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IDAHO NATIONAL LABORATORY ANNUAL SITE ENVIRONMENTAL REPORT

Idaho National Laboratory

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September 2022

Prepared by

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Anderson's Larkspur

To Our Readers

The Idaho National Laboratory (INL) Site Environmental Report for Calendar Year 2021 is an overview of environmental activities conducted on and in the vicinity of the INL Site from January 1 through December 31, 2021. This report includes:

- Effluent monitoring and environmental surveillance of air, water, soil, vegetation, biota, and agricultural products for radioactivity. The results are compared with historical data, background measurements, and/or applicable standards and requirements in order to verify that the INL Site does not adversely impact the environment or the health of humans or biota.
- A summary of environmental management systems in place to protect air, water, land, and other natural and cultural resources potentially impacted by INL Site operations.
- Ecological and other scientific research conducted on the INL Site that may be of interest to the reader.
- The report addresses three general levels of reader interest:
- The first level is a brief summary with a take-home conclusion. This is presented in the chapter highlights text box at the beginning of each chapter. There are no tables, figures, or graphs in the highlights. This section is intended to highlight general findings for an audience with a limited scientific background.
- The second level is a more in-depth discussion with figures, summary tables, and summary graphs accompanying the text. The chapters of the annual report represent this level, which requires some familiarity with scientific data and graphs. A person with some scientific background can read and understand this report after reading the section entitled, 'Helpful Information.'
- The third level includes links to supplemental and technical reports and websites that support the annual report. This level is directed toward scientists who would like to see original data and more in-depth discussions of the methods used and results.

The links to these reports may be found in the Publications tab of the webpage at https://idahoeser.inl.gov/publications.html.

The Environmental Surveillance, Education, and Research Program (ESER) is responsible for contributing to and producing the INL Annual Site Environmental Report. Environmental monitoring within the INL Site boundaries is primarily the responsibility of the INL and Idaho Cleanup Project (ICP) Core contractors. The ESER Program focuses on surveillance off the INL Site. On October 1, 2021, the ESER Program was transitioned from Veolia Nuclear Solutions - Federal Services to BEA, who manages the INL. Sampling activities were conducted by Veolia Nuclear Solutions Federal Services during the first through third quarters of 2021; therefore, the data will be represented by the ESER contractor. The sampling activities conducted during the fourth quarter of 2021 were performed under BEA, and therefore, that data will be represented by the INL contractor.

Other major contributors to the annual INL Site Environmental Report include the INL contractor (BEA); ICP Core contractor (Fluor Idaho, LLC); U.S. Department of Energy–Idaho Operations Office (DOE-ID); NOAA; and USGS. Links to their websites and the Environmental Surveillance, Education, and Research Program website are:

- INL (https://www.inl.gov/)
- ICP Core (https://fluor-idaho.com/default.aspx#about)
- DOE-ID Office (https://www.id.energy.gov/)

- Field Research Division of National Oceanic and Atmospheric Administration's Air Resources Laboratory (https://www.noaa.inl.gov)
- U.S. Geological Survey (https://www.usgs.gov/centers/idaho-water-science-center)
- Environmental Surveillance, Education, and Research Program (https://idahoeser.inl.gov/).

Elk grazing on ridgeline

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% the size of Rhode Island. It was established in 1949 as the National Reactor Testing Station, and for many years it 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.

Figure ES-1. Regional location of the INL Site.

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

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

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

Purpose of the INL Site Environmental Report

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

- Present the INL Site, mission, and programs
- Report compliance status with applicable federal, state, and local regulations
- Describe the INL Site environmental programs and activities
- Summarize results of environmental monitoring
- Discuss potential radiation doses to the public residing in the vicinity of the INL Site
- Report on ecological monitoring and research conducted by contractors and affiliated agencies and by independent researchers through the Idaho National Environmental Research Park
- Describe quality assurance methods used to ensure confidence in monitoring data
- Provide supplemental technical data and reports that support the INL Site Environmental Report (https://idahoeser.inl.gov/publications.html).

Major INL Site Programs and Facilities

There are two primary programs at the INL Site: INL and the ICP Core. The prime contractors at the INL Site in 2021 were: Battelle Energy Alliance (BEA), the management and operations contractor for INL, and Fluor Idaho, which managed ongoing cleanup operations under the ICP Core and operated the Advanced Mixed Waste Treatment Project (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% of employees work in administrative, scientific support, and non-nuclear laboratory programs at offices in Idaho Falls.

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

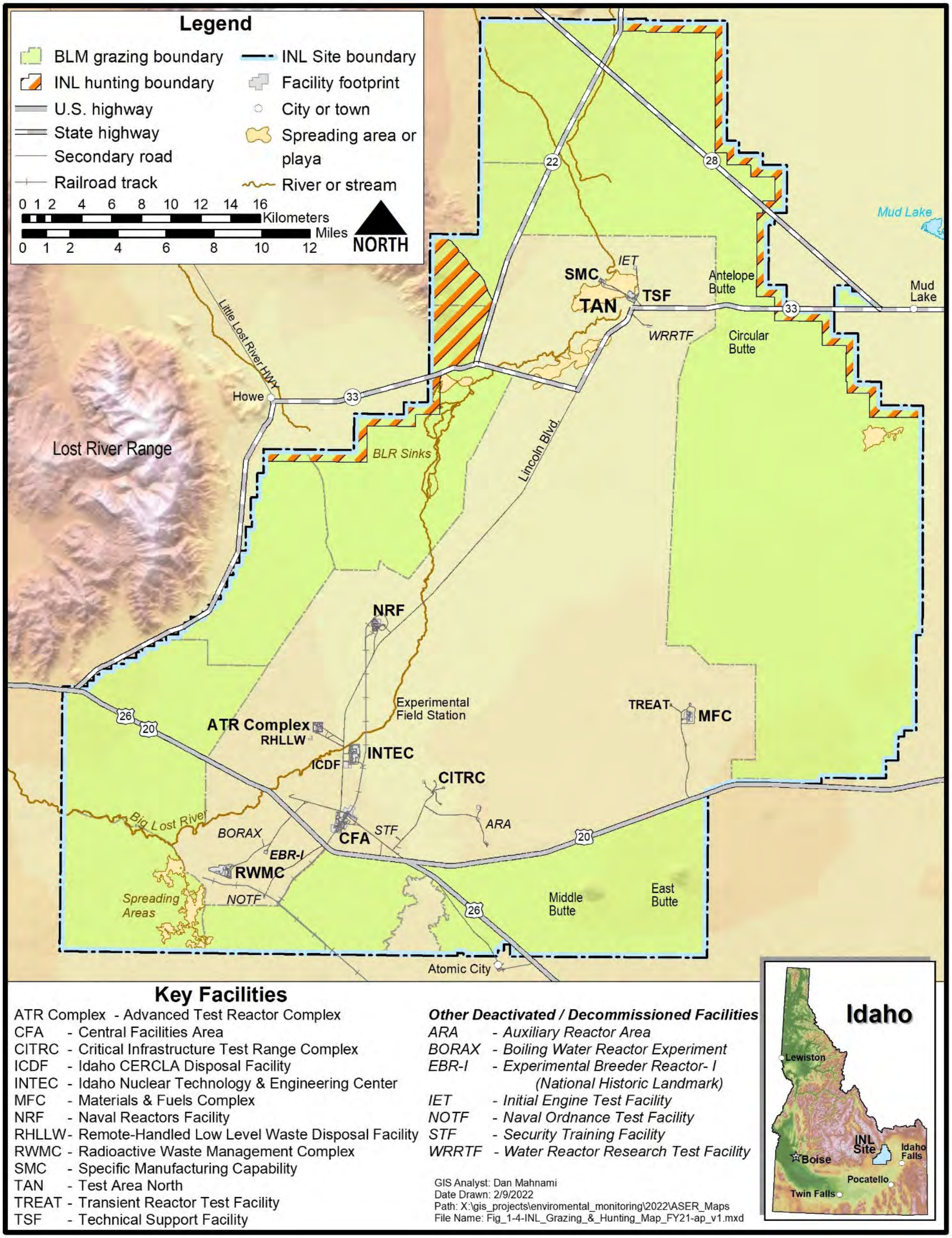

Figure ES-2. INL Site facilities.

Table ES-1. Major INL Site areas and missions.

MAJOR INL SITE AREA[a]	OPERATED BY	MISSION
Advanced Test Reactor Complex	INL	Research and development of nuclear reactor technologies. Home of the ATR, a DOE Nuclear Science User Facility and the world's most advanced nuclear test reactor. The ATR provides unique irradiation capabilities for nuclear technology research and development.
Central Facilities Area	INL	INL support for the operation of other INL Site facilities and management responsibility for the balance of the INL outside of the facility boundaries.
Critical Infrastructure Test Range Complex	INL	Supports National and Homeland Security missions of the laboratory, including program and project testing (i.e., critical infrastructure resilience and nonproliferation testing and demonstration).
Idaho Nuclear Technology and Engineering Center	ICP Core	Dry and wet storage of spent nuclear fuel; management of high-level waste calcine and sodium-bearing liquid waste; and operation of the Idaho Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Disposal Facility including a landfill, evaporation ponds, and a staging and treatment facility.
Materials and Fuels Complex	INL	Research and development of nuclear fuels. Pyro-processing, which uses electricity to separate waste products in the recycling of nuclear fuel, is also researched here. Nuclear batteries for use on the nation's space missions are made at MFC.
Radioactive Waste Management Complex	ICP Core	Environmental remediation and waste treatment, storage, and disposal for wastes generated at the INL Site and other DOE sites. The AMWTP characterizes, treats, and packages transuranic waste for shipment out of Idaho to permanent disposal facilities. Location of the Integrated Waste Treatment Unit (IWTU), a first-of-a-kind, 53,000-square-foot facility, that will treat 900,000 gallons of liquid radioactive and hazardous waste that has been stored in underground storage tanks.
Research and Education Campus	INL	Located in Idaho Falls, Idaho, REC is home to DOE's Radiological and Environmental Sciences Laboratory (RESL), 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/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 the manufacture of tank armor for the U.S. Army's battle tanks at the SMC for the U.S. Department of Defense (DoD).

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

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, a radioactive waste management program, and programs addressing radiation protection of the public and the environment. BEA and Fluor Idaho have each established and implemented an EMS, as well as contributing 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 Site

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 (ISMS) and EMS.

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 the U.S. Environmental Protection Agency (EPA). The FFA/CO governs the INL Site's environmental remediation activities. It specifies actions that must be completed to safely clean-up sites at the INL Site in compliance with the CERCLA, as well as the corrective action requirements of the Resource Conservation and Recovery Act (RCRA). 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 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 2021, 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. 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 2021 from the air pathway was 0.067 mrem (0.67 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 as determined by the air dispersion model. This person is assumed to live at a location east of INL's east entrance and south of Highway 20. For comparison, the dose from natural background radiation was estimated in 2021 to be 387 mrem (3,870 µSv) to an individual living on the Snake River Plain.

The maximum potential population dose to the approximately 353,435 people residing within an 80 km (50 mi) radius of any INL Site facility was calculated as 0.028 person-rem (0.00028 person-Sv), below that expected from exposure to background radiation (136,779 person-rem or 1,368 person-Sv). The 50 mi population dose calculated for 2021 is lower than that calculated for 2020 (0.054 person-rem or 0.00054 person-Sv).

The maximum potential individual dose from consuming waterfowl contaminated at the INL Site, based on the highest concentrations of radionuclides measured in edible tissue of samples collected near the ATR Complex ponds, was estimated to be 0.002 mrem (0.02 µSv). In 2021, none of the game samples collected (e.g., eight elk and two mule deer) had a detectable concentration of cesium-137 (^{137}Cs) or other human-made radionuclides. When the dose estimated for the air pathway was summed with the dose from consuming contaminated waterfowl, assuming that the waterfowl is eaten by the same hypothetical individual, the representative person off the INL Site could potentially receive a total dose of 0.069 mrem (0.69 µSv) in 2021. This is 0.069% of the DOE health-based dose limit of 100 mrem/yr (1 mSv/yr) from all pathways for the INL Site.

Table ES-2. Contribution to estimated annual dose from INL Site facilities by pathway (2021).

PATHWAY	ANNUAL DOSE TO MAXIMALLY EXPOSED INDIVIDUAL (mrem)	ANNUAL DOSE TO MAXIMALLY EXPOSED INDIVIDUAL (µSv)	PERCENT OF DOE 100 MREM/YR LIMIT[a]	ESTIMATED POPULATION DOSE (PERSON-mrem)	ESTIMATED POPULATION DOSE (PERSON-Sv)	POPULATION WITHIN 80 KM	ESTIMATED BACKGROUND RADIATION POPULATION DOSE (PERSON-rem)[b]
Air	0.067	0.67	0.067	0.028	0.00028	353,435	136,779
Waterfowl	0.002	0.02	0.002	NA[c]	NA	NA	NA
Big game animals	0.000	0.00	NA	NA	NA	NA	NA
Total pathways	**0.069**	**0.69**	**0.069**	**0.028**	**0.00028**	**NA**	**NA**

a. The DOE public dose limit from all sources of ionizing radiation and exposure pathways that could contribute significantly to the total dose is 100 mrem/yr (1 mSv/yr) total effective dose equivalent. It does not include dose from background radiation.

b. The individual background dose was estimated to be 387 mrem or 0.387 rem in 2021, as shown previously in Table 7-8. The background population dose is calculated by multiplying the individual background dose by the population within 80 km (50 mi) of the INL Site.

c. NA = Not applicable.

Tritium has been previously detected in two U.S. Geological Survey (USGS) monitoring wells located on the INL Site along the southern boundary. A hypothetical individual ingesting the maximum concentration of tritium (4,280 pCi/L) via drinking water from these wells would receive a dose of approximately 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 (20,000 pCi/L) corresponds to a dose of approximately 4 mrem (0.04 mSv [40 µSv/yr]).

A dose to a maximally exposed individual located in Idaho Falls near the DOE RESL and the IRC, within the REC, was calculated for compliance with the Clean Air Act. For 2021, the dose was conservatively estimated to be 0.062 mrem (0.62 µSv), which is less than 0.1% of the 10-mrem/yr federal standard.

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

Environmental Compliance

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

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	The Clean Air Act is the basis for national air pollution control. Emissions of radioactive hazardous air pollutants are regulated by EPA, via the National Emission Standards for Hazardous Air Pollutant (40 CFR 61, Subpart H).	The INL Site is in compliance, as reported in *National Emission Standards for Hazardous Air Pollutants – Calendar Year 2021*.	2.2.1 4.2 4.3 8.2.1
DOE/Order 458.1, Change 3	The order establishes requirements to protect the public and the environment against undue risk from radiation associated with radiological activities conducted under the control of DOE pursuant to the Atomic Energy Act of 1954, as amended. The Order requires preparation of an Environmental Radiation Protection Plan that outlines the means by which facilities monitor their impacts on the public and the environment.	The INL Site maintains and implements several plans and programs for monitoring the management of facilities, wastes, effluents, and emissions to determine if operations present risk to the public, workers, or the environment. Environmental monitoring plans are well documented, and the results are published in the annual INL Site Environmental Report. The INL Site maintains compliance with DOE O 458.1.	Chapter 4 Chapter 5 Chapter 6 Chapter 7 Chapter 8
EPA/40 CFR 300	The CERCLA provides the regulatory framework for remediation of releases of hazardous substances and remediation (including decontamination and decommissioning) of inactive hazardous waste disposal sites.	Nuclear research and other operations at the INL Site left behind contaminants that pose a potential risk to human health and the environment. DOE-ID entered into a tri-party agreement in 1991, the FFA/CO, the EPA, and the state of Idaho. INL Site remediation is conducted by the ICP Core, which operates in compliance with the governing regulatory framework.	2.1
EPA/40 CFR 109-140	The Clean Water Act establishes goals to control pollutants discharged to U.S. surface waters.	The INL Site complies with two Clean Water Act permits as applicable or needed – the National Pollution Discharge Elimination System permits and Storm Water Discharge Permits for construction activity.	2.3.1
EPA/40 CFR 141-143	The Safe Drinking Water Act establishes primary standards for public water supplies to ensure it is safe for consumption.	The INL Site routinely sampled and analyzed 10 drinking water systems in 2021 as required by the state of Idaho and the EPA. The Site maintains compliance with the Safe Drinking Water Act.	2.3.2 6.7
EPA/40 CFR 239-282	The Resource Conservation and Recovery Act established regulatory standards for generation, transportation, storage, treatment, and disposal of hazardous waste.	The Idaho Department of Environmental Quality (DEQ) conducted a Resource Conservation and Recovery Act inspections of the INL Site in June 2021. There were no violations cited. The INL Site operates in compliance with the governing EPA and State hazardous waste regulations.	2.1.2

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 (CFR), 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 1,076 curies (3.98×10^{13} Bq) of radioactivity, primarily in the form of short-lived noble gas isotopes, were released as airborne effluents in 2021. These airborne releases of radionuclides are reported to comply with regulatory requirements and are considered in the design and conduct of INL Site environmental surveillance activities.

The INL Site environmental surveillance programs, conducted by the INL, ICP Core, and ESER contractors, emphasize measurement of airborne radionuclides, because air transport is considered the major potential pathway from INL Site releases to human receptors. During 2021, the INL contractor monitored ambient air at 16 locations on the INL Site and at six locations off the INL Site. The ICP Core contractor focused on ambient air monitoring of waste management facilities, namely INTEC and RWMC. The ESER contractor monitored 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.

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

All radionuclide concentrations in ambient air samples were below DOE radiation protection standards for air. 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 measurable in environmental air samples.

The INL contractor collected atmospheric moisture samples at two stations on and two stations off the INL Site in 2021. The ESER contractor collected atmospheric moisture at one location on and three locations off the INL Site. Precipitation was collected at the same four locations. The INL and ESER samples were all analyzed for tritium. The results were within measurements made historically and below DOE Derived Concentration Standards (DCS). Tritium measured in these samples is most likely the result of natural production in the atmosphere and remnants of nuclear weapons testing and not the result of INL Site effluent releases.

Environmental Monitoring of Groundwater, Drinking, and Surface Water

The INL and ICP Core contractors monitor liquid effluents (wastewater), 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 an industrial waste pond at MFC. DOE-ID complies with the state of Idaho groundwater quality, wastewater, and reuse rules for these effluents through reuse permits, which provide for monitoring of the wastewater and, in some instances, groundwater in the area. During 2021, liquid effluent and groundwater monitoring were conducted in support of reuse permit requirements. An annual site performance report for each permitted reuse facility was prepared and submitted to the DEQ. No permit limits were exceeded.

Additional liquid effluent monitoring was performed at the ATR Complex Cold Waste Pond, INTEC, and MFC Industrial Waste Pond 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. The INL and ICP Core contractors monitored 10 drinking water systems at the INL Site in 2021. (The NRF contractor monitors an additional drinking water system, the results of which are reported separately by NRF.) Results were below limits for all relevant drinking water standards.

Surface water flows off the Subsurface Disposal Area (SDA) following periods of heavy precipitation or rapid snowmelt. During these times, water may be pumped out of the SDA retention basin into a drainage canal, potentially carrying radionuclides originating from radioactive waste or contaminated surface soil off the SDA. Surface water is collected when it is available. Americium-241, and $^{239/240}$Pu were detected in 2021 samples collected from the SDA Lift Station. 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 is perhaps the single-most important aquifer in Idaho. Composed of layered basalt lava flows and some sediment, it covers an area of approximately 27,972 km^2 (10,800 square miles). The highly productive aquifer has been declared a sole source aquifer by the EPA due to the nearly complete reliance on the aquifer for drinking water supplies in the area.

The USGS began to monitor the groundwater below the INL Site in 1949. Currently, the USGS performs groundwater monitoring, analyses, and studies of the eastern Snake River Plain Aquifer under and adjacent to the INL Site. These activities utilize an extensive network of strategically placed monitoring wells on and around the INL Site. In 2021, 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. Results for monitoring wells sampled within the plumes show nearly all wells had decreasing trends of tritium and ^{90}Sr concentrations over time.

Volatile organic compounds (VOCs) are present in water from the eastern Snake River Plain Aquifer because of historical waste disposal practices at the INL Site. Several purgeable VOCs were detected by USGS in 29 groundwater monitoring wells and one perched well sampled at the INL Site in 2021. Most concentrations of the 61 analyzed compounds were either below the laboratory reporting levels or their respective primary contaminant standards. Trend test results for tetrachloromethane concentrations in water from the RWMC production well show a decreasing trend in that well since 2005. The more recent decreasing trend indicates that remediation efforts designed to reduce VOC movement to the aquifer are having a positive effect. Concentrations of tetrachloromethane from USGS-87 and USGS-120, south of RWMC, have had an increasing trend since 1987, but concentrations have decreased through time at USGS-88. Trichloroethylene was detected above the maximum contaminant level (MCL) in one well sampled by the USGS 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 2021. At TAN (WAG 1), groundwater monitoring continues to monitor the progress of remediation of the plume of trichloroethylene in addition to ^{90}Sr, ^{137}Cs, tritium, and uranium-234 (^{234}U). Remedial action consists of three components: in situ bioremediation; pump and treat; and monitored natural attenuation. Strontium-90 and ^{137}Cs were present in wells in the source area at levels higher than those prior to starting in situ bioremediation. The elevated concentrations of these radionuclides are due to in situ bioremediation activities. The radionuclide concentrations will continue to be evaluated to determine if they will meet remedial action objectives by 2095.

Groundwater samples were collected from seven aquifer wells in the vicinity of ATR Complex (WAG 2) during 2021 and were analyzed for ^{90}Sr, cobalt-60 (^{60}Co), tritium, and chromium. Chromium and tritium were the only analytes detected; however, neither of the concentrations were above their respective drinking water MCL established by the EPA.

Groundwater samples were collected from 17 aquifer monitoring wells at and near INTEC (WAG 3) during 2021 and analyzed for a suite of radionuclides and inorganic constituents. Strontium-90, technetium-99 (^{99}Tc), and nitrate exceeded their respective drinking water MCLs in one or more aquifer monitoring wells at or near INTEC, with ^{90}Sr exceeding its MCL by the greatest margin in a well south (downgradient) of the former INTEC injection well. All other well locations showed ^{90}Sr levels similar or slightly lower than those reported in previous samples.

Monitoring of groundwater at CFA (WAG 4) consists of CFA landfill monitoring as well as monitoring of a nitrate plume south of the CFA. Wells at the landfill were monitored in 2021 for metals (filtered), VOCs, and anions (e.g., nitrate, chloride, fluoride, sulfate). Iron and pH for CFA landfill monitoring exceeded a secondary MCL. Nitrate continued to exceed the EPA MCL in one well in the plume south of the CFA in 2021, and overall, the data show a downward trend since 2006.

Groundwater samples were collected from monitoring wells near the RWMC (WAG 7) in April/May 2021 and analyzed for radionuclides, inorganic constituents, and VOCs. No analytes were detected above the MCLs in samples collected from the aquifer in April/May 2021.

Wells at MFC (as part of WAG 9, and the MFC Industrial Waste Pond Reuse Permit) were sampled for radionuclides, metals, and other water quality parameters in the spring and fall of 2021. Overall, the results were not above the Primary Constituent Standard (PCS)/Secondary Constituent Standard (SCS) and show no evidence of impacts from MFC activities.

Wells along the southern INL Site boundary (as part of WAG 10) are sampled every two years. Groundwater samples were collected in 2021 and were analyzed for chloride, nitrate/nitrite as nitrogen, gross alpha, and gross beta. None of the analytes exceeded EPA MCLs or secondary maximum contaminant levels (SMCLs).

Groundwater is monitored at the Remote-Handled Low Level Waste Facility (RHLLW) for gross alpha, gross beta, carbon-14 (^{14}C), iodine-129 (^{129}I), ^{99}Tc, and tritium. Samples were collected from three monitoring wells in April 2021. The results were not above the PCS/SCS and show no discernable impacts to the aquifer from RHLLW operations.

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 INL Site.

