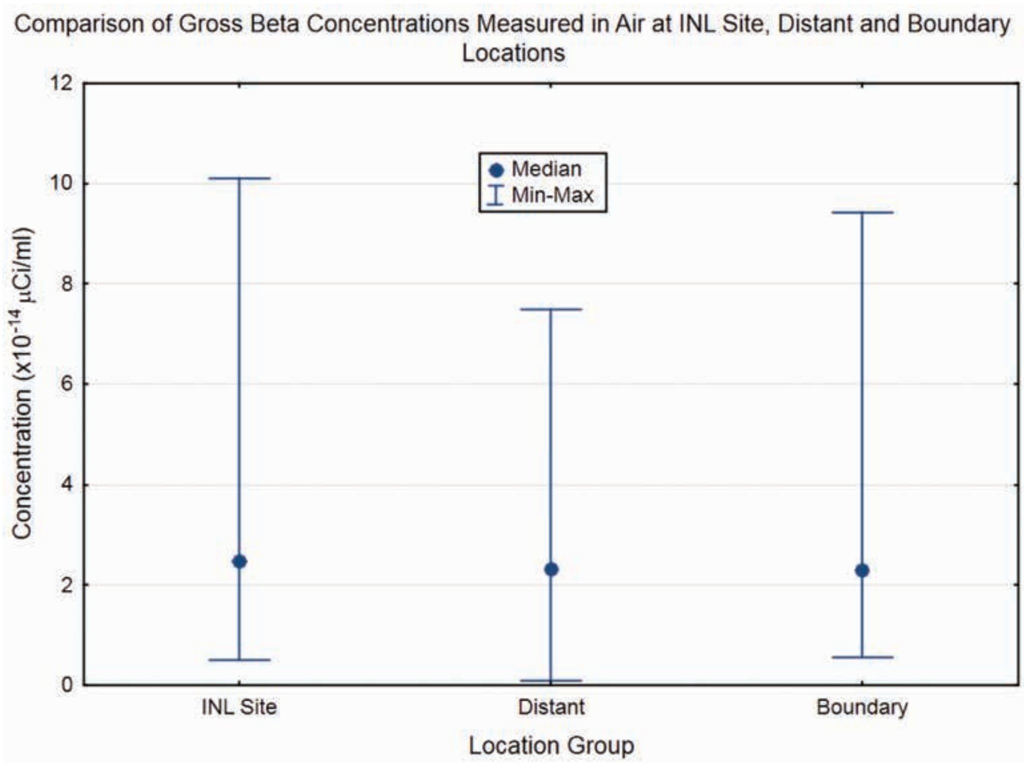
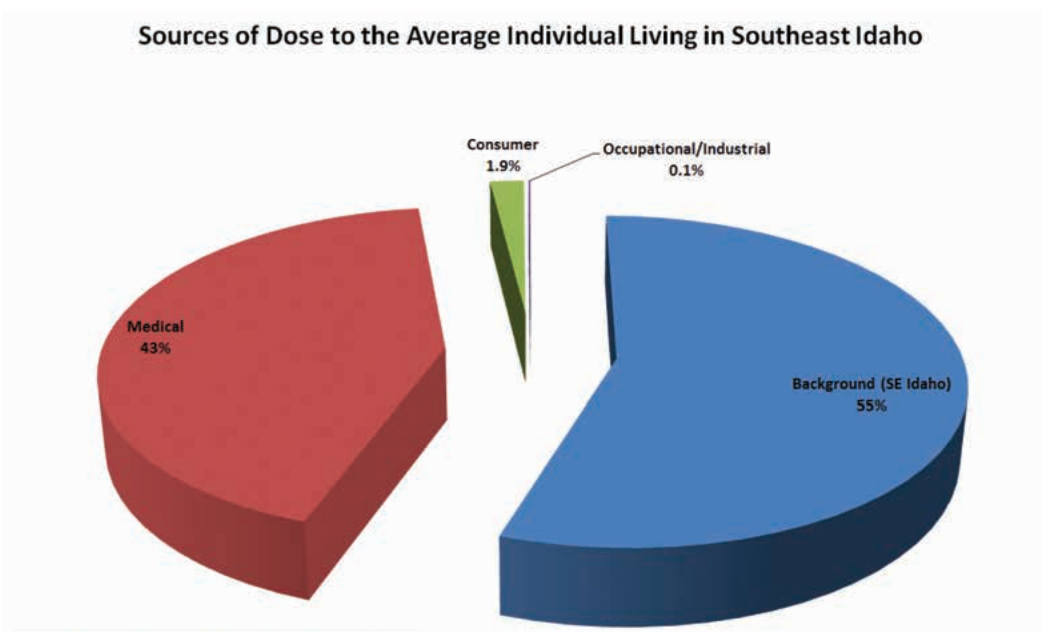


Figure HI-2. A Graphical Representation of Minimum, Median, and Maximum Results.



Exposure Category	Effective Dose (mrem)	% of Total
Background (SE Idaho)	388	55
Medical	300	43
Consumer	13	1.9
Occupational/industrial	0.8	0.1
TOTAL	702	100

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

A ***column or bar chart*** can show data changes over a period of time or illustrate comparisons among items. Figure HI-4 illustrates the contribution of radionuclides released into air from INL Site operations from 1975 through 1985 to the dose (mrem) calculated for the maximally exposed individual. 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 radionculides are transported (i.e., air, water, and food). One column (red) represents the annual dose from krypton-88 (^{88}Kr) released. The second column (green) plots the annual dose from all radionuclides released into the air. The chart shows the general decreasing trend of the dose as well as the relative contribution to dose from the ^{88}Kr. The relative contribution to the total dose from ^{88}Kr varies over time. For example, it represents approximately one-third of the total dose in 1975 and a little over one-half of the dose in 1976.

A ***plot*** can be useful to visualize differences in results over time. Figure HI-5 shows the tritium measurements in two wells collected by USGS for eighteen years (1998 through 2015). 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 ^{3}H in groundwater around the Idaho Nuclear Technology and Engineering Center (INTEC). Each contour line, or isopleth, represents a specific concentration of the 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

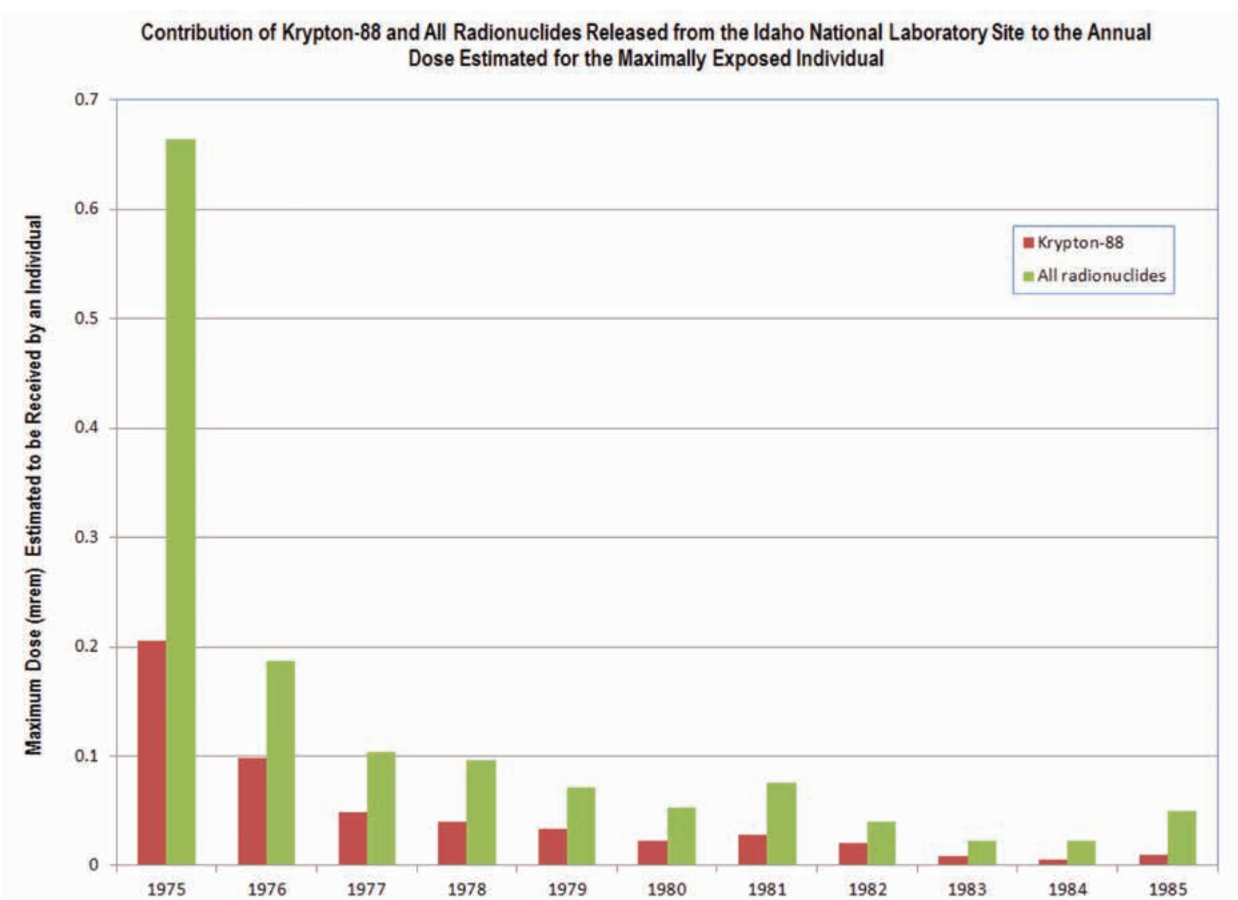


Figure HI-4. Data Plotted Using a Column Chart.

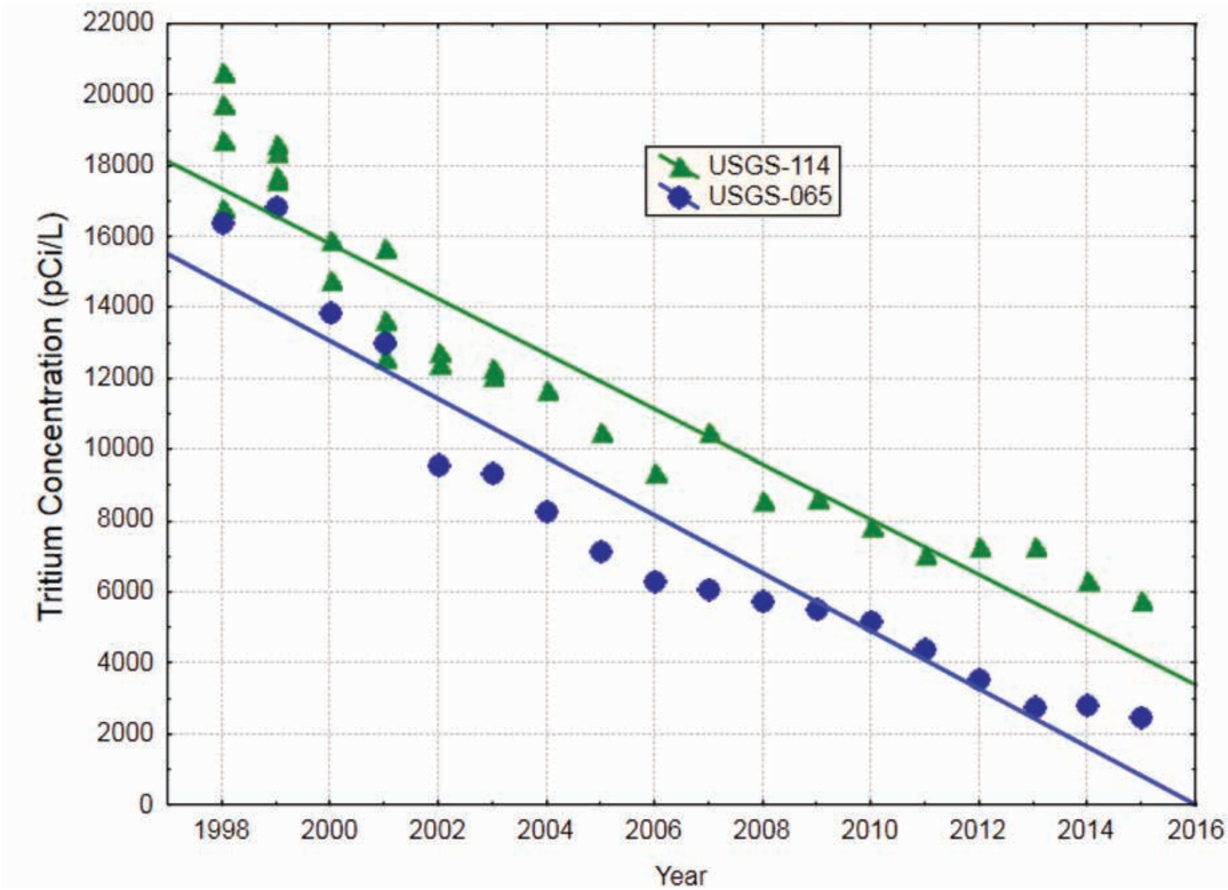


Figure HI-5. Data Plotted Using a Linear Plot.

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 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.

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

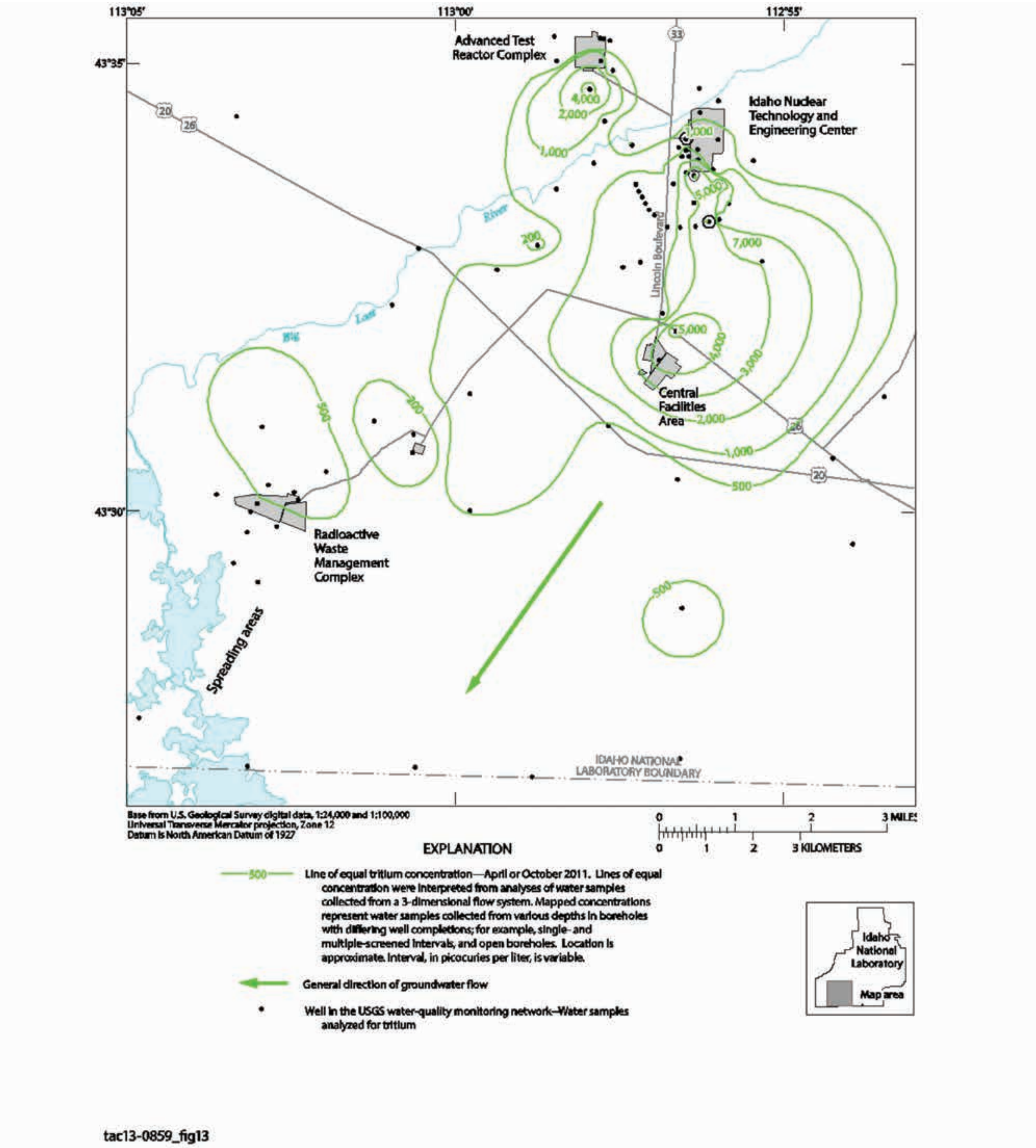


Figure HI-6. Data Plotted Using Contour Lines. Each contour line drawn on this map connects points of equal tritium concentration in water samples collected at the same depth from wells on the INL Site.

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, NCRP 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 2015 to receive an average dose of about 388 mrem/yr (3.9 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.

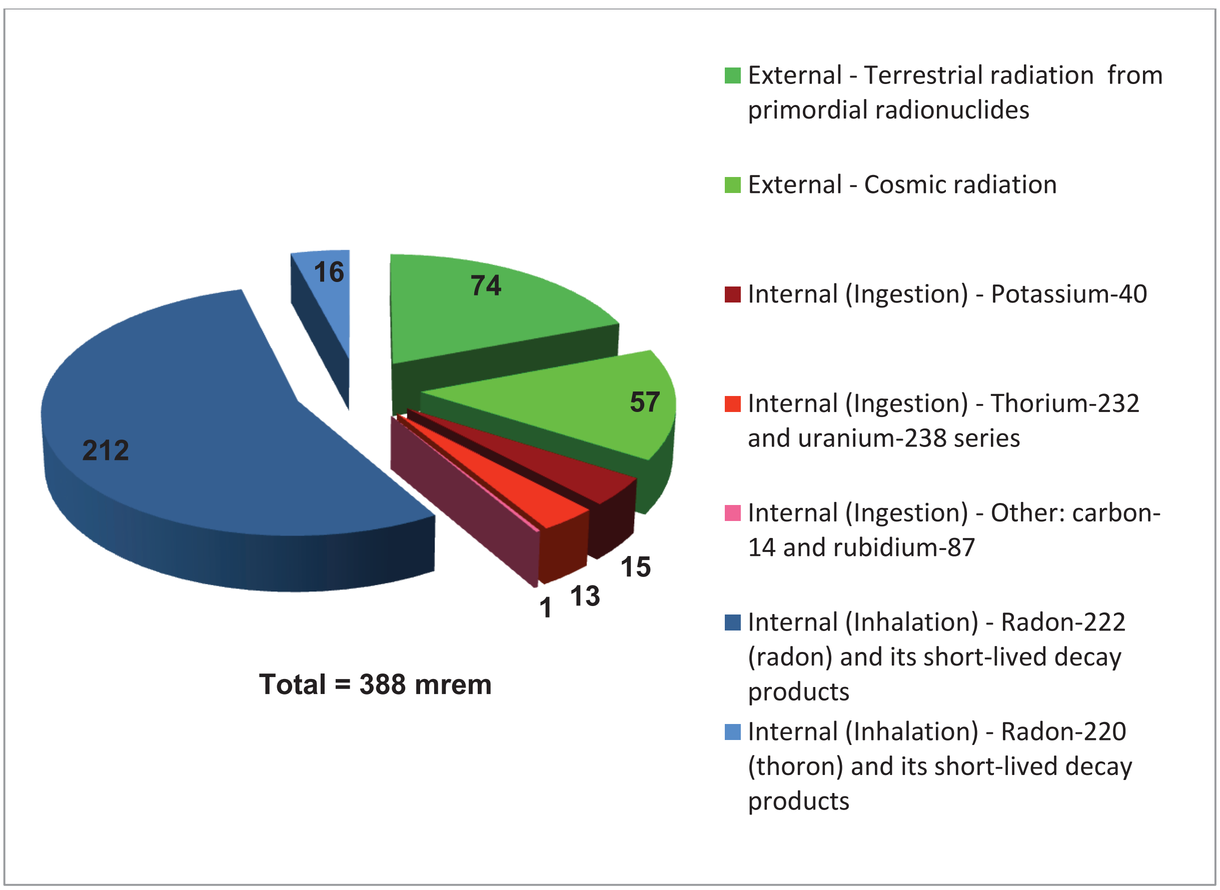


Figure HI-7. Calculated Doses (mrem per year) from Natural Background Sources for an Average Individual Living in Southeast Idaho (2015).

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 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 which 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)	53.3 days	Cosmic rays	Rain, air
Tritium (^{3}H)	12.3 yr	Cosmic rays	Water, rain, air moisture
Potassium-40 (^{40}K)	1.26×10^{9} yr	Primordial	Water, air, soil, plants, animals
Thorium-232 (^{232}Th)	1.4×10^{10} yr	Primordial	Soil
Uranium-238 (^{238}U)	4.5×10^{9} yr	Primordial	Water, air, soil
Uranium-234(^{234}U)	2.5×10^{5} yr	^{238}U progeny	Water, air, soil
Radium-226 (^{226}Ra)	1,620 yr	^{238}U progeny	Water

The parent radionuclide of the thorium series is ^{232}Th. Another isotope of radon (^{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, which resulted in the release of radionuclides into the upper atmosphere. This 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 though. France continued atmospheric testing until 1974, and China until 1980. Additional fallout, but to a substantially smaller extent, was produced by the Chernobyl nuclear accident in 1986.

Most of the radionuclides associated with nuclear weapons testing and the Chernobyl accident 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 lodge 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 (ICRP) and the National Council on Radiation Protection and Measurements (NCRP). The ICRP is an association of scientists from many countries, including the United States. The NCRP 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.

Risk can be defined in general as the probability (chance) of injury, illness, or death resulting from some activity. There are a large amount of data showing the effects of receiving high doses of radiation, especially in the range of 50 to 400 rem (0.5 to 4.0 Sv), delivered acutely (all at once.) These are largely data resulting from studies of the survivors of the Japanese atomic bombing and of some relatively large groups of patients who were treated with substantial doses of X-rays.

It is difficult to estimate risks from low levels of radiation. 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.

Each radionuclide represents a somewhat different health risk. However, health physicists (radiation protection professionals) currently estimate that overall, 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 five or six more people to die of cancer than would otherwise (EPA 2013). In this group of 10,000 people, about 2,000 would be expected to die of cancer from all non-radiation causes. A lifetime exposure to 1 rem (0.01 Sv) of radiation would increase that number to about 2,005 or 2,006. For perspective, most people living on the eastern Snake River Plain receive over one-third of a rem (388 mrem or 3.9 mSv) every year from natural background sources of radiation.

DOE 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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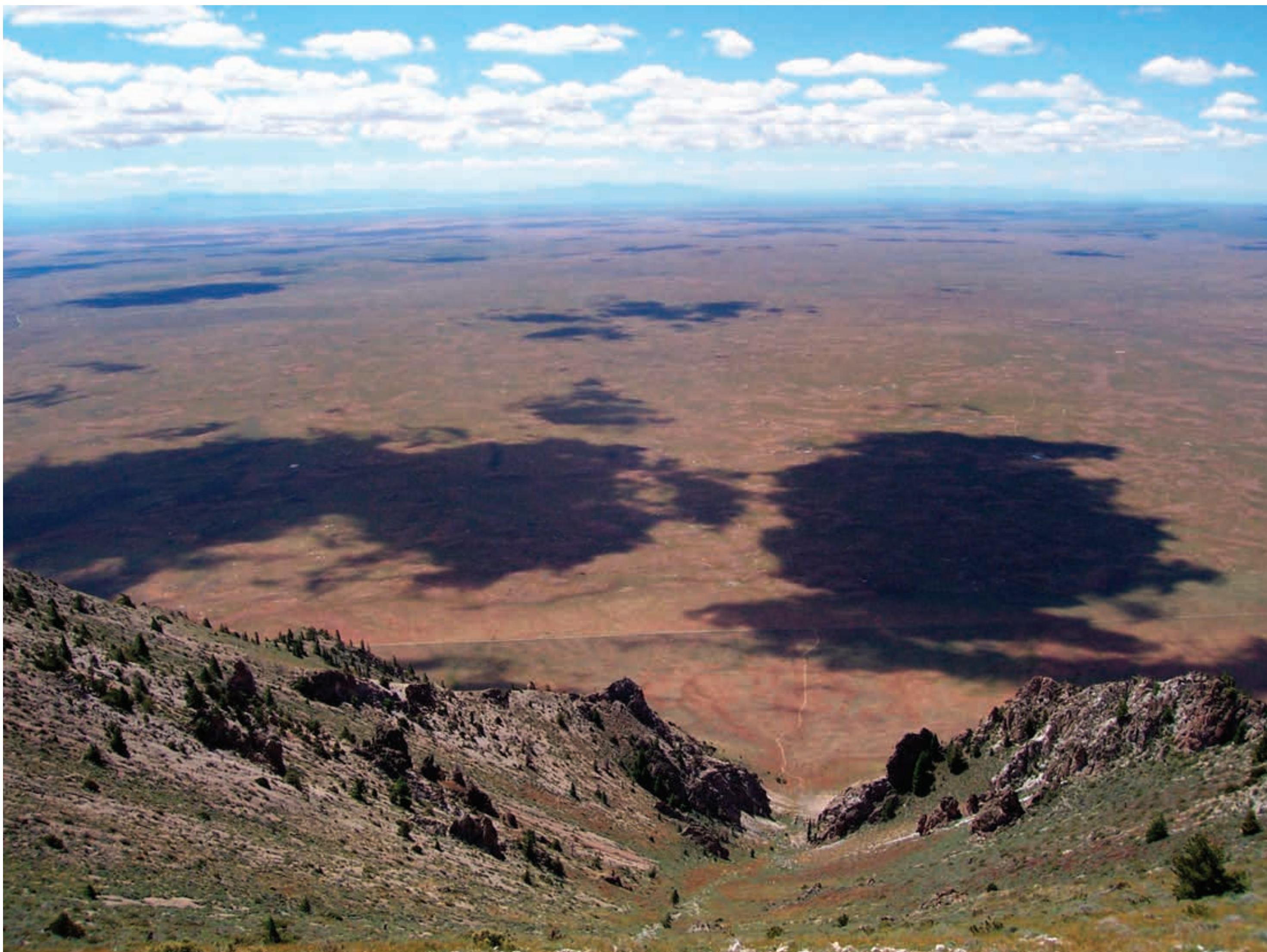
Cottontail Rabbit

Acronyms

ALS-FC	ALS-Fort Collins
AMWTP	Advanced Mixed Waste Treatment Project
ARP	Accelerated Retrieval Project
ATR	Advanced Test Reactor
BEA	Battelle Energy Alliance
BBS	Breeding Bird Survey
BLS	Below Land Surface
CAA	Clean Air Act
CAP88-PC	Clean Air Act Assessment Package, 1988 Personal Computer
CCA	Candidate Conservation Agreement
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFA	Central Facilities Area
CFR	Code of Federal Regulations
CITRC	Critical Infrastructure Test Range Complex
CRM	Cultural Resource Management
CRMO	Cultural Resource Management Office
CTF	Contained Test Facility
CWA	Clean Water Act
CWI	CH2M-WG Idaho, LLC
CWP	Cold Waste Pond
DCS	Derived Concentration Standard
DEQ	Department of Environmental Quality (state of Idaho)
DEQ-INL OP	DEQ-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 Monitoring Program
EA	Environmental Assessment
EBR-I	Experimental Breeder Reactor-I
EBR-II	Experimental Breeder Reactor-II
EFS	Experimental Field Station
EIC	Electret Ionization Chamber
EIS	Environmental Impact Statement
EMS	Environmental Management System
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ESA	Endangered Species Act
ESER	Environmental Surveillance, Education, and Research
ESRP	Eastern Snake River Plain
FFA/CO	Federal Facility Agreement and Consent Order
FWS	U.S. Fish and Wildlife Service
FY	Fiscal Year
GHG	Greenhouse Gas
GPR	Global Positioning Radiometric Scanner
GSS	Gonzales-Stoller Surveillance, LLC
GWMP	Groundwater Monitoring Program
HETO	Heritage Tribal Office
HSS	Office of Health, Safety and Security
ICDF	Idaho CERCLA Disposal Facility
ICP	Idaho Cleanup Project

ICRP	International Commission on Radiological Protection
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)
IRC	INL Research Center
ISB	In Situ Bioremediation
ISFSI	Independent Spent Fuel Storage Installation
ISO	International Organization for Standardization
ISU	Idaho State University
ISU-EAL	Idaho State University-Environmental Assessment Laboratory
IWTU	Integrated Waste Treatment Unit
LCS	Laboratory Control Sample
LEMP	Liquid Effluent Monitoring Program
LOFT	Loss-of-Fluid Test
LTV	Long-Term Vegetation
Ma	Million years
MAPEP	Mixed Analyte Performance Evaluation Program
MCL	Maximum Contaminant Level
MDC	Minimum Detectable Concentration
MDIFF	Mesoscale Diffusion Model
MEI	Maximally Exposed Individual
MESODIF	Mesoscale Diffusion Model
MLLW	Mixed Low-level Waste
MFC	Materials and Fuels Complex
MQO	Method Quality Objective
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
NHPA	National Historic Preservation Act
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NOAA ARL-FRD	National Oceanic and Atmospheric Administration Air Resources Laboratory Field Research Division
NRF	Naval Reactors Facility
OMB	Office of Management and Budget
OSLD	Optically Stimulated Luminescent Dosimeters
PLN	Plan
QA	Quality Assurance
QAPjP	Quality Assurance Project Plan
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
REC	Research and Education Campus
RESL	Radiological and Environmental Sciences Laboratory
RPD	Relative Percent Difference
ROD	Record of Decision
RSD	Relative Standard Deviation
RSWF	Radioactive Scrap and Waste Facility
RWMC	Radioactive Waste Management Complex
SDA	Subsurface Disposal Area

SEM	Scanning Electron Microscopy
SGCA	Sage-grouse Conservation Area
SHPO	State Historic Preservation Office
SMC	Specific Manufacturing Capability
SNF	Spent Nuclear Fuel
TAN	Test Area North
TCE	Trichloroethylene
TLD	Thermoluminescent Dosimeter
TMI	Three Mile Island
TRU	Transuranic waste
TSF	Technical Support Facility
TSCA	Toxic Substances Control Act
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOC	Volatile Organic Compound
WAG	Waste Area Group
WIPP	Waste Isolation Pilot Plant
WNS	White-nose Syndrome
WRP	Wastewater Reuse Permit



INL Site from Big Southern Butte

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
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
mi	mile
min	minute
mL	milliliter
mR	milliroentgen
mrad	millirad
mrem	millirem
mSv	millisievert
oz	ounce
pCi	picocurie (10^{-12} curies)
R	roentgen
rad	radiation absorbed dose
rem	roentgen equivalent man
yd	yard
yr	year

Buckweed and Rabbitbrush

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Big Southern Butte

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 Idaho National Laboratory (INL) Site's 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 almost 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 on INL Site land 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 21.6 cm/yr [8.5 in./yr]), warm summers (average daily temperature of 18.3°C [64.9°F]), and cold winters (average daily temperature of -7.3°C [18.9°F]), with all averages based on observations at Central Facilities Area from 1950 through 2006 (NOAA 2007). The altitude, intermountain setting, and latitude of the INL Site combine to produce a semiarid 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. Vegetation is dominated by big sagebrush (*Artemisia tridentata*). Beneath these shrubs are grasses and wildflowers adapted to the harsh climate. A total of 409 different kinds (taxa) of plants have been recorded on the INL Site (Anderson et al. 1996).

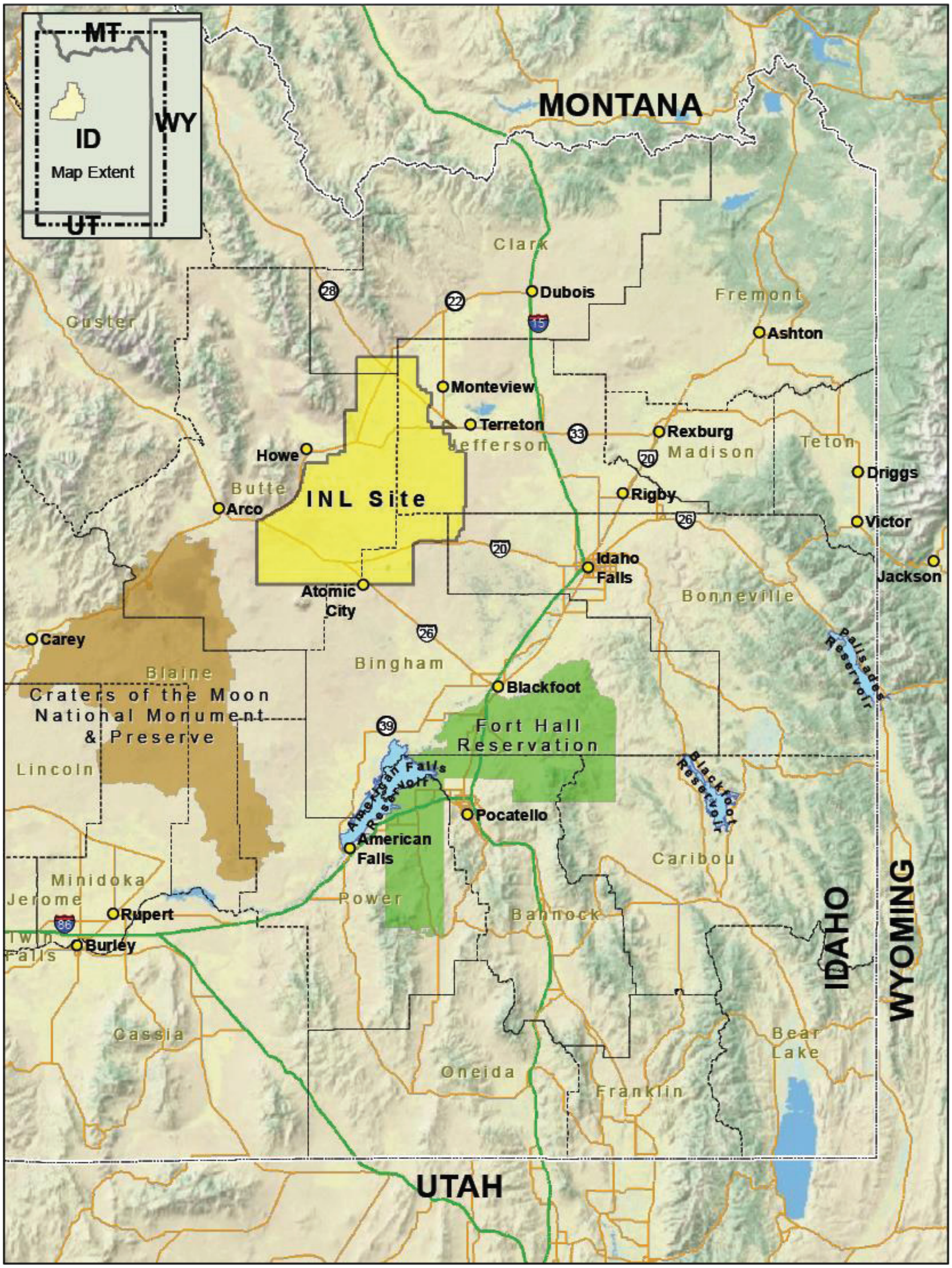

Figure 1-1. Location of the Idaho National Laboratory Site.

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

The Big Lost River on the INL Site flows northeast, ending in a playa area, called the Big Lost River Sinks, on the northwestern portion of the INL Site. Here, the river evaporates or infiltrates the subsurface, with no surface water moving off the INL Site.

The fractured volcanic rocks under the INL Site form a portion of the eastern Snake River Plain aquifer (Figure 1-2), which stretches 320 km (199 mi) from Island Park to King Hill, and stores one of the most bountiful

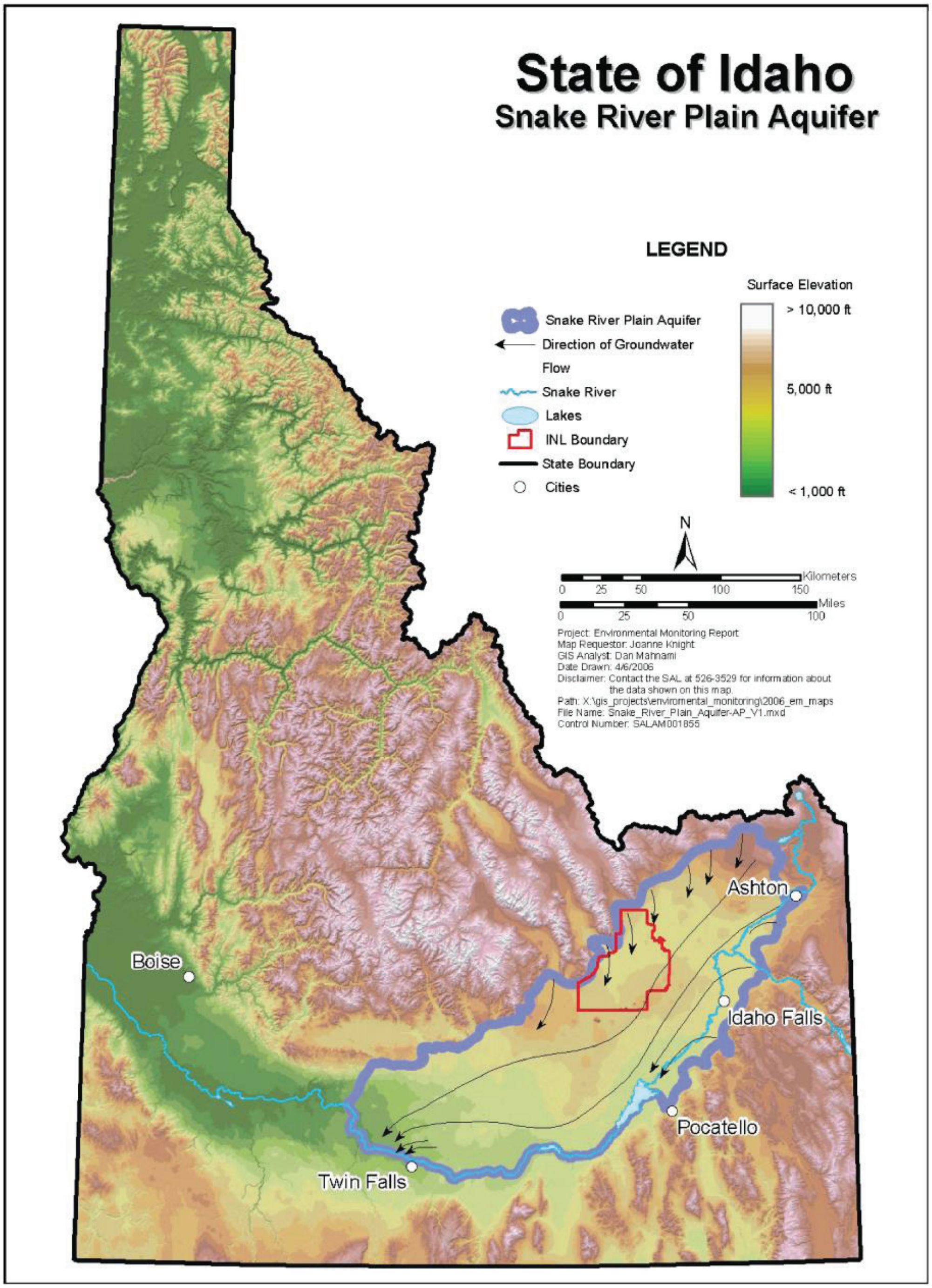

Figure 1-2. Idaho National Laboratory Site in Relation to the Eastern Snake River Plain Aquifer.

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 recharged from the Henry's 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 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 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.

1.3.1 Idaho National Laboratory

The INL mission is to ensure the nation's energy security with safe, competitive, and sustainable energy systems, and unique national and homeland security capabilities. Its vision is to be the preeminent nuclear energy laboratory, with synergistic, world-class, multi-program capabilities and partnerships. 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, 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.

1.3.2 Idaho Cleanup Project

The Idaho Cleanup Project (ICP) 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 is led by CH2M-WG Idaho, LLC. 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.

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

1.3.3 Advanced Mixed Waste Treatment Project

The Advanced Mixed Waste Treatment Project (AMWTP) prepares and ships contact-handled transuranic and mixed low-level waste out of Idaho. AMWTP is managed and operated by Idaho Treatment Group, LLC. Operations at AMWTP retrieve, characterize, treat, package, and ship transuranic waste currently stored at the INL Site. The project's schedule is aligned with court-mandated milestones in the 1995 Settlement Agreement (DOE 1995) between the state of Idaho, U.S. Navy, and DOE to remove waste from Idaho. The majority of waste AMWTP processes resulted from the manufacture of nuclear weapons' components at DOE's Rocky Flats Plant in Colorado. This waste was shipped to Idaho in the 1970s and early 1980s for storage and contains industrial debris, soil and sludge, and is contaminated with transuranic radioactive elements (primarily plutonium). Most of the waste is "mixed waste" that is contaminated with radioactive and nonradioactive hazardous chemicals, such as oil and solvents. Since 1999, more than 55,126 m^3 (72,102 yd^3) of transuranic waste has been shipped off the INL Site or certified for disposal at WIPP in Carlsbad, New Mexico.

1.3.4 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 1-3).

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 management of sodium-bearing waste, spent nuclear fuel storage, environmental remediation, disposing of excess facilities, and management of the Idaho Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Disposal Facility (ICDF). The ICDF is the consolidation point for CERCLA-generated wastes within the INL Site boundaries. The Idaho Nuclear Technology and Engineering Center is operated by the ICP 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, 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 2016).

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 WIPP.

The Subsurface Disposal Area is a 39-hectare (96-acre) radioactive waste landfill that was used for more than 50 years. Approximately 14 of the 39 hectares (35 of 96 acres) contain waste, including radioactive ele-

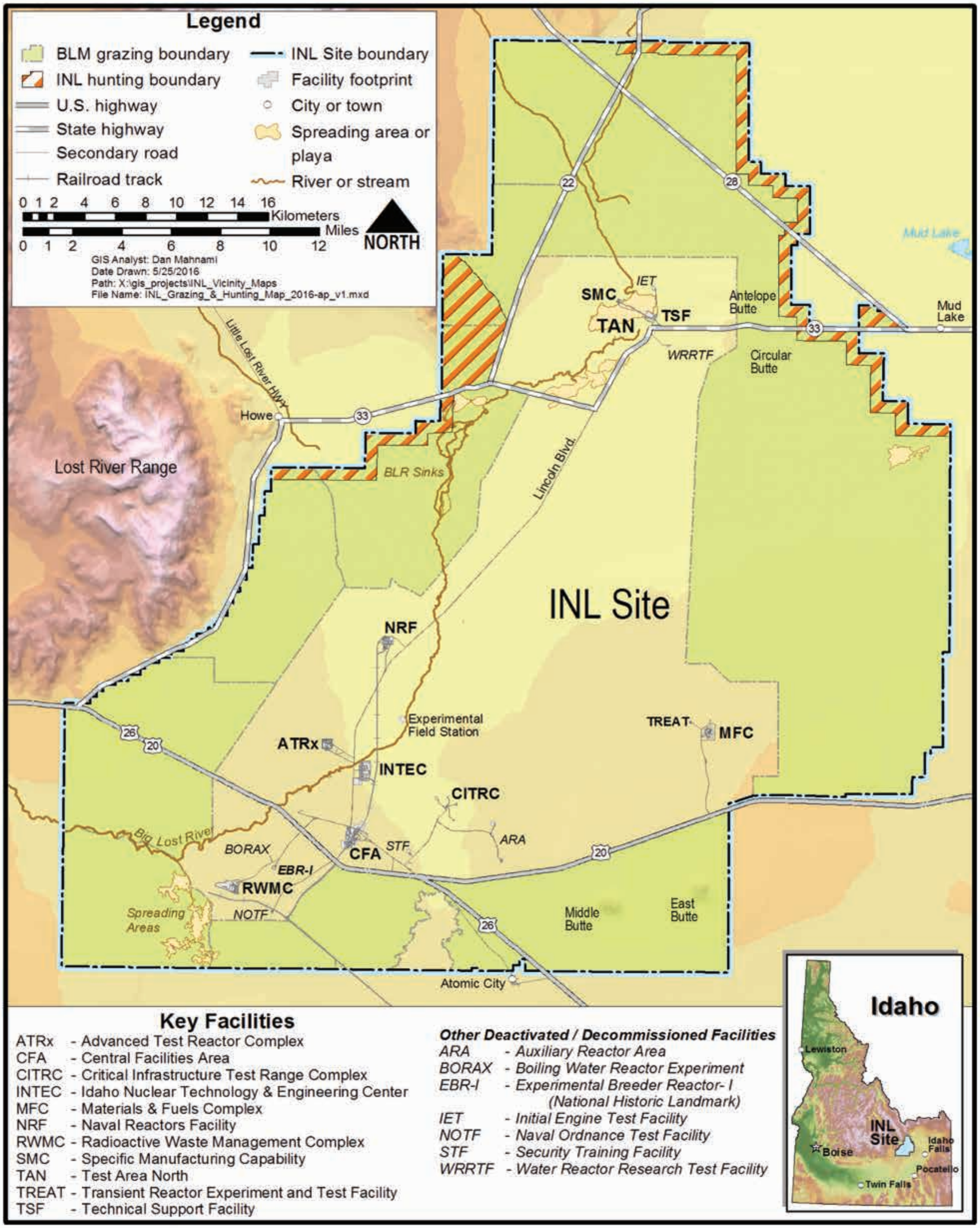

Figure 1-3. Location of the Idaho National Laboratory Site, Showing Facilities.

ments, organic solvents, acids, nitrates, and metals from historical operations such as reactor research at INL 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. Through December 2015, 4.02 of the required 5.69 acres (1.63 of 2.30 hectares) have been exhumed and 5,594 m^3 (7,316 yd^3) of waste have been shipped out of Idaho. The total volume of waste certified for disposal and not shipped is 887 m^3 (1,160 yd^3), due to suspension of operations at WIPP. Cleanup of RWMC is managed by the ICP 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 Nuclear Science 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. The Center for Advanced Energy Studies, designed to promote education and world-class research and development, is also located at the REC. Two new laboratory facilities, the Energy Systems Laboratory and the Energy Innovation Laboratory (Figure 1-4), were constructed in 2013 and

Figure 1-4. The New Energy Innovation Laboratory (EIL) at the INL's Research and Education Campus. *The EIL has received international and regional acclaim for sustainable design and construction and has earned the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) Platinum Certification. Worldwide, fewer than 5 percent of research labs in the LEED Registry are Platinum-certified.*

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. 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 assure key DOE missions are completed in a safe and environmentally responsible manner. By assuring the quality and stability of key laboratory measurement systems throughout DOE, and by providing expert technical assistance to improve those systems and programs, RESL assures 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 Department of Energy Laboratory Accreditation Program. The new Department of Energy 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 Unit 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 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 WAG 1 status in Table 3-3.

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.

1.4 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). The 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, there was a series of giant, caldera-forming eruptions, 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 (by which time the fur trade was essentially over) and 1857, an estimated 240,000 immigrants passed through southern Idaho on the Oregon Trail. By 1868, treaties had been signed forcing the native populations onto the reservation at Fort Hall. During the 1870s, miners entered the surrounding mountain ranges, followed by ranchers grazing cattle and sheep in the valleys.

A railroad was opened between Blackfoot and Arco, Idaho, in 1901. 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 attempt building 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. The relatively isolated Snake River Plain was chosen as the best location. Thus, the Naval Proving Ground became the National Reactor Testing Station in 1949.

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 U.S. 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, and on February 1, 2005, the Idaho National Engineering and Environmental Laboratory and Argonne National Laboratory-West became the Idaho National Laboratory.

1.5 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 323,111. Over half of this population (175,237) resides in the census divisions of Idaho Falls (105,342) and northern Pocatello (69,895). Another 28,604 live in the Rexburg census division. Approximately 19,476 reside in the Rigby census division and 15,481 in the Blackfoot census division. The remaining population resides in small towns and rural communities.

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2015

2. Environmental Compliance Summary


Lost River Range

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. Actions related to environmental compliance in 2015 include:

- The *National Emission Standards for Hazardous Air Pollutants-Calendar Year 2015 INL Report for Radionuclides* report was submitted to U.S. Environmental Protection Agency, DOE Headquarters, and state of Idaho officials in June 2016, in compliance with the Clean Air Act. The dose to hypothetical Maximally Exposed Individual from airborne releases was estimated to be far below the regulatory limit of 10 mrem per year.
- Measurements of radionuclides in environmental media sampled on and around the INL Site in 2015 did not exceed Derived Concentration Standards established in DOE Order 458.1, "Radiation Protection of the Public and the Environment."
- There were no reportable environmental releases at the INL Site in 2015, per EPCRA regulations.
- On March 25, 2015, President Obama issued Executive Order 13693, "Planning for Federal Sustainability in the Next Decade." The order required federal agencies to establish greenhouse gas reduction goals. In response to this order, DOE committed to agency-wide reductions.
- In 2015, 31 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 50 proposed activities.
- TRU waste shipments halted in 2014 due to Waste Isolation Pilot Plant suspension of operations.
- A notice of violation was issued on January 6, 2015, for failure to cease use of Idaho Nuclear Technology and Engineering Center tanks storing sodium-bearing mixed waste.

2. ENVIRONMENTAL COMPLIANCE SUMMARY

This chapter reports the compliance status of the Idaho National Laboratory (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 U.S. Department of Energy (DOE) orders. These are listed in Appendix A. The programs in place to comply with environmental protection requirements are discussed in Chapter 3.

2.1 Air Quality and Radiation Protection

2.1.1 Clean Air Act

The Clean Air Act (CAA) is the basis for national air pollution control. Congress passed the original CAA in 1963, which resulted in non-mandatory air pollution standards and studies of air pollution, primarily from automobiles. Amendments to the CAA are passed periodically, with significant amendments enacted in 1970, 1977, and 1990. These amendments contained key pieces of legislation that are considered basic elements of the CAA, which are listed below:

- ***National Ambient Air Quality Standards.*** The National Ambient Air Quality Standards establish permissible exposure levels for six pollutants (criteria air pollutants) identified as primary contributors to health-related deaths and illnesses. The six pollutants are carbon monoxide, lead, nitrogen dioxide, ozone, particulates, and sulfur oxides.
- ***State Implementation Plans.*** A state may assume responsibility for the CAA by developing a U.S. Environmental Protection Agency (EPA)-approved state implementation plan. A state implementation plan contains the laws and regulations a state will use to administer and enforce the provisions of the CAA.

The state of Idaho has been delegated authority for the CAA through an approved state implementation plan.

- ***New Source Performance Standards.*** The New Source Performance Standards program is a permitting performance standard for specific industry source categories. The standard targets sources that contribute significantly to air pollution and ensures the sources meet ambient air quality standards. The criteria air pollutants are the focus of the New Source Performance Standards Program.
- ***Prevention of Significant Deterioration.*** The Prevention of Significant Deterioration program applies to new major sources or major modifications to existing sources where the source is located in an area that is designated as attainment or unclassifiable/attainment with the National Ambient Air Quality Standards. An attainment area is one that meets the national primary or secondary ambient air quality standards. An unclassifiable/attainment area is one that cannot be classified on the basis of available information as meeting or not meeting the national primary or secondary ambient air quality standards but it is reasonably believed to be in attainment and is not contributing to nearby violations. The INL Site is in an unclassifiable/attainment area.
- ***National Emissions Standards for Hazardous Air Pollutants (NESHAP).*** The NESHAP program regulates emissions of hazardous air pollutants from a published list of industrial sources. The source categories must meet control technology requirements for these hazardous air pollutants. The state of Idaho has supplemented the federal NESHAP list of hazardous air pollutants with the State List of Toxic Air Pollutants.

  The state of Idaho has not been delegated authority for one key subpart of the NESHAP program. Specifically, Subpart H, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities" (40 Code of Federal Regulations [CFR] 61, Subpart H), is regulated by EPA. Subpart H applies to facilities owned or operated by DOE, including the INL Site. The Department of Energy, Idaho Operations Office (DOE-ID) submits an annual NESHAP Subpart H report to EPA and the Idaho Department of Environmental Quality (DEQ). The latest report is *National Emission Standards for Hazardous Air Pollutants – Calendar Year 2015 INL Report for Radionuclides* (DOE-ID 2016). The annual NESHAP Subpart H report uses an EPA-approved computer model to calculate the hypothetical maximum individual effective dose equivalent to a member of the public resulting from INL Site airborne radionuclide emissions. The calculations for this code are discussed further in Chapter 8, "Dose to the Public and Biota."
- ***Stratospheric Ozone Protection Program.*** The Stratospheric Ozone Protection Program limits emissions of chlorofluorocarbons, halons, and other halogenic chemicals that contribute to the destruction of stratospheric ozone.
- ***Enforcement Provisions.*** Enforcement provisions establish maximum fines and penalties for CAA violations.
- ***Operating Permit Program.*** The Operating Permit Program provides for states to issue federally enforceable operating permits to applicable stationary sources. The permits aid in clarifying operating and control requirements for stationary sources.

  The Idaho Air Quality Program is primarily administered through a permitting process that sets conditions under which facilities that generate air pollutants may operate. Potential sources of air pollutants are evaluated against regulatory criteria to determine if the source is exempt from permitting. If the source is not exempted, the type of permit required depends on the type of emission, emitting source or both. Two primary types of air permits have been issued to the INL Site (Table 2-1).
- ***Permit to Construct.*** An air quality permit to construct is required of new or modified stationary sources, such as buildings, structures or equipment that may emit pollutants into the air. State of Idaho air regulations and guidelines are used to apply for all permits to construct.
- ***Title V Operating Permit.*** A Title V operating permit, also known as a Tier I operating permit, is required for major sources. Major sources emit, or have the potential to emit per year, 10 tons or more of one hazardous air pollutant, 25 tons or more of any combination of hazardous air pollutants, or 100 tons or more of any regulated air pollutant. EPA promulgated regulations in July 1992 that established the Tier I requirements for state programs. Through

Table 2-1. Environmental Permits for the INL Site (2015).

Permit Type	Active Permits
Air Emissions:	
Permit to Construct	14
Title V Operating Permit	1
Groundwater:	
Injection Well	10
Well construction	1
Surface Water:	
Wastewater Reuse Permits	4
Industrial Wastewater Acceptance	1
Resource Conservation and Recovery Act:	
Part A	2
Part B	7[a]
Ecological:	
Migratory Bird Treaty Act Special Purpose Permit	1

a. The Part B permit is a single permit comprised of several volumes.

the state implementation plan, Idaho has approved one Tier I operating permit for the INL Site.

2.1.2 DOE Order 458.1, Radiation Protection of the Public and the Environment

DOE Order 458.1, "Radiation Protection of the Public and the Environment," 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 objectives of this order are:

- To conduct DOE radiological activities so that exposure to members of the public is maintained within the dose limits established in this order
- To control the radiological clearance of DOE real and personal property
- To ensure that potential radiation exposures to members of the public are as low as reasonably achievable
- To ensure that DOE sites have the capabilities, consistent with the types of radiological activities conducted, to monitor routine and non-routine radiological releases and to assess the radiation dose to members of the public
- To provide protection of the environment from the effects of radiation and radioactive material.

The Order sets the public dose limit at a total effective dose not to exceed 100 mrem/yr (1 mSv/yr) above background radiation levels. Chapter 8 presents dose calculations for INL Site releases for 2015.

DOE Standard DOE-STD-1196-2011, Derived Concentration Technical Standard supports implementation of DOE Order 458.1. The standard defines the quantities used in the design and conduct of radiological environmental protection programs at DOE facilities and sites. These quantities, Derived Concentration Standards (DCSs), 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 via each of the following pathways: ingestion of water, submersion in air, and inhalation. Measurements of radionuclides in environmental media sampled on and around the INL Site were all below appropriate DCSs.

In addition to discharges to the environment, the release of property containing residual radioactive material is a potential contributor to the dose received by the public. DOE Order 458.1 specifies limits for unrestricted release of property to the public. All INL Site contractors use a graded approach for release of material and equipment for unrestricted public use. Material has been categorized so that in some cases an administrative release can be accomplished without a radiological survey. Such material originates from non-radiological areas and includes the following:

- Personal items or materials
- Documents, mail, diskettes, compact disks, and other office media
- Paper, cardboard, plastic products, aluminum beverage cans, toner cartridges, and other items released for recycling
- Office trash
- Non-radiological area housekeeping materials and associated waste
- Break-room, cafeteria, and medical wastes
- Medical and bioassay samples
- Other items with an approved release plan.

Items originating from non-radiological areas within the Site's controlled areas not in the listed categories are surveyed prior to release to the public, or a process knowledge evaluation is conducted to verify that material has not been exposed to radioactive material or beams of radiation capable of creating radioactive material. In some cases, both a radiological survey and a process knowledge evaluation are performed (e.g., a radiological survey is conducted on the outside of the item, and a process knowledge form is signed by the custodian for inaccessible surfaces).

When the process knowledge approach is employed, the item's custodian is required to sign a statement that specifies the history of the material and confirms that no radioactive material has passed through or contacted the item. Items advertised for public sale via an auction are also surveyed by the contractor prior to shipment to the INL property/excess warehouse where the materials are again resurveyed on a random basis by INL personnel prior to release, giving further assurance that material and equipment are not being released with inadvertent contamination.

All contractors complete material surveys prior to release and transport to the state-permitted landfill at the Central Facilities Area. The only exception is for items that could be internally contaminated; these items are submitted to Waste Generator Services for disposal using one of the offsite treatment, storage, and disposal facilities that can accept low-level contamination. All INL Site contractors continue to follow the requirements of the scrap metal suspension. No scrap metal directly released from radiological areas is recycled.

2.2 Environmental Protection and Remediation

2.2.1 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. DOE-ID, the state of Idaho, and EPA Region 10 signed the Federal Facility Agreement and Consent Order in December 1991 (DOE 1991). The Idaho Cleanup Project contractor, in accordance with the Federal Facility Agreement and Consent Order, is conducting environmental restoration activities at the INL Site. Specific environmental restoration activities are discussed in Chapter 3.

2.2.2 DOE Order 436.1, Departmental Sustainability

The purpose of DOE Order 436.1, "Departmental Sustainability," is to provide requirements and responsibilities for managing sustainability within DOE to:

- Ensure the department carries out its missions in a sustainable manner that addresses national energy security and global environmental challenges and advances sustainable, efficient and reliable energy for the future
- Institute wholesale cultural change to factor sustainability and greenhouse gas reductions into all DOE corporate management decisions
- Ensure DOE achieves the sustainability goals established in its Strategic Sustainability Performance Plan pursuant to applicable

laws, regulations and executive orders, related performance scorecards, and sustainability initiatives.

2.2.3 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 2-2.

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 2015.

Sections 311 and 312 – Sections 311 and 312 require facilities manufacturing, processing, or storing designated hazardous chemicals to make material 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 material safety data sheets to state and local officials and local fire departments. The INL Site satisfies the requirements of Section 311 by submitting quarterly reports 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 2015.

2.2.4 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 Order 451.1B, "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 21, 2015. The summary is a requirement of DOE Order 451.1B, and is prepared to inform the public and other DOE elements of:

- The status of ongoing NEPA compliance activities
- Environmental assessments (EAs) expected to be prepared in the next 12 months

Table 2-2. INL Site EPCRA Reporting Status (2015).

EPCRA Section	Description of Reporting	2015 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

- Environmental Impact Statements (EISs) expected to be prepared in the next 24 months
- The planned cost and schedule for completion of each NEPA review identified.

The NEPA Planning Summary identified no planned or ongoing NEPA reviews, and during 2015, DOE-ID did not initiate or prepare any EAs or EISs.

2.2.5 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 for 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 Service (USFWS) and Idaho Department of Fish and Game.

There are two species categorized under the ESA which occur or may occur on the INL Site. Table 2-3 presents a list of those species and the likelihood of their 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 USFWS withdrew a proposal to list the North American wolverine (*Gulo gulo 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 USFWS 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.

In March 2010, the USFWS classified the Greater sage-grouse (*Centrocercus urophasianus*) as a candidate for listing under the ESA. This means that although the species warrants protection under the ESA, it is currently precluded from being listed due to higher agency priorities. In a recent (2011) U.S. district court lawsuit settlement, the USFWS agreed to make a final listing decision on all candidate species by 2016. As part of the agency work plan developed in response to the settlement, USFWS conducted a status review and, in September 2015, announced that the Greater Sage-grouse does not warrant protection under the ESA. USFWS 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 (*Centrocercus uraphasianus*) on the INL Site that DOE and USFWS 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. WNS has been labeled by some as the greatest wildlife crisis of the past century, and 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 lucifugus*) and the big brown bat (*Eptesicus fuscus*). In 2010, the little brown myotis was petitioned for emergency listing under the ESA, and the USFWS 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 a Bat Protection Plan for the INL Site. The Bat Protection Plan would allow the INL Site to proactively position itself to continue its

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.

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.

2.2.6 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 did not have to use the permit to relocate or destroy any active migratory bird nests in 2015. DOE-ID is required to submit an annual report to USFWS by January 31 of each year detailing reportable activities related to migratory birds.

2.2.7 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).

2.2.8 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 Clean Water Act.

The only area of the INL Site currently identified as potentially jurisdictional wetlands is the Big Lost River Sinks. The USFWS National Wetlands Inventory map is used to identify potential jurisdictional wetlands and non-regulated sites with ecological, environmental, and future development significance. In 2015, no actions took place or impacted potential jurisdictional wetlands on the INL Site.

2.2.9 Sustainability Requirements

On March 25, 2015, President Obama issued Executive Order 13693, "Planning for Federal Sustainability in the Next Decade." The executive order superseded Executive Order 13514, "Federal Leadership in Environmental, Energy, and Economic Performance," and Executive

Order 13423, "Strengthening Federal Environmental, Energy, and Transportation Management."

The objective of Executive Order 13693 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. Select goals are compared in Table 2-4.

As specified in Table 2-4, Executive Order 13693 required federal agencies to establish greenhouse gas reduction goals. In a letter to the Council of Environmental Quality and Office of Management and Budget dated June 23, 2015, DOE committed to agency-wide reductions of 50 percent for scope one and two and 25 percent for scope three. These reductions are relative to a Fiscal Year 2008 baseline.

On May 22, 2011, DOE issued DOE Order 436.1 "Departmental Sustainability." As discussed in Section 2.2.2, the order defines requirements and responsibilities for managing sustainability at DOE to ensure that the department carries out its missions in a sustainable manner that addresses national energy security and global environmental challenges; advances sustainable, efficient and reliable energy for the future; institutes wholesale cultural change to factor sustainability and greenhouse gas reductions into all DOE corporate management decisions; and ensures that DOE achieves the sustainability goals established in its Strategic Sustainability Performance Plan. DOE-ID submitted the *FY 2016 INL Site Sustainability Plan with the FY 2015 Annual Report* to DOE Headquarters in December 2015 (DOE-ID 2015). This year, the plan reports performance to the Executive Order 13514 goals and contains strategies and activities to facilitate progress for the INL Site to meet the goals and requirements of Executive Order 13693 in 2016.

A more detailed discussion of the sustainability and pollution prevention programs is provided in Chapter 3.

2.3 Waste Management

2.3.1 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 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 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 270.14 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 2015 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. On December 31, 2015, DEQ submitted correspondence to the DOE-ID acknowledging the completion of closure activities for Materials and Fuels Complex Secondary Sodium System Ancillary Piping and Equipment.

RCRA Inspection. For fiscal year 2015, DEQ conducted an annual RCRA inspection of the INL Site from December 1 through December 5, 2014. On March 17, 2015, DEQ issued a Warning Letter to DOE and the responsible INL Site contractors. The Warning Letter stated that three apparent violations—two at the Advanced Mixed Waste Treatment Project and one at the Idaho Nuclear Technology and Engineering Center (INTEC)—were documented in association with the INL Site annual inspection. One of the apparent violations at the Advanced Mixed Waste Treatment Project had been self-reported to DEQ; however, self-disclosure does not constitute a defense or shield from any enforcement action.

RCRA Consent Order. A fifth modification to the Notice of Noncompliance-Consent Order was fully executed March 3, 2015, to resolve the Notice of Violation issued January 6, 2015, for failure to cease use of the INTEC tanks storing sodium bearing mixed waste. A compliance schedule was submitted and approved by the DEQ establishing milestones for the initiation of waste treatment in the IWTU, treating the sodium bearing waste, and the permanent cease use of the INTEC tanks. A civil penalty of $648,000 was assessed to the Depart-

Table 2-4. Executive Order Established Goals.

Goal Category	EO 13693 Goals and Requirements	Goals and Requirements in Earlier Authorities
GHG emissions – Scopes 1 and 2	Agencies propose new Fiscal Year (FY) 2025 goal within 90 days of EO (by 23 June 2015), with same baseline [§2]. The federal-wide goal is a 40 percent reduction by FY 2025 (§1).	FY 2020 goal set by agencies relative to FY 2008 baseline (EO 13514)
GHG emissions – Scope 3	Agencies propose new FY 2025 goal within 90 days of EO (by 23 June 2015), to include leased space (§2).	FY 2020 goal set by agencies relative to FY 2008 baseline (EO 13514)
Energy – intensity (Btu/GSF)	Annually reduce 2.5 percent from FY 2015, from FY 2016 through FY 2025 ([§3(a)(i)].	Reduce by 30 percent (3 percent annually) by FY 2015 (from FY 2003 baseline) (EISA 2007 and EO 13423)
Energy – renewable electricity targets	10 percent in FY 2016–17 15 percent in FY 2018–19 20 percent in FY 2020–21 25 percent in FY 2022–23 30 percent by FY 2025 [§3(c)]	10 percent of annual electricity use in FY 2015, rising to 20 percent in FY 2020, per December 2013 Presidential Memo. EPACT was 7.5 percent by FY 2015.
Fleet – fuel use	Reduce GHG emissions per mile from the fleet, relative to the FY 2014 baseline: 4 percent by FY 2017 15 percent by FY 2021 30 percent by FY 2025 [§3(g)(ii)]	Reduce overall vehicle fuel petroleum use by 30 percent from FY 2005 to FY 2020 (2 percent annually) (EO 13514, EISA, EO 13423) Increase overall non-petroleum fuel use by 10 percent annually between FY 2005 and FY 2015 (EISA, EO 13423)

ment, which was partially fulfilled by the implementation of four Supplemental Environmental Projects.

2.3.2 Federal Facility Compliance Act

The Federal Facility Compliance Act requires the preparation of site treatment plans for the treatment of mixed wastes stored or generated at DOE facilities. Mixed waste contains both hazardous and radioactive components. The INL Site Proposed Site Treatment Plan was submitted to the state of Idaho and EPA on March 31, 1995. This plan outlined DOE-ID's proposed treatment strategy for INL Site mixed-waste streams, called the backlog, and provided a preliminary analysis of potential offsite mixed low-level waste treatment capabilities. The Federal Facility Compliance Act Consent Order and Site Treatment Plan was finalized and signed by the state of Idaho on November 1, 1995 (DEQ 1995). A status of Site Treatment Plan milestones for 2015 is provided in Chapter 3.

2.3.3 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 CAA, the Clean Water Act (CWA) and the Occupational Safety and Health Act. Because the INL Site does not produce chemicals, compliance with 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 in a TSCA-approved disposal facility.

2.3.4 DOE Order 435.1, Radioactive Waste Management

DOE Order 435.1, "Radioactive Waste Management," was issued to ensure that all DOE radioactive waste is managed in a manner that protects the environment as well as worker and public safety and health. INL Site activities related to this order are discussed in Chapters 3 and 6.

2.3.5 1995 Settlement Agreement

On October 16, 1995, DOE, the U.S. Navy, and the state of Idaho entered into an agreement that guides management of spent nuclear fuel and radioactive waste at the INL Site. The Agreement (DOE 1995) limits shipments of DOE and Naval spent nuclear fuel into the state and sets milestones for shipments of spent nuclear fuel and radioactive waste out of the state. DOE must have Idaho spent nuclear fuel in dry storage by 2023 and all spent nuclear fuel out of Idaho by the end of 2035.

The Settlement Agreement also requires DOE to ship all waste stored as transuranic waste on the INL Site in 1995, when the agreement was signed, out of Idaho by December 31, 2018. The estimated volume of that waste was 65,000 cubic meters (m^3). There is an additional requirement to ship an annual three-year running average of 2,000 m^3 (2,616 cubic yards, [yd^3]) of that waste out of the state each year. In February 2014, the shipment of transuranic waste was curtailed due to the suspension of Waste Isolation Pilot Plant (WIPP) operations in Carlsbad, New Mexico. The INL Site continued to process and certify stored waste subject to the Settlement Agreement for shipment offsite. The annual three-year running average of Settlement Agreement waste stored as transuranic waste shipped out of Idaho over the past three years was 1,184 m^3 (1,549 yd^3). Due to the curtailment of shipments to WIPP, Idaho was unable to ship any Settlement Agreement transuranic waste out of Idaho in calendar 2015. Although none was shipped, 1,076 m^3 was certified for disposal at WIPP and placed in to compliant storage.

In 2015, 624 m^3 (816 yd^3) of buried transuranic waste was certified for disposal at WIPP and placed into compliant storage.

2.4 Water Quality and Protection

2.4.1 Clean Water Act

The Clean Water Act (CWA), passed in 1972, established goals to control pollutants discharged to U.S. surface waters. Among the main elements of the CWA are effluent limitations for specific industry categories set by EPA and water quality standards set by states. 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 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 requirements, monitoring requirements and effluent concentration limits for specific parameters. All discharges in 2015 were within compliance levels established in the INL Research Center Wastewater Acceptance Permit.

2.4.2 Safe Drinking Water Act

The Safe Drinking Water Act establishes rules governing the quality and safety of drinking water. The Idaho DEQ promulgates the Safe Drinking Water Act 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.

2.4.3 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 to provide moisture and nutrients to vegetation, and recharge to groundwater.

To protect public 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 DEQ issues the reuse permits in accordance with IDAPA 58.01.17 Recycled Water Rules, IDAPA 58.01.16 Wastewater Rules, and IDAPA 58.01.11 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:

- Central Facilities Area Sewage Treatment Plant
- Advanced Test Reactor Complex Cold Waste Ponds
- Idaho Nuclear Technology and Engineering Center New Percolation Ponds
- Materials and Fuels Complex Industrial Waste Ditch and Industrial Waste Pond.

Chapter 5 contains details on Wastewater Reuse monitoring.

2.4.4 Corrective Action/Monitoring Plan for Petroleum Release Associated with Well ICPP-2018

The *Corrective Action/Monitoring Plan for Well ICPP-2018 Petroleum Release at the Idaho Nuclear Technology and Engineering Center* was written to address a release of petroleum hydrocarbons detected in 2007 in perched water monitoring Well ICPP-2018 at Idaho Nuclear Technology and Engineering Center (ICP 2014). The removal of petroleum product and the sampling and analysis of groundwater for benzene, toluene, ethylbenzene and xylenes compounds and polynuclear aromatic hydrocarbons are required per IDAPA 58.01.02 Water Quality Standards, Subsection 852, "Petroleum Release Response and Corrective Action." The Plan identifies activities for removing petroleum product from perched water Well ICPP-2018, as well as any other monitoring well where product is found, and outlines the proposed perched water and groundwater monitoring schedule.

Over the past several years, absorbent SoakEase® socks have been effective in removing petroleum product from the well; however, due to declining thickness of weathered free product, the Soak Ease® absorbent device was removed from Well ICPP-2018 on August 5, 2013. The well remained dry during the autumn and winter months, but water had reappeared in the well prior to April 2014. At the same time, weathered free product thickness increased slightly to 0.22 ft. in April 2014, the maximum observed during the reporting period. No weathered free product was recovered from Well ICPP-2018 during 2014. From June 2014 through July 2015, 0.11 L of petroleum product was removed from Well ICPP-2018. The declining trend of weathered free product thickness in Well ICPP-2018 is indicative of continuing hydrocarbon biodegradation. To assure adequate protection of human health and the environment and to meet the objectives of the corrective action plan, the following activities will continue:

- Continue using the SoakEase® absorbent sock for removal of petroleum product
- Monitor Well ICPP-2018 quarterly for water level and presence of petroleum hydrocarbons
- Annually sample Well ICPP-2018 for analysis of petroleum hydrocarbons.

2.4.5 Underground Storage Tanks (USTs)

Petroleum underground storage tanks (USTs) are regulated under 40 CFR 280. Effective October 13, 2015, the EPA made revisions to the 1988 UST regulation and to the 1988 state program approval regulation (40 CFR 281). The changes established federal requirements that are similar to key portions of the Energy Policy Act of 2005 and updated the 1988 UST and state program approval regulations. Changes to the regulations included: adding secondary containment requirements for new and replaced tanks and piping; adding operator training requirements; adding periodic operation and maintenance requirements for UST systems; addressing UST systems deferred in 1988 UST regulation; adding new release prevention and detection technologies; updating codes of practice; making editorial corrections and technical amendments; and updating state program approval requirements to incorporate the new changes. Although some changes were effective immediately, implementation for most of the changes is October 13, 2018.

The Idaho DEQ is authorized by EPA, under 40 CFR 281, to regulate USTs within Idaho. To establish a state underground storage tank program, the state of Idaho passed the Idaho Underground Storage Tank Act in 2007. The Idaho DEQ is evaluating the federal regulation changes and potential changes to the state program. During 2015, DEQ did not perform any UST inspections at the INL Site.

INL has initiated a risk ranking for evaluating the UST systems and monitoring equipment. Considerations in the risk ranking include the ages of the systems, potential impacts from the new regulations, previous deficiencies, cost, and programmatic needs. INL will use this risk ranking to help guide decision making.

One 15,000-gallon E-85 UST, Tank ID Number 98IRC00006, was closed at the Research and Education Campus due to lack of use and availability of a local source of E-85. The tank is not suspected of leaking. Removal of the tank is planned for 2016.

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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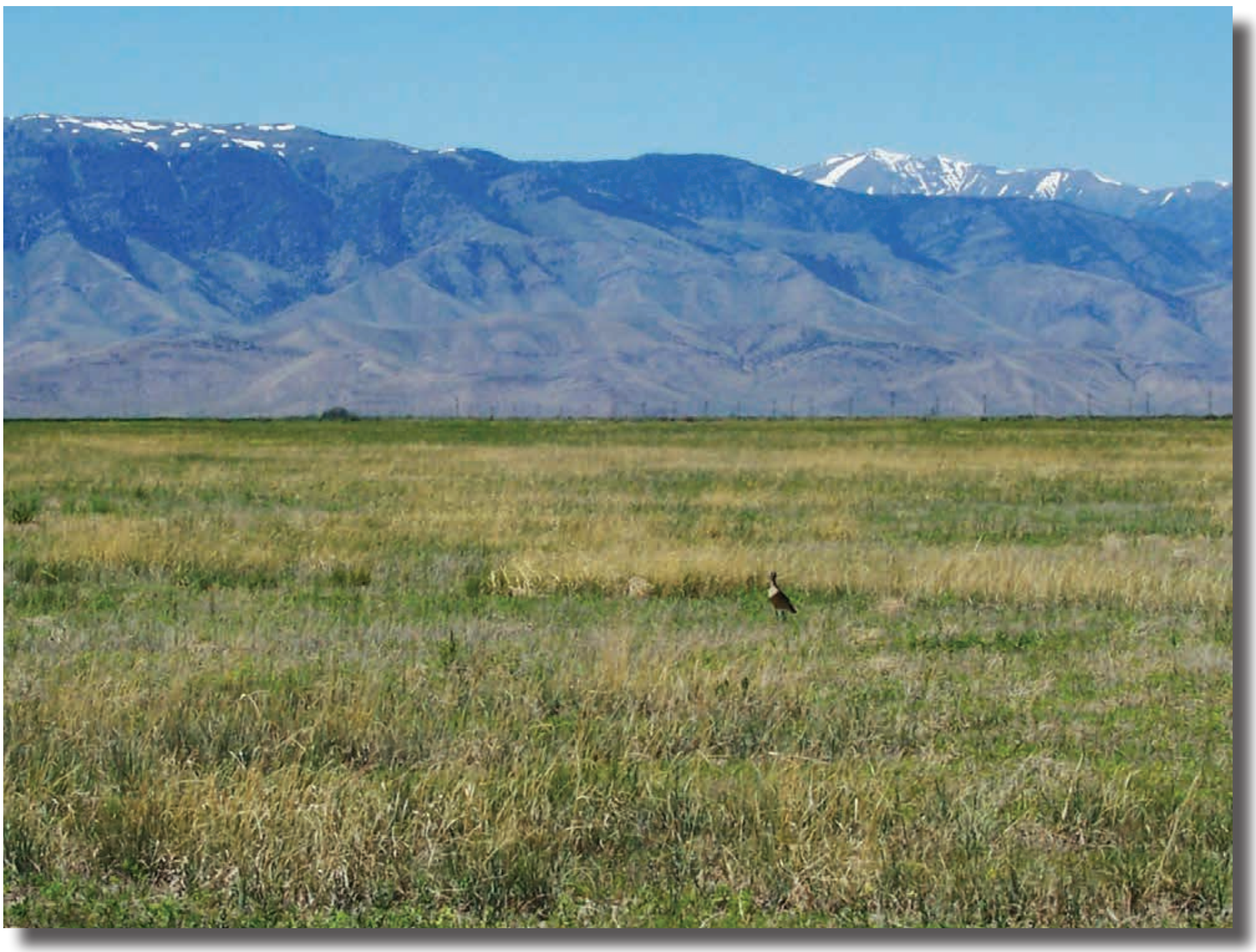

Lost River Sinks

2015

3. Environmental Program Information


Birch Creek

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, natural, archaeological, and cultural resources potentially affected by operations and activities conducted at the Idaho National Laboratory (INL) Site. This policy is implemented by integrating environmental requirements, pollution prevention, and sustainable practices into work planning and execution, as well as taking actions to minimize impact of INL operations and activities. Environmental monitoring and surveillance is conducted to determine and report the impact of INL Site operations on the environment.

DOE requires major INL site contractors to implement an environmental management system (EMS) conforming to 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 sustainability strategies and practices that will meet key DOE sustainability goals. An annual Site Sustainability Plan was prepared in 2015 to present the INL Site's performance status and planned actions for meeting goals.

The INL Site strives to prevent or reduce pollution and waste generation wherever feasible. Goals and policies are documented in the INL Site Pollution Prevention Plan.

Environmental restoration at the INL Site continues. Active remediation of six of ten waste areas groups established under the Federal Facility Agreement and Consent Order has been completed to date.

Management and disposal of radioactive wastes produced at the INL Site is conducted to ensure safe operations and meet commitments of the Idaho Settlement Agreement and the 2015 Idaho National Laboratory Site Treatment Plan. During 2015 four mixed waste Site Treatment Plan milestones were met and one milestone extension associated with the sodium-bearing waste treatment facility was requested and approved.

Other major environmental programs and activities at the INL Site include decontamination and decommissioning activities, management of spent nuclear fuel, the INL Oversight Program maintained by the state of Idaho, the Citizen's Advisory Board, sitewide monitoring committees, and environmental education outreach to the public.

3. ENVIRONMENTAL PROGRAMS INFORMATION

It is the policy of the U.S. Department of Energy (DOE) that all Idaho National Laboratory (INL) Site work be conducted in a manner that preserves and protects human health and the environment and is in full compliance with applicable environmental laws, regulations, and other requirements. This policy is implemented by integrating environmental requirements, pollution prevention, and sustainable practices into work planning and execution, as well as taking actions to minimize impact of INL operations and activities. Environmental monitoring and surveillance is conducted to determine and report the impact of INL Site operations on the environment.

Current environmental programs and focus areas highlighted in this chapter include:

- Environmental Management System (EMS)
- Site Sustainability Program
- Pollution Prevention Program
- Environmental Restoration
- Waste Management and Disposition
- Decontamination and Decommissioning
- Spent Nuclear Fuel
- Environmental Oversight and Monitoring Agreement
- Citizens Advisory Board

- Sitewide Monitoring Committees
- Environmental Education Outreach Program.

Additional environmental programs are focused on the collection of environmental data to determine and report the impact of existing INL Site activities on the environment. These programs and related topics are presented in separate chapters as follows:

- Environmental Monitoring Program for Air (Chapter 4)
- Compliance Monitoring for Liquid Effluents, Groundwater, Drinking Water, and Surface Water (Chapter 5)
- Environmental Monitoring Program for the Eastern Snake River Plain Aquifer including drinking water (Chapter 6)
- Environmental Monitoring Program for Agriculture Products, Wildlife, Soil, and Direct Radiation (Chapter 7)
- Dose to the Public and Biota (Chapter 8)
- Monitoring Wildlife Populations (Chapter 9)
- Environmental Research at the INL Site (Chapter 10)
- Quality Assurance of Environmental Monitoring Programs (Chapter 11).

3.1 Environmental Management System (EMS)

An 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 DOE has chosen to employ 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 (DOE 2011), "Departmental Sustainability," which require federal facilities to put into practice environmental management systems. Sites must maintain their EMS as being certified to 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 replaces the ISO 14001:2004 standard. New EMSs and recertification of existing EMSs—required every three years—will need to meet the new standard.

The three main INL Site contractors have established EMSs for their respective operations. The Idaho Cleanup Project (ICP) and INL contractors maintain ISO 14001 systems certified and registered by accredited registrars. Auditors from the registrars conduct periodic surveillances and full audits of the systems to determine improvement or degradation and eligibility for recertification. June 16–17, 2015, CH2M –WG Idaho, LLC successfully completed an ISO 14001:2004 surveillance audit to maintain registration of their EMS. No nonconformities were identified; five system strengths and two opportunities for improvement were identified. June 17–19, 2015, Battelle Energy Alliance (BEA) successfully completed an ISO 14001:2004 surveillance audit to maintain registration of their EMS. Two minor nonconformities were identified; five system strengths and three opportunities for improvement were noted. July 16, 2015, BEA provided the auditor a corrective action plan to address the two minor nonconformities.

The Advanced Mixed Waste Treatment Project (AMWTP) contractor's EMS is self-declared conformant to the ISO standard, based upon conformance audits by independent, external, qualified auditors. DOE strongly supports the management system concept and reviews contractor processes to ensure they meet DOE's requirements.

3.2 Sustainability Program

Each DOE site is required to prepare an annual Site Sustainability Plan (DOE-ID 2015) that articulates the site's performance status and planned actions for meeting DOE's Strategic Sustainability Performance Plan (DOE 2015) goals and broader sustainability program. The Site Sustainability program implemented sustainable practices in facility design, operation, procurement, and program operations to meet the sustainability goals of EO 13514, "Federal Leadership in Environmental, Energy, and Economic Performance," and DOE Order 436.1, "Departmental Sustainability." Fiscal Year (FY) 2015 performance to select goals is specified in Table 3-1. In March 2015, EO 13514 was superseded by EO

13693, "Planning for Federal Sustainability in the Next Decade."

3.3 Pollution Prevention

The INL Pollution Prevention Program incorporates national and DOE requirements to reduce, reuse, and recycle wastes and pollutants by implementing cost-effective techniques, practices, and programs. Such actions are required by various federal statutes, including, but not limited to the Pollution Prevention Act and Resource Conservation and Recovery Act (RCRA).

The INL Site Pollution Prevention Plan (DOE-ID 2014) describes the pollution prevention practices pursued at the INL Site. This plan reflects the goals and policies for pollution prevention and sustainability at the INL Site and represents an ongoing effort to make pollution prevention and sustainability part of the INL Site's operating philosophy. The INL Site is required to conduct and complete a source reduction evaluation review and written plan, which can include a pollution prevention opportunity assessment (PPOA). The 2015 activities will be reported in the next update scheduled for 2018.

3.4 Environmental Restoration

Environmental restoration at the INL Site is conducted under the Federal Facility Agreement and Consent Order (FFA/CO) (DOE 1991). The FFA/CO outlines how the INL Site will comply with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). It identifies a process for U.S. Department of Energy-Idaho Operations Office (DOE-ID) to work with its regulatory agencies to safely execute cleanup of past release sites at the INL Site.

The INL Site is divided into 10 waste area groups (WAG) (Figure 3-1) 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 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. The remedial investigation/feasibility study is used to determine the nature and extent of the problem presented by the past release of contamination and to develop and evaluate options for remedial action. Results from the remedial investigation/feasibility study form the basis for risk assessments and alternative cleanup actions. This information, along with the regulatory agencies' proposed cleanup plan, is presented to the public in a document called a proposed plan. Proposed plans present cleanup alternatives and recommend a preferred cleanup alternative to the public. After consideration of public comments, DOE, the Environmental Protection Agency, and the state of Idaho develop a record of decision (ROD) that selects a cleanup approach from the alternatives evaluated. Cleanup activities then can 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 remedial investigation/feasibility studies have been completed for WAGs 1–5, 7–9, and 6/10 (6 is combined with 10). Active remediation is complete 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. The status of ongoing active remediation activities at WAGs 1, 3, 7 and 10 are described in Table 3-2.

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

3.5 Waste Management and Disposition

Waste management and disposition covers a variety of operations and functions, including: (1) storage of waste pending disposition; (2) characterization of waste to allow it to be placed in storage or to be transported, treated, or disposed of; (3) transportation of waste to locations on or off the INL Site for treatment or disposal or both; (4) treatment of waste prior to disposal; and (5) disposal. Safe operations and compliance with applicable federal, state, and local regulations are the highest priorities, along with meeting the commitments made in the Idaho Settlement Agreement (DOE 1995) and the *2015 Idaho National Laboratory Site Treatment Plan* (ICP 2015).

3.5.1 Federal Facility Compliance Act

The Federal Facility Compliance Act requires preparation of a site treatment plan for the treatment of mixed

Table 3-1. Sustainability Goals and Performance (FY 2015).

DOE Goals	FY 2015 Performance	Planned Actions and Contributions
50 percent Scope 1 and 2[a] Green House Gas (GHG) reduction by Fiscal Year (FY) 2025 from a FY 2008 baseline (2015 target: 21 percent)	The INL Site combined Scope 1 and 2 GHG emissions are down 33.5 percent from the FY 2008 baseline.	GHG emission reductions will primarily be obtained through efforts to reduce building and transportation energy. Expected completion of ICP missions and transitioning facilities to cold, dark, and dry status will contribute to further GHG reductions.
25 percent Scope 3[b] GHG reduction by FY 2025 from a FY 2008 baseline (2015 target: 6 percent)	The INL Site combined Scope 3 GHG emissions are down 29.4 percent from the FY 2008 baseline.	The INL Site will reduce Scope 3 GHG emissions primarily through employee commute and travel reduction tactics.
25 percent energy intensity (Btu per gross square foot) reduction in goal-subject buildings, achieving 2.5 percent reductions annually by FY 2025 from a FY 2015 baseline.	The INL Site has reduced energy intensity 19.6 percent from the FY 2003 baseline intensity. (The FY 2003 baseline was designated by EO 13415. EO 13693 designates FY 2015 as the new baseline for the FY 2025 goal.)	The INL Site has numerous energy reduction projects identified and ready for final development and implementation. Implementation of these capital project upgrades is highly dependent upon available funding. Both ICP and AMWTP mission completion will contribute to further reductions toward the goal.
EISA Section 432 energy and water evaluations	The INL Site completed energy and water evaluations in 39 of 151 covered facilities in FY 2015. A total of 94 audits have been completed to date, accounting for 62 percent of the INL Site covered inventory.	INL's strategy to implement the Energy Independence and Security Act (EISA) Section 432 evaluations includes subcontracting in FY 2016 to perform energy and water audits on approximately 25 percent of all covered facilities. Results from these audits are expected to provide additional cost effective project opportunities for FY 2017.
At least 15 percent (by building count or gross square feet) of existing buildings greater than 5,000 gross square feet are compliant with the *revised* Guiding Principles for High Performance and Sustainable Buildings by FY 2025, with progress to 100 percent thereafter	Six additional buildings became compliant with the Guiding Principles, bringing the total to 18 buildings or 12 percent of existing covered INL Site facilities. 15 percent of the INL Site's 151 covered facilities calculates to 23 facilities that need to meet the Guiding Principles. INL identified 26 facilities with the highest probability of meeting the Guiding Principles. These facilities were entered into Portfolio Manager and are included in plans for energy and water efficiency upgrades. Of the 23 facilities, at the end of FY 2015, one is LEED Platinum, four are LEED Gold, one is LEED Certified, and 12 are Guiding Principle Compliant, for a total of 18 buildings or 12 percent of the INL Sites covered buildings meeting the Guiding Principles.	The balance of five buildings needing to meet the Guiding Principles will be documented in FY 2016. Efforts will include implementation of energy and water reduction projects and performing energy-use modelling to determine performance as compared to the American Society of Heating, Refrigerating, and Air-Conditioning Engineers building design baseline. AMWTP and ICP projects focus on completing the cleanup mission, so most facilities have limited operational terms and only minimal planned investments. Upgrades to meet the Guiding Principles will be considered for maintenance projects or if major modifications are required to meet mission requirements.

Table 3-1. Sustainability Goals and Performance (FY 2015). (cont.)

DOE Goals	FY 2015 Performance	Planned Actions and Contributions
36 percent potable water intensity (gallons per gross square foot) reduction by FY 2025 from a FY 2007 baseline (2015 target: 16 percent)	The INL Site has reduced water use intensity by 19.9 percent and total water pumped by 23.3 percent as compared to the FY 2007 baseline.	The INL Site will continue to develop and install projects that conserve water when cost effective and feasible. EM mission progress, including completion of the AMWTP treatment, will contribute to further reductions in both water use and the building footprint by near-term completion of mission objectives leading to building consolidations and other improvements, such as converting steam-heated buildings to electric heat.
20 percent reduction in annual petroleum consumption by FY 2015 relative to a FY 2005 baseline; maintain 20 percent reduction thereafter (2015 target: 20 percent)	In FY 2015, the INL Site used 672,761 gasoline gallon equivalents of petroleum, a 28.3 percent reduction from FY 2005.	Even though this goal does not continue past FY 2015, the INL Site will continue to obtain increasingly fuel-efficient light-duty vehicles; continue to use B20, E-85, and natural gas fuels; and to document the performance and efficiency of recent bus conversions to natural gas/biodiesel dual fuel systems. Continuation of this practice contributes towards the new GHG emissions/mile goal. EM mission completion will contribute to further reductions, helping to exceed the goal.
10 percent increase in annual alternative fuel consumption by FY 2015 relative to a FY 2005 baseline; maintain 10 percent increase thereafter (2015 target: 10 percent)	The INL Site has exceeded the FY 2015 goal by increasing alternative fuel 166.8 percent relative to FY 2005. In FY 2015, the INL Site used 203,940 gasoline gallon equivalents of alternative fuels.	Even though this goal does not continue past FY 2015, the INL Site will continue to obtain alternative fuel vehicles in support of this goal. INL will optimize the fleet through bus and heavy truck replacements that are more efficient and operate on biodiesel and liquefied natural gas. Continuation of this practice contributes towards the new GHG emissions/mile goal.
Promote sustainable acquisition and procurement to the maximum extent practicable, ensuring Bio Preferred and biobased provisions and clauses are included in 95 percent of applicable contracts	The INL Site achieved 98 percent inclusion of sustainable acquisition clauses in construction and janitorial contracts.	INL will continue to incorporate improvements to the Sustainable Acquisition Program, including procedures, policies, and enhanced work processes that increase the visibility, availability, and use of sustainable products. The forthcoming EM closure contract includes environmental sustainability clauses requiring the contractor to assist the DOE through direct participation and other support in achieving DOE's sustainability goals.
Divert at least 50 percent of non-hazardous solid waste, excluding construction and demolition debris	In FY 2015, INL Site facilities recycled 1,567,266 lbs (710.9 metric tons [MT]) of materials, including co-mingled materials, office paper, cardboard, scrap metal, wood, cooking oil, and wood pallets. This accounts for a 38.9 percent diversion of municipal solid wastes collected at INL Site facilities.	The INL Site will continue to evaluate potential outlets and the expansion of recyclable waste streams and to further increase the amount of wastes diverted from the landfill.

Table 3-1. Sustainability Goals and Performance (FY 2015). (cont.)