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

To help assess the impact of contaminants released to the environment by operations at the INL Site, agricultural products (e.g., milk, lettuce, alfalfa, grain, potatoes) and wildlife were sampled and analyzed for radionuclides in 2021. The agricultural products were collected on, around, and distant from the INL Site by the ESER contractor.

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

No human-made radionuclides were detected in big game animal samples collected in 2021. Cobalt-60, and ^{90}Sr were detected in tissues of waterfowl collected near the ATR Complex ponds indicating that they accessed the contaminated ponds.

Cobalt-60, zinc-65 (^{65}Zn), ^{90}Sr, ^{137}Cs, ^{238}Pu and $^{239/240}Pu$ were detected in some composited bat samples, indicating that bats may have visited radioactive wastewater ponds, such as those at the ATR Complex.

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

Natural and Cultural Resources Conservation and Monitoring

Conservation planning, land stewardship, and natural resource monitoring and research are routinely used to provide information and direction about protecting or restoring the ecological resources of the INL Site. These efforts also ensure compliance to various environmental laws and regulations so that the INL Site mission and goals can be achieved.

Conservation plans are developed for the protection of species and ecosystems to maintain healthy populations and restore, protect, or enhance natural ecosystems. These plans are initiated when a concern is identified that may impact the INL mission or to protect valuable ecosystems unique to the INL Site. Conservation plans define the concern, develop methods to monitor species and its habitat, and identify best management practices that can be implemented to minimize impacts to species and ecosystems. Conservation plans that have been implemented on the INL Site consist of:

- A Candidate Conservation Agreement (CCA) for the Greater Sage-Grouse (*Centrocercus urophasianus*) was approved and signed by DOE-ID and the U.S. Fish and Wildlife Service in 2014. This conservation agreement provides for the protection of the greater sage-grouse and its habitat on the INL Site. This voluntary agreement developed conservation measures and objectives to avoid or minimize threats to sage-grouse and established a sage-grouse Conservation Area (SGCA). The CCA also established a population trigger based on the 2011 male sage-grouse lek attendance on 27 active leks and a habitat trigger based on sagebrush-dominated habitats within the SGCA at the beginning of 2013.
- The INL Site Bat Protection Plan was finalized in 2018 and identifies threats to bats, provides monitoring and surveying directions, and identifies conservation measures that can be used to conserve bats and their habitat on the INL Site.
- The Sagebrush Steppe Ecosystem Reserve (SSER) was established in 1999 on the INL Site, due to the recognition of the value and uniqueness of this undisturbed sagebrush ecosystem. The primary mission of this area is to conserve native ecosystem components, cultural resources, and Native American Tribal values. The SSER also provides opportunities for scientific investigation of the resources present on the Reserve.
- A Migratory Bird Conservation Plan and a Power Management Avian Protection Plan and Bird Management Policy are in place to protect migratory bird species that inhabit the INL Site for breeding, nesting, or foraging purposes. These plans identify conservation measures that provide protection to birds. A Bird/Wildlife Conservation Working Group has also been established that enables staff members to discuss bird or wildlife issues at their respective facilities, and to identify solutions that can be used to minimize impacts to nesting birds and ensure compliance with requirements of the Migratory Bird Treaty Act.

The INL Site strives to be good stewards of the land by addressing both natural and human caused impacts (e.g., wildland fires, weed invasions). Land stewardship efforts consider climate change and address impacts already being experienced as a result of the changing climate. These efforts include:

- Wildland Fire Protection Planning, Management, and Recovery documents address how to plan for, respond to, and mitigate impacts from wildland fire. Wildland fire is considered a primary threat to the sagebrush steppe ecosystem and those species that rely on this system. Wildland fires have become more frequent than historically experienced. To combat this, a balanced fire management approach has been adopted to ensure the protection of improved laboratory assets in a manner that minimizes effects on natural, cultural, and biological resources.
- Restoration and revegetation are key elements in the preservation of the sagebrush steppe ecosystem at the INL Site. These activities are utilized when native species have been removed by either a project or by wildland fire. Revegetation using native species is also used to stabilize soils and to aid in the prevention of invasive or noxious weed infestations. The INL Site also carries out a compensatory sagebrush mitigation strategy for projects that remove sagebrush habitat. This strategy outlines an approach for projects to provide funds for sagebrush to be restored in designated priority restoration areas where they can provide the greatest habitat benefit for sage-grouse and other wildlife species that depend on sagebrush for survival.
- Rangelands store most of their carbon long-term in the soil in the form of organic carbon through deep-rooted native perennial grasses and shrubs. Keeping INL Site rangeland soils intact is an important action for preserving natural carbon storage. Below-ground carbon stores are lost when annual invasive grasses, like cheatgrass, displace deep-rooted perennial plants. Preventative management and targeted restoration are being used to combat this threat.
- Noxious weeds are spreading at an alarming rate across the western U.S., including the state of Idaho. State and federal regulations require noxious weed control on all lands, including federal reservations such as the INL Site. The INL Site has developed a noxious weed management program to remain in compliance with state and federal laws and have been implementing methods to meet management objectives.

Natural resource monitoring and research at the INL Site are used to support both conservation planning and land stewardship by providing current data on species or areas of concern. Much of the annual monitoring that occurs on the INL Site has been conducted for 30+ years with long-term vegetation data being collected for more than 70 years. Monitoring of sage-grouse, breeding birds, and raptors occurs on an annual basis, while long-term vegetation data is collected once every five-years. More recently, a geographic information system (GIS) has been used for inventory and monitoring of ecological resources on the INL Site. All monitoring data are used to determine current species status and provides valuable information regarding the health of vegetation communities on the INL Site and how they are responding after disturbance. Data are also used to support National Environmental Policy Act (NEPA) analysis. Research is a valuable resource to aid in achieving environmental goals on the INL Site. In 1975, the INL Site was designated a National Environmental Research Park which facilitates various university-led research projects, such as documenting ants and associated arthropods, tracking rattlesnake movements, and addressing ecohydrology in sagebrush steppe.

The INL Cultural Resource Management Office (CRMO) coordinates cultural resource-related activities at the INL Site and implements the INL Cultural Resource Management Plan (DOE-ID 2016) with oversight by DOE-ID's Cultural Resource Coordinator. Cultural resource identification and evaluation studies in fiscal year (FY) 2021 included: (1) archaeological field surveys; (2) monitoring, and site updates related to INL Site project activities; and (3) meaningful collaboration with members of the Shoshone-Bannock Tribes and public stakeholders.

USGS Research

The USGS INL Project Office drills and maintains research wells that 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 2021, the USGS published four research reports and two software releases.

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 2021. Data reported in this document were obtained from several commercial, university, government, and government contractor laboratories. To ensure quality results, these laboratories participated in a number of laboratory quality check programs. Quality issues that arose with laboratories used by the INL, ICP Core, and ESER contractors during 2021 were addressed with the laboratories and have been or are being resolved.

Helpful Information

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What is Radiation?

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.

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' throughout this report. The most common types of radiation are alpha particles, beta particles, X-rays, and gamma-rays. X-rays and gamma-rays, just like visible light and radio waves, are packets of electromagnetic radiation. Collectively, packets of electromagnetic radiation are called photons. One may, for instance, speak of X-ray photons or gamma-ray photons.

Alpha Particles. An alpha particle is a helium nucleus without orbital electrons. It is composed of two protons and two neutrons and has a positive charge of two. Because alpha particles are relatively heavy and have a double charge, they cause intense tracks of ionization but have little penetrating ability, as observed in Figure HI-1. Alpha particles can be stopped by thin layers of materials, such as a sheet of paper or a piece of aluminum foil. Examples of alpha-emitting radionuclides include 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, as can be seen in 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 with very short wave-lengths 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 depend 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, as shown in Figure HI-1.

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

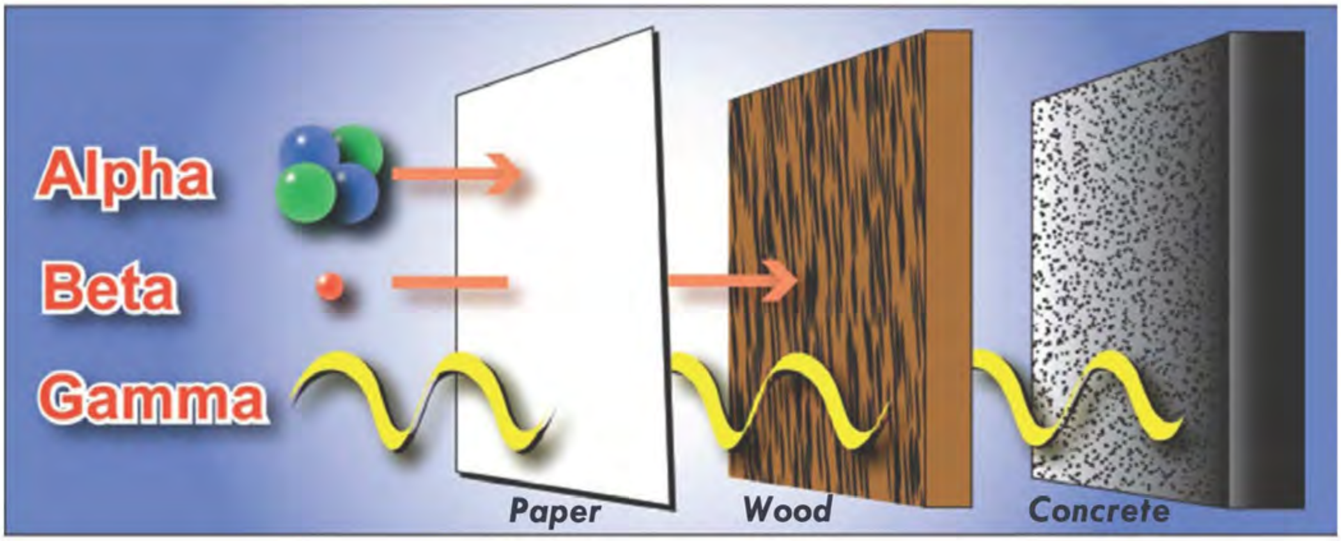


Figure HI-1. Comparison of penetrating ability of alpha, beta, and gamma radiation.

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. This 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-emitting 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-emitting 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 counter. However, detection of specific beta-emitting radionuclides, such as ^{3}H and ^{90}Sr, requires chemical separation first.

Table HI-1. Radionuclides and their half-lives.

SYMBOL	RADIONUCLIDE	HALF-LIFE[a,b]	SYMBOL	RADIONUCLIDE	HALF-LIFE[a,b]
^{241}Am	Americium-241	432.2 yr	^{54}Mn	Manganese-54	312.12 d
^{243}Am	Americium-243	7,370 yr	^{59}Ni	Nickel-59	1.01×10^{5} yr
^{125}Sb	Antimony-125	2.75856 yr	^{63}Ni	Nickel-63	100.1 yr
^{41}Ar	Argon-41	109.61 min	^{238}Pu	Plutonium-238	87.7 yr
^{137m}Ba	Barium-137m	2.552 min	^{239}Pu	Plutonium-239	2.411×10^{4} yr
^{140}Ba	Barium-140	12.752 d	^{240}Pu	Plutonium-240	6,564 yr
^{7}Be	Beryllium-7	53.22 d	^{241}Pu	Plutonium-241	14.35 yr
^{14}C	Carbon-14	5,700 yr	^{242}Pu	Plutonium-242	3.75×10^{5} yr
^{141}Ce	Cerium-141	32.508 d	^{40}K	Potassium-40	1.251×10^{9} yr
^{144}Ce	Cerium-144	284.91 d	^{226}Ra	Radium-226	1,600 yr
^{134}Cs	Cesium-134	2.0648 yr	^{228}Ra	Radium-228	5.75 yr
^{137}Cs	Cesium-137	30.1671 yr	^{220}Rn	Radon-220	55.6 s
^{51}Cr	Chromium-51	27.7025 d	^{222}Rn	Radon-222	3.8235 d
^{60}Co	Cobalt-60	5.2713 yr	^{103}Ru	Ruthenium-103	39.26 d
^{152}Eu	Europium-152	13.537 yr	^{106}Ru	Ruthenium-106	373.59 d
^{154}Eu	Europium-154	8.593 yr	^{90}Sr	Strontium-90	28.79 yr
^{3}H	Tritium	12.32 yr	^{99}Tc	Technetium-99	2.111×10^{5} yr
^{129}I	Iodine-129	1.57×10^{7} yr	^{232}Th	Thorium-232	1.405×10^{10} yr
^{131}I	Iodine-131	8.0207 d	^{233}U	Uranium-233	1.592×10^{5} yr
^{55}Fe	Iron-55	2.737 yr	^{234}U	Uranium-234	2.455×10^{5} yr
^{59}Fe	Iron-59	44.495 d	^{235}U	Uranium-235	7.04×10^{8} yr
^{85}Kr	Krypton-85	10.756 yr	^{238}U	Uranium-238	4.468×10^{9} yr
^{87}Kr	Krypton-87	76.3 min	^{90}Y	Yttrium-90	64.1 hr
^{88}Kr	Krypton-88	2.84 hr	^{65}Zn	Zinc-65	244.06 d
^{212}Pb	Lead-212	10.64 hr	^{95}Zr	Zirconium-95	64.032 d

a. From ICRP Publication 107 (ICRP 2008).

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

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 ^{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} (or 1.3E-06). To convert this number to its decimal form, the decimal point is moved left by the number of places equal to the exponent (in this case, six). The number 1.3×10^{-6} may also be expressed as 0.0000013. When considering large numbers with a positive exponent, such as 1.0×10^{6}, the decimal point is moved to the right by the number of places equal to the exponent. In this case, 1.0×10^{6} represents one million and may also be written as 1,000,000.

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

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

Units of Radioactivity. The basic unit of radioactivity used in this report is the curie (abbreviated Ci) which is based on the disintegration rate occurring in 1 gram of the radionuclide radium-226 (^{226}Ra) that is 37 billion (3.7×10^{10}) disintegrations per second (becquerels). For any other radionuclide, 1 Ci is the amount of the radionuclide that produces this same decay rate.

Units of Exposure and Dose (Table HI-3). Exposure, or the amount of ionization produced by gamma or X-ray radiation in air, is measured in terms of the roentgen (R). Dose is a general term to express how much radiation energy is deposited in something. The energy deposited can be expressed in terms of absorbed, equivalent, and/or effective dose.

The term rad, which is short for radiation absorbed dose, is a measure of the energy absorbed in an organ or tissue. The equivalent dose, which considers the effect of different types of radiation on tissues and is therefore the potential for biological effects, is expressed as the R equivalent man or 'rem.' Radiation exposures to the human body, whether from external or internal sources, can involve all or a portion of the body. To enable radiation protection specialists to express partial-body exposures (and the accompanying doses) to portions of the body in terms of an equal dose to the whole body, the concept of 'effective dose' was developed.

Table HI-3. Names and symbols for units of radioactivity and radiological dose used in this report.

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

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

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

There is always uncertainty associated with the measurement of radioactivity in environmental samples. This is mainly because radioactive decay events are inherently random. Thus, when a radioactive sample is counted again and again for the same length of time, the results will differ slightly, but most of the results will be close to the true value of the activity of the radioactive material in the sample. Statistical methods are used to estimate the true value of a single measurement and the associated uncertainty of the measurement. The uncertainty of a measurement is reported by following the result with an uncertainty value that is preceded by the plus or minus symbol, ± (e.g., 10 ± 2 pCi/L). The uncertainty is often referred to as sigma (or σ). For concentrations of greater than or equal to three times the uncertainty, there is 95% 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.

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/kg) 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

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 minimum results represent the range of the measurements.

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

How are Data Represented Graphically?

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

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 the National Council on Radiation Protection and Measurements Report No. 160 (NCRP 2009). The contribution from background (e.g., natural radiation, mostly radon) is estimated in Table 7-7 of this report.

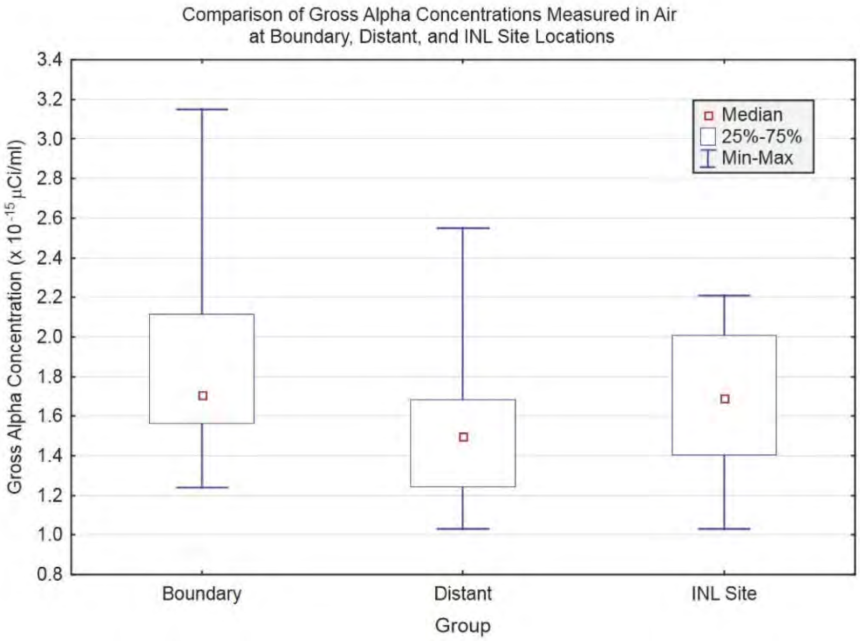
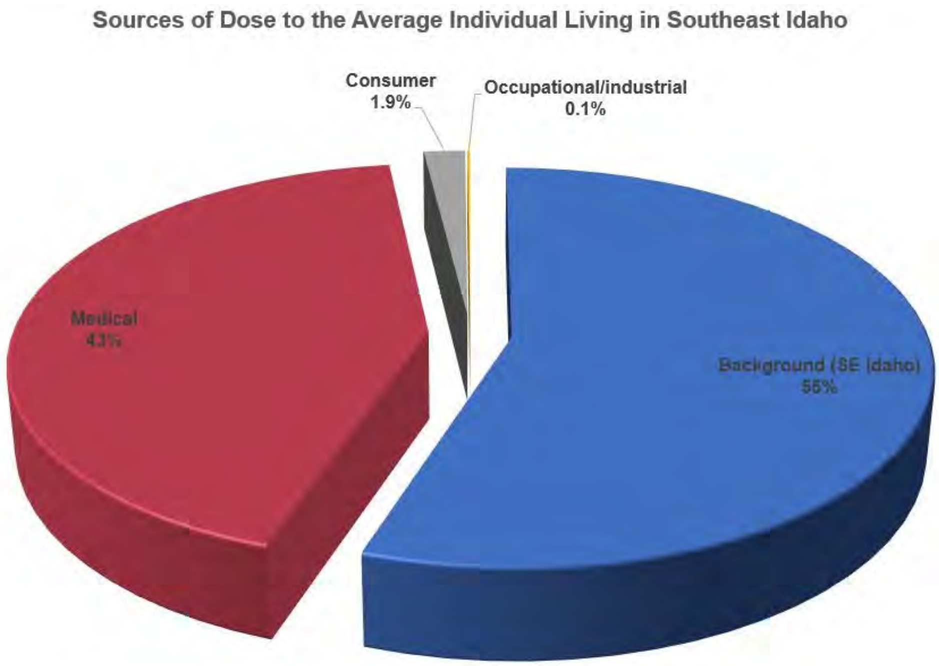


Figure HI-2. A graphical representation of minimum, median, and maximum results with a box plot. *The 25th and 75th percentiles are the values such that 75% of the measurements in the data set are greater than the 25th percentile, and 75% of the measurements are less than the 75th percentile.*



	Effective dose (mrem)	% of Total
Background	387	55%
Medical	300	43%
Consumer	13	1.9%
Occupational/industrial	0.8	0.1%
Total	701	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 maximum dose (mrem) calculated for the maximally exposed individual from 2012 through 2021. The maximally exposed individual is a hypothetical member of the public who is exposed to radionuclides from airborne releases through various environmental pathways and the media through which the radionuclides are transported (i.e., air, water, and food). The chart shows the general trend of the dose over time.

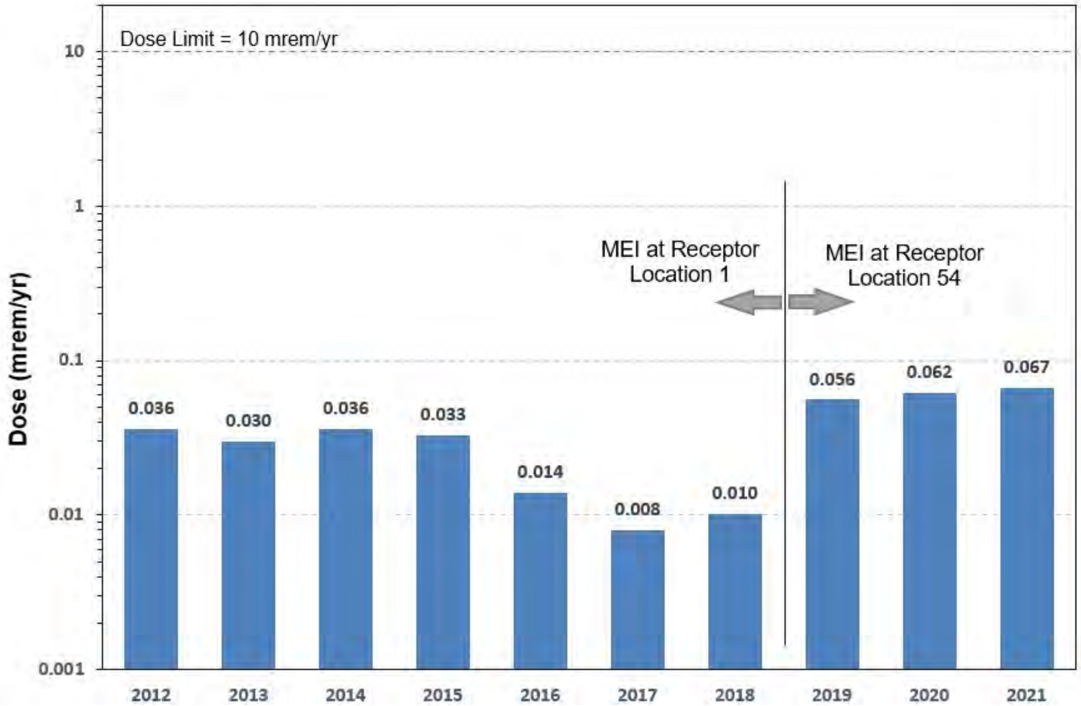


Figure HI-4. Data plotted using a column chart.

A ***plot*** can be useful to visualize differences in results over time. Figure HI-5 shows the ^{90}Sr measurements in three wells collected by USGS for 21 years (2001-2021). The results are plotted by year.

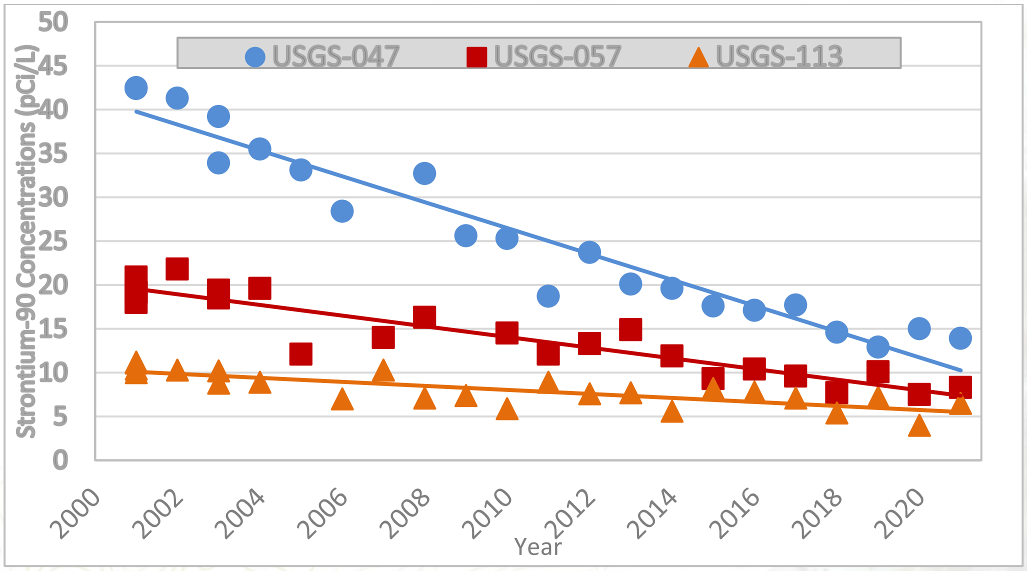


Figure HI-5. Data plotted using a linear plot.

Contour lines are sometimes drawn on a map to discern patterns over a geographical area. For example, Figure HI-6 shows the distribution of ^{90}Sr in groundwater around 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 lowest farther away. It reflects the movement of the radionuclide in groundwater from INTEC where it was injected into the aquifer in the past.

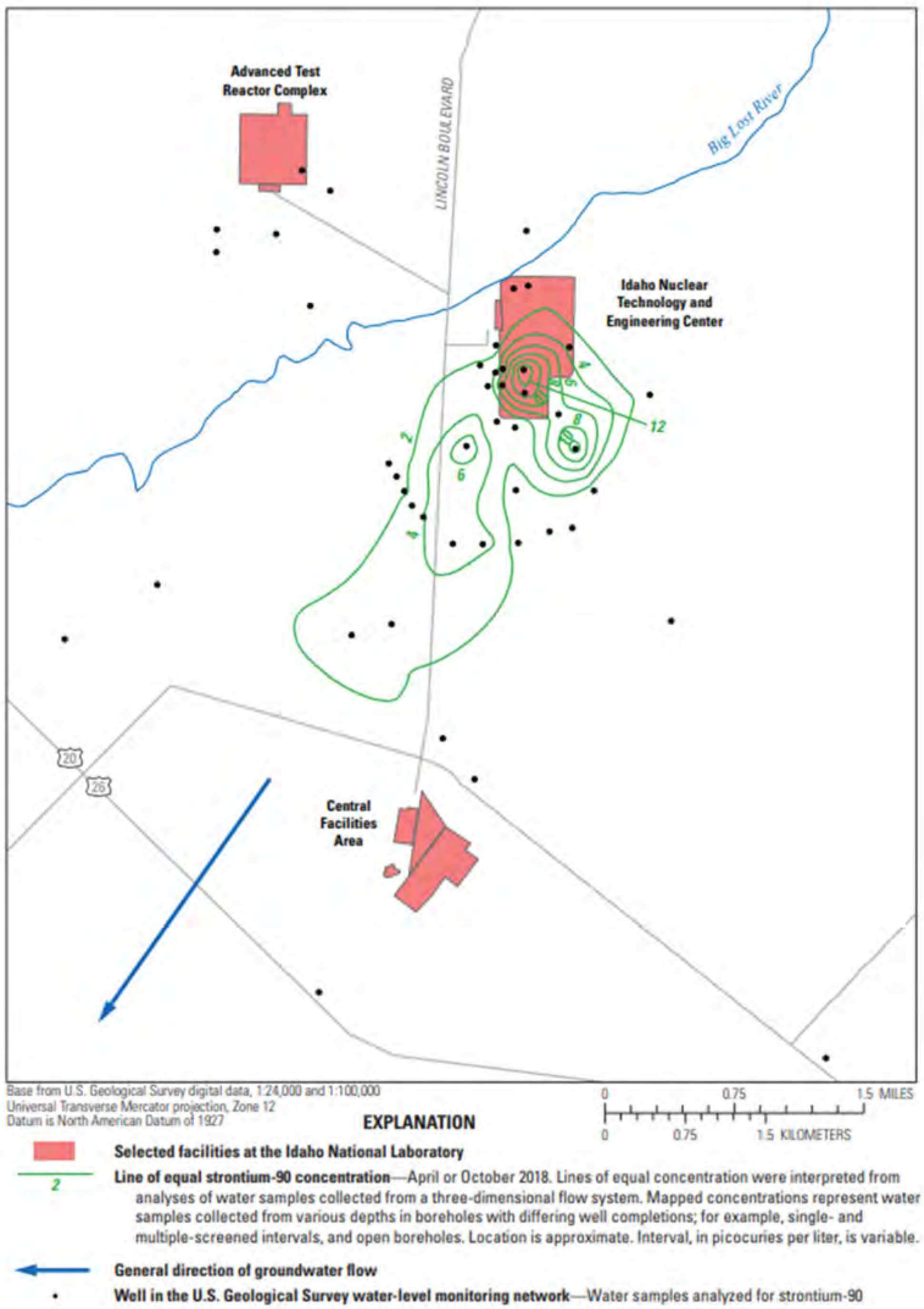


Figure HI-6. Data plotted using contour lines. *Each contour line drawn on this map connects points of equal ^{90}Sr concentration in water samples collected at the same depth from wells on the INL Site.*

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 from 2012 to 2018 followed by a slight increase from 2019 to 2021. 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: (1) radiation of extraterrestrial origin (called cosmic rays); (2) radionuclides produced in the atmosphere by cosmic ray interaction with matter (called cosmogenic radionuclides); and (3) 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, which is natural background, represent a major source of human radiation exposure (NCRP 1987, 2009). For this reason, natural radiation frequently is used as a standard of comparison for exposure to various human-generated sources of ionizing radiation. An individual living in southeast Idaho was estimated, in 2021, to receive an average dose of about 387 mrem/yr (3.8 mSv/yr) from natural background sources of radiation on earth, as observed in Figure HI-7. These sources include cosmic radiation and naturally occurring radionuclides.

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

Naturally occurring radionuclides are of two general kinds: cosmogenic and primordial. Cosmogenic radionuclides are produced by the interaction of cosmic radiation within the atmosphere or in the earth. Cosmic 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 ^{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 U.S. (NCRP 2009). Tritium and ^{7}Be are routinely detected in environmental samples collected by environmental monitoring programs on and around the INL Site, as observed in Table HI-5, but contribute little to the dose that might be received from natural background sources.

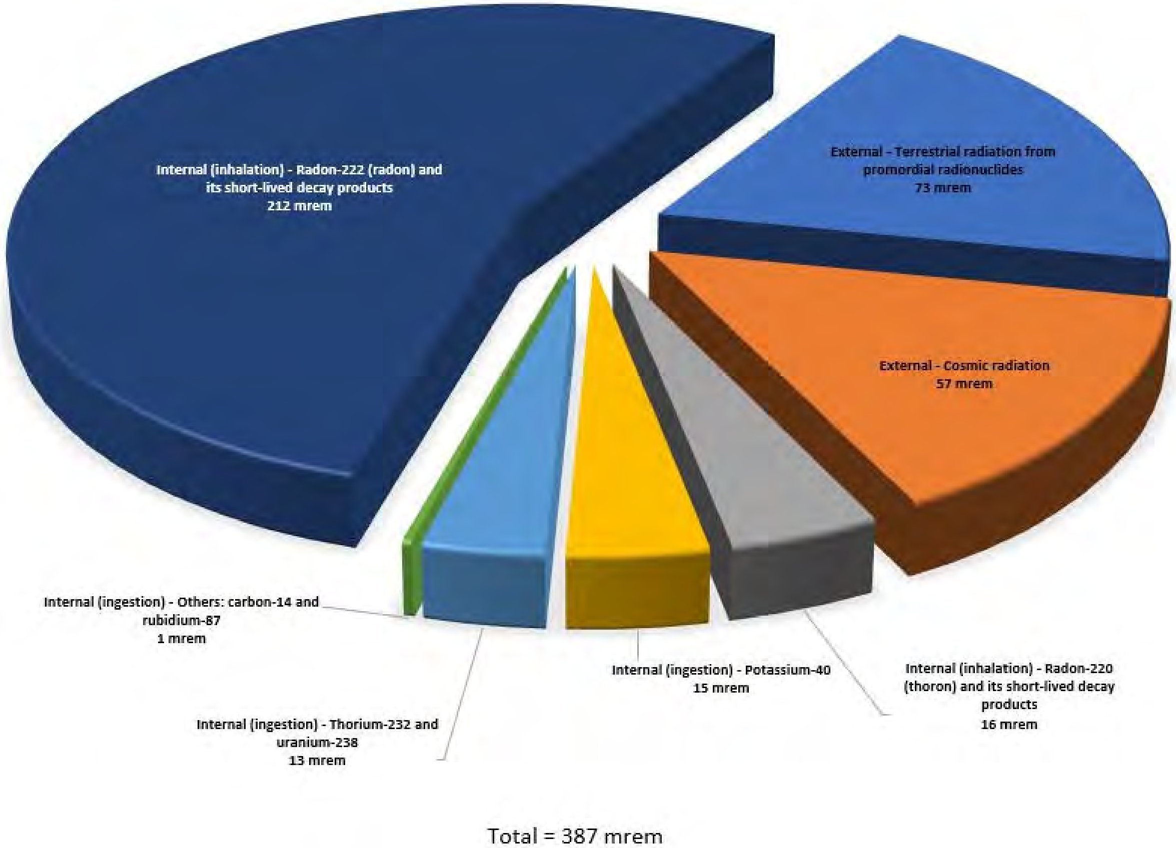


Figure HI-7. Calculated doses (mrem per year) from natural background sources for an average individual living in southeast Idaho (2021).

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)	53.22 da	Cosmic rays	Rain, air
Tritium (^{3}H)	12.32 yr	Cosmic rays	Water, rain, air moisture
Potassium-40 (^{40}K)	1.2516×10^{9} yr	Primordial	Water, air, soil, plants, animals
Thorium-232 (^{232}Th)	1.405×10^{10} yr	Primordial	Soil
Uranium-238 (^{238}U)	4.468×10^{9} yr	Primordial	Water, air, soil
Uranium-234(^{234}U)	2.455×10^{5} yr	^{238}U progeny	Water, air, soil
Radium-226 (^{226}Ra)	1,600 yr	^{238}U progeny	Water

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 (73 mrem/yr or 0.73 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 (e.g., an average of 200 mrem/yr [2.0 mSv/yr] nationwide) produced by naturally occurring radionuclides, as shown in Figure HI-7.

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 are often detected in environmental samples (Table HI-5).

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

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

The deposition of these radionuclides on the earth's surface varies by latitude, with most occurring in the northern hemisphere at approximately 40^{o}. Variation within latitudinal belts is a function primarily of precipitation, topography, and wind patterns. The dose produced by global fallout from nuclear weapons testing has decreased steadily since 1970. The annual dose rate from fallout was estimated in 1987 to be less than 1 mrem (0.01 mSv) (NCRP 1987). It has been nearly 34 years since that estimate, so the current dose is assumed to be even lower.

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

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

A large amount of data exists concerning the effects of acute delivery (all at once) of high doses of radiation, especially in the range of 50 to 400 rem (0.5 to 4.0 Sv). Most of this information was gathered from the Japanese atomic bombing survivors and patients who were treated with substantial doses of X-rays. Conversely, information is limited, and therefore, it is difficult to estimate risks associated with low level exposure. Risk can be defined in general as the probability (chance) of injury, illness, or death resulting from some activity. Low-dose effects are those that might be caused by doses of less than 20 rem (0.2 Sv), whether delivered acutely or spread out over a period as long as a year (Taylor 1996). Most of the radiation exposures that humans receive are very close to background levels. Moreover, many sources emit radiation that is well below natural background levels. This makes it extremely difficult to isolate its effects. For this reason, government agencies make the conservative (cautious) assumption that any increase in radiation exposure is accompanied by an increased risk of health effects. Cancer is considered by most scientists to be the primary health effect from long-term exposure to low levels of radiation while each radionuclide represents a somewhat different health risk. A 2011 report by the U.S. Environmental Protection Agency (EPA) estimated a 5.8×10^{-2} Gy^{-1} cancer mortality risk coefficient for uniform whole-body exposure throughout life at a constant dose rate. Given a 1 gray (100 rad) ionizing radiation lifetime exposure this corresponds to 580 deaths, above normal cancer mortality rates, within an exposure group of 10,000 people. For low-linear energy transfer radiation (i.e., beta and gamma radiation) the dose equivalent in Sv (100 rem) is numerically equal to the absorbed dose in Gy (100 rad). Therefore, if each person in a group of 10,000 people is exposed to 1 rem (0.01 Sv) of ionizing radiation in small doses over a lifetime, we would expect around six people to die of cancer than would otherwise. For perspective, most people living on the eastern Snake River Plain receive over 381 mrem (3.8 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 O 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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Northwest Indian Paintbrush and Bombus

Acronyms

AFV	alternative fuel vehicle
ANL	Argonne National Laboratory
ARP	Accelerated Retrieval Project
ATR	Advanced Test Reactor
BBS	breeding bird survey
BCG	Biota Concentration Guide
BEA	Battelle Energy Alliance, LLC
BLM	Bureau of Land Management
BMP	best management practices
BRR	Biological Resource Review
C&D	construction and demolition
CA	corrective action
CAA	Clean Air Act
CAES	Center for Advanced Energy Studies
CAP	criteria air pollutant
CAP88-PC	Clean Air Act Assessment Package-1988 computer model, PC
CARP	Climate Adaptation and Resilience Plan
CCA	Candidate Conservation Agreement
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFA	Central Facilities Area
CFR	Code of Federal Regulations
CITRC	Critical Infrastructure Test Range Complex
CTF	Contained Test Facility
CWA	Clean Water Act
CWP	Cold Waste Pond
CY	calendar year
D&D	decontamination and decommissioning
DCS	Derived Concentration Standard
DEQ	Department of Environmental Quality (state of Idaho)
DEQ-IOP	Department of Environmental Quality – INL Oversight Program
DOE	U.S. Department of Energy
DOE-ID	U.S. Department of Energy, Idaho Operations Office
DOSEMM	dose multi-media
DQO	data quality objective
EA	Environmental Assessment
EAL	Environmental Assessments Laboratory
EBR-I	Experimental Breeder Reactor-I
ECP	Environmental Compliance Permits
EFS	Experimental Field Station
EMS	Environmental Management System
EO	Executive Order
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
EPEAT	Electronic Product Environmental Assessment Tool
EPI	emergency plan implementing procedures
EROB	Engineering Research Office Building
ESA	Endangered Species Act
ESER	Environmental Surveillance, Education, and Research
ESPC	Energy Savings Performance Contract
ESRP	Eastern Snake River Plain
EV	electric vehicle
FCF	Fuel Conditioning Facility
FFA/CO	Federal Facility Agreement and Consent Order

FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FWS	U.S. Fish and Wildlife Service
FY	fiscal year
GPRS	Global Positioning Radiometric Scanner
HAA5	haloacetic acids
HEU	highly enriched uranium
HFC	hydrofluorocarbons
HLW	high level waste
HYSPLIT	Hybrid Single-particle Lagrangian Integrated Trajectory
IC	institutional control
ICDF	Idaho CERCLA Disposal Facility
ICP	Idaho Cleanup Project
ICPP	Idaho Chemical Processing Plant
IDAPA	Idaho Administrative Procedures Act
IDFG	Idaho Department of Fish and Game
INEEL	Idaho National Engineering and Environmental Laboratory
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center (formerly Idaho Chemical Processing Plant)
IRC	INL Research Center
ISA	Idaho Settlement Agreement
ISB	in situ bioremediation
ISO	International Organization for Standardization
IUPAC	International Union of Pure and Applied Chemistry
IWCS	Industrial Wastewater Collection System
IWD	Industrial Waste Ditch
IWTU	Integrated Waste Treatment Unit
LAN	local area network
LCS	laboratory control spike
LCSD	laboratory control spike duplicate
LED	light emitting diode
LLW	low-level waste
LTV	long-term vegetation
Ma	million years
MAPEP	Mixed Analyte Performance Evaluation Program
MCL	maximum contaminant level
MEI	maximally exposed individual
MFC	Materials and Fuels Complex
MLLW	mixed low-level waste
MLMS	multilevel monitoring system
MS	matrix spike
MSD	matrix spike duplicate
MVMS	Mountain View Middle School
N&HS	National and Homeland Security
NA	not applicable
NAREL	National Analytical Radiation Environmental Laboratory
NCRP	National Council on Radiation Protection and Measurements
NFPA	National Fire Protection Association
ND	not detected
NEPA	National Environmental Policy Act
NERP	National Environmental Research Park
NESHAP	National Emission Standards for Hazardous Air Pollutants
NM	not measured
NOAA	National Oceanic and Atmospheric Administration
NON/CO	Notice of Noncompliance/Consent Order
NS	no sample
O&M	Operations & Maintenance
OSLD	optically stimulated luminescence dosimeter
PCB	polychlorinated biphenyls
PCS	primary constituent standard
PE	performance evaluation

PFAF	perfluoroalkyl substance
PFOA	perfluorooctanic acid
PFOS	perfluorooctane sulfonate
PI	principal investigator
PL	primary line
PR	principal researcher
PUE	power usage effectiveness
QA	Quality Assurance
QC	Quality Control
QSM	Quality System Manual
RCRA	Resource Conservation and Recovery Act
REC	Research and Education Campus
RESL	Radiological and Environmental Sciences Laboratory
RHLLW	Remote Handled Low-level Waste Disposal Facility
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RRTR-NTR	Radiological Response Training Range – Northern Test Range
RWMC	Radioactive Waste Management Complex
SDA	Subsurface Disposal Area
SGCA	Sage-grouse Conservation Area
SMC	Specific Manufacturing Capability
SMCL	secondary maximum contaminant level
SNF	spent nuclear fuel
SOC	synthetic organic compound
SSER	Sagebrush Steppe Ecosystem Reserve
STP	Sewage Treatment Plant
TAN	Test Area North
TCE	trichloroethylene
TLD	thermoluminescent dosimeter
TREAT	Transient Reactor Experiment and Test Facility
TRU	transuranic
TSCA	Toxic Substances Control Act
TTHM	total trihalomethane
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UTL	Upper Tolerance Limit
UTV	utility task vehicle
VOC	volatile organic compound
WAG	waste area group
WFMC	Wildland Fire Management Committee
WIPP	Waste Isolation Pilot Plant
WMF	Waste Management Facility
WNS	white-nose syndrome
YOY	year over year

Scarab beetle

Units

Bq	becquerel
C	Celsius
cfm	cubic feet per minute
CFU	colony forming unit
Ci	curie
cm	centimeter
cps	counts per second
d	day
F	Fahrenheit
ft	feet
g	gram
gal	gallon
Gy	gray
ha	hectare
keV	kilo-electron-volts
kg	kilograms (10^3) gram
km	kilometer (10^3) meter
L	liter
lb	pound
m	meter
µCi	microcurie (10^{-6}) curies
µg	microgram (10^{-6}) grams
µR	microroentgen (10^{-6}) roentgen
µS	microsiemen (10^{-6}) siemen
µSv	microsievert (10^{-6}) sievert
Ma	million years
mCi	millicurie (10^{-3}) curies
MeV	mega electron volt
mg	milligram (10^{-3}) grams
MG	million gallons
mGy	milligray (10^{-3}) gray
Ml	million liters
mi	mile
min	minute
mL	milliliter (10^{-3}) liter
mR	milliroentgen (10^{-3}) roentgen
mrad	milliard (10^{-3}) rad
mSv	millisievert (10^{-3}) sievert
oz	ounce
pCi	picocurie (10^{-12} curies)
R	roentgen
rad	radiation absorbed dose
rem	roentgen equivalent man
Sv	sievert
yd	yard
yr	year

Gray-crowned Rosy Finch

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Chapter 1: Introduction

1. INTRODUCTION

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

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

The purpose of the report, as outlined in DOE O 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 O 458.1 requirements and, therefore, describes the DOE Idaho National Laboratory (INL) Site impact on the public and the environment with an 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% 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 entrance is approximately 40 km (25 mi) west of Idaho Falls. Other towns surrounding the INL Site include Arco, Atomic City, Blackfoot, Rigby, Rexburg, Terreton, and Howe. Pocatello is 85 km (53 mi) to the southeast.

Federal lands surround much of the INL Site, including U.S. Bureau of Land Management lands and Craters of the Moon National Monument and Preserve to the southwest, Salmon-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.

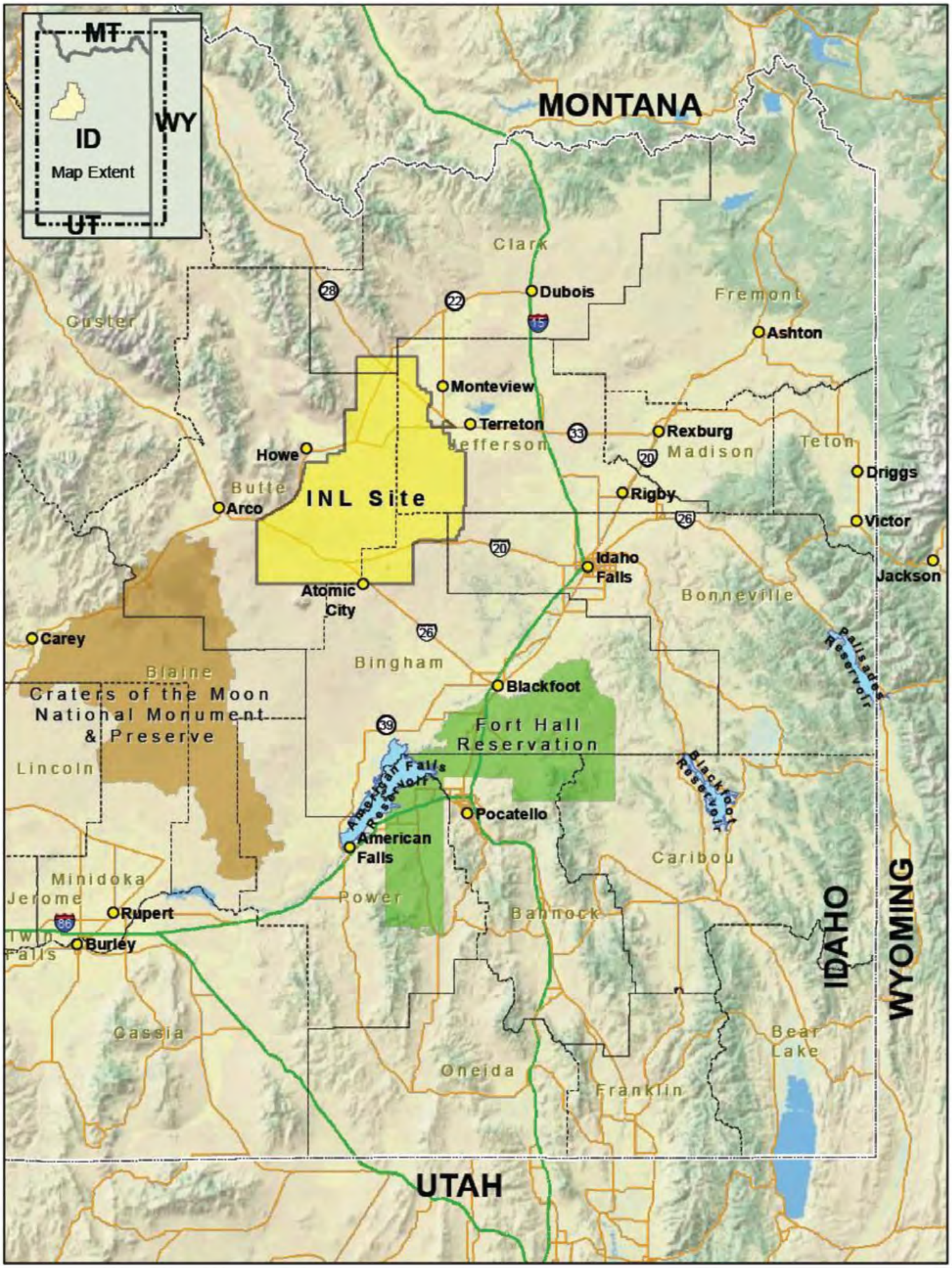

Figure 1-1. Location of the INL Site.