DOE Goals	FY 2015 Performance	Planned Actions and Contributions
Divert at least 50 percent of construction and demolition materials and debris	The INL Site diverted 33.8 percent (2,027 MT) of its construction and demolition waste in FY 2015.	The INL Site will work to incorporate additional materials into current construction and demolition waste diversion processes.
Update policies to incentivize planning for and addressing the impacts of climate change	INL partnered/subcontracted with the University of Idaho to complete a climate change vulnerability assessment. The assessment included impact and associated risks to affected program operations.	Develop and implement collaborations with regional universities and governmental agencies to understand how climate change impacts regional fire risk, ecosystem function, and water resources, and how it will impact the delivery of energy and water services to both INL facilities and the regional community at large. As DOE Orders are revised to incorporate climate change adaptation, the INL Site will implement the requirements into project planning and authorization basis documents as appropriate.

a. Scope 1 and 2 greenhouse gases are attributable to DOE operations. Scope 1 are emitted from sources that are owned or controlled by DOE and Scope 2 are emitted by others as a result of DOE purchased energy.

b. Scope 3 GHG emissions are from sources related to DOE activities, but not directly tied to operations, such as, employee commuting, business travel, and municipal waste disposal.

wastes at the INL Site. Mixed wastes contain both radioactive and RCRA-regulated hazardous components. A backlog of mixed waste is being managed in RCRA-permitted storage units at the INL Site. During 2015, the INL Site treated or processed 3,042.98 m^3 (3,980.07 yd^3) of legacy mixed waste. Of that total, 1,266.45 m^3 (1,656.45 yd^3) was mixed low-level waste shipped off-site for treatment/disposal and 1,776.53 m^3 (2,323.61 yd^3) was mixed transuranic waste that was certified for disposal at the Waste Isolation Pilot Plant or was volume reduced due to processing.

In accordance with the INL Site Treatment Plan (ICP 2015), the INL Site began receiving mixed waste from offsite locations for treatment in January 1996. Mixed waste has been received from other sites within the DOE complex, including Hanford, Los Alamos, Paducah, Pantex, Sandia, Savannah River, Argonne, and six locations managed by the Office of Naval Reactors. No offsite mixed waste was treated or shipped offsite within the 2015.

During 2015, four INL Site Treatment Plan milestones were met and one milestone extension, associated with the sodium-bearing waste treatment facility, was requested. An extension was requested for the (P-5) milestone to commence operations due to delays associated with the startup of the sodium-bearing waste treatment facility (Integrated Waste Treatment Unit). DOE made the request to the DEQ in a letter, dated June 18, 2015, and it was subsequently approved August 5, 2015. The following milestones were completed:

- Sodium-Bearing Waste Schedule for System Backlog – (P-6)
- Commercial Backlog Treatment/Disposal – 130 m^3 (170.03 yd^3)
- Sodium Components Maintenance Shop Backlog Treatment – 4 m^3 (5.23 yd^3)
- Original Volume Transuranic-Contaminated Waste Backlog Treatment/Processing – 4,500 m^3 (5,885.78 yd^3).

3.5.2 Advanced Mixed Waste Treatment Project (AMWTP)

Operations at AMWTP require 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. The waste contains industrial debris, such as rags, work clothing, machine parts, and tools, as well as soil and sludge. The waste is contaminated with transuranic radioactive elements (primarily plutonium).

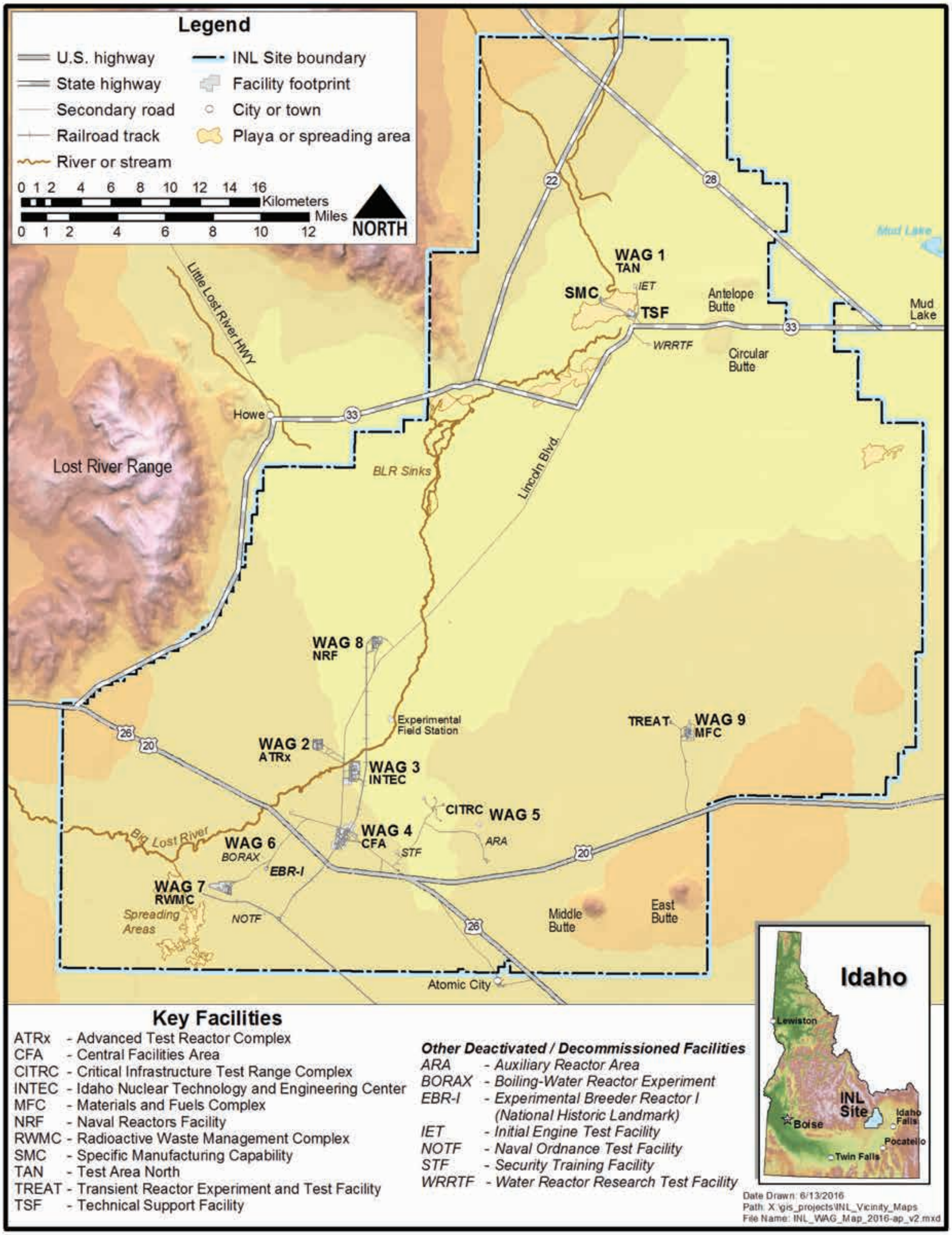

Figure 3-1. Map of the Idaho National Laboratory Site Showing Facilities and Corresponding Waste Area Groups (WAG).

Table 3-2. 2015 Status of Active Waste Area Groups Cleanup.

Waste Area Group	Facility	Status
1	Test Area North	Groundwater cleanup of trichloroethene (TCE) for Operable Unit 1-07B continued through 2015. 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 test plan will be revised in 2016 to establish how the groundwater cleanup at Test Area North will continue. During 2015, two wells were constructed and further in situ bioremediation has begun in a specific area where previous efforts had not achieved the desired reduction in contaminant levels. All institutional controls (IC) and operations and maintenance (O&M) requirements were maintained in 2015.
3	Idaho Nuclear Technology and Engineering Center	The 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 ICDF Complex Operational and Monitoring Sampling and Analysis Plan, and results are sent to the Environmental Protection Agency and the state of Idaho Department of Environmental Quality. Remedial actions required by the WAG 3, Operable Unit 3-14 ROD, implemented in 2013, included the reduction of approximately 9 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 institutional controls and operations and maintenance requirements were maintained in 2015.
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 3-2). 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 above-grade 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. A variety 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 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

Table 3-2. 2015 Status of Active Waste Area Groups Cleanup. (cont.)

Waste Area Group	Facility	Status
		1990s, and disposal of contact-handled waste was discontinued at the end of FY 2008. Currently, only remote-handled, low-level waste is being disposed in the SDA. The Operable Unit 7-13/14 ROD (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 2015, 7,069 m^3 (9,246 yd^3) of targeted waste has been retrieved and packaged from a combined area of 1.63 hectares (4.02 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 (UU/UE)—and explosive hazards associated with historic military operations on the INL Site. All institutional controls and operations and maintenance requirements were maintained in 2015 under the Site-wide IC/O&M Plan. A CERCLA five-year review was also completed during 2015 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 2015 to verify that there is no unacceptable threat to human health or the environment from commingled plumes or along the southern INL Site boundary.

After the waste containers have been retrieved from waste storage, they are examined in the AMWTP Characterization Facility. During characterization, each container is examined to determine its contents. Characterized waste containers that need further treatment before they can be shipped offsite for disposal are sent to one of several treatment processes, including: the AMWTP Treatment Facility, the Drum Treatment Tents in WMF-628 and WMF-635, the Sludge Repackaging Project in Accelerated Retrieval Project (ARP)-V, and the Debris Repackaging Project in ARP-VII. The AMWTP Treatment Facility treats the waste by size-reducing, sorting, and repackaging the waste, and supercompacting the waste for volume reduction. Waste sent to the Treatment Facility is transported to different areas within the facility by an intricate system of conveyers, and most of the waste handling operations are performed remotely. The Treatment Facility houses a supercompactor for major size reduction of the waste, and a shredder for processing empty waste containers. Any restricted items, such as liquids or compressed gas cylinders, are removed or remediated as the waste is repackaged. The Sludge Repackaging Project primarily treats drums that contain sludge waste with excess liquids by adding liquid absorbent. The Drum Treatment Tents are primarily used to repackage old drums into new drums or to overpack drums in to waste boxes. The Debris Repackaging Project primarily handles boxed waste that contains oversized or overweight components that are too large to be handled in the Treatment Facility.

There are two loading areas at the AMWTP. In both loading facilities, the waste containers go through two major steps: payload assembly and shipment loading. Payload assembly includes grouping the waste into four different configurations consisting of 55-gal drums, 100-gal puck drums (i.e., drums of compacted waste), waste over-packed into boxes, and waste over-packed into ten drum overpacks. Then, the waste is loaded into the TRUPACT II containers awaiting shipment to WIPP or onto trailers for shipment to Nevada National Security Site or commercial facilities as mixed low-level waste (MLLW). A TRUPACT II container is a special double-containment vessel that is approved for transuranic waste transport. MLLW shipments follow all applicable Department of Transportation requirements. After the transuranic payloads are placed in the TRUPACT II containers, the containers are visually and mechanically inspected before they are certified for travel. Once a TRUPACT II container is certified for travel, the waste is sent 2,092 km (1,300 mi) to its final destination at the WIPP.

Due to the temporary closure of WIPP as the result of an upset condition caused by waste received from the Los Alamos National Laboratory during 2014, the AMWTP did not ship stored transuranic waste to the WIPP. Despite the WIPP closure, AMWTP continued to certify waste for disposal at WIPP once operations resume. During 2015, the AMWTP certified 1,703 m^3 (2,227 yd^3) of stored transuranic waste to the WIPP for a cumulative total of 44,605 m^3 (58,341 yd^3) of transuranic waste shipped off the INL Site or certified for shipment. The AMWTP shipped offsite 906 m^3 (1,185 yd^3) of mixed low-level waste that historically had been managed as stored transuranic waste, for a cumulative total of 10,522 m^3 (13,762 yd^3) of MLLW shipped offsite. A combined cumulative total of 55,126 m^3 (72,102 yd^3) of stored waste has been shipped offsite or certified for shipment once WIPP reopens. Due to suspension of WIPP operations, AMWTP was not able to ship a large quantity of waste that would otherwise have been sent to WIPP. This has resulted in a large backlog of waste that is certified for WIPP disposal, but will be compliantly stored at AMWTP until WIPP resumes operations. The current backlog of certified waste stored at AMWTP is 2,559 m^3 (3,347 yd^3).

3.5.3 High-Level Waste and Facilities Disposition

In 1953, reprocessing of spent nuclear fuel (SNF) began at the Idaho Nuclear Technology and Engineering Center (INTEC), resulting in the generation of liquid high-level waste and sodium-bearing waste. Those wastes were placed into interim storage in underground tanks at the INTEC Tank Farm. Treatment of those wastes began in 1963 through a process called calcining. The resultant waste form, calcine, was placed in storage in stainless steel bins at the Calcine Solids Storage Facility. DOE announced the decision to stop processing SNF in 1992. Calcining of all nonsodium-bearing, liquid, high-level waste was completed on February 20, 1998, four months ahead of the June 30, 1998, Idaho Settlement Agreement milestone. Calcining of remaining sodium-bearing waste began immediately following completion of nonsodium-bearing, liquid, high-level waste treatment, more than three years ahead of the Idaho Settlement Agreement milestone. All such waste was required to be treated by the end of 2012.

In October 2002, DOE issued the *Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement* (DOE 2002), which included alternatives other than calcination for treatment of the sodium-bearing waste. DOE-ID issued a ROD for this Final Environmental Impact Statement on December 13, 2005 (DOE 2005). This ROD specified steam reforming to treat the remaining sodium-bearing waste at the INTEC Tank Farm. This technology will treat the remaining approximately 3.4 million L (900,000 gal) of liquid, sodium-bearing waste that has been consolidated into three 1.14-million-L (300,000-gal) below-grade tanks at the INTEC Tank Farm for interim storage.

A new facility, the Integrated Waste Treatment Unit (IWTU) was constructed and approved for operation in 2012. The IWTU is a facility for treatment of the remaining liquid sodium-bearing waste utilizing the steam reforming process. Processing of the sodium-bearing waste by IWTU has not been initiated due to problems that occurred in June 2012, during initial start-up testing and follow-on equipment commissioning. The facility has completed facility hardware and operational modifications to address issues identified during the initial start-up. The facility continued its startup activities during 2015. Also in 2015, DOE-ID and the DEQ negotiated a revised completion date for treatment of the sodium-bearing waste. The revised consent order milestone is December 2018.

Seven other 1.14-million-L (300,000-gal) INTEC Tank Farm tanks have been emptied, cleaned, and removed from service in preparation for final closure. With regard to tank closures, DOE issued a final Section 3116 Waste Determination and amended ROD in November 2006 (71 Federal Register 68811-13). Filling the seven cleaned tanks and their surrounding vaults began in November 2006 and was completed in March 2008.

The Final Environmental Impact Statement also included analysis of alternatives for treating the calcined waste. On December 23, 2009, DOE issued an amended ROD (75 FR 137.40, 75 FR 1615-16) for the treatment of calcine using an industrially mature manufacturing process known as hot isostatic pressing (HIP).

A RCRA Part B permit was submitted to the DEQ on November 27, 2012, for the HIP process. The permit is based upon the utilization of the existing IWTU facility to the extent practicable by retrofitting the IWTU to accommodate the HIP process. Current efforts are focused on Calcine Bin Set conceptual design activities and response to any comments from the state regarding the RCRA Part B Permit application.

3.5.4 Low-Level and Mixed Radioactive Waste

In 2015, approximately 1,682 m^3 (2,199 yd^3) of mixed low-level waste and 968 m^3 (1,266 yd^3) of low-level waste was shipped off the INL Site for treatment, disposal, or both. Approximately 47.88 m^3 (62.62 yd^3) of newly generated, low-level waste was disposed of at the Subsurface Disposal Area in 2015 (Figure 3-2).

3.5.5 Remote-Handled Low-Level Waste (RH-LLW) Disposal Facility Project

The new INL RH-LLW Disposal Facility is under construction and will provide uninterrupted RH-LLW disposal capability in support of the DOE Office of Nuclear Energy nuclear research mission and the U.S. Navy's naval nuclear propulsion program. The need for the project is based on the upcoming closure of the Subsurface Disposal Area at the Radioactive Waste Management Complex under the CERCLA (42 USC 9601 et seq. 1980). In accordance with the National Environmental Policy Act (42 USC §4321 et seq.), an Environmental Assessment was performed where reasonable alternatives were analyzed for their environmental consequences. After evaluating the results, the Department of Energy, Idaho Operations office manager issued a Finding of No Significant Impact on December 21, 2011, and identified the alternative to construct and operate a new disposal facility onsite for disposal of RH-LLW generated at INL as the preferred alternative. The Finding of No Significant Impact also identified an area south of the ATR Complex as the preferred location for the facility. The initial construction footprint of the facility will provide disposal capability for approximately 20 years of RH-LLW generated at INL with the capability to expand to provide an additional 30 years of disposal services. The project is currently in the construction phase and is forecasted to commence disposal operations on or before March 2019.

3.6 Decontamination and Decommissioning Activities

Through September 2014, the ICP decontamination and decommissioning project had safely decontaminated and decommissioned 221 buildings and structures for a total footprint reduction of over 2.2 million ft^2 (204,000 m^2) at the INL Site. The project demolished three nuclear reactors, two hot cell facilities, the largest hot shop in the world, a spent fuel reprocessing complex, large laboratory buildings, and numerous warehouses and storage buildings. This effort significantly reduced life-cycle cost and risk by eliminating aging facilities that were no longer needed for the INL Site mission.

In 2015, the ICP funded additional decontamination and decommissioning work at the Materials and Fuels Complex (MFC). Sodium-contaminated piping in MFC-766 (Sodium Boiler Building) was treated and removed. The MFC-799 Sodium Process Facility, MFC-770C Nuclear Calibration Laboratory, and MFC-TR-55 were deactivated and demolished. MFC-767 Experimental Breeder Reactor-II (EBR-II) building deactivation activities continued in 2015, and are expected to be completed in 2016. The final preparations for demolition of MFC-766 Sodium Boiler Building have been completed. The demolition of that building is expected early in FY 2016. Additional decontamination and decommissioning work will be done as funding allows and as facility missions are completed.

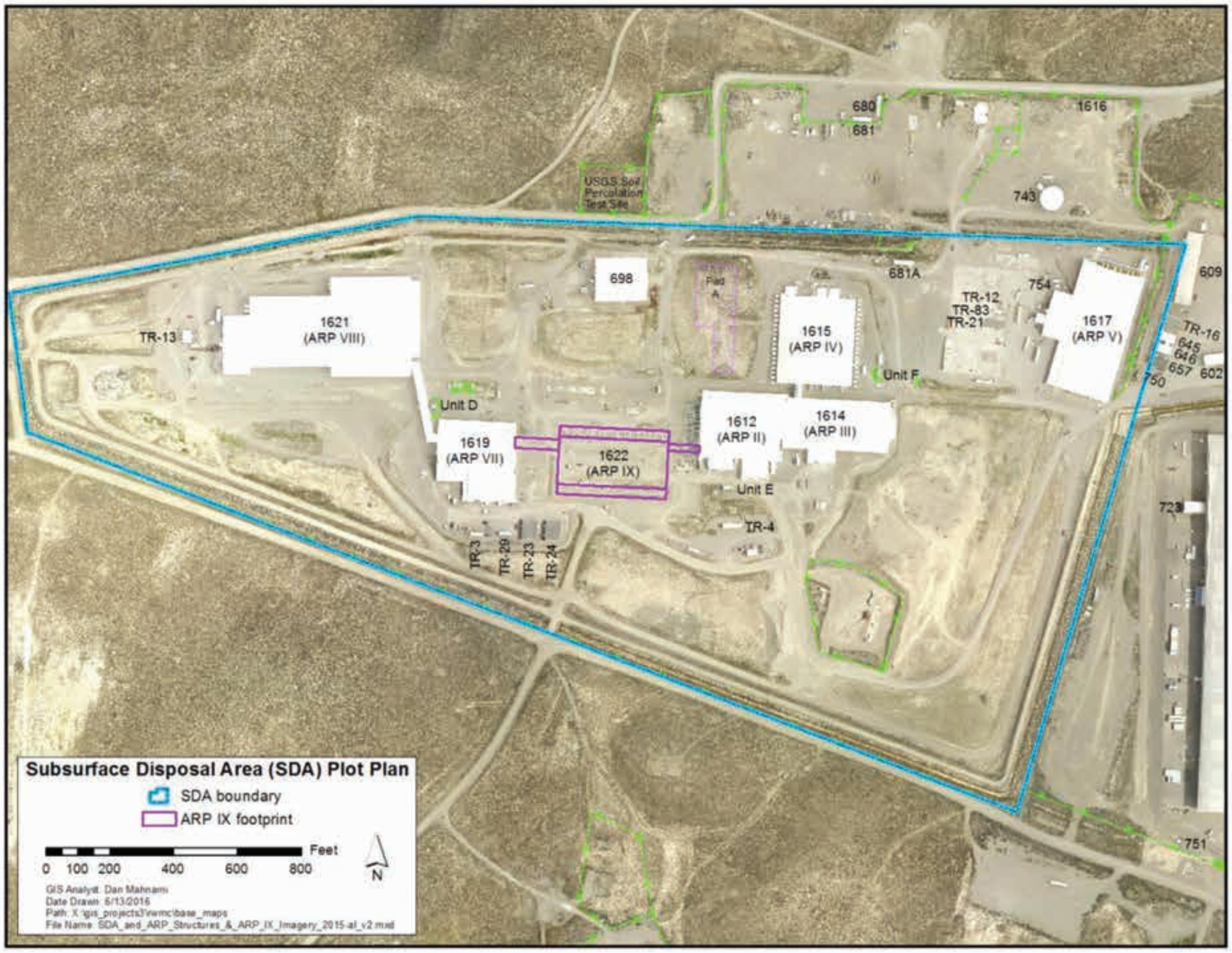

Figure 3-2. Radioactive Waste Management Complex Subsurface Disposal Area (2015).

3.7 Spent Nuclear Fuel (SNF)

SNF is nuclear fuel that has been withdrawn from a nuclear power 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 the ICP contractor at INTEC, the Naval Nuclear Propulsion Program at the Naval Reactors Facility (NRF), and the INL contractor at the Advanced Test Reactor (ATR) Complex and MFC.

Between 1953 and 1991, SNF was reprocessed at the INTEC to recover fissile material for reuse. In 1992, President G.H.W. Bush halted weapons processing in a policy statement on nuclear nonproliferation. As a result, the secretary of the DOE issued an order to terminate all programs for the recovery of uranium from SNF. That decision left a large quantity of SNF in storage.

The Nuclear Waste Policy Act of 1984 made DOE responsible for finding a site and then building and operating an underground disposal facility called a geologic repository. By law, the repository was to accept 70,000 MT of combined SNF and high-level waste (HLW) and would be operational by January 31, 1998. In 2002, President G.W. Bush accepted DOE's recommendation to select the Yucca Mountain Project and proposed to devise "a new strategy toward nuclear waste disposal."

In 2010, President B. H. Obama established the Blue Ribbon Commission on America's Nuclear Future and charged it with reviewing SNF management policies. The Commission issued a report to the Secretary of Energy in January 2012, detailing recommendations for creating a safe, long-term solution for managing and disposing of the nation's SNF and HLW. DOE published a response to the Blue Ribbon Commission report titled *Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste* in January 2013 (DOE 2013). The DOE document contains a framework for moving toward a program to deploy an integrated system capable of transporting, storing, and disposing of SNF and HLW from civilian nuclear power generation, defense, national security, and other activities.

With the publication of a ROD in May of 1995, DOE established its complex-wide strategy for the management of SNF. The relevant provision of the preferred alternative, with the associated environmental impact statement, mandated that the Savannah River Site SNF program would receive aluminum-clad SNF, and the INL SNF program would receive all other fuel types for consolidation prior to ultimate dispositioning. The ROD selected the preferred alternative.

Upon completion of the 1995 DOE SNF EIS mandated by the preceding Court Order of 1993, the DOE and U.S. Navy entered into a Settlement Agreement with the state of Idaho that put into place, among other things, several requirements with completion dates (milestones) for the management of SNF at the INL with resulting impacts throughout the DOE complex. Relevant remaining milestones within the Idaho Settlement Agreement require that:

- DOE shall complete the transfer of spent fuel from wet storage facilities at INEL 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. Descriptions of SNF storage facilities follow.

Fluorinel Dissolution Process and Fuel Storage Facility (CPP-666) – This INTEC facility, also called FAST, is divided into two parts: 1) an SNF storage basin area and 2) the Fluorinel Dissolution Facility, which operated from 1983 to 1992 and is currently being used in remote-handled transuranic waste management. The storage area consists of six storage basins currently storing SNF under about 3.5 million gallons of water, which provides protective shielding and cooling. All ICP-managed SNF has been removed from the basins and stored in the INTEC dry storage facilities described below. SNF from other program elements (the ATR, EBR-II, and Naval Nuclear Propulsion Program) is stored in the basins. DOE-ID is currently engaged in the transfer of two of the three fuels to dry storage. EBR-II SNF is being transferred to MFC for processing within a technology demonstration project, and Navy SNF is being transferred to the NRF for dry storage. A campaign for transfer of ATR SNF to dry storage is under development.

TMI-2 Independent Spent Fuel Storage Installation (CPP-1774) – The TMI-2 License Renewal Application (early) Processes commenced in 2015 and will continue into 2016. This renewal application will request a 20-year license extension for fuel debris storage at the TMI-2 ISFSI. This INTEC facility is a U.S. Nuclear Regulatory Commission (NRC)-licensed dry storage facility for the fuel debris retrieved from the Three Mile Island reactor accident. NRC-licensed SNF dry storage facilities are known as Independent Spent Fuel Storage Installations (ISFSI). The fuel debris was transferred to Test Area North on the INL Site for examination, study, and storage following the accident. After the examination, the fuel debris was transferred from Test Area North to the ISFSI located at INTEC. The ISFSI provides safe, environmentally secure, above ground storage for the fuel debris. The facility consists of fuel debris sealed in welded stainless steel canisters, placed in carbon steel casks shielded within concrete vaults. The initial TMI-2 NRC License was granted for a period of 20 years from March 1999 through March 2019.

Fort Saint Vrain Independent Spent Fuel Storage Installation – DOE-ID manages this NRC-licensed dry storage facility located near Platteville in northern Colorado. It contains about two-thirds of the SNF generated over the operational life of the Fort Saint Vrain reactor. The rest of the SNF from the Fort Saint Vrain reactor is stored in the Irradiated Fuel Storage Facility, described previously. The NRC granted a 20-year license extension for material possession in this storage facility (2011-2031).

Radioactive Scrap and Waste Facility (MFC-771) – The Radioactive Scrap and Waste Facility is located at MFC and has operated since 1964 for the dry storage of SNF and solid radioactive wastes resulting from nuclear energy research and development. It is a fenced outdoor compound with over 1,000 steel pipe storage vaults set into the ground. The storage vaults are typically 0.6 m

(24 in.) in diameter and just over 3.7 m (12 ft.) long. The pipe storage vaults have concrete or steel shield plugs inserted into their tops to protect workers from radiation fields and to prevent water intrusion. The storage vaults also are cathodically protected from corrosion. Currently, 19.6 metric tons (43,120 lb.) of SNF, mostly from the deactivated EBR-II, are stored in the steel pipe storage vaults.

The Radioactive Scrap and Waste Facility also stores mixed waste (primarily steel reactor components waste contaminated with sodium metal) and is managed under a RCRA hazardous waste storage permit.

3.8 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 state of Idaho was signed September 2015. 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.

3.9 Citizens Advisory Board

The INL Site Environmental Management 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. 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 nonstockpile 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 www.inlcab.energy.gov.

3.10 Sitewide 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 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 Sitewide water programs: drinking water, wastewater, storm water, and groundwater. The Committee includes monitoring personnel, operators, scientists, engineers, management, data entry, validation representatives of the DOE-ID, INL Site contractors, U.S. Geological Survey, and NRF, and 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.

3.11 Environmental Education Outreach

The Environmental Surveillance, Education, and Research (ESER) program provides the DOE Idaho Operations Office with technical support on National Environmental Policy Act environmental analyses, such as wildlife surveys; ecological compliance, including threatened and endangered species assessment; and off-site 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 radio-ecological 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 2015, ESER created and presented educational programs to over 13,000 students in their classrooms. Presentations cover physical science, biological science, and ecological science subjects, are adapted for grade level, and are aligned with Idaho State Science Standards.

ESER maintains a website (www.idahoeser.com) to be used as a means of communicating ESER program information, status, and activities to stakeholders and the public. The website has a user-friendly (i.e., non-technical) searchable database that contains the results of ESER Program activities. Reports published under this contract are also posted on the website.

The ESER Education Program worked together with DOE, the INL contractor, the ICP 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 five two-day workshops for ISU credit: 1) Wild Animals and Wild Places (mountain habitat); 2) Caves and Volcanoes (desert habitat); 3) Wonderful Wetlands; 4) Floating, Fishing and Fun (river and stream habitats); and 5) Energy Sources.

An additional teachers' workshop through ISU was initiated in 2015 after receiving a grant from the Idaho Department of Education. This workshop, called Bring Idaho Alive in Your Classroom, consisted of five seminars presented by local scientists during the spring semester: Idaho Geology, Idaho Weather, Idaho Plants, Idaho Animals, and Idaho History. 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 2015, the ESER Education Program participated in the Idaho Region 6 iSTEM Conference at ISU. As well as working on the organizing committee, Gonzales-Stoller Surveillance, LLC (GSS) organized and presented one of the six tracks available for teachers at the conference. The track, entitled "Using iSTEM to teach Ecology," included 19 hours of coursework presented by the GSS ESER Program, Friends of the Teton River, Idaho Department of Environmental Quality, 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 3-3). 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 2015 was sponsored by the ESER Program, GSS, the Post Register, INL, Idaho Department of Fish and Game, Idaho Department of Environmental Quality, 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.

Figure 3-3. Rocky Mountain Adventure Camp (2015).

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 Scientist" 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, INL, Brigham Young University-Idaho, Bureau of Land Management, Idaho Fish and Game, and National Weather Service were presenters during 2015.

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Great Basin Rattlesnake

2015

4. Environmental Monitoring Programs: Air


INL Site Sunrise

An estimated total of 1,870 Ci (6.92×10^{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 2015. The highest contributors to the total release were the Advanced Test Reactor Complex at 49.0 percent, Idaho Nuclear Technology and Engineering Center at 46.8 percent, and the Radioactive Waste Management Complex at 4.07 percent of total.

The INL Site environmental surveillance programs emphasize measurements of airborne contaminants in the environment because air is the most important transport pathway from the INL Site to receptors living outside the INL Site boundary. Because of this, samples of airborne particulates, atmospheric moisture, and precipitation were collected on the INL Site, at INL Site boundary locations, and at distant communities and were analyzed for radioactivity in 2015.

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

Strontium-90 was reported on several quarterly composited air filters collected on and off the INL Site near detection or background levels and below the DCS for ^{90}Sr. The levels are consistent with historical measurements associated with global fallout. Americium-241 was reported in three composited samples collected on the INL Site during the second quarter and were most likely false positives (i.e., probably not detected). Plutonium-239/240 was detected just above the detection limit, within historical measurements, and below the DCS for $^{239/240}$Pu. No other human-made radionuclides were detected in air filters.

Airborne particulates were also 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 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 2015. Detections of americium and plutonium isotopes were comparable to past measurements and are likely due to resuspended soils contaminated from past burial practices at the Subsurface Disposal Area. The results were below the DCSs established for those radionuclides.

Atmospheric moisture and precipitation samples were obtained at the INL Site and off the INL Site and analyzed for tritium. Tritium detected in some samples was most likely present due to natural production in the atmosphere and not INL Site releases. All measured results were below health-based regulatory limits.

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). Review of historical environmental data and modeling of environmental transport of radionuclides show that air is the most important radionuclide transport pathway to members of the general public (DOE-ID 2014a). The INL Site air monitoring programs emphasize measurement of airborne radioactive contaminants because air has the potential to transport measureable amounts of radioactive materials to receptors in a relatively short period and can directly expose human receptors located off the INL Site.

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) contractor, and the Environmental Surveillance, Educa-

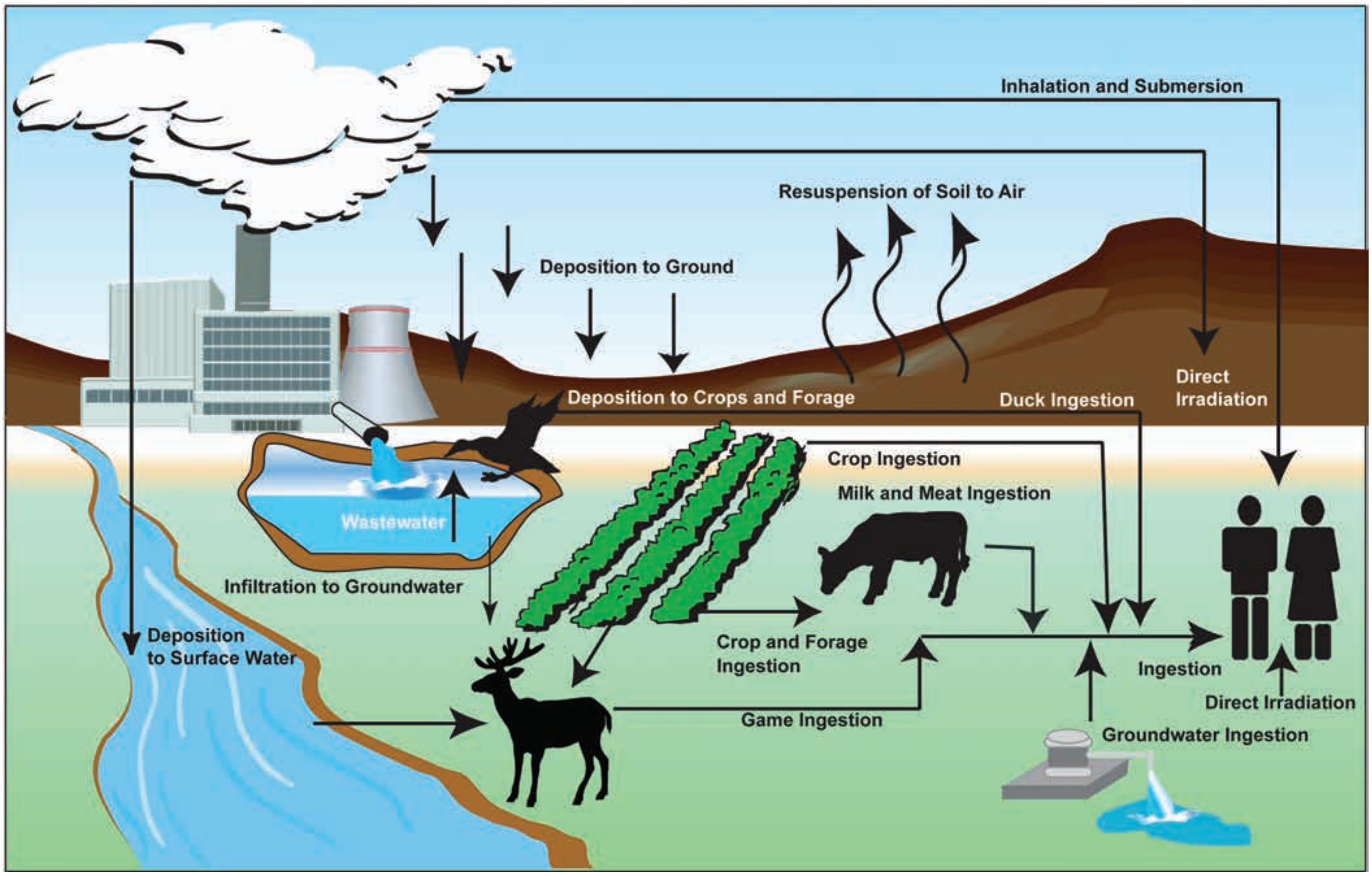

Figure 4-1. Potential Exposure Pathways to Humans from the Idaho National Laboratory Site.

tion, 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 Environmental Monitoring Plan* (DOE-ID 2014b).

4.1 Organization of Air Monitoring Programs

The INL contractor documents airborne effluents at INL facilities in an annual report prepared in accordance with the 40 CFR 61, Subpart H, National Emission Standards for Hazardous Air Pollutants (NESHAPs). Section 4.2 summarizes the emissions reported in *National Emission Standards for Hazardous Air Pollutants—Calendar Year 2015 INL Report for Radionuclides* (DOE-ID 2016). The report also documents the estimated 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. In 2015, the INL contractor collected about 2,400 air samples (primarily on the INL Site) for various radiological analyses and air moisture samples at four sites for tritium analysis. The ESER contractor collects air samples across a 23,390 km^2 (9,000 mi^2) region that extends from locations on and around the INL Site to locations near Jackson, Wyoming. In 2015, the ESER contractor collected approximately 2,000 air samples, primarily off the INL Site, for various radiological analyses. The ESER contractor also collects air moisture and precipitation samples at select locations for tritium analysis. Figure 4-2 shows the regional ambient air monitoring locations. Ambient air monitoring by the INL and ESER contractors is discussed in Section 4.3.

The ICP 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

Table 4-1. Air Monitoring Activities by Organization.

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

a. INTEC = Idaho Nuclear Technology and Engineering Center, RWMC = Radioactive Waste Management Complex, MFC = Materials and Fuels Complex, INL = INL Site facilities as shown in Table 4-2, Regional = locations outside of the INL Site as shown in Table 4-3.
b. Facilities that required monitoring during 2015 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 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, and ESER contractors quarterly.
d. The ICP 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, “Radiation Protection of the Public and the Environment.”

Waste Management Complex (RWMC) and the Idaho Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Disposal Facility (ICDF). These locations are shown in Figure 4-2. Section 4.4 discusses air sampling by the ICP contractor in support of waste management activities.

Unless specified otherwise, the radiological results reported in the following sections are considered statistically positive detections. See the Supplemental Report to this Annual Site Environmental Report entitled *Statistical Methods Used in the Idaho National Laboratory Annual Site Environmental Report* for more information.

Meteorological data have been collected at the INL Site since 1950 by the National Oceanic and Atmospheric Administration (NOAA). The data have historically been tabulated, summarized, and reported in several climatography reports for use by scientists at the INL Site to evaluate atmospheric transport and dispersion

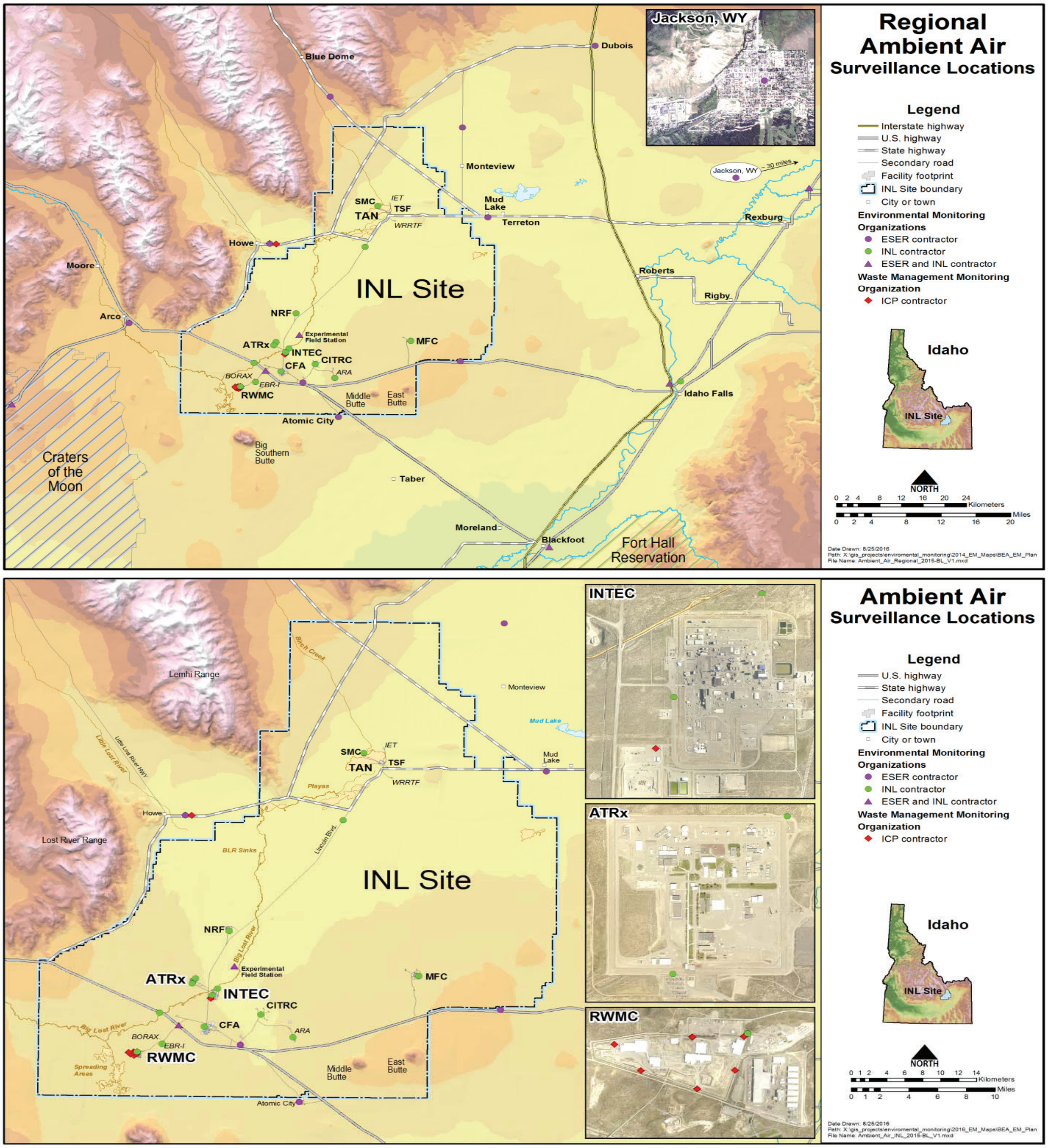

Figure 4-2. INL Site Environmental Surveillance Air Sampling Locations (Regional [top] and on the INL Site [bottom]).

from INL sources. The latest report, *Climatography of the Idaho National Laboratory 3rd Edition* (Clawson et al 2007), was prepared by the Field Research Division of the Air Resources Laboratory of NOAA and presents over 10 years (1994–2006) of quality-controlled data from the NOAA INL mesonet meteorological monitoring network (www.niwc.noaa.inel.gov/climate/INL_Climate_3rdEdition.pdf). More recent data are provided by the Field Research Division to scientists modeling the dispersion of INL Site releases and resulting dose impact (see Chapter 8 and *Meteorological Monitoring*, a supplement to this annual report).

4.2 Airborne Effluent Monitoring

Each regulated INL Site facility determines its airborne effluent concentrations as required under state and federal regulations. Radiological air emissions from INL Site facilities are also used to estimate the dose to the maximally exposed individual (MEI), who is a member of the public (see Chapter 8). Radiological effluents and the resulting dose for 2015 is reported in *National Emission Standards for Hazardous Air Pollutants—Calendar Year 2015* (DOE-ID 2016), referred to hereafter as the NESHAPs Report.

The NESHAP Report describes three categories of airborne emissions:

- Sources that require continuous monitoring under the NESHAP regulation: these are primarily stacks at the Advanced Test Reactor (ATR) Complex and Idaho Nuclear Technology and Engineering Center
- Releases from other point sources, such as stacks and exhaust vents
- Nonpoint—or diffuse—sources, which include radioactive waste ponds and contaminated soil areas, and decontamination and decommissioning of facilities.

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 to the cumulative total of 99.9 percent of the dose estimated for each facility area. During 2015, an estimated 1,870 Ci (6.92×10^{13} Bq) of radioactivity were released to the atmosphere from all INL Site sources. The 2015 release is within the range of releases from previous years and is consistent with the continued downward trend observed over the last ten 10 years. For example, 6,614 Ci was reported to be released in 2005.

Approximately 71 percent of the radioactive effluent consisted of the noble gases argon, krypton, and xenon. These noble gases are inert—they do not chemically react or combine with other elements. The remaining 29 percent of the radioactive effluent consisted of tritium and less than 0.1 percent other elements. The following facilities were contributors to the total emissions (Figure 4-3):

- ***Advanced Test Reactor (ATR) Complex Emissions Sources (49.0 percent of total)*** — 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 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 wet chemical analysis to determine trace radionuclides, higher level radionuclides, inorganic, and general purpose analytical chemistry. High-efficiency particulate air filtered hoods are located in the laboratory, including the radiological control room, which is used for analysis of contaminated samples.
- ***Idaho Nuclear Technology and Engineering Center (INTEC) Emissions Sources (46.8 percent of total)*** — Radiological air emissions from INTEC sources are primarily associated with liquid waste operations, including effluents from the Tank Farm Facility, Process Equipment Waste Evaporator, and Liquid Effluent Treatment and Disposal, which are exhausted through the Main Stack. These radioactive emissions include particulates and gaseous radionuclides. Additional radioactive emissions are associated with wet-to-dry spent nuclear fuel movements, interim storage of nuclear reactor fuel from Three-Mile Island, remote-handled transuranic waste management, radiological and hazardous waste storage facilities, and maintenance of contaminated equipment.

  The ICDF is located on the southwest corner of INTEC. Radiological emissions from this facility are estimated from waste disposal in the landfill, evaporation pond operations, and waste treatment operations.

  Most of the INTEC emissions contained krypton-85 (^{85}Kr). Krypton-85 is a radionuclide commonly

Table 4-2. Radionuclide Composition of INL Site Airborne Effluents (2015)[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	Total
Am-241	432.2 y	2.22E-05	—[f]	—	5.18E-06	7.01E-07	—	3.33E-03	—	3.36E-03
Am-243	7,380 y	—	—	—	—	2.20E-06	—	—	—	2.20E-06
Ar-41	1.827 h	5.61E+02	—	—	—	—	—	—	—	5.61E+02
C-14	5730 y	—	—	—	—	—	9.60E-01	2.83E-02	—	9.88E-01
Cm-244	18.11 y	—	2.04E-08	—	—	—	—	1.15E-05	—	1.15E-05
Co-60	5.271 y	1.30E-02	—	—	2.80E-05	—	—	—	—	1.30E-02
Cs-137	30.0 y	6.26E-03	—	—	1.75E-02	—	1.10E-04	—	—	2.39E-02
Cs-138	32.2 m	9.83E-02	—	—	—	—	—	—	—	9.83E-02
H-3	12.35 y	3.13E+02	6.70E-01	—	1.42E+02	2.13E-01	1.50E-02	7.60E+01	3.26E-02	5.32E+02
I-129	1.57E07 y	—	—	—	2.15E-02	—	3.80E-05	—	—	2.15E-02
I-131	8.04 d	2.72E-03	—	—	—	8.28E-03	—	—	—	1.10E-02
Kr-85	10.72 y	—	—	—	7.33E+02	—	—	—	—	7.33E+02
Kr-85m	4.48 h	1.93E+00	—	—	—	—	—	—	—	1.93E+00
Kr-87	1.27 h	5.32E+00	—	—	—	—	—	—	—	5.32E+00
Pu-238	87.74 y	—	—	—	1.12E-04	—	—	2.09E-05	—	1.33E-04
Pu-239	24,065 y	8.46E-06	—	—	2.11E-04	—	4.30E-06	4.49E-04	—	6.73E-04
Pu-240	6,537 y	—	—	—	1.11E-04	—	—	7.92E-05	—	1.90E-04
Pu-241	14.4 y	—	—	—	3.40E-03	—	—	7.93E-04	—	4.19E-03
Sb-125	2.77 y	—	—	—	—	7.33E-04	—	—	—	7.33E-04
Sr-90	29.12 y	1.70E-02	—	—	1.34E-02	—	6.40E-05	—	1.02E-06	3.05E-02
Tc-99m	6.02 h	—	—	3.00E-05	—	—	—	—	—	3.00E-05
U-232	68.9 y	—	—	—	—	—	—	1.97E-07		1.97E-07
U-233	1.585E05 y	—	—	—	—	7.50E-06	—	7.69E-06	—	1.52E-05
Xe-135	9.09 h	9.85E+00	—	—	—	—	—	—	—	9.85E+00
Xe-135m	15.29 m	4.03E+00	—	—	—	—	—	—	—	4.03E+00
Xe-138	14.17 m	2.02E+01	—	—	—	—	—	—	—	2.02E+01
Zn-65	243.9 d	3.26E-05	—	—	—	—	—	—	—	3.26E-05
Total Ci released		9.16E+02	6.70E-01	3.00E-05	8.75E+02	2.26E-01	1.06E+00	7.61E+01	3.26E-02	1.87E+03
Dose (mrem)[g]		8.29E-03	1.68E-05	4.20E-11	9.95E-03	6.04E-06	2.35E-04	1.48E-02	3.14E-07	3.33E-02

a. Radionuclide release information provided by the INL contractor.
b. One curie (Ci)= 3.7 x 10^{10} becquerels (Bq)
c. Includes only those radionuclides which collectively contribute ≥ 99.99 percent of the total dose estimated for each INL Site facility (see footnote g). Other radionuclides not shown in this table account for less than 0.01 percent of the dose estimated for each facility. All radionuclides used in the dose calculation may be found in DOE-ID (2016).
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.
f. A long dash signifies the radionuclide was not reported to be released to air from the facility in 2015.
g. The annual dose (mrem) for each facility was calculated at the location of the hypothetical maximally exposed individual using estimated radionuclide releases and methodology recommended by the Environmental Protection Agency. See Chapter 8 for details.

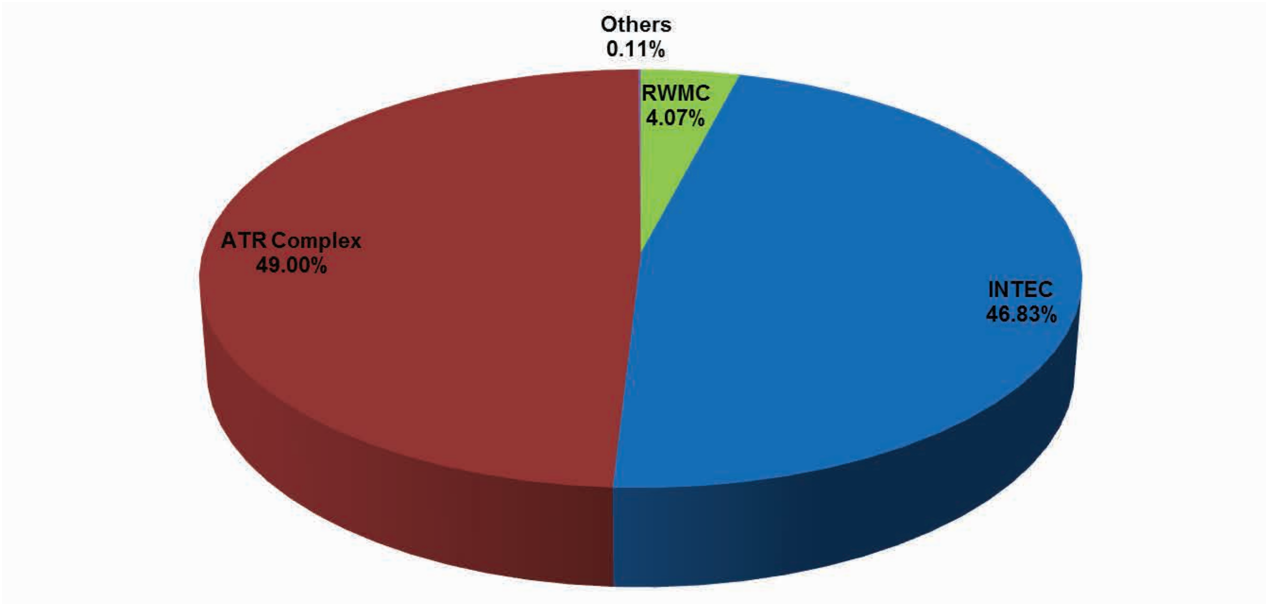

Figure 4-3. Percent Contributions, by Facility, to Total INL Site Airborne Releases (2015).

associated with the nuclear fuel cycle and has a 10-year half-life. The dose potentially received from ^{85}Kr is primarily external exposure from immersion in a contaminated plume.

- ***Radioactive Waste Management Complex (RWMC) Emissions Sources (4.07 percent of total)*** — Emissions from RWMC result from various activities associated with the facility's mission to manage the low-level radioactive site and treat and temporarily store contact-handled and remote-handled transuranic waste for shipment to other designated facilities for disposal. In addition, various activities are being conducted in the SDA at RWMC to complete environmental cleanup of the area under CERCLA. These include waste retrieval activities (Accelerated Retrieval Projects [ARPs]) and operation of several units that extract volatile organic compounds from the subsurface.

  Potential unabated emissions from the ARP and sludge repackaging in ARP-V exceeded the 0.1 mrem/yr (0.001 mSv/yr) standard. By agreement with U.S. Environmental Protection Agency (EPA), the ARP and sludge repackaging project uses ambient air monitoring to verify compliance with the standard during ARP and sludge repackaging operations. Real-time ambient air monitoring is still conducted using continuous air monitors for detection of off-normal emissions.

  RWMC processed (retrieved, sorted, and repackaged) radionuclide-contaminated soils and sludge within the ARP-V enclosure as part of the ARP CERCLA remediation. Exhumation of waste from the ARP-V area within WMF-1617 was completed in August 2011. As of November 2012, the ARP-V facility (i.e., WMF-1617) was excessed from CERCLA, and a Resource Conservation and Recovery Act (RCRA) permit was submitted and approved, which allowed processing of RCRA waste from the Advanced Mixed Waste Treatment Project (AMWTP) facility in WMF-1617. Processing of 6,000 drums of sludge from AMWTP under the RCRA permit was completed in June 2014. Approximately 2,600 drums of waste were processed in 2015.

  The AMWTP sludge processing activity was designed to ensure contact-handled stored transuranic waste is compliant with off-site disposal facility waste acceptance criteria by removing prohibited waste items (e.g., free liquids). The emissions from RWMC were estimated to be almost exclusively tritium.

- ***Central Facilities Area (CFA) Emissions Sources (0.04 percent of total)*** — 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.

- ***Materials and Fuels Complex (MFC) Emissions Sources (0.0121 percent of total)*** — 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 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. Radiological emissions at MFC also occurred from ICP decontamination and decommissioning activities in MFC-766, Sodium Boiler Building.
- ***Test Area North (TAN) Emissions Sources (0.0174 percent of total)*** — The main emissions sources at TAN are from the Specific Manufacturing Capability project, and the New Pump and Treat Facility. Radiological air emissions from Specific Manufacturing Capability are associated with processing of depleted uranium. Potential emissions are uranium isotopes and associated radioactive progeny. Low levels of strontium-90 (^{90}Sr) and tritium are present in the treated water from the new pump and treat facility and are released to the atmosphere by the treatment process.

Estimated radionuclide releases (Ci/yr) from INL Site facilities, shown in Table 4-2, were used to calculate the dose to the hypothetical MEI, who is assumed to reside near the INL Site perimeter. The estimated dose to the MEI in calendar year 2015 was 0.033 mrem/yr (0.33 µSv/yr). Potential radiation doses to the public are discussed in more detail in Chapter 8 of this report.

4.3 Ambient Air Monitoring

Ambient air monitoring is conducted on and off the INL Site to confirm the impact of INL Site releases. Filters are collected weekly by the INL and ESER contractors from a network of low-volume air monitors (Table 4-3). At each monitor, a pump pulls air (about 57 L/min [2 ft^3/min]) through a 5-cm (2-in.), 1.2-µm membrane 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 beta activity. Gross alpha and 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 beta radioactivity in air samples are usually dominated by the presence of naturally occurring radionuclides. Because of this, gross alpha and gross beta radioactivity is, with rare exceptions, detected in each air filter collected. If the results are higher than normal, sources other than background radionuclides may be suspected, and other laboratory techniques can be used to identify specific radionuclides of concern. Gross alpha and 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 cesium-137 (^{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, plutonium-238 (^{238}Pu), plutonium-239/240 ($^{239/240}$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.

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 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.

The ESER and INL contractors monitor tritium in atmospheric water vapor in ambient air on the INL Site at the Experimental Field Station (EFS) and Van Buren

Table 4-3. INL Site Ambient Air Monitoring Summary (2015).

Medium Sampled	Type of Analysis	Frequency	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	18	4	**22**	5	14	**19**	1 x 10^{-15} µCi/mL
	Gross beta	Weekly	18	4	**22**	5	14	**19**	2 x 10^{-15} µCi/mL
	Specific gamma[c]	Quarterly	18	4	**22**	5	14	**19**	2 x 10^{-16} µCi/mL
	Plutonium-238	Quarterly	18	2	**20**	5	4-5	**9-10**	3.5 x 10^{-18} µCi/mL
	Plutonium-239/240	Quarterly	18	2	**20**	5	4-5	**9-10**	3.5 x 10^{-18} µCi/mL
	Americium-241	Quarterly	18	2	**20**	5	4-5	**9-10**	4.6 x 10^{-18} µCi/mL
	Strontium-90	Quarterly	18	2	**20**	5	4-5	**9-10**	3.4 x 10^{-17} µCi/mL
	Iodine-131	Weekly	18	4	**22**	5	14	**19**	1.5 x 10^{-15} µCi/mL
	Total particulates	Weekly	–	4	**4**	–	14	**14**	10 µg/m^3
Air (high volume)[d]	Gross beta scan	Biweekly	–	–	–	–	1[e]	**1**	1 x 10^{-15} µCi/mL
	Gamma scan	Continuous	–	–	–	–	1[e]	**1**	Not applicable
	Specific gamma[c]	Annually[f]	–	–	–	–	1[e]	**1**	1 x 10^{-14} µCi/mL
	Isotopic U and Pu	Every four yrs	–	–	–	–	1[e]	**1**	2 x 10^{-18} µCi/mL
Air (atmospheric moisture)[g]	Tritium	3–6/quarter	–	–	–	–	4	**4**	2 x 10^{-13} µCi/mL (air)
		2–4/quarter	2	–	**2**	2	–	**2**	1 x 10^{-11} µCi/mL (air)
Air (precipitation)[h]	Tritium	Monthly	–	1	**1**	–	1	**1**	100 pCi/L
		Weekly	–	1	**1**	–	–	–	

a. Low volume (LV) air samplers are operated on the INL site by the INL contractor at the following locations: ARA, ATR Complex (two air samplers), CFA (two LV air samplers), EBR-I, EFS, Highway 26 Rest Area, INTEC (three air samplers), Gate 4, MFC, NRF, PBF (CITRC), RWMC, SMC, and Van Buren. The INL contractor also samples offsite (i.e., outside INL Site boundaries) at Blackfoot, Craters of the Moon, Idaho Falls, IRC, and Sugar City. (ARA = Auxiliary Reactor Area; ATR = Advanced Test Reactor; CFA = Central Facilities Area; CITRC = Critical Infrastructure Test Range Complex; 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 Reactor Facility; PBF = Power Burst Facility; RWMC = Radioactive Waste Management Complex; SMC = Specific Manufacturing Capability)

b. The Environmental Surveillance, Education, and Research (ESER) contractor operates LV samplers on the INL Site at Main Gate, EFS, Van Buren, and one rotating duplicate location for QA. Offsite locations include Arco; Atomic City; Blackfoot; Blue Dome; Craters of the Moon; Dubois; FAA Tower; Howe; Idaho Falls; Jackson, WY; Monteview; Mud Lake; Sugar City; and one rotating duplicate location for QA.

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

d. The Environmental Protection Agency (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 Environmental Protection Agency (EPA) RadNet program and sent to NAREL. Data are reported by the Environmental Protection Agency's RadNet at http://www.epa.gov/radnet/radnet-databases-and-reports.

e. Gross beta scans were conducted by ESER personnel through June 2015. All scans and analyses are now performed by EPA at NAREL.

f. 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.

g. Atmospheric moisture is sampled using two methods. The first method used by ESER resulted in a lower MDC. Locations sampled using the first method are Atomic City, Blackfoot, Idaho Falls, and Sugar City. Locations sampled using the second method are EFS and Van Buren (onsite) and Craters of the Moon and Idaho Falls (offsite).

h. Precipitation samples are collected onsite at EFS and at CFA when available. Samples are collected offsite at Idaho Falls.

Boulevard, and off the INL Site at Atomic City, Blackfoot, Craters of the Moon, Idaho Falls, and Sugar City. Air passes through a column of molecular sieve, which is an adsorbent material that adsorbs water vapor in the air. Columns are 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. Tritium is present in air moisture due to natural production in the atmosphere and is also released by INL Site facilities (Table 4-2).

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

4.3.1 Ambient Air Monitoring Results

Gaseous Radioiodines — The INL contractor collected and analyzed approximately 1,200 charcoal cartridges in 2015. There were no statistically positive measurements of ^{131}I. During 2015, the ESER contractor analyzed 924 cartridges, usually in batches of 10 cartridges, looking specifically for ^{131}I. Iodine-131 was detected near the detection limit in one batch of ten cartridges collected on October 7, 2015. Further counting or subsets found no detectable ^{131}I.

Gross Activity — Gross alpha and 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 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., on site, boundary, and offsite locations) and for unusually elevated results. Anomalies are further investigated by reviewing sampler 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 are summarized in Tables 4-4 and 4-5. Concentrations reported for samples collected by both INL and ESER contractors at common locations reflect all results except duplicate measurements. Results are discussed further below.

- **Gross Alpha.** Gross alpha concentrations measured, on a weekly basis, in individual air samples ranged from a low of $(-0.48 \pm 0.81) \times 10^{-15}$ µCi/mL collected at EFS during the week ending on June 3, 2015, to highs of $(7.9 \pm 1.8) \times 10^{-15}$ µCi/mL and $(7.9 \pm 1.9) \times 10^{-15}$ µCi/mL collected, respectively, at the northeast corner of INTEC on August 19, 2015, and at SMC on August 26, 2015 (Table 4-4). The maximum result was equal to the measured historical high concentrations and attributed to naturally occurring gross alpha in smoke particles from regional wildfires.

  The median annual gross alpha concentrations were typical of previous measurements. All results were within the range of historical measurements. The maximum result is less than the Derived Concentration Standard (DCS) of 4×10^{-14} µCi/mL for ^{241}Am (see Table A-2 of Appendix A), which is the most conservative specific radionuclide DCS that could be applied to gross alpha activity.

- **Gross Beta.** Weekly gross beta concentrations measured in air samples ranged from a low of $(0.085 \pm 0.095) \times 10^{-14}$ µCi/mL at Idaho Falls during the week ending on December 2, 2015, to a high of $(10.1 \pm 0.12) \times 10^{-14}$ µCi/mL at Van Buren during the week ending on January 7, 2015 (Table 4-5). All results were within valid measurements taken during the last 10 years. 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 typically 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 2015, the most prominent inversion period occurred in January and November. All gross beta results measured during 2015 were within the range of historical measurements. The maximum median weekly gross beta concentration was 4.3×10^{-14} µCi/mL for all filters collected on January 7, 2015, which 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).

Table 4-4. Median Annual Gross Alpha Concentrations in Ambient Air Samples Collected in 2015.

Group	Location[a]	No. of Samples[b]	Range of Concentrations[c] ($\times 10^{-15}$ µCi/mL)	Annual Median[c] ($\times 10^{-15}$ µCi/mL)
Distant				
	Blackfoot	103[d]	-0.18 – 5.3	1.2
	Craters of the Moon	103[d]	0.11 – 5.4	1.1
	Dubois	52	0.30 – 5.0	1.2
	Idaho Falls	103[d]	-0.05 – 4.8	1.3
	Jackson	40[e]	0.51 – 3.7	1.3
	Sugar City	101[d]	-0.09 – 6.1	1.3
	IRC[f]	51	0.10 – 3.5	1.1
			Distant Median:	1.2
Boundary				
	Arco	51	0.44 – 3.4	1.2
	Atomic City	52	-0.29 – 3.9	1.2
	Blue Dome	52	0.21 – 5.7	1.0
	FAA Tower	52	-0.26 – 3.8	1.1
	Howe	52	0.38 – 3.6	1.2
	Monteview	52	0.55 – 5.6	1.2
	Mud Lake	51	0.39 – 4.2	1.3
			Boundary Median:	1.2
INL Site				
	ARA	51	-0.18 – 5.7	1.3
	ATR Complex (south side)	51	0.06 – 5.6	1.5
	ATR Complex (NE corner)	51	-0.13 – 7.3	1.5
	Big Lost River Rest Area	51	-0.16 – 5.1	1.2
	CFA	51	-0.30 – 5.2	1.4
	CITRC	50	-0.08 – 5.6	1.1
	EBR-I	51	-0.15 – 5.0	1.2
	EFS	102[d]	-0.48 – 5.9	1.1
	Gate 4	51	-0.17 – 4.3	1.5
	INTEC (NE corner)	51	-0.14 – 7.9	1.5
	INTEC (west side)	50	0.13 – 6.0	1.4
	Main Gate	52	0.38 – 4.1	1.2
	MFC	51	-0.41 – 6.2	1.2
	NRF	51	-0.30 – 4.4	1.5
	RWMC	51	-0.07 – 6.5	1.1
	SMC	51	-0.23 – 7.9	1.1
	Van Buren	103[d]	0.19 – 7.1	1.2
			INL Site Median:	1.2

a. ARA = Auxiliary Reactor Area, ATR = Advanced Test Reactor Complex, CFA = Central Facilities Area, CITRC = Critical Infrastructure Test Range Complex, 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, 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.

d. Includes all samples collected by the INL and ESER contractors at this location, with the exception of duplicate QA sample. See Table 4-3.

e. The Jackson sampler was shut down on October 5, 2015, pending relocation to a more suitable location.

f. 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 2015.

Group	Location[a]	No. of Samples[b]	Range of Concentrations[c] ($\times 10^{-14}$ µCi/mL)	Annual Median[c] ($\times 10^{-14}$ µCi/mL)
Distant				
	Blackfoot	103[d]	0.86 – 7.5	2.4
	Craters of the Moon	103[d]	0.44– 3.7	2.3
	Dubois	52	0.89 – 6.6	2.2
	Idaho Falls	103[d]	0.085 – 5.3	2.4
	Jackson	40[e]	1.2 – 4.7	2.5
	Sugar City	101[d]	0.74 – 4.6	2.3
	IRC[f]	51	0.83 – 3.8	2.2
			Distant Median:	2.3
Boundary				
	Arco	51	0.88 – 7.9	2.3
	Atomic City	52	0.94 – 8.1	2.3
	Blue Dome	52	0.78 – 6.6	2.2
	FAA Tower	52	0.63 – 6.7	2.2
	Howe	52	0.84 – 9.2	2.3
	Monteview	52	1.1 – 9.4	2.3
	Mud Lake	51	0.55 – 7.9	2.5
			Boundary Median:	2.3
INL Site				
	ARA	51	0.81 – 4.5	2.5
	ATR Complex (south side)	51	0.74 – 4.3	2.4
	ATR Complex (NE corner)	51	1.1 – 4.6	2.4
	Big Lost River Rest Area	51	0.71 – 5.2	2.6
	CFA	51	1.2 – 4.4	2.7
	CITRC	50	0.79 – 5.4	2.6
	EBR-I	51	0.50– 4.3	2.3
	EFS	102[d]	0.50 – 8.5	2.2
	Gate 4	51	0.69 – 4.8	2.6
	INTEC (NE corner)	51	0.95 – 4.8	2.6
	INTEC (west side)	50	0.71 – 4.3	2.5
	Main Gate	52	0.72 – 9.9	2.4
	MFC	51	0.69 – 4.1	2.5
	NRF	51	0.69 – 4.9	2.4
	RWMC	51	1.1 – 4.8	2.6
	SMC	51	0.81 – 4.8	2.6
	Van Buren	103[d]	0.81 – 10.1	2.7
			INL Site Median:	2.5

a. ARA = Auxiliary Reactor Area, ATR = Advanced Test Reactor Complex, CFA = Central Facilities Area, CITRC = Critical Infrastructure Test Range Complex, 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, 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.

d. Includes all samples collected by both the INL and ESER contractors at this location, with the exception of duplicate QA sample. See Table 4-3.

e. The Jackson sampler was shut down on October 5, 2015, pending relocation to a more suitable location.

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

- **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. There were no statistical differences between annual concentrations collected from the INL Site, boundary, and distant locations in 2015. There were a few statistical differences between weekly boundary and distant data sets collected by the ESER contractor during the 52 weeks of 2015 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 alpha and gross beta concentrations from samples collected at onsite and offsite locations. Statistical tests were performed to help determine if there was a significant difference between the two locational datasets. The gross beta t-test showed a potential for a difference between the onsite and offsite concentrations; however, further evaluation of the onsite and offsite mean concentrations ($2.6 \pm 0.3 \times 10^{-14}$ and $2.4 \pm 0.3 \times 10^{-14}$ μCi/mL, respectively) showed equivalence at one sigma uncertainty and were within measured historical values and attributable to natural data variation. Statistical evaluation revealed no significant difference between onsite and offsite concentrations.

Specific Radionuclides — The ESER and INL contractors reported five detections of ^{90}Sr during 2015 (Table 4-6). These occurred on and off the INL Site. All were just above the minimum detectable concentration for ^{90}Sr and were within the range previously detected in the past several years. Strontium-90 is widely dispersed in the environment from atmospheric testing of nuclear weapons in the 1950s and 1960s and is most likely the source of detections in the air filters. The DCS for ^{90}Sr in air is 2.5×10^{-11} μCi/mL.

Plutonium-239/240 was detected in a composite sample collected by the ESER contractor during the second quarter at Van Buren (Table 4-6). The result was just above the detection limit and was well below the DCS for $^{239/240}Pu$ in air (3.4×10^{-14} μCi/mL).

> ***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.

Plutonium isotopes (i.e., $^{239/240}Pu$ and ^{238}Pu) were reported by the analytical laboratory in several other quarterly composite samples collected by the INL and ESER contractors throughout 2015. However, as discussed in Chapter 11 (Sections 11.3.2.5 and 11.3.2.6), there were a number of issues with these data, including contamination with naturally occurring polonium-210 and detections of the analytes in blanks, method blanks, and unspiked quality assurance samples submitted during the year. This led to the conclusion that these data are likely false positives and are therefore invalid.

The laboratory reported traces of ^{241}Am in nine quarterly composite samples, but the validity of these results are questionable and are further discussed in Section 11.3.2.6. As a result, only 2nd quarter ^{241}Am results are reported in Table 4-6, but even these should be used with caution given the issues with the other data.

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.

4.3.2 Atmospheric Moisture Monitoring Results

In 2015, the INL contractor collected a total of 44 samples for atmospheric moisture at EFS, Van Buren Boulevard, and Craters of the Moon (off the INL Site). Traces of tritium within historical measurements were detected in samples from EFS during September and November.

Table 4-6. Human-made Radionuclides Detected in Ambient Air Samples Collected in 2015.

Radionuclide	Result[a] (µCi/mL)	Location[b]	Group	Quarter Detected
Strontium-90	$(2.6 \pm 0.81) \times 10^{-17}$	CFA[c]	INL Site	1st
Strontium-90	$(2.2 \pm 0.65) \times 10^{-17}$	Howe[d]	INL Boundary	1st
Strontium-90	$(2.4 \pm 0.57) \times 10^{-17}$	Dubois[d]	Distant	3rd
Strontium-90	$(2.1 \pm 0.52) \times 10^{-17}$	EFS[d]	INL Site	3rd
Strontium-90	$(1.5 \pm 0.49) \times 10^{-17}$	Mud Lake[d]	INL Boundary	3rd
Plutonium-239/240	$(3.5 \pm 1.1) \times 10^{-18}$	Van Buren[d]	INL Site	2nd
Americium-241[e]	$(0.80 \pm 0.18) \times 10^{-17}$	Van Buren[c]	INL Site	2nd
	$(0.57 \pm 0.15) \times 10^{-17}$	CFA[c]	INL Site	2nd
	$(0.43 \pm 0.14) \times 10^{-17}$	TRA[c]	INL Site	2nd

a. Results ± 1s. Results shown are ≥ 3s.
b. CFA = Central Facilities "Area; EFS = Experimental Field Station; TRA = Test Reactor Area at Advanced Test Reactor Complex.
c. Sample collected by INL contractor.
d. Sample collected by ESER contractor.
e. See section 11.3.2.6.

During 2015, the ESER contractor collected 62 atmospheric moisture samples. 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 45 samples, with a high of 15.5×10^{-13} µCi/mL_{air} at Sugar City. The highest concentration of tritium detected in an atmospheric moisture sample since 1998 was 38×10^{-13} µCi/mL_{air} at Atomic City. The results are within historical measurements and are probably natural and/or weapons testing fallout in origin. The highest observed tritium concentration is far below the DCS for tritium in air (as hydrogen tritium oxygen) of 2.1×10^{-7} µCi/mL_{air} (see Table A-2 of Appendix A).

4.3.3 Precipitation Monitoring Results

The ESER contractor collects precipitation samples weekly at EFS, when available, and monthly, when available, at CFA and off the INL Site in Idaho Falls. A total of 41 precipitation samples were collected during 2015 from the three sites. Tritium was detected in 23 samples, and detectable results ranged up to a high of 393 pCi/L at Idaho Falls during February. 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 1.9×10^{6} pCi/L and within the historical normal range at the INL Site. The maximum concentration measured since 1998 was 553 pCi/L at EFS in 2000. The results were also comparable to detections made by the EPA in Idaho during the 10-year period from 2002 through 2011 (data after 2011 are not available). The detected concentrations for tritium ranged from 81 to 1718 pCi/L at Idaho Falls (www.iaspub.epa.gov/enviro/erams_query_v2.simple_query). Tritium was not detected in most EPA samples because the minimum detectable concentration (MDC) is relatively high (average of 139 pCi/L) compared to the ESER MDC of about 80 pCi/L.

Average annual concentrations measured in atmospheric moisture and precipitation samples collected by the ESER Program from 2007 through 2015 are shown in Figure 4-4. The results appear to be similar for each year. Statistical comparisons of both sets of data show that there is no difference between average annual tritium concentrations measured in atmospheric moisture and precipitation samples collected from 2007 through 2015. This confirms that the source of the tritium is environmental and not from INL Site releases.

4.3.4 Suspended Particulates Monitoring Results

In 2015, 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.

Table 4-7. Tritium Concentrations in Atmospheric Moisture Samples Collected Off the INL Site in 2015[a].

	Atomic City	Blackfoot	Idaho Falls	Sugar City
Number of samples	13	17	16	16
Number of detections	8	12	13	11
Detection percentage	62%	71%	81%	69%
Concentration range ($\times 10^{-13}$ $\mu Ci/mL_{air}$)[b]	0.38 ± 0.35 – 7.9 ± 0.64	1.7 ± 0.84 – 14.8 ± 0.96	-4.7 ± 0.82 – 9.6 ± 1.7	1.1 ± 0.48 – 15.5 ± 2.4
Mean concentration ($\times 10^{-13}$ $\mu Ci/mL_{air}$)[b]	3.3	6.4	4.5	6.9

a. Forty additional samples were collected on the INL Site at EFS and Van Buren and off the INL Site at Idaho Falls and Craters of the Moon using different methodology and a much higher detection limit. Tritium was detected in trace amounts in samples collected from EFS in July and November. Tritium was not detected in any other onsite sample.

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.

Table 4-8. Tritium Concentrations in Precipitation Samples Collected in 2015.

	Central Facilities Area	Experimental Field Station	Idaho Falls
Number of samples	9	20	12
Number of detections	2	14	7
Detection percentage	22%	70%	58%
Concentration range (pCi/L)	15.6 ± 24.6 – 127 ± 22.9	-110 ± 26 – 250 ± 25.5	-62.1 ± 25.6 – 393 ± 27.1
Mean concentration (pCi/L)	63.2	100.6	86.7

a. 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.

Mean annual particulate concentrations ranged from 6.8 μg/m³ at Blue Dome to 18.9 μg/m³ at Arco. In general, particulate concentrations were higher at offsite locations than at the INL Site stations. This is most likely influenced by agricultural activities off the INL Site.

4.4 Waste Management Environmental Surveillance Air Monitoring

4.4.1 Gross Activity

The ICP contractor conducts environmental surveillance in and around waste management facilities to comply with DOE Order 435.1, "Radioactive Waste Management." Currently, ICP waste management operations occur at the SDA at RWMC and the ICDF at INTEC and have the potential to emit radioactive airborne particulates. The ICP contractor collected samples of airborne particulate material from the perimeters of these waste management areas in 2015 (Figure 4-5).

On September 24, 2015, a transformer near sample location SDA 6.3 blew a fuse, which caused the sampler to lose power. On October 18, 2015, the sampler was moved approximately 600 ft west to the closest available power source. The new location is designated as SDA 6.3A. Sampler location SDA 4.2 is a replicate sampler used for quality assurance purposes, and the data from that sampler are not used to summarize results. The ICP contractor also collected samples from 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

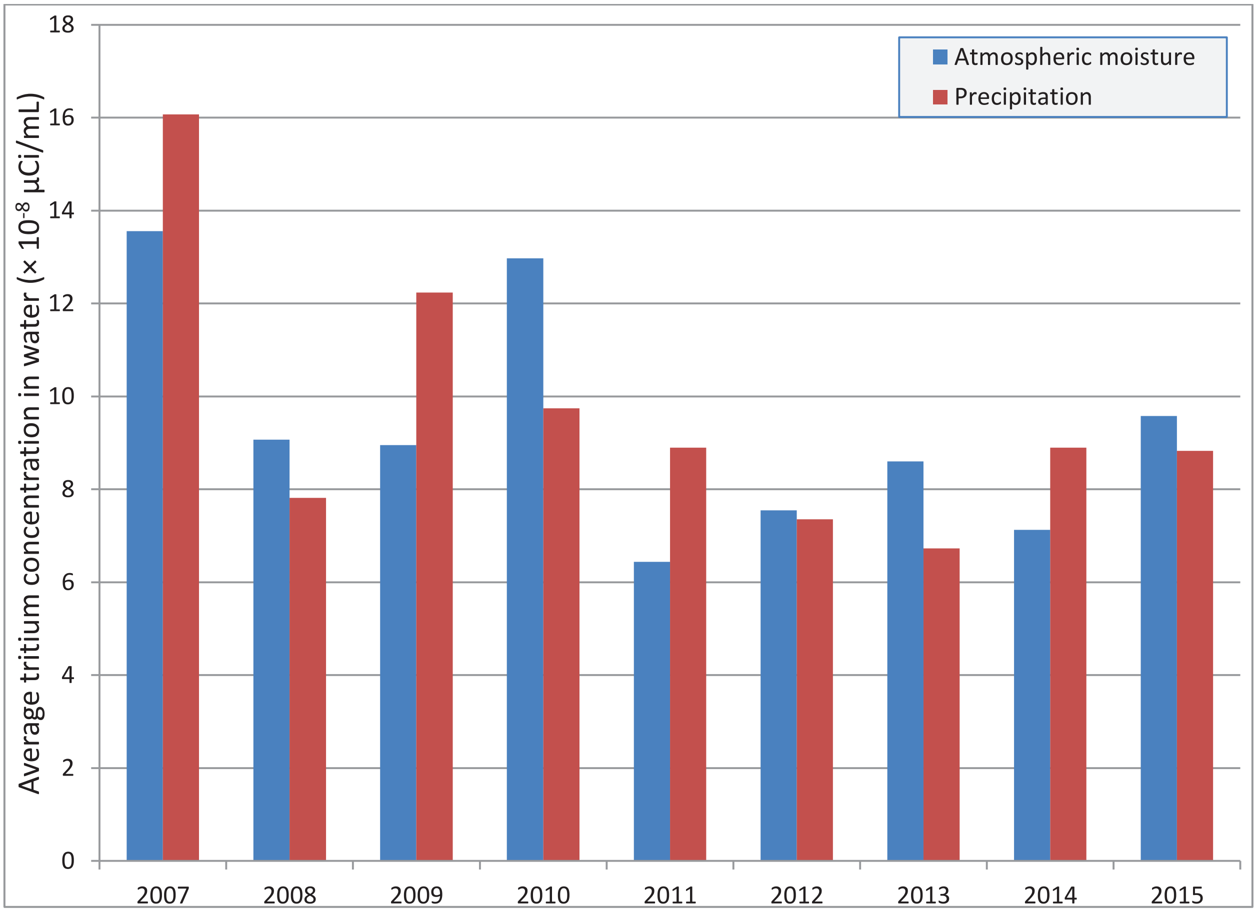

Figure 4-4. Average Annual Tritium Concentrations Measured in Atmospheric Moisture and Precipitation from 2007 through 2015.

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 measured at waste management operations ranged from a low of $(0.18 \pm 0.07) \times 10^{-15}$ µCi/mL collected at SDA 11.3 on February 16, 2015, to a high of $(15.10 \pm 4.12) \times 10^{-15}$ µCi/mL at SDA 6.3 on August 25, 2015.

Table 4-10 shows the median annual and range of gross beta concentrations at each location. Gross beta concentrations measured at waste management operations ranged from a low of $(0.505 \pm 0.05) \times 10^{-14}$ µCi/mL at HOWE 400.4 on February 16, 2015, to a high of $(6.34 \pm 0.89) \times 10^{-14}$ µCi/mL at SDA 6.3 on August 25, 2015.

The highest readings for both gross alpha and gross beta occurred during unusual smoky conditions caused by wildfires in the northwest. The gross alpha and gross beta results for the SDA and ICDF are comparable to historical results, and no new trends were identified.

4.4.2 Specific Radionuclides

The air filters are composited monthly and analyzed in a laboratory by gamma spectroscopy and radiochemically analyzed for specific alpha- and beta-emitting radionuclides.

In 2015, 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.

Table 4-11 shows human-made specific alpha- and beta-emitting radionuclides detected at the SDA in 2015. These detections are consistent with levels measured in air at RWMC in previous years, and are attributed to resuspension of soils in and adjacent to RWMC. The values and locations for plutonium and americium detec-

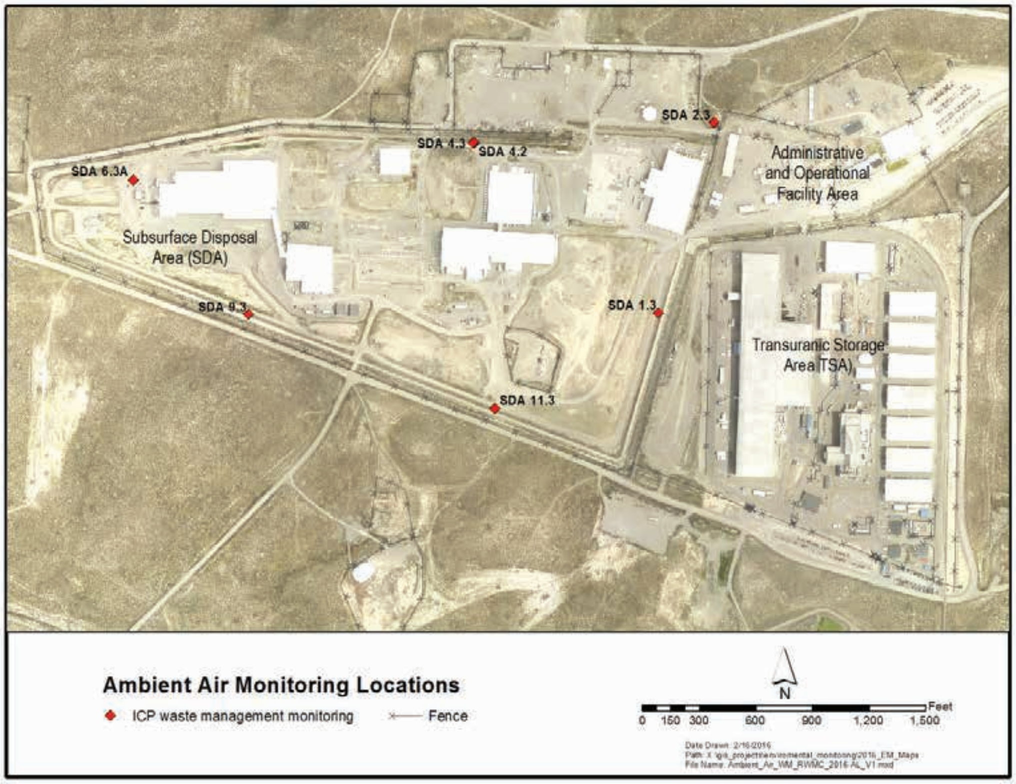

Figure 4-5. Locations of Low-volume Air Samplers at Waste Management Areas (RWMC [top] and ICDF [bottom]).

Table 4-9. Median Annual Gross Alpha Concentration in Air Samples Collected at Waste Management Sites in 2015.[a]

Group	Location	No. of Samples	Range of Concentrations ($\times 10^{-15}$ µCi/mL)	Annual Median ($\times 10^{-15}$ µCi/mL)
Subsurface Disposal Area	SDA 1.3	25	0.24 - 12.30	1.82
	SDA 2.3	25	0.35 - 10.30	2.15
	SDA 4.3	25	0.30 - 12.30	1.81
	SDA 6.3[b]	24	0.35 - 15.10	1.91
	SDA 9.3	25	0.24 - 6.70	1.67
	SDA 11.3	25	0.18 - 11.70	2.12
Idaho CERCLA Disposal Facility	INT 100.3	25	0.42 - 6.82	2.12
Boundary	HOWE 400.4	25	0.30 - 9.34	1.81

a. Results ± 1s.
b. Includes results from location SDA 6.3A.

Table 4-10. Median Annual Gross Beta Concentration in Air Samples Collected at Waste Management Sites in 2015.[a]

Group	Location	No. of Samples	Range of Concentrations ($\times 10^{-14}$ µCi/mL)	Annual Median ($\times 10^{-14}$ µCi/mL)
Subsurface Disposal Area	SDA 1.3	25	0.64–5.67	3.10
	SDA 2.3	25	0.58–4.84	3.05
	SDA 4.3	25	0.56–5.33	2.39
	SDA 6.3[b]	24	0.59–6.34	2.59
	SDA 9.3	25	0.51–4.48	2.60
	SDA 11.3	25	0.63–5.39	2.78
Idaho CERCLA Disposal Facility	INT 100.3	25	0.70–5.69	3.01
Boundary	HOWE 400.4	25	0.51–5.85	2.41

a. Results ± 1s.
b. Includes results from location SDA 6.3A.

tions remained consistent from 2014 to 2015. The detections shown in Table 4-11 are likely due to resuspension of contaminated soils as a result of early burial practices (Markham et al. 1978), previously flooded areas inside or northeast of the SDA, and ARP fugitive emissions. Studies of radionuclide concentrations in soils (VanHorn et al. 2012) confirm that $^{239/240}$Pu and ^{241}Am are still present in measurable amounts in surface soils surrounding RWMC, with maximum concentrations northeast of the SDA. Although radionuclides were detected, all detections were three to four orders of magnitude below the DCS reported in DOE (2011), and statistically false positives at the 95 percent confidence error are possible. The ICP contractor will continue to closely monitor radionuclides to identify trends.

Table 4-11. Human-made Radionuclides Detected in Air Samples Collected at Waste Management Sites in 2015.[a]

Radionuclide	Result (µCi/mL)	Location	Quarter Detected
Americium-241	(2.71 ± 0.64) E-18	SDA[b] 2.3	1st
	(1.34 ± 0.16) E-17	SDA 4.3	1st
	(2.02 ± 0.53) E-18	SDA 1.3	2nd
	(4.65 ± 0.78) E-18	SDA 2.3	2nd
	(1.72 ± 0.19) E-17	SDA 4.3	2nd
	(3.93 ± 0.74) E-18	SDA 9.3	2nd
	(3.07 ± 0.59) E-18	SDA 11.3	2nd
	(1.97 ± 0.55) E-18	SDA 1.3	3rd
	(5.03 ± 1.13) E-18	SDA 2.3	3rd
	(9.70 ± 1.64) E-18	SDA 4.3	3rd
	(2.53 ± 0.68) E-18	SDA 9.3	3rd
	(2.87 ± 0.91) E-18	SDA 11.3	3rd
	(4.76 ± 0.73) E-18	SDA 2.3	4th
	(3.79 ± 0.36) E-17	SDA 4.3	4th
Plutonium-239/240	(2.98 ± 0.59) E-18	SDA 1.3	1st
	(1.22 ± 0.40) E-18	SDA 2.3	1st
	(6.67 ± 0.97) E-18	SDA 4.3	1st
	(8.42 ± 2.74) E-19	SDA 9.3	1st
	(1.58 ± 0.40) E-18	SDA 11.3	1st
	(1.67 ± 0.47) E-18	SDA 1.3	2nd
	(4.23 ± 0.75) E-18	SDA 2.3	2nd
	(9.50 ± 1.27) E-18	SDA 4.3	2nd
	(1.89 ± 0.50) E-18	SDA 6.3	2nd
	(2.91 ± 0.64) E-18	SDA 9.3	2nd
	(5.04 ± 0.80) E-18	SDA 11.3	2nd
	(1.45 ± 0.48) E-18	INT 100.3	2nd
	(2.32 ± 0.51) E-18	SDA 1.3	3rd
	(2.52 ± 0.55) E-18	SDA 2.3	3rd
	(8.23 ± 1.29) E-18	SDA 4.3	3rd
	(1.66 ± 0.55) E-18	SDA 6.3	3rd
	(2.93 ± 0.63) E-18	SDA 9.3	3rd
	(2.21 ± 0.58) E-18	SDA 11.3	3rd
	(1.70 ± 0.51) E-18	SDA 2.3	4th
	(2.30 ± 0.26) E-17	SDA 4.3	4th
	(1.34 ± 0.42) E-18	SDA 9.3	4th
Strontium-90	(3.17 ± 0.98) E-17	SDA 2.3	4th

a. Results ± 1s. Results shown are ≥ 3s.
b. SDA - Subsurface Disposal Area.

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5. Environmental Monitoring Programs: Liquid Effluent Monitoring

Big Lost River

Liquid effluents and surface water runoff were monitored in 2015 by the Idaho National Laboratory (INL) contractor and the Idaho Cleanup Project contractor for compliance with permit requirements and applicable regulatory standards established to protect human health and the environment.

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. During 2015, permitted facilities were: Advanced Test Reactor Complex Cold Waste Pond; Central Facilities Area (CFA) Sewage Treatment Plant; Idaho Nuclear Technology and Engineering Center New Percolation Ponds; and Materials and Fuels Complex 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. No wastewater was applied to the CFA land application area in 2015 so no effluent monitoring was required. All of the facilities were in compliance with the requirements of their Wastewater Reuse Permits in 2015. Additional liquid effluent and groundwater monitoring were performed in 2015 at these facilities to comply with environmental protection objectives of the U.S. Department of Energy. All parameters were below applicable health-based standards in 2015.

Surface water that ran off the Subsurface Disposal Area at the Radioactive Waste Management Complex during periods of rapid snowmelt or heavy precipitation was sampled and analyzed for radionuclides. The detected concentrations of americium-241, plutonium-239/240, and strontium-90 were approximately the same as 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) personnel conduct liquid effluent monitoring through wastewater, liquid effluent, and surface water runoff sampling and surveillance programs. Sampling of groundwater related to sites of wastewater and direct discharges is also conducted as part of these programs.

Table 5-1 presents 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 (MCLs). 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 parameters in the influent waste, effluent waste, and groundwater in accordance with the Idaho ground water quality standards stipulated in the "Ground Water Quality Rule" (IDAPA 58.01.11). Some facilities may have specified radiological parameters monitored for surveillance purposes (not required by regulations). The permits specify annual discharge volumes, application rates, and effluent quality limits. Annual reports (ICP 2016a, 2016b; INL 2015a, 2015b, 2015c, 2015d, 2015e) were prepared and submitted to the Idaho Department of Environmental Quality (DEQ).

During 2015, 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)

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 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 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.

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

Additional effluent parameters are monitored at these facilities to comply with environmental protection objectives of DOE Order 458.1 and are discussed in Section 5.2.

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 (.75 mile) northwest of the Big Lost River channel (Figure 5-1). The existing CWP was excavated in 1982. It consists of two 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 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, 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.

Table 5-2. Status of Wastewater Reuse Permits.

Facility[a]	Permit Status at End of 2015	Explanation
ATR Complex Cold Waste Pond	Renewal Permit issued	DEQ[b] issued Permit #LA-000161-01 on February 26, 2008, modified on August 20, 2008, with a scheduled expiration date of February 25, 2013. A renewal permit application (INL 2013) was submitted to DEQ. DEQ issued Permit I-161-02 on November 20, 2014.
CFA Sewage Treatment Plant	Permit issued	DEQ issued Permit #LA-000141-03 on March 17, 2010. The permit will expire on March 16, 2015. A recycled water reuse permit application was submitted to DEQ in September 2014.
INTEC New Percolation Ponds	Permit issued	DEQ issued Permit #LA-000130-05 on March 14, 2012, with a minor modification issued on June 1, 2016. The permit will expire on March 14, 2017.
MFC Industrial Waste Pond and Industrial Waste Ditch	Permit issued	In 2010, 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 (Miller 2014a).

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

b. DEQ = Idaho Department of Environmental Quality

DEQ issued a wastewater reuse permit for the pond in February 2008. A permit renewal application was submitted to DEQ on August 21, 2012 (INL 2013). DEQ issued a new permit (I-161-02) on November 20, 2014 (Neher 2014).

Wastewater Monitoring Results for the Wastewater Reuse Permit. Permit #LA-000161-01 was superseded by I-161-02 on November 20, 2014. The 2014 report did not include December 2014 data due to changes in the analyte list under the new permit. The 2015 report includes data from December 2014 to December 2015 for monitoring activities required by permit I-161-02.