1.2 Environmental Setting

The INL Site is located in a large, relatively undisturbed expanse of sagebrush steppe. Approximately 94% 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% of the INL Site is open to livestock grazing. Controlled hunting is permitted, but is restricted to a very small portion of the northern half of the INL Site.

The climate of the high desert environment of the INL Site is characterized by sparse precipitation (about 21.4 cm/yr [8.43 in./yr]), warm summers (average daily temperature of 18.8°C [65.8°F]), and cold winters (average daily temperature of -7.3°C [18.9°F]), based on observations at Central Facilities Area from 1991 through 2020 (NOAA 2022). The altitude, intermountain setting, and latitude of the INL Site combine to produce a semi-arid climate. Prevailing weather patterns are from the southwest, moving up the Snake River Plain. Air masses, which gather moisture over the Pacific Ocean, traverse several hundred miles of mountainous terrain before reaching southeastern Idaho. Frequently, the result is dry air and little cloud cover. Solar heating can be intense, with extreme day-to-night temperature fluctuations.

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

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

The Big Lost River on the INL Site flows northeast, ending in a playa area on the northwestern portion of the INL Site, called the Big Lost River Sinks. Here, the river evaporates or infiltrates to the subsurface, with no surface water moving off the INL Site. Normally, the riverbed is dry because of upstream irrigation and rapid infiltration into desert soil and underlying basalt (Figure 1-2). The river rarely flows onto the INL Site. Water demands upstream at the Mackay Reservoir inhibited river flow onto the INL from March to May 2021 and flow never went as far as the Lincoln Blvd bridge. No river samples were collected during 2021 at the INL because of the lack of surface water flow in the Big Lost River.

Fractured volcanic rocks under the INL Site form a portion of the eastern Snake River Plain aquifer (Figure 1-3), which stretches 320 km (199 mi) from Island Park to King Hill, which is 9.7 km (6 mi) northeast of Glenns Ferry and stores one of the most bountiful supplies of groundwater in the nation. An estimated 247 to 370 billion m^3 (200 to 300 million acre-ft) of water is stored in the aquifer's upper portions. The aquifer is primarily recharged from the Henrys Fork and the South Fork of the Snake River, and to a lesser extent from the Big Lost River, Little Lost River, Birch Creek, and irrigation. Beneath the INL Site, the aquifer moves laterally southwest at a rate of 1.5 to 6 m/day (5 to 20 ft/day) (Lindholm 1996). The eastern Snake River Plain aquifer emerges in 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.

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

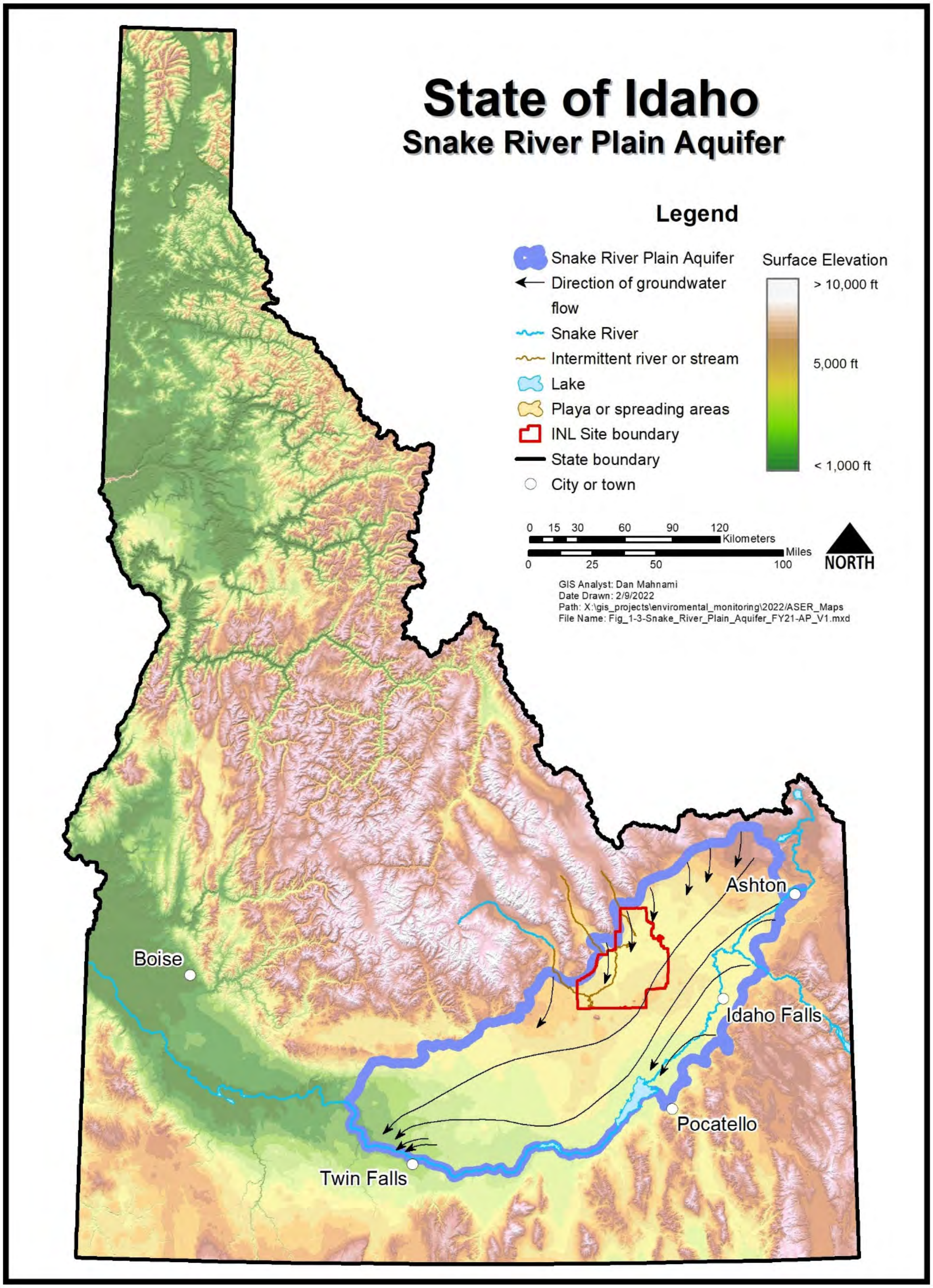

Figure 1-3. INL Site relation to the eastern Snake River Plain Aquifer.

1.3 History of the INL Site

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

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

The earliest human occupants of the eastern Snake River Plain were the Shoshone and Bannock people, the ancestors of the present-day Shoshone-Bannock Tribes. Their presence dates back 13,500 years. Tools recovered from this period indicate they 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 (DOE-ID 2016).

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

Between 1840 and 1857, an estimated 240,000 immigrants passed through southern Idaho on the Oregon Trail. The Shoshone and Bannocks entered into peace treaties in 1863 and 1868 known today as the Fort Bridger Treaty. The Fort Hall Reservation was reserved for the various tribes under the treaty agreement. During the 1870s, miners entered the surrounding mountain ranges, followed by ranchers grazing cattle and sheep in the valleys.

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

During World War II, large guns from U.S. Navy warships were retooled at the U.S. Naval Ordnance Plant in Pocatello, Idaho. These guns needed to be tested, and the nearby uninhabited plain was used as a gunnery range, known then as the Arco 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 an ample groundwater supply on which to build and test nuclear power reactors. In 1949, the Arco Naval Proving Ground became the National Reactor Testing Station.

In 1951, the 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, which was the first time a nuclear reactor powered an entire community in the United States. The laboratory also developed prototype nuclear propulsion plants for Navy submarines and aircraft carriers. Over time, the Site evolved into an assembly of 52 reactors, associated research centers, and waste handling areas.

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

With renewed interest in nuclear power, DOE announced in 2003 that Argonne National Laboratory-West and the Idaho National Engineering and Environmental Laboratory would be the lead laboratories for development of the next generation of power reactors. On February 1, 2005, Battelle Energy Alliance, LLC, took over operation of the laboratory, merged with Argonne National Laboratory-West, and the facility name was changed to Idaho National Laboratory. At this time, the site's cleanup activities were moved to a separate contract, the Idaho Cleanup Project, which is currently managed by Fluor Idaho, LLC. Research activities, which include projects other than nuclear research such as National and Homeland Security projects, were consolidated in the newly named Idaho National Laboratory.

1.4 Human 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 348,024. Over half of this estimated population (184,761) resides in the census divisions of Idaho Falls (116,693) and northern Pocatello (68,068). Another 32,652 are projected to live in the Rexburg census division. Approximately 23,308 are estimated to reside in the Rigby census division and 16,311 in the Blackfoot census division. The remaining population resides in small towns and rural communities. Note: The 2020 census was not available at the time of report preparation.

1.5 Idaho National Laboratory Site Primary Program Missions and Facilities

The INL Site mission is to operate a multi-program national research and development laboratory and to complete environmental cleanup activities stemming from past operations. The U.S. Department of Energy, Idaho Operations Office (DOE-ID) receives implementing direction and guidance primarily from two DOE Headquarters offices—the Office of Nuclear Energy and the Office of Environmental Management. The Office of Nuclear Energy is the Lead Program Secretarial Office for all DOE-ID-managed operations on the INL Site.

The Office of Environmental Management provides direction and guidance to DOE-ID for environmental cleanup on the INL Site and functions in the capacity of Cognizant Secretarial Office. Naval Reactors operations on the INL Site report to the Pittsburgh Naval Reactors Office, which fall outside the purview of DOE-ID and therefore are not included in this report.

1.5.1 Idaho National Laboratory

The INL mission is to discover, demonstrate, and secure innovative nuclear energy solutions, other clean energy options, and critical infrastructure. Its vision is to change the world's energy future and secure our nation's critical infrastructure. To fulfill its assigned duties during the next decade, INL will work to transform itself into a laboratory leader in nuclear energy and homeland security research, development, and demonstration. This transformation will be the development of nuclear energy and national and homeland security leadership highlighted by achievements such as demonstration of Generation IV reactor technologies; the creation of national user facilities, including the Advanced Test Reactor National Scientific User Facility, Wireless National User Facility, and Biomass Feedstock National User Facility; the Critical Infrastructure Test Range Complex; 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.

On February 22, 2021, an addendum to the 2019 memorandum of understanding between the DOE and the Nuclear Regulatory Commission (NRC) formalized the coordination between these two federal agencies in regard to National Reactor Innovation Center projects. This addendum specifically focuses on research, development, and demonstration projects, and it solidifies a partnership in order to deliver successful nuclear reactor demonstrations. The National Reactor Innovation Center is a national DOE program led by INL, allowing collaborators to harness the world-class capabilities of the U.S. National Laboratory System. The Center is charged with and committed to demonstrating advanced reactors by the end of 2025.

Battelle Energy Alliance, LLC, is responsible for management and operation of the INL.

1.5.2 Idaho Cleanup Project

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

Most of the cleanup work under the contract is driven by regulatory compliance agreements. The two foundational agreements are: (1) the 1991 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)-based Federal Facility Agreement and Consent Order (DOE 1991), which governs the cleanup of contaminant releases to the environment; and (2) the 1995 Idaho Settlement Agreement (DOE 1995), which governs the removal of transuranic waste, spent nuclear fuel, and high-level radioactive waste from the state of Idaho. Other regulatory drivers include the Federal Facility Compliance Act-based Site Treatment Plan (treatment of hazardous wastes), and other environmental permits, closure plans, federal and state regulations, Records of Decision and other implementing documents.

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

1.5.3 Primary Idaho National Laboratory Site Facilities

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

Advanced Test Reactor Complex – The Advanced Test Reactor (ATR) Complex was established in the early 1950s and has been the primary operations site for three major test reactors: (1) the Materials Test Reactor (1952–1970), (2) the Engineering Test Reactor (1957–1982), and (3) the Advanced Test Reactor (1967–present). The current primary mission at the ATR Complex is operation of the Advanced Test Reactor, the world's premier test reactor used to study the effects of radiation on materials. This reactor also produces rare and valuable medical and industrial isotopes. The ATR is a National Scientific User Facility. The ATR Complex also features the ATR Critical Facility, Test Train Assembly Facility, Radiation Measurements Laboratory, Radiochemistry Laboratory, and Safety and Tritium Applied Research Facility, which is a national fusion safety user facility. The ATR Complex is operated by the INL contractor.

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: (1) physical security, (2) contraband detection and (3) infrastructure testing. It is operated by the INL contractor.

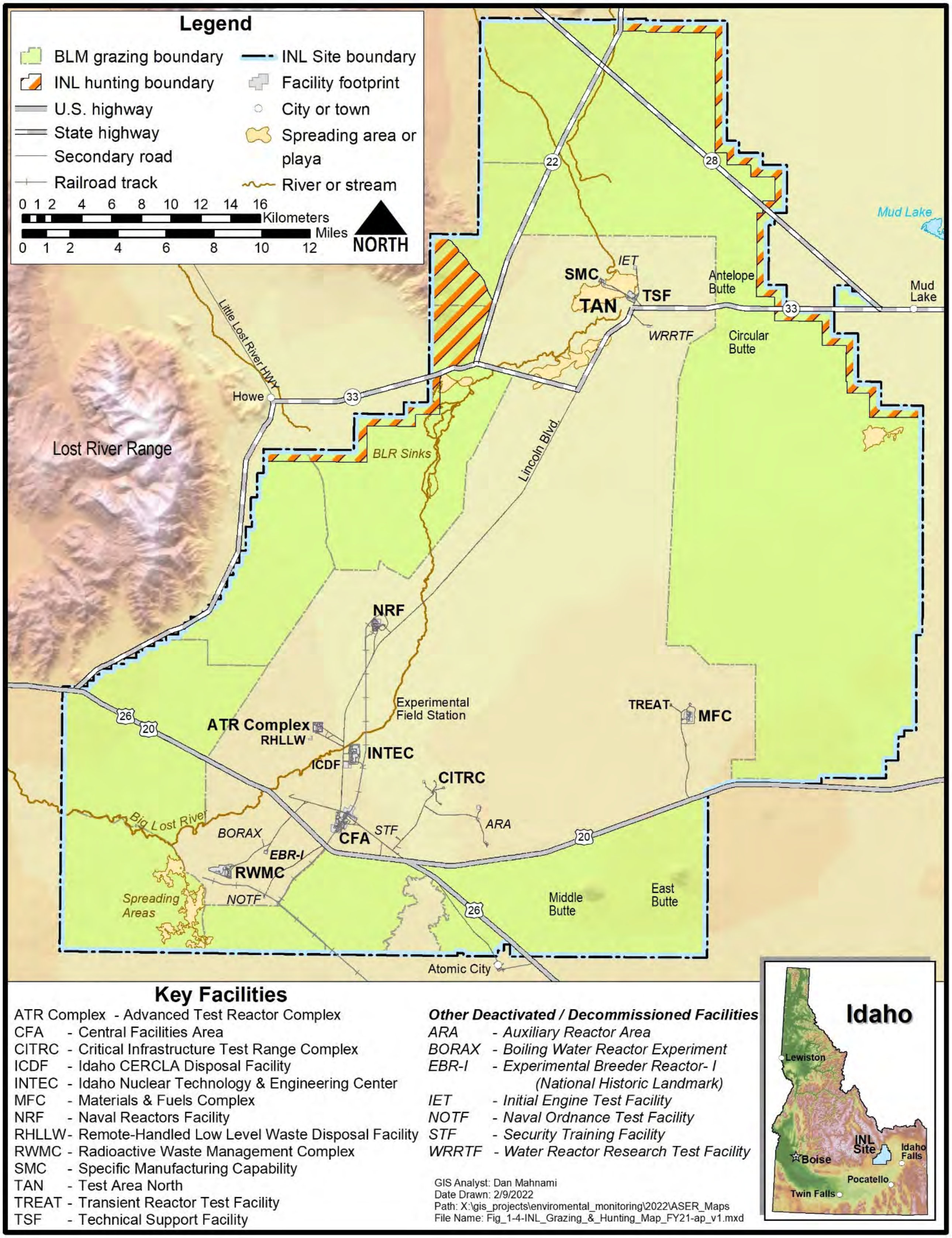

Figure 1-4. Location of the INL Site, showing key facilities.

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

Materials and Fuels Complex – The Materials and Fuels (MFC) 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 Fluor Marine Propulsion, LLC. As established in Executive Order 12344 (1982), the Naval Nuclear Propulsion Program is exempt from the requirements of DOE O 436.1, DOE O 458.1, and DOE O 414.1D. Therefore, NRF is excluded from this report. The director of the Naval Nuclear Propulsion Program establishes reporting requirements and methods implemented within the program, including those necessary to comply with appropriate environmental laws. The NRF's program is documented in the NRF Environmental Monitoring Report (FMP 2021).

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

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

Remote-Handled Low-Level Waste Disposal Facility – The Remote-Handled Low-Level Waste (RHLLW) Disposal Facility is a Hazard Category 2 nuclear facility providing below-grade, permanent radioactive waste disposal capability critical for INL nuclear research and Naval Reactors missions at the INL Site. RHLLW is generated from nuclear programs conducted at INL Site facilities, including the NRF, the ATR Complex, and the MFC. The facility began operations in 2018 and will support an anticipated 20 years of waste disposal operations with an expansion capability for up to 50 years. The facility comprises an administration building, a maintenance building, and a 175,000-square-foot vault yard that includes monitoring wells, a robust drainage system, and 446 below-grade concrete waste disposal vaults sized to accommodate 939 stainless steel waste canisters of various configurations dependent on the waste type and waste generator facility.

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, as well as the in-town laboratories where researchers work on a wide variety of advanced scientific research and development projects. As the name implies, the REC uses both basic science research and engineering to apply new knowledge to products and processes that improve quality of life. This reflects the emphasis INL is placing on strengthening its science base and increasing the commercial success of its products and processes. Two new laboratory facilities—the Energy Systems Laboratory (ESL) and Energy Innovation Laboratory (EIL) —were constructed in 2013 and 2014. In 2019, the Idaho

Board of Education and INL completed the construction of two new research facilities: the (1) Cybercore Integration Center; and the (2) Collaborative Computing Center. The Cybercore Integration Center leads national efforts to secure critical infrastructure control systems from cyber threats while the Collaborative Computing Center will advance the computational science needs of INL while providing academia and industry with unprecedented access to high-performance computing. These and other facilities are integral for transforming INL into a renowned research laboratory.

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

Test Area North – Test Area North (TAN) was established in the 1950s to support the government's Aircraft Nuclear Propulsion program with the goal to build and fly a nuclear-powered airplane. When President John F. 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 (e.g., 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 NRC 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 the state of Pennsylvania. In October 2006, the LOFT reactor and facilities were decontaminated, decommissioned, and demolished.

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

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

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

1.5.4 Independent Oversight and Public Involvement and Outreach

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

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

1.5.5 Citizens Advisory Board

The ICP Citizens Advisory Board is a federally appointed citizen panel formed in 1994 that provides advice and recommendations on the 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. Board members comprise a variety of backgrounds and viewpoints, 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 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 nonvoting liaisons include representatives from DOE-ID, Environmental Protection Agency Region 10, and the Idaho Department of Environmental Quality (DEQ). These liaisons provide information to the Citizens Advisory Board on their respective agencies' policies and views.

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

1.5.6 Site-wide Monitoring Committees

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

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

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

1.5.7 Environmental Oversight and Monitoring Agreement

A new five-year Environmental Oversight and Monitoring Agreement (DOE-ID 2021) between DOE-ID, Naval Reactors Laboratory Field Office/Idaho Branch Office, and the Idaho DEQ was signed March 2021. The 2021 version is the latest in a succession of agreements that was first implemented in 1990. The new Environmental Oversight and Monitoring Agreement governs the activities of the DEQ-INL Oversight Program and DOE-ID's cooperation in providing access to facilities and information for non-regulatory, independent oversight of INL Site impacts to public health and the environment. The first agreement established in 1990 created the state of Idaho INL Oversight Program.

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

1.5.8 Environmental Education Outreach

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

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

The 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. Because of the unique challenges posed by the COVID-19 pandemic, nearly all programs had to be modified to some extent. In some cases, schools were closed or visiting speakers were not allowed. Despite these challenges during 2021, ESER was still able to create and present educational programs to over 3,000 students online and in their classrooms. Presentations covering physical science, biological science, and ecological science subjects, are adapted for grade level, and are aligned with Idaho State Science Standards. Because of the online learning burnout created by the long duration of the COVID-19 pandemic, classroom visits were pursued wherever possible in accordance with local and corporate safe exposure policies.

The ESER Education Program worked together with DOE, INL contractor, ICP Core contractor, and other businesses and agencies to present community outreach programs when possible. The prohibition against large gatherings resulted in outright cancellation of certain traditional events like the Water Awareness Festival and modification to others. In spite of these challenges, ESER staff were instrumental in the organization and creation of websites to communicate information.

The ESER Education Program, the Museum of Idaho, and Boise State University collaborated on teacher outreach program development, which 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. A grant from the Idaho Department of Education allowed the expansion of an online course called “Bring Idaho Alive in Your Classroom.” By expanding the online format, 45 teachers were able to attend a two-credit six-month course. Tool kits were also provided to the teachers to supplement learning.

The ESER Education Program, Idaho Falls Zoo, and Idaho State Department of Education collaborated on teacher outreach program development called the “i-STEM Strand Program.” The two-credit online workshop was coordinated through the Idaho Science, Technology, Engineering, and Mathematics (STEM) Action Center and allow 20 teachers to learn about wildlife conservation and the important role played by zoos.

The ESER Education Program worked with the education staff at the Museum of Idaho to provide summer camps for both students and educators through the Rocky Mountain Adventure Program. Three sets of 12 student camps were offered for younger children and three sets for middle-school students. These workshops focused on a combination of scientific, habitat, and historical aspects (Figure 1-5). Three teacher workshops were also offered. These workshops were offered in conjunction with Northwest Nazarene College for two credits. Staff from ESER assisted with the field portion of the teacher classes and various locations were utilized to expose teachers to different habitats (Figure 1-6).

Figure 1-5. Students in the Gross Science Summer Camp dissecting owl pellets.

Figure 1-6. ESER environmental educator, Gregg Losinski, explaining the native fauna to teachers in the Rocky Mountain Adventure program.

COVID-19 restriction eased just in time for ESER to join with the Idaho Falls Zoo in offering a bat night. This unique learning opportunity allowed 100 guests to learn about, view, and hear bats at the only chiropterarium at a zoo in the country (Figure 1-7).

Figure 1-7. Visitors experience the only zoo chiropterarium in the nation at bat night at the Idaho Falls Zoo (left). ESER bat biologist, Bill Doering, explains the unique relationship between humans and bats to participants of bat night (right).

In partnership with the Idaho Falls Post Register newspaper, the ESER Program creates a weekly column called “Ask a Scientist” Which began in 2007. In 2021, the column was sponsored by the ESER Program, the Post Register, and INL. 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 at www.idahoaskascientist.com.

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Chapter 2:
Environmental Compliance Summary

CHAPTER 2

Operations at the Idaho National Laboratory (INL) Site are subject to numerous federal and state environmental statutes, executive orders, and U.S. Department of Energy (DOE) orders. As a requirement of many of these regulations, the status of compliance with the regulations and releases of non-permitted hazardous materials to the environment must be documented. Environmental permits have been issued to the INL Site, primarily by the state of Idaho (Appendix A, Table A-7). There were no reportable environmental releases at the INL Site during calendar year 2021. In 2021, the DOE Idaho Operations Office (DOE-ID) operated in compliance with most of the requirements defined in governing documents. Instances of noncompliance were reported to regulatory agencies and resolved. Significant environmental compliance issues/actions in 2021 include:

- Environmental restoration continued in 2021 at four active Waste Area Groups. Six Waste Area Groups were previously remediated per the Federal Facility Agreement and Consent Order (FFA/CO) signed by DOE-ID, the U.S. Environmental Protection Agency (EPA), and the State of Idaho in 1991. The FFA/CO outlines how the INL Site will comply with the Comprehensive Environmental Response, Compensation, and Liability Act.
- The state of Idaho Department of Environmental Quality (DEQ) performed a Resource Conservation and Recovery Act inspection in April 2021. Due to the challenges associated with the COVID-19 pandemic and the declared state of emergency, Idaho DEQ provided advanced notice of the inspection to DOE-ID and requested documents for review prior to arrival on-site. Idaho DEQ issued a final report, noting that at the time of the inspection, no alleged violations of the Rules and Standards for Hazardous Waste and INL Partial Permits were observed.
- DOE-ID finalized an environmental assessment and issued a Finding of No Significant Impact for the Microreactor Applications Research, Validation and Evaluation project. The Microreactor Applications Research, Validation and Evaluation environmental assessment analyzed the potential impacts of a proposal to construct a microreactor inside INL's Transient Reactor Test (TREAT) Facility.
- The FFA/co requires the preparation of site treatment plans for the treatment of mixed waste stored or generated at DOE facilities. During 2021, four transuranic (TRU) INL Site Treatment Plan milestones including treatment of remote-handled waste, two certification milestones of original volume TRU-contaminated contact-handled waste, and the treatment of sodium contaminated debris were completed. The Idaho DEQ granted milestone extensions associated with the start-up of the Integrated Waste Treatment Unit (IWTU) following the completion of a 30-day public comment period. The original estimated volume of TRU waste at the INL Site was 65,000 m^3 (85,016 yd^3), while the total cumulative volume of TRU waste shipped out of Idaho, as of December 2021 was 60,829 m^3 (79,561 yd^3).
- In 2021, approximately 514 m^3 (672 yd^3) of mixed low-level waste and 226 m^3 (295 yd^3) of low-level waste was shipped off the INL Site for treatment, disposal, or both. Approximately 18.63 m^3 (24.37 yd^3) of low-level waste was disposed of at the Subsurface Disposal Area (SDA) in 2021.
- The Idaho DEQ has promulgated Safe Drinking Water Act regulations. Ten active drinking water systems at INL Site facilities were sampled according to these regulations and were well below regulatory limits for drinking water.
- The Idaho DEQ issues reuse permits for municipal and industrial effluent discharges in accordance with Idaho DEQ rules. No DEQ inspections of INL or ICP Core contractors reuse systems occurred in 2021. All systems at the INL Site were operated in substantial compliance with permit requirements during 2021.

- One reportable release occurred during 2021. About 70 gallons of hydraulic fluid leaked from a sonic drilling rig. The affected hose, which appeared to have been damaged by rodents, was wrapped in absorbent and taped to mitigate further leaks. DEQ was notified, and the contaminated soil was shoveled, containerized and disposed of through the ICP Core waste management organization.
- INL Site cultural resources are numerous and represent at least 13,000 years of human land use in the region. As a federal agency, the DOE has been directed by Congress, the U.S. president, and the American public to provide leadership in the preservation of precontact, historic, and other cultural resources on the lands it administers. DOE-ID prepared an assessment, in compliance with Executive Order 13287, “Preserve America,” of the current status of the inventory of historic properties on the INL Site, the general condition and management needs of the properties, and the steps underway or planned to meet management needs. The report was submitted to the DOE Federal Preservation Officer.

2. ENVIRONMENTAL COMPLIANCE SUMMARY

This chapter reports the compliance status of the U.S. Department of Energy (DOE) 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 DOE orders. These are listed in Appendix A.

2.1 Environmental Restoration and Waste Management

2.1.1 Comprehensive Environmental Response, Compensation, and Liability Act

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

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

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

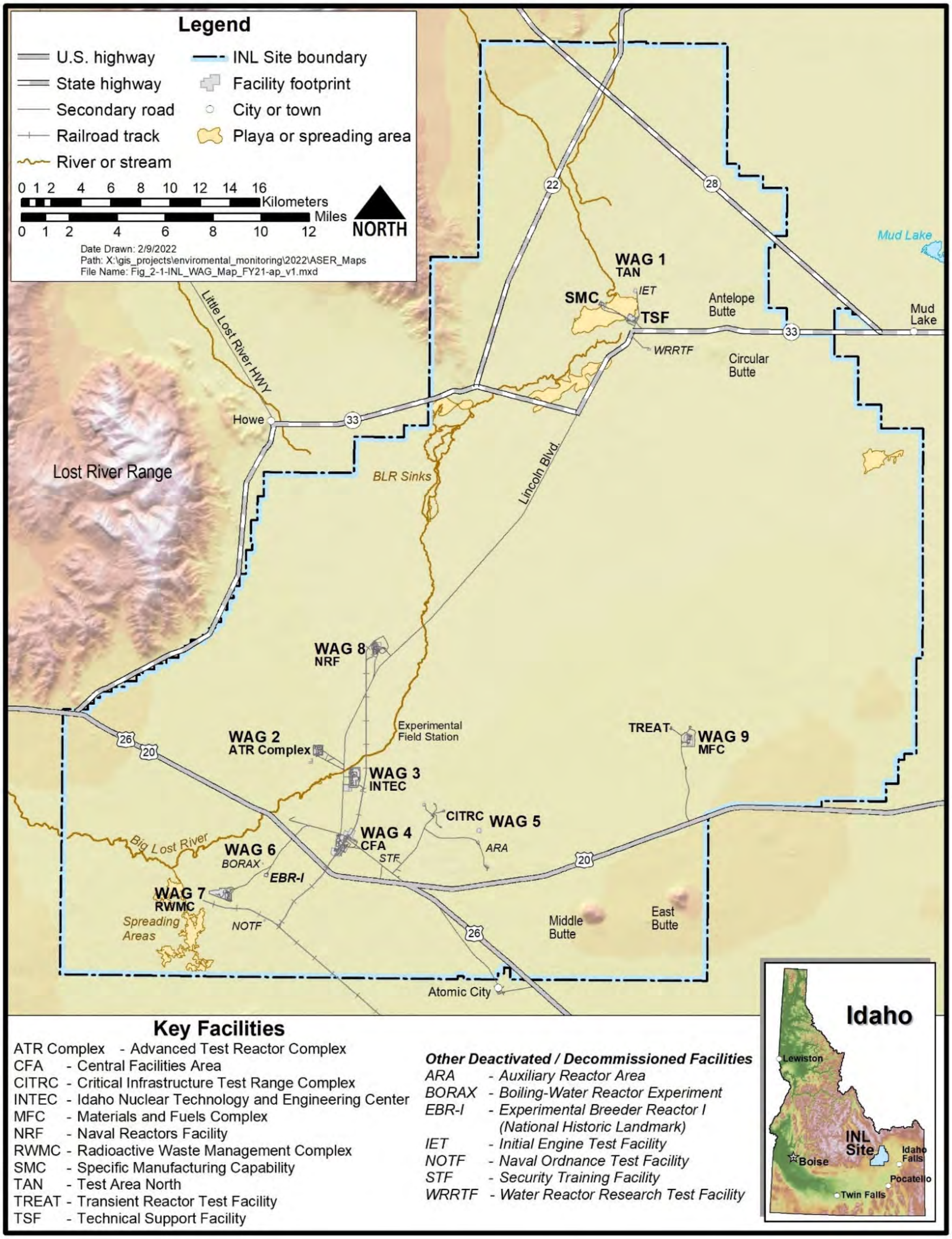

Figure 2-1. INL Site showing facilities and corresponding WAGs.

Since the FFA/CO was signed in December 1991, the INL Site has cleaned up release sites containing asbestos, petroleum products, acids and bases, radionuclides, unexploded ordnance and explosive residues, polychlorinated biphenyls, heavy metals, and other hazardous materials. All 24 RODs that were scheduled have been signed and are being implemented. Comprehensive RI/FSs have been completed for WAGs 1–5, 7–9, and 6/10 (6 is combined with 10). Active remediation is completed at WAGs 1 (excluding Operable Unit 1-07B), 2, 4, 5, 6, 8, and 9. Institutional controls and operations and maintenance activities at these sites are ongoing and will continue to be monitored under the *Site-wide Institutional Controls and Operations and Maintenance Plan* (DOE-ID 2022). The status of on-going active remediation activities at WAGs 1, 3, 7, and 10 is described in Table 2-1.

Table 2-1. 2021 status of active WAGs cleanup.

WASTE AREA GROUP	FACILITY	STATUS
1	Test Area North	Groundwater cleanup of trichloroethene for Operable Unit 1-07B continued through 2021. The New Pump and Treat Facility generally operated four days per week, except for downtime due to maintenance, to maintain trichloroethene concentrations in the medial zone below specified targets. The in-situ bioremediation transitioned into a rebound test in 2012 to determine the effectiveness of the remedy to date. The revised test plan was finalized in early 2017 to establish how the groundwater cleanup at Test Area North will continue. Two in-situ bioremediation injection wells were constructed in 2015 to further in-situ bioremediation efforts and one monitoring well was constructed in 2017 to better monitor the plume at its distal edge. During 2021, one in-situ bioremediation injection well was constructed, and further in-situ bioremediation continues 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 during 2021.
3	Idaho Nuclear Technology and Engineering Center	The Idaho CERCLA Disposal Facility (ICDF) disposes of contaminated soils and debris from CERCLA remediation operations for the protection of human health and the environment and is located southwest of INTEC. Consolidation of waste at the ICDF reduces the risk of exposure of contaminants to human and ecological receptors, and the use of an engineered facility with leachate collection is protective of the underlying Snake River Plain Aquifer (SRPA). The ICDF functions as an INL-Sitewide disposal facility for CERCLA soils and debris from other WAGs in compliance with strict waste acceptance criteria. The facility continues to receive small amounts of liquid and solid waste periodically for disposal in the ICDF evaporation ponds and disposal cells, respectively. The ICDF evaporation ponds are sampled annually in accordance with the ICDF Complex O&M Sampling and Analysis Plan, and results are sent to the EPA and the state of Idaho DEQ. Remedial actions required by the WAG 3, Operable Unit 3-14 ROD, implemented in 2013, included the reduction of approximately nine million gallons of anthropogenic recharge to the northern perched water zones. Remedial actions were taken at the Tank Farm Facility to reduce water infiltration that potentially could transport contaminants from the perched water to the underlying aquifer. Perched and groundwater monitoring under and near the facility will continue until the risk posed by contamination left in place is below target levels. All ICs and O&M requirements were maintained in 2021. An interim low-permeability asphalt barrier was placed over the western two-thirds of the Tank Farm during 2017 to further reduce infiltration of precipitation water until a final cover is constructed after Idaho Nuclear Technology and Engineering Center (INTEC) closure.
7	Radioactive Waste Management Complex	WAG 7 includes the Subsurface Disposal Area (SDA), a 39-hectare (96-acre) radioactive waste landfill that is the major focus of remedial response actions at the Radioactive Waste Management Complex (RWMC) (Figure 2-2). Waste is buried in approximately 14 of the 39 hectares (35 of the 96 acres) within 21 unlined pits, 58 trenches, 21 soil vault rows, and, on Pad A, an 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 DOE

Table 2-1. continued.

WASTE AREA GROUP	FACILITY	STATUS
		Rocky Flats Plant near Boulder, Colorado, was authorized to send waste to the RWMC for disposal. The Rocky Flats Plant was a nuclear weapons production facility with peak operations during the Cold War era. Various types of radioactive waste streams were disposed of, including process waste (e.g., sludge, graphite molds and fines, roaster oxides, and evaporator salts), equipment, and other waste incidental to production (e.g., contaminated gloves, paper, clothing, and other industrial trash). Much of the Rocky Flats Plant waste was contaminated with transuranic (TRU) isotopes and solvents (e.g., carbon tetrachloride). In 1970, burial of TRU waste was prohibited. In 1984, disposal practices were modified to eliminate disposal of mixed waste. Since 1984, only low-level waste was disposed of in the SDA. Disposal of waste from offsite generators was discontinued in the early 1990s, and disposal of contact-handled waste was discontinued at the end of fiscal year (FY) 2008. Currently, only remote-handled, low-level waste is being disposed of in the SDA. The Operable Unit 7-13/14 ROD (DOE/ID-11359, [DOE-ID 2008]) was signed in 2008. The ROD is consistent with DOE's obligations for removal of TRU waste under the *Agreement to Implement U.S. District Court Order Dated May 25, 2006*, between the Idaho DEQ and DOE-ID, 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 TRU 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 2021, 10,309 m^3 (13,483 yd^3) of targeted waste has been retrieved and packaged from a combined area of 3 hectares (7.41 acres). In addition to targeted waste retrieval, the ROD addresses remaining contamination in the SDA through a combination of continued vapor-vacuum extraction and treatment of solvent vapors from the subsurface, in-situ grouting of specified waste forms containing mobile contaminants (completed 2010), constructing an evapotranspiration surface barrier over the entire landfill, and long-term management and control following construction. Construction will be complete by 2028.
10	10-04 INL Site-wide Miscellaneous Sites and Comprehensive RI/FS	Operable Unit 10-04 addresses long-term stewardship functions—ICs and O&M for sites that do not qualify for Unlimited Use/Unrestricted Exposure—and explosive hazards associated with historical military operations on the INL Site. All ICs and O&M requirements were maintained in 2021, under the Site-wide IC/O&M Plan. The fourth Site-wide CERCLA five-year review covering the period from 2015 through 2019 was finalized in January 2021. The purpose of the CERCLA five-year review is to verify that implemented cleanup actions continue to meet cleanup objectives documented in RODs.
	10-08 INL Sitewide 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 2021 to verify that there is no unacceptable threat to human health or the environment from commingled plumes or along the southern INL Site boundary.

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

2.1.2 Resource Conservation and Recovery Act

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

RCRA Reports. As required by the Idaho DEQ, the INL Site submitted the 2021 annual Idaho Hazardous Waste Generator Annual Report (DOE/ID-11441) on the types and quantities of hazardous wastes generated, shipped for treatment and disposal, and remaining in storage. Federal regulations require large quantity generators to submit a report every two years regarding the nature, quantities, and disposition of hazardous waste generated at their facility. The EPA refers to this as the National Biennial RCRA Hazardous Waste Report or Biennial Report. The Biennial Report form (EPA form 8700-13A/B) is submitted to the Idaho DEQ by March 1 of every even-numbered year for the previous calendar year. The biennial report was not required in 2021.

RCRA Closure Plan. There were no closure activities completed in 2021.

RCRA Inspection. For FY 2021, Idaho DEQ performed a RCRA inspection from April 26-27, 2021. Due to the challenges associated with the COVID-19 pandemic and the declared state of emergency, Idaho DEQ provided advanced notice of the inspection to DOE-ID and requested documents for review prior to arrival on-site. On June 22, 2021, Idaho DEQ issued the final report, noting that at the time of the inspection, no alleged violations of the Rules and Standards for Hazardous Waste and the INL Partial Permits were observed.

RCRA Consent Order. Due to DOE-ID's inability to meet commitments to initiate waste treatment in the Integrated Waste Treatment Unit (IWTU) and cease use of the Idaho Nuclear Technology and Engineering Center (INTEC) tanks, Idaho DEQ assessed a penalty to DOE-ID pursuant to the provisions under Section VII of the Fifth Modification to the Notice of Noncompliance-Consent Order, in the amount of $552,000 for the period of noncompliance from March 30, 2020, to March 31, 2021. Supplemental Environmental Projects were utilized in lieu of the payment, which was reduced due to adverse impacts to IWTU's outage schedule resulting from the COVID-19 global pandemic.

2.1.3 National Environmental Policy Act

The National Environmental Policy Act (NEPA) requires federal agencies to consider potential environmental impacts of proposed actions in the decision-making process. Federal agencies are required to provide a detailed statement on proposals for major federal actions significantly affecting the quality of the human environment. The purpose and function of NEPA is satisfied if federal agencies have considered relevant environmental information, and the public has been informed regarding the decision-making process. DOE-ID implements NEPA according to procedures in the CFR (40 CFR 1500 - 1508; 10 CFR 1021) and assigns authorities and responsibilities according to DOE Policy 451.1, "National Environmental Policy Act Compliance Program." Processes specific to DOE-ID are set forth in its Idaho Operations Office Management System. In 2021, DOE-ID finalized an environmental assessment and issued a Finding of No Significant Impact for the Microreactor Applications Research, Validation, and Evaluation project. The Microreactor Applications Research, Validation and Evaluation environmental assessment analyzed the potential impacts of a proposal to construct a microreactor inside INL's Transient Reactor Test (TREAT) Facility.

2.1.4 Toxic Substances Control Act

The Toxic Substances Control Act (TSCA), which is administered by the EPA, requires the regulation of production, use, or disposal of chemicals. TSCA supplements sections of the Clean Air Act (CAA), the Clean Water Act (CWA), and the Occupational Safety and Health Act. Because the INL Site does not produce chemicals, compliance with the TSCA is primarily directed towards the use and management of certain chemicals—particularly polychlorinated biphenyls (PCBs). The INL Site manages radioactive mixed waste containing PCBs received from other DOE Sites many years ago for disposal. Environmental remediation activities include the re-processing of these waste materials for disposition off-site. In addition, PCBs were used in the manufacture of many different items and materials including liquid filled electrical equipment such as transformers and capacitors, paint, and caulking. Whenever any of these items or materials are discovered, they are disposed of off the INL Site at a TSCA-approved disposal facility. Requirements for the reporting of PCB-related activities are found in 40 CFR 761 Subpart J, "General Records and Reports." These regulations require a facility to maintain a written record documenting all PCB management activities until the PCBs are disposed of and this written record must be available for inspection or submission if requested by the EPA. It must be prepared each year by July 1 and maintained at the facility for at least three years after the facility ceases using or storing PCBs and PCB items. The INL prepares the required annual documentation each year. It includes an inventory of PCB/radioactive waste in storage at the INL for the previous year and documents progress made toward disposal in accordance with applicable regulations. The INL Site maintains rigorous compliance with all applicable PCB regulations.

2.1.5 Federal Insecticide, Fungicide and Rodenticide Act

The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) regulations found in 40 CFR parts 150-189 are promulgated and administered by the EPA. The term “pesticide” means (1) any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest, (2) any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant, and (3) any nitrogen stabilizer. The FIFRA provides for federal regulation of pesticide distribution, sale, and use. All pesticides distributed or sold in the U.S. must be registered (licensed) by the EPA. The process of registering a pesticide is a rigorous scientific, legal, and administrative procedure. The EPA evaluates a pesticide registration application to assess a wide variety of potential human health and environmental effects associated with use of the product.

The EPA also evaluates and approves the language that appears on each pesticide label to ensure the directions for use and safety measures are appropriate to any potential risk. The label on a pesticide package or container and the accompanying instructions are a very important part of pesticide regulation for the applicator. The label provides critical information about how to handle and safely use the pesticide product and avoid harm to human health and the environment. Using a pesticide product inconsistent with the label requirements is a violation of federal law.

All pesticides applied on the INL Site are EPA approved products. All pesticide applications are made by trained and licensed pesticide applicators. The pesticide label requirements are rigorously followed to ensure the safety of the applicators, site personnel, and the environment, including non-target organisms like wildlife and desirable native vegetation. Most applications target state listed noxious weeds and invasive vegetative species for which control is required by federal orders and to mitigate the amount of potential fuel for wildland fire. Other uses include maintaining clear buffer areas for INL facilities and roadways, as well as controlling insects in building interiors and landscape maintenance. Refer to Section 9.2.4 for additional information about INL contractor’s efforts to control noxious and invasive vegetative species.

2.1.6 DOE O 435.1, Radioactive Waste Management Compliance

The Atomic Energy Act of 1954 (42 U.S.C § 2011 1954) Section 161(i) authorizes DOE to regulate activity involving certain radioactive materials, including radioactive waste, to “protect human health and minimize danger to life or property.” This authority is implemented through DOE O 435.1, “Radioactive Waste Management,” and the accompanying DOE Manual 435.1-1, “Radioactive Waste Management Manual,” which set forth the requirements for assuring the safety of the generation, treatment, storage, and disposal of DOE-owned radioactive waste. These DOE Directives ensure that radioactive waste management activities are systematically planned, documented, executed, and evaluated. Specifically, the order and the manual:

- Establish requirements to implement DOE regulating authority and responsibilities for radioactive waste management
- Define DOE radioactive waste types: (1) high-level waste, (2) TRU waste, and (3) low-level waste
- Emphasize management for disposal and establish requirements for waste characterization, waste certification, and waste acceptance criteria

- Identify performance-based requirements
- Require life-cycle management (i.e., from generation planning to disposal)
- Rely on existing nuclear safety philosophies (e.g., Integrated Safety Management System, Graded Approach, Defense-in-Depth)
- Require a DOE-approved Radioactive Waste Management Basis (RWMB) to ensure hazards have been identified, analyzed, and mitigated.

The INL contractor manages all hazardous high-level waste (HLW), mixed low-level waste (MLLW), low-level waste (LLW), contact-handled TRU waste, and remote-handled-TRU waste generated at INL facilities. The Waste Management Program is the lead organization for ensuring compliant cradle-to-grave waste management of containerized waste as described in PDD-17000, "Waste Management Program."

The Idaho Cleanup Project (ICP) Core manages all hazardous, MLLW, LLW, contact-handled TRU waste, and remote-handled-TRU waste that is generated and stored at the Site and approved off-INL Site waste streams. Management activities include, but are not limited to, storing waste, treating waste, and transporting and disposing of waste. The overall responsibility for managing waste resides within the Fluor Idaho Waste Management Programs organization according to PDD-234, "Waste Management Program." All waste management activities described herein are conducted in compliance to all applicable provisions of DOE O 435.1.

See Table 2-2 for information on wastes managed at the INL Site by the INL and ICP Core contractors.

Table 2-2. Wastes managed at the INL Site.

FACILITY	GENERATION	TREATMENT	STORAGE	DISPOSAL
INL CONTRACTOR				
Advanced Test Reactor	LLW	—	LLW	—
Central Facilities Area	LLW	—	LLW	—
Materials and Fuels Complex/INTEC	TRU/LLW	LLW	TRU/LLW	—
Remote Handled Low-level Waste Disposal Facility	LLW	—	LLW	LLW
Research and Education Campus	LLW	—	LLW	—
Specific Manufacturing Capability	LLW	LLW	LLW	—
ICP CORE CONTRACTOR				
Advanced Mixed Waste Treatment Project	TRU/LLW	TRU/LLW	TRU/LLW	—
Idaho CERCLA Disposal Facility	—	—	—	LLW
INTEC Calcined Solids Storage Facility	—	—	HLW	—
INTEC Tank Farm Facility	—	—	HLW	—
Integrated Waste Treatment Unit	—	HLW	HLW	—
Radioactive Waste Management Complex Accelerated Retrieval Project	TRU/LLW	TRU/LLW	TRU/LLW	—
Radioactive Waste Management Complex Active Low-level Waste Disposal Facility	—	—	—	LLW

See Table 2-3 for the status of each phase of the LLW management process for facilities managed at the INL Site by the INL and ICP Core contractors.

Table 2-3. Listing of the status of each phase of the LLW management process for sites authorized to manage a LLW facility.