The industrial wastewater reuse permit requires monthly sampling of the effluent to the CWP. The minimum, maximum, and median results of all parameters monitored are presented in Table C-1.

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. To measure potential impacts from the CWP, the permit requires groundwater monitoring in April/May and September/October at six wells (Figure 5-1; Table C-2 and Table C-2a). USGS-058 is monitored for limited constituents compared to the other five wells per permit requirements. Iron and manganese were elevated in some of the unfiltered samples because of suspended aquifer matrix material or rust in the well water. The metals concentrations in the filtered samples were below the applicable standards.

5.1.2 Central Facilities Area Sewage Treatment Plant

Description. The CFA Sewage Treatment Plant 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 7.2.2 for further information.

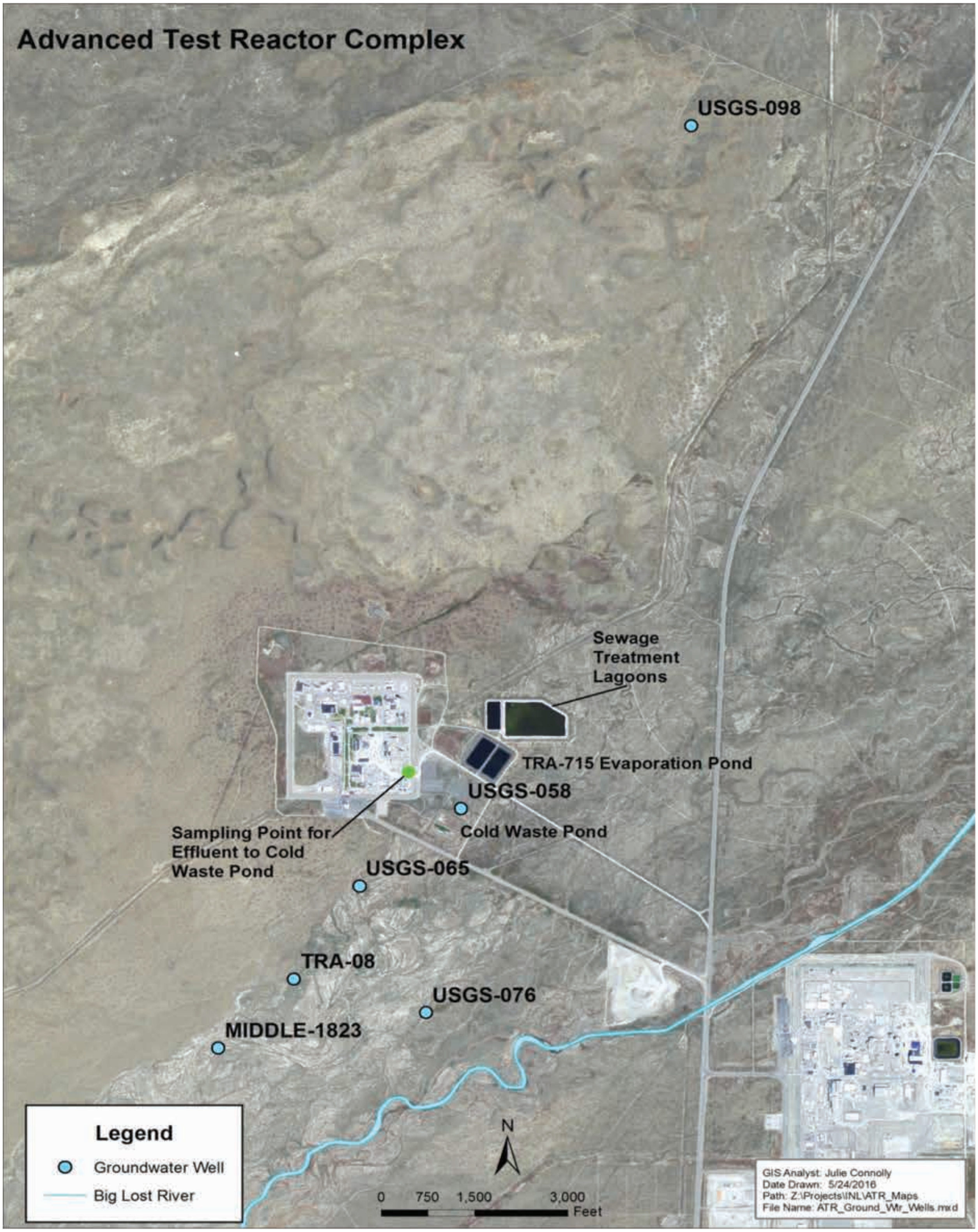

Figure 5-1. Permit Monitoring Locations for the ATR Complex Cold Waste Pond.

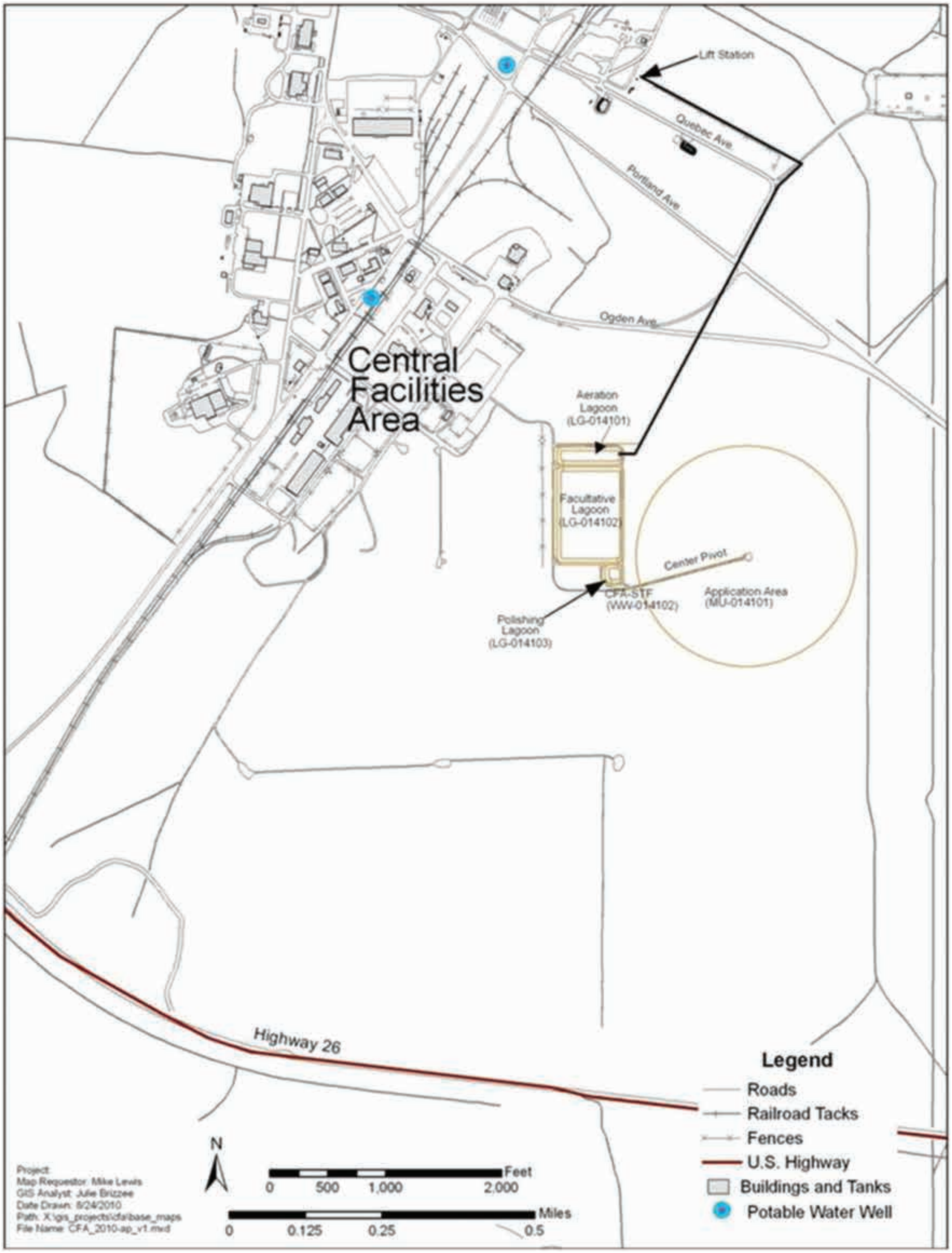

Figure 5-2. CFA Sewage Treatment Plant. Samples are collected at the irrigation pump pivot, sampling point CFA–STF.

Wastewater Monitoring Results for the Wastewater Reuse Permit. DEQ issued a permit for the CFA Sewage Treatment Plant on March 17, 2010. The permit required 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 2015 permit year, no wastewater was applied to the land application area; therefore, no effluent sampling was required by the permit. A recycled water reuse permit application was submitted to DEQ in September 2014 (INL 2014).

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

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 × 93 m (305 ft × 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 3 MG per day.

The INTEC New Percolation Ponds receive discharge of only nonhazardous 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

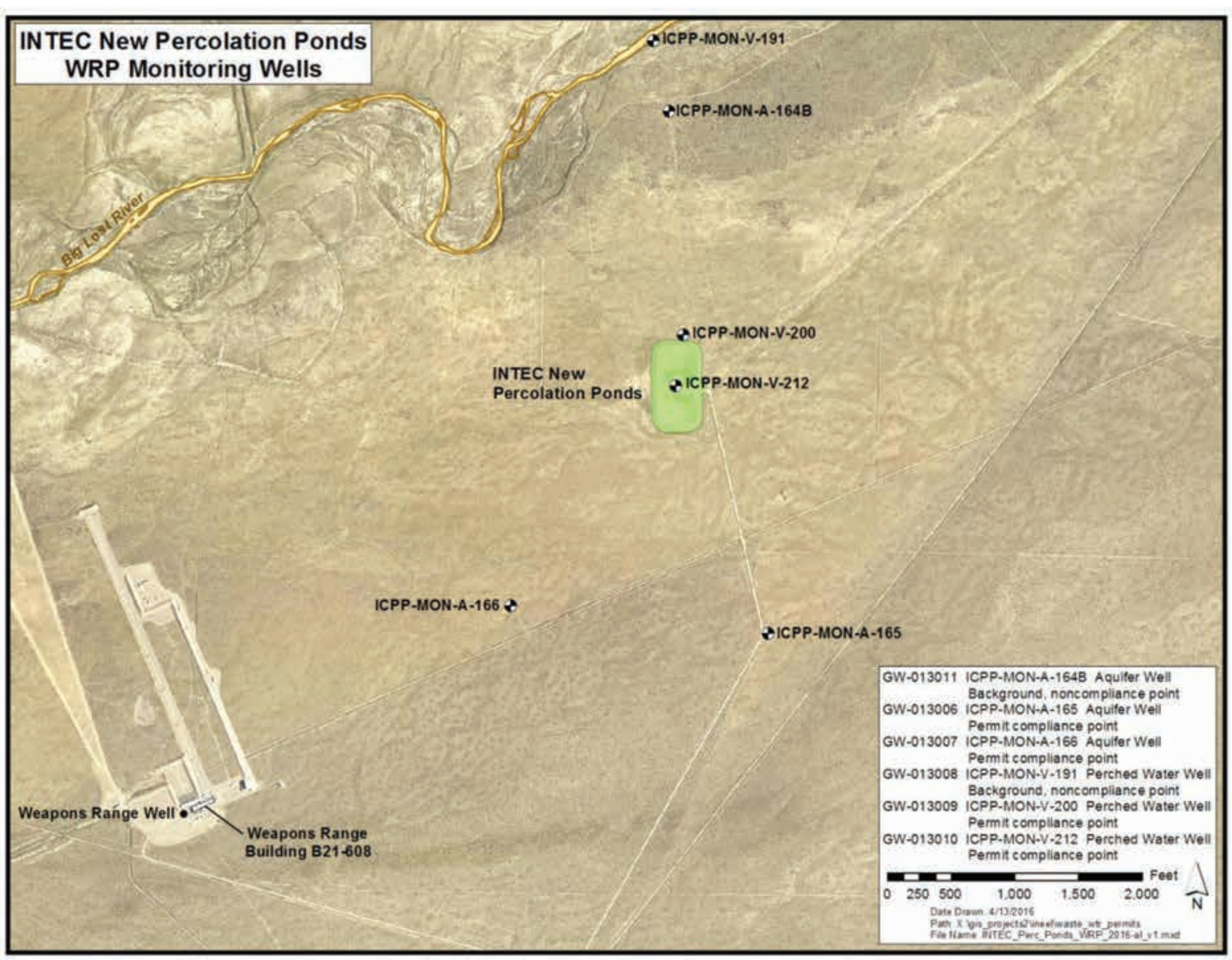

Figure 5-3. Permit Groundwater Monitoring Locations for INTEC New Percolation Ponds *(Weapons Range Well is not a permitted well and is shown for location reference only)*.

of other nonhazardous liquids. Municipal wastewater (i.e., sanitary waste) is treated at the INTEC Sewage Treatment Plant.

The Sewage Treatment Plant 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 Sewage Treatment Plant 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.

The INTEC New Percolation Ponds are permitted by DEQ to operate as a wastewater reuse facility under Wastewater Reuse Permit LA-000130-05 (DEQ 2016). The renewed permit became effective on March 14, 2012.

Wastewater Monitoring Results for the Wastewater Reuse Permit. Monthly samples were collected from:

- CPP-769 – Influent to Sewage Treatment Plant
- CPP-773 – Effluent from Sewage Treatment Plant prior to combining with service waste
- CPP-797 – Combined effluent prior to discharge to the INTEC New Percolation Ponds.

As required by the permit, all samples are collected as 24-hour flow proportional composites, except pH and total coliform, which are collected as grab samples. The permit specifies the parameters that must be monitored for each location. Because the permit does not specify any wastewater discharge limits, the monitoring results are compared to the primary and secondary constituent standards in "Ground Water Quality Standards" (IDAPA 58.01.11.200) and historical data collected at these three monitoring points.

The 2015 monitoring results (minimum, maximum, and mean) for CPP-769, CPP-773, and CPP-797 are presented in Tables C-3, C-4, and C-5, respectively. For 2015, none of the parameters exceeded their respective primary and secondary constituent standards. The monitoring results for all of the samples were within their expected concentrations, except for the following, which were above their expected concentrations:

- May 2015 biochemical oxygen demand sample collected at CPP-773 (78.8 mg/L)
- May 2015 biochemical oxygen demand sample collected at CPP-797 (13.5 mg/L)
- June 2015 biochemical oxygen demand sample collected at CPP-773 (78.7 mg/L)
- June 2015 biochemical oxygen demand sample collected at CPP-797 (19.5 mg/L)
- June 2015 total suspended solids sample collected at CPP-773 (72 mg/L)
- July 2015 biochemical oxygen demand sample collected at CPP-797 (20.1 mg/L)
- September 2015 total coliform sample collected at CPP-773 (8,000 colonies/100 mL)
- September 2015 total coliform sample collected at CPP-797 (121 colonies/100 mL)
- October 2015 total coliform sample collected at CPP-773 (3,600 colonies/100 mL)
- October 2015 total coliform sample collected at CPP-797 (175 colonies/100 mL)
- October 2015 chloride sample collected at CPP-797 (53.5 mg/L).

The permit specifies maximum daily and yearly hydraulic loading rates for the INTEC New Percolation Ponds. As shown in Table 5-3, the maximum daily flow and the yearly total flow to the INTEC New Percolation Ponds were below the permit limits in 2015.

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 parameters must be analyzed. Contaminant concentrations in the compliance wells are limited by primary constituent standards and secondary constituent standards, specified in IDAPA 58.01.11, "Ground Water Quality Rule." All permit-required samples are collected as unfiltered samples, except aluminum, iron, manganese, and silver. The results of dissolved concentrations (i.e., filtered samples) of these four parameters are used for secondary constituent standard compliance determinations.

Table 5-3. Hydraulic Loading Rates for the INTEC New Percolation Ponds.

	Maximum Daily Flow	Yearly Total Flow
2015 Flow	1,038,000 gallons	214 MG[a]
Permit Limit	3,000,000 gallons	1,095 MG

a. MG = million gallons.

Table C-6 shows the 2015 water table elevations and depth to water table, determined prior to purging and sampling, and the analytical results for all parameters specified by the permit for the aquifer wells. Table C-7 presents similar information for the perched water wells. Perched water well ICPP-MON-V-191 was dry during 2015, and, therefore, samples could not be collected.

As Tables C-6 and C-7 show, all permit-required parameters associated with the aquifer and perched water wells were below their respective primary constituent standards and secondary constituent standards in 2015.

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

Description. The wastewater reuse permit issued by DEQ for the MFC Industrial Waste Ditch and Pond became effective May 1, 2010. The MFC Industrial Waste Pond was first excavated in 1959 and has a design capacity of 285 MG at a maximum water depth of 13 ft (Figure 5-4).

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.

Wastewater composed of intermittent reverse osmosis effluent and discharge to a laboratory sink flows from the MFC-768 Power Plant to Ditch C via the Industrial Waste Water Underground Pipe.

Wastewater Monitoring Results for the Wastewater Reuse Permit. The industrial wastewater reuse permit requires monthly sampling of the effluent to the pond discharged to the Industrial Waste Pipeline. The permit requires quarterly samples of the discharge to Ditch C from the Industrial Waste Water Underground Pipe. The permit sets monthly concentration limits for total suspended solids (100 mg/L) and total nitrogen (20 mg/L). During 2015, no samples for total suspended solids or total nitrogen exceeded the permit limit (Table 5-4). The minimum, maximum, and median results of all parameters monitored are presented in Tables C-8 and C-9.

Groundwater Monitoring Results for the Wastewater Reuse Permit. To measure potential impacts from the Industrial Waste Pond, the permit requires groundwater monitoring in April/May and September/October at one upgradient and two downgradient wells (Figure 5-4).

The analytical results are summarized in Table C-10. Analyte concentrations in the downgradient wells were indistinguishable from 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-11 lists wastewater surveillance monitoring results for those parameters with at least one detected result. Radionuclides detected in groundwater samples are summarized in Table C-12. The tritium concentrations are below the Idaho groundwater primary constituent standard for tritium (20,000 pCi/L), which is the same as the Environmental Protection Agency health-based MCL for tritium in drinking water (40 CFR 141).

5.2.2 Central Facilities Area

The effluent from the CFA Sewage Treatment Plant is monitored according to the wastewater reuse permit. No wastewater was land-applied in 2015; therefore, no effluent samples were collected at the treatment facility.

Figure 5-4. Wastewater and Groundwater Sampling Locations at the MFC.

Table 5-4. Total Nitrogen and Total Suspended Solids Effluent Monitoring Results in Discharges to the MFC Industrial Waste Pond (2015).[a]

Parameter	Minimum	Maximum	Median	Permit Level
Industrial Waste Water Underground Pipe				
Total nitrogen[b] (mg/L)	5.703	8.35	6.104	20
Total suspended solids (mg/L)	<4 U[c]	7.0	<4 U	100
Industrial Waste Pipeline				
Total nitrogen[b] (mg/L)	0.932	4.88	1.051	20
Total suspended solids (mg/L)	<4 U	<4 U	<4 U	100

a. Duplicate samples were collected at both locations in September, and the results for the duplicate samples are included in the data summary.
b. Total nitrogen is calculated as the sum of total Kjeldahl nitrogen and nitrate + nitrite, as nitrogen.
c. U flag indicates the result was below detection limit.

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 the INTEC Sewage Treatment Plant, prior to discharge into the INTEC New Percolation Ponds and the groundwater, with respect to the INTEC New Percolation Ponds. Table C-13 summarizes the results of radiological monitoring at CPP-773 and CPP-797, and Table C-14 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.

Samples were collected from the CPP-773 effluent in April 2015 and September 2015 and analyzed for specific gamma-emitting radionuclides, gross alpha, gross beta, and total strontium activity. As shown in Table C-13, no gross alpha or total strontium was detected in any of the samples collected at CPP-773 in 2015. Potassium-40 was detected in the September 2015 sample (71.8 pCi/L) collected at CPP-773, and gross beta was detected in both the April 2015 sample (18.8 pCi/L) and the September 2015 sample (28.1 pCi/L). The gross beta results were within their expected historical concentrations.

Twenty-four-hour flow proportional samples were collected from the CPP-797 wastewater effluent and composited daily into a monthly sample. The monthly composite samples were analyzed for specific gamma-emitting radionuclides, gross alpha, gross beta, and total strontium activity. As shown in Table C-13, no gamma or total strontium was detected in any of the samples collected at CPP-797 in 2015. The gross alpha and gross beta results were within their expected historical concentrations.

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 2015 and September 2015 and analyzed for gross alpha and gross beta. As shown in Table C-14, gross alpha was not detected in any of the four monitoring wells in April 2015, but was detected in aquifer well ICPP-MON-A-166 (9.75 pCi/L) and perched water well ICPP-MON-V-212 (4.48 pCi/L) in September 2015. Gross beta was detected in all four monitoring wells in April 2015 and September 2015. The gross beta results were within their expected historical concentrations.

5.2.4 Materials and Fuels Complex

The Industrial Waste Pond is sampled quarterly for gross alpha, gross beta, gamma spectroscopy, and tritium (Figure 5-4). Annual samples are collected and analyzed for selected isotopes of americium, curium, iron, strontium, plutonium, and uranium. Gross beta, potassium-40, and uranium isotopes were detected in 2015 within their expected historical concentrations (Table C-15).

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 contractor collects surface water runoff samples at the RWMC SDA from the location shown in Figure 5-5. Surface water is collected to determine if radionuclide concentrations exceed administrative control levels or if concentrations have increased significantly compared to historical data. A field blank is also collected for comparison. Samples were collected quarterly during 2015.

Table 5-5 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 detected in previous years and are well below the U.S. Department of Energy (DOE) Derived Concentration Standards (DOE 2011).

The ICP contractor will sample quarterly during 2016, when water is available, and evaluate the results to identify any potential abnormal trends or results that would warrant further investigation.

Table 5-5. Radionuclides Detected in Surface Water Runoff at the Radioactive Waste Management Complex Subsurface Disposal Area (2015).

Parameter	Maximum Concentration[a] (pCi/L)	% Derived Concentration Standard[b]
Americium-241	0.220 ± 0.020	0.13
Plutonium-239/240	0.092 ± 0.010	0.07
Strontium-90	0.575 ± 0.072	0.05

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

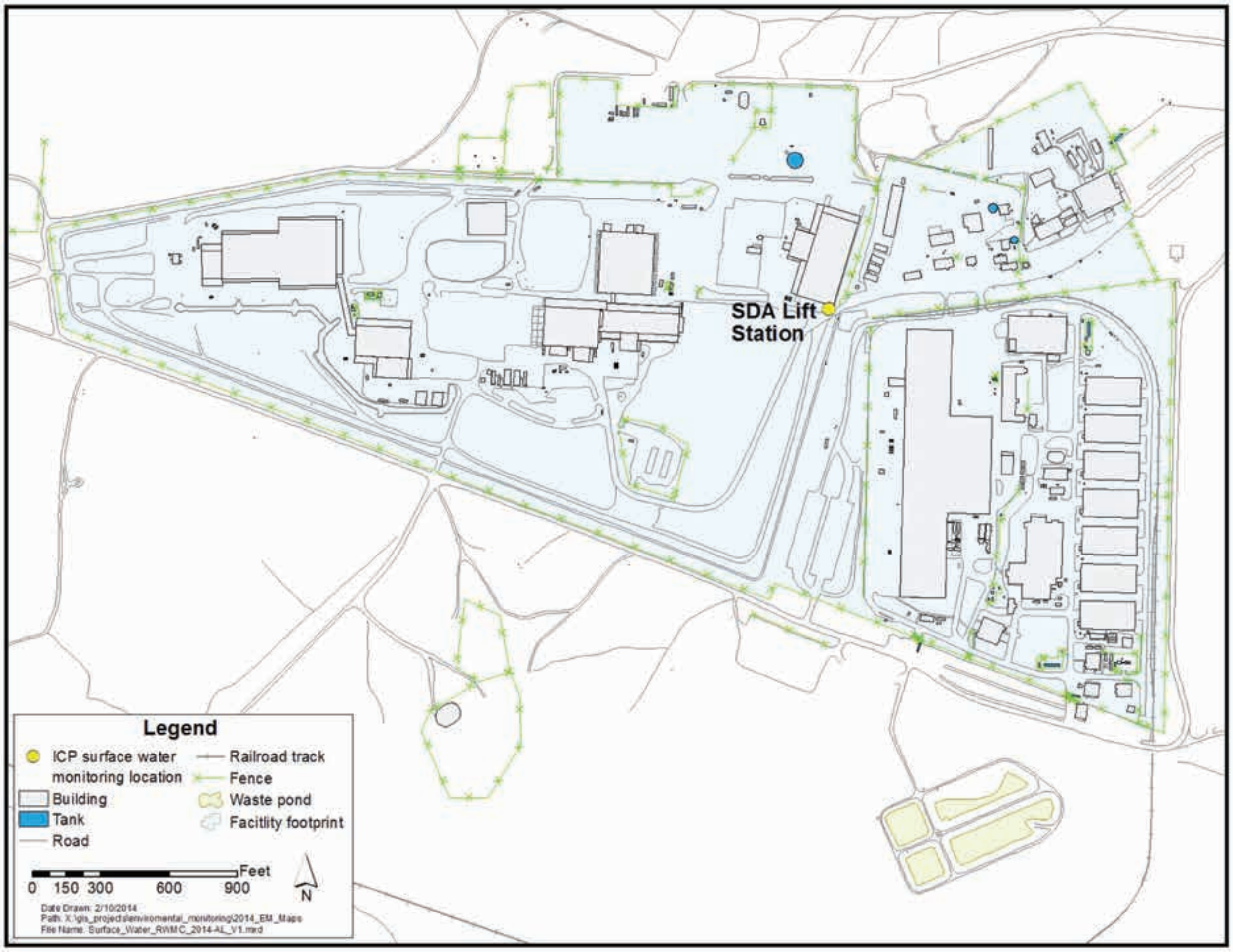

Figure 5-5. Surface Water Sampling Location at the Radioactive Waste Management Complex Subsurface Disposal Area.

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Big Lost River

6. Environmental Monitoring Programs: Eastern Snake River Plain Aquifer

Lemhi Mountains

One potential pathway for exposure from contaminants released at the Idaho National Laboratory (INL) Site is through the groundwater pathway. Historic 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 probably the result of radioactive decay, discontinued disposal, dispersion, and dilution within the aquifer.

In 2015, USGS sampled 24 groundwater monitoring wells and one perched well at the INL Site for analysis of 61 purgeable (volatile) organic compounds (POC). USGS also conducted a special study in 2015 to collect samples from 31 wells around Idaho Nuclear Technology and Engineering Center for analysis of 49 POCs. Several POCs continue to be detected. None of the concentrations exceeded any maximum contaminant levels established for public drinking water supplies.

Historically, concentrations of volatile organic compounds (VOCs) in water samples from several wells at and near the Radioactive Waste Management Complex exceeded the reporting levels. However, concentrations for all VOCs except carbon tetrachloride were less than the maximum contamination level for drinking water. Trend test results for carbon tetrachloride concentrations in water from the Radioactive Waste Management Complex production well indicate a statistically significant increase in concentrations has occurred since 1987. However, trend analysis of more recent data indicates that the trend is not as significant, which may indicate that engineering practices designed to reduce VOC concentration movement to the aquifer are having a positive effect.

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 1– 4, 7, 9, and 10 in 2015.

There are 12 drinking water systems on the INL Site. All contaminant concentrations measured in drinking water systems in 2015 were below regulatory limits. Because of the potential impacts to workers at Central Facilities Area 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 Central Facilities Area during 2015 was 0.186 mrem (1.86 µSv). This value is below the U.S. Environmental Protection Agency standard of 4 mrem/yr for public drinking water systems.

Drinking water and springs were sampled by the Environmental Surveillance, Education, and Research contractor in the vicinity 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 not sampled in 2015 because the river contained no water at any time during the year.

6. ENVIRONMENTAL MONITORING PROGRAMS: EASTERN SNAKE RIVER PLAIN AQUIFER

The eastern Snake River Plain aquifer serves as the primary source for 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),

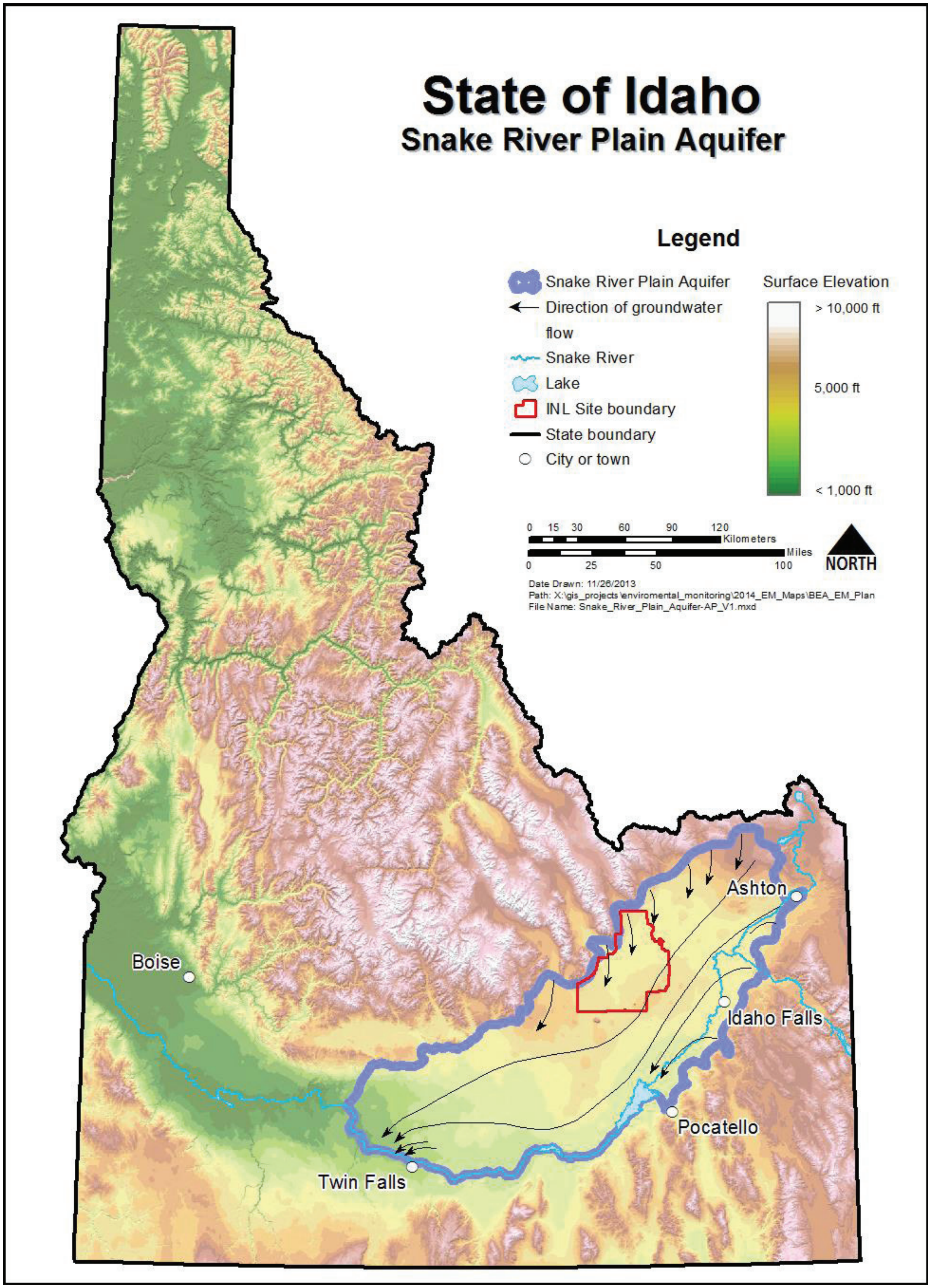

Figure 6-1. The Eastern Snake River Plain Aquifer and Direction of Groundwater Flow.

which flows through the INL Site and helps to recharge the aquifer. The purpose of the monitoring is to ensure that:

- 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 a depression 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 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 (DOE) 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 studies of the eastern Snake River Plain aquifer under 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 2015, USGS personnel collected and analyzed over 1,200 samples for radionuclides and inorganic constituents, including trace elements and 35 samples for purgeable organic compounds along with a special study looking at purgeable organic compounds in 31 wells around Idaho Nuclear Technology and Engineering Center (INTEC) (Maimer and Bartholomay, 2016). USGS INL Project Office personnel also published six 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) 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 Radioactive Waste Management Complex (RWMC). In 2015, the ICP 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 drinking water program. The ICP contractor collected and analyzed over 90 drinking water samples for microbiological hazards, radionuclides, inorganic compounds, and volatile organic compounds (VOCs) in 2015.
- The INL contractor monitors groundwater at the Materials and Fuels Complex (MFC) (WAG 9) (Figure 6-16) 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 2015, the INL contractor sampled and analyzed 206 groundwater and 295 drinking water samples for radionuclides, inorganic compounds, and VOCs.
- The Environmental Surveillance, Education and Research (ESER) contractor collects drinking water samples off the INL Site, as well as samples from natural surface waters. This includes the Big Lost River, which occasionally flows through the INL Site, and springs along the Snake River that are downgradient of the INL Site. A summary of the program may be found in Table 6-4. In 2015, the ESER contractor sampled and analyzed 26 surface and drinking water samples.

Details of the aquifer, drinking water, and surface water programs may be found in the *Idaho National Lab-*

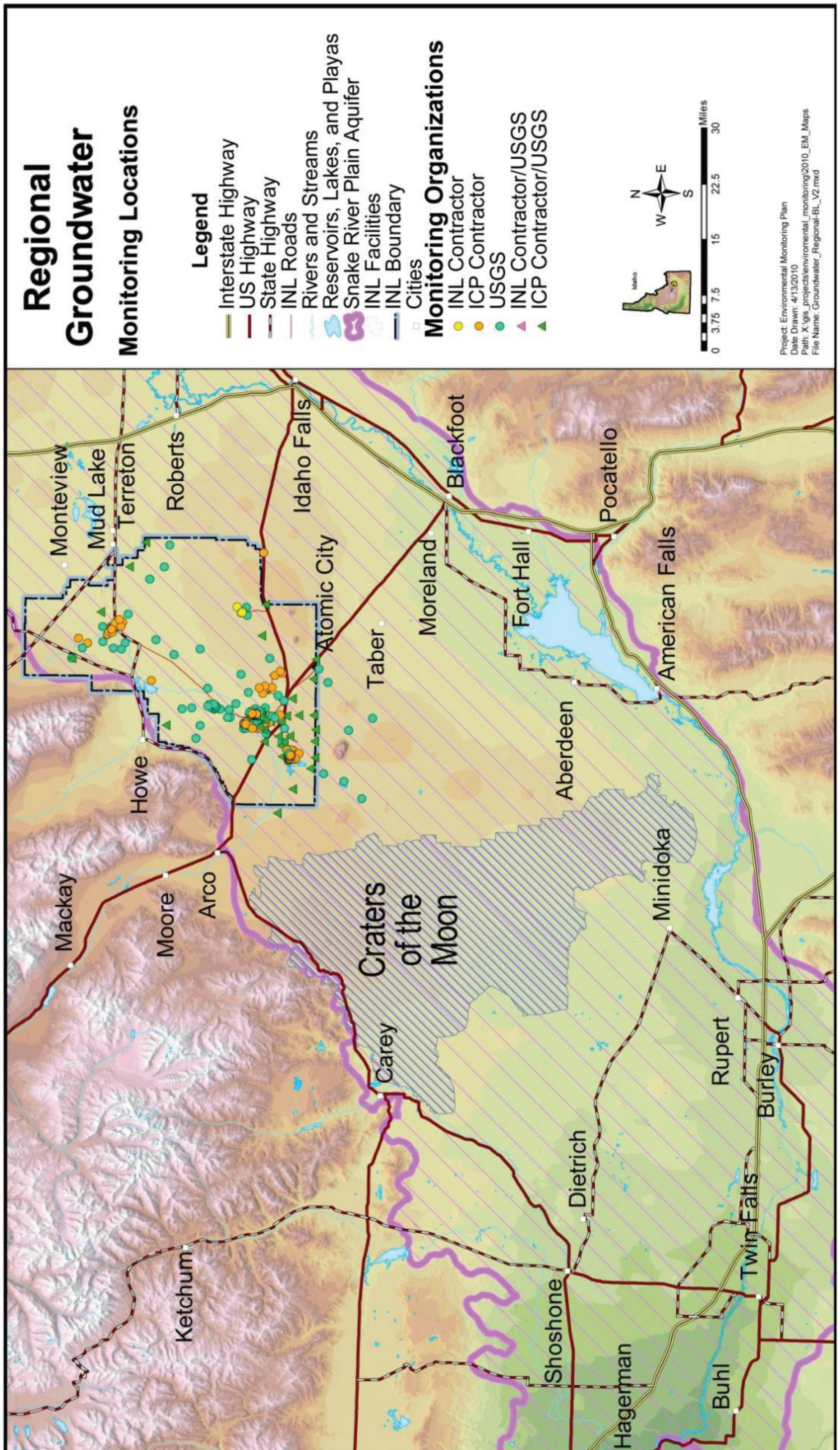

Figure 6-2. Regional Groundwater Monitoring Locations On and Off the INL Site.

Table 6-1. U.S. Geological Survey Monitoring Program Summary (2015).

Constituent	Groundwater		Surface Water		Minimum Detectable Concentration or activity
	Number of Sites[a]	Number of Samples	Number of Sites	Number of Samples	
Gross alpha	50	48	4	1	1.5 pCi/L
Gross beta	50	48	4	1	3.4 pCi/L
Tritium	144	141	7	4	200 pCi/L
Gamma-ray spectroscopy	89	86	4	1	—[b]
Strontium-90	90	88	—[c]	—	2 pCi/L
Americium-241	22	22	—[c]	—	0.03 pCi/L
Plutonium isotopes	22	22	—[c]	—	0.02 pCi/L
Iodine-129	0	0	—[c]	—	<1aCi/L
Specific conductance	144	142	7	4	Not applicable
Sodium ion	138	136	—[c]	—	0.1 mg/L
Chloride ion	144	142	7	4	0.1 mg/L
Nitrates (as nitrogen)	117	116	—[c]	—	0.05 mg/L
Fluoride	4	4	—[c]	—	0.1 mg/L
Sulfate	125	123	—[c]	—	0.1 mg/L
Chromium (dissolved)	74	73	—[c]	—	0.005 mg/L
Purgeable organic compounds[d]	24	35	—[c]	—	Varies
Trace elements	11	11	—[c]	—	Varies

a. Number of samples does not include 12 replicates and 5 blanks collected in 2015. Number of samples was different than the number of sites because one site for VOCs is sampled monthly, and several sites had pump problems and were not sampled, or in the case of surface water in the Big Lost River, three sites were dry. Number of sites does not include 24 zones from 11 wells sampled as part of the multi-level monitoring program.

b. Minimum detectable concentration for gamma spectroscopic analyses varies depending on radionuclide.

c. No surface water samples collected for this constituent.

d. Each purgeable organic compound water sample is analyzed for 61 purgeable organic compounds. Number of samples does not reflect 31 wells sampled for purgeable organic compounds at INTEC as part of a special study.

oratory Site Environmental Monitoring Plan (DOE-ID 2014a) and the *Idaho National Laboratory Groundwater Monitoring Contingency Plan Update* (DOE-ID 2012).

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 environmental data collected in support of ICP and 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 Site Sample and Analysis Management Program consolidates environmental sampling activities and analytical data management. The Sample and Analysis Management Program provides

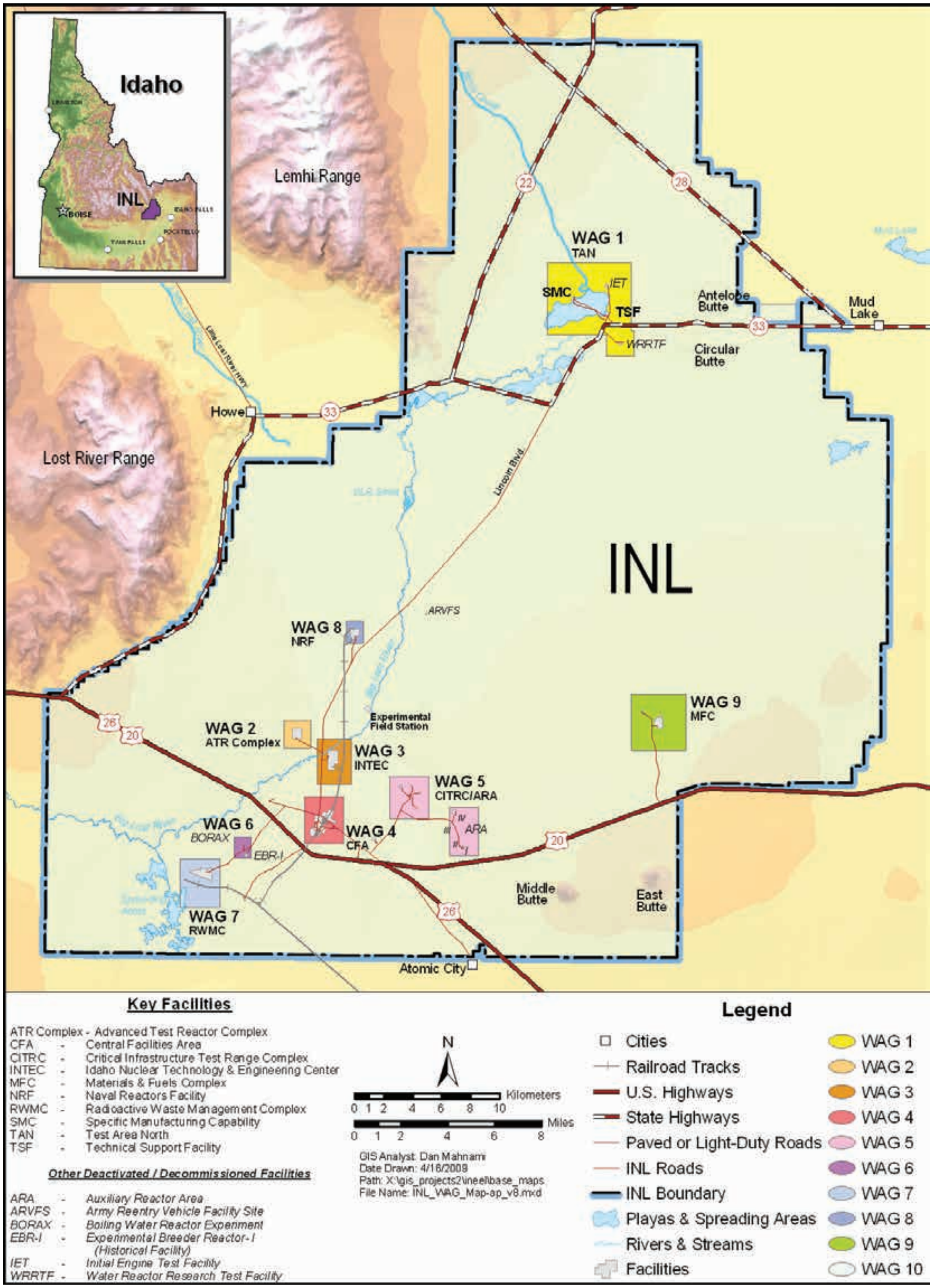

Figure 6-3. Map of the INL Site Showing Locations of Facilities and Corresponding Waste Area Groups.

Table 6-2. Idaho Cleanup Project Contractor Drinking Water Program Summary (2015).

Type of Analysis	Frequency (onsite)	Maximum Contaminant Level
Gross alpha	2 semiannually	15 pCi/L
Gross beta	2 semiannually	4 mrem/yr
Haloacetic acids	1 annually	0.06 mg/L
Total coliform	6 to 8 monthly	If <40 samples/month, no more than one positive for total coliform
E. coli	6 to 8 monthly	Any E. coli positive routine sample
Nitrate	2 annually	10 mg/L (as nitrogen)
Strontium-90	2 annually	8 pCi/L
Total trihalomethanes	1 annually	0.08 mg/L
Tritium	2 annually	20,000 pCi/L
Volatile organic compounds	2 quarterly	Varies

Table 6-3. Idaho National Laboratory Contractor Drinking Water Program Summary (2015).

Type of Analysis	Frequency (onsite)	Maximum Contaminant Level
Gross alpha	9 semiannually	15 pCi/L
Gross beta	9 semiannually	4 mrem/yr
Tritium	11 annually, 11 semiannually	20,000 pCi/L
Iodine-129	1 semiannually	1 pCi/L
Parameters required by the state of Idaho under authority of the Safe Drinking Water Act	9 triennially	Varies
Nitrate	9 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	2 semiannually	Varies

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 www.waterdata.usgs.gov/id/nwis/qw.

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 contractor and USGS above the primary constituent standard in some surveillance wells between INTEC and CFA. Other radionuclides (e.g., gross alpha) have been detected above

Table 6-4. Environmental Surveillance, Education, and Research Surface and Drinking Water Program Summary (2015).

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]	Gross alpha	6 annually	4 semiannually	3 pCi/L
	Gross beta	6 annually	4 semiannually	2 pCi/L
	Tritium	6 annually	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 (if running) at the public rest stop on Highway 20/26, at two locations along Lincoln Boulevard, at EFS, 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.

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 (2011), are shown in Figure 6-4 (Davis et al. 2013). 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 recent time (Figure 6-5). For this reason, these two wells are considered representative of maximum concentration trends in the rest of the aquifer. The average tritium concentration in USGS-065 near ATR Complex decreased from 2,800 ± 90 pCi/L in 2014 to 2,460 ± 100 pCi/L in 2015; the tritium concentration in USGS-114, south of INTEC, decreased from 6,330 ± 140 pCi/L in 2014 to 5,750 ± 120 in 2015.

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 12.3 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.

Strontium-90 – The configuration and extent of ^{90}Sr in groundwater, based on the latest published USGS data, are shown in Figure 6-6 (Davis et al. 2013). 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 2015. 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 (1995–2015) 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 through this period. The general decrease is probably the result of radioactive decay (^{90}Sr has a half-life of 29.1 years), discontinued ^{90}Sr disposal,

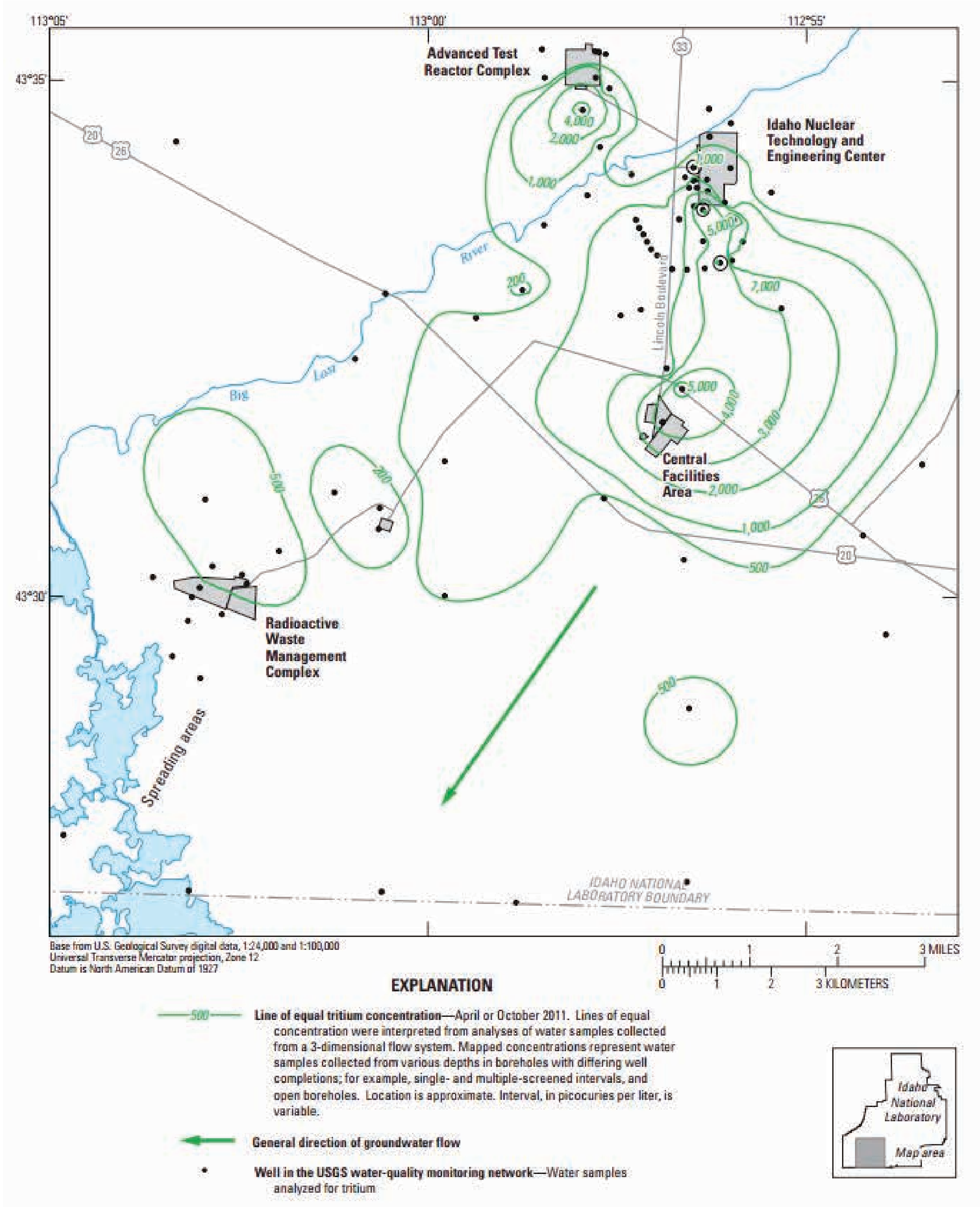

Figure 6-4. Distribution of Tritium in the Eastern Snake River Plain Aquifer on the INL Site in 2011 (from Davis et al. 2013).

advective dispersion, and dilution within the aquifer. 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 that 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

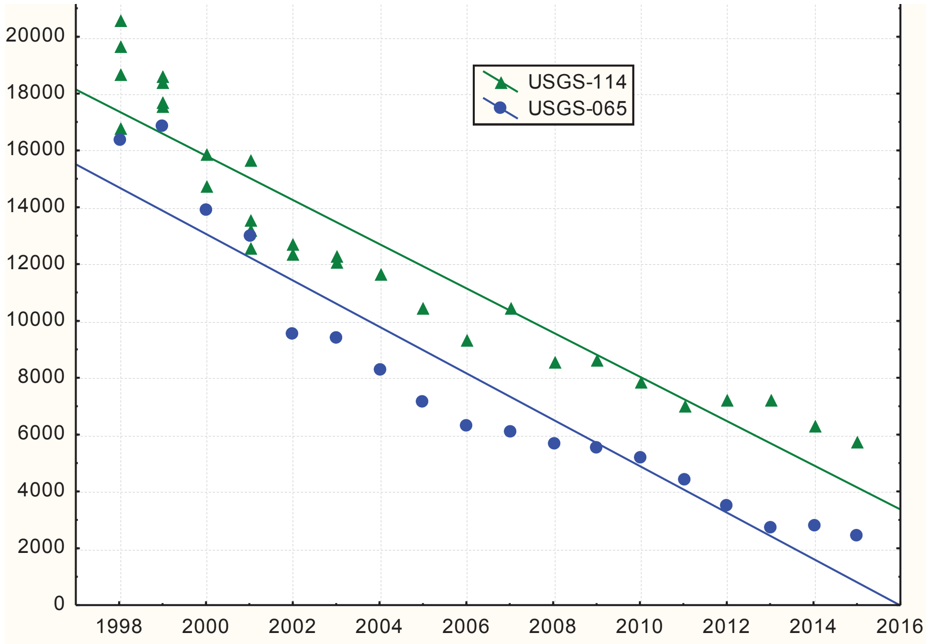

Figure 6-5. Long-Term Trend of Tritium in Wells USGS -065 and -114 (1998 – 2015).

in 2015 are available at www.waterdata.usgs.gov/id/nwis/. Monitoring results for 2009–2011 are summarized in Davis et al. (2013). During 2009–2011, 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 reporting level. In 2009, reportable concentrations of gross alpha radioactivity were observed in 13 of the 52 wells and ranged from 2.7 ± 0.9 to 4.3 ± 1.4 pCi/L. The change in the amount of reportable concentrations was attributed to increasing the sensitivity of the analyses and changing the radionuclide reported for gross alpha radioactivity (Davis et al. 2013). During 2010–11, concentrations of gross-alpha radioactivity in 52 wells sampled were less than the reporting level. Beta radioactivity exceeded the reporting level in 43 of 52 wells sampled, and concentrations ranged from 1.9 ± 0.6 to 19 ± 1.7 pCi/L (Davis et al. 2013).

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, and 2007 were summarized in Mann et al. (1988), Mann and Beasley (1994), and Bartholomay (2009). The USGS sampled for ^{129}I in wells at the INL Site in the fall of 2011 and in the spring and summer of 2012; results were published in Bartholomay (2013). Average concentrations of 15 wells sampled in 1990–91, 2003, 2007, and 2011–12 decreased from 1.15 pCi/L in 1990–91 to 0.173 pCi/L in 2011–12. 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 2011–12 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). Davis et al. (2013) provides a detailed discussion of results for samples collected during 2009–2011. 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 2015 at 72.8 µg/L; 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

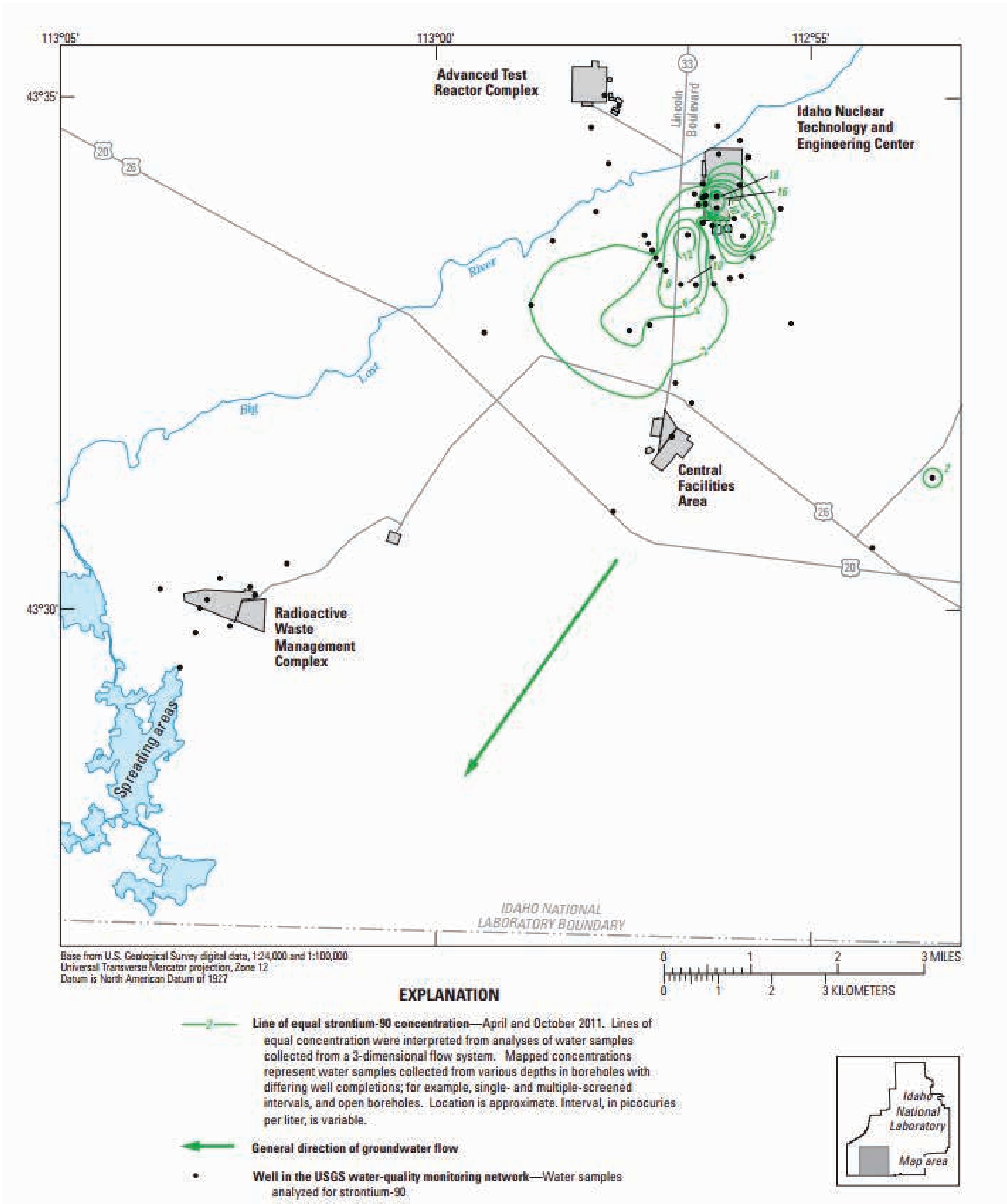

Figure 6-6. Distribution of ^{90}Sr in the Eastern Snake River Plain Aquifer on the INL Site in 2011 (from Davis et al. 2013).

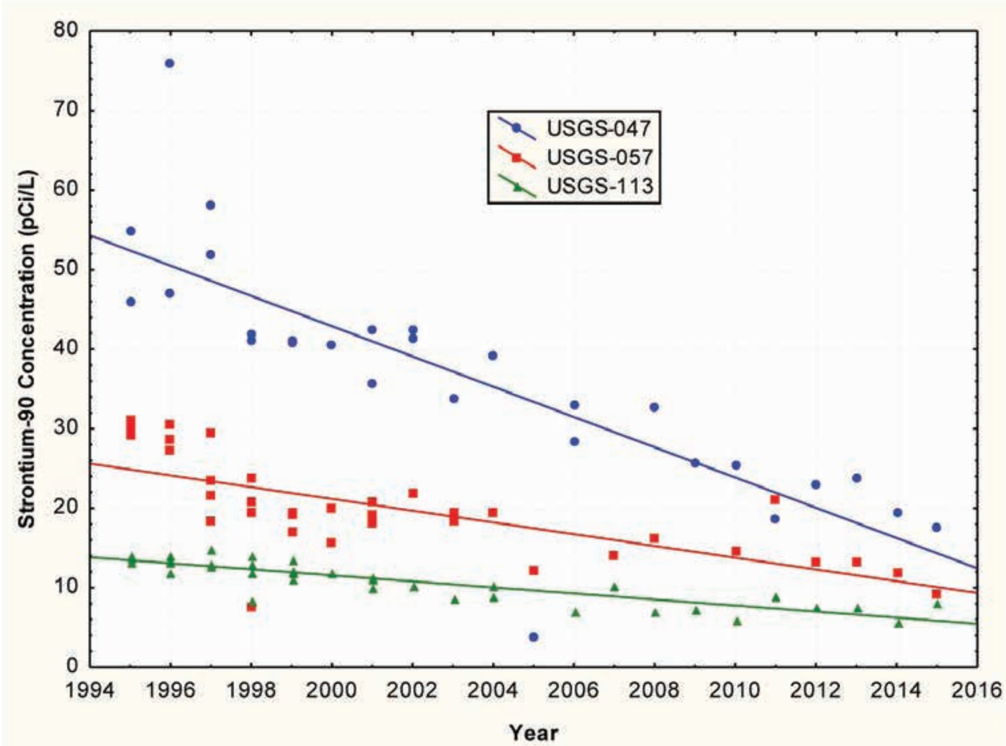

Figure 6-7. Long-Term Trend of ^{90}Sr in Wells USGS-047,-057, and -113 (1995 – 2015).

in many wells at the INL Site, but concentrations were below established MCLs or secondary MCLs (SMCLs) in all wells during 2011 (Davis et al. 2013).

Volatile organic compounds (VOCs) are present in water from the eastern Snake River Plain aquifer because of historical waste disposal practices at INL. The VOCs were used for degreasing, decontamination, and other activities at INL Site facilities. USGS sampled for purgeable (volatile) organic compounds in groundwater at the INL Site during 2015. Samples from 24 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. In addition, as part of a special study (Maimer and Bartholomay, 2016), the USGS collected samples for 49 VOCs from 31 wells around INTEC. 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). Nine purgeable organic compounds were detected above the 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 tetracholoromethane (also known as carbon tetrachloride) were less than the MCL for drinking water (EPA 2013). The production well at the RWMC was monitored monthly for tetrachloromethane during 2015, and concentrations exceeded the MCL of 5 µg/L during 11 of 12 months (Table 6-6). Concentrations have routinely exceeded the MCL for carbon tetrachloride in drinking water (5 µg/L) since 1998 (Note: VOCs are removed from the production well water prior to human consumption—see Section 6.4.4). 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. Davis et al. (2013) indicated that more recent data collected since 2005 may be showing indications that concentrations are leveling off in the RWMC production well. To further test this statement, a trend analyses was run on the dataset from 2005 through 2012 (Davis et al. 2015). The trend test on that dataset still shows a positive increase, but the trend is not considered significant. The lack of a more recent significant

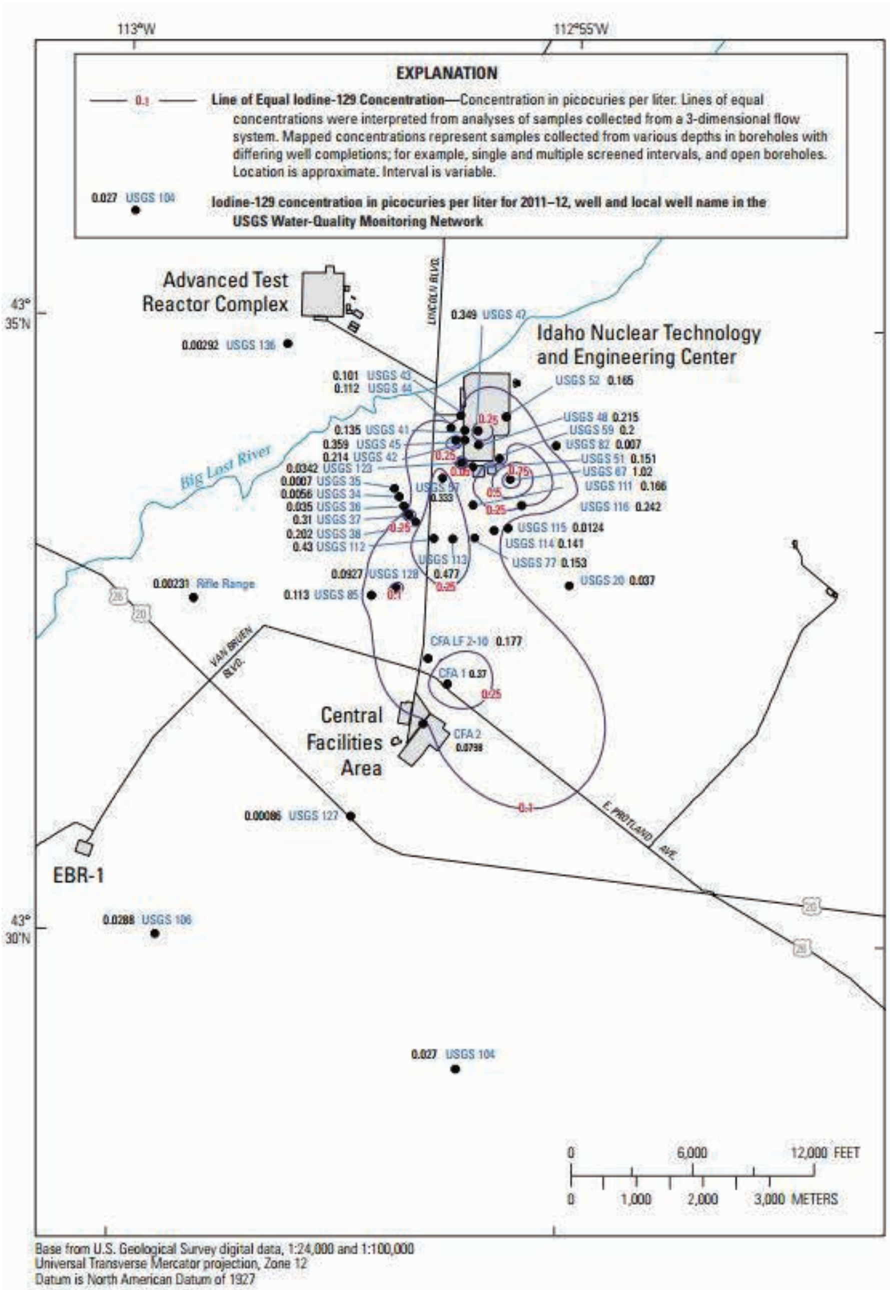

Figure 6-8. Distribution of ^{129}Iodine in the Snake River Plain Aquifer on the INL Site in 2011-12 (from Bartholomay 2013).

increasing trend may indicate that engineering practices designed to reduce VOC movement to the aquifer are having a positive effect.

Tetrachloromethane also exceeded the MCL in one sample collected from Well M7S, north of the RWMC. 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.

Table 6-5. Purgeable Organic Compounds in Annual USGS Groundwater Well Samples (2015).

Constituent[a]	GIN 2	RWMC-M7S	USGS-087	USGS-88	USGS-120
Tetrachloromethane (µg/L) (MCL=5)[b]	ND[c]	5.02	4.34	0.356	0.64
Trichloromethane (µg/L) (MCL=80)	0.14	1.17	0.371	0.435	ND
1,1,1-Trichloroethane (µg/L) (PCS=200)[d]	ND	0.411	0.179	ND	ND
Tetrachloroethene (µg/L) (MCL=5)	1.87	0.373	0.179	ND	ND
Trichloroethene (µg/L) (PCS=5)	7.82	2.67	1.08	0.343	ND

a. GIN 2 contains 0.1 µg/L cis-1,2,-Dichloroethene. TAN-2271 contains 3.47 µg/L cis-1,2-Dichloroethene, 1.93 µg/L vinyl chloride; 36.7 µg/L trans-1,2-Dichloroethene; 0.218 µg/L 1,1-Dichloroethane; and 4.73 µg/L trichloroethene.
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 (2015).

Constituent	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Tetrachloromethane (µg/L) (MCL=5)[a]	6.35	6.91	6.04	5.07	6.7	7.57	6.17	4.12	6.05	5.22	5.84	6.1
Trichloromethane (µg/L) (MCL=80)[b]	2.06	2.15	1.91	2.74	1.88	2.1	1.71	1.18	2.14	1.93	1.82	1.97
Tetrachloroethene (µg/L) (PCS=5)[c]	0.369	0.416	0.340	0.449	0.340	0.386	0.319	0.248	0.437	0.374	0.352	0.364
1,1,1-Trichloroethane (µg/L) (PCS=200)	0.391	0.428	0.356	0.484	0.358	0.367	0.331	0.222	0.412	0.338	0.340	0.350
Trichloroethene (µg/L) (PCS=5)	3.51	3.70	3.24	4.45	3.39	3.76	3.06	2.03	3.88	3.52	3.26	3.46

a. MCL = maximum contaminant level values from the Environmental Protection Agency (40 CFR 141).
b. The MCL for total trihalomethanes is 100 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 Comprehensive Environmental Response, Compensation, and Liability Act Groundwater Monitoring During 2015

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 www.ar.icp.doe.gov. WAG 8 is managed by the Naval Reactors Facility and is not discussed in this report.

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.

In 2015, an ISB rebound test was in progress. During 2015, anaerobic conditions created by ISB remained in the hot spot area, and TCE concentrations were near or below MCLs in all the former ISB injection wells. After background aquifer conditions are re-established, the effectiveness of the ISB part of the remedy will be evaluated (DOE-ID 2016a).

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. 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.

To address the TCE source affecting TAN-28, two wells were drilled and completed in the summer of 2015. ISB injections into the new wells are planned to start in 2016.

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 shutdowns due to maintenance. All 2015 New Pump and Treat Facility compliance samples were below the discharge limits. TCE concentrations used to define the medial zone are based on data collected in 1997 before remedial actions started (Figure 6-9) and do not reflect current concentrations. TCE concentrations in the medial zone wells are significantly lower than the historically defined range of 1,000 to 20,000 μg/L. 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 were less than 60 μg/L in 2015.

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 2015 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 the plume has expanded but is within the limits allowed in the Record of Decision Amendment (DOE-ID 2001).

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 will be evaluated as competing cation concentrations decline toward background conditions during the ISB rebound test to determine if they will meet the remedial action objective of declining below MCLs by 2095.

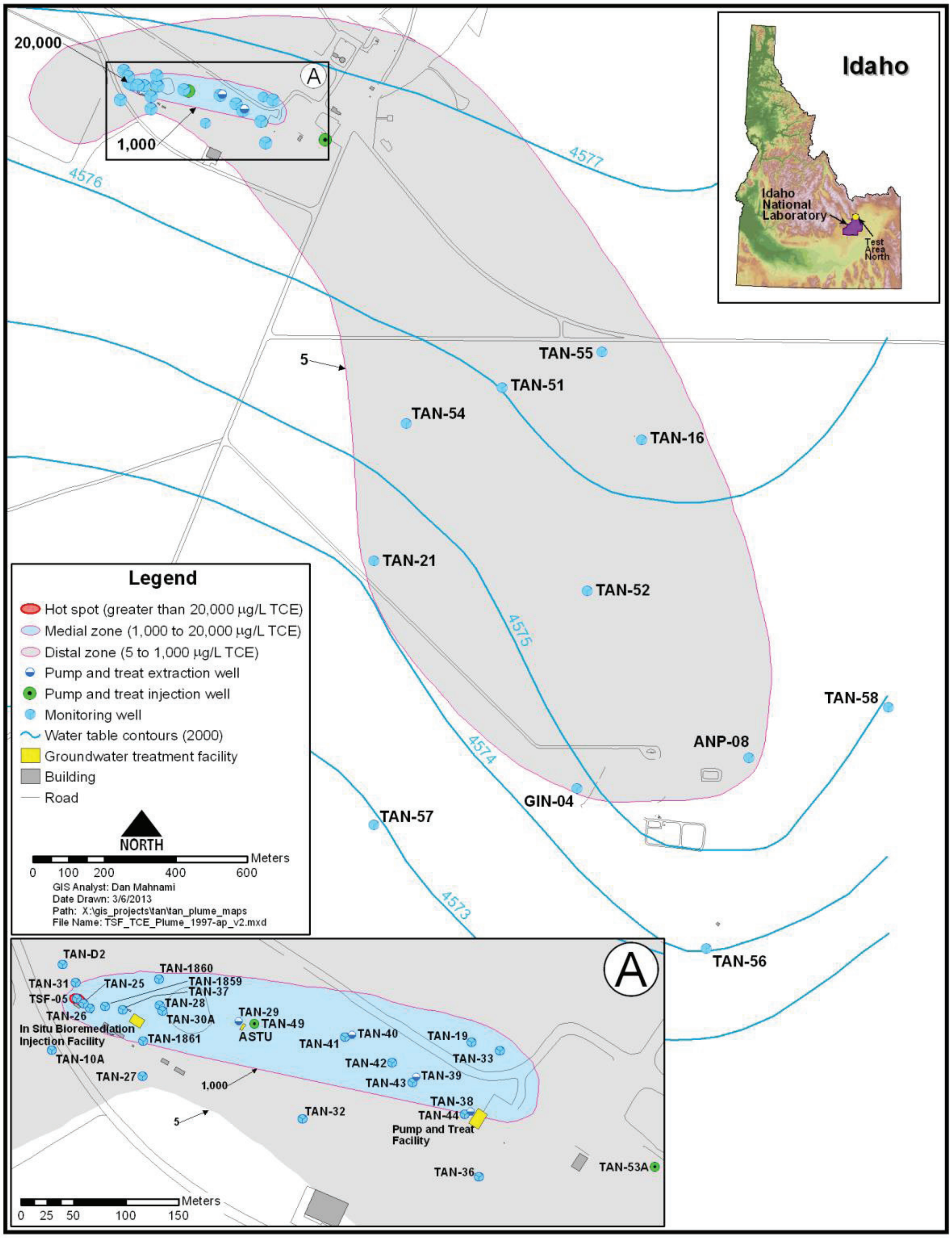

Figure 6-9. Trichloroethene Plume at Test Area North in 1997.

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 2015. 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 (cobalt-60), tritium, and chromium (filtered). The data for the October 2015 sampling event will be included in the Fiscal Year 2016 Annual Report for WAG 2 when it is finalized. The October 2015 sampling data are summarized in Table 6-7.

No analyte occurred above its MCL. The highest chromium concentration occurred in Well TRA-07 at 84.1 µg/L and was below the MCL of 100 µg/L. The chromium concentration in Well USGS-065 was also elevated at 77.4 µg/L. Although chromium increased in both TRA-07 and USGS-065 in 2015, the chromium concentrations in both wells are still 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 8,160 pCi/L in Well TRA-07. In the past, Well TRA-08 had detections of ^{90}Sr, but ^{90}Sr has been below detection limits since October 2010.

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 October 2015 eastern Snake River Plain aquifer water table map prepared for the vicinity of ATR Complex was consistent with previous maps showing similar groundwater flow directions. Water levels in the vicinity of ATR Complex fell approximately 0.48 feet on average from October 2014 to October 2015.

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 2015 (Figure 6-11). Groundwater samples were analyzed for a suite of radionuclides and inorganic constituents, and the data are summarized in the 2015 Annual Report (DOE-ID 2016b). Table 6-8 summarizes the maximum concentrations observed, along with the number of MCL exceedances reported for each constituent.

Strontium-90, technetium-99 (^{99}Tc), total dissolved solids, 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 five of the well locations sampled. During 2015, the highest ^{90}Sr level in eastern Snake River Plain aquifer groundwater was at monitoring Well USGS-047 (16.1 ± 1.47 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 2015, the highest ^{99}Tc level in eastern Snake River Plain aquifer groundwater was at monitoring Well ICPP-MON-A-230 (1,270 ± 72.7 pCi/L), located north of the INTEC Tank Farm. All wells sampled showed stable or declining trends from the previous reporting period.

Table 6-7. WAG 2 Aquifer Groundwater Quality Summary for 2015.

Analyte	MCL[a]	Background[b]	Maximum	Minimum	Number of Wells above MCL
Chromium (filtered) (µg/L)	100	2–3	84.1	1.72	0
Cobalt-60 (pCi/L)	100	0	ND[c]	ND	0
Sr-90 (pCi/L)	8	0	ND	ND	0
Tritium (pCi/L)	20,000	75–150	8,160	ND	0

a. MCL = maximum contaminant level.
b. Background concentrations are from Knobel et al. (1992), except tritium, which is from Orr et al. (1991).
c. ND = not detected.

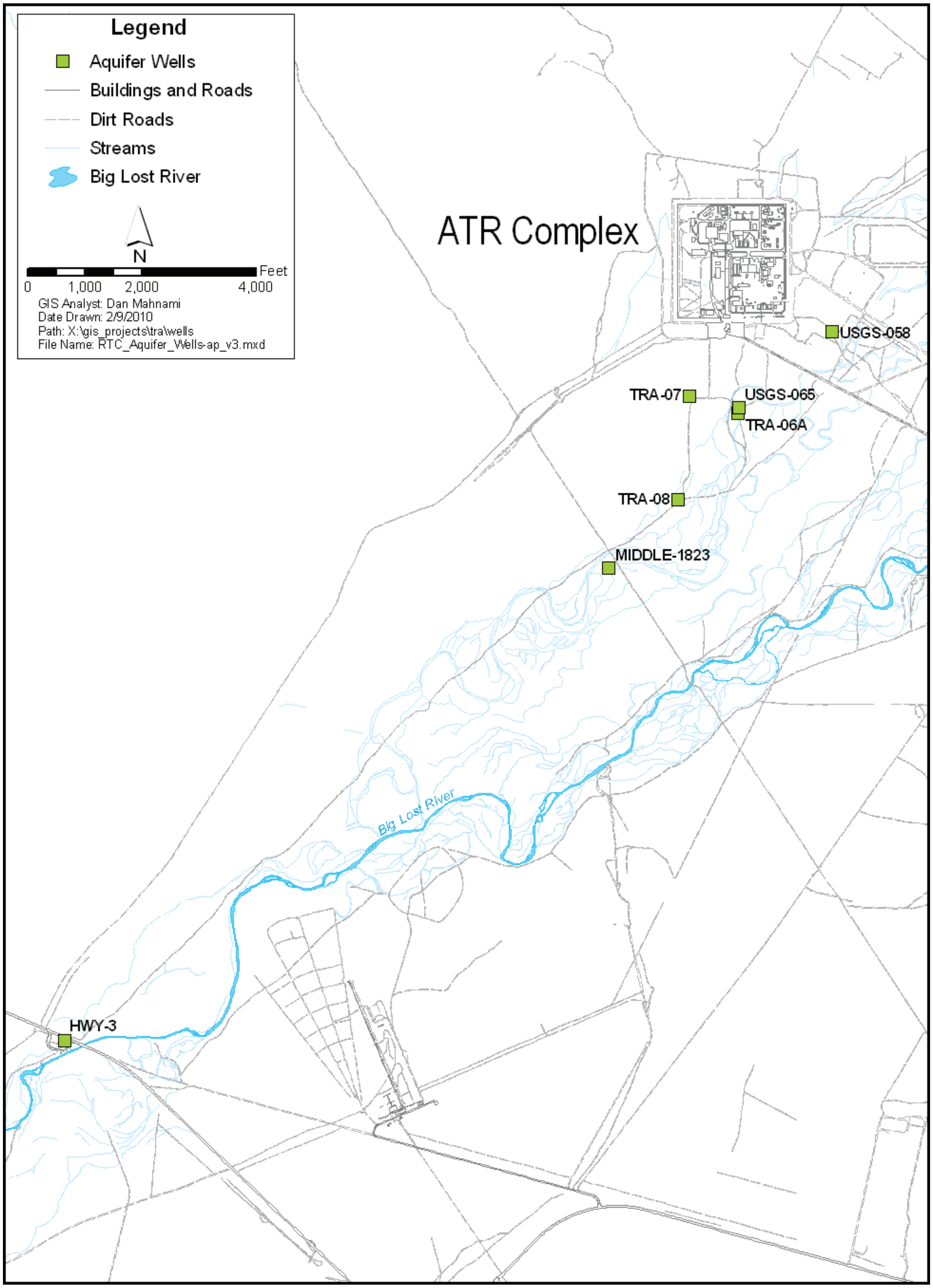

Figure 6-10. Locations of WAG 2 Aquifer Monitoring Wells.

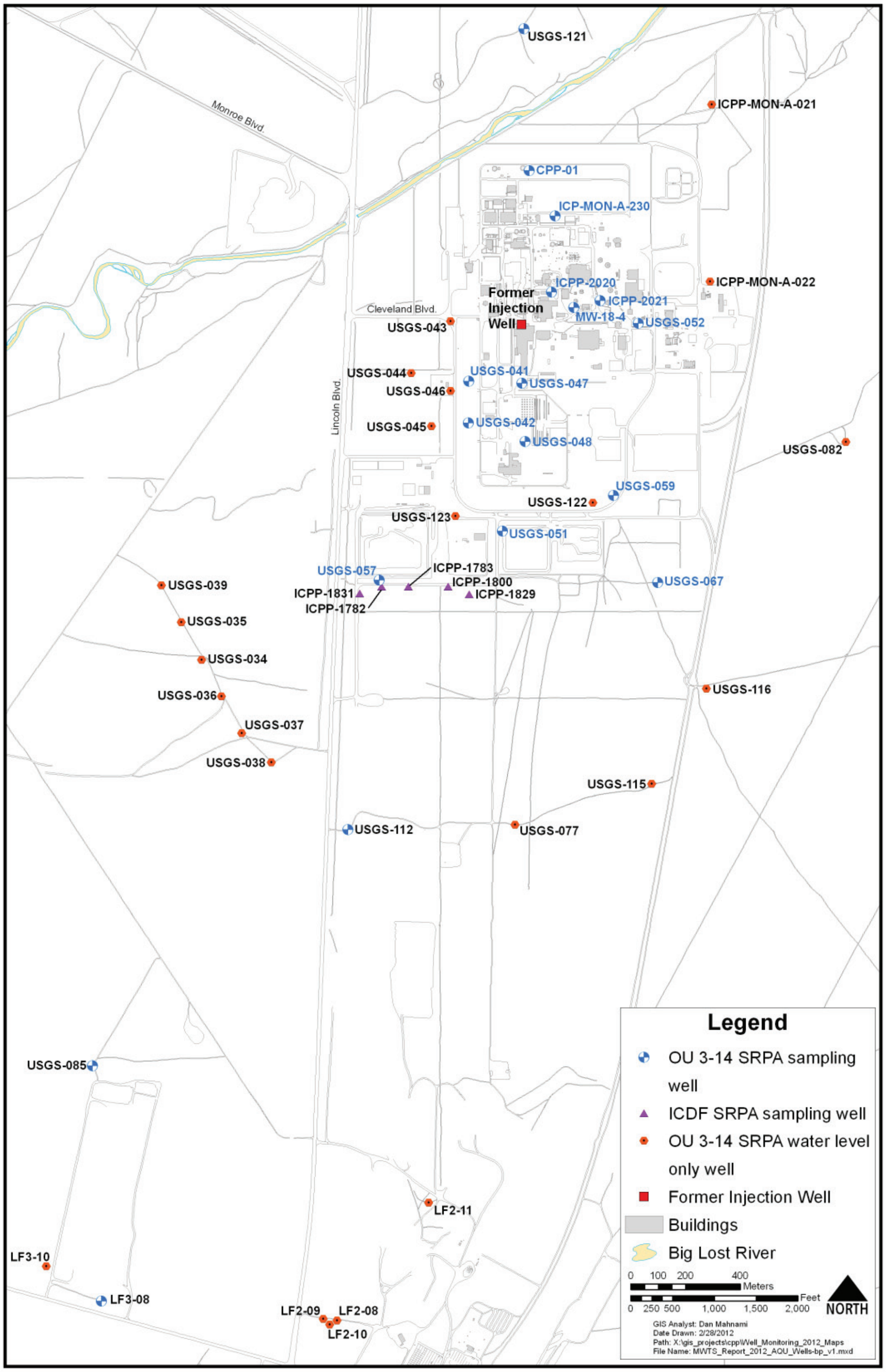

Figure 6-11. Locations of WAG 3 Monitoring Wells.

Table 6-8. Summary of Constituents Detected in WAG 3 Aquifer Monitoring Wells (FY 2015).

Constituent	EPA MCL[a]	Units	Snake River Plain Aquifer Groundwater – March 2015		
			Maximum Reported Value[b]	Number of Results[c]	Results > MCL[c]
Gross alpha	15	pCi/L	ND[d]	18	0
Gross beta	NA[e]	pCi/L	552 ± 6.58	18	NA
Cesium-137	200	pCi/L	ND	18	0
Strontium-90	8	pCi/L	**16.1 ± 1.47**[f]	18	5
Technetium-99	900	pCi/L	**1,270 ± 72.7**	18	1
Iodine-129	1	pCi/L	ND	18	0
Tritium	20,000	pCi/L	3,620 ± 399	18	0
Plutonium-238	15	pCi/L	ND	18	0
Plutonium-239/240	15	pCi/L	ND	18	0
Uranium-233/234	15	pCi/L	2.63 ± 0.507	18	0
Uranium-235	15	pCi/L	0.116 ± 0.0492 J	18	0
Uranium-238	15	pCi/L	1.21 ± 0.331	18	0
Bicarbonate	NA	mg/L	317	18	NA
Calcium	NA	mg/L	69.1	18	NA
Chloride	250	mg/L	135	18	0
Magnesium	NA	mg/L	23.5	18	NA
Nitrate/Nitrite (as N)	10	mg/L	**14.6 J**	18	1
Potassium	NA	mg/L	5.0	18	NA
Sodium	NA	mg/L	30.8	18	NA
Sulfate	250	mg/L	42.1	18	0
Total dissolved solids	500	mg/L	**537**	18	2

a. EPA = Environmental Protection Agency; MCL = maximum contaminant level.
b. Data-qualifier flags: J = estimated value.
c. Does not include field duplicates.
d. ND = constituent not detected in any sample.
e. NA = not applicable.
f. **Bolded** values exceed MCL.

Nitrate was detected in all wells sampled during this reporting period. The highest concentration was reported at Well ICPP-2021-AQ (14.6 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 concentrations were below detection limits at all well 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 USGS-51, near the former percolation ponds (3,620 ± 399 pCi/L), and Well ICPP-2021-AQ, southeast of the Tank Farm (3,400 ± 379 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 (1.21 ±

0.331 pCi/L) near Central Facilities Area (CFA). Similarly, uranium-234 (^{234}U) also was detected in all groundwater samples, with concentrations ranging as high as 2.63 ± 0.507 pCi/L at Well LF3-08. Uranium-234 is the daughter product of alpha decay of the long-lived, naturally occurring ^{238}U. The higher uranium concentrations at Well LF3-08 are believed to be associated with suspended sediment in the unfiltered sample from this location. Because the water table at this location has declined to within approximately 10 ft of the bottom of the well, Well LF3-08 had to be sampled with a bailer instead of a submersible pump. As a result, the field notes indicate the groundwater sample from LF3-08 was very muddy and sandy. Excessive turbidity likely explains the elevated uranium activities because 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 similar 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 only two groundwater samples: Wells MW-18-4 (0.116 ± 0.0492J pCi/L) and USGS 041 (0.114 ± 0.0507J pCi/L). 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.

The 2015 groundwater contour map is similar in shape to the maps prepared for previous years, although water elevations vary slightly from year to year in response to wet-dry climate cycles. Groundwater levels declined during 2000–2005 as a result of the drought during this period. However, as a result of near normal precipitation during 2005–2015 and corresponding periods of flow of the Big Lost River, groundwater levels have remained relatively constant during this period.

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 2015 Monitoring Report (DOE-ID 2016c).

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. Nitrate concentrations decreased in 2015 to 13.6 mg/L-N in CFA-MON-A-002, and the data has exhibited a decreasing trend since 2006.

The nitrate concentration of 8.2 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 2015, chloroform was the only VOC detected downgradient from the CFA landfills. The source of the chloroform in the groundwater is uncertain because the soil gas samples do not indicate a source in the landfills for this compound that appears capable of causing the groundwater contamination.

A comparison of the maximum detected concentrations for filtered metals to background and the defined regulatory levels shows that all metals, except aluminum and iron, were below MCLs, SMCLs, or action levels in all the landfill wells. The aluminum concentration in LF3-08 exceeded the upper SMCL of 200 µg/L, but the high aluminum concentration is inconsistent with the near neutral pH condition in this well. Iron concentrations exceeded the SMCL of 300 µg/L in Wells LF3-08 and LF3-10. However, these iron concentrations are inconsistent with the high dissolved oxygen levels (5.73 and 5.53 mg/L) in these wells and pH readings of 6.42 to 6.81. Although precautions were taken to guard against filter breakthrough, like monitoring backpressure, it is possible that particles less than 0.45 microns may have gone through the filter, or the filter may have experienced a minor breakthrough.

Water-level measurements taken in the CFA in 2015 suggest that after the sharp drop in water levels

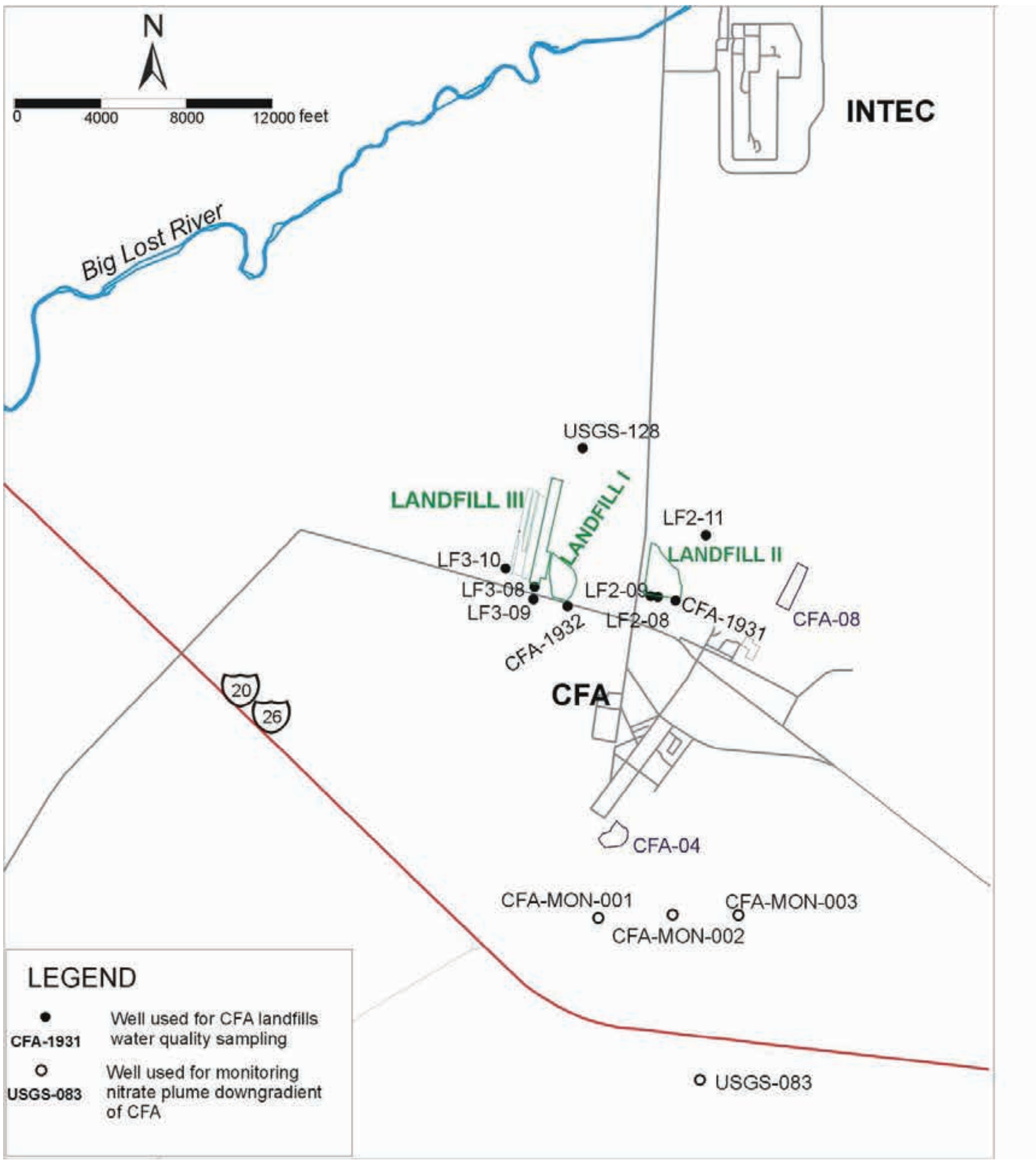

Figure 6-12. Locations of WAG 4/CFA Monitoring Wells Sampled in 2015.

Table 6-9. Comparison of WAG 4 Groundwater Sampling Results to Regulatory Levels (2015).

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]	65.9	0
Fluoride (mg/L)	2	0.249	0
Sulfate (mg/L)	*250*	30.8	0
Nitrate/nitrite (mg-N/L)	10	**13.6**[d]	1
Central Facilities Area Landfill Wells			
Anions			
Chloride (mg/L)	*250*	69.8	0
Fluoride (mg/L)	2	0.211	0
Sulfate (mg/L)	*250*	43.6	0
Nitrate/nitrite (mg-N/L)	10	2.58	0
Common Cations			
Calcium (µg/L)	None	59,100	NA[e]
Magnesium (µg/L)	None	19,200	NA
Potassium (µg/L)	None	5,720	NA
Sodium (µg/L)	None	33,700	NA
Inorganic Analytes			
Antimony (µg/L)	6	ND[f]	0
Aluminum (µg/L)	*50–200*	**217**	1
Arsenic (µg/L)	10	2.61	0
Barium (µg/L)	2,000	95.7	0
Beryllium (µg/L)	4	ND	0
Cadmium (µg/L)	5	ND	0
Chromium (µg/L)	100	39.4	0
Copper (µg/L)	*1,300/1,000*	1.88	0
Iron (µg/L)	300	**1,200**	2
Lead (µg/L)	15	1.03	0
Manganese (µg/L)	50	12.5	0
Mercury (µg/L)	2	ND	0
Nickel (µg/L)	None	112	NA
Selenium (µg/L)	50	2.01	0
Silver (µg/L)	100	ND	0
Thallium (µg/L)	2	ND	0
Vanadium (µg/L)	None	7.46	NA
Zinc (µg/L)	*5,000*	279	0
Detected Volatile Organic Compounds			
Chloroform (µg/L)	100	0.88	0

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

from 2000 to 2005, water levels appear to be stabilizing, having changed little since 2005. A water table map produced from water levels collected in July 2015 was consistent with previous maps in terms of gradients and groundwater flow directions (DOE-ID 2016c).

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 2015 were analyzed for radionuclides, inorganic constituents, VOCs, and 1,4-dioxane. Of the 322 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 2015, but did not exceed its MCL (5 µg/L). The carbon tetrachloride concentrations declined overall in wells near, upgradient, and downgradient of the RWMC (Figure 6-13).
- ***Gross beta*** — There were no reportable detections of radiological analytes in 2015. However, gross beta activity was detected above the regional background concentration (7 pCi/L) in a sample collected from Well M16S (31 ± 3 pCi/L).
- ***Tetrachloroethylene*** — Tetrachloroethylene was the only analyte detected in the groundwater above its MCL (5 µg/L). Tetrachloroethylene was detected at Well MIDDLE-2051 Port 12, 604-ft depth (5.84 µg/L), and above the quantitation limit (1 µg/L) in MIDDLE 2051 Port 9, 750-ft depth (2.78 µg/L). These results are suspect due to the upgradient location of MIDDLE-2051 (Figure 6-14) and no previous tetrachloroethylene detections at this location. An evaluation is being conducted to confirm or reject these detections.
- ***Trichloroethylene*** — Trichloroethylene concentrations either decreased or changed only slightly in November 2015, as compared with previous results.
- ***Inorganic analytes*** — Inorganic analytes were not detected above reporting thresholds in groundwater samples in 2015.

As in previous years, groundwater level measurements in RWMC-area monitoring wells during 2015 indicate groundwater flow to the south-southwest (Figure 6-15).

6.5.8 Summary of Waste Area Group 9 Groundwater Monitoring Results

Five wells (four monitoring and one production) at the Materials and Fuels Complex are sampled twice a

Table 6-10. Summary of WAG 7 Aquifer Sampling and Analyses for Relevant Analytes in 2015.

Analyte	Number of Wells Sampled	Number of Analyses[a]	Number of Reportable Detections[a, b]	Concentration Maximum[a]	Number of Detections Greater Than MCL[a]	MCL[c]
Carbon tetrachloride	11	17	6	4.91 µg/L	0	5 µg/L
Gross beta	11	14	1	31 ± 3 pCi/L	0	NA
Tetrachloroethylene	11	14	2	5.84 µg/L	1	5 µg/L
Trichloroethylene	11	14	4	2.74 µg/L	0	5 µg/L

a. Includes field duplicate samples collected for quality control purposes.
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).

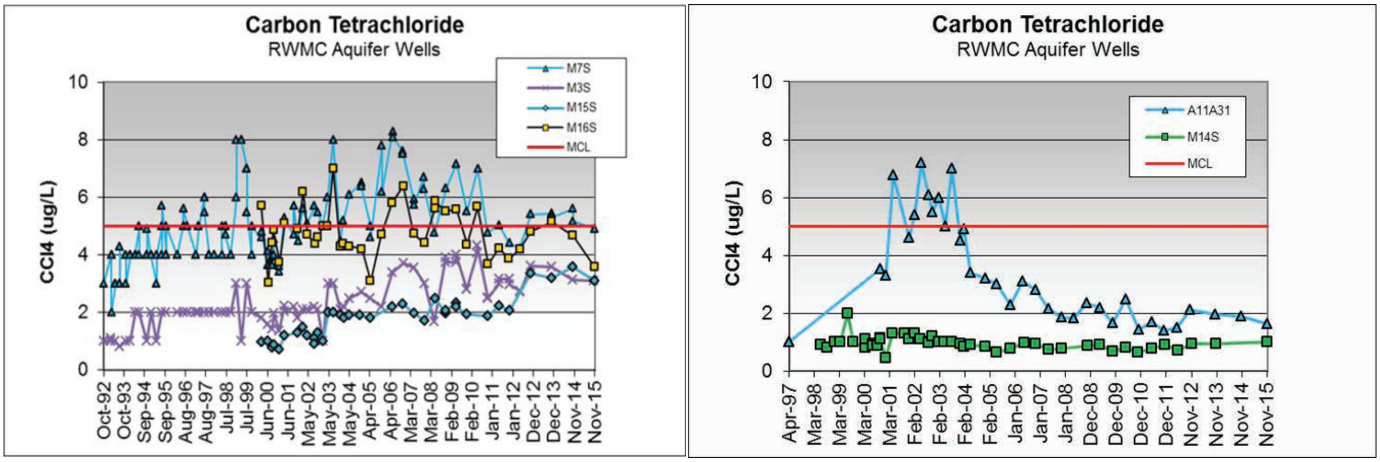

Figure 6-13. Concentration History of Carbon Tetrachloride for Wells Near, Upgradient, and Downgradient of the Radioactive Waste Management Complex.

year by the INL contractor for selected radionuclides, metals, total organic carbon, total organic halogens, and other water quality parameters, as required under the WAG 9 Record of Decision (Figure 6-16; 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 Materials and Fuels Complex.

6.5.9 Summary of Waste Area Group 10 Groundwater Monitoring Results

In accordance with the Operable Unit 10-08 monitoring plan (DOE-ID 2014b), groundwater samples are collected every two years at the locations shown on Figure 6-17. In 2015, eight wells were sampled, and six intervals from three Westbay wells were sampled (DOE-ID 2016d). Groundwater samples were analyzed for VOCs, metals (filtered), anions, and radionuclides (i.e., ^{129}I, tritium, ^{99}Tc, gross alpha, and ^{90}Sr). No contaminant exceeded EPA MCLs, and only iron exceeded its SMCL (Table 6-12). The only iron detection above the SMCL was questionable because its occurrence is inconsistent with background dissolved oxygen and pH values.

6.6 Onsite Drinking Water Sampling

The INL and ICP 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 contractor monitor these systems to ensure a safe working environment. The INL contractor monitors nine of these drinking water systems, ICP contractor monitors two, and Naval Reactors Facility has 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 water systems. The five INL contractor transient, non-community water systems are at the Experimental Breeder Reactor-I (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/Contained Test Facility (CTF). The two ICP contractor non-transient, non-community water systems are INTEC and the RWMC, which also supplies drinking water to the Advanced Mixed Waste Treatment Project facilities.

As required by the state of Idaho, the INL contractor and the ICP 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

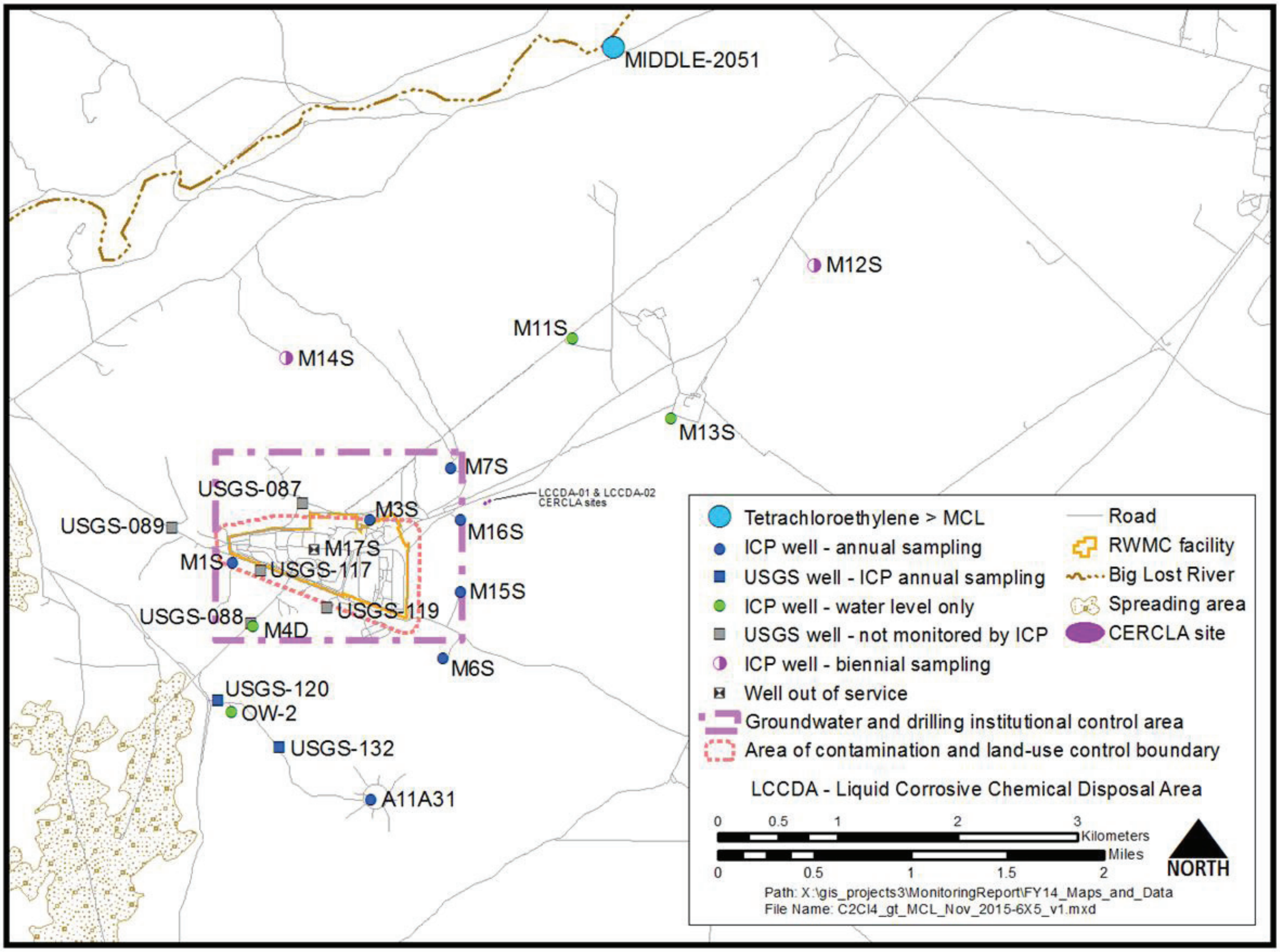

Figure 6-14. Aquifer Monitoring Wells Near the Radioactive Waste Management Complex and the Location Where Tetrachloroethylene Exceeded its MCL in November 2015.

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 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 contractor drinking water systems during months of operation. Because of known groundwater plumes near two INL contractor drinking water wells and one ICP contractor drinking water well, additional sampling is conducted for tritium at CFA, for trichloroethylene at TAN/TSF, and for carbon tetrachloride at RWMC.

During 2015, DEQ performed sanitary surveys on all INL Site drinking water systems (except EBR-I, INTEC, and RWMC). No deficiencies were identified in any of the systems.

6.6.1 INL Site Drinking Water Monitoring Results

During 2015, the INL contractor collected 295 routine samples and 22 quality control samples from nine INL Site drinking water systems. In addition to routine samples, the INL contractor also collected 33 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 2015. The quality control

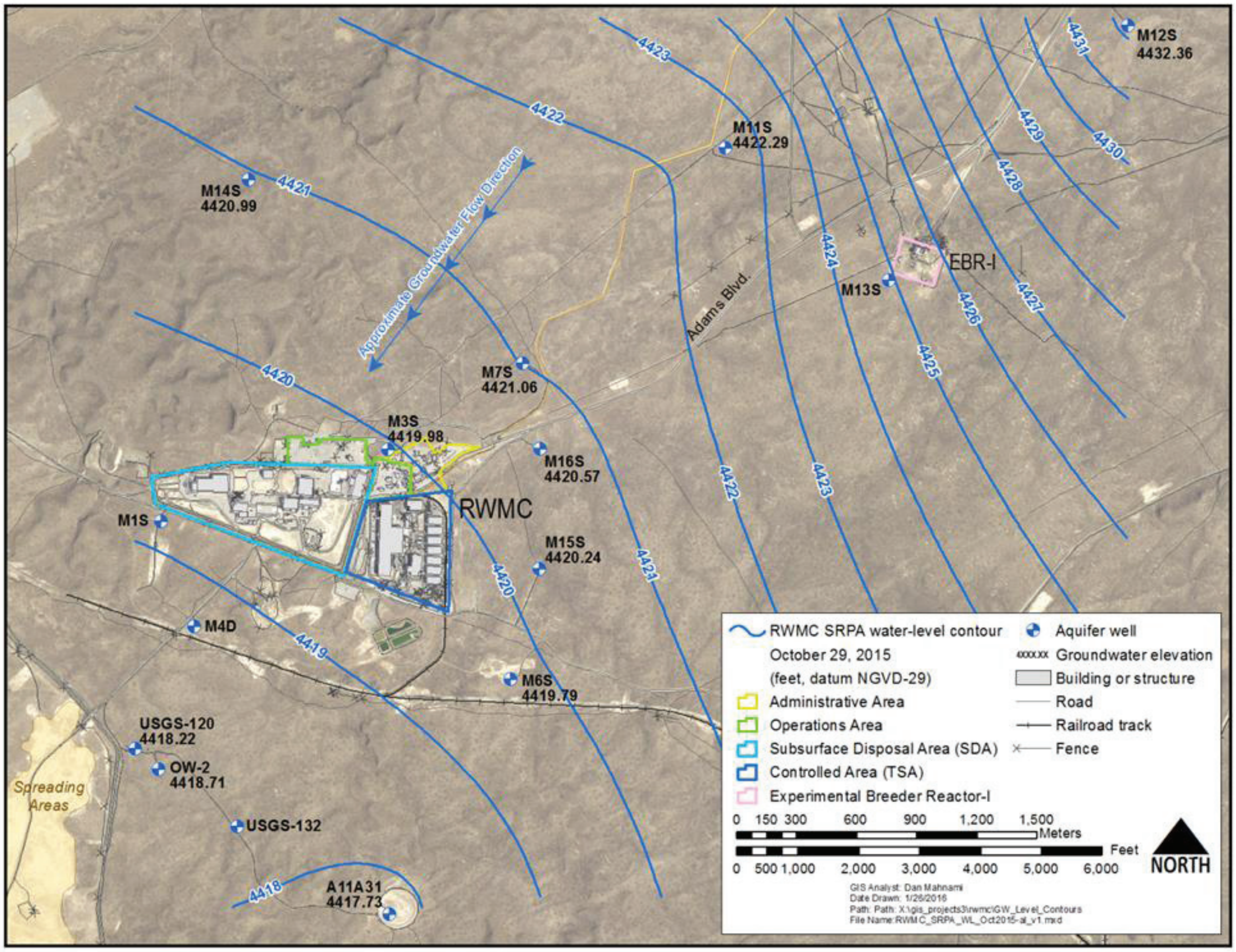

Figure 6-15. Groundwater-Level Contours in the Aquifer Near the Radioactive Waste Management Complex Based on November 2015 Measurements.

program associated with these data is discussed in Section 11.3.2.4.

Drinking water systems at EBR-I, CITRC, Gun Range, 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 3.02 mg/L at CFA and 1.75 mg/L at MFC. Total coliform bacteria and E. coli was detected, in October 2015, at the Main Gate (Badging Facility) water system. Samples with positive detections were collected from an outside tap while samples from the well did not identify E. coli or total coliform bacteria. The total coliform detected in the distribution system was attributed to stagnant water and limited use (two permanent employees). The water system and well was remedied through chlorination and total coliform or E. coli was not detected after resampling. No other compliance samples were positive for bacteria in 2015.

Total trihalomethanes (TTHMs) and haloacetic acids (HAA5s), which are disinfectant by-products, were sampled at MFC and ATR Complex. The highest concentration of TTHMs were 3.5 ppb at TAN/CTF while HAA5s were non-detects. The MCL is 80 ppb for TTHMs and 60 ppb for HAA5s.

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 con-

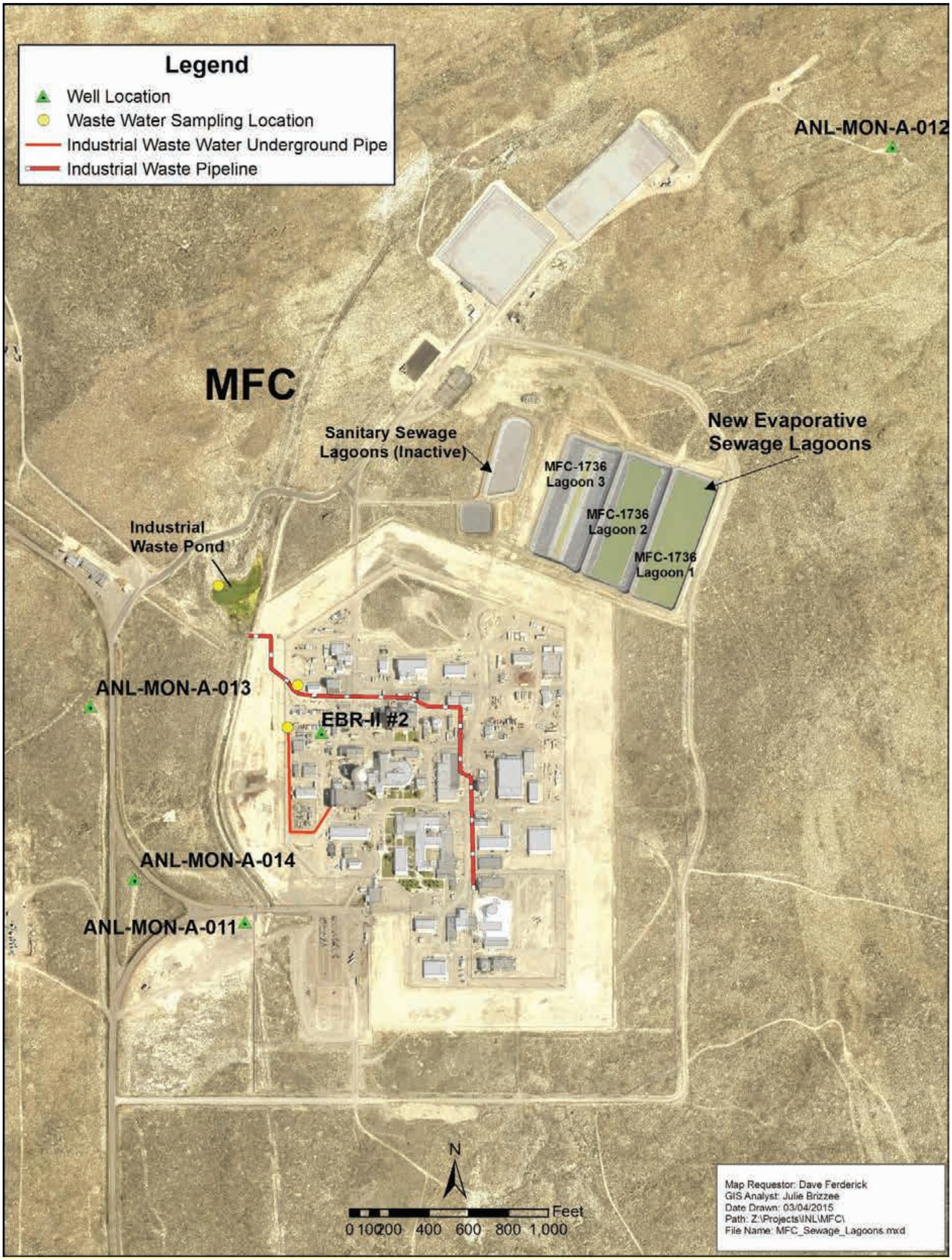

Figure 6-16. Locations of WAG 9 Wells Sampled in 2015.

Table 6-11. Comparisons of Detected Analytes to Drinking Water Standards at WAG 9 Monitoring Wells (2015).

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:	**04/29/2015**	**0923/2015**	**04/28/2015**	**09/22/2015**	**04/28/2015**	**09/22/2015**	**04/28/2015**	**09/22/2015**	**4/29/2015**	**09/23/2015**	
Radionuclides[c]											
Gross alpha (pCi/L)	ND[d]	ND	ND	ND	ND	ND	ND	ND	ND (ND)[f]	2.17 ± 0.443	15 pCi/L
Gross beta (pCi/L)	2.96 ± 0.676	5.07 ± 0.548	3.1 ± 0.391	4.43 ± 0.523	2.8 ± 0.459	4.69 ± 6.26	3.53 ± 0.61	4.15 ± 0.544	2.39 ± 0.381 (2.67 ± 0.585)	3.48 ± 0.506	4 mrem/yr
Uranium-233/234 (pCi/L)	1.51 ± 0.196	1.52 ± 0.183	1.38 ± 0.186	1.46 ± 0.188	1.19 ± 0.153	1.33 ± 0.168	1.70 ± 0.227	1.41 ± 0.175	1.19 ± 0.169 (1.51 ± 0.209)	1.28 ± 0.156	186,000 pCi/L (30 µg/L)
Uranium-238 (pCi/L)	0.533 ± 0.0998	0.733 ± 0.111	0.505 ± 0.0975	0.715 ± 0.116	0.648 ± 0.102	0.769 ± 0.116	0.684 ± 0.124	0.678 ± 0.107	0.676 ± 0.116 (0.525 ± 0.107)	0.623 ± 0.0966	9.9 pCi/L (30 µg/L)
Metals											
Aluminum (µg/L)	8.87 [2.05]	9.23 [29.9]	7.87[4.58]	7.99 [3.59]	45.3 [2.14]	18.1 [2.94]	3.14 [5.12]	4.53 [1.87]	1.96 [1.98] (2.1) [(2.18)]	21.1 [8.07]	200
Antimony (µg/L)	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U (0.4 U)	0.4 U	6
Arsenic (µg/L)	2.29	2.38	2.25	2.18	2.26	1.97	2.27	2.13	2.11 (2.22)	2.27	50
Barium (µg/L)	36.2	35.3	37.5	37.6	35.2	36	40.5	37.3	35.5 (35.4)	36.1	2,000
Calcium (mg/L)	38.3	37.0	38.3	38.0	38.2	37.8	41.3	37.7	38.3 (38.2)	38.0	NE[e]
Chromium (µg/L)	6.22	3.32	2.5 U	2.5 U	4.47	5.55	9.96	4.05	2.5 U (2.5 U)	2.5 U	100
Copper (µg/L)	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	3.6 (6.27)	6.91	1,300
Iron (µg/L)	**306**[g] [50 U][f]	248 [50 U]	144 50 U]	121 [50 U]	**686** [50 U]	**760** [50 U]	67.8 [50 U]	64.7 [50 U]	50 U [50 U]	50 U [50 U]	300
Lead (µg/L)	0.5 U	0.5 U	0.5 U	0.5 U	0.679	0.5 U	0.5 U	0.5 U	1.08 (1.53)	4.02	15
Magnesium (mg/L)	12.4	11.8	11.7	11.7	12.2	12.1	13.5	12.2	12.1 (12.1)	12.0	NE
Manganese (µg/L)	2.5 U	2.5 U	3.3	2.98	11.6	11.9	2.5 U	2.5 U	2.5 U (2.5 U)	2.5 U	
Nickel (µg/L)	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	6.51 (7.3)	101	NE
Potassium (mg/L)	3.28	3.25	3.43	3.37	3.32	3.38	3.43	3.28	3.21 (3.22)	3.23	NE
Selenium (µg/L)	0.519	0.737	0.502	0.793	0.5 U	0.721	0.633	0.734	0.5 U (0.5 U)	0.694	50
Sodium (mg/L)	19.6	18.8	17.9	17.3	18.8	18.5	23.7	22.0	17.8 (17.8)	17.3	NE
Vanadium (µg/L)	5.83	5.9	5.35	4.93	5.88	6.41	6.21	7.07	5.81 (5.48)	5.15	NE
Zinc (µg/L)	2.5 U	2.5 U	3.89	4.04	3.33	2.5 U	2.5 U	2.5 U	21.9 (25.3)	126	5,000
Anions											
Chloride (mg/L)	21.9	19	18.2	17.5	19.3	19.8	26.3	20.8	19 (18.9)	17.8	250
Nitrate-as nitrogen (mg/L)	2.48	2.24	2.14	2.09	2.19	2.1	2.84	2.36	2.16 (2.18)	2.1	10
Phosphorus (mg/L)	0.0134	0.0208	0.0138	0.0171	0.0149	0.0279	0.0134	0.0177	0.0132 (0.0114)	0.0179	NE

Table 6-11. Comparisons of Detected Analytes to Drinking Water Standards at WAG 9 Monitoring Wells (2015). (cont.)

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]
Sulfate (mg/L)	20.3	18.2	17.1	17	18.9	19.4	31.3	23.2	18 (18)	17.3	250
Water Quality Parameters											
Alkalinity (mg/L)	140	146	144	149	147	148	141	153	140 (141)	141	NE
Bicarbonate alkalinity (mg/L)	140	146	144	149	147	148	141	153	140 (141)	141	NE
Total dissolved solids (mg/L)	248	227	240	224	241	217	280	244	232 (237)	228	500
Total organic carbon (mg/L)	0.535	0.406	0.454	0.386	0.517	0.426	0.55	0.412	0.448 (0.446)	0.37	NE

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. NE = not established. A primary or secondary constituent standard has not been established for this constituent.
f. Results in parentheses are field duplicate. Results in brackets are filtered (i.e., dissolved) concentrations.
g. Concentrations shown in bold are above the Ground Water Quality Rule SCS. Filtered sample results, shown in brackets, are below the SCS.

centrations in groundwater have been decreasing (Figure 6-18) 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 2015, Well CFA# 1 was used to supply approximately 25 percent of drinking water at CFA. Well CFA# 2 was used to supply approximately 75 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 2015 dose calculation, it was assumed that each worker's total daily water intake would come from the CFA drinking water distribution system. This assumption 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 2015, as calculated from samples taken from the CFA distribution system, was 0.186 mrem (1.86 µSv). This value is below the EPA standard of 4 mrem/yr for public drinking water systems. See section 8.4 for more information.

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 2015, 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.

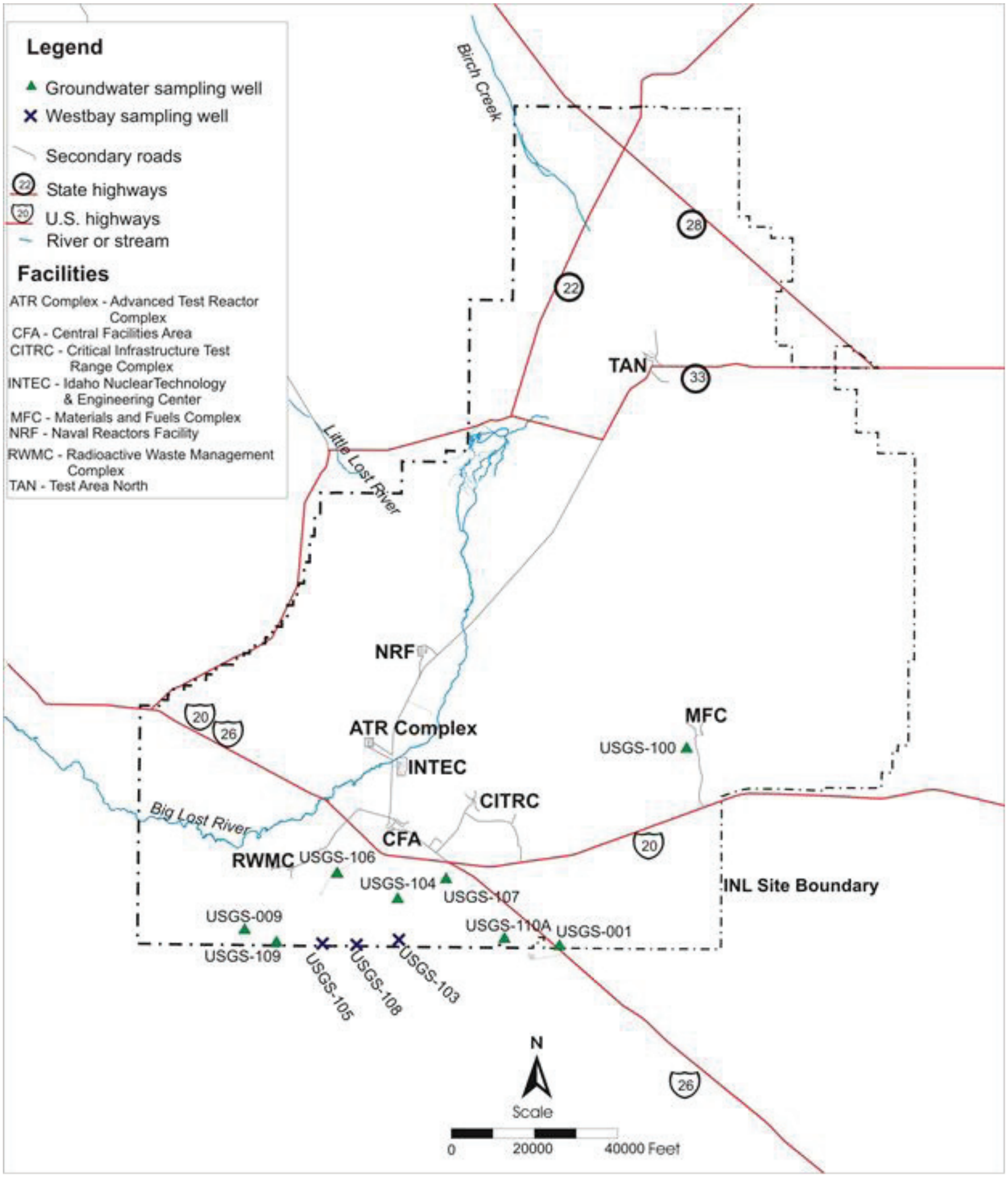

Figure 6-17. Well Locations Sampled for Operable Unit 10-08.

Table 6-12. Comparison of Waste Area Group 10 Analytes with Regulatory Levels for 2015.

Analyte	MCL/SMCL[a]	Maximum Concentration	Detections above MCL/SMCL
Radionuclides			
Gross alpha (pCi/L)	15	ND	0
Iodine-129 (pCi/L)	1	ND	0
Technetium-99 (pCi/L)	900	ND	0
Strontium-90 (pCi/L)	8	ND	0
Tritium (pCi/L)	20,000	743	0
Volatile Organic Compounds[b]			
Chloromethane (µg/L)	None	0.53	0
Toluene (µg/L)	1,000	0.33	0
Anions			
Chloride (mg/L)	*250*	21.5	0
Fluoride (mg/L)	*2*	0.655	0
Nitrate/nitrite as N (mg/L)	10	2.1	0
Sulfate (mg/L)	*250*	26.5	0
Common Cations			
Calcium (µg/L)	None	46,900	NA
Magnesium (µg/L)	None	18,300	NA
Potassium (µg/L)	None	3,440	NA
Sodium (µg/L)	None	17,900	NA
Metals			
Aluminum (µg/L)	*50 to 200*	ND	0
Antimony (µg/L)	6	ND	0
Arsenic (µg/L)	10	3.42	0
Barium (µg/L)	2,000	58.2	0
Beryllium (µg/L)	4	ND	0
Cadmium (µg/L)	5	ND	0
Chromium (µg/L)	100	8.27	0
Cobalt (µg/L)	None	ND	NA
Copper (µg/L)	1,300/*1,000*	0.627	0
Iron (µg/L)	*300*	**892**[c]	1
Lead (µg/L)	15[d]	5.94	0
Manganese (µg/L)	*50*	39.1	0
Mercury (µg/L)	2	ND	0
Nickel (µg/L)	None	0.708	NA
Selenium (µg/L)	50	ND	0
Silver (µg/L)	None	ND	NA
Thallium (µg/L)	2	ND	0
Uranium (µg/L)	30	2.32	0
Vanadium (µg/L)	None	8.75	NA
Zinc (µg/L)	*5,000*	74.1	0

a. Maximum contaminant levels are in regular text, and secondary maximum contaminant levels are in *italics*.
b. Only the detected volatile organic compounds are listed.
c. Bold values exceed an MCL or SMCL
d. The action level for lead is 15 µg/L.

MCL maximum contaminant level
NA not applicable
ND not detected
SMCL secondary maximum contaminant level

Table 6-13. Summary of INL Site Drinking Water Results (2015).

Constituent	Maximum Contaminant Level	ATR-Complex	CFA	CITRC	EBR-I	GUN RANGE	MAIN GATE	MFC	TAN CTF	TAN TSF
Gross Alpha	15 pCi/L	ND[b]	ND	ND	ND	ND	ND	ND	ND	ND
Gross Beta	50 pCi/L screening or 4 mrem	ND	5.97-7.88	3.29-3.96	ND-3.23	2.54-5.01	ND-4.66	ND-3.27	2.16-3.07	2.39-3.04
Tritium	20,000 pCi/L	ND	3,200-4,010	ND	ND	461-703	ND	ND	ND	ND
Iodine-129[a]	1 pCi/L	-	0.0155-0.0403	-	-	-	-	-	-	-
Nitrate	10 mg/L	ND	3.02	ND	ND	ND	ND	1.75	ND	ND
TTHMs	80 ppb	0.6	NA[c]	NA	NA	NA	NA	3.5	NA	NA
HAA5s	60 ppb	ND	NA	NA	NA	NA	NA	ND	NA	NA
VOCs	5 ppb for most VOCs	NA	NA	NA	NA	NA	NA	NA	NA	ND

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

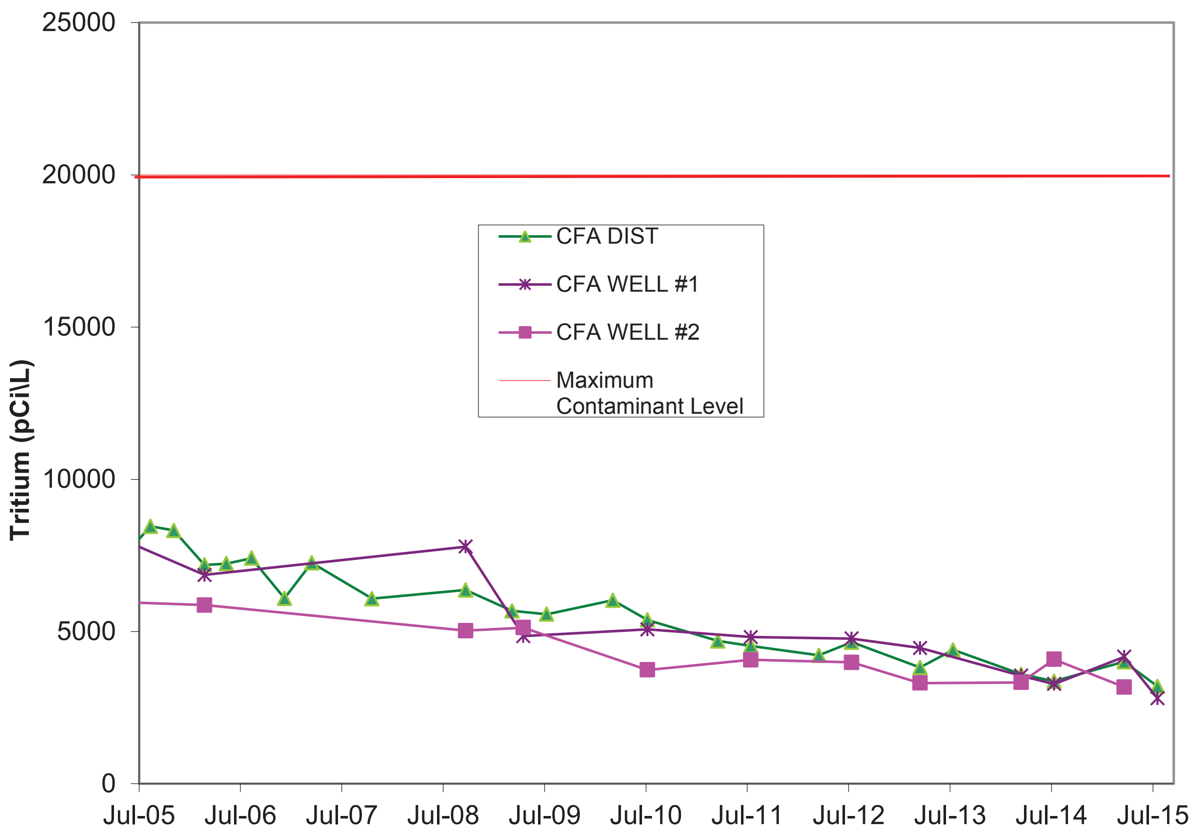

Figure 6-18. Tritium Concentrations in CFA Wells and Distribution System (2005 – 2015). Note: In 2015, CFA #1 Well was used 25 percent. CFA #2 Well was used 75 percent.

Table 6-14. 2015 Compliance Monitoring Results for the INTEC Drinking Water System – PWS#6120012.

Contaminant Sampled	# Samples Collected	Frequency	Average Result	Range Detected	MCL or Action Level
Total coliform	4	1 per quarter	Absent	Absent	No more than 1 sample during a quarter is total coliform positive
E. coli	4	1 per quarter	Absent	Absent	Any E. coli positive routine sample
Nitrate	1	1 per year	0.6 mg/L	NA	10 mg/L (as nitrogen)
Total trihalomethanes	1	1 per year	0.0011 mg/L	NA	0.080 mg/L
Haloacetic acids	1	1 per year	< 0.002 mg/L	NA	0.060 mg/L

Table 6-15. 2015 Surveillance Monitoring Results for the INTEC Drinking Water System – PWS #6120012.

Contaminant Sampled	# Samples Collected	Frequency	Average Result	Range Detected	MCL or Action Level
Total coliform	42	3 – 4 per month	41 Absent 1 Present	41 Absent 1 Present	No more than 1 sample is total coliform positive
E. coli	42	3 – 4 per month	42 Absent	42 Absent	Any E. coli positive routine sample
Gross alpha	2	2 per year	2.22 pCi/L	ND – 2.22 pCi/L	15 pCi/L
Gross beta	2	2 per year	2.89 pCi/L	2.25 – 3.52 pCi/L	50 pCi/L screening level or 4 mrem
Tritium	1	1 per year	138 pCi/L U	ND	20,000 pCi/L
Strontium-90	1	1 per year	0.544 pCi/L U	ND	8 pCi/L

ND = non-detect.

Four compliance samples and 42 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 except for total coliform, which was present in one surveillance sample collected at CPP-1683 in May 2015. The sampling location was taken out-of-service, flushed, and resampled. The results for the resampling were reported as absent for both total coliform and E. coli.

One compliance sample was collected at CPP-614 on June 24, 2015, and analyzed for nitrate as N by EPA Method 353.2. The result was 0.6 mg/L and below the nitrate MCL of 10 mg/L.

One compliance sample was collected at CPP-1666 on August 12, 2015, and analyzed for total trihalomethanes by EPA Method 524.2. The result was 0.0011 mg/L and below its MCL of 0.080 mg/L.

One compliance sample was collected at CPP-1666 on August 15, 2015, and analyzed for haloacetic acids by EPA Method 552.2. Haloacetic acids were not detected (<0.002 mg/L) in the sample. The MCL for haloacetic acids is 0.060 mg/L.

A surveillance sample was collected at CPP-614 on January 26, 2015, and analyzed for gross alpha and gross beta. Gross alpha was not detected, and gross beta was detected at 2.25 pCi/L, below its screening level of 50 pCi/L. Another surveillance sample was collected on

July 23, 2015, and analyzed for gross alpha, gross beta, tritium, and ^{90}Sr. Gross alpha was detected at 2.22 pCi/L, below its MCL of 15 pCi/L; gross beta was detected at 3.52 pCi/L, below its screening level of 50 pCi/L; and tritium and ^{90}Sr were reported as non-detects.

Three quality control samples (field duplicates) were collected in 2015. 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 and the Advanced Mixed Waste Treatment Project. 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 2015, 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, 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 13 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 17 samples were reported as absent. Nineteen 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 19 samples were reported as absent.

One compliance sample was collected at WMF-604 on June 24, 2015, and analyzed for nitrate as N by EPA Method 353.2. The result was 1 mg/L, below the nitrate MCL of 10 mg/L.

A surveillance sample was collected at WMF-604 on January 26, 2015, and analyzed for gross alpha and gross beta. Gross alpha was detected at 1.67 pCi/L, below its MCL of 15 pCi/L, and gross beta was detected at 3.52 pCi/L, below its screening level of 50 pCi/L. Another surveillance sample was collected on July 23, 2015, and analyzed for gross alpha, gross beta, tritium, and ^{90}Sr. Gross alpha was not detected. Gross beta was detected at 3.97 pCi/L and below its screening level of 50 pCi/L. Tritium was detected at 659 pCi/L, but below its MCL of 20,000 pCi/L. Strontium-90 was reported as non-detect.

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 January 21, 2015, sample, the April 29, 2015, sample, or the July 29, 2015, sample. Total xylenes were detected in the October 28, 2015, sample (0.0006 mg/L), but below the total xylenes MCL of 10 mg/L.

Four surveillance samples were collected at WMF-604 and analyzed for VOCs by EPA Method 524.2. Carbon tetrachloride and trichloroethylene were not detected (<0.0005 mg/L) in any of the samples collected at WMF-604. No other VOCs were detected in any of the samples.

Four 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 the samples. Carbon tetrachloride was detected in all four samples and ranged in concentration from 0.0047 mg/L to 0.0051 mg/L. Trichloroethylene was also detected in all four samples and ranged in concentration from 0.0022 mg/L to 0.0026 mg/L.

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

6.6.5 Test Area North/Technical Support Facility

Well TSF #2 supplies drinking water to less 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 contami-

Table 6-16. 2015 Compliance Monitoring Results for the RWMC Drinking Water System – PWS#6120018.

Contaminant Sampled	# Samples Collected	Frequency	Average Result	Range Detected	MCL or Action Level
Total coliform	4	1 per quarter	Absent	Absent	No more than 1 sample during a quarter is total coliform positive
E. coli	4	1 per quarter	Absent	Absent	Any E. coli positive routine sample
Nitrate	1	1 per year	1.0 mg/L	1.0 mg/L	10 mg/L (as nitrogen)
Xylenes (total)	4	1 per quarter	0.0006 mg/L	ND – 0.0006 mg/L	10 mg/L

ND—non-detect.

Table 6-17. 2015 Surveillance Monitoring Results for the RWMC Drinking Water System – PWS#6120018.

Contaminant Sampled	# Samples Collected	Frequency	Average Result	Range Detected	MCL or Action Level
Total coliform	13	1 per month	Absent	Absent	No more than 1 sample during a quarter is total coliform positive
E. coli	13	1 per month	Absent	Absent	Any E. coli positive routine sample
Volatile organic compounds	8	2 per quarter	0.0036 mg/L	ND – 0.0051 mg/L	0.002 – 10 mg/L
Gross alpha	2	2 per year	1.67 pCi/L	ND – 1.67 pCi/L	15 pCi/L
Gross beta	2	2 per year	3.75 pCi/L	3.52 – 3.97 pCi/L	50 pCi/L screening level or 4 mrem
Tritium	1	1 per year	659 pCi/L	659 pCi/L	20,000 pCi/L
Strontium-90	1	1 per year	ND	ND	8 pCi/L

ND—non-detect.

nation was an 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 6-19 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 2015 was less than the reporting limit of 0.5 µg/L (10 percent of the MCL).

6.7 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 2015. 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 2015. 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 con-

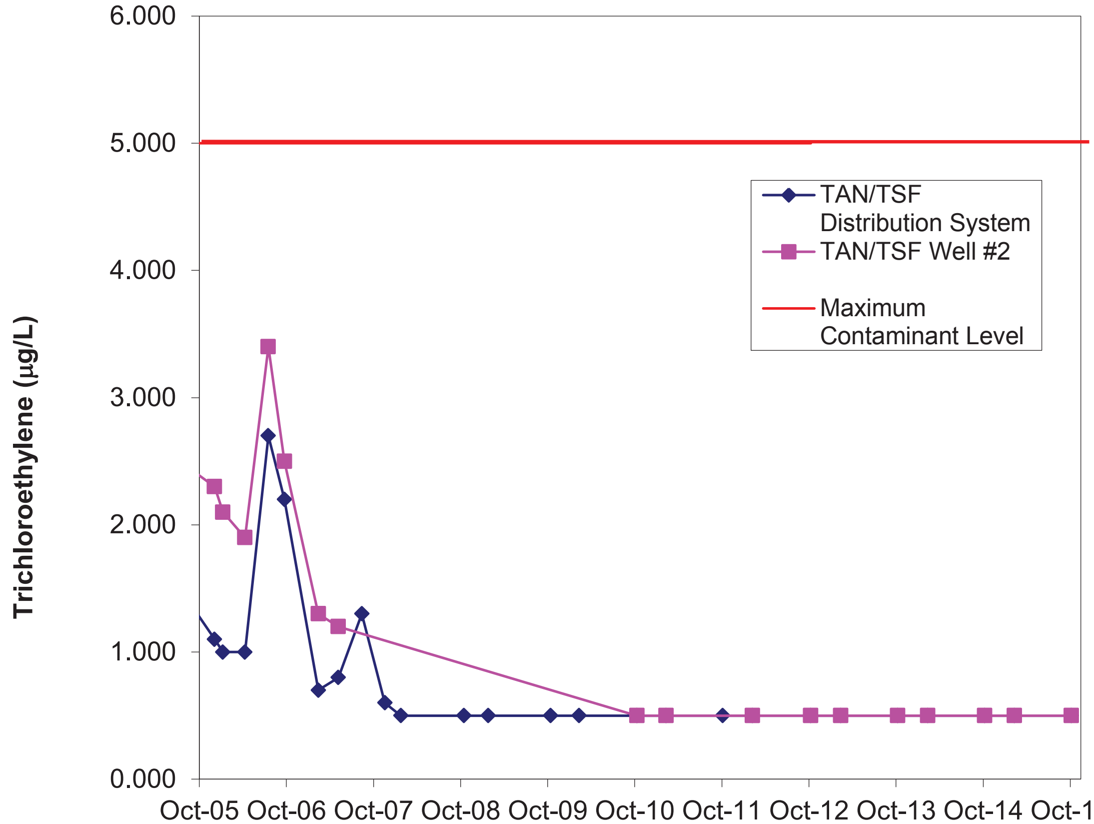

Figure 6-19. Trichloroethylene Concentrations in TSF Drinking Water Well and Distribution System (2005 – 2015).

Table 6-18. Trichloroethylene Concentrations at TAN/TSF Well #2 and Distribution System (2015).

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)	2	<0.5	<0.5	<0.5	5.0

a. MCL = Maximum contaminant level (see Table A-3).
b. NA = Not applicable. Maximum contaminant level applies to the distribution system only.

tractor 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 in three samples (Atomic City, Craters of the Moon, and Minidoka) at just above the minimum detectable concentration. Gross beta activity was detected in all but four drinking water samples collected by ESER, but not in either sample of the bottled water. Gross beta activity has been measured at these levels historically in offsite drinking water samples. The results are below the screening level of 50 pCi/L for gross beta activity, with a maximum of 4.63 pCi/L. If gross beta activity exceeds 50pCi/L, an analysis of the sample must be performed to identify the major radionuclides present (40 CFR 141).

Tritium was detected in some of the drinking water samples, including both of the bottled water control samples, collected in 2015. The results were within historical measurements and well below the EPA MCL of 20,000 pCi/L.

Table 6-19. Gross Alpha, Gross Beta, and Tritium Concentrations in Offsite Drinking Water Samples Collected by the ESER Contractor in 2015.

Location	Sample Results (pCi/L)[a]		
Gross Alpha			
	Spring	*Fall*	*EPA MCL*[b]
Atomic City	ND[c]	2.23 ± 0.70	15 pCi/L
Control (bottled water)	ND	ND	15 pCi/L
Craters of the Moon	ND	2.15 ± 0.66	15 pCi/L
Howe (duplicate in Spring)	ND (ND)	ND	15 pCi/L
Idaho Falls	ND	ND	15 pCi/L
Minidoka	2.76 ± 0.68	ND	15 pCi/L
Mud Lake (Well #2)	ND	ND	15 pCi/L
Rest Area (Highway 20/26)	ND	ND	15 pCi/L
Shoshone	ND	ND	15 pCi/L
Gross Beta			
	Spring	*Fall*	*EPA MCL*
Atomic City	3.44 ± 0.51	1.91 ± 0.59	4 mrem/yr (50 pCi/L)[d]
Control (bottled water)	ND	ND	4 mrem/yr (50 pCi/L)
Craters of the Moon	4.53 ± 0.47	2.60 ± 0.59	4 mrem/yr (50 pCi/L)
Howe (duplicate in Spring)	ND (ND)	2.50 ± 0.56	4 mrem/yr (50 pCi/L)
Idaho Falls	3.13 ± 0.53	ND	4 mrem/yr (50 pCi/L)
Minidoka	4.17 ± 0.54	2.40 ± 0.55	4 mrem/yr (50 pCi/L)
Mud Lake (Well #2)	4.34 ± 0.51	4.63 ± 0.60	4 mrem/yr (50 pCi/L)
Rest Area (Highway 20/26)	1.93 ± 0.50	ND	4 mrem/yr (50 pCi/L)
Shoshone	3.90 ± 0.53	2.52 ± 0.55	4 mrem/yr (50 pCi/L)
Tritium			
	Spring	*Fall*	*EPA MCL*
Atomic City	95 ± 22	ND	20,000 pCi/L
Control (bottled water)	82 ± 22	181 ± 28	20,000 pCi/L
Craters of the Moon	81 ± 22	137 ± 26	20,000 pCi/L
Howe (duplicate in Spring)	ND (ND)	ND	20,000 pCi/L
Idaho Falls	ND	117 ± 25	20,000 pCi/L
Minidoka	ND	ND	20,000 pCi/L
Mud Lake (Well #2)	ND	ND	20,000 pCi/L
Rest Area (Highway 20/26)	87 ± 22	ND	20,000 pCi/L
Shoshone	79 ± 22	ND	20,000 pCi/L

a. Result ± 1s.
b. EPA = Environmental Protection Agency; MCL = Maximum Contaminant Level.
c. ND = not detected (results < 3s).
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.

6.8 Surface Water Sampling

Surface water was co-sampled with DEQ-IOP in May and November 2015 at three springs located downgradient of the INL Site: Alpheus Springs near Twin Falls, Clear Springs near Buhl, and a trout farm near Hagerman (see Figure 6-20). ESER contractor results are shown in Table 6-20. Gross alpha activity was detected in two samples, one collected at Alpheus Springs and one from JW Bill Jones Jr Trout Farm. Gross beta activity was detected in all surface water samples. The highest result 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.

Tritium was detected in three of the seven 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 100 miles (160 km) away at Thousand Springs near Hagerman and other springs downstream of Twin Falls. The ESER contractor did not collect surface water samples from the Big Lost River on the INL Site in 2015 because the river contained no water at any time during the year.

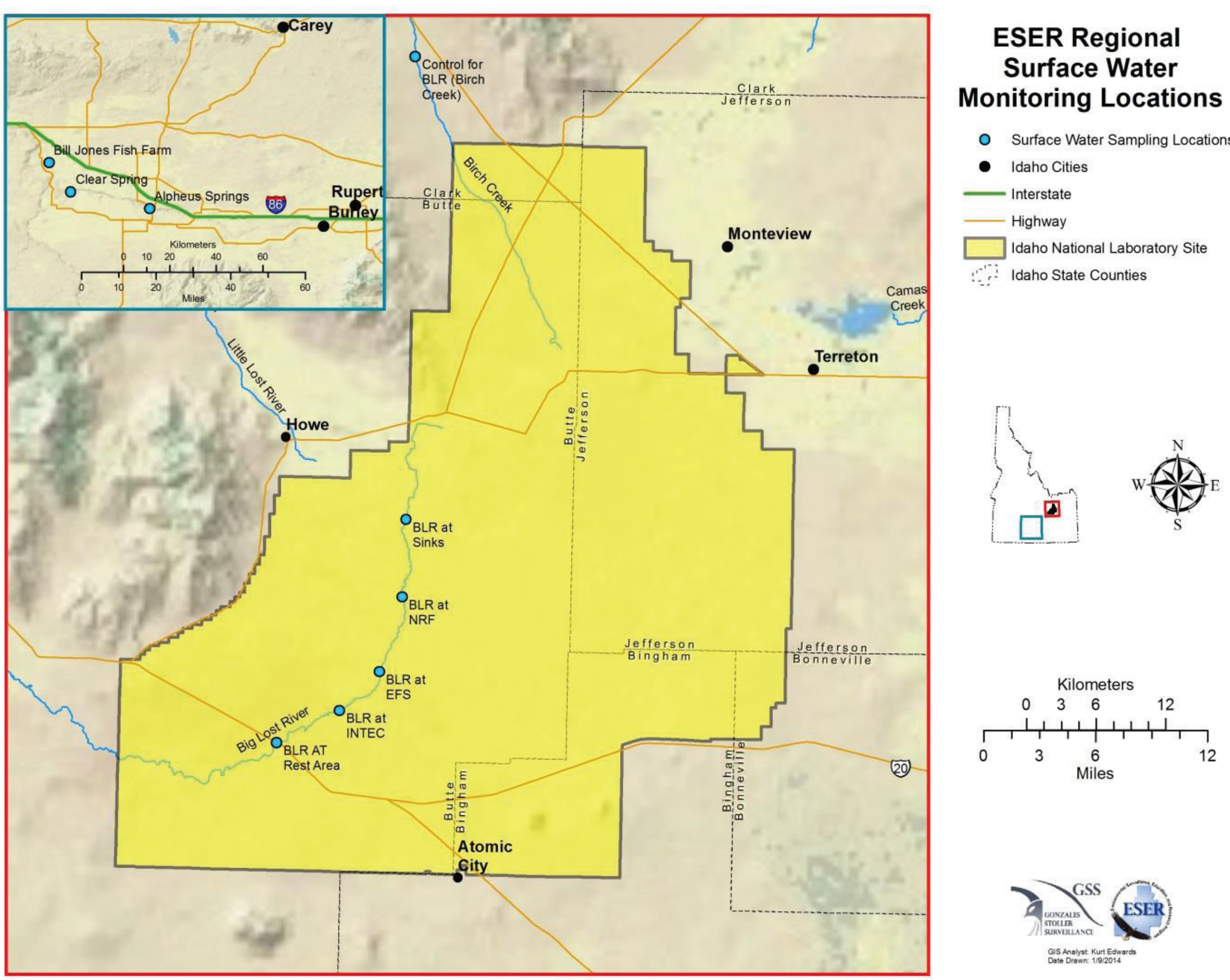

Figure 6-20. Detailed Map of ESER Program Surface Water Monitoring Locations.

Table 6-20. Gross Alpha, Gross Beta, and Tritium Concentrations in Surface Water Samples Collected by the ESER Contractor (2015).

Location	Sample Results (pCi/L)[a]		
Gross Alpha			
	Spring[b]	*Fall*[b]	*EPA MCL*[c]
Alpheus Springs-Twin Falls	ND[d]	3.20 ± 0.80	15 pCi/L
Clear Springs-Buhl	ND	ND	15 pCi/L
JW Bill Jones Jr Trout Farm-Hagerman (duplicate in fall)	1.80 ± 0.56	ND (ND)	15 pCi/L
Gross Beta			
	Spring	*Fall*	*EPA MCL*
Alpheus Springs-Twin Falls	6.33 ± 0.62	4.30 ± 0.60	4 mrem/yr (50 pCi/L)[e]
Clear Springs-Buhl	3.85 ± 0.55	5.29 ± 0.62	4 mrem/yr (50 pCi/L)
JW Bill Jones Jr Trout Farm-Hagerman (duplicate in fall)	2.73 ± 0.51	3.95 ± 0.56 (3.83 ± 0.56)	4 mrem/yr (50 pCi/L)
Tritium			
	Spring	*Fall*	*EPA MCL*
Alpheus Springs-Twin Falls	96 ± 22	ND	20,000 pCi/L
Clear Springs-Buhl	ND	277 ± 26	20,000 pCi/L
JW Bill Jones Jr Trout Farm-Hagerman (duplicate in fall)	73 ± 22	ND (ND)	20,000 pCi/L

a. Result ± 1s.
b. The springs and trout farm were sampled on May 11, 2015, and November 5, 2015.
c. EPA = Environmental Protection Agency; MCL = Maximum Contaminant Level.
d. ND = not detected (result < 3s).
e. 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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7. Environmental Monitoring Programs: Agricultural Products, Wildlife, Soil and Direct Radiation

Lost River Sinks

Radionuclides released by Idaho National Laboratory (INL) Site operations and activities may be assimilated by agricultural products and game animals which can then be consumed by humans. These media are thus 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 2015. The results could not be directly linked to operations at the INL Site and are likely due 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 three road-killed animals sampled in 2015. Eight human-made radionuclides (chromium-51, cobalt-58, cobalt-60, zinc-65, selenium-75, ^{90}Sr, cesium-134, ^{137}Cs) 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.

Soil samples were collected at the Radioactive Waste Management Complex (RWMC) in 2015. Strontium-90, plutonium-239/240, and americium-241 were detected at or below levels observed historically in RWMC soils. All results were below dose-based Environmental Concentration Guides established at the INL Site for protection of human health.

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 122 mrem off the INL Site. 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 RWMC and the 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 2015. 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), 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 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).

7.1.1 Milk

Milk is sampled to monitor the pathway from potentially contaminated, regionally grown feed to cows to milk, which is then ingested by humans. During 2015, the ESER contractor collected 138 milk samples 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 busi-

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

Area/Facility[a]	Media: 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 Contractor							
RWMC			•		•	•	•

a. INL Site = Idaho National Laboratory Site facility areas and areas between facilities.
RWMC = Radioactive Waste Management Complex.

ness. 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 were analyzed for strontium-90 (^{90}Sr) and tritium.

Iodine is an essential nutrient and is readily assimilated by cows eating 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 (^{134}Cs) 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. Small amounts of ^{131}I were released in 2015 at the Materials and Fuels Complex (MFC) (approximately 8.3 mCi) and Advanced Test Reactor (ATR) Complex (approximately 2.7 mCi), but these quantities were not detected in air samples collected at or beyond the INL Site boundary (Chapter 4). Iodine-131 was not detected in any milk samples during 2015.

Cesium-137 is chemically analogous to potassium in the environment and behaves similarly. 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 reported in any milk samples collected in 2015.

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 environ-

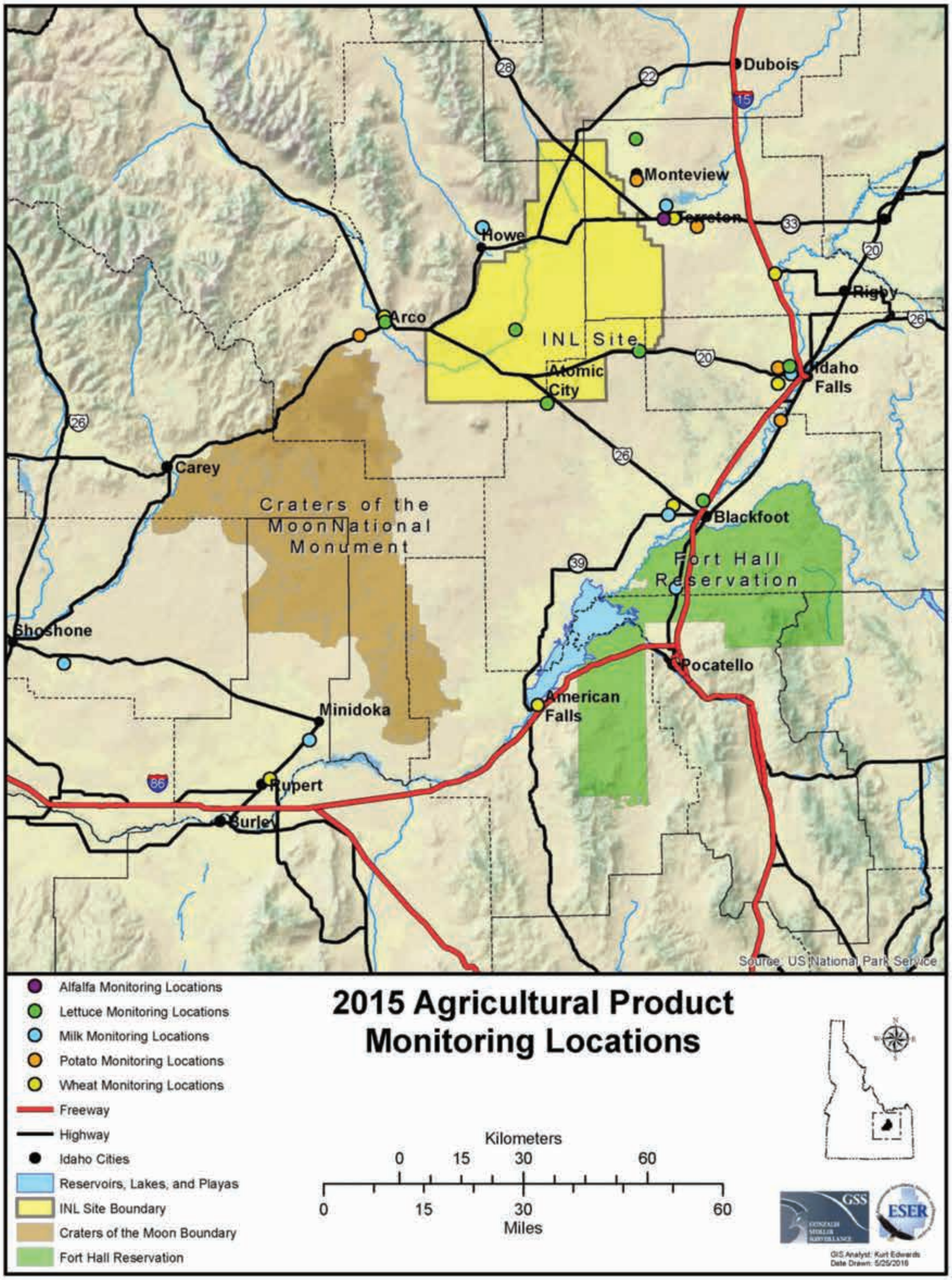

Figure 7-1. Locations of Agricultural Project Samples Collected (2015).

ment. Strontium tends to form compounds that are more soluble than ^{137}Cs, and is therefore comparatively mobile in ecosystems. Strontium-90 was detected in 13 of the 15 milk samples analyzed, including the two control samples from outside the state. Concentrations ranged from 0.11 pCi/L at Blackfoot to 0.64 pCi/L at Idaho Falls (Figure 7-2). Overall, concentrations were fairly consistent in 2015 with those in 2014 (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) of a limited data set of six samples collected over a 10-year period (2005-2014) ranged from 0 to 0.96 pCi/L (EPA 2016).

DOE has established Derived Concentration Standards (DCSs) 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 is no established DCS 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 (0.64 pCi/L) is approximately 0.06 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 it 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 animals drink, as well as from plants that contain water. Tritium was detected in nine of 15 milk samples analyzed at concentrations ranging from 69 pCi/L in the store-bought organic milk to 144 pCi/L in Dietrich milk. These concentrations are similar to those of previous years and are consistent with those found in atmospheric moisture and precipitation

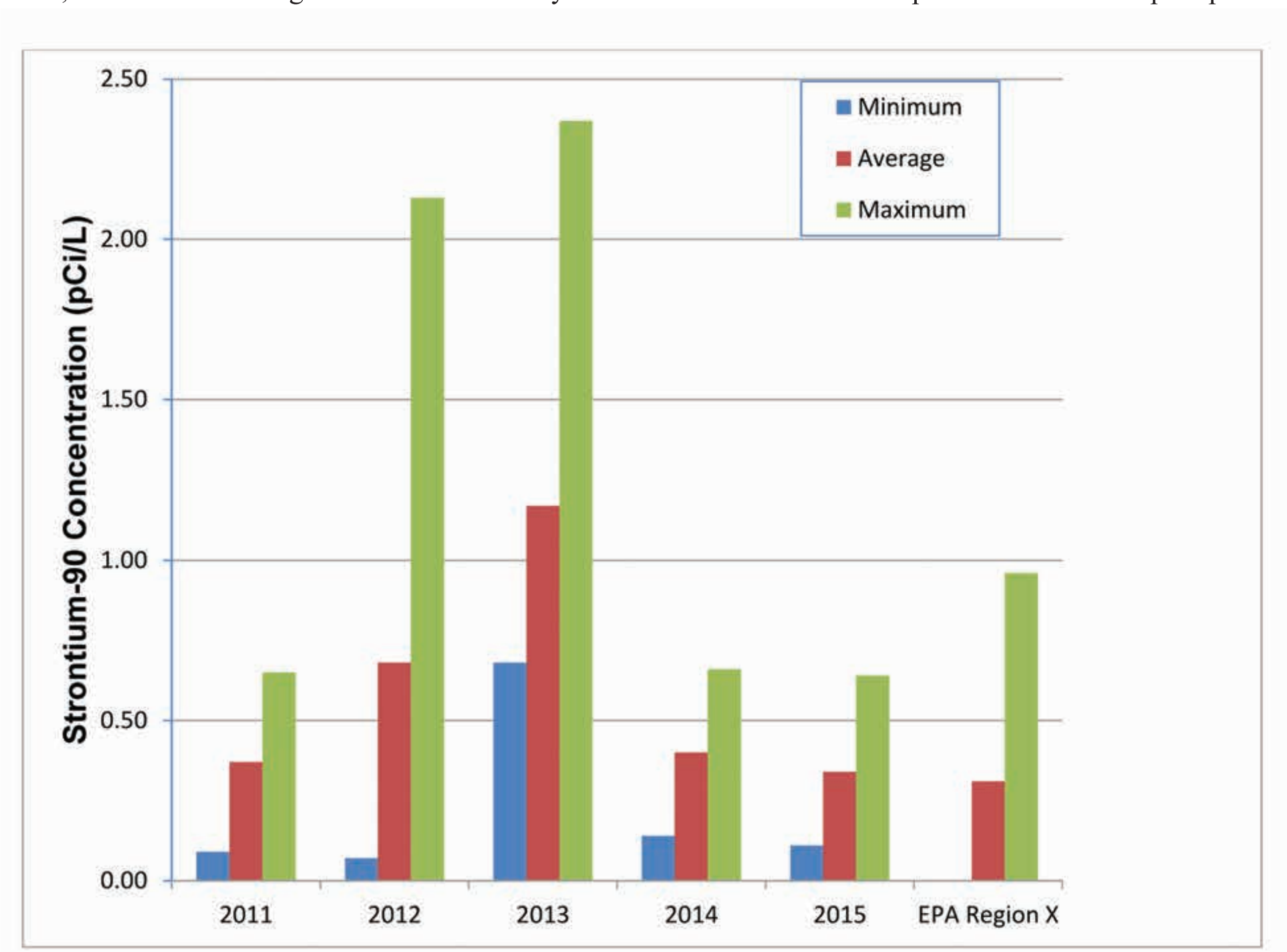

Figure 7-2. Strontium-90 Concentrations in Milk (2011 – 2015).

samples. The DCS for tritium in water is 19,000 pCi/L. The maximum observed value in milk samples is about 0.8 percent of the DCS.

7.1.2 Lettuce

Lettuce was sampled in 2015 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 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 other kinds of plants. The ESER contractor collects lettuce samples every year from areas on and adjacent to the INL Site. 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 7-3) 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.

Five lettuce samples were collected from portable planters at Arco, Atomic City, the Experimental Field Station, the Federal Aviation Administration (FAA) Tower, and Monteview. In addition, samples were obtained from gardens at Blackfoot and Idaho Falls. A control sample from an out-of-state location (Oregon) was obtained, and a duplicate sample was collected at Atomic City. The samples were analyzed for ^{90}Sr and gamma-emitting radionuclides. Strontium-90 was detected in all of the lettuce samples collected locally except for Blackfoot and was also found in the control sample purchased at the grocery store. Figure 7-4 shows the average and range of all measurements (including those below detection levels) from 2011 through 2015. The maximum ^{90}Sr concentration of 372 pCi/kg, measured in the lettuce sample from FAA Tower, was at the upper end of the

Figure 7-3. Portable Lettuce Planter.

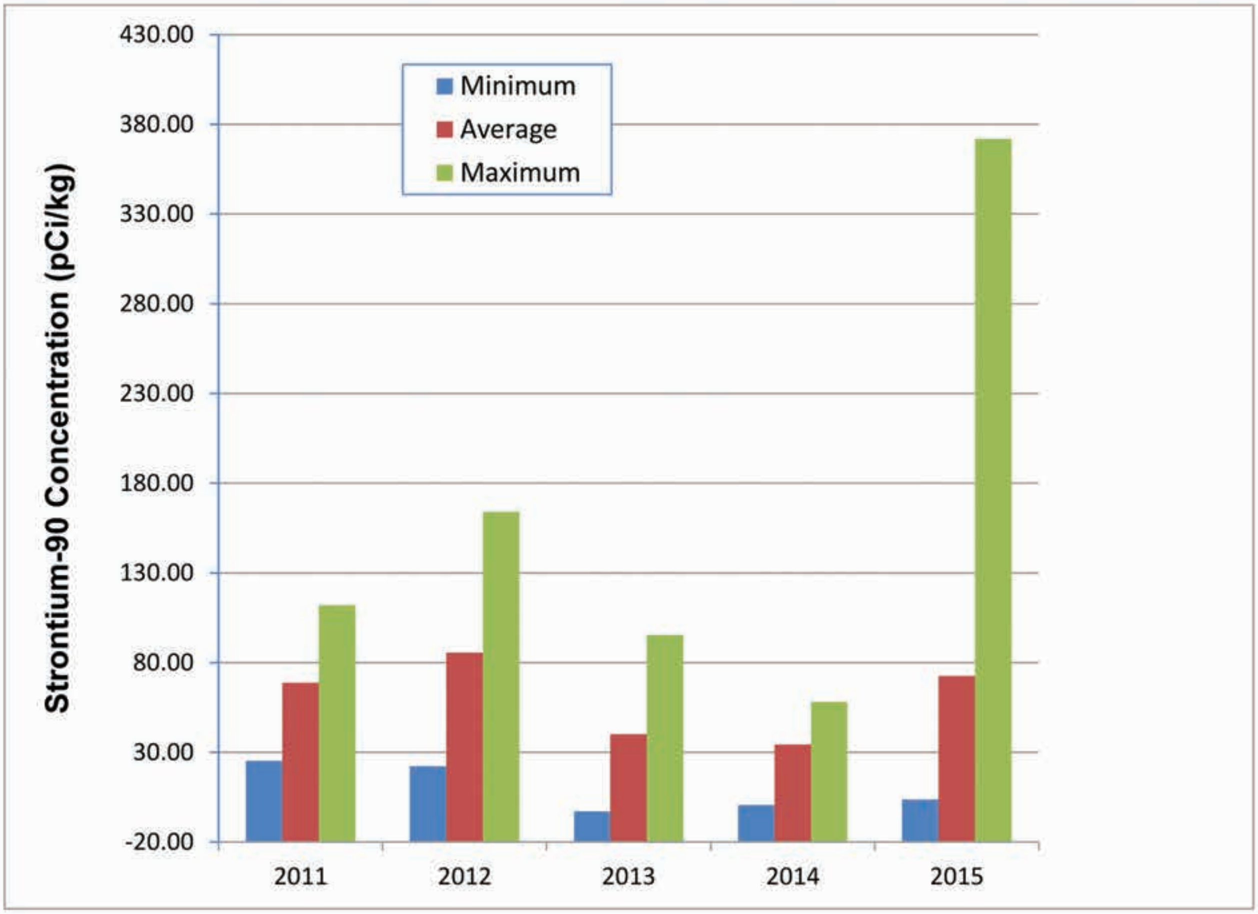

Figure 7-4. Strontium-90 Concentrations in Lettuce (2011 – 2015).

range of concentrations detected in the past five years. This sample was grown in a portable lettuce sampler using soil from the vicinity of the sampling location with no added potting soil. Gardeners in the region typically amend the native soil with additives such as peat moss, manure, or potting soil. Other results for 2015 were similar to others from the five year period shown. 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 above-ground 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 et al. 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.

7.1.3 Grain

Grain (including wheat and barley) is sampled because it is a staple crop in the region. The ESER contractor collected nine grain samples from areas surrounding the INL Site in 2015 and obtained one commercially available sample 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.

One of the 10 grain samples collected in 2015 contained a detectable concentration of ^{90}Sr. This sample was from Roberts and had a concentration of 8.3 pCi/kg. The concentrations of ^{90}Sr sometimes measured in grain are generally less than those measured in lettuce and the frequency of detections is much 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 7.1.2, strontium in soil from fallout is more bioavailable to plants than cesium.

7.1.4 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 they 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 seven locations in the vicinity of the INL Site (including a duplicate) and obtained from one location outside eastern Idaho. None of the eight potato samples collected during 2015 contained a detectable concentration of any human-made, gamma-emitting radionuclides or ^{90}Sr. Strontium-90 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.

7.1.5 Alfalfa

In addition to analyzing milk, the ESER contractor began collecting data in 2010 on alfalfa consumed by milk cows. This was in response to the DOE Headquarters Independent Oversight Assessment of the Environmental Monitoring program at the INL Site conducted during that year. The assessment team commented, with reference to the milk sampling program, that the ESER contractor should consider sampling locally grown alfalfa offsite, along with collection of alfalfa usage data. Questionnaires were sent to each milk provider concerning what they feed their cows. All of the dairies feed their cows locally grown alfalfa. 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 or ^{90}Sr were detected in any of the subsamples. As with wheat and potatoes, ^{90}Sr has only been detected in a limited number of samples during the past few years.

7.1.6 Large Game Animals

Muscle samples were collected by the ESER contractor from three game animals (one mule deer and two elk) accidentally killed on INL Site roads, from one mule deer that was killed to determine the health of a set of deer at an INL Site facility, and from one elk that was poached within the INL Site boundary. One thyroid and two liver samples were also obtained. The samples were analyzed for ^{137}Cs because it is an analogue of potassium and is readily incorporated into muscle and organ tissues. Thyroids are analyzed for ^{131}I because, when assimilated by higher animals, it selectively concentrates in the thyroid gland and is, thus, an excellent bioindicator of atmospheric releases.

No ^{131}I was detected in the thyroid sample. 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 2002). 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 above-ground nuclear weapons testing. Allowing for radioactive decay since the time of the study, background measurements would be expected to range from about 3 to 10 pCi/kg in 2015. With the exception of an immature deer sampled in 2008 that had elevated ^{137}Cs concentrations, all detected values have been within this range.

7.1.7 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 samples from wastewater ponds located at the ATR Complex, plus two control samples, 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 are often measured in liquid effluents from some INL Site facilities (Chapter 5). 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 eight human-made radionuclides were detected in the samples from at least one of the ducks collected at the ATR Complex ponds. These were ^{134}Cs, ^{137}Cs, chromium-51 (^{51}Cr), cobalt-58 (^{58}Co), cobalt-60 (^{60}Co), selenium-75 (^{75}Se), ^{90}Sr, and zinc-65 (^{65}Zn). All of these were also detected in the edible tissues of at least one duck, with the exception of ^{51}Cr (Figure 7-5). In the control ducks, ^{90}Sr was detected in the external and remainder portions of the ducks, but it was not found in the edible tissues.

Because more human-made radionuclides were found in ducks from 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 at the ATR Complex were higher in 2015 than in the past several sampling events. At the time of sample collection, the wastewater ponds were in the process of being dewatered to replace the hypalon liners. This likely resulted in a concentration of the radionuclides in the remaining pond water and an increased availability to the sediment on the liners.

Potential doses from consuming these ducks are discussed further in Chapter 8.

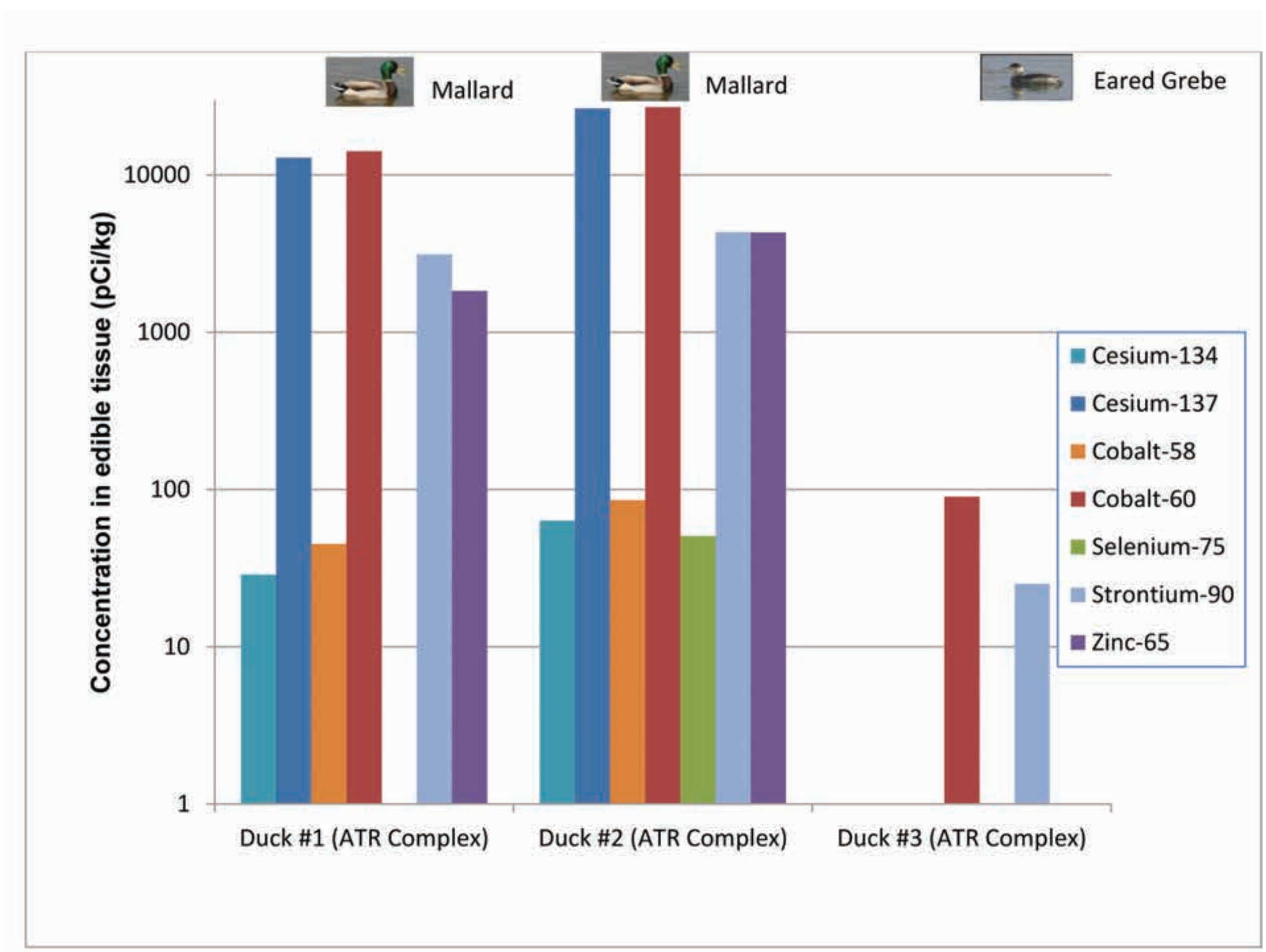

Figure 7-5. Radionuclide Concentrations Detected in Edible Tissues of Waterfowl Collected from ATR Complex (2015).

7.2 Soil Sampling and In Situ Gamma Spectrometry

7.2.1 Soil Sampling off the INL Site

Above-ground nuclear weapons testing resulted in many radionuclides being distributed throughout the world via atmospheric deposition. Cesium-137, ^{90}Sr, ^{238}Pu, $^{239/240}$Pu, and ^{241}Am can be detected in soil because of global fallout but could also be present from INL Site operations. These radionuclides are of particular interest because of their abundance resulting from nuclear fission events (e.g., ^{137}Cs and ^{90}Sr) or from their persistence in the environment due to long half-lives (e.g., $^{239/240}$Pu, with a half-life of 24,110 years). Soil samples are collected by the ESER contractor every two years (in even-numbered years). Results to date indicate that the source of these 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 2015, but soil will be sampled in 2016.

7.2.2 Wastewater Reuse Permit Soil Sampling at Central Facilities Area

The Idaho Department of Environmental Quality issued a permit for the CFA 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 2015.

7.2.3 In Situ Gamma Spectrometry

No in situ gamma spectroscopy was completed in 2015.

7.3 Direct Radiation

Thermoluminescent dosimeters (TLDs) measure cumulative exposures in air (in milliRoentgen or mR) to ambient ionizing radiation. TLDs detect changes in ambient exposures attributed to handling, processing, transporting, or disposing of radioactive materials. The TLD packets contain four lithium fluoride chips and are placed about 1 m (about 3 ft) above the ground at specified locations (Figure 7-6).

Beginning with the May 2010 distribution of dosimeters, the INL contractor began collocating optically stimulated luminescent dosimeters (OSLDs) with TLDs. The last set of TLD results were from November 2012. The ESER contractor began the use of OSLDs in November 2011 in addition to the TLDs. The primary advantage of the OSLD technology to 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 sampling periods for 2015 were from November 2014-April 2015 and May 2015–October 2015.

The measured cumulative environmental radiation exposure in milliroentgens (mR) for locations off the INL Site from November 2014 through October 2015 is shown in Table 7-2 for TLDs. For purposes of comparison, annual exposures from 2011 through 2014 also are included for each location. Table 7-3 shows the cumulative radiation doses measured at offsite locations using OSLDs for 2015. Available data for the three previous years are also included for comparison purposes.

The mean annual exposure measured using TLDs from distant locations in 2015 was 120 mR. The boundary location average was 115 mR. The average annual dose equivalent resulting from external exposure was estimated by converting the exposure measured in free air (mR) to dose equivalent (in mrem) by the factor of 1.03 reported for ^{137}Cs radiation by American National Standards Institute (1983). The average annual dose for all dosimeters was thus estimated to be 122 mrem.

Using OSLDs, the mean annual ambient dose for distant locations was estimated at 116 mrem and for boundary locations at 112 mrem. The mean annual ambient dose for all locations combined was 114 mrem.

The 2015 results for OSLDs collected by the INL contractor are provided in Appendix D. Locations of the dosimeters maintained on the INL Site are shown in Figures D-1 through D-13. The results for these locations are displayed in the figures. The OSLD data are reported in units of ambient dose equivalent (mrem).

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 and locations of 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-contam-

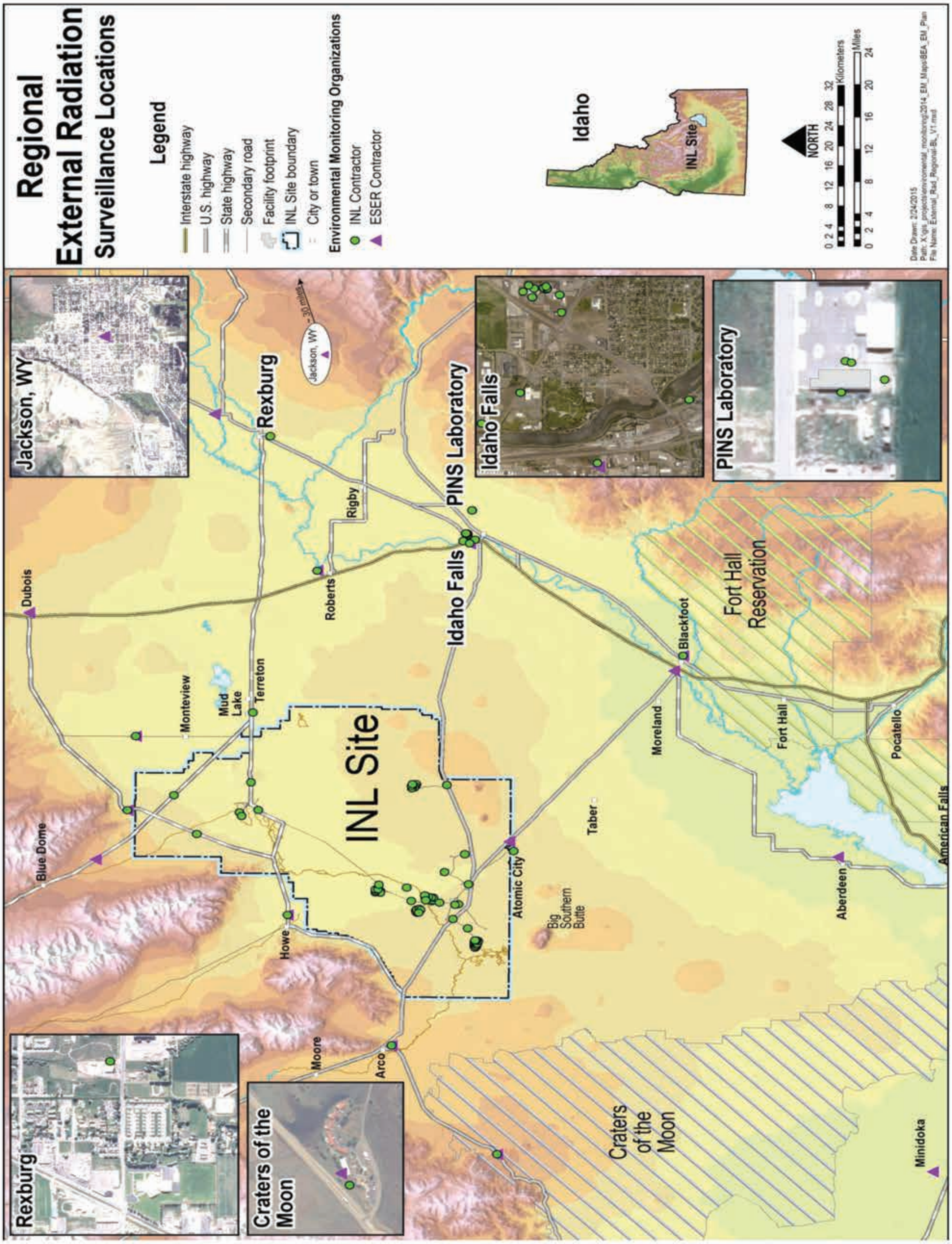

Figure 7-6. Regional Direct Radiation Monitoring Locations.

Table 7-2. Annual Environmental Radiation Exposures Using TLDs (2011 – 2015).

Location	2011	2012	2013 (mR)	2014	2015
Distant Group					
Aberdeen	127	132	129	130	123
Blackfoot	120	120	119	NA[a]	123
Craters of the Moon	118	129	122	125	118
Dubois	100	107	109	108	105
Idaho Falls	121	131	125	126	118
Jackson	101	102	104	102	NA[b]
Minidoka	116	122	121	118	108
Mountain View	118	118	114	113	113
Rexburg/Sugar City	131	142	153[c]	156	148
Roberts	134	144	138	135	126
Mean	119	125	123	124	120
Boundary Group					
Arco	130	130	128	119	117
Atomic City	122	132	129	132	123
Birch Creek Hydro	110	116	115	116	105
Blue Dome	105	107	109	109	103
Howe	112	125	122	125	114
Monteview	114	126	118	122	118
Mud Lake	133	140	134	136	127
Mean	118	125	122	123	115

a. The dosimeter was in an area with elevated natural radioactivity levels for part of the year and does not represent background values.
b. Location was temporarily discontinued during 2015.
c. Dosimeter was moved to Sugar City in July 2013.

inated ponds and soil areas. 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 locations while still measuring area exposures. Dosimeters which were phased out in 2015 are shown in Appendix D tables with an "end" descriptor. Additional monitoring locations have been added near select Research and Education Campus facilities in Idaho Falls. These locations include the INL Research Center Laboratory Building (IF-603), Willow Creek Building (IF-616), Systems Analysis Facility (IF-627), INL Research Center Physics Lab (IF-638), the Center for Advanced Energy Studies (IF-665), Bonneville County Technology Center (IF-670), and the Portable Isotopic Neutron Spectroscopy facility (IF-675). There are identified as "new" in Appendix D tables.

Dosimeters are received from the manufacturer in Glenwood, Illinois; placed in the field for six months; and then returned to the manufacturer for analysis. Transit control dosimeters shipped with the field dosimeters are used 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. The results from the six month sampling events are compared to the historical background dose for that area. It is anticipated that 5 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

Table 7-3. Annual Environmental Radiation Doses Using OSLDs (2012 – 2015).

Location	2012	2013	2014	2015
	mrem			
Aberdeen[a]	128	119	112	119
Blackfoot[b]	113	107	NA[g]	114
Craters of the Moon[a]	125	109	117	120
Dubois[b]	96	90	95	90
Idaho Falls[a]	125	112	111	117
Jackson[b]	88	81	89	NA[c]
Minidoka[c]	115	105	104	101
Mountain View[a]	114	104	108	108
Rexburg/Sugar City[d,e]	137	114	134	146
Roberts[a]	141	127	129	126
Mean	118	107	111	116
Arco[a]	126	112	122	119
Atomic City[a]	129	114	118	117
Birch Creek Hydro[a]	112	101	105	103
Blue Dome[b]	96	86	84	95
Howe[a,f]	112	104	110	105
Monteview[a]	121	103	110	112
Mud Lake[a]	127	123	126	131
Mean	117	106	111	112

a. Represents the mean of data collected by both the ESER contractor and the INL contractor.
b. Represents data collected by the ESER contractor only.
c. Represents the mean of data collected by both the ESER and INL contractors during 2012 and 2013. The INL contractor discontinued sampling here in 2014.
d. Represents the mean of data collected by both the ESER and INL contractors from 2012–2014. The INL contractor discontinued sampling here in 2015.
e. Dosimeter was moved to Sugar City in July 2013.
f. The INL contractor dosimeter was missing for part of the time during 2012 and 2015 and was not included in the average for those years.
g. The dosimeter was in an area with elevated natural radioactivity levels for part of the year and does not represent background values.

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.

The 2015 direct radiation results 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 2015 reported values for field locations were primarily below the historic background six-month UTL. Table 7-4 shows the locations that exceeded the facility specific six-month UTL.

All neutron dosimeters collected in 2015 were reported "M" (dose equivalents below the minimum measurable quantity of 10 mrem). The INL contractor is following the recommendations of the manufacturer to prevent environmental damage to the neutron dosimetry by wrapping each with aluminum foil. To keep the foil intact, the dosimeter is inserted into an ultraviolet protective cloth pouch when deployed.

Table 7-5 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 rec-

Table 7-4. Dosimeter Locations Above the Six-Month Background Upper Tolerance Limit (2015).

Location	Collect Date	Mean (mrem)	Standard Deviation (mrem)	Background Level (UTL) (mrem)	Dose (gross in mrem)
ICPP O-20[a]	10/2015	78.95	11.79	102.0	197
ICPP O-30[a]	10/2015	78.95	11.79	102.0	157
ICPP TreeFarm O-1[a]	10/2015	78.95	11.79	102.0	107
ICPP TreeFarm O-4[a]	10/2015	78.95	11.79	102.0	115
RWMC O-13A	4/2015	70.54	7.917	85.78	88
TRA O-17[a]	10/2015	78.72	8.94	96.39	116
TRA O-19[a]	10/2015	78.72	8.94	96.39	160
TRA O-20[a]	10/2015	78.72	8.94	96.39	172
TRA O-21[a]	10/2015	78.72	8.94	96.39	334
TRA O-22[a]	10/2015	78.72	8.94	96.39	119

a. These locations have not been included in the facility-specific UTL calculation since they are new and have not been monitored long enough to apply the statistics. The doses reported here were compared to the facility UTL and found to be above that limit.

ommendations of the National Council on 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 through 1993, as summarized by Jessmore et al. (1994). Concentrations of naturally occurring radionuclides in soil do not change significantly over this relatively short period. Data indicated the average concentrations of ^{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 Idaho residents receive from soil, a correction factor must be made each year to the estimated 76 mrem/yr. In 2015, this resulted in a reduction in the effective dose from soil to a value of 74 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 about 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 2015 was estimated to be 131 mrem/yr. This is slightly higher than the 118 mrem/yr measured at offsite locations using TLD and OSLD data. Measured values are typically within normal variability of the calculated background doses. Therefore, it is unlikely that INL Site operations contributed to background radiation levels at distant locations in 2015.

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 7-5 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

Table 7-5. Calculated Effective Dose from Natural Background Sources (2015).

Source of Radiation Dose	Total Average Annual Dose Calculated (mrem)	Total Average Annual Dose Measured[a] (mrem)
External irradiation		
Terrestrial	74[b]	NA[c]
Cosmic	57[d]	NA
Subtotal	131	118
Internal irradiation (primarily ingestion)[e]		
Potassium-40	15	
Thorium-232 and uranium-238	13	
Others (carbon-14 and rubidium-87)	1	
Internal irradiation (primarily inhalation)[d]		
Radon-222 (radon) and its short-lived decay products	212	
Radon-220 (thoron) and its short-lived decay products	16	
Total	388	

a. Calculated from the average annual external exposure at all offsite locations measured using TLDs and OSLDs.
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.

adult living in the U.S. 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 388 mrem/yr (Table 7-5). This value was used in Table 8-4 to calculate background radiation dose to the population living within 50 miles 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.