PHASE	REMOTE-HANDLED LLW DISPOSAL FACILITY	RWMC ACTIVE LLW DISPOSAL FACILITY	ICDF
Performance Assessment (PA)	DOE/ID-11421, "Performance Assessment for the Idaho National Laboratory Remote-Handled Low-Level Waste Disposal Facility"	DOE/NE-ID-11243, "Performance Assessment for the RWMC Active Low-Level Waste Disposal Facility at the Idaho National Laboratory Site"	DOE/ID-10978, "Performance Assessment for the Idaho CERCLA Disposal Facility Landfill"
Composite Analysis (CA)	DOE/ID-11422, "Composite Analysis for the Idaho National Laboratory Remote-Handled Low-Level Waste Disposal Facility"	DOE/NE-ID-11244, "Composite Analysis for the RWMC Active Low-Level Waste Disposal Facility at the Idaho National Laboratory Site"	DOE/ID-10979, "Composite Analysis for the INEEL CERCLA Disposal Facility Landfill"
Closure Plan	PLN-3370, "Preliminary Closure Plan for the Idaho National Laboratory Remote-Handled Low-Level Waste Disposal Facility"	RPT-576, "Interim Closure Plan for the RWMC Active Low-Level Waste Disposal Facility at the Idaho National Laboratory Site"	A preliminary closure plan has been developed for the closure of the entire ICDF Complex. This preliminary closure plan was included in the "ICDF Complex Remedial Action Work Plan" (DOE/ID-10984)
PA/CA Maintenance Program	PLN-3368, "Maintenance Plan for the Remote-Handled Low-Level Waste Disposal Facility Performance Assessment and Composite Analysis"	RPT-431, "Performance Assessment and Composite Analysis Maintenance Plan for the RWMC Active Low-Level Waste Disposal Facility"	RPT-791, "Performance Assessment and Composite Analysis Maintenance Plan for the Idaho CERCLA Disposal Facility"
Latest Annual PA/CA Summary Report	INL/RPT-22-65681, "Annual Summary Report for the Remote-Handled Low-Level Waste Disposal Facility—FY 2021"	RPT-1895, "Annual Summary Report: Review for Continued Adequacy of the Performance Assessment, Composite Analysis, and Supporting Documents for the Active Low-Level Waste Disposal Facility at the RWMC – FY 2020"	RPT-1894, "Annual Summary Report: Review for Continued Adequacy of the Performance Assessment, Composite Analysis, and Supporting Documents for the ICDF Landfill – FY 2020"
Disposal Authorization Statement (DAS)	Bishop, T., memorandum to R. Provencher, May 22, 2018, "Operating Disposal Authorization Statement for the Remote-Handled Low-Level Waste Disposal Facility Idaho National Environmental Laboratory, Idaho," U.S. DOE-NE, May 22, 2018	Marcinowski, F., memorandum to E. Sellers, January 30, 2008, "Revision of the Disposal Authorization Statement for the Idaho National Laboratory Active Low-Level Waste Disposal Facility within the Radioactive Waste Management Complex," CCN 323845	Marcinowski, F., memorandum to R. Provencher, April 7, 2011, "Revision of the Disposal Authorization Statement for the Idaho Comprehensive Environmental Response, Compensation, and Liability Act Disposal Facility," CCN 311791

2.1.7 DOE O 458.1, Radiation Protection of the Public and the Environment

DOE O 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 a member of the public is maintained within the dose limits established in this order
- Control the radiological clearance of DOE real and personal property
- Ensure that potential radiation exposures to members of the public are as low as reasonably achievable

- 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
- 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 2021.

DOE standard DOE-STD-1196-2011, Derived Concentration Technical Standard, supports implementation of DOE O 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, known as 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: (1) ingestion of water, (2) submersion in air, and (3) inhalation. Measurements of radionuclides in environmental media sampled on and around the INL Site were all below appropriate DCSs.

DOE O 458.1 specifies the limits for unrestricted release of property to the public. All INL and ICP Core 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 for recycling
- Office trash
- Non-radiological area housekeeping materials and associated waste
- Breakroom, cafeteria, and medical wastes
- Medical and bioassay samples
- Other items with an approved release plan.

Items originating from non-radiological areas within the INL 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 history of the material 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 Site property/excess warehouse where the materials are again resurveyed on a random basis by 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. INL and ICP Core contractors continue to follow the requirements of the scrap metal suspension. No scrap metal directly released from radiological areas is recycled.

2.1.8 INL Site Agreements

The INL has three major site agreements that contain regulatory commitments and milestones. These major Site Agreements are known as the Site Treatment Plan (STP), the Idaho Settlement Agreement (ISA), and the Notice of Noncompliance/Consent Order (NON/CO).

The FFA/CO requires the preparation of site treatment plans for the treatment of mixed waste stored or generated at DOE facilities. Mixed waste contains both hazardous and radioactive components. The INL STP was signed by the Idaho DEQ on November 1, 1995, and is updated annually (DEQ 1995). This plan outlines DOE-ID's proposed treatment strategy for the mixed-waste streams, called the backlog, and identifies onsite and offsite MLLW treatment capabilities.

During 2021, DOE-ID completed four STP milestones including the treatment of remote-handled waste, two certification milestones of original volume TRU-contaminated contact-handled waste, and the treatment of sodium contaminated debris. DOE-ID made a request to the Idaho DEQ to extend milestones associated with the start-up of the IWTU and treatment of sodium bearing waste, which the state approved in September 2021. Idaho DEQ granted the IWTU milestone extensions for good cause after a 30-day public comment period had been completed.

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

The STP and the ISA required DOE-ID to process and ship all waste out of Idaho by December 31, 2018, respectively, stored as TRU waste on the INL Site in 1995, when the agreements were signed. The estimated volume of that waste was 65,000 m^3 (85,016 yd^3). This milestone was not achieved; however, revised STP milestones were agreed upon with the Idaho DEQ and an Addendum to the ISA was signed on November 6, 2019, to address the milestone.

As of December 31, 2021, a total of 60,829 m^3 (79,561 yd^3) of original volume TRU-contaminated waste had been processed (i.e., shipped or certified for disposal to Waste Isolation Pilot Plant [WIPP]). DOE-ID completed certification of 25% of the Original Volume Transuranic Contaminated waste remaining inventory to be certified for shipment and disposal at WIPP. DOE-ID made 122 shipments of ISA TRU waste to WIPP in 2021, comprised of 102 shipments of legacy TRU waste and 20 shipments of buried TRU.

The ICP Core contractor manages and operates several projects to facilitate the disposition of radioactive waste as required by the ISA and STP. The Advanced Mixed Waste Treatment Project performs retrieval, characterization, treatment, packaging, and shipment of TRU waste currently stored at the INL Site. Most of the waste processed at the Advanced Mixed Waste Treatment Project resulted from the manufacture of nuclear components at DOE's Rocky Flats Plant in Colorado. This waste is contaminated with TRU radioactive elements (primarily plutonium).

The final agreement, the NON/CO and recent modification, in conjunction with the STP, requires the treatment of sodium bearing waste stored at the INTEC Tank Farm at the IWTU. To meet the milestones in the NON/CO and STP, DOE-ID and its ICP Core contractor, Fluor, continued their methodical approach to startup the IWTU, which is designed to process the remaining 3,407,000 L (900,000 gal) of liquid waste stored at INTEC. This waste is stored in three stainless steel underground tanks, and a fourth is always kept empty as a spare. All four will be closed in compliance with hazardous waste regulations. A total of 11 other liquid storage tanks have been emptied, cleaned, and closed. The waste was originally scheduled to begin processing in 2012, but several technical problems have delayed IWTU.

The previous ICP Core contractor assembled a team of nationwide experts on fluidized bed technology to resolve issues with the IWTU identified during previous testing, which occurred incrementally from 2016 and into 2019 during numerous simulant test runs and interim plant outages which was largely retained by the current contractor. The methodical approach includes: (1) implementing design and mechanical modifications; (2) testing and verifying the changes; (3) initiating radiological operations at the facility; and (4) completing processing of the remaining liquid waste. The completion of the previous major outage was delayed in early 2020 due to the onset of COVID-19. The project implemented the final anticipated major facility modifications during its last outage which began in June 2019 and concluded in July 2021, despite adverse schedule impacts resulting from the COVID-19 global pandemic. The major modifications that were installed included wet and dry decontamination systems, canister decontamination robotic systems, re-designed process off gas filter bundles, and other contamination control modifications. The facility commenced a planned confirmatory run in late 2021, but technical challenges interrupted the run prior to completing all test objectives. Minor corrective actions will be implemented in early 2022 followed by another confirmatory run prior to commencing radiological operations anticipated to begin in late 2022.

2.1.9 Low-level and Mixed Radioactive Waste

In 2021, approximately 514 m^3 (672 yd^3) of MLLW and 226 m^3 (295 yd^3) of low-level waste was shipped off the INL Site for treatment, disposal, or both. Approximately 18.63 m^3 (24.37 yd^3) of low-level waste was disposed at the SDA in 2021 as shown in Figure 2-2.

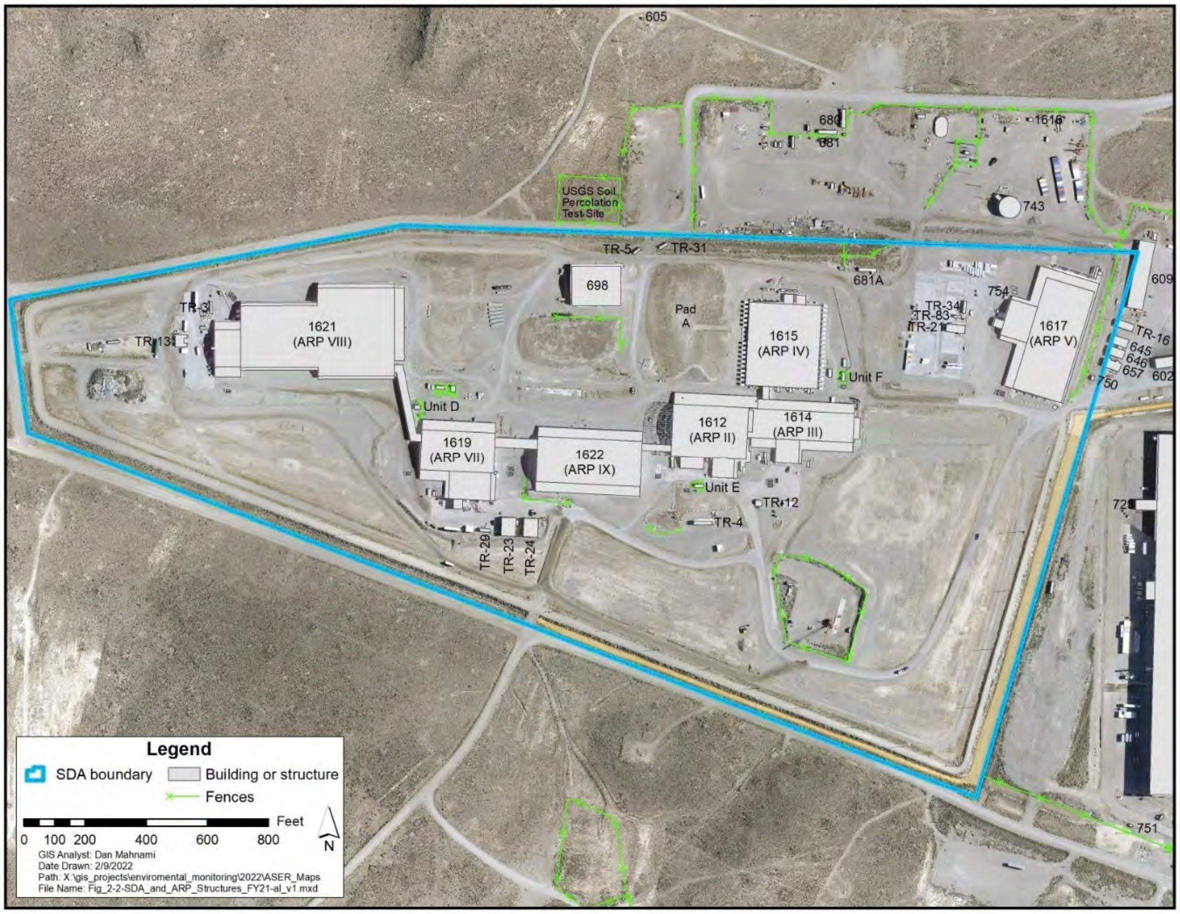

Figure 2-2. Radioactive Waste Management Complex Subsurface Disposal Area (2021).

2.1.10 Spent Nuclear Fuel

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

The ISA put milestones into place for the management of SNF at the INL Site:

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

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

2.2 Air Quality and Protection

2.2.1 Clean Air Act

The Clean Air Act (CAA) is the basis for national air pollution control. Congress passed the original CAA in 1963, and several amendments containing key pieces of legislation have been passed with the latest in 1990, which resulted in the current CAA law. The CAA provides the EPA with broad authority to implement and enforce regulations to reduce air pollutant emissions with an emphasis on cost-effective methods. In addition to EPA, states, tribes, and local governments play a key role in the implementation of the CAA. The Idaho DEQ has been delegated authority to implement the CAA through the development of an EPA-approved state implementation plan. DOE-ID holds a synthetic minor, Sitewide, air quality permit to construct with a facility emission cap component from the Idaho DEQ for INL to limit its potential to emit to less than major facility limits for criteria air pollutants (CAPs) regulated under Section 109 of the CAA. INL is currently a major source of CAP emissions and an area source of hazardous air pollutant emissions regulated under Section 112 of the CAA. The facility emission cap includes enforceable CAP and hazardous air pollutant limits to ensure that current and future operations will not trigger the requirement to obtain a Title V/Tier I operating permit or implementation of current or future major source maximum achievable control technology standards.

No air quality inspections were performed by the Idaho DEQ during calendar year 2021.

2.2.2 Hydrofluorocarbon Phasedown

In October 2021, EPA issued regulations to decrease the production of hydrofluorocarbons (HFCs) over the next fifteen years thereby decreasing the supply (40 CFR 84). HFCs were developed and manufactured to replace chlorofluorocarbons, which damage the stratospheric ozone layer. HFC uses include refrigerants, solvents, fire suppressants, and aerosols. Through these regulations, EPA seeks to reduce HFC consumption and production to 15% of a 2011-2013 baseline by 2036. These regulations do not prevent entities from using equipment containing HFCs that have already been purchased are currently in use. However, as the phasedown progresses, these HFCs will become less available and more expensive. The DOE Office of Environment, Health, Safety, and Security published OE-3: 2021-06, "Hydrofluorocarbon Phasedown," to provide information and suggestions to DOE programs and sites about these new regulations. A summary of the INL and ICP Core contractors HFC uses, replacements, procurement, and proactive measures taken as a result of the HFC phasedown can be found in Section 4.2.1.

2.3 Water Quality and Protection

2.3.1 Clean Water Act

The Clean Water Act (CWA), which was 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, as well as regulating water quality standards for surface water. The CWA also provided for the National Pollutant Discharge Elimination System (NPDES) permit program, requiring permits for discharges into regulated surface waters. The Idaho DEQ has been authorized by the EPA to assume permitting authority over the NPDES program. The Idaho DEQ program is called the Idaho Pollutant Discharge Elimination System (IPDES). The INL and ICP Core contractors do not currently hold any IPDES permits but in town facilities discharge to the city of Idaho Falls wastewater treatment plant which is required by the IPDES permit program to set pretreatment standards for nondomestic discharges to publicly owned treatment works. The INL Research Center complies with an Industrial Wastewater Acceptance permit for discharges to the city of Idaho Falls. This program is set out in Title 8, Chapter 1 of the Municipal Code of the city of Idaho Falls. All discharges in 2021 were within levels established in the INL Research Center Industrial Wastewater Acceptance permit. An inspection was performed April 14, 2021, by the city of Idaho Falls and was found to be in substantial compliance.

2.3.2 Safe Drinking Water Act

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

The eastern Snake River Plain aquifer is the source for the 11 active public water systems at all the facilities on the INL Site. Ten are monitored by the INL and ICP Core contractors. The remaining system is monitored by the Naval Reactors Facility contractor. All INL Site public water systems sample their drinking water as required by the Idaho DEQ. There were no drinking water requirements exceedances for any of the INL public water systems during 2021. Chapter 6 contains details on drinking water monitoring.

The EPA is establishing regulations for a class of widely used and dispersed man-made chemicals called per- and polyfluoroalkyl substances. The INL site participated in a voluntary Idaho state initiative involving a select group of drinking water systems to identify drinking water sources that may contain per- and polyfluoroalkyl substances. In 2021 10 out of 13 wells were sampled that supply water to their eight water systems. Perfluorooctanoic Acid (PFOA) and Perfluorooctane Sulfonate (PFOS), for example, are two of the most widely used and studied chemicals in the perfluoroalkyl substances group. The EPA proposed an initial health advisory limit for PFOA and PFOS combined at 70 parts per trillion in drinking water. This limit is expected to be refined as more definitive health risk information is derived. INL will be reporting on sampling efforts and results for all water systems in the future.

2.3.3 Idaho DEQ Reuse Permits

Wastewater is the spent water or effluent from activities and processes occurring in dwellings, commercial buildings, industrial plants, institutions and other establishments. If the wastewater contains sewage, it is considered municipal wastewater. If it does not contain sewage, it is considered industrial wastewater. Recycled water is wastewater effluent that is treated, if necessary, and then reused for other purposes. The Idaho DEQ encourages reuse, which is the practice of using recycled water for irrigation, ground water recharge, landscape impoundments, toilet flushing in commercial buildings, dust control, and other beneficial uses.

The Idaho DEQ requires anyone choosing to use recycled water to obtain a reuse permit. Reuse permits consider the site-specific conditions of each facility and include site-specific limits and conditions as applicable to protect public health and the environment, including groundwater. The Idaho DEQ issues these 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.” The following facilities have reuse permits at the INL Site:

- Advanced Test Reactor Complex Cold Waste Ponds (I-161-03)
- INTEC New Percolation Ponds (M-130-06)
- Materials and Fuels Complex Industrial Waste Pond (I-160-02).

These reuse facilities were operated in substantial compliance with permit requirements during 2021. Chapter 5 contains details on recycled water monitoring.

2.4 Other Environmental Statutes

2.4.1 Endangered Species Act

The Endangered Species Act (ESA):

- Provides a means whereby the ecosystems endangered, and threatened species depend on may be conserved
- Provides a program to support the conservation of such endangered and threatened species and their habitats
- 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 (ESER) program conduct ecological research, field surveys, and NEPA evaluations regarding ecological resources on the INL Site (see Chapter 9). Emphasis is given to threatened and endangered species, species of conservation concern, and species of greatest conservation need identified by the U.S. Fish and Wildlife Service (FWS) and Idaho Department of Fish and Game.

Three species are currently identified as potentially occurring on the INL Site under the ESA by the FWS: (1) Canada Lynx (*Lynx canadensis* - threatened [https://www.fws.gov/species/canadian-lynx-lynx-canadensis]); (2) whitebark pine (*Pinus albicaulis* - proposed threatened [https://www.fws.gov/species/scrub-pine-pinus-albicaulis]); and (3) monarch butterfly (*Danaus plexippus* - candidate [https://www.fws.gov/species/monarch-butterfly-danaus-plexippus]).

The Canada lynx is typically found inhabiting boreal and subalpine forests where snow is deep and high densities of snowshoe hare populations, their principal prey, are present. There is no critical habitat or other resources available on the INL Site to support the Canada lynx, and if they are observed on the INL Site, it would be transitory in nature.

Whitebark pine is also associated with high subalpine elevations and can be found in the upper elevations of mountain ranges that surround the INL Site. It relies on species such as the Clark's nutcracker (*Nucifraga columbiana*) for seed dispersal. Although, the Clark's nutcracker is an uncommon visitor to juniper dominated portions of the INL Site, the proper elevations are not present for whitebark pine to survive, and it is highly unlikely that this species would ever be present.

Monarch butterfly larvae are dependent upon milkweed (*Asclepias* sp.) species as their sole food source. Milkweed species are typically found in fence rows and along the banks of rivers, lakes, ponds or other waterways; however, on the INL Site, the inconsistent water flows in the Big Lost River reduce the likelihood of milkweed species. Therefore, it is highly unlikely that Monarch butterflies would occur on the Site, and if they are observed, it would likely be transitory in nature.

One species categorized as threatened under the ESA, that may rarely traverse the INL Site is the Yellow-billed Cuckoo (*Coccyzus americanus*). On October 3, 2014, the FWS determined threatened status for the Western Distinct Population Segment of the Yellow-billed Cuckoo (*Coccyzus americanus*) (https://www.fws.gov/species/yellow-billed-cuckoo-coccyzus-americanus). The rare species is known to breed in river valleys in southern Idaho but a single sighting has been documented near the INL Site at Atomic City.

FWS conducted a status review and, in September 2015, announced that the greater sage-grouse does not warrant protection under the ESA. FWS made this determination based upon reduction in threats, which caused the FWS to initially designate the bird "warranted but precluded" in 2010. Federal, state, and private land-use conservation efforts were major factors in accomplishing threat reduction, such as the *Candidate Conservation Agreement for Greater Sage-grouse on the INL Site* (DOE-ID and USFWS 2014) that DOE-ID and FWS signed in October 2014. The voluntary agreement includes conservation measures that protect sage-grouse and its habitat while allowing DOE-ID flexibility in accomplishing its missions. For additional information regarding the CCA, refer to Chapter 9.

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 (*Pseudogymnoascus destructans*) that has killed at least 5.5 to 6.7 million bats across seven species. Many species of bats could be at risk for significant decline or extinction due to this disease. At least two species of bats that occupy the INL Site could be affected by WNS if this disease arrives in Idaho: the little brown myotis (*Myotis lucifugus*) and the big brown bat (*Eptesicus fuscus*). In 2010, the little brown myotis was petitioned for emergency listing under the ESA, and the FWS is collecting information on both species to determine if, in addition to existing threats, this disease may be increasing the extinction risk of these bats. Biologists from the ESER program operate a monitoring program using acoustical detectors set at hibernacula and important habitat features (e.g., caves and facility ponds) used by these mammals on the INL Site. Naval Reactors and DOE-ID have developed a Bat Protection Plan for the INL Site (DOE-ID 2018). The plan was updated in 2020. The Bat Protection Plan allows the INL Site to proactively position itself to continue its missions if there is an emergency listing of a bat species due to WNS. The plan is based upon monitoring data and other current knowledge of bat populations on the INL Site. Bat monitoring is discussed further in Chapter 9.

2.4.2 Migratory Bird Treaty Act

The Migratory Bird Treaty Act prohibits taking any migratory bird, or any part, nest, or egg of any such bird, without authorization from the U.S. Department of the Interior (DOI). Permits may be issued for scientific collecting, banding and marking, falconry, raptor propagation, depredation, import, export, taxidermy, waterfowl sale and disposal, and special purposes. DOE-ID has a USFWS Special Purpose Permit for limited nest relocation and destruction and the associated take of migratory birds, if necessary, for mission-critical activities. The permit would be applied in very limited and extreme situations where no other recourse is practicable. The permit also authorizes possession, salvage, and disposition of migratory birds killed through incidental take (e.g., mainly collisions with vehicles, windows, and other structures). The permit authorizes DOE-ID and contractors to relocate a limited number of active migratory bird nests for the protection of birds and human health and safety. If relocating the nest is not practicable, and all other mitigation and avoidance measures have been exhausted, the permit authorizes destruction of the nest. Nonnative species such as European starling, rock pigeon, house sparrow, and Eurasian collared dove are not protected under the Migratory Bird Treaty Act and upland gamebirds such as grouse, turkey and quail are regulated by the Idaho DEQ. Bald and golden eagles are included in the permit only to ensure reporting of potential criminal activity associated with injury or death, and to salvage and transfer carcasses to FWS for necropsy. As required by the permit, DOE-ID submitted an annual report to FWS by January 31, detailing reportable activities related to migratory birds. There were numerous salvage actions tracked, documented, and reported in compliance with permit requirements during 2021. A total of 201 birds, four nests, and six eggs were salvaged in 2021. Thirty-nine of the salvaged birds were among the August 2021 mass avian mortality discussed below. A Say's Phoebe nest with three eggs was found abandoned, a common Raven nest and a Barn Swallow nest without eggs or young were salvaged, and the fourth nest was that of the Say's Phoebe discussed below. No takes occurred in 2021.

Three migratory bird-related activities that occurred on the INL Site during 2021 are highlighted herein. No takes occurred in 2021.

- On July 6, 2021, a Barn Swallow nest with three young was found on equipment staged outdoors at the INL Site. The nest was relocated to a licensed rehabilitator in Pocatello, Idaho, but perished a short time after relocation. DOE-ID timely notified the FWS of this activity.
- On July 12, 2021, a Say's Phoebe nest with three eggs was found on equipment staged outdoors at the INL Site. Daily monitoring of the nest revealed that there was no bird activity at the nest implying that the nest was abandoned. The eggs were examined by ESER program biologists and were found to be non-viable, therefore, the nest was inactive. The nest was salvaged and will be used for training and education purposes as allowed by the permit.
- On August 30, 2021, DOE-ID reported mass avian mortalities to FWS that occurred on the INL Site from August 18-19, 2021. On recommendation from the FWS, DOE-ID shipped the carcasses to the U.S. Geological Survey National Wildlife Health Center for evaluation. In the final report dated November 9, 2021, the National Wildlife Health Center determined the birds died from blunt-force trauma, most likely through collisions with man-made structures. DOE-ID is evaluating measures to reduce the potential recurrence of a similar incident, including changes to facility lighting that may have affected the birds' flight path.