7.4.1 Vegetation Sampling at the Radioactive Waste Management Complex

At RWMC, vegetation is collected from four major areas (see Figure 7-7) and a control location approximately seven miles south of the Subsurface Disposal Area (SDA) at the base of Big Southern Butte. Crested wheat grass and rabbit brush are collected in odd-numbered years if available. In 2015, both species of vegetation were available for sampling.

Radionuclide concentrations in vegetation samples from RWMC remained at low levels and within expected bounds (Table 7-6). A comparison of radionuclide concentration data for ^{90}Sr, ^{241}Am, $^{239/240}$Pu, ^{238}Pu, and ^{137}Cs from samples collected in 2015 to previous sampling events revealed little change. Though radionuclide concentrations both increased and decreased slightly between the years, these fluctuations are expected in environmental sampling. The radionuclide uptake rate is influenced by variations in plants' age and health, seasonal fluctuations, and trimming frequency (resulting in changes in root structure and root depth).

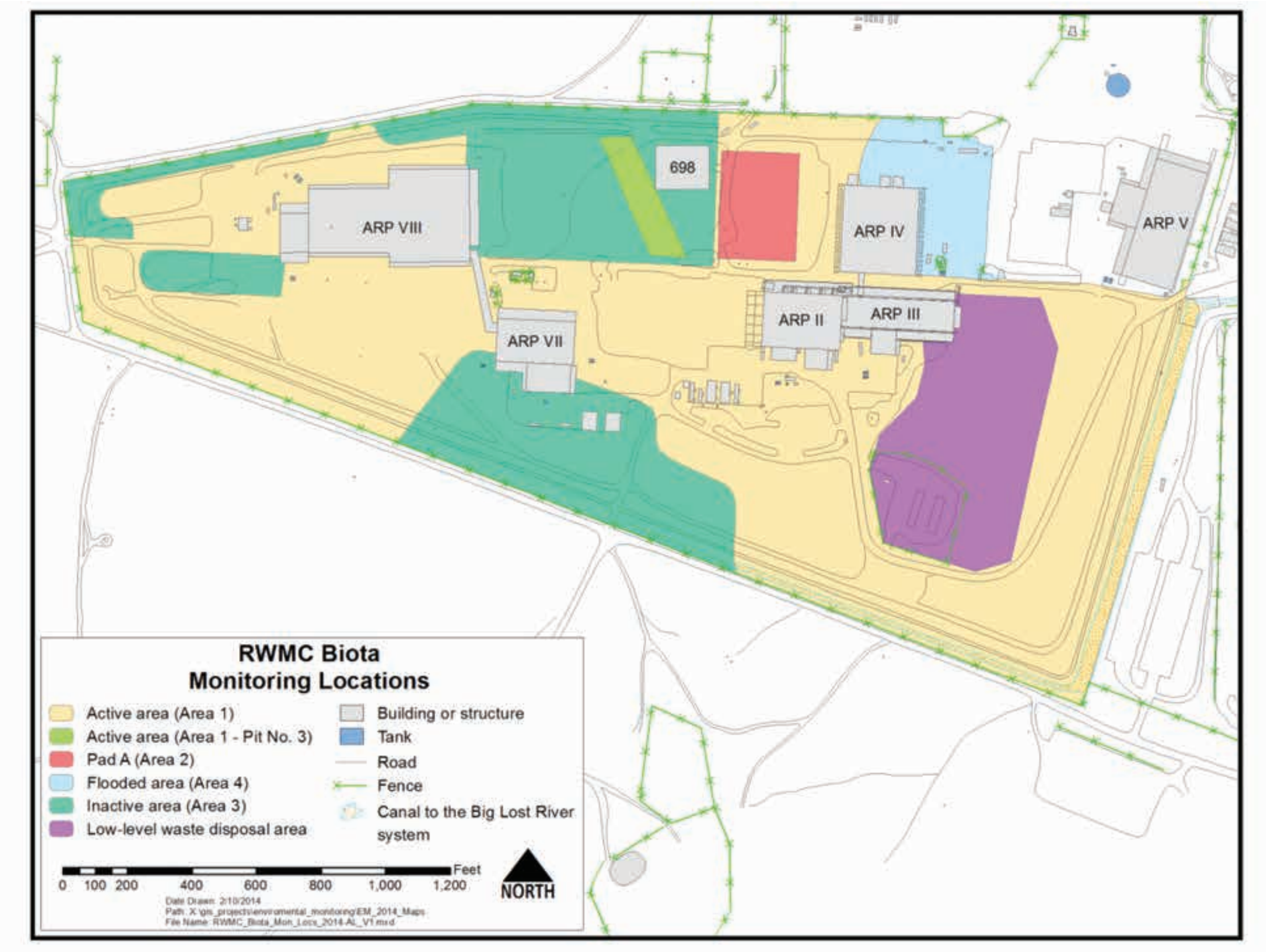

Figure 7-7. Four Vegetation Sampling Areas at the Radioactive Waste Management Complex.

7.4.2 Soil Sampling at the Radioactive Waste Management Complex

The ICP contractor samples soil every three years. The triennial soil sample was collected in 2015. Soil samples were collected to a depth of 5 cm (2 in.) at the RWMC locations shown in Figure 7-8 and at control locations shown in Figure 7-9. The soils were analyzed for gamma-emitting radionuclides. Cesium-137 was detected, but the results were below levels found at the control area because of global fallout.

Positive results were reported for ^{241}Am, $^{239/240}$Pu , and ^{90}Sr. These results are far below the Environmental Concentration Guides (EG&G Idaho 1986) established for soils (Table 7-7). The Environmental Concentration Guides were calculated to establish INL Site-specific dose guidelines for decontamination and decommissioning projects. Each Environmental Concentration Guide represents the concentration of a radionuclide in soil that would conservatively result in a dose of 100 mrem in the first year after release from an area to a hypothetical subsistence farmer.

All detected concentrations are consistent with or lower than historical concentrations measured at RWMC. These results are attributable to previous flooding and increased operational activity in the SDA, including the Accelerated Retrieval Project (construction and operations).

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 ra-

Table 7-6. Radionuclides Detected in Radioactive Waste Management Complex Vegetation in 2015.

Radionuclide	Location	Result (pCi/g)[a]
	Crested Wheat Grass	
Americum-241	Area 2 (Pad A)	(4.40 ± 0.49) E-03
	Area 3 (Inactive Area)	(6.68 ± 1.67) E-04
	Area 4 (Flooded Area)	(1.91 ± 0.27) E-03
Plutonium-239/240	Area 2 (Pad A)	(1.88 ± 0.28) E-03
	Area 3 (Inactive Area)	(4.07 ± 1.31) E-04
	Area 4 (Flooded Area)	(1.03 ± 0.19) E-04
	Frenchman's Cabin (control area)	(3.52 ± 1.02) E-04
Strontium -90	Area 1 (Active Area)	(9.10 ± 1.66) E-03
	Area 2 (Pad A)	(1.12 ± 0.18) E-02
	Area 3 (Inactive Area)	(6.13 ± 1.26) E-03
	Area 4 (Flooded Area)	(6.09 ± 1.27) E-03
	Frenchman's Cabin (control area)	(1.60 ± 0.23) E-02
Cesium-137	Area 1 (Active Area)	(2.03 ± 0.12) E+00
	Rabbit Brush	
Radionuclide	**Location**	**Result (pCi/g)**
Americum-241	Area 1 (Active Area)	(1.21 ± 0.22) E-03
	Area 1 (Active Area)	(3.66 ± 0.44) E-03
	Area 2 (Pad A)	(2.73 ± 0.43) E-03
	Area 3 (Inactive Area)	(1.28 ± 0.25) E-03
	Area 4 (Flooded Area)	(5.69 ± 0.48) E-02
Plutonium-239/240	Area 1 (Active Area)	(2.91 ± 0.87) E-04
	Area 1 (Active Area)	(5.25 ± 1.30) E-04
	Area 3 (Inactive Area)	(5.94 ± 1.20) E-04
	Area 4 (Flooded Area)	(8.08 ± 0.78) E-03
Strontium-90	Area 1 (Active Area)	(4.82 ± 0.57) E+01
	Area 1 (Active Area)	(8.43 ± 1.00) E-02
	Area 2 (Pad A)	(1.19 ± 0.16) E-02
	Area 3 (Inactive Area)	(1.17 ± 0.15) E-02
	Area 4 (Flooded Area)	(1.28 ± 0.17) E-02
	Frenchman's Cabin (control area)	(1.11 ± 0.15) E-02
Cesium-137	Area 1 (Active Area)	(65.6 ± 3.84) E+00
	Area 1 (Active Area)	(7.07 ± 1.67) E-02

a. Results ± 1s. Results shown are ≥ 3s.

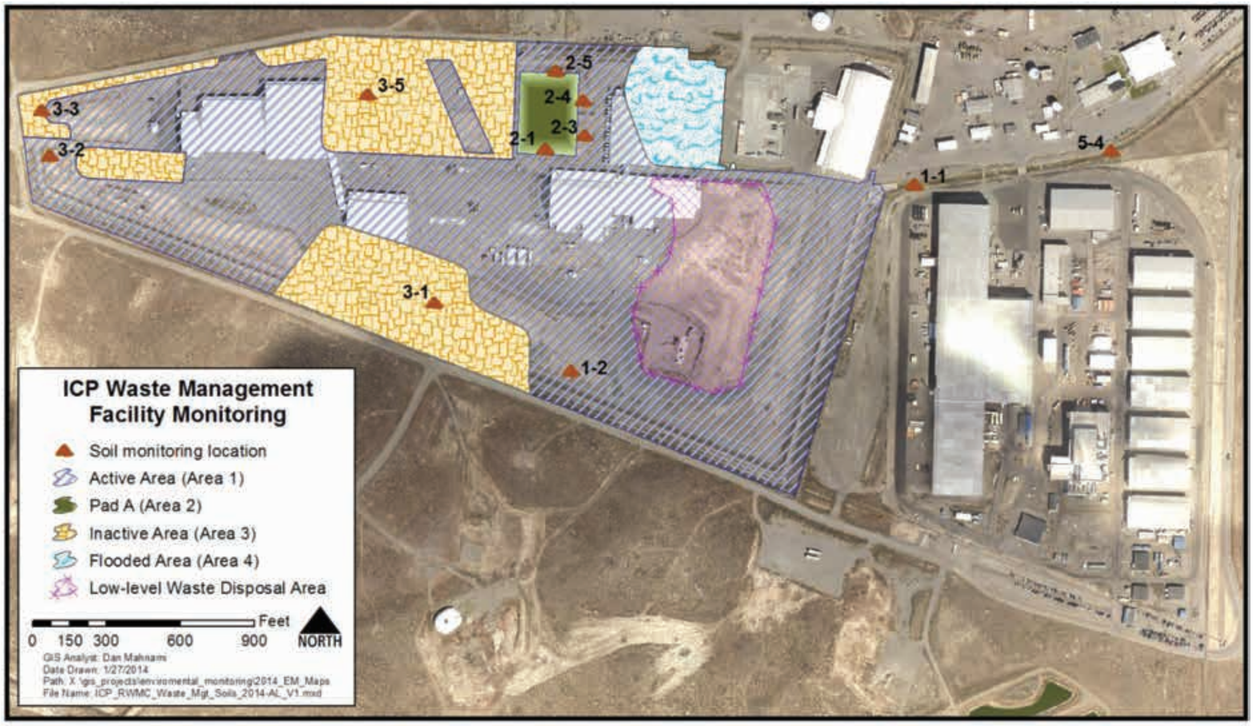

Figure 7-8. Soil Sampling Locations at the Radioactive Waste Management Complex (2015).

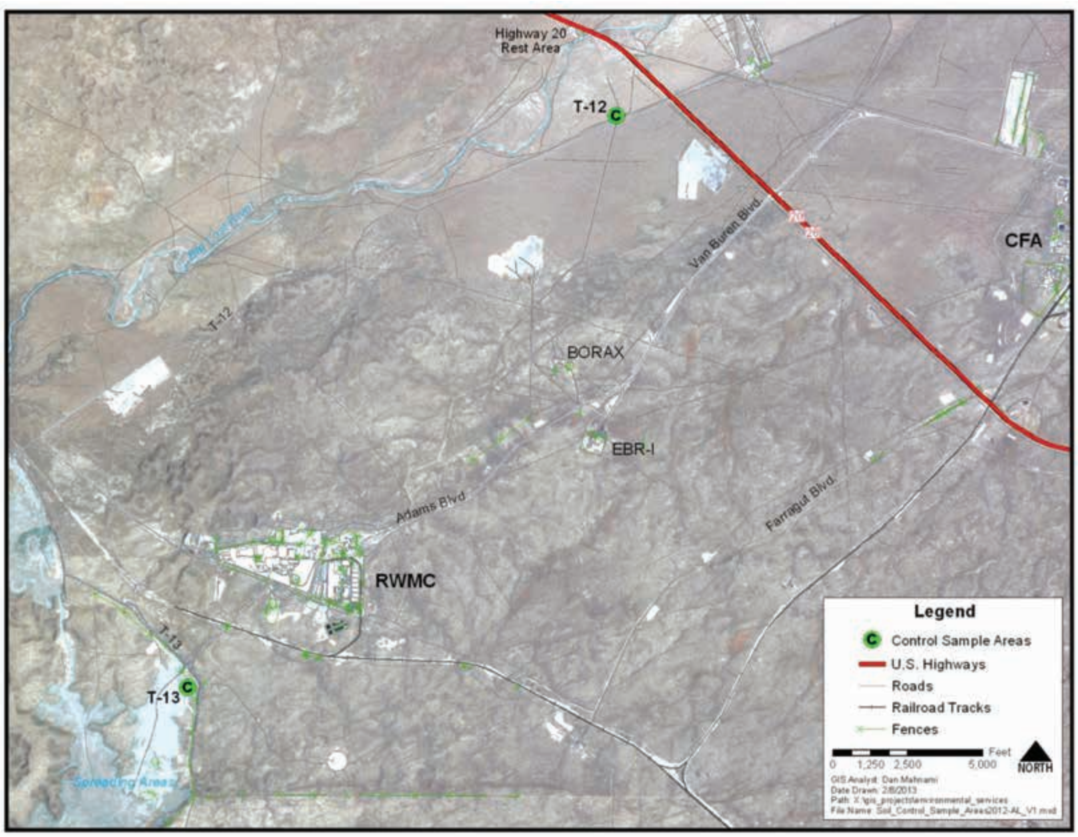

Figure 7-9. Soil Sampling Control Locations (2015).

Table 7-7. Radionuclides Detected in Radioactive Waste Management Complex Soils in 2015.

Parameter	Minimum Concentration[a] (pCi/g)	Maxiumum Concentration[a] (pCi/g)	% ECG[b] (pCi/g)
Americium-241	0.048 ± 0.009	0.635 ± 0.054	0.79
Plutonium-239/240	0.019 ± 0.004	0.946 ± 0.079	0.32
Strontium-90	0.101 ± 0.025	0.349 ± 0.047	0.70

a. Result ±1s. Results shown are ≥3s.
b. ECG = Environmental Concentration Guide (EG&G 1986).

diological 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 to complement air sampling. The SDA contains legacy waste that is in the process of being removed for repackaging and shipment to an offsite disposal facility. The Idaho CERCLA Disposal Facility 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[1] global positioning system receiver, mounted on a rack located above the front bumper of a pickup truck. The detectors are about 36 inches 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 miles per hour (7 feet per 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 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.

Figure 7-10 shows a map of the area that was surveyed at RWMC in 2015. 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 2015 results for most areas 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 pits and trenches are more visible. Average background values near or around areas that were radiometrically scanned at INL were generally below 750 counts per second. Most of the 2015 RWMC gross gamma radiation measurements were at background levels. The 2015 maximum gross gamma radiation measurement on the SDA was 15,267 counts per second, compared to the 2014 measurement of 17,414 counts per second. The maximum readings generally have been 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 Idaho CERCLA Disposal Facility is shown in Figure 7-11. The readings at the Idaho CERCLA Disposal Facility vary from year to year. These variations are related to the disposal and burial of new CERCLA remediation wastes in accordance with the Idaho CERCLA Disposal Facility waste placement plan (EDF-ER-286). In 2015, 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.

1 PRODUCT DISCLAIMER—References to any specific commercial product, process, or service by tradename, trademark, manufacturer, or otherwise, do not necessarily constitute or imply its endorsement, recommendation, or favoring by the U.S. Government, any agency thereof, or any company affiliated with the ICP.

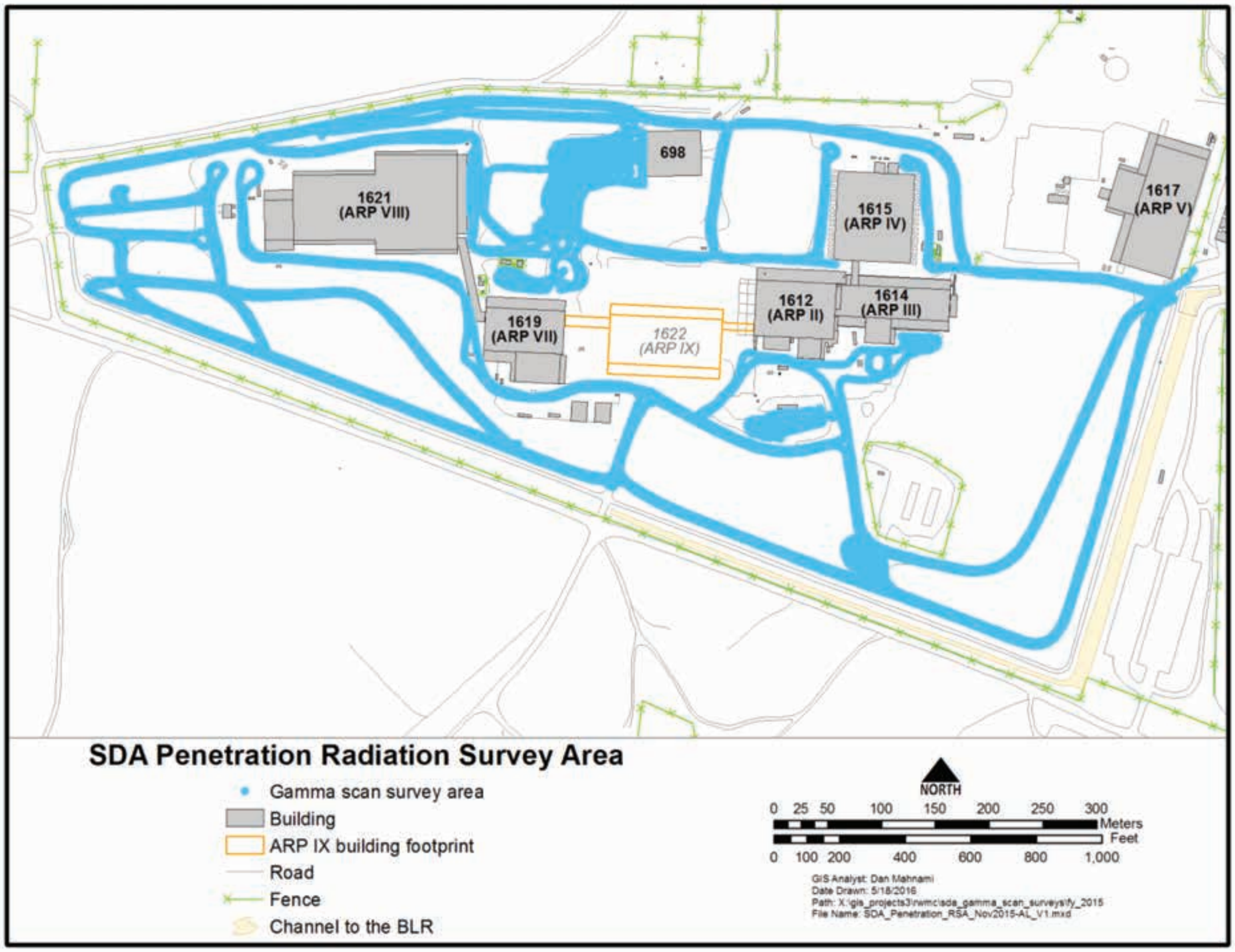

Figure 7-10. Subsurface Disposal Area Surface Radiation Survey Area (2015).

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 2002) developed under CERCLA (42 USC § 9601 et seq., 1980). 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 analysis using the latest changes in ecological data (e.g., screening and toxicity values) to produce waste area group-level 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 Van Horn (2013) offer limited habitat and considerable human activity, and are not significant in the context of the INL Site-wide population effects conclusion. The five-year review concluded the no-action decision (DOE-ID 2015):

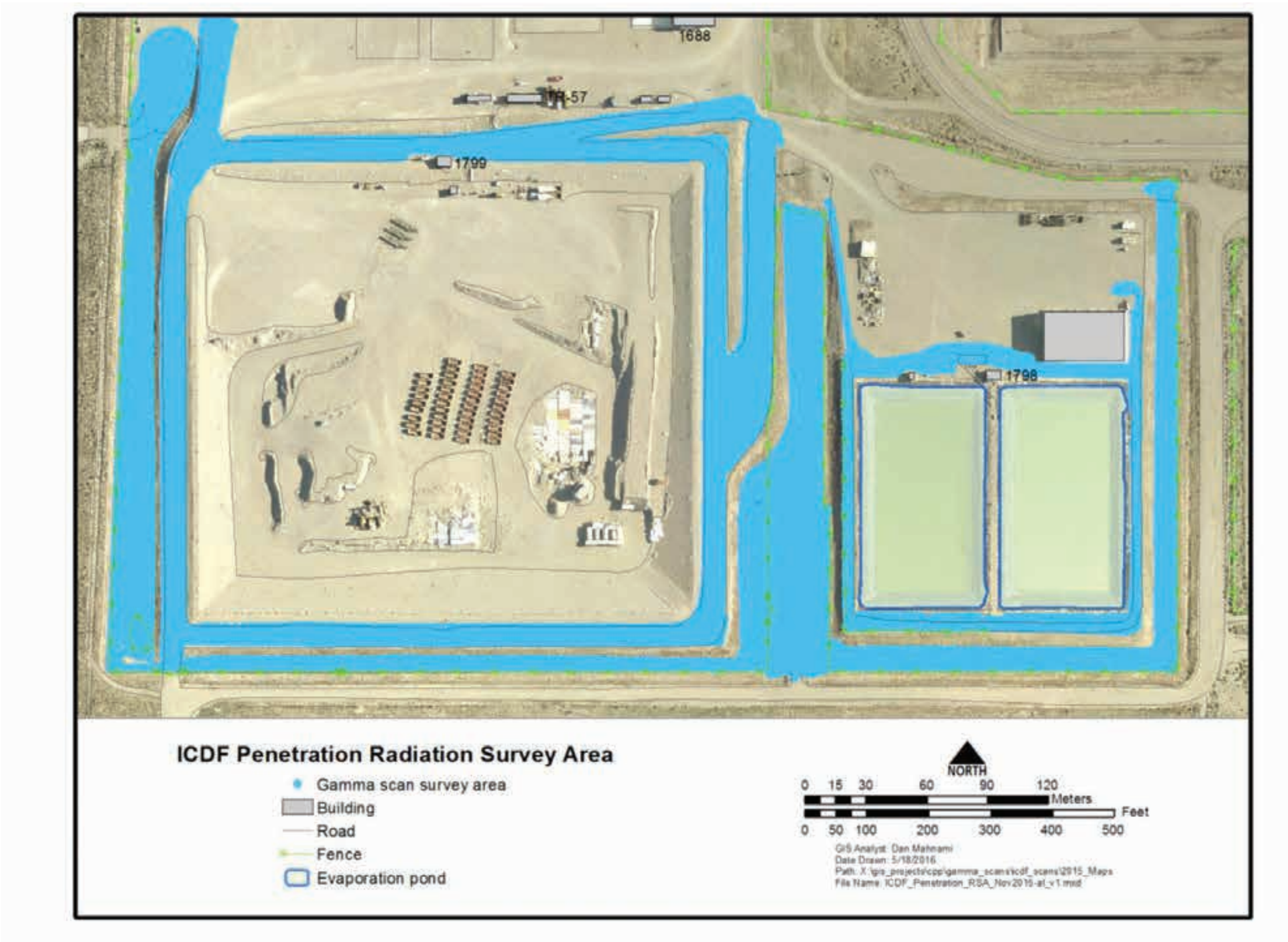

Figure 7-11. Idaho CERCLA Disposal Facility Surface Radiation Survey Area (2015).

- 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

Middle Butte

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 2015, as determined by this program, was 0.0333 mrem (0.333 µSv), well below the applicable standard of 10 mrem (100 µSv) per year. A maximum potential dose from ingestion was estimated using the highest radionuclide concentrations in the edible tissue of waterfowl collected at Advanced Test Reactor ponds in 2015. The maximum potential dose to an individual who consumes the duck was calculated to be 0.492 mrem (4.92 µSv). The total dose (via air and ingestion) estimated to be received by the MEI during 2015 was thus 0.525 mrem (5.25 µSv). The dose is far below the 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 323,111 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 developed by the National Oceanic and Atmospheric Administration Air Resources Laboratory-Field Research Division, and methodology recommended by the Nuclear Regulatory Commission. For 2015, the estimated potential population dose was 0.614 person-rem (6.14×10^{-3} person-Sv). This dose is about 0.0005 percent of that expected from exposure to natural background radiation of 125,367 person-rem (1,254 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 were used to estimate internal doses to the waterfowl. These calculations indicate that the potential doses to waterfowl do not exceed the DOE limits for biota.

No unplanned releases occurred from the INL Site in 2015, and, therefore, no doses were associated with unplanned releases.

8. DOSE TO THE PUBLIC AND BIOTA

It is the policy of the U.S. Department of Energy (DOE) to "Implement sound stewardship practices that are protective of the air, water, land, and other natural and cultural resources impacted by DOE operations and by which DOE cost-effectively meets or exceeds compliance with applicable environmental, public health, and resource protection laws, regulations, and DOE requirements" (DOE Order 436.1). DOE Order 458.1 further states, "It is also a DOE objective that potential exposures to members of the public be as far below the limits as is reasonably achievable... ." This chapter describes the potential dose to members of the public and biota from operations at the Idaho National Laboratory (INL) Site, based on 2015 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 8-1).

Airborne radioactive materials are rapidly 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

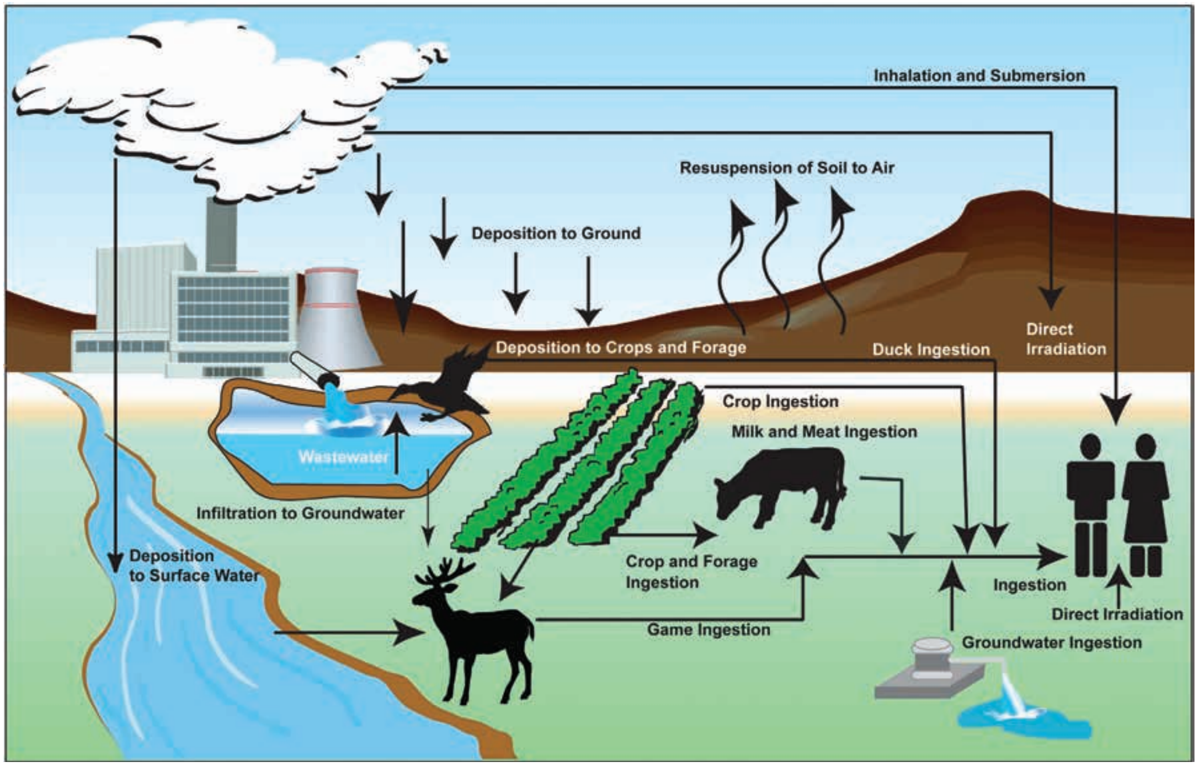

Figure 8-1. Potential Exposure Pathways to Humans from the INL Site.

projected offsite concentrations. Conservative doses were also calculated from ingestion of meat from wild game animals and waterfowl 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 and in waterfowl harvested from ponds on 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 by the facilities. During 2015, doses were calculated for the radionuclides and the data are presented in Table 4-2 and summarized in Table 8-1. Although noble gases were the radionuclides released in the largest quantities, 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. Some of the radionuclides that contributed the most to the overall estimated dose (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 National Emission Standards for Hazardous Air Pollutants (NESHAPs) regulations. The Clean Air Act Assessment Package computer code (CAP88-PC) (EPA 2007) was used to predict the maximum downwind concentration at the nearest offsite receptor location and estimate the dose to the MEI.

Table 8-1. Summary of Radionuclide Composition of Idaho National Laboratory Site Airborne Effluents (2015).

	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	3.13E+02	1.60E-08	6.02E+02	1.87E-01	1.98E-02	5.57E-03	1.70E-02	1.73E-09	8.46E-06	1.16E-04	3.12E-10
CFA	6.70E-01	—	2.00E-05	1.68E-12	7.07E-09	—	6.24E-10	9.57E-08	3.18E-10	2.51E-08	6.73E-15
CITRC	—	—	—	—	3.00E-05	—	—	—	—	—	—
INTEC	1.43E+02	7.33E+02	—	—	1.78E-02	2.15E-02	1.34E-02	1.83E-07	3.83E-03	5.18E-06	—
MFC	2.13E-01	2.51E-03	—	4.93E-07	2.41E-03	8.28E-03	3.09E-06	7.73E-06	8.45E-07	3.34E-06	—
NRF	1.50E-02	8.20E-02	—	—	9.60E-01	4.16E-05	6.40E-05	—	4.30E-06	—	—
RWMC	7.60E+01	1.67E-19	—	8.97E-19	2.83E-02	—	3.42E-10	7.95E-06	1.34E-03	3.34E-03	2.37E-09
TAN	3.26E-02	—	—	—	—	—	1.02E-06	1.07E-10	—	—	—
Total	**5.33E+02**	**7.33E+02**	**6.02E+02**	**1.87E-01**	**1.03E+00**	**3.45E-02**	**3.04E-02**	**1.60E-05**	**5.19E-03**	**3.46E-03**	**2.68E-09**

a. One curie (Ci) = 3.7 x 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); TAN = Test Area North (including SMC = Specific Manufacturing Capability).
c. Noble gases ($T_{1/2}$ > 40 days) released in 2015 = ^{39}Ar and ^{85}Kr (^{39}Ar release is negligible).
d. Noble gases ($T_{1/2}$ < 40 days) released in 2015 = ^{41}Ar, ^{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 2015 = ^{137m}Ba, ^{139}Ba, ^{141}Ba, ^{83}Br, ^{60m}Co, ^{138}Cs, ^{178m}Hf, ^{142}La, ^{56}Mn, ^{97}Nb, ^{144}Pr, ^{88}Rb, ^{89}Rb, ^{106}Rh, ^{129}Te, ^{208}Tl and ^{91m}Y.
f. Fission products and activation products ($T_{1/2}$ > 3 hours) released in 2015 = ^{110}Ag, ^{133}Ba, ^{140}Ba, ^{7}Be, ^{10}Be, ^{207}Bi, ^{210m}Bi, ^{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, ^{71}Ge, ^{175}Hf, ^{179m}Hf, ^{181}Hf, ^{182}Hf, ^{203}Hg, ^{166m}Ho, ^{192}Ir, ^{53}Mn, ^{54}Mn, ^{93}Mo, ^{99}Mo, ^{22}Na, ^{24}Na, ^{93m}Nb, ^{94}Nb, ^{95}Nb, ^{59}Ni, ^{63}Ni, ^{185}Os, ^{191}Os, ^{32}P, ^{33}P, ^{205}Pb, ^{147}Pm, ^{184}Re, ^{184m}Re, ^{186}Re, ^{186m}Re, ^{187}Re, ^{188}Re, ^{103}Ru, ^{106}Ru, ^{35}S, ^{122}Sb, ^{124}Sb, ^{125}Sb, ^{46}Sc, ^{75}Se, ^{32}Si, ^{145}Sm, ^{151}Sm, ^{113}Sn, ^{179}Ta, ^{182}Ta, ^{183}Ta, ^{160}Tb, ^{99}Tc, ^{99m}Tc, ^{123m}Te, ^{204}Tl, ^{170}Tm, ^{171}Tm, ^{49}V, ^{181}W, ^{185}W, ^{187}W, ^{188}W, ^{88}Y, ^{90}Y, ^{91}Y, ^{92}Y, ^{65}Zn, ^{93}Zr, ^{95}Zr and ^{97}Zr.
g. Radioiodine released in 2015 = ^{128}I, ^{129}I, ^{131}I, ^{132}I, ^{133}I, ^{134}I and ^{135}I.
h. Radiostrontium released in 2015 = ^{80}Sr, ^{85}Sr, ^{89}Sr, ^{90}Sr, ^{91}Sr and ^{92}Sr.
i. Uranium isotopes released in 2015 = ^{232}U, ^{233}U, ^{234}U, ^{235}U, ^{236}U and ^{238}U.
j. Plutonium isotopes released in 2015 = ^{236}Pu, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu and ^{242}Pu.
k. Other actinides released in 2015 = ^{241}Am, ^{243}Am, ^{249}Cf, ^{252}Cf, ^{242}Cm, ^{243}Cm, ^{244}Cm, ^{248}Cm, ^{237}Np, ^{239}Np, ^{233}Pa, ^{228}Th, ^{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 2015.

- ***The collective effective dose (population dose) for the population within 80 km (50 mi) of any INL Site facility.*** For this calculation, the MDIFFH model (Sagendorf et al. 2001) was used to model air transport and dispersion. The population dose was estimated using dispersion values from the model projections to comply with DOE Order 458.1.

The dose estimates considered immersion dose from direct exposure to airborne radionuclides, internal dose from inhalation of airborne radionuclides, internal dose from ingestion of radionuclides in plants and animals, and external dose from direct exposure to radionuclides deposited on soil (Figure 8-1). The CAP88-PC computer code uses dose and risk tables developed by the U.S. Environmental Protection Agency (EPA). Population dose calculations were made using the MDIFF air dispersion model in combination with Nuclear Regulatory Commission dose calculation methods (NRC 1977), DOE effective dose coefficients for inhaled radionuclides (DOE 2011), EPA dose conversion factors for ingested radionuclides (EPA 2002), and EPA dose conversion factors for external exposure to radionuclides in the air and deposited on the ground surface (EPA 2002).

8.2.1 Maximally Exposed Individual Dose

The EPA NESHAPs 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 (40 Code of Federal Regulations [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 code such as CAP88-PC to demonstrate compliance with 40 CFR 61. CAP88-PC uses a modified Gaussian plume model to estimate the average dispersion of radionuclides released from up to six sources. It uses an average annual wind file based on data collected at the INL Site by National Oceanic and Atmospheric Administration (NOAA). Assessments are done for a circular grid of distances and directions from each source with a radius of 80 kilometers (50 miles) 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 terrestrial food chain models.

The dose from INL Site airborne releases of radionuclides was calculated to the MEI to demonstrate compliance with NESHAPs and is published in the *National Emissions Standards for Hazardous Air Pollutants – Calendar Year 2015 INL Report for Radionuclides* (DOE-ID 2016). In order to identify the MEI, the doses at 62 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 screened to be to a hypothetical person living at Frenchman's Cabin, located at the southern boundary of the INL Site. This location is inhabited only during portions of the year, but it must be considered as a potential MEI location according to NESHAPs. An effective dose of 0.0333 mrem (0.333 µSv) was calculated for a hypothetical person living at Frenchman's Cabin during 2015.

Figure 8-2 compares the maximum individual doses calculated for 2006–2015. All of the doses are well below the whole body dose limit of 10 mrem (100 µSv) for airborne releases of radionuclides established by 40 CFR 61. 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 (~71 percent of the total Ci released in 2015), 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, 30 percent of the total activity released was argon-41 (^{41}Ar) (Table 4-2), yet ^{41}Ar resulted in less than 8 percent of the estimated dose. On the other hand, radionuclides typically associated with airborne particulates (^{241}Am, ^{137}Cs, ^{129}I, ^{239}Pu, ^{240}Pu, and 90Sr) were a tiny fraction (less than 0.001 percent) of the total amount of radionuclides reported to be released (Table 4-2) yet resulted in approximately 56 percent of the estimated dose (Figure 8-3). The potential dose from ingesting or inhaling ^{241}Am is higher than that for other radionuclides because it is long-lived (432.2 years) and a small amount that enters the body can get into the bones, where it can remain for many decades; a smaller amount can get into the liver and other organs, where it may remain for a few years as the body clears it. While in the body, ^{241}Am continues to expose the surrounding tissues to both alpha and gamma radiation. Tritium represented about 29 percent of the total activity released and contributed approximately 34 percent of the calculated dose

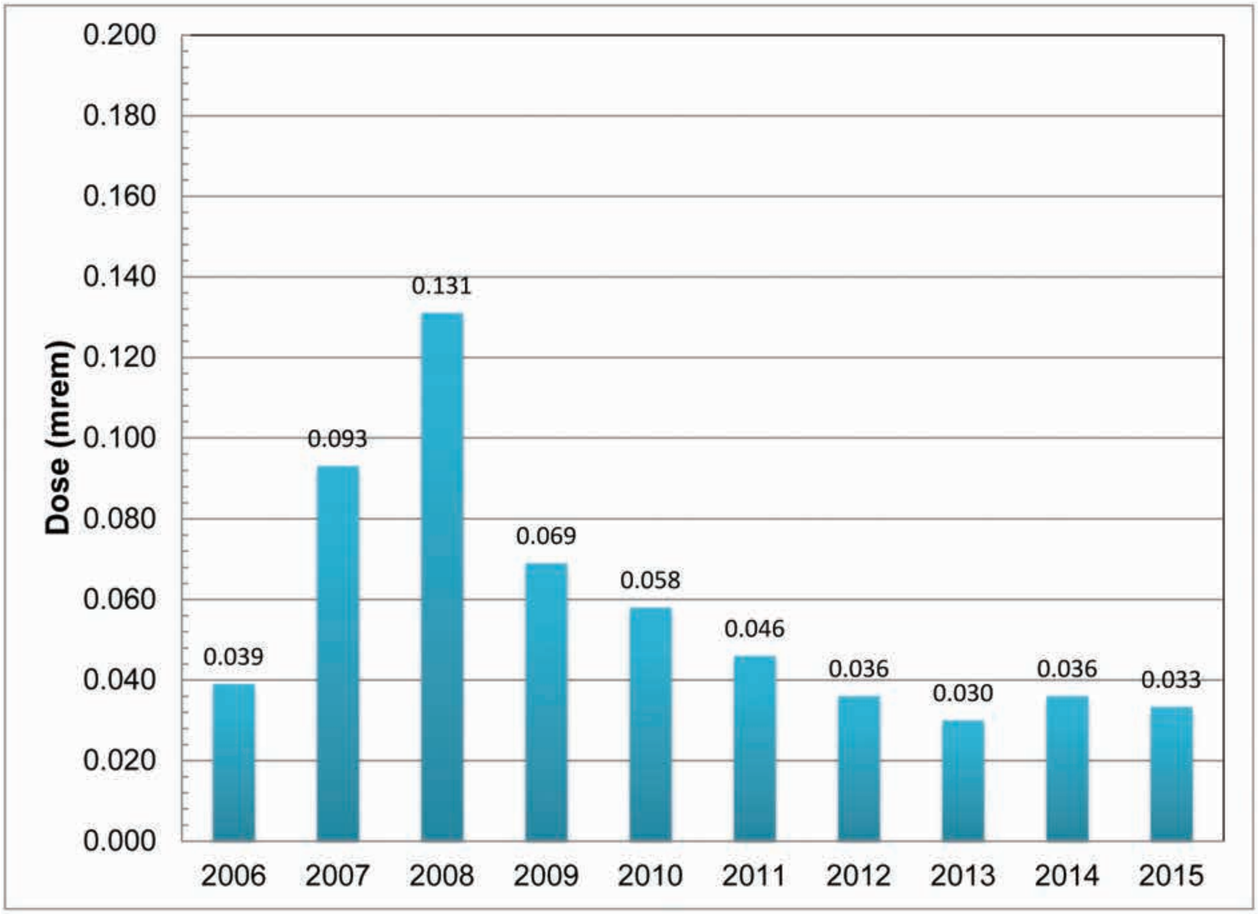

Figure 8-2. Maximum Individual Doses from INL Site Airborne Releases Estimated for 2006 – 2015.

to the MEI in 2015. 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 2016) as follows:

- The dose from tritium emissions, which accounted for approximately 33.7 percent of the total dose to the MEI, was estimated to result mainly from ATR main stack emissions and fugitive (i.e., non-point source) releases from the Warm Waste Evaporation Pond at the ATR Complex, the Three Mile Island (TMI)-2 Independent Spent Fuel Storage Installation at INTEC, and the beryllium blocks at the RWMC.
- Emissions of ^{241}Am, ^{239}Pu, and ^{240}Pu were primarily from Accelerated Retrieval Projects (ARPs), most notably sludge repackaging at WMF-1617 (ARP-V) located at the RWMC.
- 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.
- Iodine-129 releases were primarily associated with the TMI-2 Independent Spent Fuel Storage Installation at Idaho Nuclear Technology and Engineering Center (INTEC).
- Airborne emissions of ^{41}Ar were the result of the operation of the Advanced Test Reactor (ATR) at the ATR Complex.

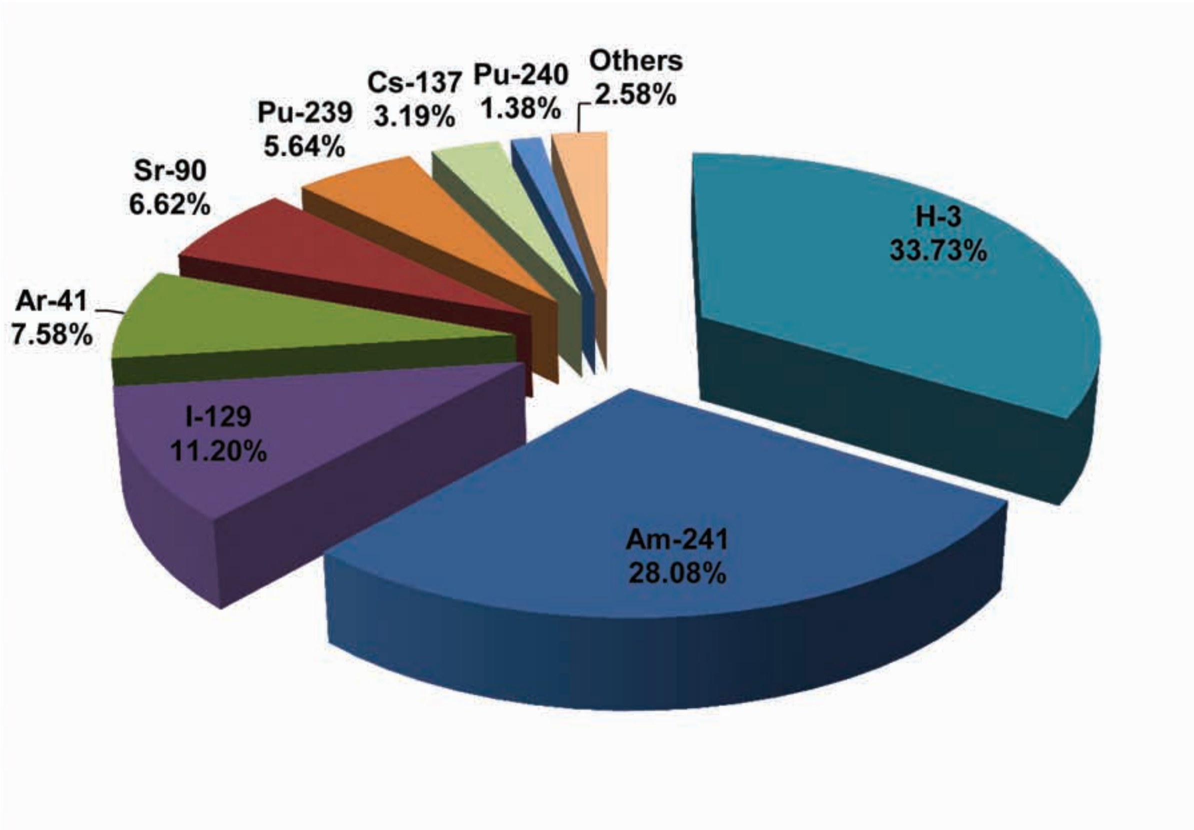

Figure 8-3. Radionuclides Contributing to Dose to Maximally Exposed Individual from INL Site Airborne Effluents as Calculated Using the CAP88-PC Model (2015).

8.2.2 Eighty Kilometer (50 Mile) Population Dose

The National Oceanic and Atmospheric Administration Air Resources Laboratory – Field Research Division (NOAA ARL-FRD) developed an air transport and dispersion model, called MDIFFH, designed specifically for estimating impacts over periods of up to a year or more on and around the INL Site (Sagendorf et al. 2001). It is based on an earlier model, called MESODIF, and was developed by the NOAA ARL-FRD from field experiments in arid environments (e.g., the INL Site and the Hanford Site in eastern Washington). The model was used in the population dose calculations. A detailed description of the model and its capabilities may be found at www.noaa.inel.gov/capabilities/modeling/T&D.htm.

During 2015, the NOAA ARL-FRD 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). The transport and dispersion of contaminants by winds was projected by the MDIFFH model using wind speeds and directions from the one-hour Mesonet database for 2015. The model predicted average annual air concentrations, resulting from INL Site airborne effluent releases, at each of over 10,000 grid points on and around the INL Site (Figure 8-5).

The results were used to prepare a contour map showing calculated annual air concentrations, called time integrated concentrations (TICs) (Figure 8-6). The higher numbers on the map represent higher annual average concentrations. So, for example, the annual air concentration resulting from INL Site releases was estimated to be approximately five times higher at Mud Lake than at Dubois. The data used to prepare this map was also used to identify where an individual might be exposed to the highest air concentration during the year, and what

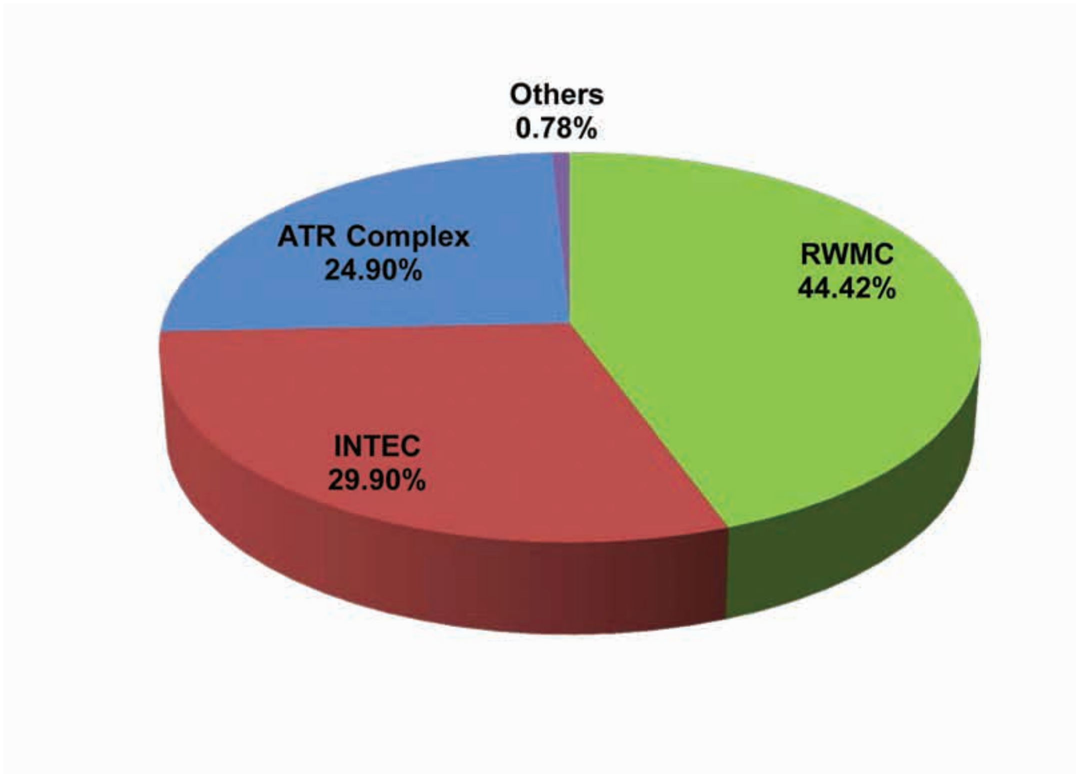

Figure 8-4. Percent Contributions, by Facility, to Dose to Maximally Exposed Individual from INL Site Airborne Effluents as Calculated Using the CAP88-PC Model (2015).

the TIC at that location was. The TIC and radionuclide release rates (Table 4-2) were then used to calculate the dose to this individual (the Reference Resident) from each facility release of radionuclides. In 2015, the Reference Resident was projected by MDIFFH to live at Frenchman's Cabin at the southern boundary of the INL Site. Frenchman's Cabin is also the location of the MEI used by for NESHAP dose assessment in 2015.

The average TIC modeled for each INL Site facility at Frenchman's Cabin was then input into an Excel workbook used to estimate doses with mathematical algorithms derived from the original AIRDOS-EPA computer code (Moore et al. 1979)—AIRDOS-EPA is the basis for CAP88-PC. The Excel workbooks are described in Appendix B of DOE-ID (2014). The dose to the Reference Resident in 2015 was estimated to be 0.0509 mrem (0.509 µSv) per year.

The population of each census division was updated with data from the 2010 census extrapolated to 2015.

The doses received by people living in each census division were calculated by multiplying the following four variables together:

- The release rate for each radionuclide (summarized in Table 8-1)
- The MDIFFH time integrated air concentration calculated for each location (a county census division)
- The population in each census division within that county division
- The dose calculated to be received by the individual exposed to the highest MDIFFH-projected time integrated air concentration (i.e., the Reference Resident).

The estimated dose at each census division was then summed over all census divisions to result in the 50-mi (80-km) population dose (Table 8-2). The estimated po-

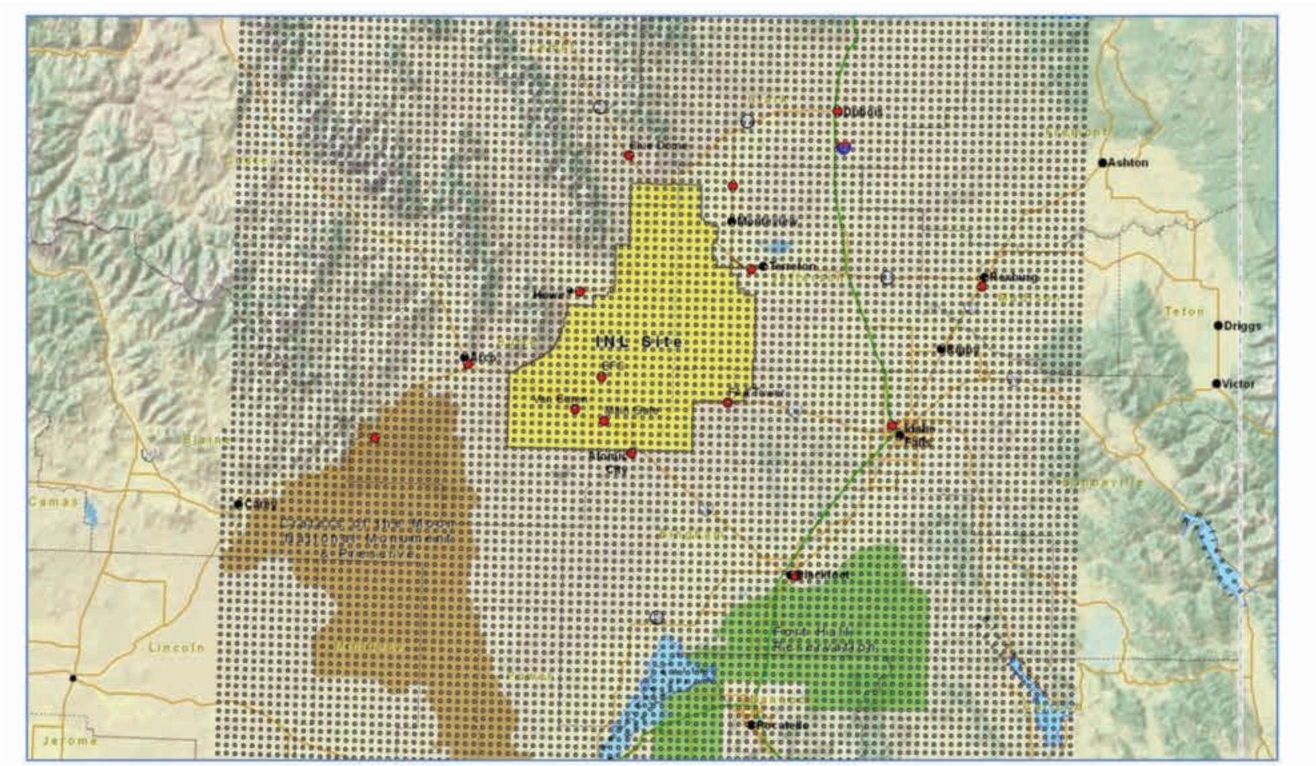

Figure 8-5. INL Site Mesoscale Grid Currently Used in MDIFFH Simulations of INL Site Air Dispersion Annual TICs. Red circles represent current ESER air monitoring locations.

tential population dose was 0.614 person-rem (6.14 x 10^{-3} person-Sv) to a population of approximately 323,111. When compared with the approximate population dose of 125,367 person-rem (1,254 person-Sv) estimated to be received from natural background radiation, this represents an increase of about 0.0005 percent. The largest collective dose was in the Idaho Falls census division due to the larger population.

The largest contributors to the population dose were ^{241}Am, contributing over 41 percent of the total population dose, and ^{129}I, contributing 32 percent of the total. These were followed by ^{239}Pu and tritium, contributing about 8 and 5 percent, respectively. Strontium-90 contributed about 4 percent, with ^{41}Ar and ^{240}Pu at about 2 percent of the total population dose (Figure 8-7). The relative contributions of these radionuclides to population dose differ from the relative contributions of the same radionuclides to the MEI dose (Figure 8-3). For example, ^{129}I contributed about 11 percent of the dose to the MEI as compared to 32 percent of the population dose. This difference can be explained by the fact that a much higher air concentration of ^{129}I was projected at Frenchman's Cabin by the MDIFFH model than was calculated using the CAP88-PC code. Tritium was estimated to produce nearly 34 percent of the dose to the MEI, as compared to 5 percent of the population dose. The difference can be attributed mainly to a higher concentration of tritium projected by CAP88-PC at Frenchman's Cabin, as well as the use of dose conversion factors in the CAP88-PC code, which are one and half to two times higher than the DOE dose conversion factors (DOE-ID 2011) used to estimate the dose to the Reference Resident. Other radionuclides, such as ^{41}Ar and ^{241}Am, resulted in slightly different doses to the MEI and the Reference Resident due to one or more factors: different air concentrations calculated by the two air dispersion models (CAP88-PC and MDIFFH), different dose conversion values and agricultural transfer factors used by CAP88-PC and DOE, and different algorithms used to estimate deposition.

For 2015, the RWMC contributed about 52 percent of the total population dose. The INTEC contributed nearly 40 percent, and the ATR Complex accounted for just over 7 percent. All other facilities contributed a total of just over 1 percent.

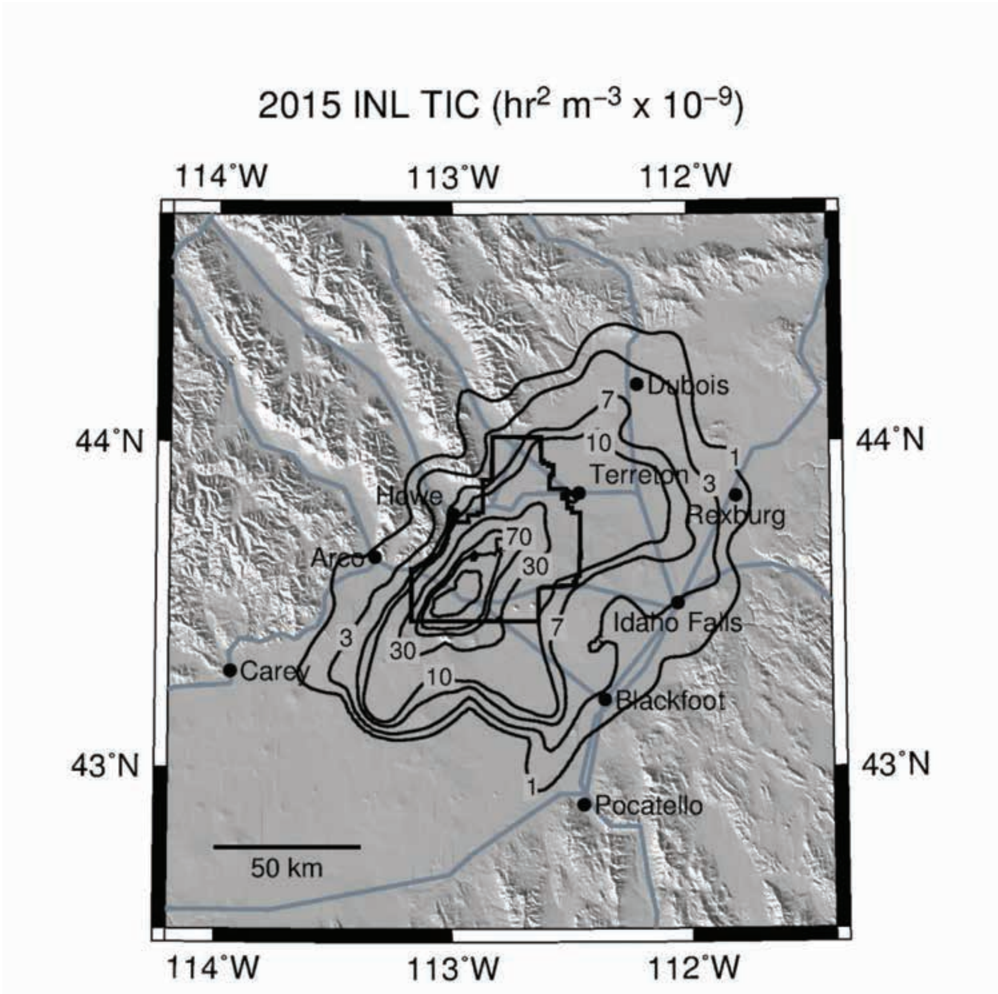

Figure 8-6. INL Site Time Integrated Concentrations (2015).

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 Materials and Fuels Complex (MFC), and game animals that may reside on or migrate through the INL Site.

8.3.1 Waterfowl

Five waterfowl were collected during 2015: three from the ATR Complex wastewater ponds and two from a control location on the Portneuf River. The maximum potential dose from eating 225 g (8 oz) of duck meat collected in 2015 is presented in Table 8-3. Radionuclide concentrations used to determine these doses are reported in Figure 7-5. 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 0.49 mrem (4.9 µSv) from these waterfowl samples is much higher than the dose estimated for 2014 (0.032 mrem [0.32 µSv]) but is below the 0.89 mrem (8.9 µSv) dose estimated from the most contaminated ducks taken from the evaporation ponds between 1993 and 1998 (Warren et al. 2001). The 2015 samples were not collected directly from the wastewater disposal ponds 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 increase in dose in 2015 may be attributed to the fact that the disposal ponds were being dewatered during this period and may have resulted in increased

Table 8-2. Dose to Population within 80 Kilometers (50 miles) of INL Site Facilities (2015).

Census County Division[a,b]	Population[c]	Population Dose	
		Person-rem	Person-Sv
Aberdeen	3480	2.02×10^{-3}	2.02×10^{-5}
Alridge	579	9.50×10^{-5}	9.50×10^{-7}
American Falls	8031	1.41×10^{-3}	1.41×10^{-5}
Arbon (part)	30	1.25×10^{-5}	1.25×10^{-7}
Arco	2612	4.76×10^{-2}	4.76×10^{-4}
Atomic City (division)	2687	2.56×10^{-2}	2.56×10^{-4}
Blackfoot	15,481	2.33×10^{-2}	2.33×10^{-4}
Carey (part)	1058	1.65×10^{-3}	1.65×10^{-5}
East Clark	81	1.13×10^{-4}	1.13×10^{-6}
East Madison (part)	282	1.23×10^{-4}	1.23×10^{-6}
Firth	3274	3.84×10^{-3}	3.84×10^{-5}
Fort Hall (part)	4469	3.32×10^{-3}	3.32×10^{-5}
Hailey-Bellevue (part)	6	3.35×10^{-10}	3.35×10^{-12}
Hamer	2353	3.47×10^{-2}	3.47×10^{-4}
Howe	378	1.40×10^{-2}	1.40×10^{-4}
Idaho Falls	105,342	1.73×10^{-1}	1.73×10^{-3}
Idaho Falls, west	1706	7.32×10^{-3}	7.32×10^{-5}
Inkom (part)	641	2.15×10^{-4}	2.15×10^{-6}
Island Park (part)	95	1.01×10^{-4}	1.01×10^{-6}
Leadore (part)	6	1.07×10^{-7}	1.07×10^{-9}
Lewisville-Menan	4270	2.60×10^{-2}	2.60×10^{-4}
Mackay (part)	1249	4.11×10^{-6}	4.11×10^{-8}
Moreland	10,559	4.58×10^{-2}	4.58×10^{-4}
Pocatello	69,895	4.27×10^{-2}	4.27×10^{-4}
Rexburg	28,604	4.34×10^{-2}	4.34×10^{-4}
Rigby	19,476	5.14×10^{-2}	5.14×10^{-4}
Ririe	1965	2.22×10^{-4}	2.22×10^{-6}
Roberts	1654	1.33×10^{-2}	1.33×10^{-4}
Shelley	8754	1.34×10^{-2}	1.34×10^{-4}
South Bannock (part)	326	1.56×10^{-4}	1.56×10^{-6}
St. Anthony (part)	2604	1.87×10^{-3}	1.87×10^{-5}
Sugar City	7209	1.41×10^{-2}	1.41×10^{-4}
Swan Valley (part)	6352	8.92×10^{-4}	8.92×10^{-6}
Ucon	6558	2.09×10^{-2}	2.09×10^{-4}
West Clark	866	1.29×10^{-3}	1.29×10^{-5}
Total	**323,111**	**0.614**	**6.14×10^{-3}**

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 2015 values based on 2010 Census Report for Idaho.

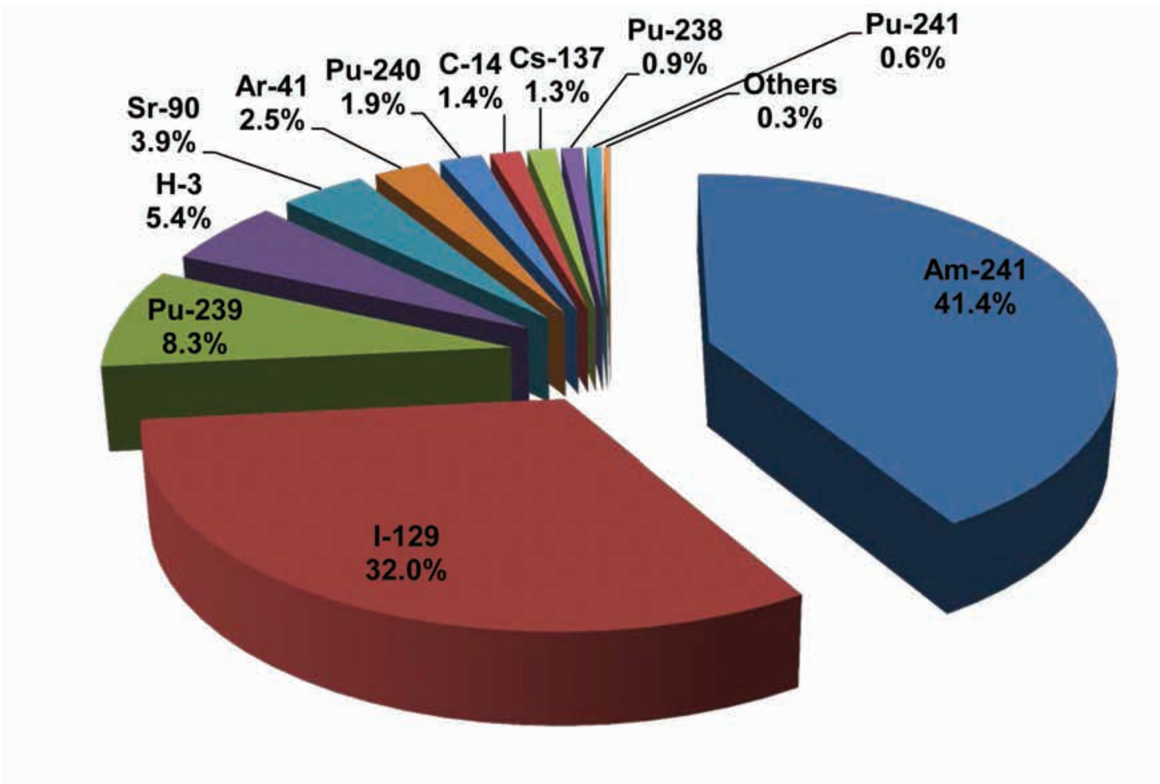

Figure 8-7. Radionuclides Contributing to Dose to the 50-Mile Population from INL Site Airborne Effluents as Calculated Using Excel Workbooks and Results of the MDIFFH Air Dispersion Model (2015).

Table 8-3. Maximum Annual Potential Dose from Ingestion of Edible Waterfowl Tissue Using INL Site Wastewater Disposal Ponds in 2015.[a]

Radionuclide	ATR Complex Maximum Dose (mrem/yr)	Control Sample Maximum Dose (mrem/yr)
Cesium-134	1.02×10^{-3}	0
Cesium-137	3.00×10^{-1}	0
Cobalt-58	5.33×10^{-5}	0
Cobalt-60	7.65×10^{-2}	0
Selenium-75	1.10×10^{-4}	0
Strontium-90	9.98×10^{-2}	0
Zinc-65	1.42×10^{-2}	0
Total Dose	**4.92×10^{-1}**	**0**

a. Effective dose from consuming 225 g (8 oz) of edible (muscle) waterfowl tissue. Dose conversion factors are from Federal Guidance Report No. 13 (EPA 2002).

concentrations of radionuclides in the remaining pond water.

8.3.2 Big Game Animals

A study on the INL Site from 1972 to 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 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 2015, none of the five game animals collected (three elk and two mule deer) 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 et al. 1983). The total population dose 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). These wells, located in an uninhabited area, have shown a historical downward trend in tritium detections. The maximum concentration (3,400 ± 200 pCi/L) 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 per year. 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 no one uses these wells for drinking water, this is an unrealistic scenario and the groundwater ingestion pathway is not included in the total dose estimate to a 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 7-8). In 2015, 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 2015, 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 on the southern INL Site boundary at Frenchman's Cabin (Figure 4-2), would receive a calculated dose from INL Site airborne releases reported for 2015 (Section 8.2.1). For this analysis, we also assumed that the same hypothetical individual would kill and eat a duck with the maximum radionuclide concentrations detected in 2015 (Figure 7-5). For this scenario, the duck would be killed at the nearby Mud Lake Wildlife Management Area. The duck would be killed soon after it left the INL Site. No dose was calculated from eating a big game animal because no human-made radionuclides were found in game animals sampled in 2015.

The dose estimate for an offsite MEI from the air and game animal pathways is presented in Table 8-4. The total dose was conservatively estimated to be 0.525 mrem (5.25 µSv) for 2015. For comparison, the total dose received by the MEI in 2014 was calculated to be 0.069 mrem (0.69 µSv). The higher value in 2015 was due to the increased dose from waterfowl, discussed in Section 8.3.1.

The total dose calculated to be received by the hypothetical MEI for 2015 (0.525 mrem [5.25 µSv]) represents about 0.14 percent of the dose expected to be received from background radiation (388 mrem [3.9 mSv], as shown in Table 7.5) and is well below the 100 mrem/yr (1 mSv/yr) limit above background established by

Table 8-4. Contribution to Estimated Dose to a Maximally Exposed Individual by Pathway (2015).

Pathway	Dose to Maximally Exposed Individual (mrem)	Dose to Maximally Exposed Individual (mSv)	Percent of Applicable Dose 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	3.33×10^{-2}	3.33×10^{-4}	3.33×10^{-1}	0.614	0.00614	323,111	125,367
Waterfowl ingestion	4.92×10^{-1}	4.92×10^{-3}	NA[c]	NA	NA	NA	NA
Big game animals	0	0	NA	NA	NA	NA	NA
Total pathways	**5.25×10^{-1}**	**5.25×10^{-3}**	**5.25×10^{-1}**	**NA**	**NA**	**NA**	**NA**

a. The EPA regulatory standard for the air pathway is 10 mrem/yr effective dose equivalent. The DOE limit for all pathways is 100 mrem/yr total effective dose equivalent.
b. The individual dose from background was estimated to be 388 mrem (3.9 mSv) in 2015 (Table 7-5).
c. NA = Not applicable.

DOE. As discussed in the Helpful Information section of this report, the 100 mrem 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 0.614 person-rem. This is approximately 0.0005 percent of the dose (125,367 person-rem) expected from exposure to natural background radiation in the region.

8.7 Dose to Biota

8.7.1 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 graded approach begins the evaluation using 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, 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.

8.7.2 Terrestrial Evaluation

Of particular importance for the terrestrial evaluation portion of the 2015 biota dose assessment is the division of the INL Site into evaluation areas based on potential soil contamination and habitat types. 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 et al. 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 1-3 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 8-5). The table includes laboratory analyses of soil samples collected in 2005, 2006, 2012, and 2015.

Using the maximum radionuclide concentrations for all locations in Table 8-6, a screening level analysis was made of the potential terrestrial biota dose. The soil concentrations are conservative because background concentrations (see Table 7-2) were not subtracted. The analysis also assumed that animals have access to water in facility effluents and ponds. The maximum radionuclide concentrations reported in Appendix C were used to represent surface water concentrations. The combined sum of fractions was less than one for both terrestrial animals (0.211) and plants (0.2011) and passed the general screening test (Table 8-6).

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.

8.7.3 Aquatic Evaluation

For the aquatic evaluation, maximum radionuclide concentrations reported in any pond or effluent at the INL Site (see Appendix C) were used. Table C-16 (results for the MFC Industrial Waste Pond) is the only table that shows measurements of specific radionuclides in pond water (^{137}Cs, $^{233/234}$U, and ^{238}U). When $^{233/234}$U was reported, it was conservatively assumed that each radionuclide was present in equal concentrations. Potassium-40 reported in ponds was assumed to be of natural origin and was not included in the 2015 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 (1.05E-02) and riparian animals (3.11E-03).

Tissue data from waterfowl collected on the ATR Complex ponds in 2015 were also available (Figure 7-5). 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 Figure 7-5. 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

Table 8-5. Concentrations of Radionuclides in INL Site Soils, by Area.

Location[a]	Radionuclide	Detected Concentration (pCi/g)[b] Minimum	Maximum
ARA	Cesium-134	4.0×10^{-2}	6.0×10^{-2}
	Cesium-137	1.3×10^{-1}	3.02
	Strontium-90	2.10×10^{-1}	3.70×10^{-1}
	Plutonium-238	------	3.90×10^{-3}
	Plutonium-239/240	1.30×10^{-2}	1.80×10^{-2}
	Americium-241	5.50×10^{-3}	8.50×10^{-3}
ATR Complex	Cesium-137	2.00×10^{-1}	6.10×10^{-1}
	Strontium-90	------	5.82×10^{-2}
	Plutonium-238	5.90×10^{-3}	4.30×10^{-2}
	Plutonium-239/240	1.70×10^{-2}	2.18×10^{-2}
CITRC	Cesium-137	1.50×10^{-1}	1.90×10^{-1}
MFC	Cesium-134	4.00×10^{-2}	6.00×10^{-2}
	Cesium-137	1.20×10^{-1}	4.90×10^{-1}
	Cobalt-60	------	5.00×10^{-2}
	Plutonium-239/240	1.50×10^{-2}	2.90×10^{-2}
	Americium-241	4.30×10^{-3}	1.20×10^{-2}
INTEC	Cesium-134	------	8.00×10^{-2}
	Cesium-137	3.00×10^{-2}	3.54
	Strontium-90	4.90×10^{-1}	7.10×10^{-1}
	Plutonium-238	2.50×10^{-2}	4.30×10^{-2}
	Plutonium-239/240	1.10×10^{-2}	2.90×10^{-2}
	Americium-241	6.10×10^{-3}	8.10×10^{-3}
Air Monitors	Cesium-134	4.00×10^{-2}	5.00×10^{-2}
	Cesium-137	2.00×10^{-2}	9.70×10^{-1}
NRF	Cesium-134	------	6.00×10^{-2}
	Cesium-137	------	3.30×10^{-1}
	Plutonium-239/240	5.70×10^{-3}	1.60×10^{-2}
	Americium-241	4.30×10^{-3}	9.70×10^{-3}
RWMC	Cesium-134	3.00×10^{-2}	9.00×10^{-2}
	Cesium-137	1.20×10^{-1}	3.13
	Srontium-90	1.01×10^{-1}	3.49×10^{-1}
	Plutonium-238	2.19×10^{-3}	1.51×10^{-2}
	Plutonium-239/240	1.9×10^{-2}	9.46×10^{-1}
	Americium-241[d]	4.8×10^{-2}	6.35×10^{-1}
TAN/SMC	Cesium-134	4.00×10^{-2}	6.00×10^{-2}
	Cesium-137	1.10×10^{-1}	3.13
	Plutonium-239/240	1.25×10^{-2}	1.74×10^{-2}
	Americium-241	3.20×10^{-3}	5.70×10^{-3}
All	Cesium-134	3.00×10^{-2}	9.60×10^{-2}
	Cesium-137	2.00×10^{-2}	3.54
	Cobalt-60	------	5.00×10^{-2}
	Strontium-90	1.23×10^{-2}	7.10×10^{-1}
	Plutonium-238	2.19×10^{-3}	4.30×10^{-2}
	Plutonium-239/240	5.70×10^{-3}	9.46×10^{-1}
	Americium-241[d]	3.20×10^{-3}	6.35×10^{-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.

b. Legend:

a.	Results measured in 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 in 2013 using in situ gamma spectroscopy. Not measured in 2014.
f.	Result measured by laboratory analyses of soil samples collected in 2015.

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 8-6. RESRAD Biota 1.5 Biota Dose Assessment (Screening Level) of Terrestrial Ecosystems on the INL Site (2015).

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	0.635	3.89E+03	1.63E-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	0.096	1.13E+01	8.50E-03
Cesium-137	0	5.99E+05	0.00E+00	3.54	2.08E+01	1.71E-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	1.57	4.01E+05	3.92E-06	0	4.83E+03	0.00E+00
Uranium-238	0.595	4.06E+05	1.47E-06	0	1.58E+03	0.00E+00
Summed	-	-	**5.38E-06**	-	-	**2.11E-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	0.635	2.15E+04	2.95E-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	0.096	1.09E+03	8.84E-05
Cesium-137	0	4.93E+07	0.00E+00	3.54	2.21E+03	1.60E-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	0.667	1.06E+10	1.48E-10	0	5.23E+04	0.00E+00
Uranium-238	0.459	4.28E+07	1.39E-08	0	1.57E+04	0.00E+00
Summed	-	-	**1.40-08**	-	-	**2.01E-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.

calculated by RESRAD-Biota 1.5 to be 0.00211rad/d (0. 0.0211 mGy/d). This dose is less than the standard of 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.

8.8 Doses from Unplanned Releases

No unplanned radioactive releases from the INL site were reported in 2015. As such, there are no doses associated with unplanned releases during 2015.

REFERENCES

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40 CFR 61, Subpart H, 2015, "National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities," *Code of Federal Regulations*, Office of the Federal Register.

Table 8-7. RESRAD Biota 1.5 Assessment (Screening Level) of Aquatic Ecosystems on the INL Site (2015).

Aquatic Animal						
	Water			Sediment		
Nuclide	Concentration (pCi/L)	BCG[a] (pCi/L)	Ratio	Concentration (pCi/g)	BCG (pCi/g)	Ratio
Uranium-233	1.57	2.00E+02	7.86E-03	0.0785	1.06E+07	7.41E-09
Uranium-238	0.595	2.23E+02	2.66E-03	0.02975	4.28E+04	6.94E-07
Summed	-	-	**1.05E-02**	-	-	**7.02E-07**
Riparian Animal						
	Water			Sediment		
Nuclide	Concentration (pCi/L)	BCG (pCi/L)	Ratio	Concentration (pCi/g)	BCG (pCi/g)	Ratio
Uranium-233	1.57	6.76E+02	2.32E-03	0.0785	5.28E+03	1.49E-05
Uranium-238	0.595	7.56E+02	7.87E-04	0.02975	2.49E+03	1.20E-05
Summed	-	-	**3.11E-03**	-	-	**2.68E-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 1.5 Assessment (Level 3 Analysis) of Aquatic Ecosystems on the INL Site Using Measured Waterfowl Tissue Data (2015).

Waterfowl Dose (rad/d)					
Nuclide	Water[a]	Soil[b]	Sediment	Tissue[c]	Summed
Americium-241	0.00E+00	4.47E-07	0.00E+00	0.00E+00	4.47E-07
Cesium-134	0.00E+00	5.73E-06	0.00E+00	1.78E-06	7.51E-06
Cesium-137	0.00E+00	7.67E-05	0.00E+00	5.27E-04	6.03E-04
Cobalt-58	0.00E+00	0.00E+00	0.00E+00	1.20E-06	1.20E-06
Cobalt-60	0.00E+00	4.97E-06	0.00E+00	9.04E-04	9.09E-04
Plutonium-238	0.00E+00	1.76E-10	0.00E+00	0.00E+00	1.76E-10
Plutonium-239	0.00E+00	1.94E-09	0.00E+00	0.00E+00	1.94E-09
Selenium-75	0.00E+00	0.00E+00	0.00E+00	3.24E-07	3.24E-07
Strontium-90	0.00E+00	5.14E-07	0.00E+00	2.48E-04	2.48E-04
Uranium-233	2.32E-04	0.00E+00	1.48E-06	0.00E+00	2.33E-04
Uranium-238	7.73E-05	0.00E+00	5.38E-07	0.00E+00	7.79E-05
Zinc-65	0.00E+00	0.00E+00	0.00E+00	3.14E-05	3.14E-05
Total	**3.09E-04**	**8.83E-05**	**2.02E-06**	**1.71E-03**	**2.11E-03**

a. Only uranium isotopes were measured in the ATR Complex Cold Waste Pond. Hence, there were no doses 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 ATR Complex were used (Table 8-5).

c. Internal doses to waterfowl were calculated using maximum concentrations in edible tissue shown in Figure 7-5.

Note: Selenium-75, uranium isotopes, and zinc-65 were not measured in soil.

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9. Monitoring Wildlife Populations

East Butte

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 environmental policies and executive orders related to protection of wildlife. During 2015, midwinter eagle, sage-grouse, breeding bird, and bat surveys were conducted on the INL Site and are highlighted as follows:

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.

Sage-grouse research has been conducted on the INL Site for over 30 years. 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 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 Candidate Conservation Agreement 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.

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 2014, in conjunction with the IDFG, Bureau of Land Management, U.S. Forest Service, and USFWS, preliminary active acoustic driving survey transects were developed for bats on the INL Site. The feasibility was assessed and preliminary data were collected in 2015. 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 raptors, sage-grouse, 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 (2011)
- Memorandum of Understanding between the United States Department of Energy and the United States Fish and Wildlife Service 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 Idaho National Laboratory Site (DOE-ID and USFWS 2014)

The following sections summarize the results from wildlife surveys conducted by the ESER contractor on the INL Site during 2015.

9.1 Midwinter Eagle Survey

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 that they see. Observers also record the same information for other raptors, common ravens, shrikes (*Lanius* spp.), and black-billed magpies they observe 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 13, 2015, ESER biologists led surveys along the two traditional INL Site routes. Observers counted 98 birds (Figure 9-1), which was lower than what is typically seen (median=118) and was the fifth-lowest count in the past 15 years. Annual one-day counts are highly variable (range: 73–484 since 2001), and thus a single low year is not cause for alarm. The common raven was the most common species seen (n = 67), accounting for over two-thirds of all observations. Consistent with past years, the rough-legged hawk, which moves south to winter in the region, was the most frequently observed bird of prey (n = 21). Rough-legged hawk observations have been an order of magnitude higher as recently as 2010, but the average over the past four years was only 19. The species' winter abundance on the INL Site may be cyclic (Figure 9-2), and past data would suggest that rough-legged hawk abundance will increase in the next year or two.

9.2 Sage-grouse

Populations of 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 sagebrush (*Artemisia* spp.), which is a central component in an ecosystem that 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 U.S. Fish and Wildlife Service (USFWS) to conserve sage-grouse and the habitats that it depends on across the INL Site (DOE-ID and USFWS 2014). This voluntary agreement established a Sage-Grouse Conservation Area (SGCA) where infrastructure development and human disturbance would be limited (Figure 9-3). 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 USFWS and DOE-ID. The population trigger would 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.

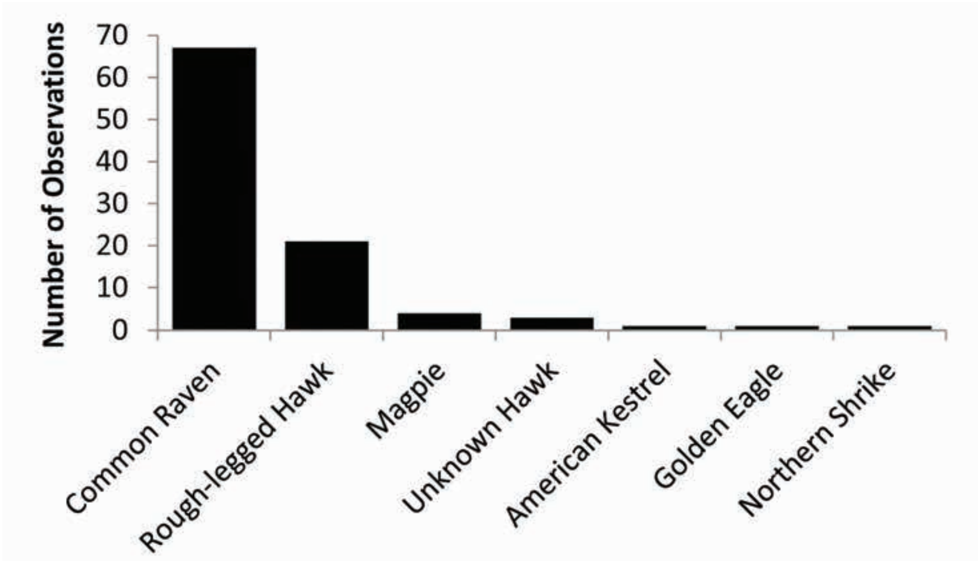

Figure 9-1. Observations of Raptors, Corvids, and Shrikes Made During the 2015 Midwinter Bald Eagle Surveys.

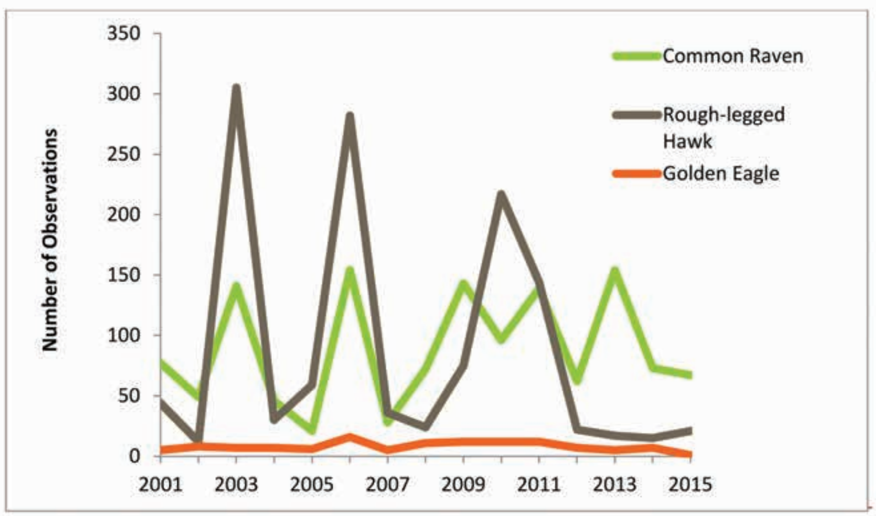

Figure 9-2. Trends of the Three Species Most Commonly Observed During Annual Midwinter Eagle Surveys. Data Were Pooled from the Northern and Southern Routes.

The CCA established a monitoring program based on this trigger threshold and other criteria (Shurtliff et al. 2016b). Part of the program includes annual surveys of sage-grouse leks on the INL Site. A lek is a traditional breeding site, located near a nesting habitat, where sage-grouse return each spring to display and mate (Jenni and Hartzler 1978, Connelly 1981). 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 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 USFWS 2014). The general tasks and their purposes are:

1) ***Lek Surveys*** - Surveys of all active leks on the INL Site, including leks on three Idaho Department of Fish and Game (IDFG) survey routes. Some of these leks comprise a baseline set that the CCA population trigger is linked to.

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.

9.2.1 Lek Surveys

In 2015, ESER biologists surveyed all 47 leks classified as active on or near the INL Site from two to seven times each (Shurtliff et al. 2016b). 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 baseline value upon which the trigger is based. The sum of peak male attendance counts across the 27 leks in 2015 was 335, and the three-year mean (2013–2015) was 340. That

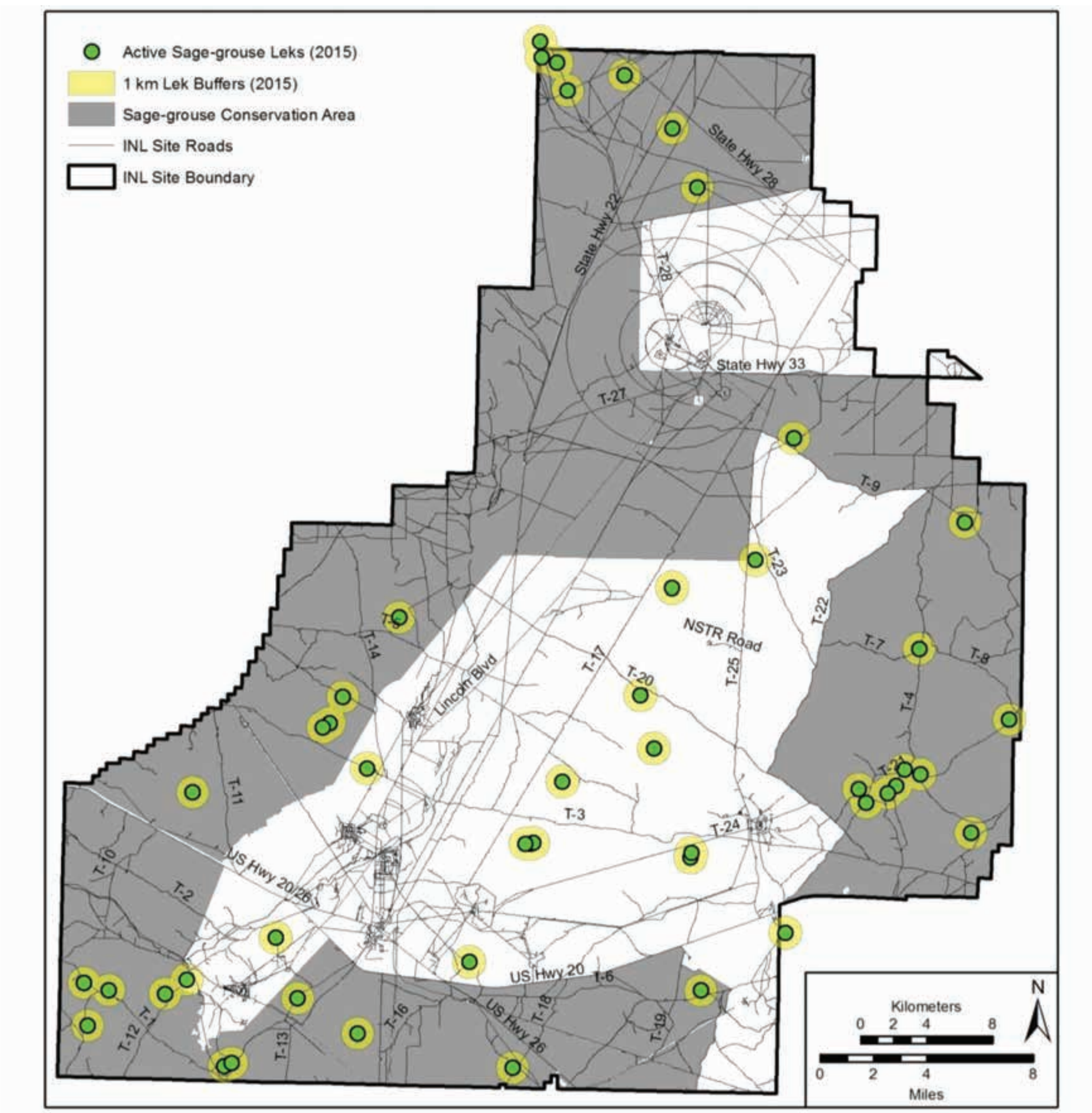

Figure 9-3. Distribution of the 48 Greater Sage-Grouse Lek Sites Classified as Active on or Near the INL Site Following the 2015 Breeding Season.Data Were Pooled from the Northern and Southern Routes.

mean is identical to the 2014 mean (Figure 9-4), and remains at 134 percent of the population trigger point (i.e., 253 males—based on data from 2011). Twenty of the 27 baseline leks remain active after two were reclassified as inactive in 2015. In each of the past three years, two or three baseline leks per year have been reclassified as inactive as an improving data set provides a more accurate picture of the activity status for each lek. These results should not be interpreted as evidence that seven leks have been abandoned in the past three years, but rather that five years of data have accumulated for most leks, allowing for more precise lek classifications.

Non-Baseline Leks. All other known active leks—whether in or out of the SGCA—that are not part of the baseline set described above fall into a second analysis category. In 2015, 23 Category 2 leks were classified as active following the breeding season. On these leks, 244 males were observed at peak attendance. By comparison, in 2014, 264 males were counted on 20 active leks outside the SGCA.

Lek Routes. The third category includes all leks, both active and inactive, that are part of three lek routes established by the Idaho Department of Fish and Game. These 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. 2016b).

Summed peak male attendance across the three lek routes was 254. This count is slightly lower than the 2014 peak of 260 males but still higher than any other year since 2010 when the largest wildland fire in INL Site history occurred (Figure 9-5). Both the Lower Birch Creek and the Tractor Flats routes had higher counts of males in 2015 than in recent years (n = 82 and 76, respectively). The Lower Birch Creek count was higher than any year since 2007, and the Tractor Flats count was the highest since the Jefferson Fire (2010). Peak male attendance on the RWMC route was 96 males, a moderate decrease following two consecutive years of increased attendance.

9.2.2 Historical Lek Surveys

During the past several decades, many leks on the INL Site have been documented by researchers and the Idaho Department of Fish and Game as a result of surveys and opportunistic observations of displaying sage-grouse. Prior to 2009, many of these historical lek sites had not been surveyed for nearly 30 years (Shurtliff and Whiting 2009). For the past seven years, 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 USFWS 2014). The objective has been to determine which historical leks remain active before ESER establishes new lek routes prior to the 2017 lek season (DOE-ID and USFWS 2014).

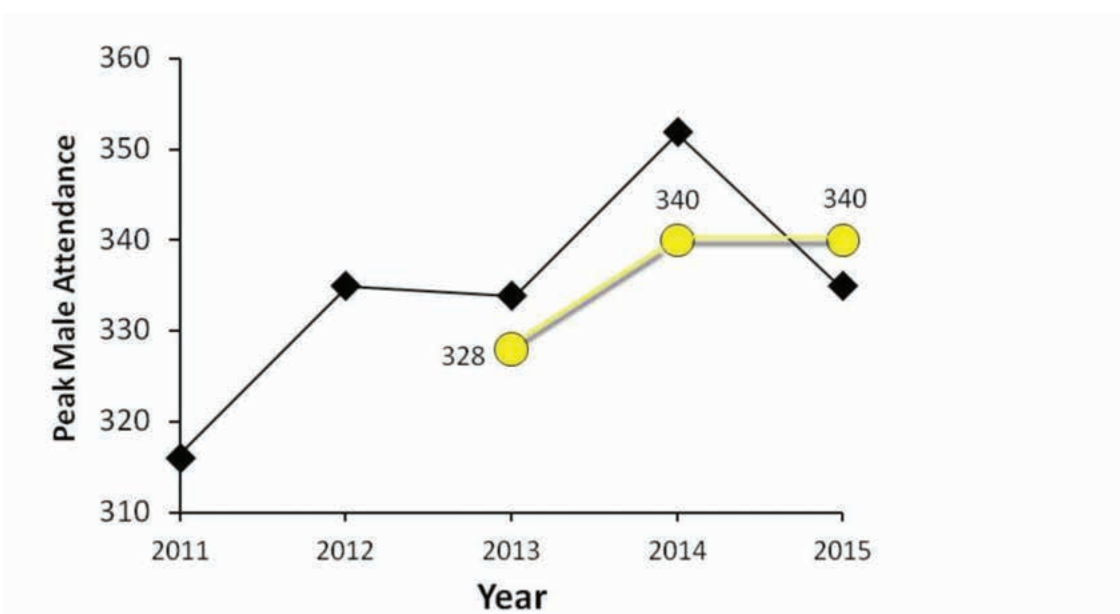

Figure 9-4. Peak Male Attendance on Leks in the SGCA. Black Squares Are Annual Counts and Yellow Dots Represent the Three-Year Running Average.

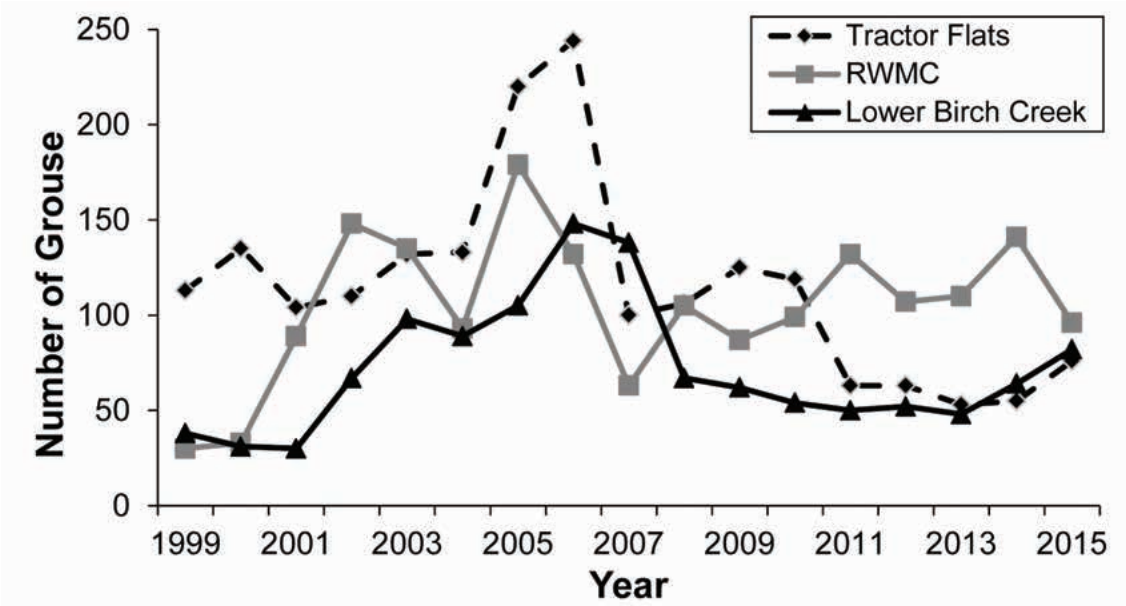

Figure 9-5. Number of Male Sage-Grouse Observed at Peak Attendance Across Three Lek Routes on the INL Site from 1999 to 2015 (from 1999 to 2007, the number of leks surveyed increased from 12 to 21; since 2008, the number of leks surveyed has increased to 24).

Fifteen historical leks were surveyed in the SGCA an average of 2.2 times (range: 2–3 surveys) and 11 historical leks outside the SGCA an average of 2.3 times (range: 2–3 surveys). Across those 26 potential lek sites, males were observed displaying on one lek on two separate visits (three males during one visit and one male during another visit) and four males displaying on another lek during a single visit (Shurtliff et al. 2016b). Consequently, these two leks were reclassified as active.

After a historical lek has been surveyed for five years without at least two years of observed breeding activity, it is reclassified as inactive. Following the 2015 survey season, 10 leks were reclassified as inactive. Fourteen leks remain classified as historical and will be surveyed again in 2016.

9.2.3 Systematic Lek Discovery Surveys

Known lek sites are few or absent across large portions of the SGCA even though habitat in these areas often appears to be adequate to support sage-grouse breeding and nesting activities (DOE-ID and USFWS 2014). Since 2013, ESER has systematically searched for unknown lek sites each spring in areas where few or no leks are known (Shurtliff et al. 2016b). The objective of this task is to continue to search for active lek sites in an effort to find as many as possible before new lek routes are established (DOE-ID and USFWS 2014).

In 2015, 74 surveys were completed (29 road, 45 remote) within the northeastern section of the INL Site and discovered one sage-grouse lek (Shurtliff et al. 2016b). Two males were counted on one visit to the new lek and three males on a second visit. On both occasions four to 14 other sage-grouse of unknown gender were also observed. Since discovery surveys commenced in 2013, ESER has discovered four previously unknown leks.

9.2.4 Sage-Grouse Abundance - Summary & Conclusions

Prior to the start of the 2015 field season, 47 leks were classified as active on or near the INL Site, including two just outside the site boundaries that are part of the IDFG survey routes. In 2015, two active lek sites were reclassified as inactive. However, three additional new active leks were added to the list (two confirmed during historical lek surveys and one documented during the lek discovery surveys), increasing the total number of known active leks on or near the INL Site to 48 (Figure 9-3). In 2009, only 26 leks were known to be active on the INL Site (Shurtliff and Whiting 2009). Although some lek sites may have become occupied since 2009, the majority of leks were simply discovered or rediscovered through the ESER program's systematic effort.

Peak male attendance in 2015 across all leks on the INL Site was 589. This count represents the summed counts from SGCA baseline leks (*n* = 335), all other active INL Site leks recognized as such at the beginning of the field season (*n* = 244), the two historical leks reclassified as active in 2015 (*n* = 7), and the newly discovered lek (*n* = 3). For greater detail on the 2015 sage-grouse monitoring season, see Shurtliff et al. (2016a).

The population trigger for sage-grouse will trip if the three-year average of peak male attendance falls below 253 males across the 27 baseline leks within the SGCA since this would represent a decrease of over 20 percent of the 316 males counted in 2011. The three-year average peak male attendance (2013–2015) on the 27 baseline leks remains at 340 individuals—the same as last year's three-year average. Therefore, this index shows no evidence that sage-grouse abundance is declining on the INL Site.

9.3 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 U.S. east of the Mississippi and Canada and by 1968, 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 9-6). Data from remote routes contribute to the USGS continent-wide analyses of bird trends and also provide information that local managers can use to track and understand population trends. Data from facility routes may be useful in detecting whether INL activities cause measurable impacts on abundance and diversity of native birds.

Surveys were conducted surveys along the 13 remote and facility routes from May 29 to June 30, 2015. In total, 3,503 birds were observed, which was 26 percent less than the 28-year average of 4,748 birds (Figure 9-7; surveys were not conducted in 1992 and 1993). Fifty-two species were recorded, which is also lower than the average of 56 (Bybee and Shurtliff 2015).

Similar patterns of bird abundance was observed among those species that have typically been the most numerous in past years. In 2015, the six species that were documented in greatest abundance were horned lark (*n* = 897), western meadowlark (n = 667), sage thrasher (*n* = 499), mourning dove (*n* = 296), sagebrush sparrow (*n* = 227), and Brewer's sparrow (*n* = 154). With the exception of the mourning dove, these species have been the five most abundant 23 times during the past 29 years of surveys, and in the remaining six years they were among the six most abundant species.

Investigators observed two species that were previously not recorded during the INL surveys: one unidentified hummingbird and one peregrine falcon. Additionally, a great blue heron was observed, which had been recorded in only two of the past 28 years. Species observed during the 2015 BBS that are considered by the Idaho Department of Fish and Game as species of conservation concern included the Franklin's gull (*n* = 76), grasshopper sparrow (*n* = 6), ferruginous hawk (*n* = 15), long-billed curlew (*n* = 7), peregrine falcon (*n* = 1), greater sage-grouse (*n* = 1), and burrowing owl (*n* = 1).

Two negative trends were noted regarding sagebrush specialist species. Brewer's sparrow and sagebrush sparrow (both specialists) have been at historically low levels since 2011. This decline is attributed to the loss of sagebrush habitats during large fires in 2010 and 2011. Conversely, the common raven, which preys on sage-grouse eggs (another sagebrush specialist), continues to trend upward and was observed in 2015 at higher levels than in any other INL Site breeding bird survey, except 2010.

9.4 Raven Nest Surveys

The common raven is a native bird of high intelligence that adapts well to human disturbance and habitat fragmentation. Ravens prey on sage-grouse eggs and chicks, and consequently they 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).

The sage-grouse CCA describes predation threats associated with what appears to be a growing raven

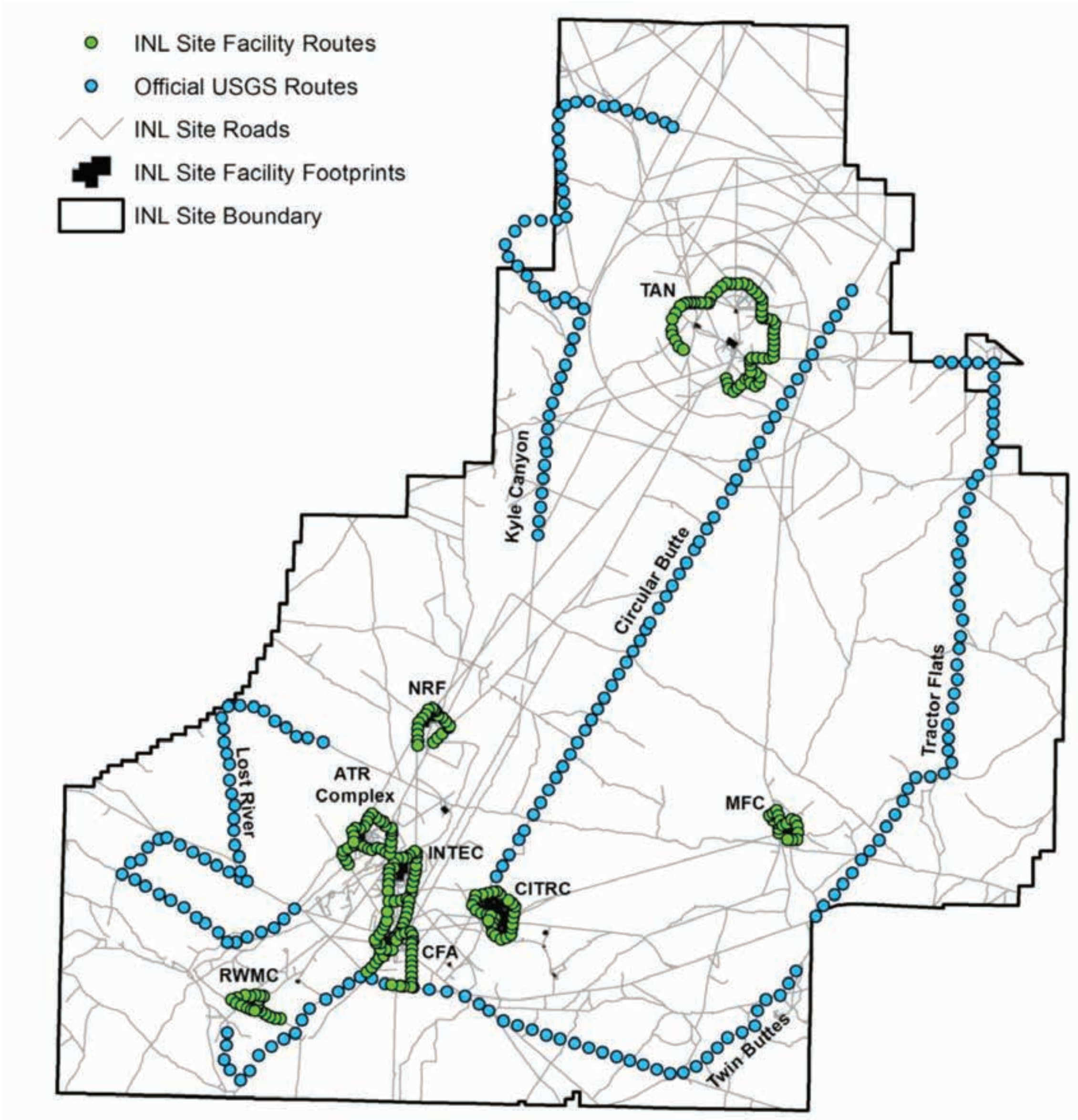

Figure 9-6. Location of Breeding Bird Survey Routes on the INL Site.

population on the INL Site (DOE-ID and USFWS 2014, section 10.8). The current understanding of raven population trends on the INL Site is based solely on breeding bird surveys that have been conducted most years since the mid-1980s. The weakness of this approach is that the breeding bird surveys count all ravens, but territory-holding ravens (i.e., nesting pairs) probably are responsible for the majority of sage-grouse nest depredation (Bui et al. 2010). On the INL Site, most ravens nest on man-made structures, such as power lines, towers, and building platforms (Howe et al. 2014), rather than on natural substrates, such as cliffs and trees. To better track the raven population trend as it relates to sage-grouse predation and to evaluate the influence of infrastructure on raven nesting, the ESER program annually surveys all infrastructure on the INL Site multiple times and documents active raven nests. This monitoring program has now been fully operated for two years. If results confirm that raven use of infrastructure as nesting substrates is expanding, DOE-ID may experiment with nest deterrent devices that discourage raven nesting in high-priority sage-grouse habitat (DOE-ID and USFWS 2014).

During 2014 and 2015, searches were conducted throughout April and May for raven nests along 197 miles of power lines, within 11 facilities, and at 11 tow-

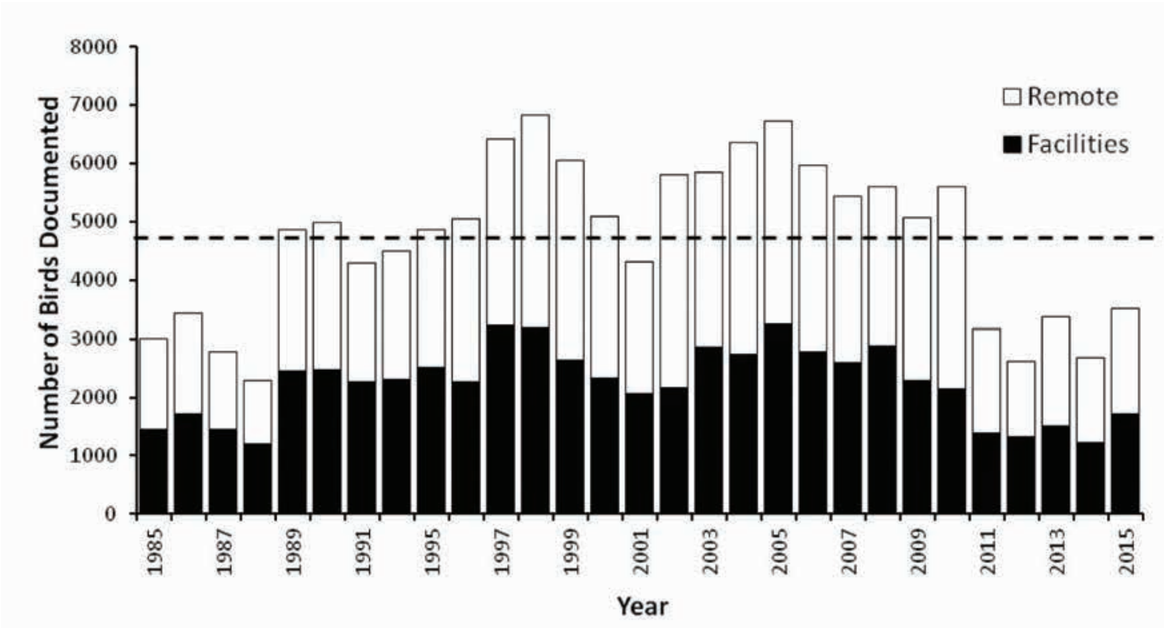

Figure 9-7. Number of Birds Observed During Breeding Bird Surveys on the Idaho National Laboratory Site (the dashed line indicates the mean number of birds observed from 1985 to 2014; no BBSs were conducted on the INL Site in 1992 or 1993).

ers on the INL Site. Thirty-seven nests were found in 2014 and 39 in 2015 (Shurtliff et al. 2016b). In both years, the majority of nests (n = 31) were on power lines, primarily the two-pole transmission structures (Figure 9-8). In 2015, a raven pair nested at a majority (n = 6) of facilities and on two remote weather towers. In response to these data, ESER has begun working with the National Oceanic and Atmospheric Administration to install wire mesh on meteorological towers to discourage raven nesting. In its annual report, DOE-ID committed to the USFWS that they would search for cost-effective ways to reduce raven nesting within facilities, though no specific actions have been identified. INL Power Management is exploring installation of nest deterrent devices while performing routine maintenance. ESER will continue to work closely with DOE-ID and contractors to reduce opportunities for raven nesting on INL Site infrastructure.

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 U.S. 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 can serve a 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

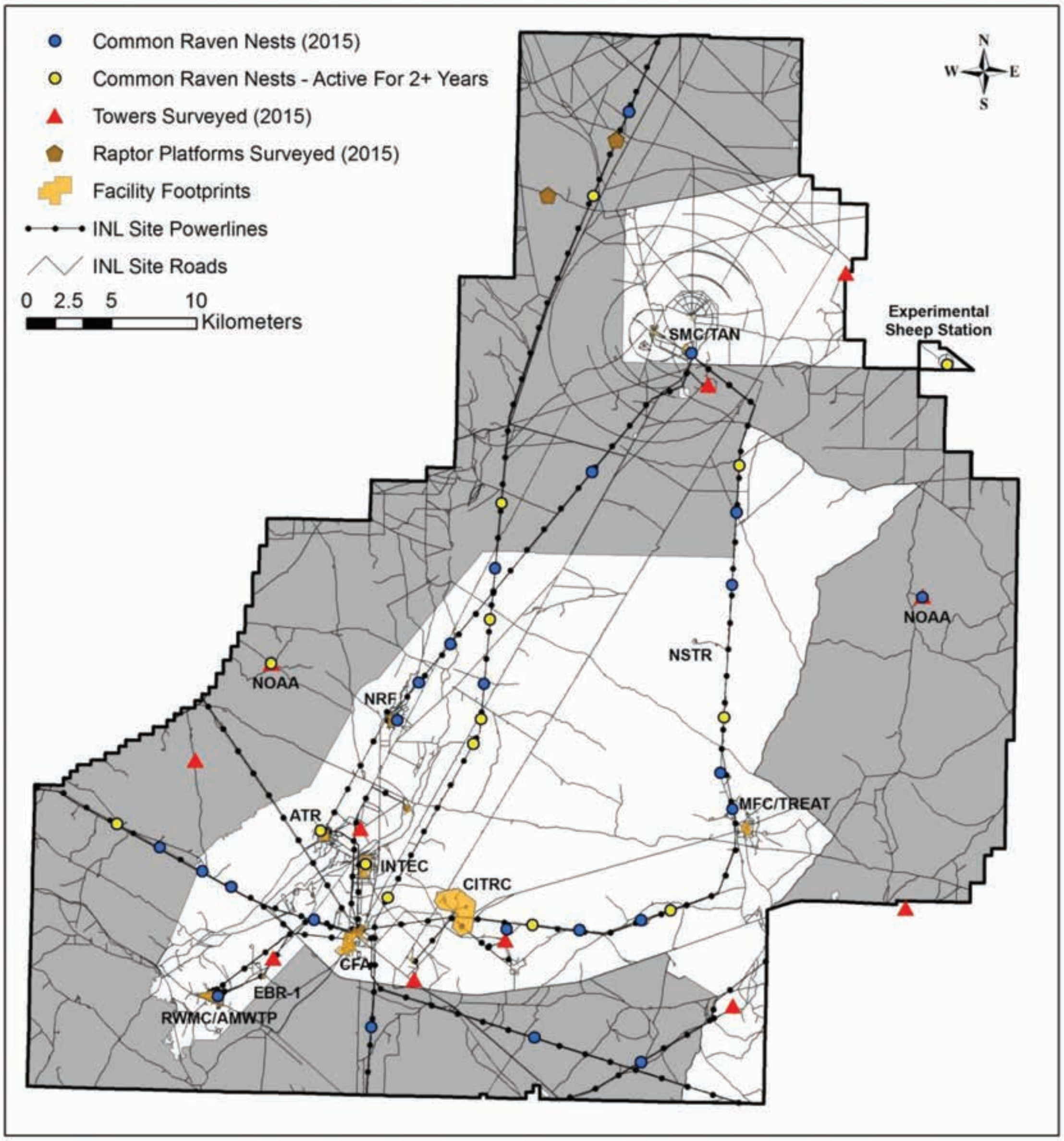

Figure 9-8. Results of 2015 Raven Nest Surveys (yellow dots represent active raven nests in 2015 that were also active in 2013, 2014, or both years).

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 5.5–6.7 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. 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 U.S., 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 reside in the state in Idaho, 11 of those species are documented to occupy the INL Site during some part of the year (Table 9-1). All 11 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 9-1). 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 9-1). Several bat species detected at the INL Site

Table 9-1. 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]	Patchy; visits caves; 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	Potentially	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

are considered for different levels of protection by the FWS, Bureau of Land Management, Western Bat Working Group, and other conservation organizations (Table 9-1).

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 2015, ESER continued monitoring bat activity using acoustical detectors set at hibernacula and other important habitat features (caves and facility waste water ponds) used by these mammals (Figure 9-9). Preliminary analysis of a pilot data set was conducted during 2015 (Figure 9-10). Over one million recorded files of bat calls were analyzed in this effort. Initial species review of these data indicate that the 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. Most identified bat species were detected at all features (both facilities and caves). One exception, Townsend's big-eared bat, was detected at all caves but only at two facilities. The two facilities (Materials and Fuels Complex and RWMC) where Townsend's big-eared bat was detected 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 the passive monitoring program will provide critical information regarding bat ecology and conservation on the INL Site.

In conjunction with the IDFG, Bureau of Land Management, U.S. Forest Service, and USFWS, 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. High-flying, open-air foragers; big brown bats; and silver-haired bats were detected most frequently on survey routes. The expectation is that at least one of the driving survey routes will become a North American Bat Monitoring Program participating transect, and that data from these transects can be used by state and federal agencies to better understand regional and nationwide bat population trends.

Figure 9-9. A Passive-Acoustical Monitoring Station for Bats with a Microphone Mounted at the Top (these devices record the echolocation calls of bats).

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 (*Lasiurus cinereus*) and possibly the western red bat (*L. blossevillii*). 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 Bureau of Land Management 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. All internal surveys are conducted consistent with OP-8, ESER Cave Protection and Access, and an approved INL Site cave entry permit. The latest USFWS decontamination protocol to avoid the spread of WNS is carefully followed.

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 9-11). Historically over-wintering big brown bats have been encountered but not during the most recent surveys.

Anthropogenic structures (facilities, bridges, and culverts) are also used as habitat by bats on the INL Site. These areas, and their associated lands, occupy about

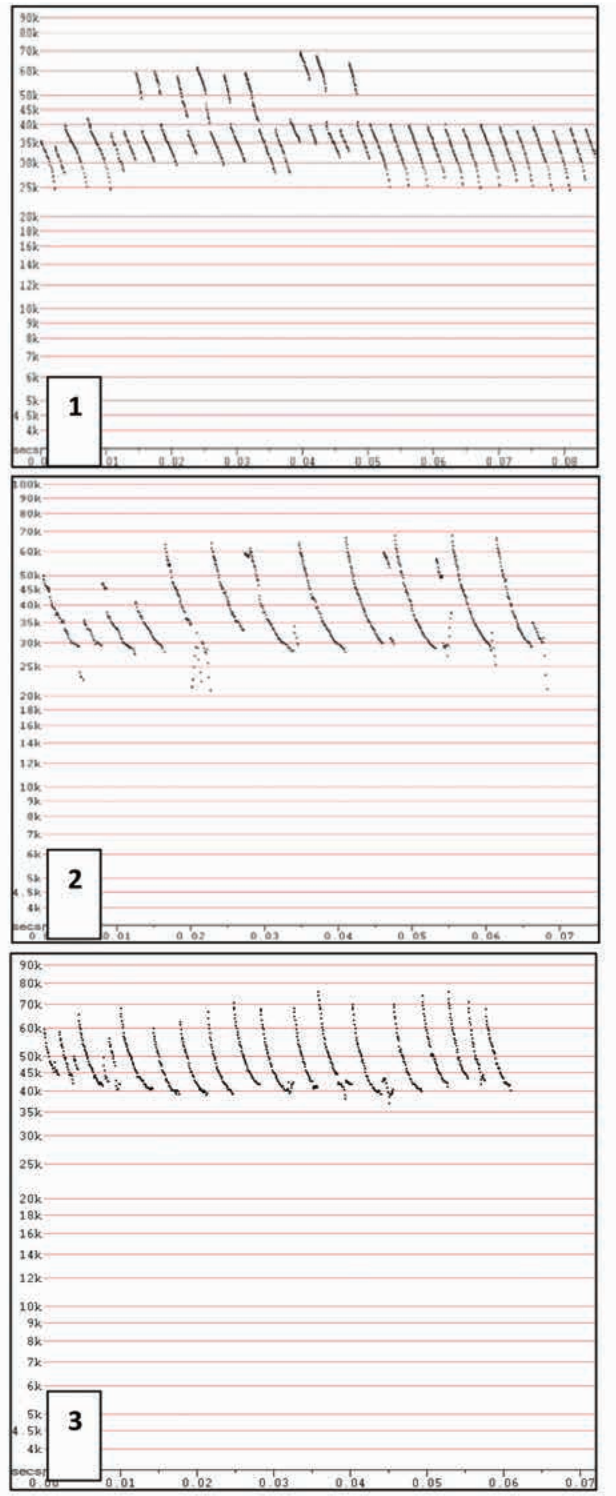

Figure 9-10. Echolocation Calls of Three Species of Bats Recorded by AnaBat Detectors (1 = Townsend's big-eared bat, 2 = big brown bat, 3 = western small-footed myotis) From Caves on the INL Site.

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. Indeed, during summer, all resident and migratory bat species use anthropogenic structures around facilities and near roads for roost sites (Keller et al. 1993, Haymond and Rogers 1997). An analysis of passive acoustic data collected at facility ponds indicated high variability in activity across facilities and seasons (Figure 9-12).

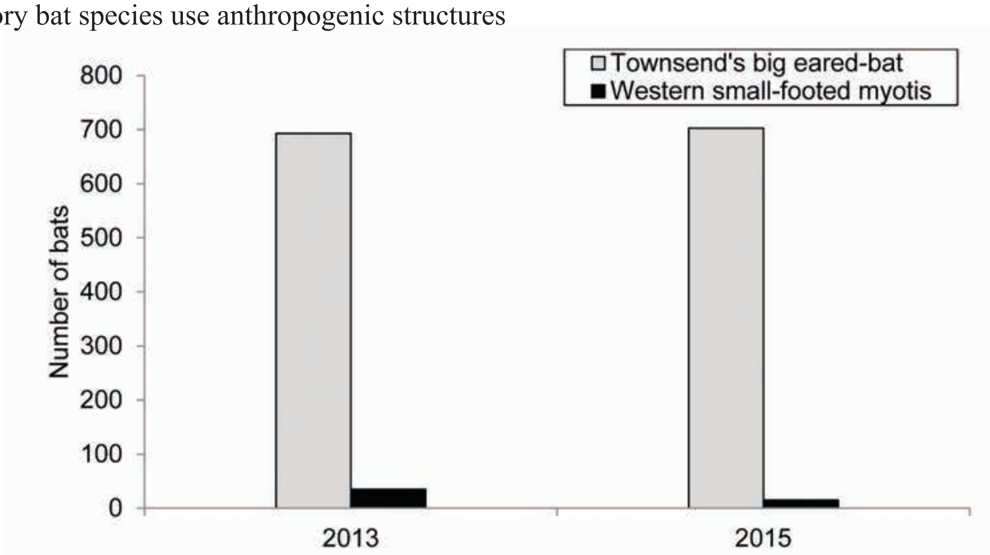

Figure 9-11. Number of Two Bat Species Counted at all Nine Known Hibernacula on the INL Site During the Past Two Survey Periods (counts appear stable; Link Sausage Cave was not surveyed in 2015; historically, we have only counted six (SD ± 4 bats) Townsend's big-eared bats in that cave).

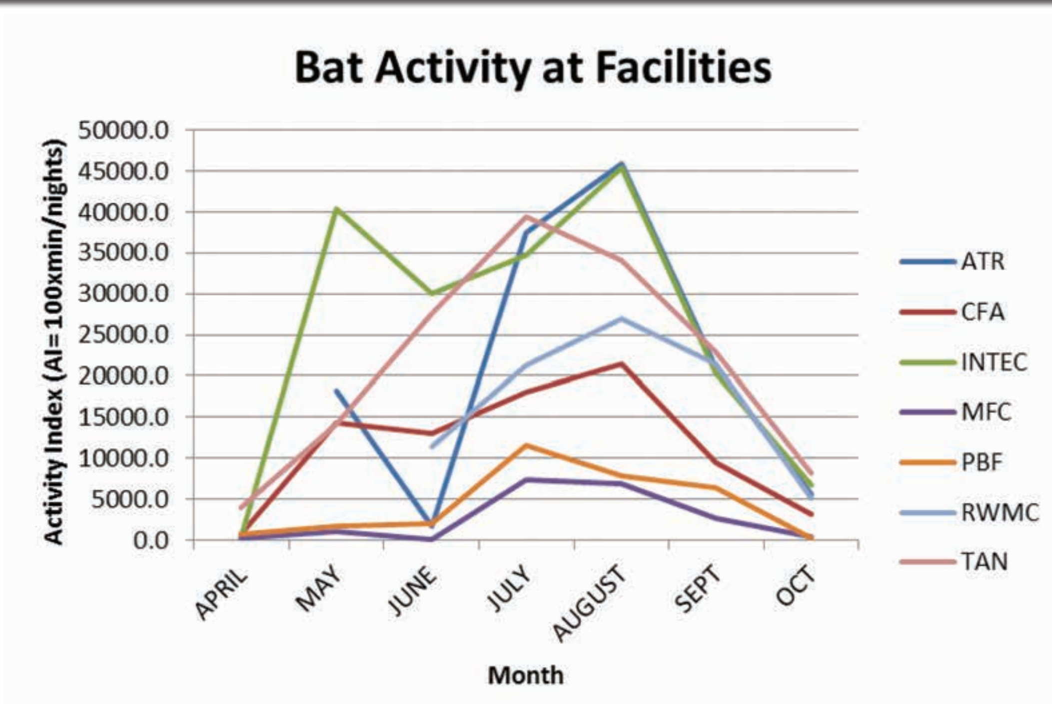

Figure 9-12. Relative Levels of Bat Activity Across the Summer Activity Season (April–October) for Select Facilities. *An Activity Index (AI) was used as a relative measure of bat activity and was calculated as 100 times the number of one minute intervals containing a bat call file divided by the number of nights the detector functioned during a given month.*

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Big Southern Butte

10. Environmental Research at the Idaho National Laboratory Site

Crater Butte

The Idaho National Laboratory Site was designated as a National Environmental Research Park (NERP) 40 years ago in 1975. The NERP program was established in response to recommendations from citizens, scientists, and members of Congress to set aside land for ecosystem preservation and study. In many cases, these protected lands became the last remaining refuges of what were once extensive natural ecosystems. The NERPs 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 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. During 2015, four ecological research projects were conducted on the Idaho NERP.

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. Six reports were published in 2015 by the Idaho National Laboratory Project Office.

10. ENVIRONMENTAL RESEARCH AT THE IDAHO NATIONAL LABORATORY SITE

This chapter summarizes ecological research performed at the Idaho National Laboratory (INL) Research Park (Sections 10.1 through 10.7) and research conducted on the eastern Snake River Plain (ESRP) and ESRP aquifer by the United States Geological Survey (USGS) (Section 10.8) during 2015.

10.1 Ecological Research at the Idaho National Environmental Research Park

The INL Site was designated as a National Environmental Research Park (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 National Environmental Policy Act (NEPA), the Energy Reorganization Act, and the Non-nuclear Energy Research and Development Act (ERDA). 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.

This 2015 annual report marks 40 years since the designation of the Idaho NERP and provides an opportunity to look back at the events leading up to that designation. Much of the history outlined here is based on information found in the 1989 ParkNet Notebook and the Forward written by Donna L. Parsons to the 1974 Proceedings of the National Environmental Research Park Symposium.

10.2 Long Term Research Sites

In the late 1960s and early 1970s, there was considerable interest in setting aside lands representing a broad range of ecosystem types for ecological research. A Federal Committee on Research Areas was established in 1966, and in 1968 it released a list of 336 Federal Research Natural Areas. In 1974, Bettie Willard of the President's Council on Environmental Quality expressed strong concern about the loss of areas suitable for ecological research. A federal interagency report in 1974 noted the formation of the NERPs as important sites for manipulative experiments, testing of management options, and observation of human impact. That report recommended that these research parks form the basis for a National System of Ecological Research Areas. This recommendation appears to be a response to the environmental goals of the NEPA of 1969 and closely aligns with the wording of the charter and program objectives for the NERP program.

In 1977, The National Science Foundation (NSF) published a report titled "Experimental Ecological Re-serves: A Proposed National Network." This network consisted of 67 field research facilities, about half of which were on land managed by federal lands, including Forest Service, Agricultural Research Service, and Bureau of Land Management. However, more than half of the total land occupied by these federal lands was under the stewardship of ERDA and attributable to the NERPs. In 1980, NSF announced their Long-Term Ecological Research Program, and the following year designated their first six Long-Term Ecological Research sites. That network has now grown to include 26 sites.

10.3 Ecological Research at DOE Sites

In many ways, the origin of the NERPs at U.S. Department of Energy (DOE) sites is an "accident" of locations selected during and soon after World War II. Nuclear weapons research required large, remote sites to provide for both maximum security and safety. Due to those two requirements, several large tracts of land were set aside at locations around the United States. As a result, these sites represented areas with restricted access, a variety of climates, and a variety of ecosystem types, including deserts, forests, grasslands, shrub-steppes, and other types. Because of the need to develop a system to monitor inadvertent releases of radioactive materials and track atmospheric fallout, these sites were also staffed with experienced environmental scientists. This confluence of attributes made these facilities ideal locations to conduct long-term, controlled experiments on the impacts of weapons and energy production on the environment. At some sites, environmental and ecological research was encouraged. When NEPA was signed into law, it brought about a new awareness of the importance of managing human impacts to the environment and a requirement that agencies consider those impacts in its activities. With that, environmental and ecological scientists who had been conducting this kind of research at sites operated by Atomic Energy Commission (AEC) found themselves as leaders in many scientific subdisciplines necessary for addressing environmental impacts.

The earliest discussions that would eventually culminate in the formal network of environmental research sites occurred during a review of the environmental research being conducted at the Savannah River Site (SRS) in 1971. Similar reviews had been conducted in previous years at Oak Ridge and Hanford and included many of the same personnel in all three reviews. It became obvious to those involved that each of the agency's sites were conducting comparable research and could provide for both long-term and cross-site comparisons to support understanding and managing environmental impacts. Many of the concepts that followed from those discussions at SRS formed the basis for the NERP Charter.

In the months following the meeting at SRS, a tentative charter for the NERPs was drafted and a proposal for designating SRS as the first NERP was developed. The documentation for the SRS designation was described as "immense" and contained comments from "several hundred" individuals within the agency who felt their administrative responsibilities would be considerably altered by the NERP program. However, nearly all of those "several hundred" individuals also provided an endorsement supporting the NERP program. The NERP designation for SRS came in April 1972. The final charter for the NERP program, along with program objectives, was released in August 1976. It had been reviewed by many individuals within the agency. It was also reviewed and approved by an outside committee that included eight past and future presidents of the Ecological Society of America.

10.4 A NERP for Idaho

Gene Rutledge, Executive Director of the Idaho Nuclear Energy Commission (INEC), became interested in establishing an Idaho NERP after learning that the SRS had been designated as a NERP. He met with AEC Chairman James Schlesinger during a visit to Idaho Falls and suggested that the National Reactor Testing Station (NRTS) also be considered for designation as a NERP. Rutledge contacted Donna Parsons, Director of the Regional Studies Center, and other scientists at the College of Idaho about hosting a symposium featuring research on natural resources and radioecology at the NRTS. Planning began in 1973 and the symposium was set for October 1974. Concurrently, Donald Walker, United States AEC IDO, and his staff began preparing a proposal to identify the NRTS as a NERP.

In April 1974, Donald J. MacKay, Chairman of the INEC, contacted AEC Chair Dixie Lee Ray about designating a NERP in Idaho and received a supportive response. Ray also supported the idea of the symposium on environmental research at NRTS by the Regional Studies Center, INEC, and other interested AEC sites. The AEC sites that participated in the symposium included the SRS, Oak Ridge, Los Alamos, Hanford, and Nevada. The SRS presentation reported on its NERP status, and the other sites presented their own proposals for NERP designation. Dr. Walker delivered his proposal for an Idaho NERP at the symposium in October 1974. Parsons reported that the symposium was a "striking success," and a proceedings document was prepared and published by the Regional Studies Center at the College of Idaho.

As the end of 1974 approached, and along with it the phase out of the AEC and formation of the ERDA and Nuclear Regulatory Commission, there was concern that a delay in designating the Idaho NERP could mean that the proposal would get lost in the agency transition. This generated a sense of urgency, and work to gain a NERP designation was greatly accelerated. Noted Idaho raptor biologist, Morlan Nelson, and Mel Alsager (INEC member) met with Governor Cecil Andrus in December 1974 to brief him on the proposal to create an Idaho NERP. On December 19, 1974, Andrus requested that Dr. James Liverman (Assistant Administrator for Environment and Safety, U.S. ERDA) give prompt consideration to the proposal prepared by Dr. Walker. Governor Andrus also contacted Congressman Orval Hansen, who was also a member of the Joint Committee on Atomic Energy, to gain his support. Between Christmas and New Year's Eve, there was a flurry of phone calls involving Rutledge, Hansen, Ray, and Liverman that culminated in the official announcement on January 3, 1975, that Idaho had been designated as the second NERP.

10.5 NERP Objectives

Five basic objectives guide activities on NERPs:

- Develop methods for assessing and documenting environmental consequences of human actions related to energy development
- Develop methods for predicting environmental consequences of ongoing and proposed energy development
- Explore methods for eliminating or minimizing predicted adverse effects from various energy development activities on the environment
- Train people in ecological and environmental sciences
- Educate the public on environmental and ecological issues.

NERPs provide rich environments for training researchers and introducing the public to the ecological sciences. They have been used to educate grade school and high school students and the general public about ecosystem interactions at 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. Ecological research on NERPs is leading to better land-use planning, identifying sensitive areas on DOE sites so that restoration and other activities are compatible with ecosystem protection and management, and increasing contributions to ecological science in general.

10.6 Ecological Research at the Idaho NERP

Ecological research was conducted at federal laboratories long before NERPs were established. For example, at the INL Site, ecological research began in 1950 with the establishment of what would become the Long-Term Vegetation (LTV) transect study. This project was initiated as part of a larger study to gather baseline ecological data during the construction of the Experimental Breeder Reactor-I (Singleviche t al 1951). This is perhaps DOE's oldest, continuing ecological monitoring project and one of the most intensive data sets for sagebrush steppe. Experimental Breeder Reactor-I was the first nuclear reactor to produce useable amounts of electricity, and the ecological monitoring aimed to provide information on the potential presence of radionuclides from that reactor and their effects on the surrounding environment.

Radioecology (first introduced in 1956) is a branch of ecology that studies how radioactive substances interact with nature and how different mechanisms affect the substances' migration and uptake in food chains and ecosystems. A wide array of radioecology studies were conducted on the Idaho NERP since its inception in 1975 (and before) and continued through 2001. Studies were conducted not only by ESER scientists but also by researchers from a multitude of universities and agencies. They studied uptake and transport of radionuclides by biota, dosimetry of biota residing at radioactive waste areas, tissue concentrations, radionuclide elimination rates, radiation effects on biota chromosomes, radionuclide concentration factors, radionuclide to young from adult biota, and effects of radionuclide concentrations in game animals on human dose. A multitude of species have been studied radiologically, including waterfowl, rabbits, mourning dove, greater sage-grouse, yellow-bellied marmot, small mammals, barn swallows, elk, mule deer, pronghorn, northern harrier, American kestrel, benthic invertebrates, carrion beetles, big sagebrush, squirreltail grass, and tumbleweed. Many studies evaluated radionuclide concentration, distribution, and transport through ecosystem components, including soil, flora, fauna, sediments, and water. A multitude of radionuclides were assessed, such as iodine-129 and 131; plutonium-238, 239, and 240; strontium-90; cobalt-60; and cesium-124 and 137, to determine accumulation, elimination, and transport in various ecological components and ecosystems. These studies also provide data for biota dose assessments. The dozens of radioecological studies on the Idaho NERP have verified that those ecosystems and their components have radionuclide levels well below regulatory limits.

A number of other major areas of ecological research have been conducted at the Idaho NERP. The LTV plots have provided a wealth of data that have been used to understand the basic plant ecology of the sagebrush steppe ecosystem. Fire ecology research has been conducted at the Idaho NERP since the early 1980s when a small prescribed burn was conducted. Effects on plants, birds, small mammals, and reptiles were examined by collecting abundance data before and after the fire. With the series of large fires that began in 1994, several projects have been conducted to understand the recovery of vegetation —especially sagebrush—associated with these big fires. Research on the loss of soil due to wind erosion following these fires also played an important role in the Wildland Fire Management Plan for the INL Site.

Beginning in the 1980s, the Idaho NERP hosted a series of integrated plant, animal, soil, and water studies that culminated in the Protective Cap/Biobarrier Experiment, which evaluated the long-term performance of evapotranspiration caps and biological intrusion barriers to prevent spread of waste buried in landfills. After completion of the Protective Cap/Biobarrier Experiment study, the plots lived a second life as a test bed to investigate hypotheses on the potential effects of climate change on landscapes of the western United States.

The Idaho NERP has also hosted numerous other studies covering much of the full range of ecology. There have been a number of radio telemetry studies on sage-grouse, elk, mule deer, pronghorn, coyotes, pygmy rabbits, and rattlesnakes. The NERP hosts 13 Breeding Bird Survey routes designed to address long-term trends in bird abundance and distribution as well as the effects of agency facilities on those populations. More recently, the Idaho NERP has developed a significant program for monitoring bat populations associated with lava tube caves and ponds at facility areas. This monitoring provided the basis for plans to limit the potential for damage to bat populations by White Nose Syndrome and the development of a Bat Protection Plan. Long-term monitoring of sage-grouse leks on the Idaho NERP led to the development of a Candidate Conservation Agreement (CCA) while that species was under consideration for protection under the Endangered Species Act. The LTV plots provided the initial basis for the development of a vegetation community classification and mapping effort, which has provided the habitat component for the CCA and other conservation and impact analysis needs. Research on natural patterns of sagebrush growth and recovery following disturbance at the Idaho NERP has provided important insights into the management of sagebrush habitat that have not been evaluated anywhere else.

The Idaho NERP provides coordination of ecological research and information exchange at the INL Site. It facilitates ecological research on the INL Site by attracting new researchers to use the area, providing background data for new research projects, and assisting researchers in obtaining access to the INL Site. The Idaho NERP provides infrastructure support to ecological researchers through the Experimental Field Station and reference specimen collections. The NERP tries to foster cooperation and research integration by encouraging researchers to collaborate, developing interdisciplinary teams to address more complex problems, encouraging data sharing, and leveraging funding across projects to provide more efficient use of resources. It also integrates research results from many projects and disciplines and provides analysis of ecosystem-level responses. The Idaho NERP has developed a centralized ecological data repository to provide an archive for ecological data and to facilitate data retrieval for new research projects and land management decision making. It also provides interpretation of research results to land and facility managers to support compliance with natural resource laws, including the NEPA, Endangered Species Act, Migratory Bird Treaty Act, and the Bald and Golden Eagle Protection Act.

10.7 2015 Ecological Research Activities

A total of 17 undergraduate students, graduate students, post-doctoral students, faculty, and agency and contractor scientists participated in four research projects on the Idaho NERPs in 2015. Several undergraduate students and technicians also gained valuable experience through participation in these research activities. The four projects include four graduate student research projects, with students and faculty from Idaho State University (ISU), Boise State University, and The College of Idaho. Other researchers represented the Environmental Surveillance, Education, and Research (ESER) Program and USGS Forest and Range Ecosystem Science Center.

One of the projects received funding from U.S. Department of Energy, Idaho Operations Office (DOE-ID) through the ESER Program. In addition, all projects received in-kind support (logistics, badging, and training) from DOE-ID through ESER. Other funding sources included the NSF, ISU, USGS – Forest and Rangeland Ecosystem Science Center, Great Basin Landscape Conservation Cooperative, and the Orma J. Smith Museum of Natural History at The College of Idaho.

Most of the DOE-ID-funded research, and much of the research funded by other agencies, addresses land management issues applicable to the INL Site. These issues include preparing for potential Endangered Species Act listings, understanding wildland fire effects, minimizing invasive species impacts, and understanding long-term trends in plant community composition, sagebrush health, and potential effects of climate change. The results of these projects will be utilized for ecological and conservation support to land management on the INL Site.

10.7.1 Long-Term Vegetation Transects – Monitoring Recovery on the T-17 Fire Plots

Investigators and Affiliations

- Amy D. Forman, Plant Ecologist, Environmental Surveillance, Education, and Research Program, Gonzales-Stoller Surveillance, Idaho Falls, ID
- Jackie R. Hafla, Natural Resource Specialist, Environmental Surveillance, Education, and Research Program, Gonzales-Stoller Surveillance, Idaho Falls, ID
- Roger D. Blew, Ecologist, Environmental Surveillance, Education, and Research Program, Gonzales-Stoller Surveillance, Idaho Falls, ID

Funding Sources

- U.S. Department of Energy, Idaho Operations Office

Background

The CCA for Greater Sage-grouse (DOE-ID and USFWS 2014) requires that post-fire vegetation management strategies address specific targets and objectives. Specific requirements may include: active restoration decisions be made within a short time period subsequent to a fire, risk of poor native recovery or weed invasion be assessed in post-fire communities, and recommendations for burned areas include targeting locations that may benefit most from active restoration practices. Although previous fire recovery studies on the INL Site (e.g., Ratzlaff and Anderson 1995, Buckwalter 2002) provide a solid general philosophy for managing pre-fire communities in a manner consistent with promoting the return of good condition post-fire vegetation, results from these studies aren't detailed enough for developing post-fire recommendations specific to a burn or to a plant community.

The aforementioned studies were conducted entirely post-fire, and pre-burn conditions were extrapolated from general conditions reported for plant communities across the INL Site. Because pre- and post-burn communities were not colocated, study results offered little direction for specific scenarios, such as enhancing shrub recovery in the short term or identifying specific events or conditions that may shift the recovery trajectory of a plant community to a less desirable state. More detailed information about pre- and post-burn plant communities are needed to develop the specific, localized post-fire vegetation management strategies that may be required by current conservation goals. The opportunity to collect the type of data necessary to address post-fire recovery within context of pre-burn condition at a specific location presented itself in 2011.

During the summer of 2011, LTV data were collected across all active LTV plots, and data collection was completed in the first week of August. On August 25, the T-17 fire burned 11 LTV plots along T-17 (Figure 10-1), providing a unique 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. Sampling of these 11 plots several years post-fire will facilitate assessment of the burned area in a condition comparable to that of new burns where post-fire assessments may be necessary. However, sampling the burned LTV plots provides the benefit of being able to interpret post-fire vegetation composition within the context of site-specific pre-burn and historical data. The information generated from this short-term monitoring effort will support future restoration prioritization by providing a framework for interpreting how the potential for recovery in burned communities compares to range of variability in pre-burn communities.

Understanding not only the current condition of a site but also its status in terms of its potential historical range of variability can be a powerful tool for determining the need for active restoration. For example, lack of precipitation could result in the slow recovery of native

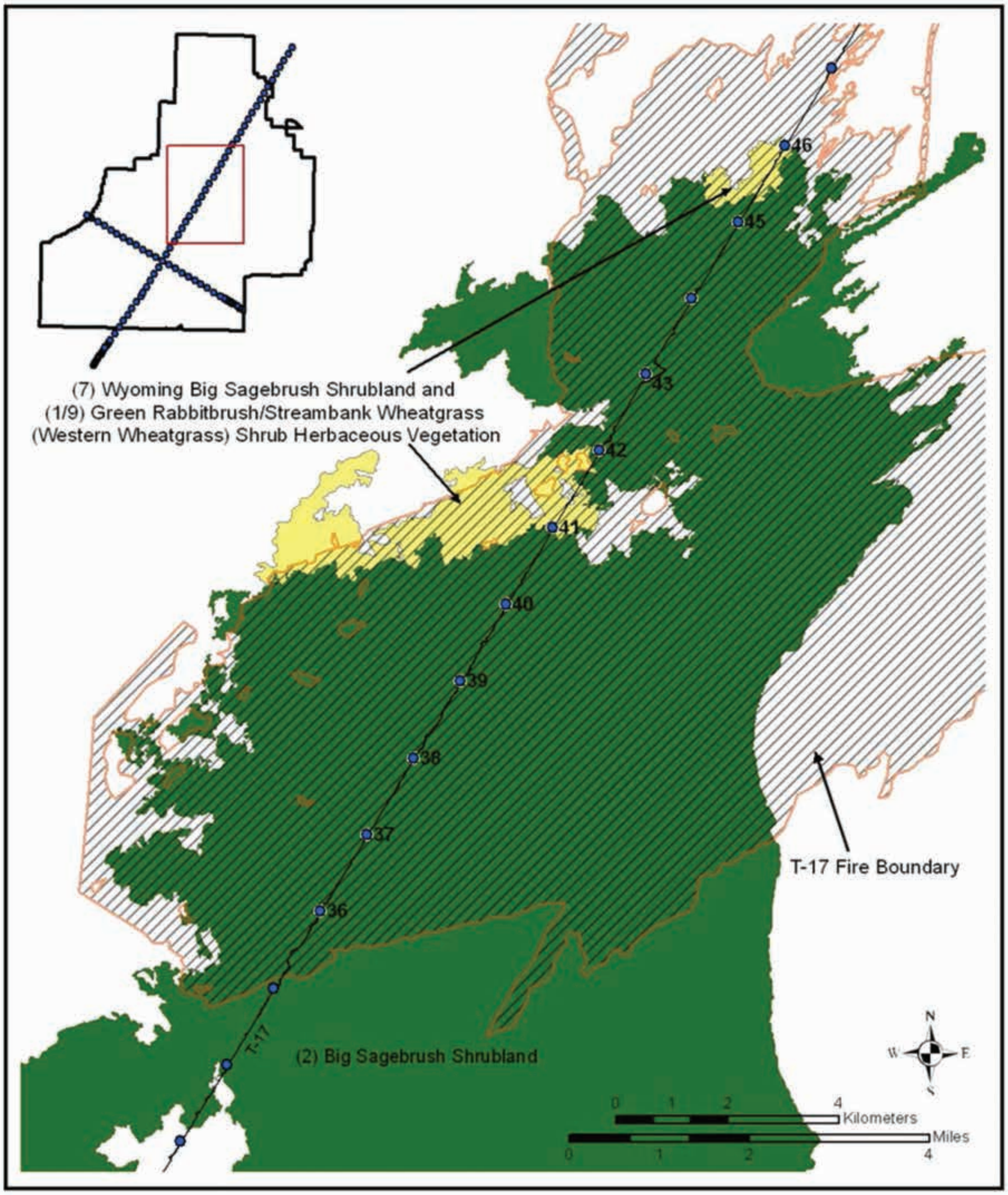

Figure 10-1. Location of 11 Long-Term Vegetation Transect Plots Which Burned During the 2011 T-17 Fire. Vegetation Classes Represented are Prior to the Fire and are From Shive et al. (2011).

grasses during the growing season immediately post-fire, when an assessment would be conducted. In many cases, it would be difficult for the person conducting the assessment to know whether post-fire abundance of native grasses was simply an ephemeral precipitation response or whether it signaled an irreversible decline in condition that was not apparent pre-fire. The characterization of pre- and post-fire conditions of the T-17 plots could be used to provide some longer-term perspective to specific pre- and post-fire data points for future fires, which would help determine whether native grass abundance in new burns truly deviates from historical patterns. This is true for not only native grasses but also for assessing the risk of other factors that may affect post-fire recovery, like increases in cheatgrass density/frequency, loss of diversity, and delayed recovery of shrub species.

Objectives

The primary objective of this post-fire monitoring effort is to follow short-term vegetation recovery patterns on the 11 plots burned in the 2011 T-17 fire and to assess the extent to which post-fire plant communities recover. Specifically, we are interested in how quickly community dynamics reflect pre-burn range of variability and to what extent other factors, like weather and non-native species, influence vegetation recovery. We also hope to gain information useful for developing more specific guidelines for post-fire assessments of potential recovery to support conservation planning on the INL Site. Issues affecting post-fire recovery that can necessitate active restoration and can be monitored using this data set include: risk of post-fire cheatgrass dominance based on pre-fire abundance, effects of precipitation patterns on various native and non-native functional groups pre- and post-burn, and length of time fire-induced vegetation compositional changes (other than loss of sagebrush) may persist.

Ultimately, this monitoring effort will be used to help build a framework for assessing post-fire risk. In the future, CCA Habitat Condition monitoring plots may be used to help define the pre-burn condition of a burned area under consideration for active restoration. The pre-fire plot data, along with site-specific post-fire assessments, may be compared to similar points in time from pre- and post-burn conditions on the 11 burned LTV plots. Interpretation of these "point-in-time" comparisons within the context of the historical range of variability from the burned LTV plots will help natural resource specialists determine if the condition of burned area under consideration is within the possible range of variation for healthy communities or has deviated from that range and may require active restoration.

Accomplishments through 2015

During the summer of 2011, all active LTV plots were sampled for the 12th time using the same standard techniques that have been used for estimating cover and density throughout the history of the LTV project. See Forman et al. (2010) for detailed sampling methodology. From 2012 through 2015 we sampled the 11 plots that burned in the T-17 during the same timeframe (late-June to mid-July), within about one week of when they were sampled in 2011. Initial results comparing the plant community composition of each plot immediately prior to the fire to the composition of each plot almost one year after the fire are included in the most recent comprehensive LTV report (Forman et al. 2013). Data from 2013, the second post-fire growing season, and beyond, will be analyzed with the next full LTV effort.

Results

Initial results from data collected in 2011 and 2012 confirm that shrub and perennial forb cover are significantly reduced one year post-fire. However, cover from native, perennial graminoids was not significantly different post-fire than it was pre-fire (Table 10-1). This result indicates established perennial grasses readily resprout post-fire, and this response is particularly impressive given that total precipitation in spring and early summer of 2012 were far below average. Introduced annual and biennial cover, mostly from cheatgrass, was significantly lower post-fire than it was pre-fire (Table 10-1). This pattern has been noted in other post-fire data sets from the INL Site (Rew et al. 2012, Forman et al. 2013), but it is unclear whether reductions in abundance are from effects of the fire or are related to precipitation patterns that happen to coincide with post-fire recovery. It is also unknown whether post-fire reductions in cheatgrass are temporary and limited to a few seasons post-fire, or whether they persist and change the trajectory of a plant community long-term. See Forman et al. (2013) for more detailed results from comparison of the 2011 and 2012 data.

Precipitation patterns between 2011 and 2015 have been conducive for short-term assessment of variability in post-fire plant communities (Figure 10-2). The second growing season post-fire (2013) was the driest on record since precipitation data collection began in 1950. Some of the wettest seasonal events have also occurred within the same five-year period. October precipitation imme-

Table 10-1. Mean absolute cover by functional group and one-way repeated measures ANOVA results comparing pre- and post-fire vegetation on 11 Long-Term Vegetation Transect plots at the Idaho National Laboratory Site.

	2011	2012	Significant
Native Shrubs	18.04	0.48	Yes
Native Perennial Graminoids	7.81	5.98	No
Native Perennial Forbs	1.60	0.74	Yes
Native Succulents	0.16	0.03	Yes
Native Annuals and Biennials	0.23	0.09	No
Introduced Annuals and Biennials	11.96	0.55	Yes

diately following the T-17 fire was several times higher than average, August 2014 was the wettest August on record, and precipitation in May 2015 was double average values. This range of precipitation scenarios has the potential to produce a highly variable range of post-fire vegetation responses, which will help with characterization of variability during the first few years post-fire.

Plans for Continuation

Monitoring these 11 plots annually for the five years between comprehensive LTV sampling periods (2011 and 2016) will provide important and useful insight on the recovery of native species and on the redistribution and spread of introduced species following fire. Short-term annual data collection will also allow us to characterize the relative importance of precipitation on recovery. Comparing recovery data over a five-year period to historical vegetation dynamics should provide enough information to begin developing a basis for prioritizing restoration activities in burned areas elsewhere on the INL Site using short-term post-fire vegetation data. A comprehensive data analysis from monitoring the 11 LTV plots located in the T-17 burned area for five years post-fire will be included in the next LTV report, following complete LTV sampling in 2016.

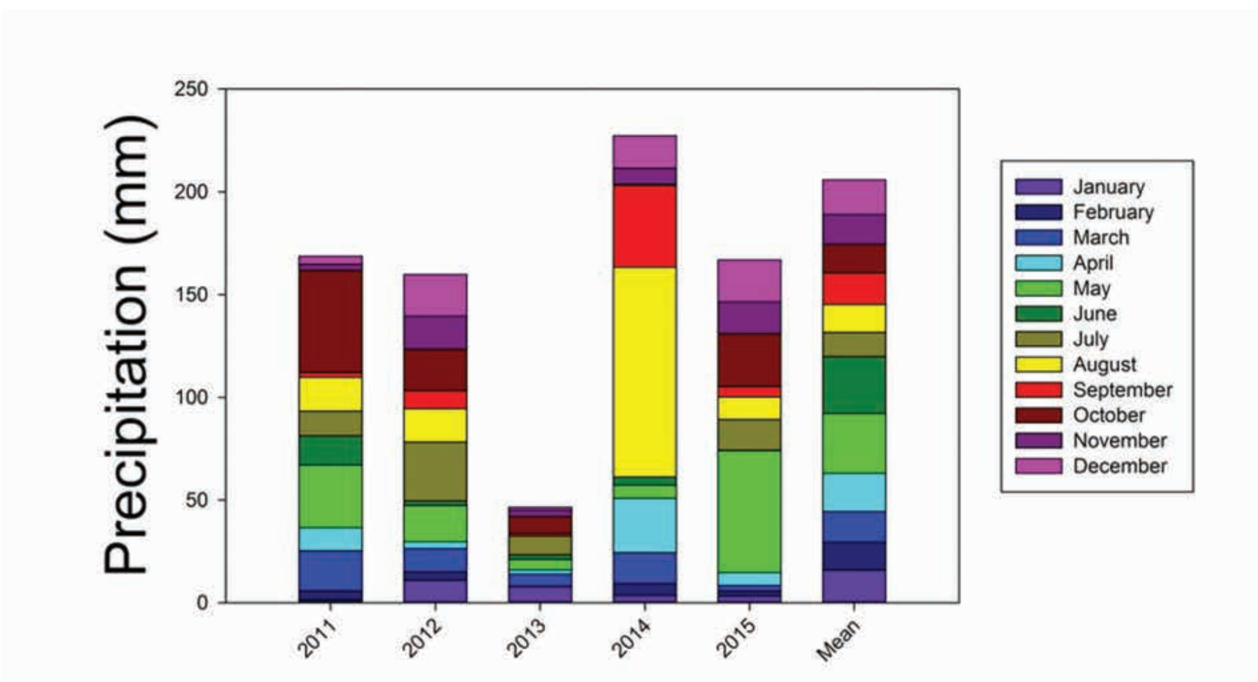

Figure 10-2. Annual Precipitation by Month From the Central Facilities Area, INL Site. Mean Monthly Precipitation Includes Data From 1950 Through 2015.

Publications, Theses, Reports, etc.

Forman, A. D., J. R. Hafla, and R. D. Blew, 2013, *The INL Site Long-Term Vegetation Transects: Understanding Change in Sagebrush Steppe*. Environmental Surveillance, Education, and Research Program, Gonzales-Stoller Surveillance, LLC, Idaho Falls, ID. GSS-ESER-163.

10.7.2 Time Interval Photography Monitoring of Cinder Butte Snake Hibernaculum

Investigators and Affiliation

- Charles R. Peterson, Ph.D., Department of Biological Sciences, Idaho State University, Pocatello, ID
- Jeremy P. Shive, Environmental Surveillance, Education, and Research Program, Gonzales-Stoller Surveillance, LLC., Idaho Falls, ID

Funding Sources

- Idaho State University Department of Biological Sciences, Idaho NERP

Background

The T-17 wildland fire burned approximately 17,807 ha (44,000 acres) in 2011, including the area around Cinder Butte (Figure 10-3). The basalt outcropping near Cinder Butte supports multiple snake hibernacula, including the primary North den, which has been monitored by the ISU Herpetology Laboratory for over 25 years. Anecdotal field observations following the T-17 fire indicate there was considerable soil and sand movement in the areas devoid of vegetation. The wind-blown sand was beginning to fill in the interspaces of the basalt rock and there was concern whether access to the den would be restricted and the individuals returning for winter hibernation would be stranded with no alternative refuge.

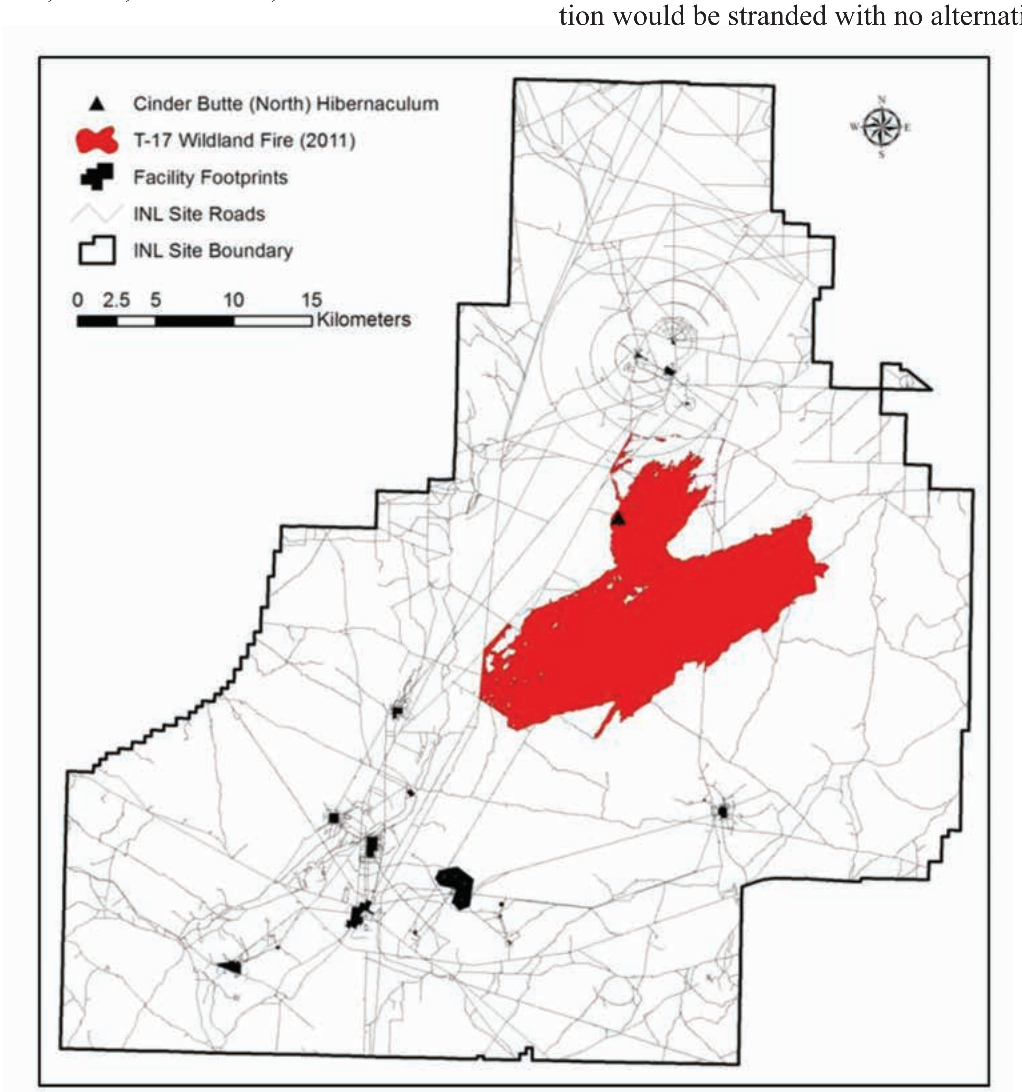

Figure 10-3. The Idaho National Laboratory Site Showing the Extent of the T-17 Wildland Fire and the Location of the Cinder Butte (North) Snake Hibernaculum.

Population monitoring can be costly and require a considerable amount of sampling time and effort. We have been testing the use of time-interval photography as a less expensive monitoring strategy to document snake presence and relative abundance of each species at the Cinder Butte hibernaculum.

A Reconyx PC900 Hyperfire Professional IR camera was positioned to image the main den opening and the surrounding vicinity of ledges and rock overhangs where snakes are commonly observed. Two additional camera systems were temporarily deployed to better understand snake detectability. A Reconyx HC500 Hyperfire IR camera was positioned perpendicular to the main den opening, and a continuous video camera system was positioned alongside the Reconyx PC900 pointed at the main opening. The time-interval cameras were configured to collect images every minute from approximate sunrise to sunset.

We also deployed temperature data loggers using snake physical models to calculate operative temperatures rather than only knowing the measured air temperature.

Objectives

The primary goal of monitoring the Cinder Butte snake hibernaculum is to document the continued use of the den site and to identify which species of snakes remain present following the T-17 wildland fire. Additional objectives include comparing seasonal activity patterns with an established seasonal baseline to better understand if populations are increasing or decreasing and to assess rates of detectability using various time-intervals to maximize accuracy and minimize sampling effort.

The second time-interval camera was positioned to image a region near the main den opening where snakes have commonly been observed moving in and out during previous sampling. The images collected from the side perspective will provide insights regarding how many individuals we may be missing with the standard imaging view extent. The continuous video camera system was intended to collect a consistent record representing truth that could then be compared to the one-minute interval images to evaluate how often individual snakes are being missed due to the one-minute sampling interval.

Figure 10-4. An Example of a Time-interval Image Collected Showing the Main Den Opening and a Great Basin Rattlesnake Leaving the Den.

Accomplishments through 2015

In 2015, we collected over 41,000 images from the primary imaging location from 4/23 to 6/17 (Figure 10-4). There was a lapse in data collection from 5/24 to 6/2 when an SD memory card filled up and wasn't replaced in time. The second camera, oriented perpendicular to the main opening, collected over 35,000 images from 5/7 to 6/19, and there was also a lapse in data collection from 5/28 to 6/3 (Figure 10-5). The continuous video camera recorded data from 4/23 to 5/7.

All images were initially reviewed once and each observation event was recorded. An observation event is defined as one snake observed for one or more consecutive images. If an individual moved out of view or retreated back into the den, it concluded the observation event even if an individual was seen back at the same spot minutes later. Because we cannot be sure it was the same individual, we treated each instance as a new observation event.

Results

Time-interval photography continues to be an effective method for monitoring snake species at the Cinder Butte hibernaculum. Three of the four species (Great Basin Rattlesnake, *Crotalus oreganus lutosus*; Gopher Snake, *Pituophis catenifer*; Striped Whipsnake, *Coluber taeniatus*) previously documented at the Cinder Butte hibernaculum by the ISU Herpetology Laboratory were successfully detected and present in spring 2015. The terrestrial garter snake (*Thamnophis elegans*) was not detected this spring; however, it is important to note the last few seasons of imaging only detected one or two individuals of this species. The lack of detection this season does not necessarily mean this species has been lost permanently from this hibernaculum. In general, there was a greater frequency of Great Basin Rattlesnakes observations this year and much lower frequency of Gopher Snakes observations compared to previous years of sampling.

The camera was deployed during the third week of April, and there were snakes observed on the first day of imaging, suggesting that we missed first emergence this season. The last spring snake observation was made on May 24; however, the camera did not function for over a week after that date and there could have been additional observations that were missed during that time.

Figure 10-5. Example Image Collected From the Second Camera Position Perpendicular to the Main Den Opening. A Great Basin Rattlesnake is Visible in the Bottom Center of Image.

Plans for Continuation

There have only been preliminary comparisons made between the original camera system and the perpendicular-oriented camera system. There was considerable spring precipitation that promoted the growth of grasses around the den opening during the last few weeks of imaging. Therefore, the perpendicular perspective was limited by tall grasses that affected the visibility of specific regions where snakes have been most commonly observed from previous sampling. Further quantitative comparisons will be made to document the number of individuals observed from the perpendicular perspective compared to the standard imaging view.

The continuous video dataset will be analyzed to determine the sampling parameters needed to optimize the accuracy of snake detections while minimizing overall sampling effort. Once the video data have been completely reviewed for observation events, the data could be manually subsampled at varying time intervals (e.g., 30-second, one-minute, two-minute, etc.), and detection rates of each interval can be compared to the results from continuous sampling. If fewer images need to be collected, and detection rates do not vary considerably, overall image processing time could be reduced while maintaining a high level of detectability.

We plan to model operative temperatures using the operative temperature data from the physical snake models. By comparing the internal camera system thermometer with the physical models, it will allow us to understand the relationship between camera measurements and the temperatures the snakes are more realistically experiencing at the den.

Publications, Reports, Theses, etc.

Additional data analysis and statistical modeling are planned for 2016 but have not been initiated.

10.7.3 Ecosystem Responses of Sagebrush Steppe to Altered Precipitation, Vegetation and Soil Properties

Investigators and Affiliations

- PI: Matthew J. Germino, Ph.D., Research Ecologist, USGS, Forest and Rangeland Ecosystem Science Center, Boise, ID
- Co-PI: Keith Reinhardt, Ph.D., Assistant Professor, Idaho State University, Pocatello, ID

Collaborators

- Lar Svenson, M.S., US Geological Survey, USGS, Forest and Rangeland Ecosystem Science Center, Boise, ID
- Kevin Feris, Ph.D., Assistant Professor, Boise State University, Boise, ID
- Kathleen Lohse, Ph.D., Assistant Professor, Idaho State University, Pocatello, ID
- Marie-Anne deGraff, Ph.D., Assistant Professor, Boise State University, Boise, ID
- David Huber, Ph.D. candidate, Idaho State University, Pocatello, ID
- Patrick Sorenson, M.S., Boise State University, Boise, ID
- Patricia Xochi Campos, M.S. candidate, Boise State University, Boise, ID
- Kate McAbee, M.S. candidate, Idaho State University, Pocatello, ID
- Andrew Bosworth, Science Teacher, Ririe High School, Ririe, ID

Funding Sources

- Idaho Experimental Program to Stimulate Competitive Research, NSF
- US Geological Survey, Forest and Rangeland Ecosystem Science Center
- Great Basin Landscape Conservation Cooperative
- In-kind facilities and infrastructure support from DOE INL, logistics support through Stoller-Gonzales LLC

Background

The INL Site and other landscapes with sagebrush steppe vegetation are experiencing a simultaneous change in climate and floristics that results from increases in exotic species. Determining the separate and combined/interactive effects of climate and vegetation change is important for assessing future changes on the landscape and for hydrologic processes.

This research uses the 72 experimental plots established and initially maintained for many years as the "Protective Cap Biobarrier Experiment" by Dr. Jay Anderson and the DOE ESER program—the experiment is also now referred to as the "INL Ecohydrology Study." We are evaluating long-term impacts of different plant communities commonly found throughout Idaho subject to different precipitation regimes and different soil depths. Treatments of amount and timing of precipitation (irrigation), soil depth, and either native/perennial or exotic grass vegetation allow researchers to investigate how vegetation, precipitation, and soil interact to influence soil hydrology and ecosystem biogeochemistry. This information will be used to improve a variety of models as well as provide data for these models.

Objectives

The goal of this study is to assess the interactive and reciprocal effects of hydroclimate shifts and plant community composition on ecohydrological and biogeochemical processes, with the specific objectives to:

- Determine response of vegetation to timing of irrigation and soil depth, and conversely the influence of plant communities and vegetation type on deep soil water infiltration
- Investigate microbial communities and soil microbial enzymatic activity and soil aggregation/porosity to assess whether fundamental ecosystem changes to treatments are occurring and could feed back on water flow patterns
- Investigate changes in plant and soil nutrient pools and fluxes due to vegetation and precipitation differences.

Accomplishments through 2015

In 2015, our focus was on wrapping up studies led by (1) Kate McAbee (M.S. received under Keith Reinhardt), who did a year-long assessment of in-situ chamber measurement of soil and net-ecosystem flux of carbon dioxide as it relates to standing crop (biomass and productivity) for her thesis under Keith Reinhardt; and (2) Xochi Campos (M.S. received under Marie Anne DeGraff), who finished a multi-year assessment of soil physical and biological responses.

Results

Data from McAbee (2015) suggest that supplemental watering/precipitation increased net carbon uptake whether added in the winter or summer and increased standing crop of biomass when added in winter only. Respiratory carbon efflux was increased by summer precipitation under some circumstances (e.g., on summer evenings, especially in plots planted with native vegetation vs. crested wheatgrass). Net ecosystem carbon exchange without supplemental water was otherwise nearly null, indicating that increases in precipitation may stimulate carbon sequestration by this vast rangeland type.

Data from Campos (2015) demonstrate that the plant and soil treatments have impacted soil physical properties via altering soil particle aggregation, in turn feeding back on the hydrology of plots. Additionally, Campos (2015) revealed that decomposition rates were differentially affected by the hydrology vs. vegetation type changes, and that this reflects microbial changes that underlie carbon respiratory effluxes from the treatments.

Plans for Continuation

We are considering that 2016 could be the last year we attempt to maintain the experiment, given uncertainties in funding, condition of pumping and irrigation equipment, and of the neutron probe, which is an irreplaceable means for us to measure soil water responses.

We expect the theses for Campos and McAbee and the dissertation for Huber to be published in 2016–2017, when conclusive findings will be available.

Publications, Theses, Reports

Publications

McAbee, K., 2015, Exotic grass species toggles the response of aboveground carbon balance to long-term precipitation shifts in cold-desert rangelands: results from a 21-year climate change experiment. MSc Thesis, Department of Biological Sciences, Idaho State University, Pocatello, ID.

McAbee, K., K. Reinhard, M. J. Germino, and A. Bosworth, Submitted. Exotic grass species toggles the response of aboveground carbon balance to long-term precipitation shifts in cold-desert rangelands: results from a 21-year climate change experiment. Oecologia.

Campos, P. X., 2015, Precipitation induced changes in decomposition processes and soil carbon stabilization. MSc Thesis, Department of Biological Sciences, Boise State University, Boise, ID.

Presentations

McAbee, K., K. Reinhard, M. J. Germino, and A. Bosworth, 2015, Exotic grass species toggles the response of aboveground carbon balance to long-term precipitation shifts in cold-desert rangelands: results from a 21-year climate change experiment, Great Basin Consortium #4, Boise, ID Feb 17–19 (poster).

10.7.4 Studies of Ants and Ant Guests at the INL Site

Investigators and Affiliations

• William H. Clark, Orma J. Smith Museum of Natural History, The College of Idaho, Caldwell, ID

Funding Sources

Funding is by the principal investigator with some assistance and collaboration with the Orma J. Smith Museum of Natural History.

Background

Clark and Blom (2007) reported the first comprehensive annotated checklist of ants at the INL Site. This publication gives a starting point for additional research relating to ants, their natural history and ecology, and ant guests at the INL Site. Ant guests (myrmecophiles) are organisms that live in close association with ants. These are generally mutualistic associations but may also be commensal or parasitic. Much research remains to be done to better the understanding between ants and their guests.

Objectives

Immediate objectives are to locate living larvae and pupae of the ant guest beetle, *Philolithus elatus* (LeConte; Coleoptera: Tenebrionidae), within nests of the harvester ant, *Pogonomyrmex salinus* (Olsen; Hymenoptera: Formicidae). These beetles have been documented from the harvester ant nests here in the past by Clark and Blom (unpublished data), but the immature stages (larvae and pupae) have not been previously described. More observations of adult female beetles ovipositing on the ant nests are also needed. The overall objective will be to document the interaction of this beetle with the ants. Other observations on additional ant guests will be made as they are encountered. Information relating to the ants of the INL Site will be documented in scientific publications, as possible.

Accomplishments through 2015

During the fall of 2011, 100 nests of the harvester ant (*Pogonomyrmex salinus*) were selected and marked along Road T-17 near Circular Butte. These nests were

Figure 10-6. Circular Butte Site at the Idaho National Laboratory, Facing East. W.H. Clark Photo. September 23, 2015.

then surveyed by INL archaeologists for cultural resources, and approval was given for excavation of nests as needed. A total of 10 percent of the nests were excavated during late 2011, and no *Philolithus elatus* were found. Additional nests were excavated during the fall of 2012, and again no *Philolithus elatus* were found. We surveyed 41 nests during July 2013 and found *Philolithus elatus* larvae in six of the nests and pupae in two of the nests. During the fall of 2014, we examined more nests in the Circular Butte area and collected additional larvae and pupae, which were preserved for study and photography. During 2015, the SEM work was completed for *Philolithus elatus* immature stages (larvae and pupae). Additional field work was conducted during 2015 at the Circular Butte Site (Figures 10-6 and 10-7). This field work involved searching for female beetles that might interact with the ant nests and other natural history observations.

Results

One 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 SEM, 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 site involving cicadas and *Pogonomyrmex salinus* nests (Blom and Clark, in prep). In addition, during 2015, we made field observations of spider 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).

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 field work. A series of live individuals, including both males and females, were needed for a proper species description. We collected 20

Figure 10-7. Typical Nest of the Harvester Ant, *Pogonomyrmex salinus* Olsen, at Circular Butte Site at the Idaho National Laboratory. W.H. Clark Photo. September 23, 2015.

live specimens 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. Both taxa will require more study during future visits to the INL Site.

Plans for Continuation

Field research will continue into the foreseeable future.

Publications, Theses, Reports, etc.

Three draft manuscripts are being prepared—so far—for this project:

Blom, P. E., and W. H. Clark, In Prep, Observations of cicada nymphs, Okanagana annulata Davis (Homoptera: Cicadidae) and the harvester ant *Pogonomyrmex salinus* Olsen (Hymenoptera: Formicidae) in southeastern Idaho, Manuscript being prepared for the Western North American Naturalist.

Clark, W. H., P. E. Blom, P. J. Johnson, and A.D. Smith, In Prep, *Philolithus elatus* (LeConte) associated with *Pogonomyrmex salinus* Olsen nest soils in southeastern Idaho (Coleoptera, Tenebrionidae, Asidinae; Hymenoptera, Formicidae, Myrmicinae), Manuscript being prepared for the Coleopterists Bulletin.

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Acknowledgments

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10.8 U.S. Geological Survey 2015 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 is used to create and refine hydrologic and geologic models of the aquifer, to track contaminant plumes in the aquifer, and 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.html.

Six reports were published by the USGS INL Project Office in 2015. The abstracts of these studies and the publication information associated with each study are presented below.

10.8.1 Geochemical Evolution of Groundwater in the Mud Lake Area, Eastern Idaho, USA (Rattray, G. W., 2015)

Groundwater with elevated dissolved-solids concentrations—containing large concentrations of chloride, sodium, sulfate, and calcium—is present in the Mud Lake area of Eastern Idaho. The source of these solutes is unknown; however, an understanding of the geochemical sources and processes controlling their presence in groundwater in the Mud Lake area is needed to better understand the geochemical sources and processes controlling the water quality of groundwater at the INL. The geochemical sources and processes controlling the water quality of groundwater in the Mud Lake area were determined by investigating the geology, hydrology, land use, and groundwater geochemistry in the Mud Lake area; proposing sources for solutes; and testing the proposed sources through geochemical modeling with PHREEQC. Modeling indicated that sources of water to the ESRP aquifer were groundwater from the Beaverhead Mountains and the Camas Creek drainage basin; surface water from Medicine Lodge and Camas Creeks, Mud Lake, and irrigation water; and upward flow of geothermal water from beneath the aquifer. Mixing of groundwater with surface water or other groundwater occurred throughout the aquifer. Carbonate reactions, silicate weathering, and dissolution of evaporite minerals and fertilizer explain most of the changes in chemistry in the aquifer. Redox reactions, cation exchange, and evaporation were locally important. The source of large concentrations of chloride, sodium, sulfate, and calcium was evaporite deposits in the unsaturated zone associated with Pleistocene Lake Terreton. Large amounts of chloride, sodium, sulfate, and calcium are added to groundwater from irrigation water infiltrating through lake bed sediments containing evaporite deposits and the resultant dissolution of gypsum, halite, sylvite, and bischofite.

10.8.2 Chemical Constituents in Groundwater from Multiple Zones in the Eastern Snake River Plain Aquifer, Idaho National Laboratory, Idaho, 2009–13 (Bartholomay, R. C et al. 2015)

From 2009 to 2013, the USGS INL Project Office, in cooperation with the DOE, collected water-quality samples from multiple water-bearing zones in the ESRP aquifer. Water samples were collected from 11 monitoring wells completed in about 250–750 feet of the upper part of the aquifer, and samples were analyzed for selected major ions, trace elements, nutrients, radiochemical constituents, and stable isotopes. Each well was equipped with a multilevel monitoring system containing four to seven sampling ports that were each isolated by permanent packer systems. The sampling ports were installed in aquifer zones that were highly transmissive and that represented the water chemistry of the top three to five model layers of a steady-state and transient groundwater flow model. The groundwater-flow model and water chemistry are being used to better define movement of wastewater constituents in the aquifer.

The water-chemistry composition of all sampled zones for the five new multilevel wells is calcium plus magnesium bicarbonate. One of the zones in well USGS 131A has a slightly different chemistry from the rest of the zones and wells, and the difference is attributed to more wastewater influence from the Idaho Nuclear Technology and Engineering Center. One well, USGS 135, was not influenced by wastewater disposal and consisted of mostly older water in all of its zones.

Tritium concentrations in relation to basaltic flow units indicate the presence of wastewater influence in multiple basalt flow groups; however, tritium is most abundant in the South Late Matuyama flow group in the southern boundary wells. The concentrations of wastewater constituents in deep zones in wells Middle 2051, USGS 132, USGS 105, and USGS 103 support the concept of groundwater flow deepening in the southwestern corner of the INL, as indicated by the INL groundwater-flow model.

10.8.3 Water-quality Characteristics and Trends for Selected Wells Possibly Influenced by Wastewater Disposal at the Idaho National Laboratory, Idaho, 1981–2012 (Davis L. C. et al. 2015)

The USGS, in cooperation with the DOE, analyzed water-quality data collected from 64 aquifer wells and 35 perched groundwater wells at the INL from 1981 through 2012. The wells selected for the study were wells that possibly were affected by wastewater disposal at INL. The data analyzed included tritium, strontium-90, major cations, anions, nutrients, trace elements, total organic carbon, and volatile organic compounds. The analyses were performed to examine water-quality trends that might influence future management decisions about the number of wells to sample at INL and the type of constituents to monitor.

The data were processed using custom computer scripts developed in the R programming language. Summary statistics were calculated for the datasets. Water-quality trends were determined using a parametric survival regression model to fit the observed data, including left-censored, interval-censored, and uncensored data. The null hypothesis of the trend test was that no relation existed between time and concentration; the alternate hypothesis was that time and concentration were related through the regression equation. A significance level of 0.05 was selected to determine if the trend was statistically significant.

Trend test results for tritium and strontium-90 concentrations in aquifer wells indicated that nearly all wells had decreasing or no trends. Similarly, trends in perched groundwater wells were mostly decreasing or no trends; trends were increasing in two perched groundwater wells near the Advanced Test Reactor Complex. Decreasing trends generally are attributed to lack of recent wastewater disposal and radioactive decay.

Trend test results for chloride, sodium, sulfate, nitrite plus nitrate (as nitrogen), chromium, trace elements, and total organic carbon concentrations in aquifer wells indicated that most wells had either decreasing or no trends. The decreasing trends in these constituents are attributed to decrease in disposal of these constituents, discontinued use of the old percolation ponds south of the Idaho Nuclear Technology and Engineering Center (INTEC), and redirection of wastewater to the new percolation ponds two miles southwest of the INTEC in 2002.

Chloride (along with sodium, sulfate, and some nitrate) concentrations in wells south of the INTEC may be influenced by episodic recharge from the Big Lost River. These constituent concentrations decrease during wetter periods, when there is probably more recharge from the Big Lost River, and increase during dry periods, when there is less recharge.

Some wells downgradient of the Central Facilities Area and near the southern boundary of INL showed increasing trends in sodium concentration, whereas there was no trend in chloride. The increasing trend for sodium could be due to the long-term influence of wastewater disposal from upgradient facilities, and the lack of trend for chloride could be because chloride is more mobile than sodium and more dispersed in the aquifer system.

Volatile organic compound concentration trends were analyzed for nine aquifer wells. Trend test results indicated an increasing trend for carbon tetrachloride for the Radioactive Waste Management Complex Production Well for the period 1987–2012; however, trend analyses of data collected since 2005 show no statistically significant trend, indicating that engineering practices designed to reduce movement of volatile organic compounds to the aquifer may be having a positive effect on the aquifer.

10.8.4 New Argon-Argon ($^{40}AR/^{39}Ar$) Radiometric Age Dates from Selected Subsurface Basalt Flows at the Idaho National Laboratory, Idaho (Hodges, M. K. V. et al., 2015)

In 2011, the USGS, in cooperation with the DOE, collected samples for 12 new argon-argon radiometric ages from ESRP olivine tholeiite basalt flows in the subsurface at the INL. The core samples were collected from flows that had previously published paleomagnetic data.

Samples were sent to Rutgers University for argon-argon radiometric dating analyses.

Paleomagnetic and stratigraphic data were used to constrain the results of the age dating experiments to derive the preferred age for each basalt flow. Knowledge of the ages of subsurface basalt flows is needed to improve numerical models of groundwater flow and contaminant transport in the ESRP aquifer. This could be accomplished by increasing the ability to correlate basalt flow from corehole to corehole in the subsurface. The age of basalt flows also can be used in volcanic recurrence and landscape evolution studies that are important to better understand future hazards that could occur at the INL.

Results indicate that ages ranged from 60 ± 16 thousand years ago for Quaking Aspen Butte to 621 ± 9 thousand years ago for State Butte.

10.8.5 Multilevel Groundwater Monitoring of Hydraulic Head and Temperature in the Eastern Snake River Plain Aquifer, Idaho National Laboratory, Idaho, 2011–2013 (Twining, B. V., and J. C. Fisher, 2015)

From 2011 to 2013, the USGS's INL Project Office, in cooperation with the DOE, collected depth-discrete measurements of fluid pressure and temperature in 11 boreholes located in the ESRP aquifer. Each borehole was instrumented with a multilevel monitoring system (MLMS) consisting of a series of valved measurement ports, packer bladders, casing segments, and couplers.

Multilevel monitoring at INL has been ongoing since 2006, and this report summarizes data collected from 2011 to 2013 in 11 multilevel monitoring wells. Hydraulic head (head) and groundwater temperature data were collected from 11 multilevel monitoring wells, including 177 hydraulically isolated depth intervals from 448.0 to 1,377.6 feet below land surface. One port (port 3) within borehole USGS 134 was not monitored because of a valve failure.

Head and temperature profiles reveal unique patterns for vertical examination of the aquifer's complex basalt and sediment stratigraphy, proximity to aquifer recharge and discharge, and groundwater flow. These features contribute to some of the localized variability even though the general profile shape remained consistent over the period of record. Twenty-two major head inflections were described for nine of 11 MLMS boreholes and almost always coincided with low permeability sediment layers and occasionally thick layers of dense basalt. However, the presence of a sediment layer or dense basalt layer was insufficient for identifying the location of a major head change within a borehole without knowing the true areal extent and relative transmissivity of the lithologic unit. Temperature profiles for boreholes completed within the Big Lost Trough indicate linear conductive trends; whereas, temperature profiles for boreholes completed within volcanic rift zones and near the southern boundary of INL, indicate mostly convective heat transfer. Select boreholes along the southern boundary show a temperature reversal and cooler water deeper in the aquifer resulting from the vertical movement of groundwater.

Vertical head and temperature change were quantified for each of the 11 multilevel monitoring systems. Vertical head gradients defined for the major inflections in the head profiles were as high as 2.9 feet per foot. In general, fractured basalt zones displayed relatively small vertical head differences and showed a high occurrence within volcanic rift zones. Poor connectivity between fractures and higher vertical gradients were generally attributed to sediment layers, layers of dense basalt, or both. Groundwater temperatures in all boreholes ranged from 10.8 to 16.3 °C.

Normalized mean head values were analyzed for all 11 multilevel monitoring wells for the period of record (2007–13). The mean head values suggest a moderately positive correlation among all boreholes and generally reflect regional fluctuations in water levels in response to seasonal climatic changes. Boreholes within volcanic rift zones and near the southern boundary (USGS 103, USGS 105, USGS 108, USGS 132, USGS 135, USGS 137A) display a temporal correlation that is strongly positive. Boreholes in the Big Lost Trough display some variations in temporal correlations that may result from proximity to the mountain front to the northwest and episodic flow in the Big Lost River drainage system. For example, during June 2012, boreholes MIDDLE 2050A and MIDDLE 2051 showed head buildup within the upper zones when compared to the June 2010 profile event, which correlates to years when surface water was reported for the Big Lost River several months preceding the measurement period. With the exception of borehole USGS 134, temporal correlation between MLMS wells completed within the Big Lost Trough is generally positive. Temporal correlation for borehole USGS 134 shows the least agreement with other MLMS boreholes located within the Big Lost Trough; however, borehole USGS 134 is close to the mountain front where tributary valley subsurface inflow is suspected.

10.5.6 Hydrologic Influences on Water-level Changes in the Eastern Snake River Plain Aquifer at and Near the Idaho National Laboratory, Idaho, 1949–2014 (Twining, B. V., and J. C. Fisher, 2015)

Since 1949, the USGS, in cooperation with the DOE, has maintained a water-level monitoring program at INL to systematically measure water levels to provide long-term information on groundwater recharge, discharge, movement, and storage in the ESRP aquifer. During 2014, water levels in the ESRP aquifer reached all-time lows for the period of record, prompting this study to assess the effect that future water-level declines may have on pumps and wells. Water-level data were compared with pump-setting depth to determine the hydraulic head above the current pump setting. Additionally, geophysical logs were examined to address changes in well productivity with water-level declines. Furthermore, hydrologic factors that affect water levels in different areas of INL were evaluated to help understand why water-level changes occur.

Review of pump intake placement and 2014 water-level data indicates that 40 wells completed within the ESRP aquifer at INL have 20 feet (ft) or less of head above the pump. Nine of the these wells are located in the northeastern and northwestern areas of the INL Site where recharge is predominantly affected by irrigation, wet and dry cycles of precipitation, and flow in the Big Lost River. Water levels in northeastern and northwestern wells generally show water-level fluctuations of as much as 4.5 ft seasonally and show declines as much as 25 ft during the past 14 years.

In the southeastern area of INL, seven wells were identified as having less than 20 ft of water remaining above the pump. Most of the wells in the southeast show less decline over the period of record compared with wells in the northeast; the smaller declines are probably attributable to less groundwater withdrawal from pumping of wells for irrigation. In addition, most of the southeastern wells show only about a 1–2 ft fluctuation seasonally because they are less influenced by groundwater withdrawals for irrigation.