In support of meeting the requirements set forth in the Migratory Bird Treaty Act and Executive Order 13186 "Responsibilities of Federal agencies to protect Migratory Birds" DOE-ID has developed a Migratory Bird Conservation Plan that provides conservation measures designed to protect nesting birds on the INL Site. To properly implement this plan and promote the conservation of migratory birds, a Migratory Bird/Wildlife Conservation Working group was established in 2019. This group routinely meets throughout the nesting season to discuss/resolve a variety of bird and wildlife-related issues experienced at INL facilities and ensure compliance with the requirements of the DOE-ID Migratory Bird Treaty Act permits issued by the FWS and the Idaho Department of Fish and Game. Chapter 9 provides additional information about the Conservation Plan and Working group.

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

2.4.3 Emergency Planning and Community Right-to-Know Act

The Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986 was created to help communities plan for emergencies involving hazardous substances. The Act establishes requirements for federal, state, and local governments; Indian tribes; and industry regarding emergency planning and "Community Right-to-Know" reporting on hazardous and toxic chemicals. The Community Right-to-Know provisions help increase the public's knowledge and access to information on chemicals at individual facilities, their uses, and releases into the environment. States and communities, working with facilities, can use the information to improve chemical safety and protect public health and the environment. The INL Site's compliance with key EPCRA provisions is summarized in the following subsections and in Table 2-4.

Table 2-4. INL Site EPCRA reporting status (2021).

EPCRA SECTION	DESCRIPTION OF REPORTING	2021 STATUS
Section 304	Extremely Hazardous Substance Release Notification	Not Required
Section 311-312	Safety Data Sheet/Chemical Inventory	Required
Section 313	Toxic Chemical Release Inventory Reporting	Required

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 2021.

Sections 311 and 312 – Sections 311 and 312 require facilities manufacturing, processing, or storing designated hazardous chemicals to make safety data sheets describing the properties and health effects of these chemicals available to state and local officials and local fire departments. Facilities are also required to report inventories of all chemicals that have safety data sheets to state and local officials and local fire departments. The INL Site satisfies the requirements of Section 311 by submitting a quarterly report to state and local officials and fire departments, identifying chemicals that exceed regulatory thresholds. In compliance with Section 312, the annual Emergency and Hazardous Chemical Inventory (Tier II) Report is provided to local emergency planning committees, the state emergency response commission, and local fire departments by the regulatory due date of March 1. This report includes the types, quantities, and locations of hazardous chemicals and extremely hazardous substances stored at the INL Site and Idaho Falls facilities that exceed regulatory thresholds. In 2021, the chemical inventory report included 71 individual chemicals at INL Site facilities and eight at Idaho Falls facilities. The INL Site also stores extremely hazardous substances, a category of chemicals that could cause serious irreversible health effects from accidental releases. Extremely hazardous substances chlorine, cyclohexylamine, nitric acid, nitrogen dioxide, and sulfuric acid were among the chemicals reported in 2021.

Section 313 – Section 313 requires facilities to submit a Toxics 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 Toxics Release Inventory Forms for chromium, diisocyanates, lead, naphthalene, nickel, nitrates and nitric acid, to EPA and the Idaho DEQ by the regulatory due date of July 1.

Reportable Environmental Releases – There was one reportable environmental release from the INL Site in 2021:

A release of hydraulic fluid was discovered and cleaned up at the RWMC on July 8, 2021. The release occurred to the gravel/soil in the Construction Laydown Area just north of the RWMC SDA north berm. The spill was determined to have occurred from a leaking hydraulic fluid system main supply hose on a 1986 sonic drilling rig. It was also determined that the hose had been destroyed by chewing rodents. The spill was estimated to be 70 gallons. The surface stain to the soil was approximately 14 feet in length and approximately 9 feet in width. All stained soil resulting from the spill was excavated and removed. The petroleum contaminated soils were containerized for disposal in eight BR-90 (90 cubic feet) steel boxes and the excavation was backfilled with clean soil. The damaged hose was wrapped in absorbent and taped to mitigate any further leaking. Because the release quantity was greater than the 25-gallon reporting threshold (IDAPA 58.01.02.851), DOE-ID notified the Idaho DEQ.

2.4.4 Executive Order 11988, Floodplain Management

Executive Order 11988 requires each federal agency to issue or amend existing regulations and procedures to ensure that the potential effects of any action it may take in a floodplain are evaluated and that its planning programs and budget requests consider flood hazards and floodplain management. It is the intent of Executive Order 11988 that federal agencies implement floodplain requirements through existing procedures, such as those established to implement NEPA.

10 CFR 1022 contains DOE policy and floodplain environmental review and assessment requirements through the applicable NEPA procedures. In those instances where impacts of actions in floodplains are not significant enough to require the preparation of an Environmental Impact Statement (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* (Bureau of Reclamation 2005). This flood hazard report is based on geomorphological models and has undergone peer review. All activities on the INL Site requiring characterization of flows and hazards are expected to use this report. For facilities at Test Area North, the 100-year floodplain has been delineated in a U.S. Geological Survey report (USGS 1997).

2.4.5 Executive Order 11990, Protection of Wetlands

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

The only areas of the INL Site currently identified as potentially jurisdictional wetland are the Big Lost River corridor and Big Lost River Sinks. The FWS National Wetlands Inventory map is used to identify potential jurisdictional wetlands and non-regulated sites with ecological, environmental, and future development significance. In 2021, no actions took place within potential wetland areas on the INL Site that would require a Jurisdictional Review or Determination to be made by the U.S. Army Corps of Engineers.

2.4.6 Executive Order 14008, Ecological Resource Conservation, Land Use, and Resilience Activities

The purpose of Executive Order 14008, “Tackling the Climate Crisis at Home and Abroad” is to make climate considerations an essential element of U.S. foreign policy and national security planning, and to understand how domestic policy can address the implications of climate change. Overarching goals for domestic policy include strengthening clean air and water protections, holding polluters accountable, delivering environmental justice, and driving the mitigation of climate-related risks in our economy. At INL, several initiatives have been undertaken to address Executive Order 14008. These initiatives include activities as diverse as evaluating infrastructure to identify opportunities to increase efficiency in electricity and water use, assessing the materials supply chain to reduce INL’s carbon footprint, implementing the INL NetZero Plan, and aligning land use/land stewardship objectives with ecosystems resilience and ecosystem services priorities.

With respect to ecological resource conservation, INL implements a number of conservation plans. Land stewardship activities prioritize conserving and restoring native communities to maximize ecosystem services like carbon sequestration. Wildland fire management is an important focus for INL land stewardship, particularly minimizing losses of native plant communities to wildland fire and restoring communities affected by wildland fire to historical ecological function. Another aspect of maintaining healthy, native ecosystems at INL is consistent implementation of the site-wide noxious weed plan. Ecological monitoring activities are conducted to continuously evaluate the condition of natural resources and ensure the local sagebrush steppe ecosystem remains healthy and resilient in its ability to respond to the stresses associated with climate change. See Chapter 9 for a more thorough discussion of the ecological aspects of implementing Executive Order 14008 on the INL Site.

Concerning Site Resiliency, INL is taking actions to bolster adaptation and increase the resilience of DOE-ID facilities and operations. INL is currently working on a number of sustainable actions. For example, in 2021, INL included sustainable acquisition clauses in electronic purchases. These new acquisitions use the Electronic Product Environmental Assessment Tool products to reduce energy use. The most prominent initiative is the INL NetZero Plan, an initiative announced in 2021 to offset any greenhouse gas emissions that are produced from its 357 buildings, 605 vehicles, and approximately 5,400 employees spread over its roughly 900-square-mile campus. Additionally, INL and ICP Core contractors are updating the Climate Vulnerability Assessment and incorporating all the requirements of the Vulnerability Assessment and Resiliency Plan. These plans intend to assess vulnerabilities, implement solutions, institutionalize climate adaptation across policies, provide climate adaptation tools, and deploy merging climate technologies. The performance status of current sustainable activities and further details of new initiatives are further discussed in Chapter 3.

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. DOE provides leadership in the preservation of precontact, historic, and other cultural resources on the lands it administers in a spirit of stewardship for the future as outlined in various federal preservation laws, regulations, and guidelines, such as the National Historic Preservation Act and the Archaeological Resources Protection Act, and the National Environmental Policy Act. These resources are nonrenewable, bear valuable physical and intangible legacies, and yield important information about the past, present, and perhaps the future. There are special challenges associated with balancing the preservation of these sites with the management and ongoing operation of an active scientific laboratory. DOE-ID is committed to a cultural resource management program that accepts these challenges in a manner reflecting both the spirit and intent of the legislative mandates. In 2004, DOE-ID entered into a Programmatic Agreement with the Idaho State Historic Preservation Office and Advisory Council on Historic Preservation (DOE-ID 2004). The Programmatic Agreement required development of the INL Cultural Resource Management Plan to govern a tailored approach for compliance with Section 106 of the National Historic Preservation Act (NHPA) for all INL Site undertakings. DOE-ID works with INL's Cultural Resource Management Office (CRMO) on the implementation of a cultural resource management program for the INL Site. Cultural resource professionals within the INL Cultural Resource Management Office coordinate cultural resource-related activities at the INL Site and implement the INL Cultural Resource Management Plan (DOE-ID 2016) with oversight by DOE-ID's Cultural Resource Coordinator. DOE-ID continues to work with the Shoshone-Bannock Tribes under the 2017 Agreement in Principle for government-to-government consultation and participation on cultural resources field surveys. The Tribes play a critical role in identifying, evaluating, and protecting cultural resources on the INL Site. Through the Shoshone-Bannock Heritage Tribal Office, Tribal cultural resource staff perform archaeological inventories with the INL CRMO for NHPA Section 106 and 110, serve as reviewers and co-authors in research proposals and publications, monitor work performed in sensitive archaeological areas, perform annual monitoring of cultural resource sites, lead tours of Tribal members of INL Site resources, provide cultural resource awareness training to INL Site personnel, and participate in meetings of the INL Site Cultural Resource Working Group.

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Chapter 3:
Environmental Management Systems

CHAPTER 3

The Idaho National Laboratory (INL) and Idaho Cleanup Project (ICP) Environmental Management Systems (EMSs) implements the U.S. Department of Energy (DOE) commitments for the 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, archeological, and cultural resources potentially affected by operations and activities conducted at the 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 the impact of INL Site operations and activities.

3. ENVIRONMENTAL MANAGEMENT SYSTEMS

The framework that the U.S. Department of Energy (DOE) has chosen to use for Environmental Management Systems (EMSs) and sustainable practices is the International Organization for Standardization (ISO) Standard 14001:2015, "Environmental Management Systems – Requirements with Guidance For Use." The ISO 14001:2015 model uses a system of policy development, planning, implementation, operation, checking, corrective action, and management review. Ultimately, ISO 14001:2015 aims to improve performance as the management cycle repeats. The EMS must also meet the criteria of Executive Order 13834, "Efficient Federal Operations," and DOE O 436.1, "Departmental Sustainability," which require federal facilities to put EMSs into practice. Sites must maintain their EMS as being certified to or conforming with the ISO 14001:2015 standard following the accredited registrar provisions or self-declaration instructions. NOTE: Executive Order 13834 sections were revoked per Executive Order 13990, "Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis."

Idaho National Laboratory (INL) balances research, development, and demonstration; waste management; and decontamination and decommissioning activities in support of the INL mission with the protection and preservation of human health and the environment and compliance with applicable laws, regulations, and other requirements. INL's EMS integrates environmental protection, environmental compliance, pollution prevention, and continual improvement into work planning and execution throughout work areas as a part of the Integrated Safety Management System.

INL is a combination of all operating contractors along with the U.S. Department of Energy, Idaho Operations Office (DOE-ID), and includes the Idaho Falls campus (Figure 3-1) and the research and industrial complexes termed the 'INL Site' that is located 50 miles west of Idaho Falls (Figure 3-2). For the purposes of this report, INL consists of those facilities operated by Battelle Energy Alliance, LLC (INL contractor) or by Fluor Idaho (Idaho Cleanup Project [ICP] Core contractor). The INL and the ICP Core contractors are referred to by their noted acronyms and include all facilities under their individual responsibilities.

The two main contractors have established EMSs for their respective operations. INL has been certified to meet the requirements of ISO 14001 since 2005. In 2019, the INL contractor became the first DOE national laboratory to be certified to the Nuclear Quality Assurance Certification Program. Many elements of the Nuclear Quality Assurance-1 align with and complement the ISO 14001:2015 standard.

Figure 3-1. INL contractor's Idaho Falls Campus (left).

Figure 3-2. INL contractor's Advanced Test Reactor (right).

INL and ICP Core contractors have established EMSs for their respective operations and were last certified to the ISO 14001:2015 standard in 2020. Recertification of the EMS is required every three years. INL and ICP Core contractors will undergo a recertification audit in 2023 to the current standard. The EMS is audited annually to verify that it is operating as intended and in conformance with ISO 14001:2015 standards. The INL and ICP Core contractors were both audited in 2021 by an external, accredited auditor and was recommended for continued certification to the ISO 14001:2015 standard. Results from the INL contractor audit showed no nonconformities, four management system strengths, and no opportunities for improvement. Results from the ICP Core audit showed no nonconformities and 10 management system strengths.

3.1 Environmental Management System Structure

The INL and ICP Core contractors EMSs incorporates a Plan-Do-Check-Act approach to provide a framework under which the environmental, safety, and health programs are managed.

- Plan – incorporates defining work scope, identifying environmental aspects and analyzing hazards, and developing hold points and mitigations
- Do – incorporates implementing defined controls and performing the work scope
- Check – comprises evaluating performance, management reviews, and contractor's assurance practices
- Act – incorporates corrective actions, improvements, and incorporating lessons learned into practices.

This approach is interactive and iterative through the various work activities and functions, including policies, programs, and processes. It also is an integral part of the overall management of the Site's environmental compliance and performance. The main focuses of this cycle are on: (1) environmental policy; (2) planning; (3) implementation and operation; (4) checking and corrective action; and (5) management review.

3.2 Environmental Policy

INL and ICP Core contractors state their commitments to the environment through an overarching policy that is displayed to employees. The policy commits specifically to:

- Environmental protection
- Environmental compliance
- Pollution prevention
- Continual improvement.

INL and ICP Core contractors' employees integrate environmental requirements and pollution prevention techniques into work planning and execution to minimize the environmental impacts of their activities.

3.3 Plan

3.3.1 Environmental Aspects

INL and ICP Core contractors have evaluated their activities, products, and services to identify the environmental aspects of its work activities having the potential to affect the environment, the public, or result in a noncompliance with regulatory requirements. INL and ICP Core contractors perform these evaluations against all applicable federal and state regulations, state permits, and local laws. These regulations and permits are the foundation for environmental standard operating procedures and implementing documents. INL and ICP Core contractors use the National Environmental Policy Act planning tool for all proposed actions to take place onsite. INL uses the Environmental Compliance Permit Process, while ICP Core uses the Environmental Checklist process to evaluate all activities and projects to ensure the proposed actions consider and mitigate environmental aspects as necessary. Environmental aspects have been identified that include the list below.

Air Emissions. Air emissions applies to operations or activities that have the potential to generate air pollutants in the form of radionuclides, chemical and combustion emissions, fugitive dust, asbestos, and refrigerants. INL and ICP Core contractors have an Environmental As Low As Reasonably Achievable review process per DOE O 458.1, "Radiation Protection of the Public and the Environment," that protects the public and the environment against undue risk of radiation. The Environmental As Low As Reasonably Achievable Committee evaluates activities that have the potential for radiological impacts on the environment and the public and determines the requirements for radiological emissions.

Chemical Use and Storage**.** Chemical use and storage apply to activities that purchase; store; or use laboratory or industrial chemicals, pesticides, or fertilizers. INL and ICP Core contractors have processes in place to maintain adequate inventory of appropriate emergency response equipment and to report inventories and releases.

Contaminated Sites Disturbance. Contaminated site disturbance applies to activities in Comprehensive Environmental Response, Compensation, and Liability Act areas of contamination or Resource Conservation and Recovery Act corrective action sites. INL and ICP Core contractors have processes to properly identify contaminated sites.

Discharging to Surface, Storm, or Groundwater. Discharging to surface water, storm water, or groundwater applies to activities that have the potential to contaminate waters of the U.S. or groundwater. INL and ICP Core contractors have spill prevention and response plans in place for areas that have the potential to contaminate waters of the U.S. or groundwater.

Drinking Water Contamination**.** Drinking water contamination activities related to constructing, operating, and maintaining drinking water supply systems and equipment, or activities with the potential to contaminate drinking water supplies. This includes bacteriological, radiological, or chemical contamination of drinking water.

Disturbing Cultural or Biological Resources. Cultural resource disturbance applies to activities that have the potential to adversely affect cultural resources, such as disturbing soils by grading, excavating, sampling, off-road vehicle use, or removing vegetation. It also applies to the protection of sensitive cultural or biological resources from disturbance. The potential for adverse effects also applies to modifying or demolishing historical buildings or structures that are 50 years old or older. INL has a cultural resources management team that evaluates work activities at INL to minimize the impact to historical buildings and cultural sites before an activity begins.

Generating and Managing Waste. Regulated, hazardous, or radioactive material and waste packaging and transportation applies to activities that generate, store, treat, or dispose hazardous, radioactive, or industrial waste. INL and ICP Core contractors have a Waste Management Program that integrates and dispositions containerized hazardous, radioactive, or industrial waste and gives guidance on how to minimize the amount of regulated waste generated.

Releasing Contaminants. Releasing contaminants applies to activities that may release potentially hazardous contaminants into water, soil, or other non-contaminated or previously contaminated locations. All INL and ICP Core contractors' employees are trained to report any release to either their Program Environmental Lead or to the Spill Notification Team. Releases are tracked to verify that they are cleaned up properly. Planned operations and research with the potential to release contaminants are evaluated to mitigate any significant environmental impacts.

Polychlorinated biphenyls (PCB) Contamination**.** PCB contamination applies to activities that use PCB-contaminated equipment or store and dispose of PCB-contaminated waste. INL and ICP Core contractors have processes in place to identify PCBs in excess equipment and to comply with regulatory requirements related to the use, marking, storage, or disposal of PCB equipment or waste.

Interaction with Wildlife/Habitat**.** Interaction with wildlife/habitat activities with the potential to disturb or affect wildlife or their habitat or activities involving revegetation and weed control. INL and ICP Core contractors have processes in place to ensure that identification and consideration is given to the cumulative impacts required by the National Environmental Policy Act, the Endangered Species Act, or the Migratory Bird Treaty Act. Procedures and process are also implemented to control noxious weeds and revegetation of disturbed sites.

Using, Reusing, and Conserving Natural Resources. Using, reusing, and conserving natural resources applies to activities that use or recycle resources such as water, energy, fuels, minerals, borrow material, wood or paper products, and other materials derived from natural resources. This beneficial aspect also applies to waste disposition activities, including building demolition and activities implementing sustainable practices and conserving of natural resources.

3.4 Do (Implementation and Operations)

3.4.1 Structure and Responsibility

INL and ICP Core contractors organizational structure establishes roles and responsibilities for environmental management within research, development, and demonstration; operations; waste management; decontamination and decommissioning; and other support organizations within Environmental, Safety, Health, and Quality. Identified technical points of contacts communicate environmental regulatory requirements and required document submittals to the U.S. Environmental Protection Agency, the Idaho Department of Environmental Quality (DEQ), and other stakeholders. The technical points of contact work with the projects, researchers, and facilities to ensure that they implemented.

3.4.2 Competence, Training, and Awareness

INL and ICP Core contractors training directorates conduct training analysis and designs, develops, and evaluate environmental training. Environmental training gives personnel the opportunity to gain experience, knowledge, skills, and abilities necessary to:

- Do their jobs in a safe and environmentally responsible manner
- Comply with federal, state, and local environmental laws; regulations and permits; and INL requirements and policies
- Increase awareness of environmental protection practices and pollution and prevention/waste minimization opportunities
- Take actions in an emergency.

3.4.3 Communication

INL and ICP Core contractors implement comprehensive communication programs that distribute timely information to interested parties like the public, news media, regulatory agencies, and other government agencies. These programs provide communications about the environmental aspects of work activities, among other topics. Examples include the Media and Community Relations Program and the Strategic Initiatives Program, which distribute information to the public through public briefings, workshops, personal contacts, news releases, media tours, public tours, and news conferences. The programs also coordinate tours of INL for schools, members of the public, special interest groups, and government and elected officials. Internal communications regarding environmental aspects are available via intranet sites, procedures, emails, posters, brochures, booklets, trainings, and personal interaction with environmental staff.

3.4.4 Operational Control

Environmental personnel evaluate each work activity at INL to determine the level of environmental review needed. Environmental personnel also apply administrative and engineering controls. Administrative controls include procedures and best management practices. Engineering controls include utilizing protective equipment and barriers to minimize or avoid impacts to the environment.

3.4.5 Document and Record Control

Environmental documents are prepared, reviewed, revised, and issued per INL and ICP Core contractors standards and procedures. INL's document control system maintains the current version of documents and makes legible and dated copies available to employees.

3.5 Check

INL and ICP Core contractors internally monitor compliance with environmental laws and regulations through the Assurance Portfolio process in the Contractor Assurance System. INL and ICP Core contractors conduct assurance activities through performance metrics, observations, and assessments. Issues, trends, or improvements identified through these activities are rolled into the INL issues management database where corrective actions are assigned and tracked to completion. Examples of contractor assurance activities include monitoring progress toward environmental objectives for each organization and an internal assessment of the EMS against the ISO 14001:2015 standard. Contractor assurance activities in the environmental organization are documented in a management review.

Various regulators also perform external assessments. Idaho DEQ conducts several inspections annually to verify that the INL is complying with state permits. The Environmental Protection Agency also participates on Federal Facility Act-driven inspections and, on a determined frequency, participates alongside Idaho DEQ in compliance evaluation inspections. Chapter 2, "Environmental Compliance Summary," lists and gives results of the annual external agency audits and inspections of INL's Environmental Program.

Annually, INL and ICP Core contractors perform a surveillance audit as required by the ISO 14001 standard. Additionally, every three years INL and ICP Core contractors are audited for recertification to the ISO 14001 standard. A qualified party outside the control or scope of the EMS must perform the formal recertification of the EMS audit. INL and ICP Core contractors have been certified to the ISO 14001 standard since 2005.

3.6 Act

INL and ICP Core contractors establish, implement, and maintain an issues management program in accordance with an internal procedure for contractor assurance. It deals with actual or potential conditions of nonconformity, such as Notices of Violation, nonconformities with regulation, and opportunities for improvement from internal assessments and audits. All employees have access to the issues management software and the authority to identify and document any conceived issue. Communication of these identified issues is performed through the management review process. Throughout all operations, environmental concerns, safety, and emergency preparedness issues are documented and rolled up for management review.

INL and ICP Core contractors' management review of the EMS occurs through a process that includes weekly, monthly, quarterly, and annual meetings with committees and councils. Management review includes identifying issues that carry the largest environmental risks and providing mitigations and hold points. Through the Contractor Assurance System, EMS performance trends, audit findings, objectives and targets, improvements, and risks are documented in a management review that is rolled up to senior management. Through this process senior management is aware of the largest environmental risks to the INL Site. Senior management evaluates the management review and recommends actions to continually improve the environmental performance.

3.7 INL Site Resiliency

Resilience includes the ability to withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents. Energy resiliency is the ability to prepare, prevent, and recover from energy and water disruptions that impact mission assurance on federal installations. This means providing reliable power under routine and off-normal conditions, including those caused from extreme weather events.

As outlined in Executive Order 14008, "Tackling the Climate Crisis at Home and Abroad," the DOE Climate Adaptation and Resilience Plan (CARP) issued in August of 2021, and the Climate Adaptation Policy Statement build upon prior DOE actions taken to bolster adaptation and increase the resilience of DOE facilities and operations. These values and ideals are paired well with the INL mission.