In the southwestern area of INL, 24 wells were identified as having less than 20 ft of water remaining above the pump. Wells in the southwest also only show small 1–2 ft fluctuations seasonally because of a lack of irrigation influence. Wells show larger fluctuation in water levels closer to the Big Lost River and fluctuate in response to wet and dry cycles of recharge to the Big Lost River.

Geophysical logs indicate that most of the wells evaluated will maintain their current production until the water level declines to the depth of the pump. A few of the wells may become less productive once the water level gets to within about 5 ft from the top of the pump. Wells most susceptible to future drought cycles are those in the northeastern and northwestern areas of the INL.

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11. Quality Assurance of Environmental Monitoring Programs

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11. QUALITY ASSURANCE OF ENVIRONMENTAL MONITORING PROGRAMS

Quality assurance (QA) consists of the planned and systematic activities necessary to provide adequate confidence in the results of effluent monitoring and environmental surveillance programs (NCRP 2012). The main objective of an environmental monitoring program is to provide data of high quality so that the appropriate assessments and decisions based on those data can be made. This chapter presents information on specific measures taken by the effluent monitoring and environmental surveillance programs in 2015 to ensure the high quality of data collected and presented in this annual report as well as a summary of performance.

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

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 National Council on Radiation Protection and Measurements (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 the 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.

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 consisting of:

- INL
- Idaho Cleanup Project (ICP)
- Environmental Surveillance, Education, and Research (ESER) Program
- United States Geological Survey
- National Oceanic and Atmospheric Administration
- Advanced Mixed Waste Treatment Project

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 2014a) 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.

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

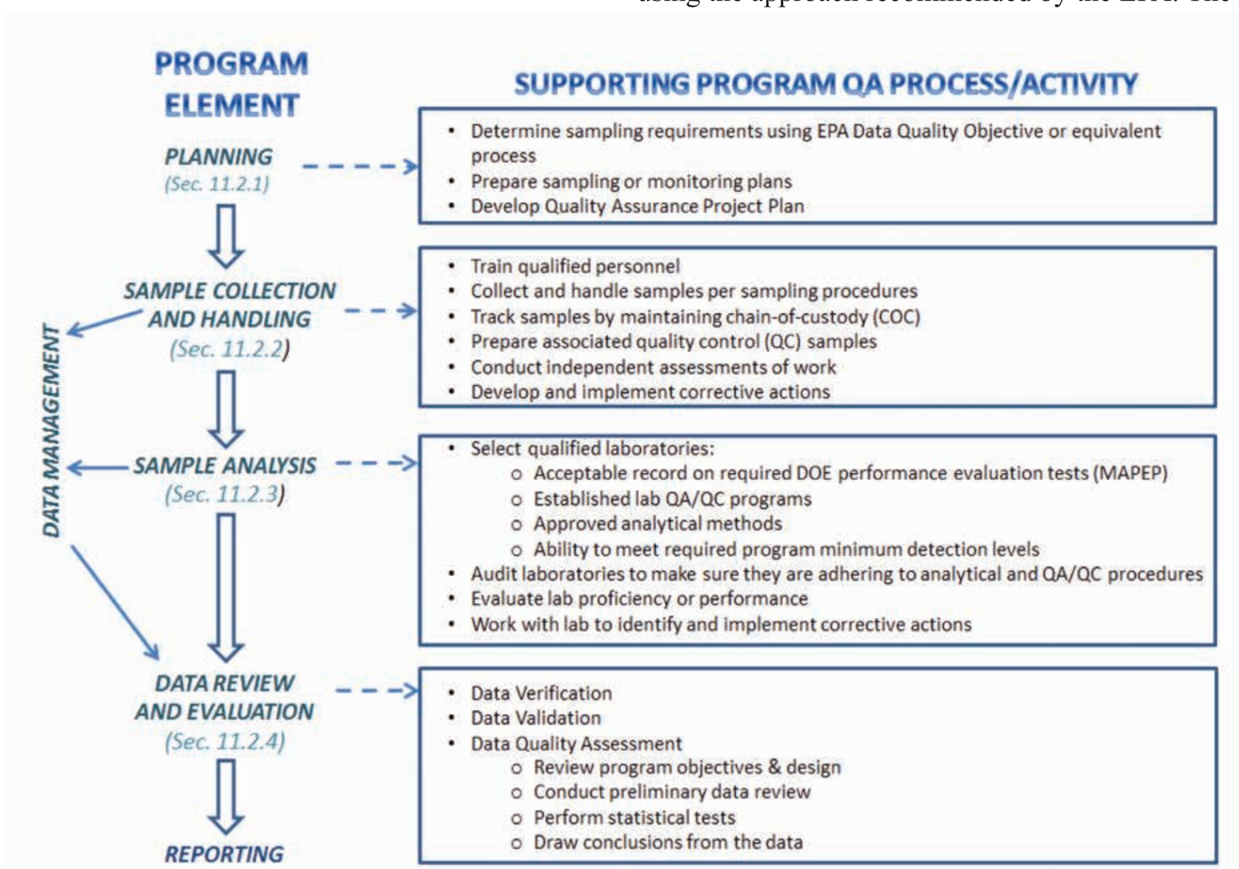

Figure 11-1. Flow of Environmental Monitoring Program Elements and Associated Quality Assurance Processes and Activities.

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 Quality Assurance Project Plan (QAPjP) 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 QAPjP.

11.2.2 Sample Collection and Handling

Strict adherence to program procedures is an implicit foundation of QA. In 2015, 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 to 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).

> 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.

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 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.

Table 11-1. Analytical Laboratories Used by INL Site Contractors and U.S. Geological Survey Environmental Monitoring Programs.

Contractor and Program	Laboratory	Type of Analysis
ICP Drinking Water Program	GEL Laboratories, LLC	Radiological
	Intermountain Analytical Service – EnviroChem	Microbiological
	UL LLC	Inorganic and organic
	Eurofins Eaton Analytical, Inc.	Inorganic and organic
ICP Environmental Program	ALS Laboratory Group – Fort Collins	Radiological
ICP Liquid Effluent Monitoring Program	ICP Wastewater Laboratory	Microbiological
	GEL Laboratories, LLC	Inorganic and radiological
ICP Groundwater Monitoring Program	GEL Laboratories, LLC	Inorganic, organic, radiological, and microbiological
	Southwest Research Institute	Inorganic, radiological, and microbiological
	Test America	Radiological, inorganic, and metals
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
	Southwest Research Institute	Inorganic
INL Environmental Surveillance Program	ALS Laboratory Group – Fort Collins	Radiological
	Environmental Services In Situ Gamma Laboratory	I-131
	Landauer Inc.	Penetrating radiation (OSL and neutron dosimeters)
Environmental Surveillance, Education, and Research Program	Environmental Assessments Laboratory at Idaho State University	Gross radionuclide analyses (e.g., gross alpha and gross beta), OSL dosimetry, liquid scintillation counting (tritium), and gamma spectrometry
	ALS Laboratory Group – Fort Collins	Specific radionuclides (e.g. ^{90}Sr, ^{241}Am, ^{238}Pu, and $^{239/240}$Pu)
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 iodine-129
	TestAmerica Laboratories	Radiological and nonradiological for the USGS Naval Reactors Facility sample program
	Brigham Young University Laboratory of Isotope Geochemistry	Low-level tritium for the USGS Naval Reactors Facility sample program

- 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 interlaboratory 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. Samples are spiked with known amounts of radionuclides or nonradioactive substances by suppliers whose spiking materials are traceable to National Institute of Standards and Technology (NIST). The contractor may submit these samples to the laboratory with regular field samples using the same labeling and sample numbering system. A third party may also submit samples independent of the contractor to evaluate the performance of the laboratory. The DOE Mixed Analyte Performance Evaluation Program (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 intralaboratory 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 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 2015

Results of the QC measurements for specific DOE-contracted environmental programs in 2015 are summarized in the following sections. The programs include results of the Mixed Analyte Performance Evaluation Program (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 (DOE 2015) 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:

- 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 (RTP) 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 RTP, 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 32 was distributed in February 2015, and Series 33 was distributed in August 2015.

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/handbookv15.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 2015, each radiological laboratory used by the INL, ICP, and ESER contractors participated in the 2015 MAPEP Series 32 (March 2015) and 33 (August 2015). The laboratories evaluated were ALS-Fort Collins (ALS-FC), Idaho State University Environmental Assessment Laboratory (ISU-EAL), GEL Laboratories, LLC (GEL), and Test America, Inc. St Louis (TAStL). The results of the MAPEP tests, as they pertain to the INL Site environmental programs, are presented below by laboratory.

ALS-Fort Collins (ALS-FC). The ESER, INL, and ICP contractors used ALS-FC for their ambient air programs. The isotopic analytes of common interest to the ESER, INL, and ICP ambient air surveillance programs include: ^{90}Sr, ^{241}Am, ^{238}Pu, and $^{239/240}Pu$. Ambient air samples collected by the INL and ICP contractors were also analyzed by ALS-FC for gross alpha/beta and for gamma-emitting radionuclides, such as ^{241}Am, ^{60}Co, ^{134}Cs, ^{137}Cs, ^{152}Eu, and ^{125}Sb. The same isotopic analytes and gamma-emitting radionuclides were analyzed for soil, water, and biota samples collected by the ICP.

The ESER contractor sent waterfowl samples to ALS-FC for analysis for ^{90}Sr, ^{241}Am, ^{238}Pu, and $^{239/240}Pu$. In addition, agricultural samples were analyzed for ^{90}Sr.

All analytes of interest were acceptable for MAPEP Series 32 and 33. The MAPEP results do not demonstrate any issues of concern for the 2015 data reported by ALS-FC. The INL, ESER, and ICP contractors will continue to monitor the MAPEP results to determine if any trends warrant further action.

Idaho State University Environmental Assessment Laboratory (ISU-EAL). 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 "A" (Acceptable), unless noted below. The MAPEP Series 32 and 33 Flag Results for ISU-EAL were:

- MAPEP Series 32 – "A" (Acceptable) for all analytes of interest
- MAPEP Series 33 – "W" (Acceptable with Warning) for ^{134}Cs gamma spectroscopy water sample

The MAPEP results for the ESER program do not demonstrate any issues of concern for the 2015 data. The ESER program will continue to monitor the MAPEP results to see if any trends warrant further action.

GEL Laboratories, LLC (GEL). The ICP groundwater program used GEL in Charleston, South Carolina, for analysis of samples. The analytes of interest to the ICP groundwater program include: gross alpha, gross beta, iodine-129 (^{129}I), ^{3}H, ^{90}Sr, total Sr, uranium-233,234 ($^{233/234}U$), uranium-238 (^{238}U), ^{238}Pu, $^{239/240}Pu$, technetium-99 (^{99}Tc), ^{241}Am, and gamma spectrometry—cerium-134 (^{134}Ce), ^{137}Ce, cobalt-57 (^{57}Co), ^{60}Co, potassium-40 (^{40}K), manganese (^{54}Mn), and zinc-65 (^{65}Zn). Water samples collected by the ICP contractor were analyzed by GEL for: gross alpha, gross beta, ^{129}I, ^{3}H, ^{90}Sr, total Sr, $^{233/234}U$, ^{238}U, ^{238}Pu, $^{239/240}Pu$, ^{99}Tc, ^{241}Am, and gamma spectrometry—^{134}Ce, ^{137}Ce, ^{57}Co, ^{60}Co, ^{40}K, ^{54}Mn, and ^{65}Zn. The MAPEP Series 32 and 33 flag results for ISU-EAL were:

- MAPEP Series 32 – "A" (Acceptable) for all analytes of interest
- MAPEP Series 33 – "W" (Acceptable with Warning) for gross alpha
- All other analytes of interest were "A" (Acceptable).

The MAPEP results for the ICP groundwater program do not demonstrate any issues of concern for the

2015 data. The ICP groundwater program will continue to monitor the MAPEP results to determine if any trends warrant further action.

During 2015, the ICP contractor used GEL for laboratory analysis of water samples. The primary radionuclide analytes of interest for the ICP Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) groundwater monitoring program include: ^{3}H, ^{60}Co, ^{90}Sr, ^{99}Tc, ^{129}I, ^{137}Cs, ^{234}U, ^{235}U, ^{238}U, ^{238}Pu, $^{239/240}$Pu, and gross alpha/beta. Inorganic constituents of interest include: calcium, chromium, magnesium, potassium, sodium, bicarbonate, chloride, nitrate, and sulfate.

For all of the MAPEP analytes, the 2015 results reported by GEL were deemed "A" (Acceptable). The MAPEP results do not demonstrate any issues of concern for the 2015 data reported by GEL.

Test America Laboratories, Inc. St Louis (TAStL). The ICP contractor used TAStL for the groundwater program. The analytes of interest to the ICP groundwater program include: $^{233/234}$U and ^{238}U. Water samples collected by the ICP contractor were analyzed by TAStL for $^{233/234}$U and ^{238}U.

All analytes of interest were acceptable for MAPEP Series 32 and 33. The MAPEP results for the ICP groundwater program do not demonstrate any issues of concern for the 2015 data reported by TAStL. The ICP groundwater program will continue to monitor the MAPEP results to determine if any trends warrant further action.

During 2015, the ICP contractor used TAStL for laboratory analysis of water samples collected for the Idaho CERCLA Disposal Facility groundwater monitoring project. The primary radionuclide analytes of interest for that project are ^{234}U and ^{238}U.

For both uranium isotopes, the 2015 results reported by TAStL were deemed "A" (Acceptable). The MAPEP results do not demonstrate any issues of concern for the 2015 data reported by TAStL.

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 2015 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 (GWMP) have specific QA/QC objectives for analytical data. Table 11-2 presents a summary of 2014 LEMP GWMP QC criteria and performance results.

Completeness – Collection and Analysis. The goal for completeness is to collect 100 percent of all required compliance samples. This goal was met in 2015.

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 2015, field duplicates were collected at the Advanced Test Reac-

Table 11-2. 2015 INL Liquid Effluent Monitoring Program, Groundwater Monitoring Program, and Drinking Water Program Quality Assurance/Quality Control Criteria and Performance.

Liquid Effluent Monitoring Program	Criterion	2015 Performance
Completeness		
Compliance Samples Successfully Collected	100%	100%
Compliance Samples Successfully Analyzed	100%	100%
Surveillance Samples Collected and Successfully Analyzed	100%	100%
Precision		
Field Duplicates	Performed at each sample location	
Field Blanks	Engineering and administrative controls applied to mitigate contamination	
Accuracy		
Performance Evaluation Samples		
Groundwater Monitoring Program	**Criterion**	**2015 Performance**
Completeness		
Compliance Samples Successfully Collected	100%	100%
Compliance Samples Successfully Analyzed	100%	100%
Surveillance Samples Collected and Successfully Analyzed	100%	100%
Precision		
Field Duplicates	Performed at each sample location	
Field Blanks	Engineering and administrative controls applied to mitigate contamination	
Accuracy		
Performance Evaluation Samples		
INL Drinking Water Monitoring Program	**Criterion**	**2015 Performance**
Completeness		
Compliance Samples Successfully Collected	100%	100%
Compliance Samples Successfully Analyzed	100%	100%
Surveillance Samples Collected and Successfully Analyzed	100%	100%
Precision		
Field Duplicates	90%	100%
Field Blanks	90%	100%
Accuracy		
Performance Evaluation Samples Note: 22 out of 98 samples were QA/QC.	90%	100%

tor Complex Cold Waste Pond, U.S. Geological Survey (USGS)-076, Materials and Fuels Complex Industrial Waste Pipeline and the Industrial Waste Water Underground Pipe, and Well ANL-2 at the Materials and Fuels Complex.

The INL contractor LEMP and GWMP requires that the RPD from field duplicates be less than or equal to 35 percent for 90 percent of the analyses. In 2015, 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 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 Contractor

The ICP 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 2015 QC criteria and performance results.

Completeness – Collection and Analysis. The ICP LEMP goal for completeness was to collect and successfully analyze 100 percent of all permit-required compliance samples. This goal was met in 2015. A total of 408 sample parameters were collected, submitted for analysis, and successfully analyzed.

The goal for completeness was to collect and successfully analyze 90 percent of the LEMP surveillance samples. This goal was exceeded in 2015; 100 percent of the samples were collected and analyzed. A total of 432 sample parameters were collected, and 432 parameters were successfully analyzed.

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 11, 2015. Eighty-six percent of the results had an RPD of less than or equal to 35 percent.

A radiological field duplicate sample is collected annually at CPP-773 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 September 29, 2015. Of the 24 parameters analyzed, only gross beta had two statistically positive results. The mean difference was calculated to be 1.88, which was less than the goal of three.

Accuracy – Performance Evaluation Samples. During 2015, performance evaluation samples were submitted to the laboratory with routine wastewater monitoring samples on December 9. One hundred percent of the results were within their QC performance acceptance limits, which exceeded the program goal of 90 percent.

Introduction of Contamination – Field Blank Samples. A field blank was collected on September 23, 2015. A total of 19 parameters were analyzed, and 18 of these parameters were not detected. Chloride was detected at 0.0759 mg/L, slightly above its detection limit of 0.067 mg/L. In addition, the reported chloride concentration was an estimate due to high (> 110 percent) matrix spike recovery. These field blank results indicate that no contamination was introduced during sample collection, storage, and transport.

Decontamination – Equipment Rinsate Samples. Equipment rinsate samples are collected annually and are used to evaluate the effectiveness of equipment decontamination. On June 10, 2015, a sample carboy associated with CPP-797 was decontaminated by the Idaho Nuclear Technology and Engineering Center (INTEC) licensed wastewater operators. After decontamination, deionized water was added to the carboy, and the rinsate samples were collected by Liquid Effluent Monitoring Program personnel. A total of 19 parameters were analyzed, and 16 of those parameters were not detected.

Table 11-3. 2015 ICP Liquid Effluent Monitoring Program, WRP Groundwater Monitoring Program, and Drinking Water Program Quality Assurance/Quality Control Goals and Performance.

ICP Liquid Effluent Monitoring Program	Criterion	2015 Performance
Completeness		
Compliance Samples Successfully Collected	100%	100%
Compliance Samples Successfully Analyzed	100%	100%
Surveillance Samples Collected and Successfully Analyzed	90%	100%
Precision		
Field Duplicates	90%	87%
Equipment Rinsates	90%	84%
Field Blanks	90%	95%
Accuracy		
Performance Evaluation Samples	90%	100%
ICP WRP Groundwater Monitoring Program	**Criterion**	**2015 Performance**
Completeness		
Compliance Samples Successfully Collected	100%	100%
Compliance Samples Successfully Analyzed	100%	100%
Surveillance Samples Collected and Successfully Analyzed	90%	100%
Precision		
Field Duplicates	90%	93%
Equipment Rinsates	90%	97%
Field Blanks	90%	100%
Accuracy		
Performance Evaluation Samples	90%	86%
ICP Drinking Water Monitoring Program	**Criterion**	**2015 Performance**
Completeness		
Compliance Samples Successfully Collected	100%	100%
Compliance Samples Successfully Analyzed	100%	100%
Surveillance Samples Collected and Successfully Analyzed	90%	100%
Precision		
Field Duplicates	90%	100%
Field Blanks	90%	100%
Trip Blanks	90%	100%
Accuracy		
Performance Evaluation Samples	90%	100%

However, three parameters—chloride (0.132 mg/L), total Kjeldahl nitrogen (0.058 mg/L), and biochemical oxygen demand (34.3 mg/L)—were detected. The INTEC licensed wastewater operators were notified of the detections and reminded that CPP-797 sample carboys should be replaced with new carboys if they cannot be adequately decontaminated.

11.3.2.2 Idaho Cleanup Project Contractor Wastewater Reuse Permit Groundwater Monitoring Quality Control Data

The ICP 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 2015 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 2015. A total of 240 sample parameters were collected and submitted for analysis, and 240 parameters were successfully analyzed. Some of the results were qualified during data validation, and the reported concentrations are provided in Tables C-6 and C-7. These qualified results are summarized in the 2015 Wastewater Reuse Report (ICP 2016).

The goal for completeness was to collect and successfully analyze 90 percent of the WRP GWMP surveillance samples. This goal was exceeded in 2015. Sixteen parameters, or 100 percent, were collected and successfully analyzed.

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 9, 2015, and from well ICPP-MON-A-166 on September 10, 2015. One hundred percent of the results had a RPD of less than or equal to 35 percent.

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 9, 2015, and from well ICPP-MON-A-166 on September 9, 2015. 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. Three of the four samples collected had statistically positive results, and two of these results had a mean difference of less than or equal to three. The September 2015 gross beta results for well ICPP-MON-A-166 had a mean difference of 3.25.

Accuracy – Performance Evaluation Samples. Performance evaluation samples were submitted to the laboratory with routine groundwater monitoring samples on April 9, 2015, and September 9, 2015. Eighty-six percent of the performance evaluation sample results were within their QC performance acceptance limits—the program goal was 90 percent. The laboratory was requested to investigate the April 2015 total phosphorus, total dissolved solids, fecal coliform, aluminum, and mercury sample results and the September 2015 mercury sample results that did not meet their acceptance criteria. Summaries of the laboratory investigations are provided in the *2015 Wastewater Reuse Report* (ICP 2016).

Introduction of Contaminants – Field Blank Samples. Field blanks were collected on April 8, 2015, and September 9, 2015, and analyzed for the permit-specific parameters. All results were below their respective detection/reporting limits for the April field blank and the September field blank, indicating that no contamination was introduced during sample collection, storage, and transport.

Introduction of Contaminants – Equipment Rinsate Samples. Equipment rinsates were collected on April 9, 2015, and September 9, 2015, and analyzed for the permit-specific parameters. All results were below their respective detection/reporting limits for the April rinsate sample, indicating that proper decontamination procedures were followed. For the September rinsate sample, all analytical results were below their respective detection/reporting limits, except for total Kjeldahl nitrogen (0.0463 mg/L) and chloride (0.0859 mg/L). WRP GWMP personnel were notified of the detections.

11.3.2.3 Idaho Cleanup Project Contractor Groundwater Monitoring Quality Control Data

QA/QC samples and results for Waste Area Group (WAG) 1, WAG 3, and WAG 4 are discussed in the annual reports for Fiscal Year 2015 (DOE-ID 2016a; DOE-ID 2016b; DOE-ID 2016c) and for WAG 2 in the Fiscal Year 2016 report (DOE-ID 2016d). 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 2015 groundwater monitoring sampling event at Radioactive Waste Management Complex (RWMC), 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), except as noted below.

Accuracy – Performance Evaluation Sample. The project objectives for accuracy were met with the exception of the performance evaluation sample described in the following paragraphs.

Double-blind performance evaluation samples containing known concentrations of selected radionuclides were prepared by RESL. The performance evaluation samples were submitted to the contract laboratory (GEL), along with the November 2015 RWMC aquifer groundwater samples, to assess analytical performance.

The analytical results reported by GEL were within acceptable limits, except for ^{57}Co and ^{90}Sr. The ^{57}Co result received a “warning” because the laboratory reported an activity 1.22 times higher than the known activity. The ^{90}Sr result was not acceptable because the laboratory result was only 70 percent of the known activity. The analytical laboratory was notified of these discrepancies. They will investigate the results and perform the appropriate corrective action(s) if necessary. However, because ^{57}Co and ^{90}Sr have not been detected in the groundwater samples collected historically from WAG 7 aquifer wells, the poor results for these two radionuclides do not adversely affect the project data set.

11.3.2.4 Drinking Water Program Quality Control Data

INL Contractor

The INL contractor Drinking Water Program 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. Drinking Water Program goals are established for precision of less than or equal to 35 percent for 90 percent of the analyses. The Drinking Water Program 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 2015, the Drinking Water Program reported 23 radiological detections and 0 nondects with 100 percent of the data meeting the RPD goal. For non-radiological 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 Drinking Water Monitoring Program (DWP) has specific quality 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 2015 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 2015. A total of 16 parameters were collected and submitted for analysis, and 16 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 2015. A total of 74 parameters were collected, and 74 parameters, or 100 percent, were successfully analyzed.

Precision – Field Duplicates. Field duplicate samples were collected on June 24, 2015, (nitrates) and October 28, 2015 (volatile organic compounds [VOCs]). The RPD determined from field duplicate samples should be 35 percent or less for 90 percent of the parameters analyzed. One hundred percent of the field duplicate sample results (with two detectable quantities) were within the program goal for RPD of less than or equal to 35 percent.

Radiological field duplicate samples were collected from WMF-604 on January 26, 2015, and analyzed for gross alpha and gross beta. Only the gross beta results were statistically positive, and the mean difference was calculated to be 0.35, which was less than the goal of three. On July 23, 2015, radiological field duplicate samples were collected from CPP-614 and analyzed for gross alpha, gross beta, ^{3}H, and ^{90}Sr. Of the four parameters analyzed, only the gross beta and ^{3}H results were statistically positive. The mean difference for gross beta was 1.02, and the mean difference for ^{3}H was 0.70, both of which were less than three.

Accuracy – Performance Evaluation Samples. Performance evaluation samples were submitted to the laboratory with routine drinking water samples on July 29, 2015, (VOCs) and August 12, 2015 (HAA5s/TTHMs). The results for 32 of the 32 performance evaluation sample parameters (100 percent) 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 21, 2015, (VOCs) 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 January 21, 2015, (VOCs) April 29, 2015, (VOCs) July 29, 2015, (VOCs) August 12, 2015, (TTHMs) and October 28, 2015, (VOCs) sampling events. 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 2015 ESER QC analysis results.

Completeness – Collection and Analysis. The ESER contractor met its completeness goals of greater than 98 percent in 2015. Three air samples were considered invalid because insufficient volumes were collected due to power interruptions (i.e., blown fuse and/or tripped breaker). The Jackson, Wyoming, air sampling location is in the process of being relocated; the last air sample for 2015 was on October 10, 2015. A few milk samples were not collected in 2015 because they were not available for collection. All other samples were collected and analyzed as planned.

Precision – Field Duplicate Samples. Field duplicate samples were collected for air, milk, lettuce, potatoes, alfalfa, and grain 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 (Main Gate and Idaho Falls) 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

Table 11-4. 2015 ESER Surveillance Program Quality Assurance Elements.

QC Program Element - 2015	Criterion	Performance[a]
Completeness		
Surveillance Samples Successfully Completed	100 percent	100 percent
Submitted Surveillance Samples Successfully Analyzed	100 percent	100 percent
Accuracy		
Blind Spike Program[b]		
Idaho State University - Environmental Assessment Lab (EAL)	90 percent	95 percent
ALS Environmental Laboratory - Fort Collins (ALS)	90 percent	36 percent
Precision		
Field Duplicates		
EAL	Differences within 3 standard deviations (3σ) or within ± 20 percent RPD	95 percent
ALS		100 percent
Field Blanks		
EAL	± 3σ of Zero	90 percent
ALS		81 percent

a. Sample matrices include: water (drinking, surface, 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, tritium, gross alpha, and gross beta.
ALS-FC - ESER requested analysis: strontium-90, americium-241, plutonium-238, and plutonium-239,240.

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 sample and duplicate results agreed with each in over 94 percent of all environmental samples collected during 2015, 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 nine double blind spike or irradiated sample sets to the ISU-EAL laboratory during the 2015 calendar year for gamma spectroscopy, liquid scintillation, and dosimetry reading analysis. The following matrices were spiked for the 2015 year: water, air particulate filters, milk, and wheat. An irradiated set of Optically Stimulated Luminescent (OSL) dosimeters, in sets of three for each spiked set (i.e., 0, 25, 50, 75, 100, 150 mrem), was also sent to the ISU-EAL during 2015. The ISU-EAL submitted sample results for 41 individual analytes that had recovery analysis completed by the RESL; 39 had an Agreement of "YES" and 2 had an Agreement "NO." This was a 95.1 percent (i.e., 39/41 x 100) performance in the ESER double blind spike program. There was one "False Positive" result for a milk blank sample analysis for ^{3}H and a gamma spectroscopy result for a wheat sample with ^{65}Zn at 132 percent of the known value.

The ESER Program sent seven double blind spike sample sets to the ALS-FC laboratory during the 2015 calendar year for radiochemical analysis. The following matrices were spiked for the 2015 year: air particulate filters, milk, and wheat. The ALS-FC submitted sample results for 11 individual analytes that had recovery analysis completed by the RESL; four had an Agreement of "YES" and seven had an Agreement of "NO," or a 36.4 percent (i.e. 4/11 x 100). There was an Agreement "NO" on two separate AP Filter spiked samples submitted to the ALS-FC for ^{90}Sr analysis, with a 45 percent and 32 percent recovery of the known amount of the spike. There was a follow-up with the ALS-FC and they reported that there may have been splattering when drying the counting planchets or muffle furnace sample preparation losses, which contributed to the low recovery. There was also an Agreement "NO" on two separate AP Filter spiked samples submitted for ^{241}Am, ^{238}Pu, and $^{239/240}Pu$ alpha spectrometry analysis. All the spike recoveries for these isotopes were between 20 percent and 45 percent of the known spiked values, with the exception of an Agreement "YES" for one of the ^{241}Am sample sets—this was a blank for ^{241}Am. A letter of concern was sent to the ALS-FC laboratory director stating the issues with recoveries not meeting the ± 30 percent of the known spiked values for AP Filter analyses for ^{90}Sr, ^{241}Am, ^{238}Pu, and $^{239/240}Pu$. The ESER will not send any further AP Filter samples to the ALS-FC until these issues are investigated by the ALS-FC and they report their findings to the ESER. A set of AP Filter samples will be sent to the ALS-FC to verify the laboratory can attain acceptable spike recoveries.

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 2015, the EAL attained over 90 percent performance of blanks within one to three standard deviations of zero; the ALS had a 81.3 percent performance of blanks (13 out of 16) with the above stated criterion.

Invalid Sample Results. The results of analyses of third quarter 2015 composited air samples showed positive hits for $^{239/240}Pu$ for all filters, including the blank. The case narrative accompanying the results states that there is an unknown peak at 5300 keV that is believed to be polonium-210 (^{210}Po), which is a naturally occurring product of the decay of ^{238}U. The analytical laboratory flagged the results with a "J" flag, indicating they are biased high and should be considered an estimated value. We showed the results to the Senior Technical Manager of the RESL who said that the regions of interest for ^{210}Po and $^{239/240}Pu$ are set too close for the analytical software to distinguish (the energy peak for $^{239/240}Pu$ is 5160 keV). He recommended that the lab try to remove the ^{210}Po chemically before counting. Backup filters collected at other locations during the third quarter were sent to ALS-FC, and the laboratory chemically removed any ^{210}Po in these samples. The final results did not indicate the presence of $^{239/240}Pu$. In addition, fourth quarter samples were analyzed in the same fashion, and $^{239/240}Pu$ was not detected in any sample. For this reason, the original third quarter sample results for $^{239/240}Pu$ were declared invalid.

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 intercomparison 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 1,200 air samples, four were invalid because of power interruptions (i.e., blown fuses and/or tripped breakers) and insufficient volumes.

Precision – Collocated Samples. The Environmental Surveillance Program rotates two replicate air samplers that are placed adjacent to regular samplers (currently at INTEC and CFA) to allow for data comparisons. The collocated samples are collected at the same time, stored in separate containers, and 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

Table 11-5. 2015 BEA Environmental Surveillance Program Quality Assurance Elements.

QC Program Element - 2015	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	98 percent
Gamma Spec[c] (Quarterly)	Ideally 100 percent	100 percent
Laboratory Control Sample		
Air	LCS percent Recovery ± 25 percent	100 percent
Field Blanks		
Air	Ideally 100 percent within 2σ of zero	91 percent

a. Includes all results for gamma spectrometry and isotopic analysis.
b. Mean difference.
c. As Be-7.

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 98 percent of the mean difference values were less than the goal of three.

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 2015 for the 19 samples spiked with gamma emitters (i.e., ^{60}Co, ^{134}Cs, ^{137}Cs, ^{54}Mn, ^{65}Zn), the results included two ^{134}Cs results that were biased low and not in agreement with the known activity, one ^{65}Zn result that was not in agreement because it was biased high, 11 results that were in agreement but in the "warning" range (all with a slight low bias), and five that were in agreement with no qualification. To help improve the gamma spectroscopy results, at the request of the INL contractor, the laboratory has developed a new gamma standard that will be used in 2016. For the nine samples spiked with radionuclides that require radiochemistry (^{90}Sr, ^{241}Am, ^{238}Pu, $^{239/240}$Pu), all results were in agreement except for one blank sample for which the laboratory reported a trace of ^{241}Am (false positive).

Introduction of Contaminants – Field Blanks. In 2015, the majority of the field blanks were within two standard deviations of zero for air. See Table 11-5 for details.

Invalid Sample Results. As discussed in Section 11.3.2.5 above, naturally occurring ^{210}Po causes interferences with accurate plutonium measurements. The INL contractor uses the same laboratory for these analyses as the ESER contractor and experienced similar issues with ^{210}Po contamination in their results, as discussed below.

Traces of $^{239/240}$Pu were reported by the laboratory to be present in the first, third, and fourth quarter of 2015 in 24 composited samples from Blackfoot, CFA, CPP, EBR-I, EFS, Gate 4, Idaho Falls, INTEC, IRC, PBF, RTC, RWMC, SMC, Sugar City, and VANB. However, the laboratory also reported the presence of ^{210}Po contamination in each of these reports. Additionally, $^{239/240}$Pu was reported to be present in method blanks and field blanks, and the laboratory case narrative mentions ^{210}Po contamination and potential for high bias in the $^{239/240}$Pu results. Because of this, these $^{239/240}$Pu data were declared invalid.

The laboratory reported a trace of ^{238}Pu in a third quarter 2015 composite sample from PBF and traces in fourth quarter composites from CFA, Gate 4, INTEC, Rest Area, RTC, SMC, and Sugar City. The ^{210}Po discussed above existed in the same final fraction for these ^{238}Pu analyses as for the $^{239/240}$Pu analyses, and interference from ^{210}Po is likely. Because of this, these ^{238}Pu data were also considered false positives and declared invalid.

The laboratory reported traces of ^{241}Am in nine quarterly composite samples. Measured concentrations were slightly above the reported minimum detectable concentration; however, in the first and third quarters the laboratory reported ^{241}Am in blind spikes that contained no ^{241}Am (false positives). The highest concentration reported in 2015 was detected in the trip blank sample during the last quarter, so these data should be used with caution as the results may be false positives. Low level false positives can occur because of incomplete chemical separation and breakthrough of natural radionuclides during laboratory analysis. For example, natural ^{228}Th can cause false positives of ^{241}Am and ^{238}Pu. The analytical laboratory is investigating their ^{241}Am procedure.

11.3.2.7 ICP Environmental Surveillance for Waste Management Quality Control Data

Table 11-6 summarizes the 2015 ICP Environmental Surveillance Program for Waste Management QC analysis results.

Completeness. The ICP Environmental Surveillance Program for Waste Management completeness goal, which includes samples collected and samples analyzed, is 90 percent. The collection of air samples was 95 percent in 2015. On September 24, 2015, a transformer near sample location SDA 6.3 blew a fuse, causing power loss. On October 18, 2015, the sampler was moved approximately 600 feet west to the closest available power source. For surface water, biota, and soil sampling, 100 percent of samples were collected. Overall sample collection for all media was 98.5 percent.

For air samples, 92 percent of the samples collected were analyzed. A five-day wait time is requested by the

Table 11-6. 2015 ICP Environmental Surveillance Program Quality Assurance Elements.

QC Program Element - 2015	Criterion	Performance[a]
Completeness		
Surveillance samples successfully completed	90 percent	99 percent
Surveillance samples successfully analyzed	90 percent	98 percent
Accuracy		
Blind Spike Program[b]		
ALS Environmental Laboratory – Fort Collins (ALS)	90 percent	82 percent
Precision		
Field Replicates/Duplicates		
Differences within 3 standard deviations (3σ)	MD[b] > 3	99 percent
Laboratory Control Sample		
All media	LCS percent recovery ±25 percent	100 percent
Field Blanks		
Air and surface water	Ideally 100 percent within 2α	99 percent

a. Sample matrices include: air filter, surface water, soil, vegetation.

b. Requested analysis—Gamma spectrometry and isotopic.

project before the laboratory analyzes for gross alpha/beta to allow naturally occurring, short-lived radon daughters to decay. The laboratory analyzed four sets of samples before the requested five-day wait time; therefore, the gross alpha/beta analyses results were rejected. The laboratory was informed and committed to adhere to the wait time in the future. For surface water, biota, and soil sampling, 100 percent of samples were analyzed. Overall sample analysis for all media was 98 percent.

Blind Spike Samples. The ICP contractor submitted air, surface water, biota, and soil blind spike samples to ALS Laboratory Group for analysis in 2015 to check laboratory accuracy. These samples were prepared at the RESL as described in Section 11.3.1. All blind spike samples showed satisfactory agreement (within ± 30 percent of the known value and within three-sigma), except for those discussed in the following paragraphs.

- ***Ambient Air*** — Two sets of blind spike samples were submitted to the laboratory in 2015. One set was submitted in April and another in November. The results for two blind spike samples submitted in April analyzed for gamma-emitting radionuclides were "not acceptable." All results were high biased. Laboratory personnel explained that the lab standard consists of a five-filter geometry as opposed to the ICP standard of a two-filter geometry. The efficiency is lower for the five filters; therefore, a lower calibrated efficiency would result in a high bias. Both samples analyzed for radiochemistry received an "acceptable" evaluation for all analytes.

  The results for two blind spike samples submitted in November analyzed for gamma-emitting radionuclides were "not acceptable" for ^{241}Am. The result was low. Laboratory personnel explained that the samples were spiked below what can be measured by gamma spectrometry analysis and was well below the requested minimum detectable concentration. One of the samples analyzed for radiochemistry received an "unacceptable" evaluation for ^{238}Pu. The result was a false positive. Laboratory personnel suspected that during the sequential preparation, a small fraction of the ^{241}Am bled through to the Pu fraction, causing the false positive. In the future, laboratory personnel will watch for this in samples with high activity.

- ***Surface Water*** — Two blind spike samples received an "acceptable" evaluation for all radionuclides, except for ^{239}Pu in one sample. A false positive result was reported. The reported activity was below the required detection limit, but the laboratory reported 94 counts in a 1,000-minute sample count time. Laboratory personnel investigated, and they found no indications of cross-contamination, and the samples were processed in a low-level laboratory. A recount of the sample had comparable results.

- ***Biota*** — The results for ^{134}Cs and ^{90}Sr received an "unacceptable" evaluation for both blind spike samples. The result for ^{241}Am received an "unacceptable" evaluation for one of two blind spike samples.

- The ^{134}Cs, ^{90}Sr, and ^{241}Am results were low. The low recovery may have been caused from loss during the muffling process, although laboratory procedures are in place to minimize this loss. For future vegetation samples, the laboratory will be extra diligent to minimize any loss.

- ***Soil*** — Two of three blind spike soil samples analyzed received 100 percent "acceptable" evaluations. The third sample received an "unacceptable" evaluation for the following analyses:

  - ^{54}Mn – Result was a possible high bias due to the density difference between the calibration source and sample.

  - ^{238}Pu – Result was a false positive, which may have been caused by a high ^{241}Am concentration in the sample. Laboratory personnel suspect that during the sequential preparation a small fraction of the ^{241}Am bled through to the Pu fraction, causing the false positive. Laboratory personnel will watch for this on future samples with high activity.

  - ^{234}U – Results were low. An investigation of the spectra reveals slight attenuation, and the ^{234}U peak tailed out of the region of interest. The laboratory analyst will watch for this in the future.

Laboratory Intercomparison QA Programs. ALS Laboratory Group participated in a variety of intercomparison QA programs, which verify all the methods used to analyze environmental samples. The programs include the DOE MAPEP and the EPA National Center for Environmental Research Quality Assurance Program. The laboratory met the performance objectives specified by these two intercomparison QA programs.

Precision – Field Duplicate/Replicate Samples. The overall precision result for all media sampled was 99.4 percent. A replicate air sampler is set adjacent to a regular sampler. The results are compared using the RPD or the standard deviation criterion (Equation 1). The RPD is acceptable if it is within 20 percent. For ambient air, an overall average performance rate of 98.8 percent was achieved.

$$|R_1 - R_2| \leq 3(s_1^2 + s_2^2)^{1/2} \qquad (1)$$

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 taken quarterly. In 2015, a field duplicate was taken during the first quarter sampling. The results of the regular sample and the duplicate sample compared at 100 percent.

Laboratory Control Samples (LCSs). All laboratory LCS 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 2015, 98.7 percent of the field blanks were within two standard deviations of zero for both air and water.

For the third quarter isotopic air results, the laboratory reported that $^{239/240}Pu$ and ^{234}U were detected in the batch blank. The sample results were reported even though there is a potential positive bias. The results were comparable to past results.

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 2015 and updated to clarify procedures and to implement new 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 Quality Assurance 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 off-site 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 et al. 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 et al. 2014). Evaluations of QA/QC data collected by USGS can be found in Wegner (1989), Williams (1996), Williams (1997), Williams et al. (1998), Bartholomay and Twining (2010), Rattray (2012), Davis et al. (2013), and Rattray (2014). During 2015, the USGS collected 17 replicate samples, seven field blank samples, one equipment blank sample, 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 contractor, and ESER contractor documentation is presented in Table 11-7, Table 11-8, and Table 11-9, respectively.

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-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-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 LI-330, Groundwater Monitoring at the Advanced Test Reactor Complex
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
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. (cont.)

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. 4, Battelle Energy Alliance Statement of Work for Analytical Services
Reference Documents	LR-8000, Environmental Requirements for Facilities, Processes, Materials and EquipmentLWP-8000, Environmental Instructions for Facilities, Process, 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

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-8550 (Table 11-7).

11.4.2 Idaho Cleanup Project 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 and Removal Actions* (DOE-ID 2009). The QAPjP was written in accordance with *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 1988).

In addition, the ICP 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 AMWTP-PD-EC&P-02, "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."

Table 11-8. ICP 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-234, Generating Sampling and Analysis Plan Tables for Environmental Sampling Activities 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
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 TRP-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 Biota SPR-106, Biotic Monitoring Air SPR-107, Waste Management Low-Volume Suspended Particulate Air Monitoring

Table 11-8. ICP Environmental Program Documentation. (cont.)

Document/Media Type	Document No.[a] and Title
	SPR-193, NESHAP Ambient Air Sampling for Accelerated Retrieval Project and RCRA Inorganic Sludge Processing Operations Soil SPR-110, Surface Soil Sampling Surface Water SPR-213, Surface Water Sampling at Radioactive Waste Management Complex Surface Radiation TPR-6525, Surface Radiation Surveys Using the Global Positioning Radiometric Scanner
Gamma Documents	TPR-7485, Filling Gamma Detector with Liquid Nitrogen TPR-7859, Shipping Screen Gamma Scan TPR-7860, Germanium Detector Calibration and Performance Testing Using Gamma Vision-32
Documentation Documents	MCP-9227, Environmental and Regulatory Services Logkeeping Practices MCP-9235, Reporting Requirements for the INTEC Wastewater Reuse Permit Monitoring Programs
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 Documents
SPR = Sampling Procedure
TPR = Technical Procedure

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
- QA Implementation Plan, which provides requirements, responsibilities, and authority for implementing the Stoller NQA-1 2008 QA Program under a graded and tailored approach to all work activities
- *ESER Quality Assurance Project Plan for the INL Offsite Environmental Surveillance Program*, which provides additional QA requirements for monitoring activities.

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 et al. 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.

Table 11-9. ESER Program Documentation.

Document/ MediaType	Document No.[a] and Title
Program Description	DOE/ID-11088 Revision 4, Idaho National Laboratory Site Environmental Monitoring Plan
Document Management	QAP-1 Revision 1, Preparation, Review, and Approval of ESER Procedures QAP-2 Revision 1, Document Control QAP-3 Revision 1, Information Management
Field Sampling Procedures	ESP-1.1, Low-Vol Sampler Revision 5 ESP-1.2, EPA Hi-Vol Air Sampling Revision 1 ESP-1.4, Precipitation Sampling, Revision 2 ESP-1.5, Atmospheric Moisture Sampling, Revision 3 ESP-1.6, Environmental Radiation Measurement, Revision 3 ESP-1.9, Jackson WY Low-Vol Air Sampler Revision 2 ESP 2.1, Drinking Water Sampling, Revision 3 ESP 2.2, Soil Sampling, Revision 4 ESP 3.1, Milk Sampling, Revision 4 ESP 3.2, Lettuce Sampling, Revision 3 ESP 3.3, Wheat Sampling, Revision 2 ESP 3.4, Potato Sampling, Revision 2 ESP 3.5, Large Game Animal, Revision 2 ESP 3.7, Bird Collection for Scientific Purposes, Revision 2 ESP 3.8, Alfalfa Sampling, Revision 1 ESP 4.1, Use of Lab Balances, Revision 1 ESP 4.2, Sample Handling and Custody, Revision 3 ESP 4.3, Sample Delivery for Analysis, Revision 3 ESP 4.6, R-275 Series Gas Flowmeter Equipment, Revision 2 ESP 4.8, Sample Retention, Revision 2
Data Analysis and Reporting	Statistical Methods Used in the Idaho National Laboratory Site Environmental Report, http://www.idahoeser.com/Annuals/2014/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

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.

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 *Environmental Radiological Effluent Monitoring and Environmental Surveillance, DOE Handbook* (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.

11.5 Duplicate Sampling Among Organizations

The ESER contractor, INL contractor, and the DEQ-INL Oversight Program (DEQ-INL OP) collects air samples at four common sampling locations: the distant locations of Craters of the Moon National Monument and Idaho Falls and on the INL Site at the Experimental Field Station and Van Buren Boulevard Gate. Results for 2014 are compared in the DEQ-INL OP Annual Report for 2014, available at www.deq.idaho.gov/media/60177317/inl-oversight-annual-report-2014.pdf. The Annual Report for 2015 has not been issued at this time. DEQ-INL OP also uses a network of passive electret ionization chambers (EICs) 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 EICs at locations monitored by DOE contractors, using TLDs (thermoluminescent dosimeters) and OSLDs (optically stimulated luminescent dosimeters). Comparisons of results may be found in the 2014 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 2014.

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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.
- 40 CFR 112, 2014, "Oil Pollution Prevention," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 122, 2015, "EPA Administered Permit Programs: the National Pollutant Discharge Elimination System," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 141, 2014, "National Primary Drinking Water Regulations," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 142, 2014, "National Primary Drinking Water Regulations Implementation," *Code of Federal Regulations*, Office of the Federal Register.
- 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 2, U.S. Department of Energy
- DOE Order 435.1, 2001, "Radioactive Waste Management," Change 2, 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," 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."
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- 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"
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- Executive Order 13423, 2007, "Strengthening Federal Environmental, Energy, and Transportation Management"
- Executive Order 13514, 2009, "Federal Leadership in Environmental, Energy, and Economic Performance"
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- 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)	(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]	3.4×10^{-14}	1.7×10^{-7}	Antimony-125	3.1×10^{-10}	2.7×10^{-5}
Gross Beta[c]	2.5×10^{-11}	1.1×10^{-6}	Iodine-129[f]	3.8×10^{-10}	3.3×10^{-7}
Tritium (tritiated water)	2.1×10^{-7}	1.9×10^{-3}	Iodine-131[f]	2.3×10^{-9}	1.3×10^{-6}
Carbon-14	6.6×10^{-10}	6.2×10^{-5}	Iodine-132[f]	3.0×10^{-8}	9.8×10^{-5}
Sodium-24	7.0×10^{-9}	7.2×10^{-5}	Iodine-133[f]	7.2×10^{-9}	6.0×10^{-6}
Argon-41[d]	1.4×10^{-8}	—	Iodine-135[f]	1.6×10^{-8}	3.0×10^{-5}
Chromium-51	9.4×10^{-8}	7.9×10^{-4}	Xenon-131m[d]	2.4×10^{-6}	—
Manganese-54	1.1×10^{-9}	4.4×10^{-5}	Xenon-133[d]	6.3×10^{-7}	—
Cobalt-58	1.7×10^{-9}	3.9×10^{-5}	Xenon-133m[d]	6.6×10^{-7}	—
Cobalt-60	1.2×10^{-10}	7.2×10^{-6}	Xenon-135[d]	7.8×10^{-8}	—
Zinc-65	1.6×10^{-9}	8.3×10^{-6}	Xenon-135m[d]	4.5×10^{-8}	—
Krypton-85[d]	3.6×10^{-6}	—	Xenon-138[d]	1.6×10^{-8}	—
Krypton-85m[d,e]	1.3×10^{-7}	—	Cesium-134	1.8×10^{-10}	2.1×10^{-6}
Krypton-87[d]	2.2×10^{-8}	—	Cesium-137	9.8×10^{-11}	3.0×10^{-6}
Krypton-88[d]	8.8×10^{-9}	—	Cesium-138	7.5×10^{-8}	3.1×10^{-4}
Rubidium-88[d]	1.2×10^{-8}	3.2×10^{-4}	Barium-139	5.8×10^{-8}	2.4×10^{-4}
Rubidium-89[d]	1.5×10^{-9}	6.6×10^{-4}	Barium-140	6.2×10^{-10}	1.1×10^{-5}
Strontium-89	4.6×10^{-10}	1.1×10^{-5}	Cerium-141	9.9×10^{-10}	4×10^{-5}
Strontium-90	2.5×10^{-11}	1.1×10^{-6}	Cerium-144	7.1×10^{-11}	5.5×10^{-6}
Yttrium-91m	3.1×10^{-7}	2.7×10^{-3}	Plutonium-238	3.7×10^{-14}	1.5×10^{-7}
Zirconium-95	6.3×10^{-10}	3.1×10^{-5}	Plutonium-239	3.4×10^{-14}	1.4×10^{-7}
Technetium-99m	1.7×10^{-7}	1.4×10^{-3}	Plutonium-240	3.4×10^{-14}	1.4×10^{-7}
Ruthenium-103	1.3×10^{-9}	4.2×10^{-5}	Plutonium-241	1.8×10^{-12}	7.6×10^{-6}
Ruthenium-106	5.6×10^{-11}	4.1×10^{-6}	Americium-241	4.1×10^{-14}	1.7×10^{-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}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 DCG 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 Levels	Groundwater Quality Standards
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 Levels (mg/L)	Groundwater Quality Standards (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 Levels (mg/L)	Groundwater Quality Standards (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-D	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 Standards[a]	Groundwater Quality Standards
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 threshold odor number	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

INL cultural resources are numerous and represent at least 13,000 years of human land use on the northeastern Snake River Plain. They include:

- prehistoric archaeological sites such as Aviators Cave, which is listed on the National Register of Historic Places
- historic archaeological sites and trails such as Goodale's Cutoff, a northern spur of the Oregon Trail
- important historic World War II and post-war sites such as the B-24 bomber crash, which has been selected to serve as an example of the impact and value of federal archaeology in the State of Idaho in celebration of the 50th anniversary of the National Historic Preservation Act
- pioneering nuclear facilities like Experimental Breeder Reactor-I, which was the first reactor in the world to produce usable electrical power and is recognized as a National Historic Landmark
- places and resources of importance to the Shoshone-Bannock Tribes
- a myriad of original historical data such as 1949 aerial photographs, as-built engineering and architectural drawings, maps, early technical reports, and oral histories.

Protection and preservation of cultural resources under the jurisdiction of federal agencies, including DOE, are mandated by a number of federal laws and their implementing regulations. Primary among them are the:

- National Historic Preservation Act (NHPA) of 1966, as amended – requires federal agencies to establish programs to locate, evaluate, and nominate to the National Register of Historic Places, historic properties under their jurisdiction and to do so in consultation with State Historic Preservation Offices (SHPO), Tribes, and stakeholders and to invite the Advisory Council on Historic Preservation to participate in the consultation. Federal agencies must establish programs to inventory and appropriately manage historic properties located on their lands (Section 110), take into account the effects of their undertakings on them, including mitigation when necessary (Section 106), involve Tribes, SHPOs, the Advisory Council on Historic Preservation (Advisory Council), and stakeholders in decisions; inform and educate the public about the resources, and maintain artifact collections and archival materials at professional standards. The Act also requires that this work and persons who complete this work meet certain professional standards. Implementing regulations are found at 36 CFR Part 800.
- National Environmental Policy Act (NEPA) of 1969, as amended – outlines the federal policy of general environmental protection and requires the use of natural and social sciences in planning and decision-making processes with regard to project impacts on the environment including historical, cultural, and natural resources that are important to national heritage.
- Archaeological Resource Protection Act (ARPA) of 1979, as amended – establishes permit requirements and civil and criminal penalties for unauthorized excavation, removal, damage, alterations, defacement, sale, purchase, exchange, transport, receipt of, or offer for sale of any archaeological resource that is more than 100 years old and that is located on federal or tribal lands. It fosters increased cooperation and exchange of information between governmental authorities, the professional archaeological community, and private individuals in the execution of these duties. The Secretary of Interior is directed to submit an annual report to Congress that summarizes the federal archaeology program and results. Implementing regulations are found at 43 CFR Part 7.
- American Indian Religious Freedom Act (AIRFA) of 1978 – prompts federal agencies to avoid interfering with access to sacred locations and traditional resources and to consult with interested Tribes to aid in the protection and preservation of cultural and spiritual traditions and sites.
- DOE Policy DOE P 141.1 - ensures that DOE programs integrate cultural resources management into their missions and activities and raises the level of awareness and accountability among DOE contractors concerning the importance of cultural resource related legal and trust responsibilities.

Many INL cultural resources remain protected and undisturbed as a result of the INL area's closure to the general public beginning in 1942, and an active, comprehensive cultural resource management program. Through contract, DOE-ID has tasked BEA's Cultural Resource Management Office (CRMO) with implementation of the program. The comprehensive INL Cultural Resource Management Plan (DOE-ID 2016) provides a tailored approach to comply with legal mandates and implements DOE cultural resource policies and goals, while meeting the unique needs of the INL. The Plan is legitimized through a 2004 Programmatic Agreement, *Concerning Management of Cultural Resources on the INL Site* (DOE-ID 2004), between DOE-ID, the Advisory Council on Historic Preservation, and the Idaho State Historic Preservation Office. DOE-ID's *Agreement in Principle* (DOE-ID 2012) with the Shoshone-Bannock Tribes is another important component of the overall approach to management of cultural resources at the INL Site.

Cultural resource management at the INL is structured to comply with a long list of Statutes, Executive Orders, and regulations identified in Table B-1, below.

In response to these legal mandates, DOE has issued department-wide guidance. This includes DOE Order 436.1, "Departmental Sustainability," which outlines requirements to develop and maintain "policies and directives for environmental protection, including the conservation and preservation of natural and cultural resources." DOE Policy 141.1, "Management of Cultural Resources," provides additional guidance for integrating cultural resource management into DOE and contractor missions and activities and raising the level of awareness and accountability concerning the importance of the Department's cultural resource-related legal and trust responsibilities. To incorporate Native American concerns into DOE activities and policy, DOE Order 144.1, "American Indian Tribal Government Interactions and Policy," communicates departmental, programmatic, and field office responsibilities for interacting with American Indian governments. Together these directives help to ensure that DOE maintains a program that reflects the spirit and intent of the legislative mandates.

DOE-ID has developed a broad program to structure INL compliance with the federal, state, and departmental requirements for cultural resource management. The cornerstone of the INL approach is the Idaho National Laboratory Cultural Resource Management Plan (DOE-ID 2016). This comprehensive plan was written specifically for INL Site resources and activities. It provides a tailored approach to comply with the legal mandates and to implement DOE-ID cultural resource policies and goals while meeting the unique needs of the INL. The Plan is reviewed annually, updated as needed, and is legitimized by the following foundational agreements between DOE-ID and other parties:

- 1994 *Memorandum of Agreement* [Middle Butte Cave – Table B-1], between DOE-ID and the Shoshone-Bannock Tribes (DOE-ID 1994)
- 1996 *Memorandum of Understanding for Curatorial Services*, between DOE-ID and the Idaho Museum of Natural History (DOE-ID 1996)
- 2004 *Programmatic Agreement Concerning Management of Cultural Resources on the INL Site*, between DOE-ID, the Advisory Council on Historic Preservation, and the Idaho State Historic Preservation Office (DOE-ID 2004)
- 2012 *Agreement in Principle*, between DOE-ID and the Shoshone-Bannock Tribes (DOE-ID 2012).

The INL Cultural Resource Management Office (CRMO) resides within DOE-ID's INL Management and Operations Contractor, Battelle Energy Alliance (BEA). Cultural resource professionals within the INL CRMO coordinate cultural resource-related activities at INL 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 BEA and other INL Site contractors and in company procedures that guide work completion. A summary of activities performed by the INL CRMO to implement the INL Cultural Resource Management Plan is provided in Table B-2.

B.1 INL Cultural Resource Project Reviews

The INL is an active facility where thousands of work orders for projects ranging from lawn care to new facility construction are processed each year. The *INL Cultural Resource Management Plan* (DOE-ID 2016) contains an approach for assessing and, when necessary, mitigating adverse impacts to cultural resources as a consequence of all activities large or small (NHPA Section 106). Under INL procedures, a cultural resource review is prompted whenever ground disturbance or major structural or landscape modifications are proposed.

Table B-1. Statutes, Executive Orders, and Regulations Pertinent to Cultural Resource Management on the INL.

Federal Statutes	• Antiquities Act of 1906 • Federal Records Act of 1950 • National Historic Preservation Act (NHPA) of 1966, as amended • National Environmental Policy Act (NEPA) of 1969 • Archaeological and Historic Preservation Act of 1974 • American Indian Religious Freedom Act (AIRFA) of 1978 • Archaeological Resources Protection Act (ARPA) of 1979, as amended • Federal Cave Resources Protection Act of 1988 • Native American Graves Protection and Repatriation Act (NAGPRA) of 1990 • Paleontological Resources Preservation Act of 2009
State Statutes	• Idaho Code, Chapter 41: Idaho Historic Preservation Act • Idaho Code, Chapter 70: Burial Act and Idaho Cave Protection Act • Idaho Code, Chapter 5: Protection of Graves
Executive Directives	• Executive Order 11593, Protection and Enhancement of the Cultural Environment (1971) • Executive Memoranda, regarding Government-to-Government Consultation with Native American Tribal Governments (1994; 2004; 2009) • Executive Order 13007, Indian Sacred Sites (1996) • Executive Order 13175, Consultation and Coordination with Indian Tribal Governments (2000) • Executive Order 13287, Preserve America (2003) • Executive Memorandum of Understanding: Interagency Coordination and Collaboration for the Protection of Indian Sacred Sites (2012)
Regulations	• 10 CFR part 1021: National Environmental Policy Act • 36 CFR part 60: National Register of Historic Places • 36 CFR part 63: Determinations of Eligibility for Inclusion in the National Register of Historic Places • 36 CFR part 65: National Historic Landmarks Program • 36 CFR part 67: Standards for Rehabilitation • 36 CFR part 68: Standards for the Treatment of Historic Properties • 36 CFR part 78: Waiver of Federal Responsibilities under Section 110 of the NHPA • 36 CFR part 79: Curation of Federally-Owned and Administered Archaeological Collections • 36 CFR part 800: Protection of Historic Properties • 36 CFR part 1220: National Archives and Records Administration • 43 CFR part 3: Protection of American Antiquities • 43 CFR part 7: Protection of Archaeological Resources • 43 CFR part 10: Native American Graves Protection and Repatriation Regulations

Table B-2. Metrics for Implementation of the *INL Cultural Resource Management Plan* (DOE-ID 2016).

Primary Drivers	Implementation	Timeframe	Status
Antiquities Act NHPA NEPA AIRFA ARPA Idaho Code E.O. 11593 E.O. 13007 E.O. 13287 43 CFR part 3 43 CFR part 7 36 CFR part 60 36 CFR part 63 36 CFR part 79 36 CFR part 800 INL PA Tribal AIP MOU Curation	CDRL F.45, Federal Archaeology Program Report to Congress	Annually 15 Feb	Submitted 15 Feb 2016
	CDRL F.46, Protection of Key Archaeological and Historic Architectural Properties (INL Cultural Resources Monitoring Report) • Field monitoring of 49 INL cultural resources in 2015 with assistance from Shoshone-Bannock tribal representatives	Annually 31 Oct	Submitted 31 Oct 2015
	CDRL F.47, INL Cultural Resource Management Plan (update)	Annually 01 Mar	No update required for 2015
	CDRL F.48, National Register of Historic Places (NRHP) Nomination Packages	As identified	None identified for 2015
	Ensure cultural resource work is conducted by qualified personnel • INL CRM team includes archaeologists, historians, and archivist that meet professional qualification standards	Ongoing	Ongoing
	Ensure information concerning the nature and location of sensitive cultural resources is protected	Annually Ongoing	Ongoing
	Conduct employee cultural resource awareness and protection training • INL Sitewide access training • Targeted training for INL employees (~200 individuals in 2015) • Civil ARPA charges against INL employee in 2015	Annually Ongoing	Complete for 2015

Table B-2. Metrics for Implementation of the *INL Cultural Resource Management Plan* (DOE-ID 2016). (cont.)

Primary Drivers	Implementation	Timeframe	Status
NHPA - Section 106 NEPA ARPA AIRFA E.O. 13175 E.O. 13287	Project-based cultural resource survey, research, review, and consultation for INL projects • 31 archaeological reviews in 2015 • 50 historic building/structure reviews in 2015 • HALS for Arco Naval Proving Ground and WW II submitted to U.S. Library of Congress in 2015	Annually Ongoing	Complete for 2015
36 CFR part 800 36 CFR part 63 36 CFR part 67 36 CFR part 68	Cultural Resource Working Group (CRWG), meetings between Shoshone-Bannock Heritage Tribal Office (HeTO), DOE-ID, INL CRMO, and INL project managers as appropriate • 6 meetings in 2015	Monthly Ongoing	Complete for 2015
DOE O 144.1 DOE P 141.1 INL PA Tribal AIP Cave MOU	Tribal participation in monitoring and survey of cultural resources associated with tribal heritage • Multiple field visits in 2015 • Tour of INL Smartgrid project in 2015	Annually Ongoing	Complete for 2015
NHPA – Section 106 Federal Records Act	Maintain INL Archives and Special Collections	Ongoing	Ongoing
36 CFR part 79 36 CFR part 1220+	Maintain records of INL cultural resource investigations and INL sitewide resource maps and databases	Ongoing	Ongoing
INL PA	Oversight of permanent professional curation of DOE-ID artifacts and documentation • Repository surveillance, April 2015	Annually Ongoing	Complete for 2015
NHPA - Section 110 Antiquities Act ARPA E.O. 11593 36 CFR part 78 36 CFR part 800	Conduct research to promote understanding of all INL cultural resources and support development of INL-wide historic contexts and research designs • Second Owsley Irrigation initial survey in 2015 • Pleistocene Lake Terreton shoreline mapping and dating project in 2015 • Lemhi Point obsidian source investigation in 2015	Annually Ongoing	Complete for 2015

Table B-2. Metrics for Implementation of the *INL Cultural Resource Management Plan* (DOE-ID 2016). (cont.)

Primary Drivers	Implementation	Timeframe	Status
DOE P 141.1	Establish cooperative relationships with cultural resource management professionals, University personnel, the public, and other INL stakeholders • National Park Service • Idaho SHPO • Middlebury College • Weber State University • Project Remembrance	Annually Ongoing	Ongoing
	Conduct public outreach and education • 9 Presentations to local schools and civic groups in 2015 • One summer internship project in 2015 • B-24 bomber crash – 2015 Making Archaeology Public Project (MAPP) video for 50-year anniversary of NHPA	Annually Ongoing	Complete for 2015
ARPA 43 CFR part 7	Oversee permits for INL cultural resource investigations for DOE-ID	Annually Ongoing	No active permits in 2015
	Cooperation and exchange of information between the INL CRMO, government agencies, and the archaeological community • Bureau of Land Management • Register of Professional Archaeologists • Academy of Certified Archivists • Society for American Archaeology • Idaho Professional Archaeological Council • Idaho Archaeological Society	Ongoing	Ongoing

Cultural resource identification and evaluation studies in 2015 were many and varied, including archaeological field surveys related to INL project activities (i.e., ground disturbance and building modifications) as well as broader research goals, archival and historic research, routine monitoring of sensitive resources and ground disturbance associated with active INL projects, and meaningful interaction with members of the Shoshone-Bannock Tribes (Figure B-1) 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 two basic types of survey: those related to INL project reviews (NHPA Section 106: 31 archaeological reviews and 50 historic architectural reviews) and those related to INL CRM Office research interests (NHPA Section 110: 5 projects). Field studies to support these projects totaled 19 throughout the year.

In 2015, 31 INL project reviews were completed to assess potential impacts to archaeological resources per the general requirements of Section 106 of the NHPA.

Figure B-1. Shoshone-Bannock Tribal Tour of Middle Butte Cave Area.

Field investigations were completed for 13 of these proposed projects and 114 acres that had never been surveyed for cultural resources were examined. 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. Four of the proposed INL projects in 2015 were located in areas at the INL Site that had been previously surveyed for cultural resources. Per the guidelines of the *INL Cultural Resource Management Plan* (DOE-ID 2016), approximately 302 acres of these previously surveyed areas were re-examined in 2015 because the original surveys were completed more than 10 years ago. Project surveys totaling approximately one acre were located at INL facilities in the City of Idaho Falls. Project-related surveys in 2015 resulted in the documentation of 29 previously unknown archaeological resources and reassessment of 15 previously recorded resources. All of these resources were recommended for avoidance or other protective measures during project implementation and none were adversely impacted by project activities in 2015. Cumulatively, the total number of acres surveyed for archaeological resources on the INL Site increased to 55,793 with the addition of these surveys (approximately 10 percent of the 890 square mile laboratory) and the total number of known archaeological resources remained at 2,806. Table B-3 provides a summary of the cultural resource reviews performed in 2015.

Cultural resource reviews of projects that had the potential to impact INL historic architectural properties were also completed for 50 proposed activities in 2015 (Table B-3). Most of these projects involved activities such as routine maintenance, internal equipment repair/replacement, and in kind replacement, which have been determined categorically to pose no significant threats to historic properties. At the ATR Complex, where the National Register-eligible Advanced Test Reactor is located, several projects were reviewed for activities such as repair/replacement of circuit breakers, fire systems, and other equipment. Numerous projects were also proposed at MFC facilities, due in part to preparation for re-starting the TREAT reactor, as well as routine maintenance and repair of electrical, plumbing, fire system upgrades, and other activities categorically exempt from cultural resource concerns under the *INL Cultural Resource Management Plan* (DOE-ID 2016).

Information gathered during INL cultural resource investigations and reviews is managed as a valuable archive of INL cultural resources and a record of decision-making related to cultural resource compliance and ongoing resource and land management. These hard copy and electronic data provide the foundation for archaeological predictive modeling efforts that facilitate land use planning in both the long- and short-term and serve important roles in local and regional archaeological research. Important documents related to the historical development of the INL Site, the ground-breaking sci-

Table B-3. Cultural Resource Reviews Performed at the INL Site (2015).

Project #	Project Name	INL CRM Activities	Acres Surveyed	Cultural Resources Identified
BEA-15-01	Blackfoot Parking Lot Improvements	Environmental Checklist review, field survey, and documentation	0.5	None
BEA-15-02	National and Homeland Security Fiber Optic Installation	Environmental Checklist review, archive check, field survey, and documentation	20	1 prehistoric site
BEA-15-03	T-5 Road Grading	Archive check, field investigation of unauthorized ground disturbance, documentation, and employee awareness training	10	1 prehistoric site, 1 prehistoric isolate, historic trail
BEA-15-04	Remote Handled Low Level Waste Facility Utility Exploration/Drilling	Environmental Checklist review, archive check, and documentation	0	None
BEA-15-05	Temperature/ Humidity Loggers in INL Caves	Environmental Checklist review, monitoring of installation, and documentation	0	None
BEA-15-06	Transformer Changeouts	Environmental Checklist review, archive check, monitoring of ground disturbance, and documentation	0	None
BEA-15-07	Land-Mobile Radio Towers and Developments	Environmental Checklist review, archive check, and documentation	0	None
BEA-15-08	Gravel Pit Expansion (T-12)	Environmental Checklist review, archive check, field check, and documentation	1	None
BEA-15-09	Sagebrush Planting	Environmental Checklist review, archive check, monitoring of ground disturbance, and documentation	0	None
BEA-15-10	Bat Hibernacula Surveys	Environmental Checklist review, monitoring of surveys, and documentation	0	None
BEA-15-11	Iona Hill Facility Road Improvements	Environmental Checklist review, archive check, and documentation	0	None
BEA-15-12	Central Facilities Area (CFA) Sewer Plant Modifications	Environmental Checklist review, archive check, and documentation	0	None
BEA-15-13	Materials and Fuels Complex (MFC) Fiber Optic Line	Environmental Checklist review, archive check, field survey, and documentation	20	None
BEA-15-14	CFA Main Firing Range Fiber Optic Line	Environmental Checklist review, archive check, field survey, and documentation	11	1 historic WW II trash dump
BEA-15-15	Cleanup Contractor Misc. Small Projects	Environmental Checklist reviews, archive check, and documentation	0	None
BEA-15-16	INL Power Management Routine Maintenance	Environmental Checklist review, archive check, field check, and documentation	5	None

Table B-3. Cultural Resource Reviews Performed at the INL Site (2015). (cont.)

Project #	Project Name	INL CRM Activities	Acres Surveyed	Cultural Resources Identified
BEA-15-17	Building PBF-622 Moran Project Modifications	Environmental Checklist review, archive check, and documentation	0	None
BEA-15-18	Filmore Facility Fire Protection	Environmental Checklist review, archive check, and documentation	0	None
BEA-15-19	Chainsaw Training	Environmental Checklist review, archive check, and documentation	0	None
BEA-15-20	Power Grid Testing 2015	Environmental Checklist reviews, archive check, and documentation	0	None
BEA-15-21	Wireless Testing 2015	Environmental Checklist reviews, archive check, and documentation	0	None
BEA-15-22	Gun Range Enhancements	Environmental Checklist review, archive check, field check, and documentation	1	None
BEA-15-23	Road Sign Removal	Environmental Checklist review, archive check, and documentation	0	None
BEA-15-24	Misc. Projects in Idaho Falls (Process Demonstration Unit storage structure, INL Research Complex (IRC) road maintenance, IRC parking, IRC fuel depot)	Environmental Checklist review, archive check, field survey, and documentation	0.5	None
BEA-15-25	INL Power Grid Test Bed Enhancements (SmartGrid)	Environmental Checklist review, archive check, field check, field survey, and documentation	325	27 known and new prehistoric resources
BEA-15-26	TAN Fiber Optic Connection	Environmental Checklist review, archive check, field survey, and documentation	6	1 prehistoric isolate
BEA-15-27	U.S. Geological Survey Well 143	Environmental Checklist review, archive check, field survey, and documentation	1	1 prehistoric site
BEA-15-28	Advanced Test Reactor Complex Pond Remediation	Environmental Checklist review, archive check, and documentation	0	None
BEA-15-29	Section 110 Surveys (Birch Creek Site, Lake Terreton, Lemhi Point, Second Owsley, B-24 crash)	Field investigations	0	2 prehistoric sites and 20 historic sites
BEA-15-30	Annual Cultural Resource Monitoring	Field investigation of 49 known cultural resources	0	None
BEA-15-31	Railroad Mowing and Road Maintenance	Environmental Checklist review, archive check, and documentation	0	None
15-001-JW	MFC-752, fire sprinkler system modifications	exempt activity	N/A	MFC-752
15-002-JW	MFC-765, Elevator Upgrade	exempt activity	N/A	MFC-765
15-003-JW	MFC-720/TREAT Reactivation, experimenter room	exempt activity	N/A	MFC-720
15-004-JW	MFC-768, Fire Sprinkler	exempt activity	N/A	MFC-768

Table B-3. Cultural Resource Reviews Performed at the INL Site (2015). (cont.)

Project #	Project Name	INL CRM Activities	Acres Surveyed	Cultural Resources Identified
	System Upgrade			
15-005-JW	TRA-670, sewer system repair	exempt activity	N/A	TRA-670
15-006-JW	MFC-776/ZPPR, Roof Repair/Replacement, test materials	project altered, materials tested at different location – no adverse effect	N/A	MFC-776/ ZPPR
15-007-JW	MFC-752, Fire Suppression System	exempt activity	N/A	MFC-752
15-008-JW	MFC-752, AL Water System Upgrade	exempt activity	N/A	MFC-752
15-009-JW	TRA-670, pressurizer seismic upgrades	exempt activity	N/A	TRA-670
15-010-JW	MFC-752, AL HVAC upgrade	exempt activity	N/A	MFC-752
15-011-JW	Emergency communications, land mobile radio	exempt activity	N/A	various
15-012-JW	TRA-670, motor control center replacement	exempt activity	N/A	TRA-670
15-013-JW	MFC-765, Elevator Upgrade	exempt activity	N/A	MFC-765
15-014-JW	TRA-616 and TRA-620, floating floor installation	mitigation completed (digital photographs)	N/A	TRA-616 TRA-620
15-015-JW	MFC-765, roof replacement	in kind materials and design; no adverse effect	N/A	MFC-765
15-H001	PBF-613 and ARA-632, electrical upgrades	exempt activity	N/A	PBF-613 ARA-632
15-H002	ATR Complex Air Conditioner Upgrades	exempt activity	N/A	ATR/various
15-H003	ATR-670, control panel replacement	exempt activity	N/A	ATR-670
15-H004	ATR/TRA-774 Substation Switchgear Upgrades	exempt activity	N/A	TRA-774
15-H005	TRA-605, PLC replacement	exempt activity	N/A	TRA-605
15-H006	ATR/TRA-670 Second Basement Fire Sprinkler System Pressure Rating Upgrade	exempt activity	N/A	TRA-670
15-H007	ATR/TRA-670 LOOP 2D-SW Inpile Tube Replacement	exempt activity	N/A	TRA-670
15-H008	ATR/TRA-670 Locker replacement	exempt activity	N/A	TRA-670
15-H009	CPP-666 and CPP-659, modifications to support sodium distillation and waste repackaging	exempt activities	N/A	CPP-666 CPP-659
15-H010	TRA-609, switchgear replacement, roll-up door	exempt activity	N/A	TRA-609

Table B-3. Cultural Resource Reviews Performed at the INL Site (2015). (cont.)

Project #	Project Name	INL CRM Activities	Acres Surveyed	Cultural Resources Identified
	installation, and diesel removal			
15-H011	ATR, primary coolant heat exchangers, pilot tube isolation valve upgrade	exempt activity	N/A	TRA-670
15-H012	TRA, manhole cover replacement	exempt activity	N/A	TRA/various
15-H013	MFC/HFEF, hot water tank replacement	exempt activity	N/A	MFC-785
15-H014	ATR/TRA-671, lower jet piping repair	exempt activity	N/A	TRA-671
15-H015	ATR/TRA-670, replacement of chemistry monitoring unit and modification of existing piping and components	exempt activity	N/A	TRA-670
15-H016	MFC-772, EDL graphite furnace glovebox	exempt activity	N/A	MFC-772
15-H017	ATR/TRA-670, removal of OOS equipment and installation of HEPA filter in pump test room	mitigation completed (digital photography)	N/A	TRA-670
15-H018	MFC-752, main stack modifications and sample probe placement	contact CRMO prior to beginning work	N/A	MFC-752
15-H019	ATR, complex-wide street light replacement	mitigation completed (digital photography)	N/A	ATR/various
15-H020	ATR, crane rated capacity upgrade	exempt activity	N/A	TRA-670
15-H021	MFC-785/HFEF, monorail support system upgrade	exempt activity	N/A	MFC-785
15-H022	INL Routine Maintenance Activities, overarching EC	exempt activity	N/A	various
15-H023	ATR Cold Waste Tank Vessel Replacement	exempt activity	N/A	TRA-670
15-H024	MFC-752, casting lab glovebox heat detection	exempt activity	N/A	MFC-752
15-H025	ATR/TRA-666, STAR emergency power upgrade	exempt activity	N/A	TRA-666
15-H026	IORC relocation	exempt property	N/A	none
15-H027	TRA-621, roof replacement	exempt property	N/A	none
15-H028	TRA-673, siren relocation	exempt activity	N/A	TRA-673
15-H029	ATR/TRA-670, sewer system repair	exempt activity	N/A	TRA-670
15-H030	PPS Battery Room Exhaust Fans, Replacement	exempt activity	N/A	TRA-670
15-H031	MFC-774 Central Alarm Station Remodel	exempt activity	N/A	MFC-774

Table B-3. Cultural Resource Reviews Performed at the INL Site (2015). (cont.)

Project #	Project Name	INL CRM Activities	Acres Surveyed	Cultural Resources Identified
15-H032	ATR/TRA-670, equipment storage cabinets, installation	exempt activity	N/A	TRA-670
15-H033	MFC-768F, removal	mitigation completed (digital photography)	N/A	MFC-768
15-H034	TRA-622, vessel replacement	exempt activity	N/A	TRA-622
15-H035	CPP-603, Large Cask Adaptability - eligible	contact CRMO prior to beginning work	N/A	CPP-603

entific research conducted throughout INL history, and inventories to identify historic properties associated with these activities are also preserved.

The results of project-specific cultural resource reviews are documented in a number of ways per the requirements outlined in the *INL Cultural Resource Management Plan* (DOE-ID 2016). Recommendations tailored to specific projects and any cultural resources that may require consideration are delivered in official e-mail notes that become part of the project's NEPA-driven Environmental Checklist and permanent record. For larger projects, technical reports are often prepared to synthesize cultural resource information and recommendations. The most ambitious report compiled in 2015 was the completion of the Historic American Landscape Survey (HALS) of buildings, structures, and landscape elements associated with the Arco Naval Proving Ground. This study was significant for the careful documentation of INL resources that manifest DOE complex-wide historical significance for their roles in aiding in the defense and eventual victory for Allied Forces in the Pacific Theater of World War II as well as significant contributions to the establishment of national standards for the safe storage and transport of conventional ordnance. The report, including both written historical narrative and extensive geospatial and photographic documentation, has been submitted to the U. S. National Park Service Heritage Documentation Program, housed in the U.S. Library of Congress to mitigate the losses from demolition. Two additional project-specific plans were also prepared in 2015:

- INL/EXT-15-36938: Cultural Resource Monitoring and Discovery Plan for the INL Power Grid Enhancement
- INL/EXT-15-35298: Cultural Resource Protection Plan for the Remote-Handled Low-Level Waste Facility.

As a final mechanism to ensure that cultural resources are not subject to unmitigated harm from INL activities, INL employees are authorized to stop work at all DOE-ID, contractor, and/or subcontractor operations if they believe the work poses an imminent danger to human health and safety, or the environment, including irreplaceable cultural resources. Procedures are in place to make immediate notifications to appropriate parties (INL CRMO, DOE-ID, Shoshone-Bannock Tribes, State of Idaho, local law enforcement) in the event of any discoveries of this nature. Additionally, areas that have previously revealed unanticipated discoveries of sensitive cultural materials are routinely monitored for new finds. No cultural materials were unexpectedly discovered at the INL Site in 2015.

B.2 INL Cultural Resource Research

INL cultural resource investigations in 2015, were also conducted to further DOE-ID obligations under Section 110 of the NHPA to develop a broad understanding of all INL Site cultural resources, not only those located in active project areas. The 2015 NHPA Section 110 field projects were focused on historic homesteads and irrigation features associated with the Second Owsley Project, an early 20th Century Carey Land Act irrigation development, at volcanic glass outcrops located on Lemhi Point, in the mouth of the Birch Creek Valley, around the margin of Pleistocene Lake Terreton, and at the B-24 bomber crash site. In keeping with INL CRM Office goals under outreach and education, all of these efforts involved students, University researchers, professional colleagues, and/or public stakeholders in the recording of 22 archaeological resources and revisits to several previously recorded resources. All of these research projects are also ongoing into 2016.

Research and documentation of the historic landscape at INL continued in 2015 with an investigation of a historic irrigation project located near present day Mud Lake. The Second Owsley Project is one of two historic irrigation networks at the INL site constructed under the Carey Act of 1894, which outlined provisions for private irrigation companies, with the approval of the state, to apply for the withdrawal of arid lands from the federal government. Unfortunately, the Second Owsley Project was one of a number of projects across southern Idaho that failed to provide water to settlers and what remains today are structural and landscape features abandoned in the late 1920's. Systematic investigation of these historic features began in 2015 with identification using aerial imagery and subsequent field reconnaissance to confirm and document homesteads, field levees, ditches, and irrigation canals, laterals, and associated control structures (Figure B-2).

Fieldwork recorded 10 homesteads (see Figure B-3), with associated ditches and field levees, and archival research at the Idaho State Historical Society Archives in Boise, Jefferson County Records in Rigby, and the online database from the Bureau of Land Management (BLM) General Land Office (GLO) (www.glorecords.blm.gov) identified individuals associated with four of the 10 homesteads. Records of the Idaho Department of Reclamation from 1927 show individuals invested was significantly higher than the number of features recorded, with 145 homesteaders holding entries on the land only a year before the project was cancelled. Challenges faced by the Second Owsley Project prompted extensive investigation of the water supply as a combined effort between the state, U.S. GLO, and the U.S. Geological Service, greatly enhancing the understanding of the hydrology of Mud Lake and the surrounding area (Stearns et al. 1939)

Linear feature recording forms were developed to enable more detailed collection of data about irrigation features. All feature data was compiled in a GIS database and the locations of identified homesteads were analyzed in relation to the irrigation network, field structures, and

Figure B-2. Lateral 6 Looking Southeast to Gate Structure with Main Owsley Canal Running East-west on the Second Owsley Project.

Figure B-3. Basalt Foundation of Homestead Located in the Second Owsley Project. The Homestead is Surrounded by Foundations for Other Structures, Field Levees, and Ditches That Cover an Entire Public Land Survey System Section North of the Main Canal.

roads in an attempt to model relationships between these features. Known homestead locations ranked high in the model and application of a model to other historic settlement areas will be considered in future work. Knowledge of Carey Act irrigation and settlement gained through the investigation of the Second Owsley Project will contribute to the ongoing development of detailed historic contexts for the *INL Cultural Resource Management Plan* (DOE-ID 2016).

In 2015, a new partnership was created with Middlebury College, Vermont, to research Pleistocene Lake Terreton beach deposits. These sandy deposits have the potential to shed new light on the timing of Big Lost River flood events and subsequent evolution of Lake Terreton shorelines over the past 35,000 years (see Figure B-4). By combining classic geomorphology and state-of-the-art geochronological analyses (30 samples analyzed in 2015) with INL CRMO program knowledge of the archaeological record and INL Site, this partnership has the potential to make significant contributions to the understanding of regional paleoclimatic reconstruction as well as prehistoric human use of the lacustrine environment.

INL CRMO program staff also established a new cooperative relationship with Weber State University and scientists from the BLM in 2015 to characterize natural deposits of volcanic glass located at Lemhi Point on the INL Site that were important sources of raw material for prehistoric toolmakers. Analyses in 2015 involved baseline characterization of the chemical signature of the source material available in natural outcrops along the southernmost extension of the Lemhi Mountain Range as well as source characterization of a sample of artifacts from a prehistoric archaeological site located along the margin of Pleistocene Lake Terreton (Tables B-4 and B-5). This work promises to refine understanding of volcanic glass transport and procurement by prehistoric populations at a regional scale.

Analysis of INL volcanic glass source samples (n=12), collected from the southern Lemhi Mountain Range, was conducted by Arkush and Hughes (2015) us-

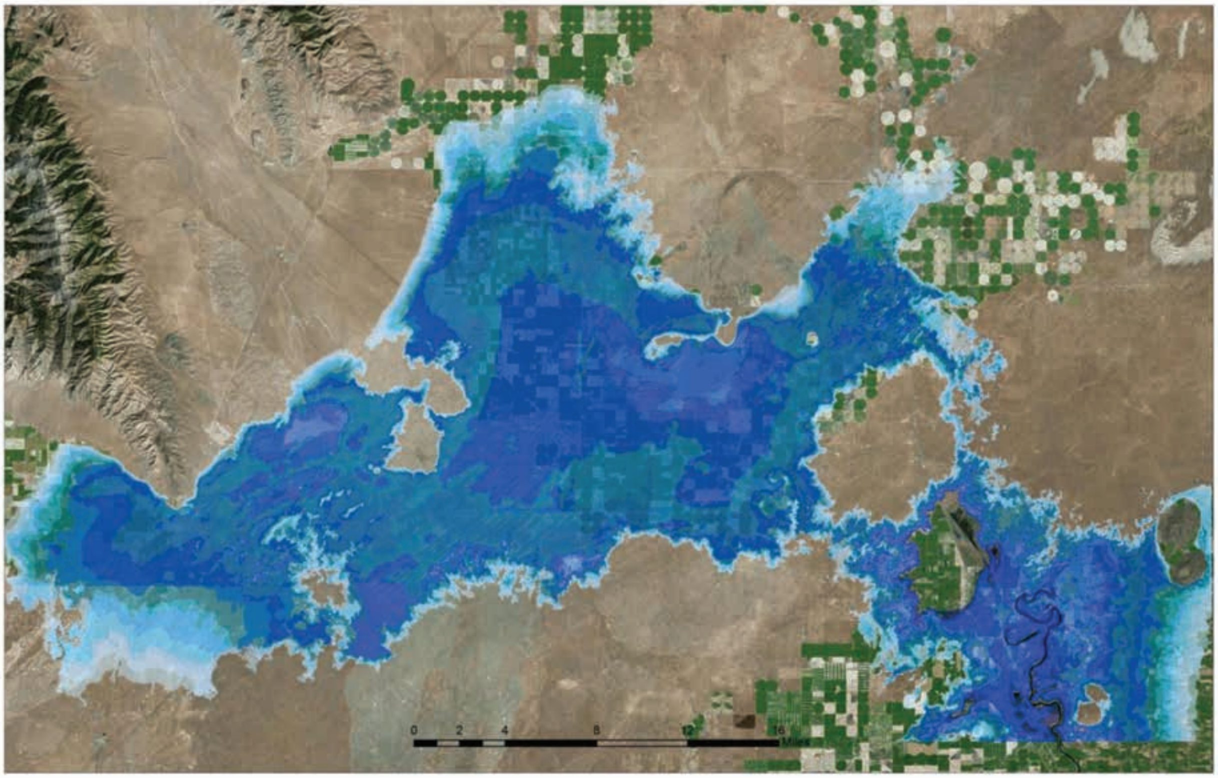

Figure B-4. Contour Map Showing Extent of Pleistocene Lake Terreton on the Northeastern Snake River Plain with Deepest Levels Shown in Dark Blue and Shallows Depicted in Lighter Shades of Blue.

ing energy dispersive x-ray fluorescence (EDXRF) and the results presented at the 2015 Society for American Archaeology Conference in Orlando, Florida. Characterization classified the INL Lemhi source material as Walcott Tuff (a.k.a. American Falls) chemical type (Table B-4), which has exposures on both the northern and southern extent of the eastern Snake River Plain (Arkush and Hughes 2015). The addition of the INL Lemhi source material to an already wide Walcott Tuff distribution presents a challenge for interpreting the acquisition and conveyance of source material on the Snake River Plain. As part of a wider study by the BLM Burley Field Office to examine potential chemical differentiation between the Walcott Tuff exposures, INL source material was sampled again in 2015 and analyzed using portable x-ray fluorescence (pXRF) (Pink 2015). Once again, the INL Lemhi source material, along with several other exposures analyzed, was classified as Walcott Tuff chemical type (Table B-4) and further work will be required in order to determine if separation of chemical signatures can be achieved for Walcott Tuff exposures and artifacts attributed to this source material (Pink 2015).

The chemical characterization of artifacts by nondestructive XRF was also conducted on a sample of artifacts from two archaeological sites at INL for assignment of source type (Table B-5). The artifacts were analyzed through a contract at the Geochemical Research Laboratory using EDXRF (Hughes 2014) and reanalyzed by pXRF at the BLM Burley Field Office to evaluate comparability of the source assignments (Pink 2015). Of the 50 artifacts analyzed for source classification only three (BEA-13-5-2-A, BEA-13-5-2-03, and BEA-13-110-01-39; Table B-5) differed in assigned source between the two labs (Pink 2015). One factor accounting for the reassignment is a difference in reference material available at each lab, which allows artifacts determined as "unknown" source by one lab to be assigned to a chemical type in another (Pink 2015). Across both studies artifacts are assigned to one of eight different sources and the Bear Gulch source, found to the northeast of the INL, dominates the artifact sample analyzed with approximately half the artifacts assigned to this chemical type in both studies (Hughes 2014; Pink 2015).

B.3 Cultural Resource Monitoring

The INL CRMO conducts yearly cultural resource monitoring that includes many sensitive archaeological, historic architectural, and tribal resources. Under

Table B-4. Chemical Type Characterization for Source Material from Lemhi Mountain Range at INL.

Sample Number	Sample Type	Source (Chemical Type) Arkush & Hughes (2015)	Source (Chemical Type) Pink (2015)
INL 14-1-1	Obsidian Source Sample	Walcott	N/A
INL 14-1-2	Obsidian Source Sample	Walcott	N/A
INL 14-1-3	Obsidian Source Sample	Walcott	N/A
INL 14-2-1	Obsidian Source Sample	Walcott	N/A
INL 14-2-2	Obsidian Source Sample	Walcott	N/A
INL 14-2-3	Obsidian Source Sample	Walcott	N/A
INL 14-3-1	Obsidian Source Sample	Walcott	N/A
INL 14-3-2	Obsidian Source Sample	Walcott	N/A
INL 14-3-3	Obsidian Source Sample	Walcott	N/A
INL 14-4-1	Obsidian Source Sample	Walcott	N/A
INL 14-4-2	Obsidian Source Sample	Walcott	N/A
INL 14-4-3	Obsidian Source Sample	Walcott	N/A
INL-Pink-02	Obsidian Source Sample	N/A	Walcott
INL-Pink-02	Obsidian Source Sample	N/A	Walcott
INL-Red-01	Obsidian Source Sample	N/A	Walcott
INL-Red-02	Obsidian Source Sample	N/A	Walcott
INL-Red-03	Obsidian Source Sample	N/A	Walcott
INL-Red-04	Obsidian Source Sample	N/A	Walcott
INL-Red-05	Obsidian Source Sample	N/A	Walcott
INL-Green-01	Obsidian Source Sample	N/A	Walcott
INL-Green-02	Obsidian Source Sample	N/A	Walcott
INL-Green-03	Obsidian Source Sample	N/A	Walcott
INL-Green-04	Obsidian Source Sample	N/A	Walcott
INL-Green-05	Obsidian Source Sample	N/A	Walcott
INL-Green-06	Obsidian Source Sample	N/A	Walcott
INL-Green-07	Obsidian Source Sample	N/A	Walcott
INL-Blue-01	Obsidian Source Sample	N/A	Walcott
INL-Blue-02	Obsidian Source Sample	N/A	Walcott
INL-Blue-03	Obsidian Source Sample	N/A	Walcott

Table B-5. Chemical Type Characterization for Artifacts from Two Archaeological Sites.

		Source (Chemical Type)	
Sample Number	Artifact Type	Hughes (2014)	Pink (2015)
BEA-13-110-01-001	Biface	Bear Gulch	Bear Gulch
BEA-13-110-01-002	Biface	Walcott	Walcott
BEA-13-110-01-003	Biface	Bear Gulch	Bear Gulch
BEA-13-110-01-004	Biface	Bear Gulch	Bear Gulch
BEA-13-110-01-005	Biface	Bear Gulch	Bear Gulch
BEA-13-110-01-006	Biface	Bear Gulch	Bear Gulch
BEA-13-110-01-007	Biface	Bear Gulch	Bear Gulch
BEA-13-110-01-008	Biface	Bear Gulch	Bear Gulch
BEA-13-110-01-009	Biface	Bear Gulch	Bear Gulch
BEA-13-110-01-010	Biface	Bear Gulch	Bear Gulch
BEA-13-110-01-011	Biface	Bear Gulch	Bear Gulch
BEA-13-110-01-012	Biface	Bear Gulch	Bear Gulch
BEA-13-110-01-013	Biface	Walcott	Walcott
BEA-13-110-01-014	Rosegate Corner-notched Arrow Point	Walcott	Walcott
BEA-13-110-01-015	Biface	Big Southern Butte	Big Southern Butte
BEA-13-110-01-016	Biface	Bear Gulch	Bear Gulch
BEA-13-110-01-017	Desert Side-notched Arrow Point	Malad	Malad
BEA-13-110-01-019	Biface	Bear Gulch	Bear Gulch
BEA-13-110-01-022	Biface	Bear Gulch	Bear Gulch
BEA-13-110-01-025	Lanceolate Spear Point	Malad	Malad
BEA-13-110-01-027	Biface	Bear Gulch	Bear Gulch
BEA-13-110-01-030	Elko Corner-notched Dart Point	Timber Butte	Timber Butte
BEA-13-110-01-033	Elko Corner-notched Dart Point	Walcott	Walcott
BEA-13-110-01-036	Biface	Bear Gulch	Bear Gulch
BEA-13-110-01-037	Cottonwood Triangular Arrow Point	Malad	Malad
BEA-13-110-01-038	Elko Corner-notched Dart Point	Big Southern Butte	Big Southern Butte
BEA-13-110-01-039	Biface	Walcott	Bear Gulch
BEA-13-110-01-042	Humboldt Lanceolate Dart Point	Big Southern Butte	Big Southern Butte
BEA-13-110-01-043	Cottonwood Triangular Arrow Point	Walcott	Walcott
BEA-13-110-01-045	Scraper	Bear Gulch	Bear Gulch
BEA-13-110-01-047	Biface	Big Southern Butte	Big Southern Butte
BEA-13-110-01-048a	Utilized Flake	Bear Gulch	Big Southern Butte
BEA-13-110-01-048	Biface	Bear Gulch	Bear Gulch
BEA-13-110-01-049	Biface	Bear Gulch	Bear Gulch

Table B-5. Chemical Type Characterization for Artifacts from Two Archaeological Sites. (cont.)

		Source (Chemical Type)	
Sample Number	**Artifact Type**	**Hughes (2014)**	**Pink (2015)**
BEA-13-110-01-050	Biface	Bear Gulch	Bear Gulch
BEA-13-110-01-051	Biface	Big Southern Butte	Bear Gulch
BEA-13-110-01-053	Humboldt Lanceolate Dart Point	Big Southern Butte	Big Southern Butte
BEA-13-110-01-055	Core	Walcott	BBB
BEA-13-110-01-058	Large Notched Dart Point	Big Southern Butte	Walcott
BEA-13-110-01-059	Core	Bear Gulch	BSB
BEA-13-110-01-061	Biface	Big Southern Butte	Bear Gulch
BEA-13-5-2-A	Elko Corner-notched Dart Point	Bear Gulch	Unknown
BEA-13-5-2-C	Biface (round)	Unknown	Bear Gulch
BEA-13-5-2-D	Bitterroot Side-notched Dart Point	Bear Gulch	Big Southern Butte
BEA-13-5-2-01	Haskett Spear Point	Walcott	Bear Gulch
BEA-13-5-2-03	Avonlea Side-notched Arrow Point	Big Southern Butte	Deadhorse Ridge
BEA-13-5-2-20	Avonlea Side-notched Arrow Point	Bear Gulch	Bear Gulch
BEA-13-5-2-30	Stemmed-Indented Base Dart Point	Chesterfield	Walcott
BEA-13-5-2-42	Besant Side-notched Dart Point	Bear Gulch	Big Southern Butte
BEA-13-5-2-47	Desert Side-notched Arrow Point	Big Southern Butte	Bear Gulch

this monitoring program, there are four possible findings, based on the level of disturbance noted:

- ***Type 1:*** no visible changes to a cultural resource [are noted] and/or a project is operating within the limits of cultural resource clearance recommendations
- ***Type 2:*** impacts are noted but do not threaten the integrity and National Register eligibility of a cultural resource and/or a project is operating outside of culturally cleared limitations
- ***Type 3:*** impacts are noted that threaten the integrity and National Register eligibility of a cultural resource and/or a project has been operating outside of culturally cleared limitations and impacts to cultural resources have occurred
- ***Type 4:*** impacts that threaten the integrity and National Register eligibility of a cultural resource are occurring during the monitoring visit, justifying the use of the INL Stop Work Authority.

If Type 2, 3, or 4 impacts are documented during monitoring, notifications are made to project managers, the DOE-ID Cultural Resources Coordinator, and various other parties, as appropriate and according to the nature and severity of the disturbance. Typically, Type 2 impacts can be corrected by CRMO personnel or with the cooperation of INL project managers, security personnel, and/or landlord organizations. In these instances, the impacts are only reported in summary fashion in year-end reports. Some Type 2 and all Type 3 or 4 impacts prompt formal investigations initiated by the INL CRMO. INL project managers, security, and/or landlord organizations, DOE-ID, and representatives from the Shoshone-Bannock Heritage Tribal Office (HeTO) may also participate in these investigations.

The INL Cultural Resource Monitoring Plan is contained in Appendix L of the *INL Cultural Resource Management Plan* (DOE-ID 2016). The Monitoring Plan describes the impact types, purpose of monitoring, process of selecting resources to be monitored each year, and how impacts will be documented.

In 2015, 67 total monitoring visits were completed, with several especially sensitive resources visited on more than one occasion. Surveillance was conducted at the following 49 individual cultural resource localities:

- three locations with Native American human remains, one of which is a cave
- nine additional caves, one of which is listed on the National Register
- twenty prehistoric archaeological sites
- four historic archaeological sites (two homesteads and two stage stations)
- two historic trails
- Experimental Breeder Reactor-I, which is a National Historic Landmark
- eight historic architectural properties associated with the Arco Naval Proving Ground
- objects of significance to INL's nuclear history (Aircraft Nuclear Propulsion program) on display at the Experimental Breeder Reactor-I public Visitors Center.

Several INL work processes and projects were also monitored in 2015 to confirm compliance with original INL CRMO recommendations and assess the effects of ongoing work. On two occasions, ground disturbing activities within the boundaries of the Power Burst Facility/Critical Infrastructure Test Range Complex (PBF/CITRC) were observed by INL CRMO staff prepared to respond to any additional finds of Native American human remains. Finally, the current location housing INL Archives and Special Collections was evaluated once.

Representatives from INL projects, DOE-ID, the Idaho SHPO, and the Shoshone-Bannock Tribe's HeTO participated in several of the trips in 2015. Throughout the year, most of the cultural resources monitored in 2015 exhibited no adverse impacts, resulting in Type 1 impact assessments. However, Type 2 impacts were noted 13 times. In one case, a portion of a historic trail was graded without prior review or coordination with the INL CRM Office, resulting in impacts to the surface of the trail and one archaeological site. A formal report was prepared to document the impacts resulting from this activity:

- INL/EXT- INL/LTD-14-33789: Investigation of Potential Damage to Cultural Resources Resulting from Maintenance of Road T-5.

Type 2 impacts were also documented when evidence of unauthorized artifact collection/ looting was discovered at three archaeological sites located along INL powerlines. Under a new Environmental Checklist for INL powerline maintenance, INL workers are reminded of their obligations to protect sensitive cultural resources, which should help to curtail these kinds of disturbances in the future.

A number of previously reported Type 2 impacts were also once again documented at the EBR-I National Historic Landmark, including spalling and deterioration of bricks due to inadequate drainage, minimal maintenance, and rodent infestation. The ANP engines and locomotive on display at the EBR-I Visitors Center also exhibited impacts related to long term exposure. Finally, most of the Arco NPG properties monitored at Central Facilities Area exhibited problems with lack of timely and appropriate maintenance as well as inadequate drainage.

In all of these cases of Type 2 findings, although impacts were noted or documentation was made of INL projects operating outside of culturally cleared limitations, cultural resources retained integrity and noted impacts did not threaten National Register eligibility.

Efforts to improve protection of archaeological sites at the INL are ongoing. An active security force monitors INL lands through ground patrols and security surveillance of public points of access. Trespassers are removed immediately upon detection and when appropriate, they have been prosecuted. Yearly on-line training modules remind INL employees of prohibitions on disturbing archaeological sites and targeted training is also conducted by INL CRMO program staff for INL employees likely to encounter archaeological sites in their work. In 2015, nearly 200 INL employees attended this training. Largely as a result of these restrictions, many archaeological sites on the INL display remarkable integrity and are virtually undisturbed.

In spite of active INL security oversight and comprehensive INL employee training, unauthorized visitation to sensitive cultural resources and some unauthorized removal of artifacts has been documented at the INL Site. The INL CRMO program has enlisted the help of DOE-ID Physical Security officers and U.S. federal agents experienced in enforcing the Archaeological Resource Protection Act to address these issues. In 2015, federal agents successfully concluded a 3-year investigation of one incident, by charging an INL employee with a civil violation of ARPA for removing artifacts from INL lands in 2012. Specific information on this prosecution will remain confidential for now so that ongoing investigations are not jeopardized. It is anticipated that interaction and cooperation between the federal agents, DOE-ID, and INL CRMO program staff will be ongoing through 2016 and beyond, leading to more effective protections for sensitive INL cultural resources.

Results of all monitoring and formal impact investigations are summarized annually in a year-end report to DOE-ID that is completed each year at the end of October. For 2015, the following report provides documentation:

- INL/EXT-15-37148: Idaho National Laboratory Cultural Resource Monitoring Report for Fiscal Year 2015

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 SHPO, 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 2015, 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 (Idaho Falls Gem and Mineral Society, Friends For Learning), and cultural resource management professionals. Archaeological awareness and protection training was also conducted on several occasions for nearly 200 INL employees.

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 2012). 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 HeTO, DOE-ID, and the INL CRMO was established in 1993. It was the first of its kind within the DOE complex and its regular Cultural Resources Working Group meetings enable issues and opportunities to be addressed in an environment of mutual respect and learning. Tribal input is sought for new and ongoing projects and a standing invitation is extended to comment on, visit, observe, and/or assist in INL CRMO field activities. The holistic view of cultural resources and cooperative spirit encouraged in this group foster an atmosphere of mutual respect that is conducive to open communication and effective consideration of tribal views in decisions regarding INL cultural resources and overall land management.

Summer internships offer a unique opportunity for students to participate in INL CRM research and compliance activities. In 2015, INL CRMO staff and a University of Idaho architectural student collaborated to recreate a 3-D model of a ca. 1886 historic landscape and homestead. Using architectural modelling software and current archaeological survey data fused with historic documents, family records, and photographs, the 3-D model created a visually stimulating piece of art capable of transporting the viewer 130 years into the past (see Figure B-5). Looking forward, the innovative 3-D model could be uploaded into INL's immersive Computer Assisted Virtual Environment facility, allowing the public

Figure B-5. 3-D Rendering of the Reno Homestead, ca. 1886.

to share in this experience and interact with history in a new and exciting hands-on way that shows great promise as a unique tool for community outreach.

Additionally, in 2015, INL CRMO staff worked with an integrated geometry/geography class from Compass Academy High School in Idaho Falls on an interpretive project focusing on the ca. 1910 Idaho Falls City Canal. Using archaeological investigation and mapping techniques, combined with historic research, students produced an interpretive panel, map, and model of the City Canal, constructed as an early hydropower project in Idaho Falls.

In celebration of the 50th anniversary of the National Historic Preservation Act (NHPA), states across the nation are participating in the Making Archaeology Public Project (MAPP), a grassroots effort with the support of major professional archaeological organizations (Society for American Archaeology, Society for Historical Archaeology, Register of Professional Archaeologists) to showcase some of the interesting and exciting finds that have been made as a result of work mandated by the NHPA. Out of six projects nominated for MAPP consideration in Idaho, an INL CRMO program investigation of a 1944 World War II B-24 bomber crash site located on the INL was unanimously selected in 2015 to represent the state.

The INL CRMO investigation of the B-24 bomber crash site involved field survey and documentation, archival study, coordination with DOE-ID and INL officials, and significant engagement with the public, including representatives from Project Remembrance and the family of one of the men who perished in the 1944 crash (see Figure B-6). The INL CRMO program has engaged a diverse team from DOE-ID, INL, BLM, Project Remembrance, and the family of Sergeant George Pearce to produce a video highlighting the discovery of the site, the research conducted to fill in the human dimensions of the story, and the public values that it embodies. The video was completed in early 2016, with screenings scheduled at national archaeology and history conferences and hosting on various local, regional, and national internet locations such as www.history.idaho.gov, https://www.youtube.com/user/IdahoNationalLab, and www.preservation50.org/mapp/.

Figure B-6. 1935 Class Ring Found at the B-24 Bomber Crash Site and Later Identified as Belonging to Sergeant George Pearce.

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Appendix C. Chapter 5 Addendum

Table C-1. Advanced Test Reactor Complex Cold Waste Pond Effluent Permit-Required Monitoring Results (December 2014 to December 2015).[a]

Parameter	Minimum	Maximum	Median
pH	6.89	8.24	7.88
Conductivity	418	1727	487
Aluminum, filtered (mg/L)	0.025U[b]	0.025 U	0.025U
Chloride (mg/L)	9.8	57.7	12.0
Chromium, filtered (mg/L)	0.00280	0.0121	0.00413
Chromium, total (mg/L)	0.00281	0.0124	0.0408
Iron, filtered (mg/L)	0.025 U	0.218	0.025 U
Manganese, filtered (mg/L)	0.0025 U	0.00822	0.0025 U
Nitrate + Nitrite as Nitrogen (mg/L)	0.815	3.38	0.864
Nitrogen, Total Kjeldahl Nitrogen (TKN) (mg/L)	0.1 U	1.51	0.207
Nitrogen, Total (mg/L)[c]	<0.932	4.88	1.0405
Solids, Total Dissolved (mg/L)	217	1330	251
Sulfate (mg/L)	19.8	661	27.5

a. Duplicate samples were collected in April 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 Kjedldahl nitrogen and nitrate +nitrite, as nitrogen.

Table C-2. Advanced Test Reactor Complex Cold Waste Pond Industrial Wastewater Reuse Permit Monitoring Well Results (2015).

Well Name	USGS-065 (GW-016102)		USGS-098 (GW-016101)		USGS-076 (GW-016104)		TRA-08 (GW-016105)		Middle-1823 (GW-016106)		PCS/SCS[a]
Sample Date	**05/07/15**	**10/14/15**	**05/06/15**	**10/13/15**	**05/06/15**	**10/13/2015**	**05/07/15**	**10/14/15**	**05/06/15**	**10/13/15**	
Water Table Depth (ft below ground surface)	475.91	477.19	429.24	430.12	484.45	485.51	490.40	491.46	494.16	495.31	NA[b]
Water Table Elevation (above mean sea level in ft)[c]	4452.61	4451.33	4457.55	4456.67	4448.76	4448.76	4453.12	4447.40	4448.71	4447.55	NA
Borehole Correction Factor (ft)[d]	NA	NA	-2.41	-2.41	NA	NA	0.63	0.63	NA	NA	NA
pH	8.15	8.00	8.15	8.01	8.13	7.90	8.33	8.10	8.12	7.96	6.5 to 8.5 (SCS)
Conductivity (µS)	594	604	384	409	426	414	424	435	418	435	NA
Total Kjeldahl nitrogen (mg/L)	0.136	0.193	0.165	0.1 U[e]	0.432	0.19	0.172	0.193	0.182	0.167 [0.171][f]	NA
Nitrite +Nitrite as Nitrogen (mg/L)	1.46	1.44	0.99	0.96	1	0.994	0.915	0.964	0.969	0.934 [0.947]	NA
Total nitrogen[g] (mg/L)	1.596	1.633	1.155	<1.06	1.432	1.184	1.087	1.157	1.151	1.101 [1.118]	NA
Total dissolved solids (mg/L)	429	401	236	222	272	248	263	252	276	242 [246]	500 (SCS)
Aluminum (mg/L)	0.00653 (0.0079)[h]	0.0148 (0.0163)	0.413 (0.00389)	0.0184 (0.005 U)	0.00596 (0.00671)	0.0097 (0.00752)	0.301 (0.0154)	0.493 (0.0093)	0.205 (0.00431)	0.0964 (0.00555) [0.0815] [(0.00511)]	0.2 (SCS)
Chloride (mg/L)	19.3	19.8	14.2	14.9	13.1	13.4	11.7	12.3	11.6	11.8 [11.8]	250 (SCS)
Chromium (mg/L)	0.0706 (0.0704)	0.0733 (0.0729)	0.149 (0.0025 U)	0.0064 (0.00544)	0.0108 (0.00982)	0.005 (0.0105)	0.082 (0.0155)	0.0345 (0.0175)	0.0117 (0.00963)	0.00923 (0.00964) [0.00957] [(0.0095)]	NA
Iron (mg/L)	0.05 U (0.05 U)	0.0719 (0.0611)	**6.82** (0.05 U)	0.0965 (0.0578)	0.05 U (0.05 U)	0.107 (0.0544)	0.412 (0.05 U)	0.306 (0.0558 U)	0.0887 (0.05 U)	0.0877 (0.05 U)	0.3 (SCS)

Table C-2. Advanced Test Reactor Complex Cold Waste Pond Industrial Wastewater Reuse Permit Monitoring Well Results (2015). (cont.)

Well Name	USGS-065 (GW-016102)		USGS-098 (GW-016101)		USGS-076 (GW-016104)		TRA-08 (GW-016105)		Middle-1823 (GW-016106)		PCS/SCS [a]
Sample Date	**05/07/15**	**10/14/15**	**05/06/15**	**10/13/15**	**05/06/15**	**10/13/2015**	**05/07/15**	**10/14/15**	**05/06/15**	**10/13/15**	
Manganese (mg/L)	0.0025 U (0.0025 U)	0.0025 U (0.0025 U)	**0.0887** (0.00785)	0.0025 U (0.0025 U)	0.0025 U (0.0025 U)	0.0025 U (0.0025 U)	0.00835 (0.0025 U)	0.00674 (0.0025 U)	0.00418 (0.0025 U)	[0.0855] [(0.0556)] 0.0025 U (0.0025 U) [0.0253] [(0.0025 U)]	0.05 (SCS)
Sulfate (mg/L)	145	157	21.6	21.4	34.2	35.3	43.4	47.7	35	35.6 [35.6]	250 (SCS)

a. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in the 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. The United States Geological Survey performed gyroscopic surveys on Wells TRA-07 and TRA-08 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. U qualifier indicates that the result was reported as below the instrument detection limit by the analytical laboratory.
f. Results shown in brackets are the results from field duplicate samples.
g. Total nitrogen is calculated as the sum of total Kjedldahl nitrogen and nitrate + nitrite, as nitrogen.
h. Filtered sample results for aluminum, iron, and manganese, shown in parentheses, are used for permit compliance determinations
i. Concentrations shown in bold are above the Ground Water Quality Rule SCS.

Table C-2a. Advanced Test Reactor Complex Cold Waste Pond Industrial Wastewater Reuse Permit Monitoring Well Results (2015).

Well Name	USGS-058 (GW-016107)		PCS/SCS[a]
Sample Date	**05/07/15**	**10/13/15**	
Water Table Depth (ft below ground surface)	472.51	473.50	NA[b]
Water Table Elevation (above mean sea level in ft)[c]	4449.38	4448.39	NA
Borehole Correction Factor (ft)[d]	NA	NA	NA
pH	8.14	7.93	6.5 to 8.5 (SCS)
Conductivity (µS)	432	435	NA
Total dissolved solids (mg/L)	**269**	245	500 (SCS)
Sulfate (mg/L)	34.4	34.9	250 (SCS)

a. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in the 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. The United States Geological Survey performed gyroscopic surveys on Wells TRA-07 and TRA-08 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. Concentrations shown in bold are above the Ground Water Quality Rule .

Table C-3. Idaho Nuclear Technology and Engineering Center Sewage Treatment Plant Influent Monitoring Results at CPP-769 (2015).

Parameter	Minimum	Maximum	Mean
Biochemical oxygen demand (5-day) (mg/L)	57.3	255	170.4
Nitrate + nitrite, as nitrogen (mg/L)	-0.0046 U[a]	0.0436	0.0107
Total Kjeldahl nitrogen (mg/L)	33.3	104	73.6
Total phosphorus (mg/L)	3.65	8.81	6.77
Total suspended solids (mg/L)	80	262	167

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 (2015).

Parameter	Minimum	Maximum	Mean
Biochemical oxygen demand (5-day) (mg/L)	5.6	78.8	24.8
Nitrate + nitrite, as nitrogen (mg/L)	0.2	3.8	2.1
pH (standard units)[a]	7.56	9.0	8.06
Total coliform (colonies/100 mL)[a]	63	8,000	1,400
Total Kjeldahl nitrogen (mg/L)	6.4	31.0	18.4
Total phosphorus (mg/L)	2.39	6.40	4.01
Total suspended solids (mg/L)	2.0	72.0	19.9

a. As required by the permit, the results for this parameter were obtained from a grab sample.

Table C-5. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Effluent Monitoring Results at CPP-797 (2015).

Parameter	Minimum	Maximum	Mean
Aluminum (mg/L)	0.068 U[a]	0.068 U	0.068 U
Arsenic (mg/L)	0.005 U	0.005 U	0.005 U
Biochemical oxygen demand (5-day) (mg/L)	-0.157 U	20.1	5.81
Cadmium (mg/L)	0.001 U	0.001 U	0.001 U
Chloride (mg/L)	13.4	53.5	19.6
Chromium (mg/L)	0.0054	0.0063	0.0060
Conductivity (µS/cm)	371	516	402
Copper (mg/L)	0.003 U	0.0066	0.0048
Fluoride (mg/L)	0.183	0.216	0.195
Iron (mg/L)	0.03 U	0.062	0.038
Manganese (mg/L)	0.002 U	0.003	0.0021
Mercury (mg/L)	0.000067 U	0.000067 U	0.000067 U
Nitrate + nitrite, as nitrogen (mg/L)	0.86	1.80	1.24
pH (standard units)[b]	7.39	8.31	7.88
Selenium (mg/L)	0.0015 U	0.0015 U	0.0015 U
Silver (mg/L)	0.001 U	0.001 U	0.001 U
Sodium (mg/L)	9.6	25.6	14.6
Total coliform (colonies/100 mL)[b]	6	175	48
Total dissolved solids (mg/L)	170	279	225
Total Kjeldahl nitrogen (mg/L)	0.088	0.844	0.371
Total phosphorus (mg/L)	0.570	0.824	0.724
Total suspended solids (mg/L)	0.1 U	2.5	0.8

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.

Table C-6. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Aquifer Monitoring Well Groundwater Results (2015).

	ICPP-MON-A-165 (GW-013006)		ICPP-MON-A-166 (GW-013007)		ICPP-MON-A-164B (GW-013011)		
Sample Date	**4/8/2015**	**9/9/2015**	**4/8/2015**	**9/9/2015**	**4/8/2015**	**9/9/2015**	**PCS/SCS[a]**
Depth to water (ft below brass cap)	503.9	505.6	511.12	512.82	503.21	504.71	NA[b]
Water table elevation (at brass cap in ft)[c]	4,449.02	4,447.31	4,448.42	4,446.72	4,448.96	4,447.46	NA
Aluminum (mg/L)[d]	0.068 U[e]	0.068 U	0.068 U	0.068 U	0.068 U	0.068 U	0.2
Arsenic (mg/L)	0.0017 U	0.0017 U	0.002	0.0017 U	0.0017 U	0.0017 U	0.05
Biochemical oxygen demand (mg/L)	-0.936 UJ[f]	0.283 UJ	0.354 UJ	0.533 UJ	0.0838 UJ	5.84 J[g]	NA
Cadmium (mg/L)	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.005
Chloride (mg/L)	46.1	43.2 J	9.5	10.2 J	9.9	10.6 J	250
Chromium (mg/L)	0.00978 U	0.00921	0.00625 U	0.0063 U	0.0118 U	0.0118 U	0.1
Coliform, fecal (CFU[h]/100 mL)	<1[i]	<1	<1[i]	<1	<1[i]	<1	<1 CFU/100 mL
Coliform, total (CFU/100 mL)	<1[i]	<1	<1[i]	<1	<1[i]	<1	1 CFU/100 mL[j]
Copper (mg/L)	0.003 U	0.003 U	0.003 U	0.003 U	0.003 U	0.003 U	1.3
Fluoride (mg/L)	0.189	0.162	0.247	0.217	0.171	0.146	4
Iron (mg/L)[d]	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.030 U	0.3
Manganese (mg/L)[d]	0.002 U	0.002 U	0.011	0.0083	0.002 U	0.002 U	0.05
Mercury (mg/L)	0.000067 U	0.000067 U	0.000067 U	0.000067 U	0.000067 U	0.000067 U	0.002
Nitrate, as nitrogen (mg/L)	1.15	1.29	0.288	0.418	0.859	1.06	10
Nitrite, as nitrogen (mg/L)	0 U	0 U	0 U	0 U	0 U	0 U	1
pH (standard units)	8.21	7.18	8.24	7.12	8.20	7.32	6.5–8.5
Selenium (mg/L)	0.00173	0.0015 U	0.0015 U	0.0015 U	0.0015 U	0.0015 U	0.05
Silver (mg/L)[d]	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.1
Sodium (mg/L)	18.2	17.1	9.27	9.21	9.63	9.95	NA

Table C-6. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Aquifer Monitoring Well Groundwater Results (2015). (cont.)

	ICPP-MON-A-165 (GW-013006)		ICPP-MON-A-166 (GW-013007)		ICPP-MON-A-164B (GW-013011)		
Sample Date	**4/8/2015**	**9/9/2015**	**4/8/2015**	**9/9/2015**	**4/8/2015**	**9/9/2015**	**PCS/SCS[a]**
Total dissolved solids (mg/L)	254	303	149	196[k]	221	227	500
Total Kjeldahl nitrogen (mg/L)	0.0619 J	-0.0431 U	-0.00118 U	-0.0323 U	-0.00316 U	-0.0322 U	NA
Total phosphorus (mg/L)	0.0126 U	0.00753 U	0.000714 U	0.0111 U	0.00287 U	0.0129 U	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. UJ flag indicates the material was analyzed for, but was not detected. The associated value is an estimate and may be inaccurate or imprecise.

g. J flag indicates the material was analyzed for and was detected at or above the applicable detection limit. The associated value is an estimate and may be inaccurate or imprecise.

h. CFU = colony-forming unit

i. A shipping issue occurred with the samples collected on 4/8/2015. Samples were recollected on 4/29/2015.

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.

k. Sample was reanalyzed outside the 7-day holding time.

Table C-7. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Perched Water Monitoring Well Groundwater Results (2015).

	ICPP-MON-V-191 (GW-013008)		ICPP-MON-V-200 (GW-013009)		ICPP-MON-V-212 (GW-013010)		
Sample Date	**4/8/2015**	**9/9/2015**	**4/9/2015**	**9/9/2015**	**4/9/2015**	**9/9/2015**	**PCS/SCS[a]**
Depth to water (ft below brass cap)	Dry[b]	Dry[b]	105.98	113.93	236.16	236.21	NA[c]
Water elevation at brass cap (ft)[d]			4,846.99	4,839.04	4,722.18	4,722.13	NA
Aluminum (mg/L)[e]			0.068 U[f]	0.068 U	0.068 U	0.068 U	0.2
Arsenic (mg/L)			0.0081	0.00712	0.00242	0.00215	0.05
Biochemical oxygen demand (mg/L)			0.05 UJ[g]	1.48 J[h]	0.21 UJ	2.45 J	NA
Cadmium (mg/L)			0.001 UJ	0.001 U	0.001 UJ	0.001 U	0.005
Chloride (mg/L)			26.8	21.6 J	37.5	36.1 J	250
Chromium (mg/L)			0.00436 J	0.00603 U	0.0116	0.00704 U	0.1
Coliform, fecal (CFU/100 mL)			<1 UJ	<1 UJ	<1 UJ	<1 UJ	<1 CFU/100 mL
Coliform, total (CFU/100 mL)			<1 UJ	<1 UJ	<1 UJ	<1 UJ	1 CFU/100 mL
Copper (mg/L)			0.00648 J	0.003 U	0.00418 J	0.003 U	1.3
Fluoride (mg/L)			0.193	0.197	0.256	0.241	4
Iron (mg/L)[e]			0.030 U	0.030 U	0.030 U	0.030 U	0.3
Manganese (mg/L)[e]			0.002 U	0.002 U	0.002 U	0.002 U	0.05
Mercury (mg/L)			0.000067 U	0.000067 U	0.000067 U	0.000067 U	0.002
Nitrate, as nitrogen(mg/L)			1.35	1.49	1.64	1.69	10
Nitrite, as nitrogen (mg/L)			0 U	0 U	0 U	0 U	1
pH (standard units)			7.61	6.76	7.81	7.03	6.5–8.5
Selenium (mg/L)			0.0015 U	0.0015 U	0.0015 U	0.0015 U	0.05
Silver (mg/L)[e]			0.00107 U	0.001 UJ	0.00137 U	0.001 UJ	0.1

Table C-7. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Perched Water Monitoring Well Groundwater Results (2015). (cont.)

	ICPP-MON-V-191 (GW-013008)		ICPP-MON-V-200 (GW-013009)		ICPP-MON-V-212 (GW-013010)		
Sample Date	**4/8/2015**	**9/9/2015**	**4/9/2015**	**9/9/2015**	**4/9/2015**	**9/9/2015**	**PCS/SCS[a]**
Sodium (mg/L)			21.7	19.5	40.4	37.7	NA
Total dissolved solids (mg/L)			209	256	253	284	500
Total Kjeldahl nitrogen (mg/L)			0.0744 J	-0.0244 U	-0.0044 U	-0.0118 U	NA
Total phosphorus (mg/L)			0.184	0.174	0.0256 U	0.0277 J	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. Perched water Well ICPP-MON-V-191was dry in April and September 2015.

c. NA—Not applicable.

d. Water table elevations referenced to North American Vertical Datum of 1988 (NAVD 88).

e. The results of dissolved concentrations of this parameter are used for secondary constituent standard compliance determinations.

f. U flag indicates the result was reported as below the detection/reporting limit.

g. UJ flag indicates the material was analyzed for, but was not detected. The associated value is an estimate and may be inaccurate or imprecise.

h. J flag indicates the material was analyzed for and was detected at or above the applicable detection limit. The associated value is an estimate and may be inaccurate or imprecise.

Table C-8. Materials and Fuels Complex Industrial Waste Pipeline Monitoring Results (2015).[a]

Parameter	Minimum	Maximum	Median
Arsenic (mg/L)	0.005 U[b]	0.00566	0.005 U
Barium (mg/L)	0.0337	0.0402	0.0376
Cadmium (mg/L)	0.001 U	0.001 U	0.001 U
Chloride (mg/L)	18.7	72.9	23.7
Chromium (mg/L)	0.0025 U	0.0036	0.0025 U
Fluoride (mg/L)	0.53	0.724	0.613
Iron[c] (mg/L)	0.0586	0.235	0.108
Lead (mg/L)	0.00025 U	0.00409	0.000372
Manganese (mg/L)	0.0025 U	0.0209	0.0025 U
Mercury (mg/L)	0.0002 U	0.0002 U	0.0002 U
Nitrate + Nitrite as Nitrogen (mg-N/L)	2.02	2.32	2.12
Nitrogen, Total Kjeldahl Nitrogen (TKN) (mg/L)	0.1 U	0.432	0.182
Nitrogen, Total[d] (mg/L)	2.152	2.712	2.321
pH (standard units)	7.44	8.48	8.38
Phosphorus, Total (mg/L)	0.0668	0.458	0.125
Selenium (mg/L)	0.000521	0.00124	0.000622
Silver (mg/L)	0.005 U	0.005 U	0.005 U
Sodium (mg/L)	18.4	54.5	22.8
Sulfate (mg/L)	17.1	21.4	18.3
Solids, Total Dissolved (mg/L)	232	340	261
Solids, Total Suspended (mg/L)	4U	4U	4U
Zinc (mg/L)	0.0101	0.0335	0.0126

a. Duplicate samples were collected in August and the results for the duplicate samples are included in the data summary.

b. U qualifier indicates the result was below the detection limit.

c. Permit-required analyte for groundwater monitoring but not for effluent monitoring.

d. Total nitrogen is calculated as the sum of total Kjeldahl nitrogen and nitrate + nitrite, as nitrogen.

Table C-9. Materials and Fuels Complex Industrial Waste Water Underground Pipe Monitoring Results (2015).[a]

Parameter	Minimum	Maximum	Median
Arsenic (mg/L)	0.005 U[b]	0.00794	0.00564
Barium (mg/L)	0.0762	0.0953	0.0911
Cadmium (mg/L)	0.001 U	0.001 U	0.001 U
Chloride (mg/L)	45.6	63.2	48.2
Chromium (mg/L)	0.00369	0.00419	0.00373
Fluoride (mg/L)	1.41	1.58	1.43
Iron[c] (mg/L)	0.025 U	0.164	0.108
Lead (mg/L)	0.00025 U	0.000552	0.000272
Manganese (mg/L)	0.0025 U	0.00368	0.0025 U
Mercury (mg/L)	0.0002 U	0.0002 U	0.0002 U
Nitrate + Nitrite as Nitrogen (mg/L)	4.89	7.02	5.41
Nitrogen, Total Kjeldahl Nitrogen (TKN) (mg/L)	0.694	2.712	2.152
Nitrogen, Total[d] (mg/L)	5.703	8.35	6.104
pH (standard units)	7.42	8.78	8.39
Phosphorus, total	0.836	1.45	1.05
Selenium (mg/L)	0.0011	0.00178	0.00132
Silver (mg/L)	0.005 U	0.005 U	0.005 U
Sodium (mg/L)	47.9	63	53.3
Sulfate (mg/L)	42.2	53.3	44.7
Solids, Total Dissolved (mg/L)	584	650	619
Solids, Total Suspended	4 U	7	4 U
Zinc (mg/L)	0.00379	0.0307	0.0126

a. Duplicate samples were collected in August and the results for the duplicate samples are included in the data summary.
b. U qualifier indicates the result was below the detection limit.
c. Permit-required analyte for groundwater monitoring but not for effluent monitoring.
d. Total nitrogen is calculated as the sum of total Kjeldahl nitrogen and nitrate + nitrite, as nitrogen.

Table C-10. Summary of Groundwater Quality Data Collected for the Wastewater Reuse Permit for the MFC Industrial Waste Ditch and Pond (2015).

Well Name	ANL-MON-A-012 (GW-016001)		ANL-MON-A-013 (GW-016002)		ANL-MON-A-014 (GW-016003)		
Sample Date	**04/28/2015**	**09/22/2015**	**04/28/2015**	**09/22/2015**	**04/28/2015**	**09/22/2015**	**PCS/SCS[a]**
Water Table Depth (ft bgs)	659.55	661.48	647.84	649.79	647.04	648.89	NA[b]
Water Table Elevation (ft above mean sea level)[c]	4473.17	4471.24	4472.49	4470.56	4471.04	4469.21	NA
pH	7.69	8.16	8.07	8.01	7.66	8.00	6.5 to 8.5 (SCS)
Temperature (°C)	13.6	13.4	13.8	14.3	13.8	14.0	None
Conductivity (µS/cm)	362	363	360	376	423	398	None
Nitrate nitrogen (mg/L)	2.14	2.09	2.19	2.1	2.84	2.36	10 (PCS)
Phosphorus (mg/L)	0.0138	0.0171	0.0149	0.0279	0.0134	0.0177	None
Total dissolved solids (mg/L)	240	224	241	217	280	244	500 (SCS)
Sulfate (mg/L)	17.1	17	18.9	19.4	31.3	23.2	250 (SCS)
Arsenic (µg/L)	2.25	2.18	2.26	1.97	2.27	2.13	50 (PCS)
Barium (µg/L)	37.5	37.6	35.2	36	40.5	37.3	2,000 (PCS)
Cadmium (µg/L)	0.25 U[d]	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	5 (PCS)
Chloride (mg/L)	18.2	17.5	19.3	19.8	26.3	20.8	250 (SCS)
Chromium (µg/L)	2.5 U	2.5 U	4.47	5.55	9.96	4.05	100 (PCS)
Iron (µg/L)	144 (50 U)[e]	121 (50 U)	**686**[f] (50 U)	**760** (50 U)	67.8 (50 U)	64.7 (50 U)	300 (SCS)
Lead (µg/L)	0.5 U	0.5 U	0.679	0.5 U	0.5 U	0.5 U	15 (PCS)
Manganese (µg/L)	3.3	2.98	11.6	11.9	2.5 U	2.5 U	50 (SCS)
Mercury (µg/L)	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	2 (PCS)

Table C-10. Summary of Groundwater Quality Data Collected for the Wastewater Reuse Permit for the MFC Industrial Waste Ditch and Pond (2015). (cont.)

Well Name	ANL-MON-A-012 (GW-016001)		ANL-MON-A-013 (GW-016002)		ANL-MON-A-014 (GW-016003)		
Sample Date	**04/28/2015**	**09/22/2015**	**04/28/2015**	**09/22/2015**	**04/28/2015**	**09/22/2015**	**PCS/SCS[a]**
Silver (µg/L)	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	100 (SCS)
Sodium (µg/L)	17,900	17,300	18,800	18,500	23,700	22,000	None
Zinc (µg/L)	3.89	4.04	3.33	2.5 U	2.5 U	2.5 U	5,000 (SCS)

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. U qualifier indicates the result was reported as below the instrument detection limit by the analytical laboratory.
e. Concentrations shown in parentheses are from filtered samples.
f. Concentrations shown in bold are above the Ground Water Quality Rule SCS.

Table C-11. Advanced Test Reactor Complex Cold Waste Pond Surveillance Monitoring Results (December 2014 to December 2015).[a]

Parameter	Minimum	Maximum	Median
Gross alpha (pCi/L ± 1s)	-1.93± 1U	2.23± 0.939	NC[c]
Gross beta (pCi/L ± 1s)	1.1± 0.62U	5.99± 1.02	NC
pH	6.89	8.24	7.88
Potassium-40 (pCi/L ± 1s)	-19.3± 12.5U	3.91± 13.8	NC

a. Only parameters with at least one detected result are shown.
b. U qualifier indicates the result was below the detection limit.
c. NC —not calculated

Table C-12. Radioactivity Detected in Surveillance Groundwater Samples Collected at the Advanced Test Reactor Complex (2015).

Monitoring Well	Sample Date	Parameter	Sample Result (pCi/L)
USGS-065	05/07/2015	Gross Alpha	3.21(± 1.1)[a]
		Gross Beta	2.17 (± 0.703)
		Tritium	2,770 (± 314)
	10/14/2015	Gross Alpha	ND[b]
		Gross Beta	3.30 (± 0.359)
		Tritium	3,340 (± 371)
USGS-098	05/06/2015	Gross Alpha	ND
		Gross Beta	5.35 (± 0.886)
		Tritium	ND
	10/13/2015	Gross Alpha	ND
		Gross Beta	2.95 (± 0.401)
		Tritium	ND
TRA-08	05/07/2015	Gross Alpha	ND
		Gross Beta	ND
		Tritium	1,360 (± 185)
	10/14/2015	Gross Alpha	ND
		Gross Beta	3.01 (± 0.782)
		Tritium	1,430 (± 197)
USGS-076	05/06/2015	Gross Alpha	ND
		Gross Beta	0.645 (± 0.858)
		Tritium	516(± 125)
	10/13/2015	Gross Alpha	1.31(± 0.332)
		Gross Beta	ND
		Tritium	463 (±124)
Middle-1823	05/06/2015	Gross Alpha	ND
		Gross Beta	ND
		Tritium	771(± 138)
	10/13/2015	Gross Alpha	ND ND[c]
		Gross Beta	2.49 (± 0.43) 1.95 (±0.497)[c]
		Tritium	1,110 (±170) 856 (±147)[c]

a. One sigma uncertainty shown in parentheses.
b. ND–Not detected.
c. Analytical result from field duplicate sample collected on October 13, 2015.

Table C-13. Liquid Effluent Radiological Monitoring Results for the Idaho Nuclear Technology and Engineering Center (2015).

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)				
April 2015	ND[c]	ND	18.8 (±1.09)	ND
September 2015	71.8 (±21.2)[d]	ND	28.1 (±1.08)	ND
Effluent to INTEC New Percolation Ponds (CPP-797)				
January 2015	ND	ND	5.41 (±0.69)	ND
February 2015	ND	ND	4.77 (±0.70)	ND
March 2015	ND	ND	5.57 (±0.94)	ND
April 2015	ND	ND	8.30 (±1.14)	ND
May 2015	ND	ND	4.57 (±0.45)	ND
June 2015	ND	ND	4.91 (±0.77)	ND
July 2015	ND	ND	7.27 (±0.61)	ND
August 2015	ND	ND	7.90 (±1.12)	ND
September 2015	ND	1.81 (±0.44)	5.12 (±0.55)	ND
October 2015	ND	2.97 (±1.00)	14.5 (±1.58)	ND
November 2015	ND	2.36 (±0.74)	4.51 (±0.74)	ND
December 2015	ND	ND	7.85 (±0.87)	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.

d. Concentration for potassium-40. Potassium-40 was not detected in the field duplicate. All other gamma-emitting radionuclides were ND.

Table C-14. Groundwater Radiological Monitoring Results for the Idaho Nuclear Technology and Engineering Center (2015).

Monitoring Well	Sample Date	Gross Alpha[a] (pCi/L)	Gross Beta[a] (pCi/L)
ICPP-MON-A-165	4/8/2015	ND[b]	5.23 (±0.67)
	9/9/2015	ND	3.78 (±0.74)
ICPP-MON-A-166	4/8/2015	ND	1.49 (±0.49)
	9/9/2015	9.75 (±1.36)	7.76 (±0.91)
ICPP-MON-V-200	4/9/2015	ND	5.86 (±0.60)
	9/9/2015	ND	5.72 (±0.74)
ICPP-MON-V-212	4/9/2015	ND	5.92 (±0.60)
	9/9/2015	4.48 (±0.97)	13.00 (±1.10)

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-15. Monitoring Results for Material and Fuels Complex Industrial Waste Pond (2015).[a]

Parameter	Minimum	Maximum	Median
Gross beta (pCi/L ± 1s)	5.18± 0.885	8.19 ± 1.04	Not calculated
Potassium-40 (pCi/L ± 1s)	0 ± 12.8 U[b]	13.1± 11.3 U	Not calculated
Uranium-233/234 (pCi/L ± 1s)[c]	1.57± 0.206	1.57± 0.206	Not calculated
Uranium-238 (pCi/L ± 1s)[c]	0.595± 0.109	0.595± 0.109	Not calculated

a. Only parameters with at least one detected result are shown.
b. U qualifier indicates the result was below the detection limit.
c. Parameter was analyzed in September only; therefore, the minimum and maximum are the same.

2015

Appendix D. Onsite Dosimeter Measurements and Locations

Location	Exposure[a] Nov. 2014 – April 2015	Exposure[a] May 2015 – Oct. 2015
ARA O-1	63	70
PBF SPERT O-1	68	62

a. All values are gross counts in mrem.

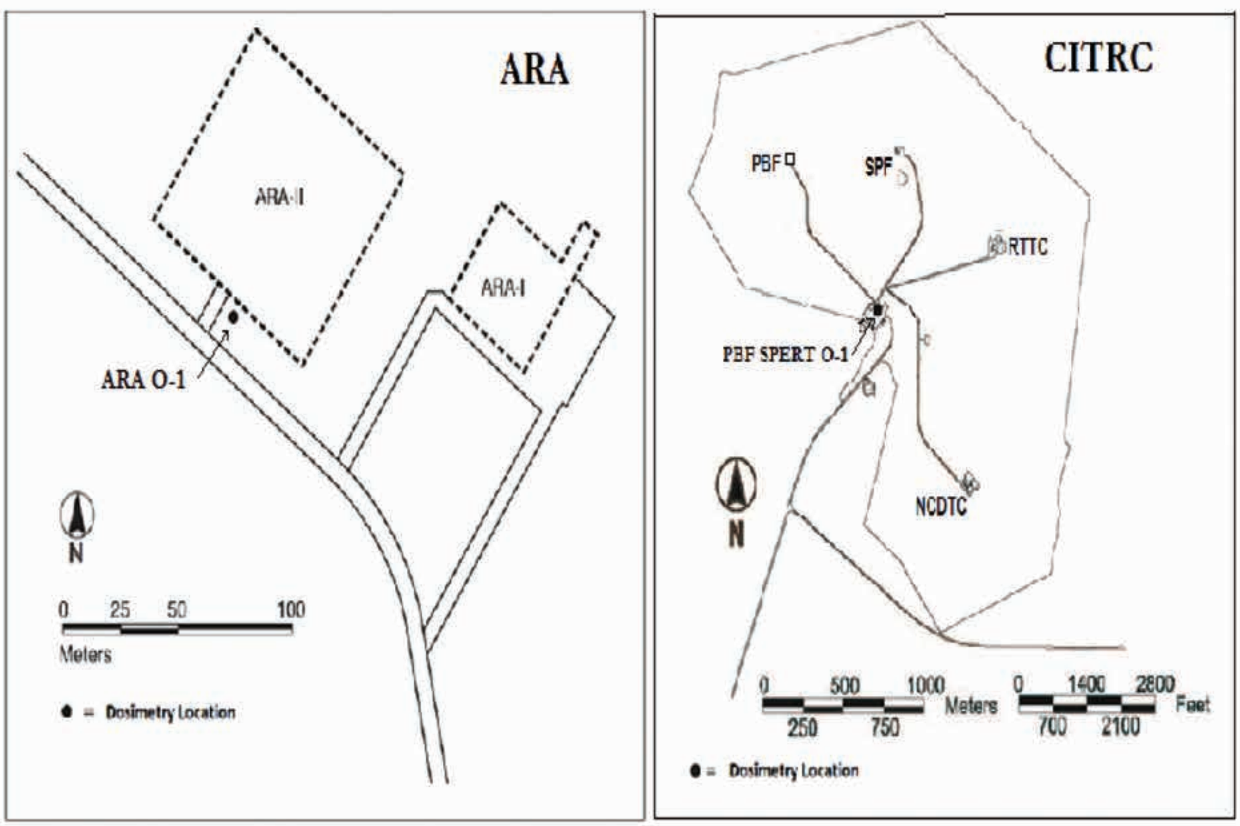

Figure D-1. Environmental Radiation Measurements at Auxiliary Reactor Area and Critical Infrastructure Test Range Complex (2015).

Location	Exposure[a] Nov. 2014 – April 2015	Exposure[a] May 2015 – Oct. 2015
TRA 1	new	71
TRA 2	73	end
TRA 4	82	end
TRA 6	72	68
TRA 7	new	68
TRA 8	74	79
TRA 9	new	73
TRA 10	78	79
TRA 11	71	78
TRA 12	new	78
TRA 13	81	70
TRA 14	new	69
TRA 15	new	66
TRA 16	new	74
TRA 17	new	116
TRA 18	new	87
TRA 19	new	160
TRA 20	new	172
TRA 21	new	334
TRA 22	new	119
TRA 23	new	71
TRA 24	new	73
TRA 25	new	70
TRA 26	new	67
TRA 27	new	71
TRA 28	new	77

a. All values are gross counts in mrem.

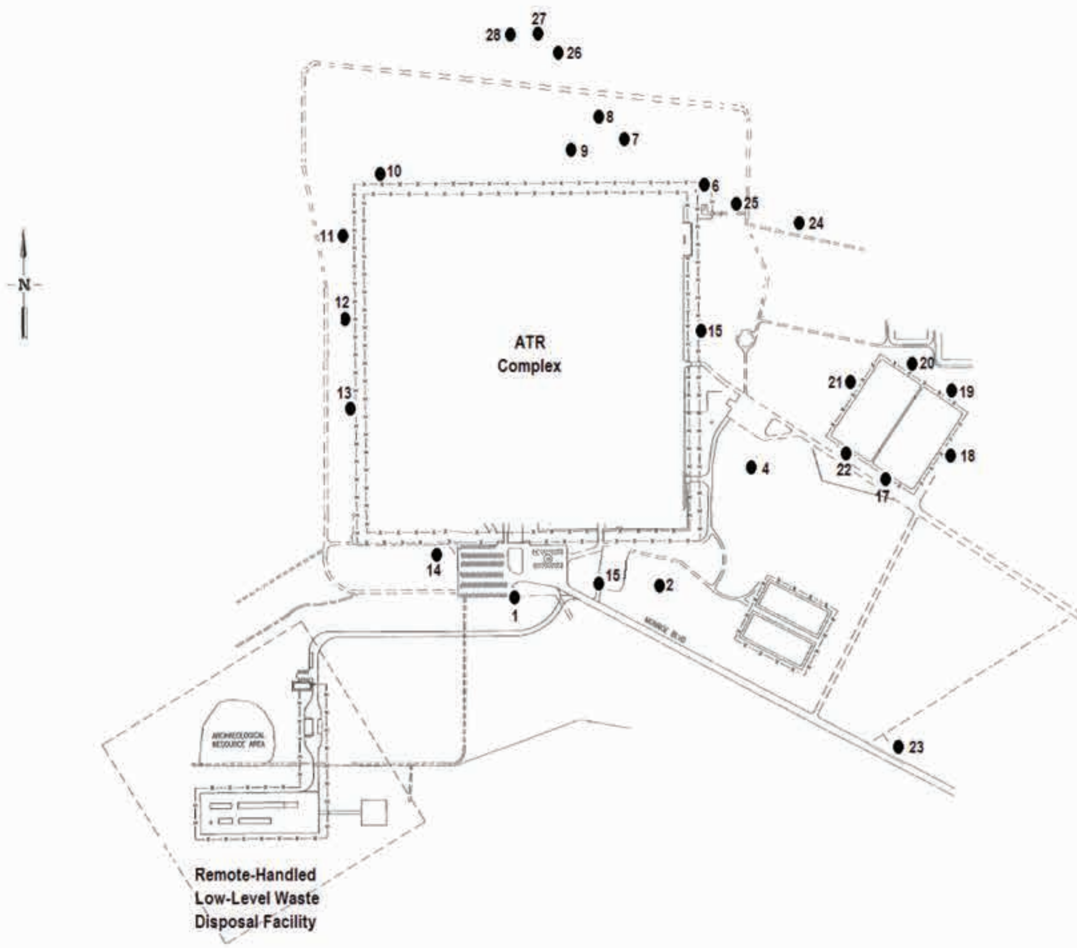

Figure D-2. Environmental Radiation Measurements at Advanced Test Reactor Complex (2015).

Location	Exposure[a]	
	Nov. 2014 – April 2015	May 2015 – Oct. 2015
CFA O-1	73	72

a. All values are gross counts in mrem.

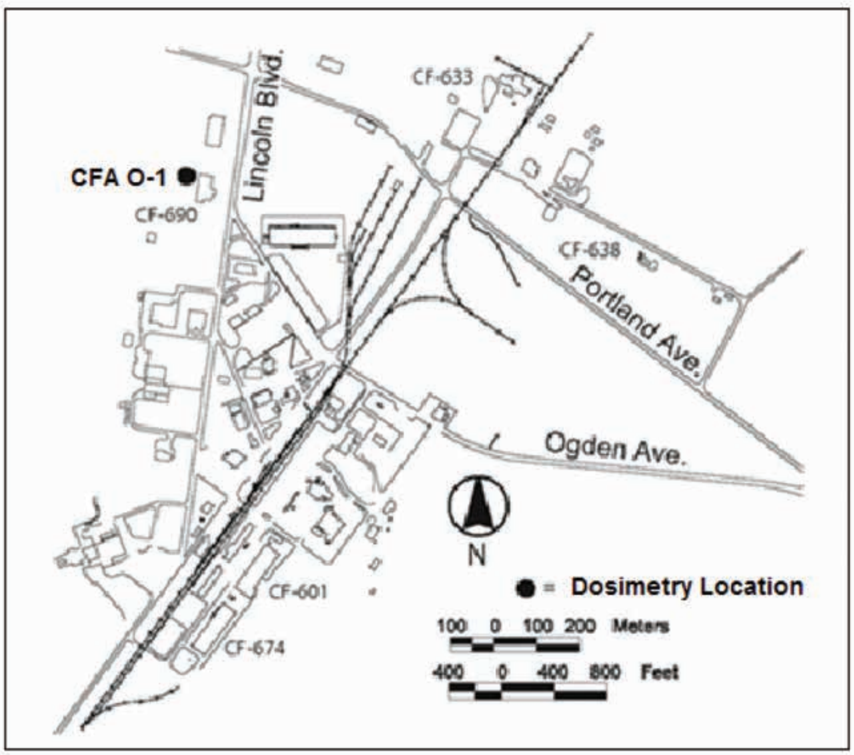

Figure D-3. Environmental Radiation Measurements at Central Facilities Area (2015).

Location	Exposure[a] Nov. 2014 – April 2015	May 2015 – Oct. 2015
ICPP 9	87	84
ICPP 14	new	84
ICPP 15	92	99
ICPP 17	71	73
ICPP 19	new	74
ICPP 20	new	197
ICPP 21	87	87
ICPP 22	new	92
ICPP 23	76	end

Location	Exposure[a] Nov. 2014 – April 2015	May 2015 – Oct. 2015
ICPP 25	71	70
ICPP 26	67	68
ICPP 27	new	95
ICPP 28	new	94
ICPP 30	new	157
TreeFarm 1	new	107
TreeFarm 2	new	90
TreeFarm 3	92	92
TreeFarm 4	new	115

a. All values are gross counts in mrem.

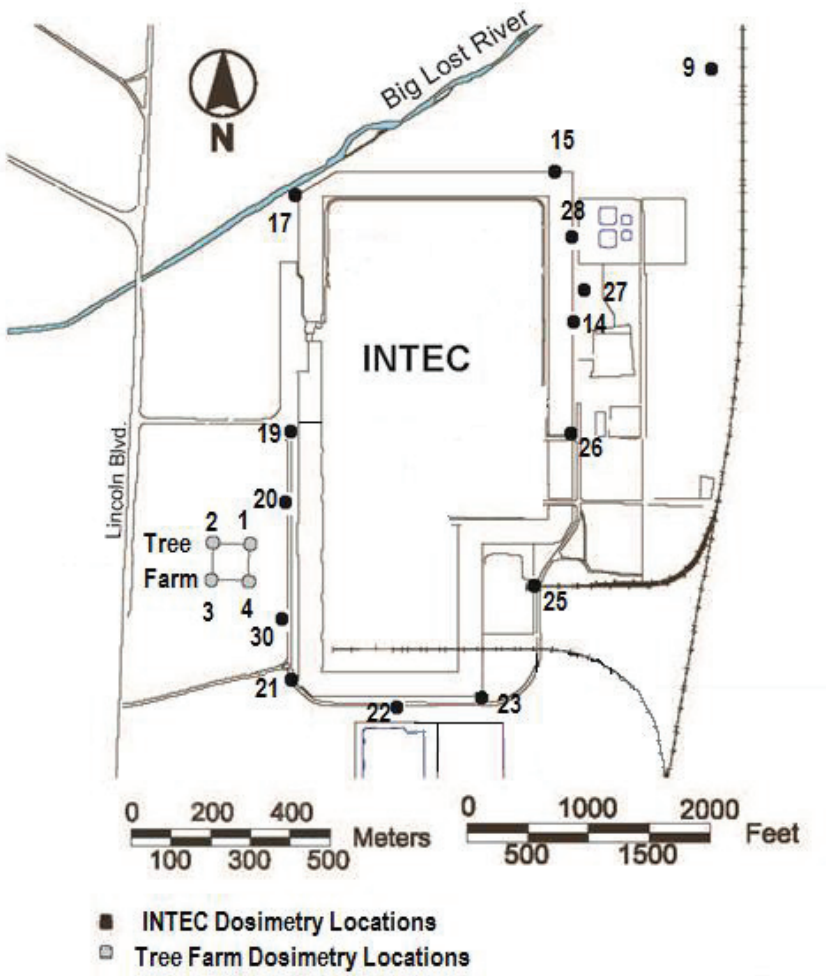

Figure D-4. Environmental Radiation Measurements at Idaho Nuclear Technology and Engineering Center (2015).

Location	Exposure[a] Nov. 2014 – April 2015	May 2015 – Oct. 2015
IF-603N O-1	56	49
IF-603E O-2	53	50
IF-603S O-3	52	52
IF-603W O-4	61	59
IF-627 O-30	52	53
IF-638N O-1	56	54
IF-638E O-2	50	55
IF-638S O-3	59	59
IF-638W O-4	59	59
IF-670N O-31	new	56
IF-670E O-32	new	50
IF-670S O-33	new	54
IF-670D O-34	new	56
IF-670W O-35	new	64
IRC O-39	54	57

a. All values are gross counts in mrem.

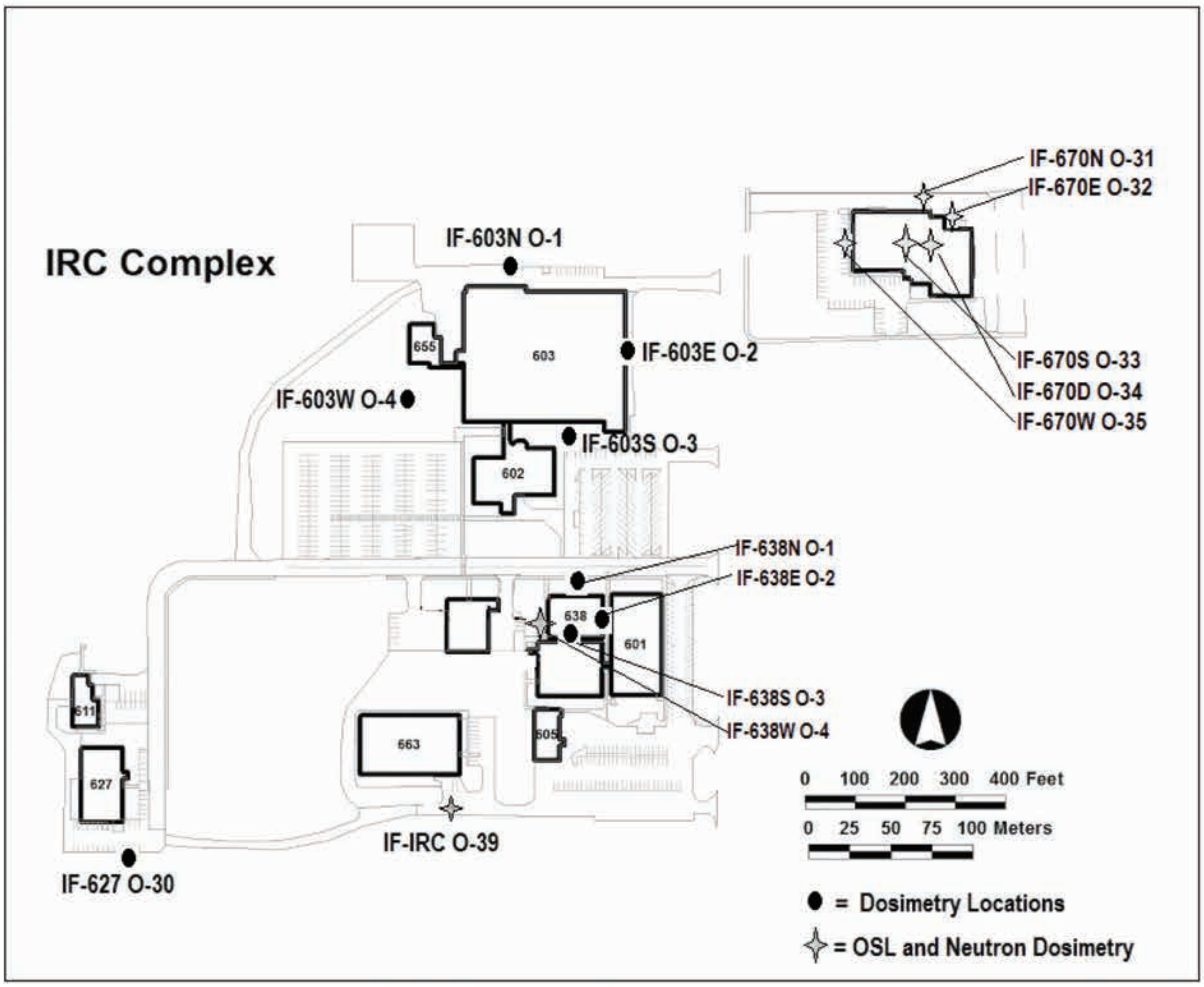

Figure D-5. Environmental Radiation Measurements at INL Research Center Complex (2015).

Location	Exposure[a] Nov. 2014 – April 2015	Exposure[a] May 2015 – Oct. 2015
ANL O-7	73	71
ANL O-8	new	59
ANL O-12	56	60
ANL O-13	64	end
ANL O-14	new	63
ANL O-15	71	75
ANL O-16	new	70
ANL O-17	63	end
ANL O-18	61	62
ANL O-19	new	68
ANL O-20	new	66
ANL O-21	new	78
ANL O-22	new	80

Location	Exposure[a] Nov. 2014 – April 2015	Exposure[a] May 2015 – Oct. 2015
ANL O-23	new	60
ANL O-24	new	63
ANL O-25	new	67
ANL O-26	new	63
TREAT O-1	new	76
TREAT O-2	new	74
TREAT O-3	new	80
TREAT O-4	new	85
TREAT O-5	new	102
TREAT O-6	new	75
TREAT O-7	new	76
TREAT O-8	new	74

a. All values are gross counts in mrem.

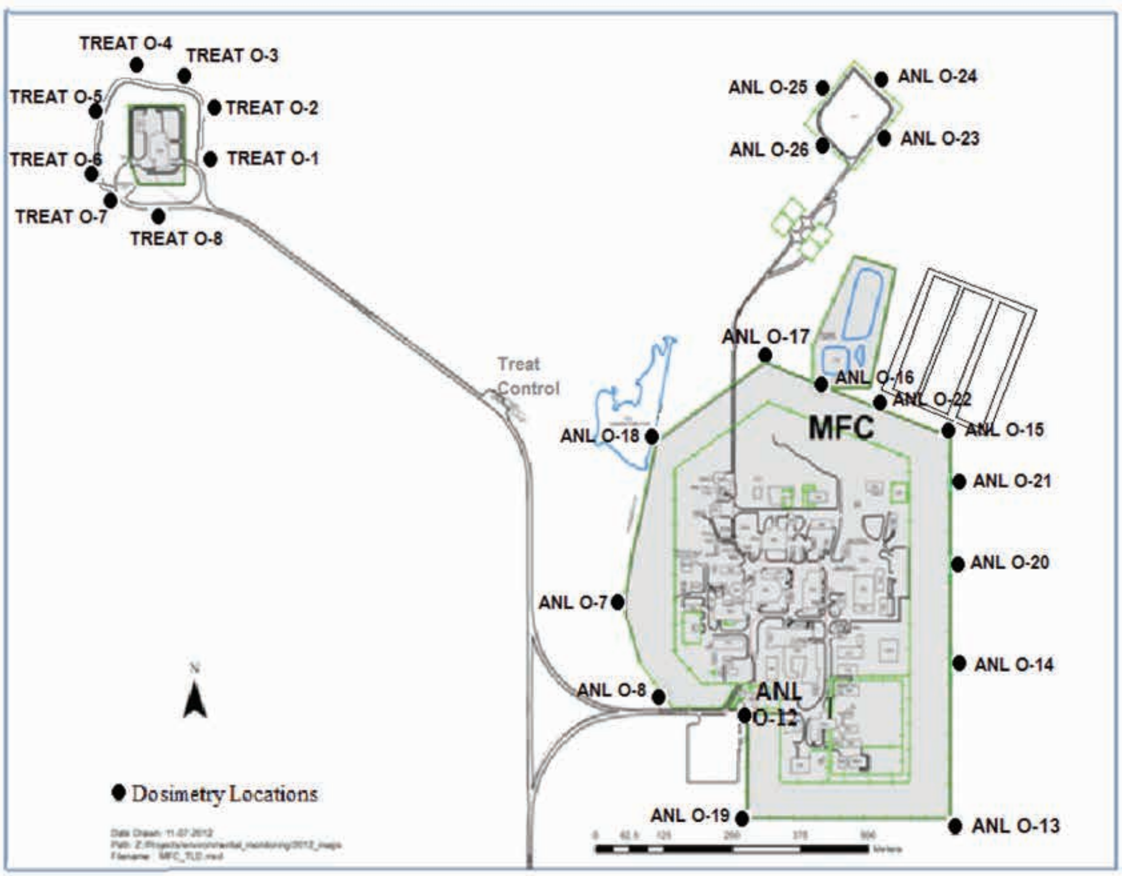

Figure D-6. Environmental Radiation Measurements at Materials and Fuels Complex (2015).

Location	Exposure[a] Nov. 2014 – April 2015	May 2015 – Oct. 2015
NRF O-4	74	68
NRF O-5	68	71
NRF O-11	new	64
NRF O-12	66	66
NRF O-13	new	66

Location	Exposure[a] Nov. 2014 – April 2015	May 2015 – Oct. 2015
NRF O-16	66	66
NRF O-18	new	69
NRF O-19	73	67
NRF O-20	66	67

a. All values are gross counts in mrem.

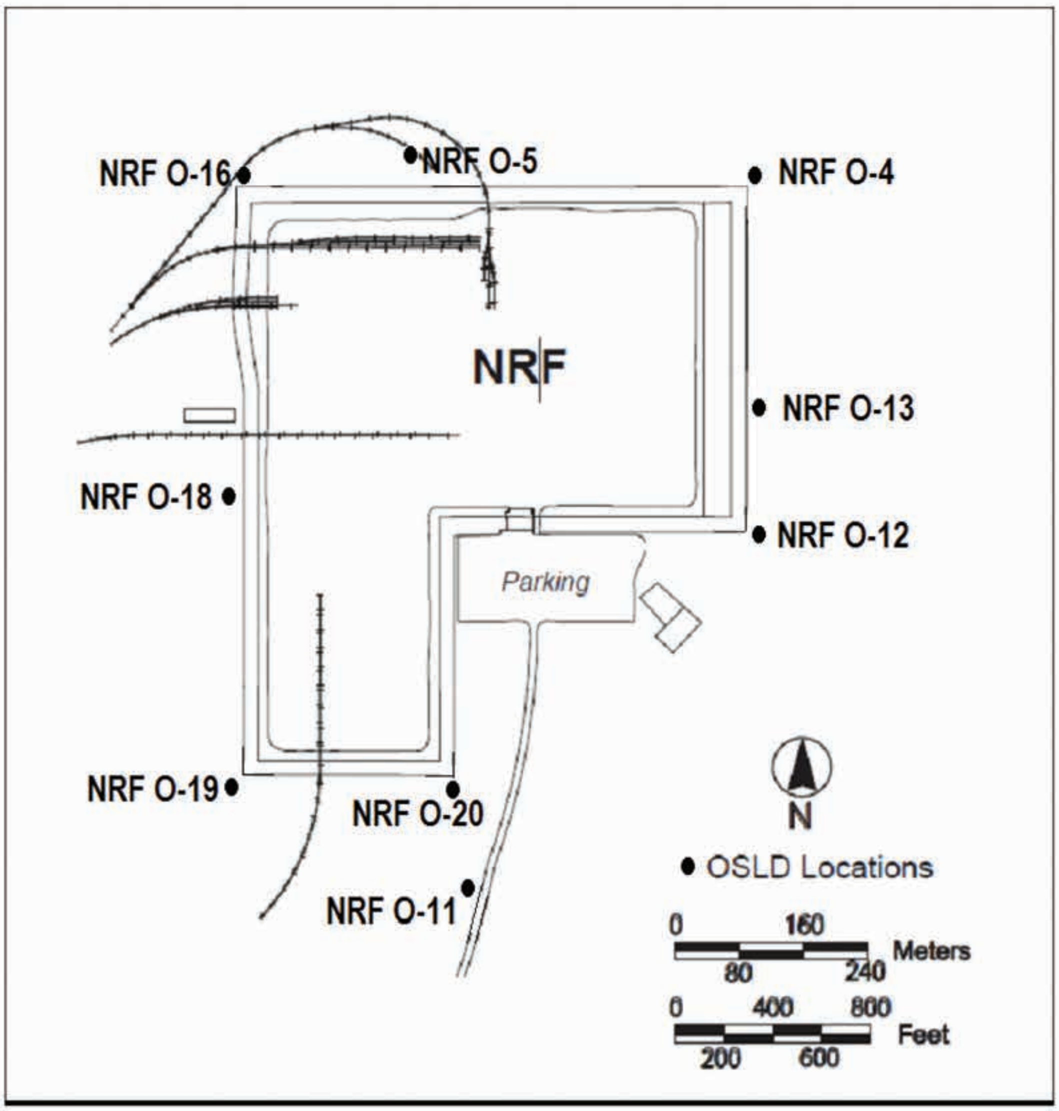

Figure D-7. Environmental Radiation Measurements at Naval Reactors Facility (2015).

Location	Exposure[a]	
	Nov. 2014 – April 2015	May 2015 – Oct. 2015
IF-675E O-31	54	52
IF-675D O-33	53	48
IF-675S O-34	56	56
IF-675W O-35	56	56

a. All values are gross counts in mrem.

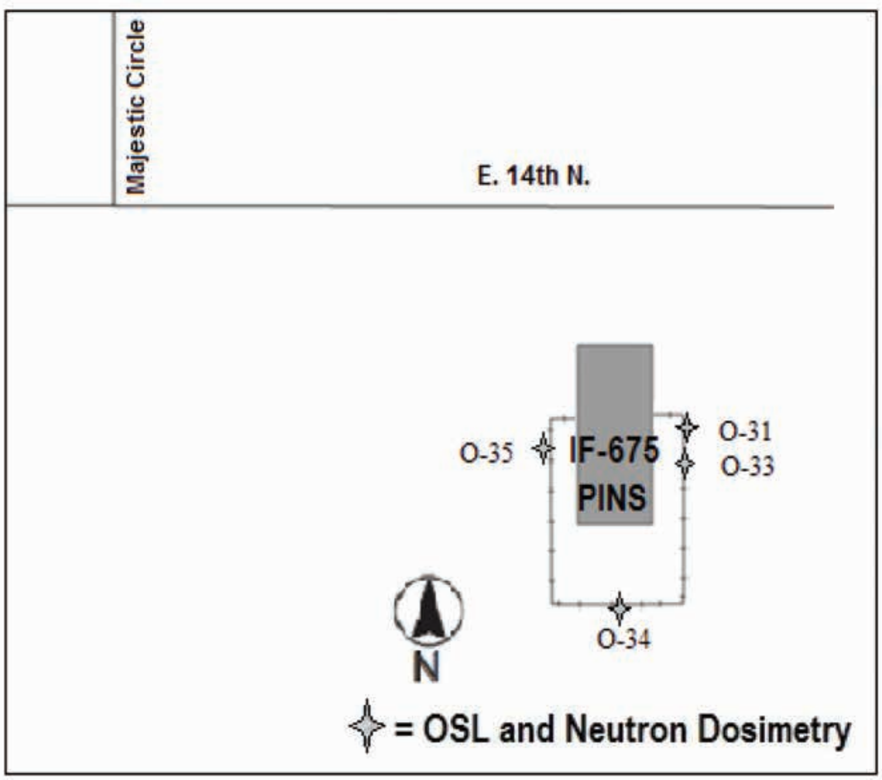

Figure D-8. Environmental Radiation Measurements at IF-675 PINS Facility (2015).

Location	Exposure[a] Nov. 2014 – April 2015	Exposure[a] May 2015 – Oct. 2015
RWMC O-3A	new	67
RWMC O-5A	new	62
RWMC O-7A	new	62
RWMC O-9A	79	80
RWMC O-11A	new	70
RWMC O-13A	88	83
RWMC O-17A	65	end
RWMC O-19A	new	66
RWMC O-21A	73	69

Location	Exposure[a] Nov. 2014 – April 2015	Exposure[a] May 2015 – Oct. 2015
RWMC O-23A	new	65
RWMC O-25A	66	64
RWMC O-27A	new	67
RWMC O-29A	71	66
RWMC O-39	65	70
RWMC O-41	114	130
RWMC O-43	68	68
RWMC O-46	62	72
RWMC O-47	new	65

a. All values are gross counts in mrem.

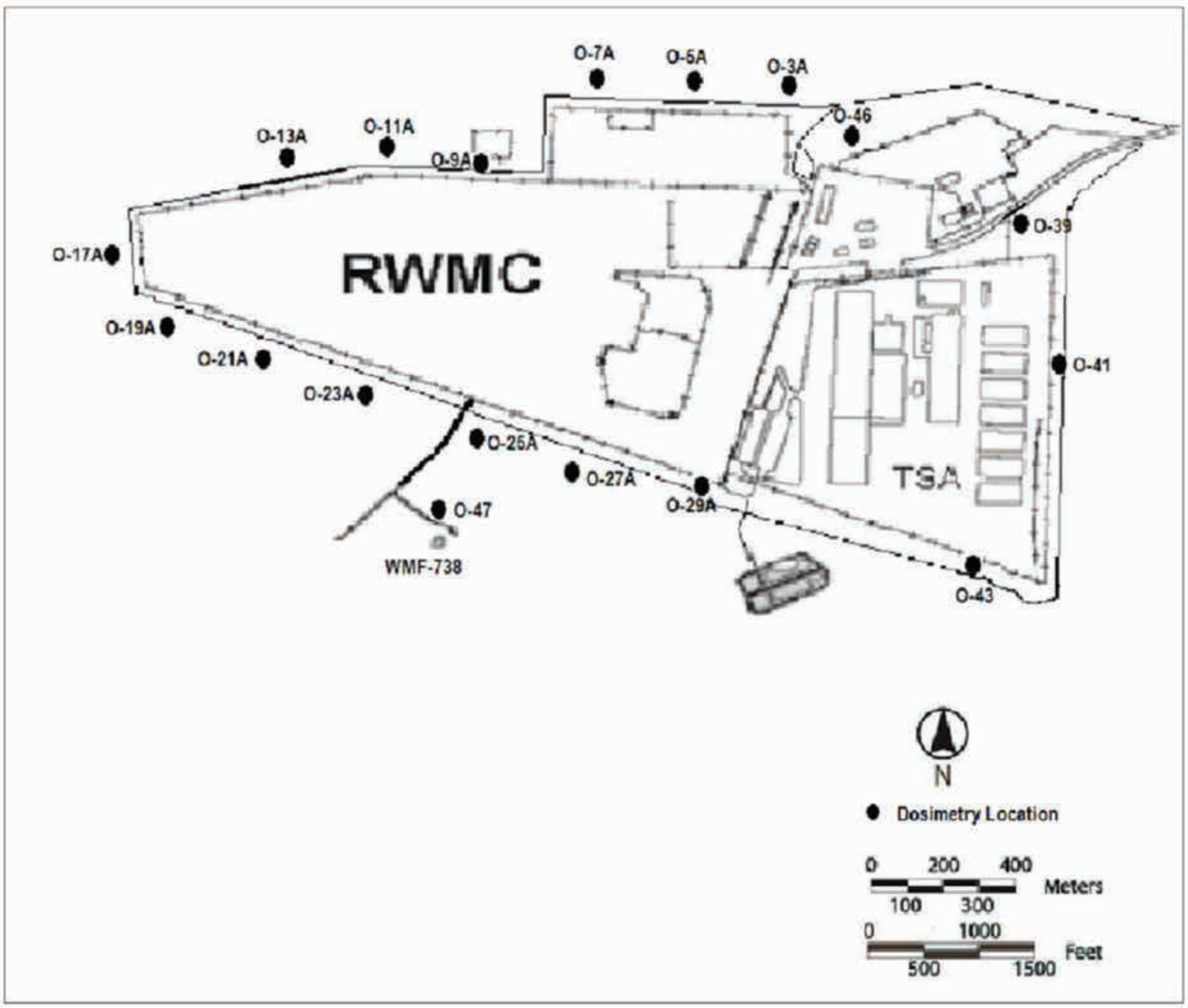

Figure D-9. Environmental Radiation Measurements at Radioactive Waste Management Complex (2015).

Location	Exposure[a] Nov. 2014 – April 2015	May 2015 – Oct. 2015
TAN LOFT O-6	72	68
TAN LOFT O-7	71	71
TAN LOFT O-8	new	65
TAN LOFT O-9	new	54
TAN LOFT O-10	new	68
TAN LOFT O-11	new	68
TAN LOFT O-12	new	65
TAN LOFT O-13	new	69

a. All values are gross counts in mrem.

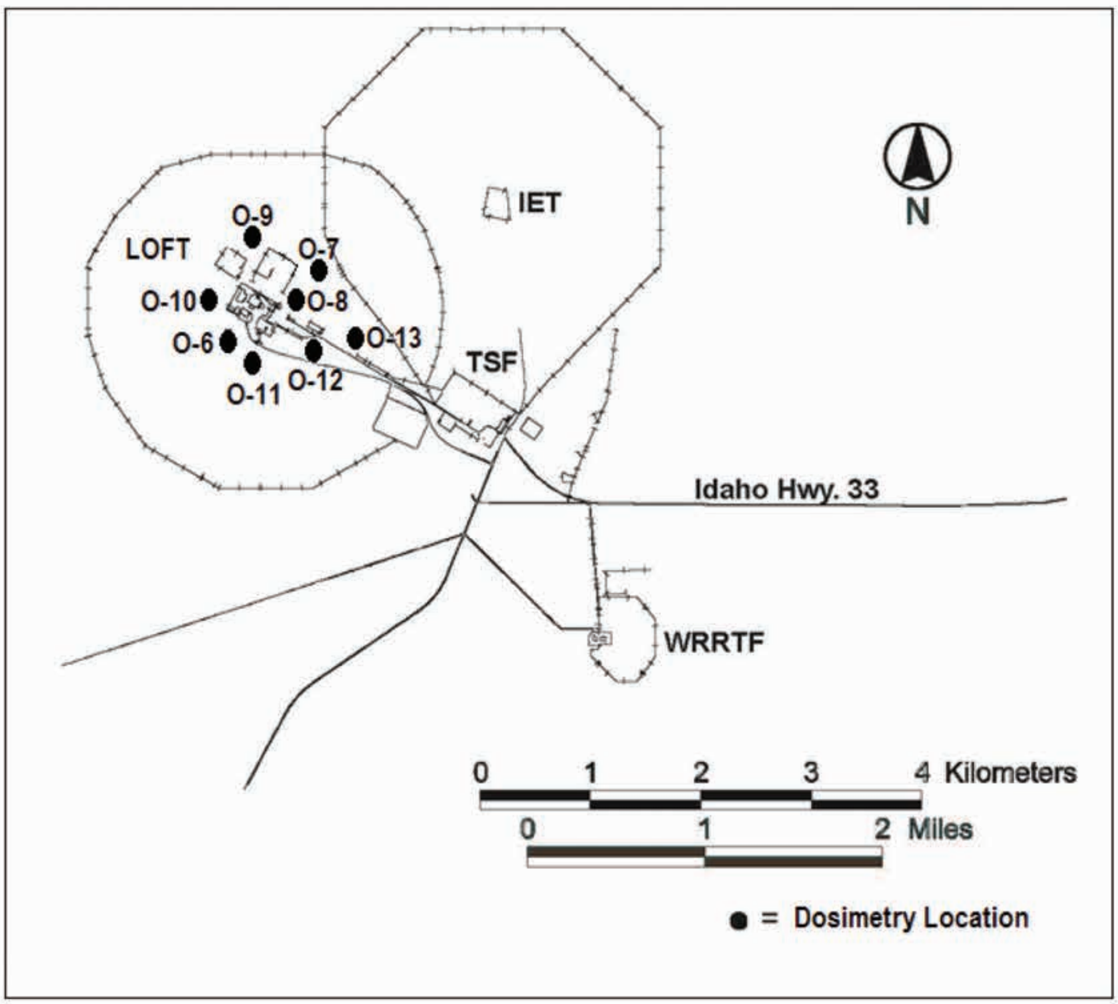

Figure D-10. Environmental Radiation Measurements at Test Area North (2015).

Location	Exposure[a] Nov. 2014 – April 2015	Exposure[a] May 2015 – Oct. 2015
EBR1 O-1	59	56
EFS O-1	67	63
Gate4 O-1	new	59
Haul E O-1	new	64
Haul W O-2	new	63
Hwy20 Mile O-266	new	62
Hwy20 Mile O-270	new	65
Hwy20 Mile O-276	68	59
Hwy22 T28 O-1	59	53
Hwy28 N2300 O-2	50	51

Location	Exposure[a] Nov. 2014 – April 2015	Exposure[a] May 2015 – Oct. 2015
Hwy33 T17 O-3	57	57
LincolnBvld O-1	70	65
LincolnBvld O-3	70	72
LincolnBvld O-5	72	72
LincolnBvld O-9	70	75
LincolnBvld O-15	new	79
LincolnBvld O-25	66	67
Main Gate O-1	71	66
Rest O-1	new	63
VANB O-1	68	68

a. All values are gross counts in mrem.

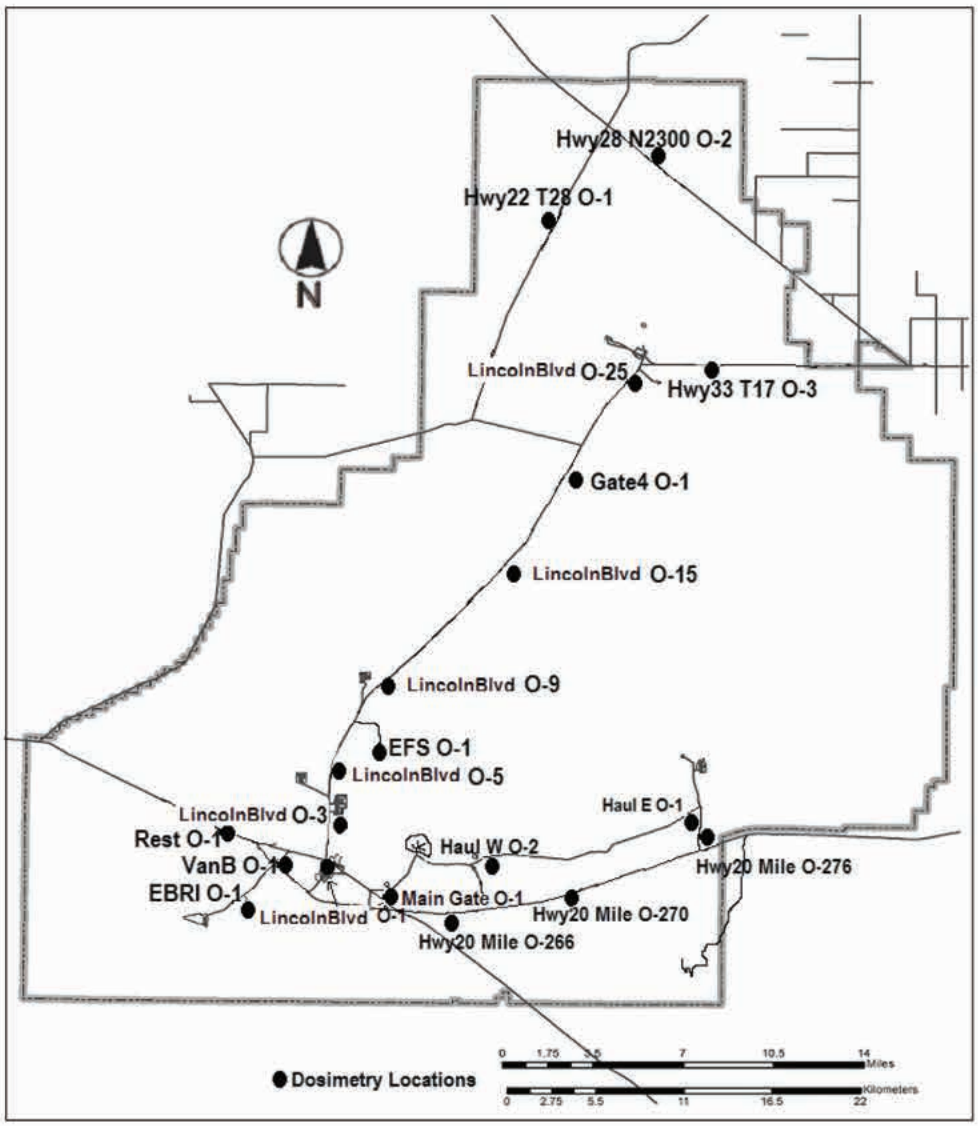

Figure D-11. Environmental Radiation Measurements at Sitewide Locations (2015).

Location	Exposure[a] Nov. 2014 – April 2015	May 2015 – Oct. 2015
Arco O-1	61	64
Atomic City O-2	58	59
Blackfoot O-9	58	56
Craters O-7	62	63
Howe O-3	lost	62
Idaho Falls O-10	62	62
IF-IDA O-38	55	54
Monteview O-4	61	56
Mud Lake O-5	67	68

Location	Exposure[a] Nov. 2014 – April 2015	May 2015 – Oct. 2015
Reno Ranch O-6	55	53
Rexburg O-12	63	end
Roberts O-13	68	67
RRL3	new	61
RRL5	new	76
RRL6	new	62
RRL17	new	55
RRL24	new	56

a. All values are gross counts in mrem.

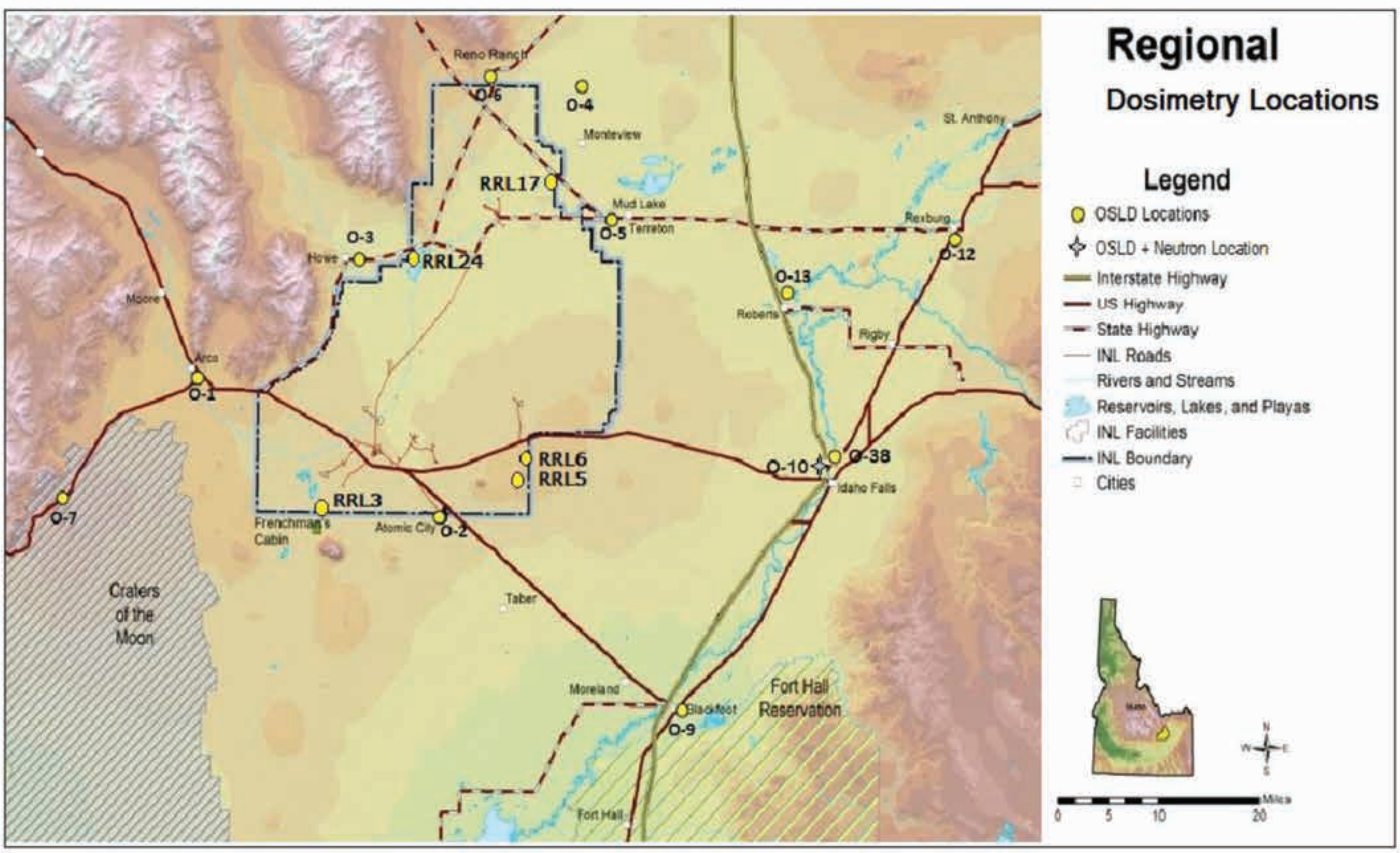

Figure D-12. Environmental Radiation Measurements at Regional Locations (2015).

Location	Exposure[a] Nov. 2014 – April 2015	May 2015 – Oct. 2015
IF-616N O-36	57	53
IF-665W O-37	52	53

a. All values are gross counts in mrem.

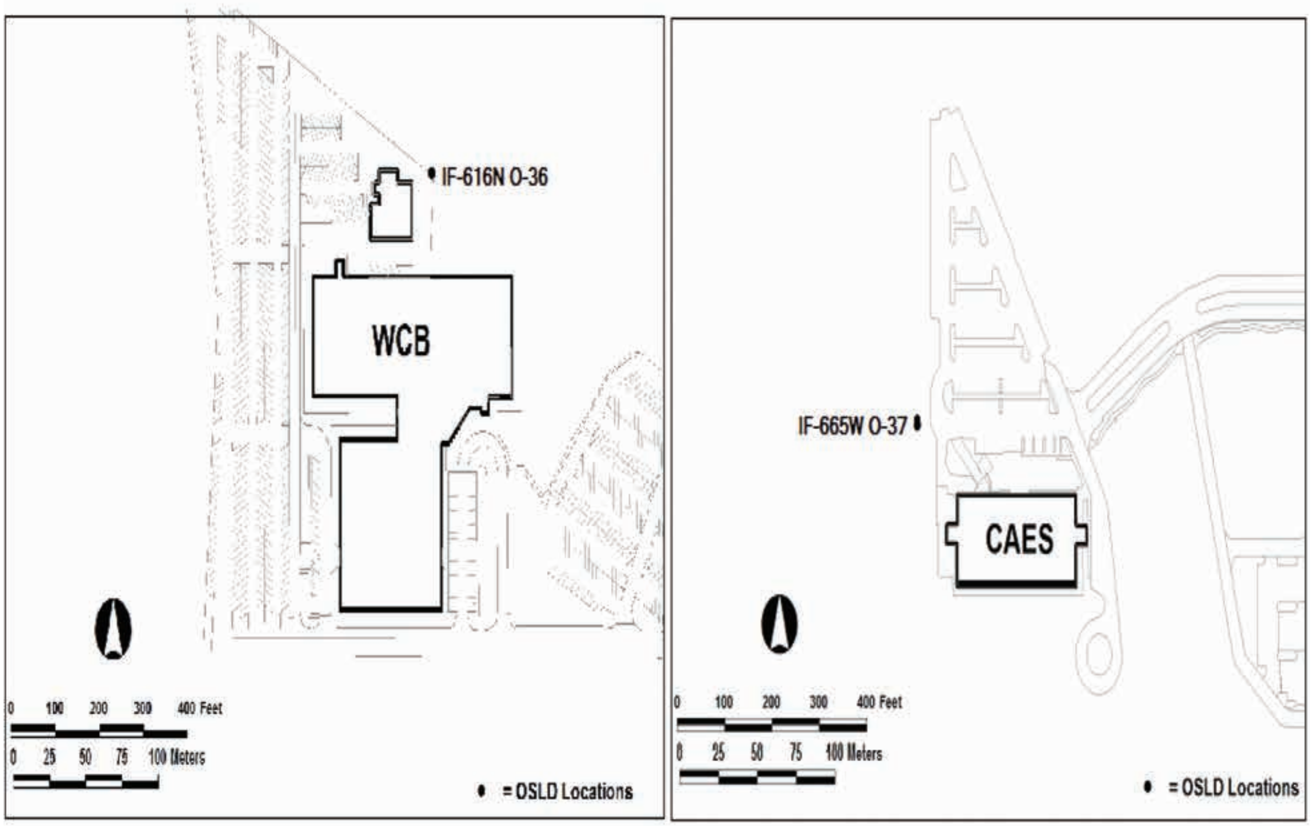

Figure D-13. Environmental Radiation Measurements at Willow Creek Building and Center for Advanced Energy Studies (2015).

Male Greater Sage-grouse

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 forward, 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 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 3.7×10^{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 × 1010 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: An area between all available data and the conclusions that are drawn from the data where the existing data are sparse or nonexistent. An example would be inferring the interactions in the environment of one radionuclide that has not been studied from a chemically similar radionuclide that has been studied.

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: 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 MDIFF air 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 (H_T): 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 that has been 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 bordering a river that 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, 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 with respect 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 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 of water soaking into 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 146 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

management and operating (M&O) contract: An agreement under which the government contracts for the operation, maintenance, or support, on its behalf, of a government-owned or -controlled research, development, special production, or testing establishment wholly or principally devoted to one or more major programs of the contracting federal agency.

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. 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 U.S. Environmental Protection Agency 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:

$$RPD = \frac{|R1 - R2|}{(R1 + R2)/2} \, x \, 100$$

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; usually are 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 rapid 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.

stochastic effect: 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 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.

Calendar Year 2015

U.S. Department of Energy
Idaho Operations Office

Idaho National Laboratory

Environmental Surveillance, Education and Research Program

Wastren Advantage Inc.
120 Technology Drive
Idaho Falls, ID 83402
208-525-8250

www.idahoeser.com