3.7.1 Performance Status

All sustainable activities support energy resiliency and, by default, make the INL Site a more resilient institution. Sustainable activities include:

- Replacement an aged underground diesel storage tank with an above ground version, thereby increasing environmental protection and lessening the impact on the environment. This is an interim step as INL moves toward net-zero emissions.
- Added sustainable acquisition clauses in electronics acquisition blanket purchase orders. As noted in the INL Green Purchaser award, using Electronic Product Environmental Assessment Tool (EPEAT) products reduces energy use, thus helping reduce electric load and demand.
- Ensuring procurement requirements lend preference to use local suppliers and manufacturers, thereby shortening the supply chain and reducing the chances of delivery disruptors.
- Completing the annual update of operational procedures and processes to address sustainability, emergency planning, and operational resiliency.
- Completing numerous energy and water-reduction projects resulting in lower energy use and load demands on the servicing utility.
- Evaluating and considering alternative energy solutions ranging in scope from microgrid renewable generation to potential small modular reactor projects capable of providing local clean alternative energy.

Ecosystem resiliency is also an integral component of sustainability. Because much of the INL Site is managed as a native sagebrush steppe ecosystem, it is vulnerable to the effects of climate change. Proactive land stewardship practices can mitigate the effects of climate change and preserve natural ecosystem services like water balance, nutrient cycling, wildlife habitat availability, and carbon sequestration. A brief list of activities that support ecosystem sustainability are included here, but additional information can be found in Chapter 9:

- Continued to implement conservation planning documents for sage-grouse, bats, migratory birds, and their habitats.
- Managed the Sagebrush Steppe Ecosystem Reserve according to the Environmental Assessment and Management Plan.
- Restored sagebrush to several hundred acres where it had been lost to wildland fire and continued to monitor natural vegetation recovery according to current fire recovery plans.
- Stabilized disturbed soils using revegetation of native species, where appropriate.

- Controlled noxious weeds to limit the risk of spread and maintain the integrity of native plant communities.
- Continued monitoring the abundance and distribution of vegetation and several wildlife taxa across the INL Site.
- Facilitated ongoing ecological research led by university collaborators through the National Environmental Research Park.

Comprehensive emergency response procedures are in place that cover all INL Site facilities:

- The INL contractor procedures include PLN-114, “Idaho National Laboratory (INL) Emergency Plan/Resource Conservation and Recovery Act (RCRA) Contingency Plan,” which addresses the elements of, and is the primary component in defining and directing the INL Emergency Management Program. The plan implements DOE policy and requirements for an EMS and a RCRA contingency plan specified in INL Requirements Document 16100, “Emergency Management System,” which includes citations to DOE O 151.1D, “Comprehensive Emergency Management System,” and other DOE requirements. The plan was updated in FY 2021.
- The ICP Core contractor procedures include PLN-2012, “ICP Core Emergency Plan/RCRA Contingency Plan,” and the emergency response elements that are required in DOE O 151.1D, “Comprehensive Emergency Management System,” for the Idaho Nuclear Technology and Engineering Center (INTEC), the Radioactive Waste Management Complex (RWMC), the Advanced Mixed Waste Treatment Project (AMWTP) and Accelerated Retrieval Project, and the ICP Core contractor operated buildings in Idaho Falls.

Several INL Emergency Management procedures were updated to better prepare the INL Site for naturally occurring phenomenon, including PLN-4267, “INL Continuity of Operations Plan.” INL’s emergency plans and emergency plan implementing procedures (EPIs) are reviewed at least annually and revised if necessary. The plans and EPIs may be revised based on:

- Changes in emergency planning or company operations, policy, concept of operations, procedures, organization and staffing, and facility operations and/or mission
- Direction of the DOE-ID Emergency Management Program administrator
- Failure of emergency plan implementing procedures during drills, exercises, and real events
- Results of audits, evaluations, appraisals, and self-assessments
- New facility information.

3.7.2 Plans and Projected Performance

The concept of resiliency is evolving in real-time. The COVID-19 era will require professionals to be strategic overseers with a lens for long-term outcomes. In this season of change, all built environments will require careful reconsiderations, and it will fall to facility management to promote a building culture that stands on the pillars of safety, quality, and efficiency.

INL and ICP Core contractors will be guided by science to build resilience into DOE-ID-managed lands, facilities, and equipment. A general framework used in resiliency planning includes identifying exposure, translating that exposure into potential impacts, prioritizing risk, devising solutions, and securing funding. INL and ICP Core contractors will work with internal and external stakeholders to address threats to missions and programs. Priority actions include:

- Developing a plan and commencing the implementation of the five priority adaptation actions found in the CARP: (1) Assess Vulnerabilities and Implement Resilience Solutions; (2) Enhance Climate Adaptation and Mitigation Co-benefits; (3) Institutionalize Climate Adaptation and Resilience Across INL Policies, Directives, and Processes; (4) Provide Climate Adaptation Tools, Technical Support, and Climate Science Information; and (5) Advance Deployment of Emerging Climate Technologies.
- Updating the existing Climate Vulnerability Assessment (e.g., priority 1 of the CARP) and incorporate all the requirements of the Vulnerability Assessment and Resiliency Plan (VARP). The classic planning approach as adopted from the VARP itself will be used to:
  - Establish a planning team (first quarter of FY 2022)

  - Update a critical asset and infrastructure (second and third quarter of FY 2022; and continuous)
  - Validate the previously characterization of climate trends and events (second quarter of FY 2022)
  - Determine the likelihood of climate change hazards (third quarter of FY 2022)
  - Characterize the impacts, which is a continuation and refinement previously completed work (third quarter of FY 2022)
  - Develop a risk matrix (third quarter of FY 2022)
  - Identify solutions (fourth quarter of FY 2022)
  - Develop a portfolio of solutions, including funding pathways (fourth quarter of FY 2022)
  - Reassess the plan and monitor the results (FY 2023 and beyond).
- Investing in research and supplying critical data and information
- Implementing actions that highlight the benefits of new technologies, innovative resource management, and infrastructure improvements that will improve the resiliency of DOE-ID's operating footprint.
- Investigating and evaluating the possibility of using the Federal Energy Management Program's Technical Resilience Navigator or the Leadership in Energy and Environmental Design's RELi 2.0 Rating Guidelines for Resilient Design and Construction.

INL continues the process of incorporating resilient design into new and existing buildings. Program leads and engineers are well-versed on the trends associated with resilient design. As this new field emerges and expertise becomes more refined, controlling documents will be targeted for incorporating resiliency tactics. A fully mature program is still being defined.

Highly energy-efficient lighting, roofing, and automation systems continue to be installed in new buildings and during retrofit activities. The result is not just an increase in the resilience of the building, but of the surrounding community as well, by decreasing demand on available resources and infrastructure.

Processes and actions for future activities include the following (for both new and existing buildings):

- Incorporating resilient design and management into the INL facilities planning process
- Identifying and evaluating vulnerabilities to natural hazard risks (e.g., storm events, localized flooding, extreme temperatures, and wildfires)
- Considering enhanced fire-proofing strategies and designs
- Considering designs for enhanced drought tolerance
- Ensuring continuity of operations and access to electricity in the event of an extended power outage
- Improving energy performance of building envelopes, such as new compressors to increase reliability and efficiency at INTEC and Integrated Waste Treatment Unit
- As appropriate, using information modeling to assess design options and to improve decisions based on life-cycle analysis
- When cost-effective, adopting passive and natural design strategies overactive and mechanical systems.

INL is well-positioned to address the need for organizational resilience elements in future plans. With leadership commitment, INL will continue to ensure that appropriate events and risk elements are considered as part of INL Site programs and planning activities. Policies and procedures will be evaluated to determine whether they should be modified to consider organizational risks. Emergency response, workplace safety and health, and the most updated scientific knowledge will continue to be incorporated into all facets of organizational resilience.

3.8 Sustainability Goals

In 2021, Executive Order 14057, “Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability,” was issued. The executive order establishes sustainable environmental stewardship goals that advance sustainable practices. Specifically, it directs agencies to reduce emissions across federal operations, invest in American clean energy industries and manufacturing, and create clean, healthy, and resilient communities. The President's executive order directs the federal government to use its scale and procurement power to achieve five goals:

1. 100% carbon pollution-free electricity by 2030, at least half of which will be locally supplied clean energy to meet 24/7 demand.
2. 100% zero-emission vehicle acquisitions by 2035, including 100% zero-emission light-duty vehicle acquisitions by 2027.
3. Net-zero emissions from federal procurement no later than 2050, including a ‘Buy Clean’ policy to promote use of construction materials with lower embodied emissions.
4. A net-zero emissions building portfolio by 2045, including a 50% emissions reduction by 2032.
5. Net-zero emissions from overall federal operations by 2050, including a 65% emissions reduction by 2030.

The evolving priorities for sustainability incorporated into planning for FY 2022 and beyond were considered in completing planned sustainability work at the end of FY 2021. The *FY 2022 Idaho National Laboratory Site Sustainability Plan* (DOE-ID 2021) describes the overall sustainability strategy for INL and ICP Core contractors during FY 2022, and includes a status of FY 2021 performance in the areas of greenhouse gas emission reduction, energy management, water management, waste diversion, fleet management, clean and renewable energy, green buildings, and other areas. Each sustainability goal, INL and ICP Core contractor’s performance status, and planned actions are detailed in Table 3-1.

3.9 Environmental Operating Objectives and Targets

INL establishes objectives based on the environmental policy, legal and other requirements, environmental aspects, INL’s Strategic Plan, and the views of its stakeholders. The INL contractor plans, implements, monitors, and reports on these objectives and targets quarterly in management review reports and an annual Performance Evaluation and Measurement Plan. The ICP Core contractor develops its objectives and targets annually and reports the status biannually to senior management through the Executive Safety Review Board.

The INL contractor completed 93% of the EMS Objectives and Targets in FY 2021. Each year, the ICP Core contractor develops measurable goals for environmental improvement in the Environmental Compliance Performance Index. The ICP Core contractor had 16 objectives implemented by 19 targets in FY 2021; 58% of the EMS Objectives and Targets were completed.

3.10 Accomplishments, Awards, and Recognition

The INL and ICP Core contractors were both audited in 2021 by an external, accredited auditor and achieved recertification for conformance to the ISO 14001:2015 standard. The result from the INL contractor audit were no nonconformities, four management system strengths, and no opportunities for improvement. Results from the ICP Core audit showed no nonconformities and 10 management system strengths.

INL and ICP Core contractors’ EMS performance data was submitted to DOE’s EMS Database Application and received a ‘Green’ score for the EMS performance metrics listed below:

- Environmental aspects were identified or reevaluated using an established procedure and updated as appropriate.
- Measurable environmental goals, objectives, and targets were identified, reviewed, and updated as appropriate.
- Operational controls were documented to address significant environmental aspects consistent with objectives and targets were fully implemented.

- Environmental training procedures were established to ensure that training requirements for individual competence and responsibility were identified, carried out, monitored, tracked, recorded, and refreshed as appropriate to maintain competence.
- EMS requirements were included in all appropriate contracts. Contractors fulfilled defined roles and specified responsibilities.
- EMS audit/evaluation procedures were established, audits were conducted, and nonconformities were addressed or corrected. Senior leadership review of the EMS was conducted, and management responded to recommendations for continual improvement.
- Using an established procedure(s), previously identified activities, products, and services (and their associated environmental aspects), as well as all newly identified activities, products, and services (and their associated environmental aspects) were evaluated for significance within the past FY. In addition, the results of the analysis were documented, and any necessary changes were made or are scheduled to be made. Documented measurable environmental objectives are in place at relevant functions and levels, and at the end of the FY, at least 80% of them had either already been accomplished or scheduled to be met.
- Within the past FY, operational controls associated with identified significant environmental aspects are established, implemented, controlled, and maintained in accordance with operating criteria.
- Within the past FY, an environmental compliance audit program was in place, audits were completed according to schedule, audit findings were documented, and corrective and preventative actions were defined/documented and on schedule for completion by an established date.
- 80 to 100% of applicable Executive Order 13834 goals are addressed in the EMS.

INL was named one of 76 winners nationwide of the 2021 EPEAT Purchaser Awards. The EPEAT awards recognize leadership in the procurement of sustainable electronics. The INL has earned the annual prestigious award since 2015 and earned the 5-star award level two years in a row.

Now in the award program's seventh year, the Green Electronics Council—the organization that manages the EPEAT ecolabel—recognized the INL for contributing to DOE reaching a savings of $10.2 million from their purchases of IT products. Winners were recognized for their purchases from six EPEAT product categories: (1) computers and displays; (2) imaging equipment; (3) mobile phones; (4) servers; (5) televisions; and (6) photovoltaic modules.

The council honored 2021 EPEAT winners July 28 at a virtual ceremony. Award winners earned one star for each product category in which they purchased EPEAT registered products, and INL was recognized as a 5-star winner.

Table 3-1. Summary table of DOE sustainability goals (DOE-ID 2022).

PRIOR DOE GOAL	CURRENT PERFORMANCE STATUS	PLANNED ACTIONS AND CONTRIBUTIONS	OVERALL RISK OF NON-ATTAINMENT
ENERGY MANAGEMENT			
Reduce energy-use intensity (Btu per gross square foot) in goal-subject buildings.	Energy-use intensity was 141,958 Btu/ft² for FY 2021, which represent a decrease of 8.0% from FY 2015 and 5.7% from FY 2020.	Seven light emitting diode (LED) lighting and controls projects are planned for FY 2022, providing $111K (1,820 MWh) in energy savings at total costs of $683K. Develop a large energy-reduction performance contract project from the compiled results of the energy and water audits.	**Medium/Financial** Low cost of energy and water make project payback difficult to justify on a life-cycle basis.
Energy Independence and Security Act Section 432 continuous (four-year cycle) energy and water evaluations.	Energy and water evaluations were completed in 18 covered buildings in FY 2021. These audits represent 18% of the current covered buildings for the first year of the third four-year audit cycle (June 1, 2020, through May 31, 2024). INL is on track with its planned and scheduled audits.	Complete annual energy audits for 25% of INL's 104 covered buildings for each year of the third four-year audit cycle (June 1, 2020, through May 31, 2024). INL plans to audit 17 buildings in FY 2022.	**Low/None** INL's building audit program is fully established.
Meter individual buildings for electricity, natural gas, steam, and water, where cost-effective and appropriate.	100% of natural gas and 65.1% of electric usage metered at the building level.	One new INL building is planned for completion in FY 2022 and will have advanced metering. Work completed in FY 2021 on ICP Core's Utility Control System project at INTEC will provide the capability to capture electrical power use in facilities fed through substations and load centers. Meter 100% of appropriate covered buildings.	**Low/None** New INL buildings are specified for advanced metering and selected appropriate buildings are specified for sub-metering.
Reduce potable water-use intensity (gal per gross square foot).	Water intensity was 140.2 gal/ft² in FY 2021, which represent a decrease of 19.4% from FY 2007 and 1.4% from FY 2020.	Prepare and implement a water balance evaluation to identify high water-use intensity processes and buildings. Implement audit-identified low and moderate cost water conservation measures in covered	**Medium** Water usage is highly dependent upon the varying process water consumption at the Advanced Test Reactor Complex.

Table 3-1. continued.

PRIOR DOE GOAL	CURRENT PERFORMANCE STATUS	PLANNED ACTIONS AND CONTRIBUTIONS	OVERALL RISK OF NON-ATTAINMENT
WATER MANAGEMENT			
		facilities, including high-efficiency water technologies.	
Reduce non-potable freshwater consumption (gal) for industrial, landscaping, and agricultural.	Not applicable. Water obtained from the Snake River Plain Aquifer and is considered potable.	Industrial, landscape, and agricultural (water is not applicable).	**Low/None** Industrial, landscape, and agricultural water is not used.
WASTE MANAGEMENT			
Reduce non-hazardous solid waste sent to treatment and disposal facilities.	Generated 2,695,757.0 lbs (1,222.8 MT) of non-hazardous Municipal Solid Waste (MSW) in FY 2021. In FY 2020, 2,562,397.5 lbs (1,162.3 MT) was generated, resulting in an increase of MSW generated of 5.2% year-over-year (YOY). Diverted 59.6% of non-hazardous solid waste in FY 2021 by recycling 1,607,025.1 lbs. (728.9 MT) of materials.	Continue to educate personnel emphasizing the priority of waste reduction from the previous year. Continue to evaluate potential outlets and expansion of recyclable waste streams and impacts from COVID-19 telework directive. Explore glass recycle partnership with the city of Idaho Falls. Investigate and develop regional composting facility based on West Yellowstone pilot project.	**Medium** Fluctuations in building use including classified spaces, employee engagement, and market forces greatly affect this goal.
Reduce construction and demolition materials and debris sent to treatment and disposal facilities.	Generated 23,184.3 MT of construction and demolition (C&D) waste in FY 2021, compared to 20,041.5 MT in FY 2020, resulting in an increase of 15.68% of C&D waste generated YOY. Diverted 58.0% (29,657,122.3 lbs or 13,452.2 MT) of its C&D waste in FY 2021.	Continue employee education and contract language inclusion and incorporate additional materials into current C&D waste diversion processes. Work with regional industrial recycle entities and develop a strategy to recycle two construction waste streams: concrete and gypsum.	**Medium** Construction continues to increase while markets accepting construction debris are limited. The cost of transporting to an acceptable recycler is a major factor in the decision process.
FLEET MANAGEMENT			
Reduce petroleum consumption.	*Preliminary data indicate* 800,420 gasoline-gallon equivalents of petroleum-based fuels was used in FY 2021, which is	As INL implements its newly developed Net-Zero Plan, a greater emphasis will be placed on acquiring electric buses and heavy equipment	**Medium** The petroleum reduction goal will be challenging due to the cost and availability of electric motor coaches and heavy equipment.

Table 3-1. continued.

PRIOR DOE GOAL	CURRENT PERFORMANCE STATUS	PLANNED ACTIONS AND CONTRIBUTIONS	OVERALL RISK OF NON-ATTAINMENT
	a 14.7% reduction from FY 2005 and a 24.1% increase from FY 2020.	along with electrifying its light-duty fleet and the installation of supporting charging stations. Optimize and right-size fleet composition by reducing vehicle size, eliminating underutilized vehicles, and acquiring vehicles to match local fuel infrastructure.	
Increase alternative fuel consumption.	*Preliminary data indicate* 35,657 gasoline-gallon equivalents of alternative fuels was used in FY 2021, which represents a 53.4% decrease from FY 2005 and a 68.1% decrease from FY 2020.	Determine less-costly sources of R99 for the interim while electric buses are being evaluated and procured.	**Medium** The alternative fuel increase goal will be challenging due to cost and availability of electric vehicles (EVs) and the excessive cost of renewable diesel.
Acquire alternative fuel and EVs.	Acquired 50 new light-duty vehicles in FY 2021, 12 of which were alternative fuel vehicles (AFVs) or EVs.	Identify the next group of petroleum-fueled vehicles for replacement with AFVs or EVs and ensure that all existing AFVs are replaced EVs when available. Work with General Services Administration to achieve 75% or greater AFV and EV light-duty acquisitions.	**Medium** This goal has historically been met but it may be difficult to reach in the future due to the availability of appropriate EV light-duty vehicle fuel types supplied by General Services Administration.
CLEAN AND RENEWABLE ENERGY			
Increase consumption of clean and renewable electric energy.	Procured 17,977 MWh of renewable energy certificates from Idaho Falls Power at a total cost of $85,390. This purchase of new renewable energy certificates (RECs), in addition to the 41.9 MWh of onsite generation (e.g., microgrid and, small photovoltaic) plus bonuses, totals 18,680 MWh (8.5%) of renewable energy for FY 2021.	As INL implements its recently developed Net-Zero Plan, a greater emphasis will be placed on the internal applications of renewable energy generation to meet this goal. Incremental increases of purchased renewable energy certificates will continue to be made along with onsite generation to meet a minimum of the 7.5% goal each YOY.	**Low** Established process for procuring RECs.
Increase consumption of clean and renewable non-electric thermal energy.	Two buildings with solar transpired walls to provide make-up air preheating.	Investigate the additional use of solar water heating, make-up air preheating, or ground source heat pumps in select locations.	**Medium** Due to the low cost of electric energy, it is challenging to justify the installation of thermal renewable energy.

Table 3-1. continued.

PRIOR DOE GOAL	CURRENT PERFORMANCE STATUS	PLANNED ACTIONS AND CONTRIBUTIONS	OVERALL RISK OF NON-ATTAINMENT
SUSTAINABLE BUILDINGS			
Increase the number of owned buildings that are compliant with the Guiding Principles for Sustainable Buildings.	At the end of FY 2021, 25 DOE-owned buildings were compliant with the Guiding Principles, which represents 25.25% of buildings. This includes six buildings less than 10,000 gross square feet.	Document Guiding Principles compliance on one new construction building in FY 2022 and three additional new construction buildings by the end of FY 2024. Implement additional audit-identified low- and moderate-cost Engineering Change Managements at covered facilities that are targeted to document the Guiding Principles.	**Low** The 15% goal was achieved.
ACQUISITIONS AND PROCUREMENT			
Promote sustainable acquisition and procurement to the maximum extent practicable, ensuring all sustainability clauses are included as appropriate.	100% of the contracts in FY 2021 contained applicable clauses.	Achieve 100% compliance. Continue to incorporate improvements to the Sustainable Acquisition Program, including procedures, policies, and enhanced work processes that increase visibility, availability, and use of sustainable products.	**Low** The goal continues to be achieved.
EFFICIENCY AND CONSERVATION MEASURE INVESTMENTS			
Implement life-cycle cost-effective efficiency and conservation measures with appropriated funds and/or performance contracts.	Six energy-reduction projects were completed in FY 2021 providing over $19K in energy cost-savings. No additional Energy Savings Performance Contract (ESPC) projects were developed in FY 2021.	LED lighting projects are planned for 11 buildings. Continue to evaluate the cost effectiveness of ESPC options.	**Low** While there are no current plans for an additional ESPC project, the INL Site does have established plans and goals for projects awarded and targeted in FY 2022.
ELECTRONIC STEWARDSHIP AND DATA CENTERS			
Electronics stewardship from acquisition, and operations, to end of life.	In FY 2021, 100% of electronic devices were reused or recycled; however, only 74.3% were recycled with a certified recycler.	100% of electronics are reused or recycled unless federal requirements dictate otherwise. Continue to partner with Information Management (IM) and Property Disposal Services to improve electronics end-of-life disposition.	**Low** This goal continues to be achieved.

Table 3-1. continued.

PRIOR DOE GOAL	CURRENT PERFORMANCE STATUS	PLANNED ACTIONS AND CONTRIBUTIONS	OVERALL RISK OF NON-ATTAINMENT
Increase energy and water efficiency in high-performance computing and data centers.	Continued consolidating server infrastructure in the old high-performance computing data center by virtualizing physical machines and taking advantage of cloud and container hosting options	Install and monitor advanced energy meters in all data centers and accurately quantify Power Usage Effectiveness (PUE).	**Medium** Low energy costs and long construction times may prohibit major investments in updated resiliency measures.
ORGANIZATIONAL RESILIENCE			
Implement climate adaptation and resilience measures.	INL emergency plans and EPIs were reviewed and revised, as necessary. Operating policies and procedures were evaluated to determine whether they should be modified to consider organizational risks. Internal procedures were modified or developed to face the challenge of the pandemic.	Conduct detailed vulnerability assessments using the Vulnerability Assessment and Resiliency Planning process to identify projects that increase resilience. Emergency response, workplace safety and health, and updated scientific knowledge will be incorporated into all facets of organizational resilience, procedures, and protocols. Pursue life-cycle cost-effective energy resilience solutions that provide the most reliable energy to critical mission operations.	**Low to Medium** Investment upgrades in existing buildings are a long-term process. New buildings are being built to include resiliency measures.
MULTIPLE CATEGORIES			
Reduce Scope 1 & 2 greenhouse gas emissions.	*Preliminary data indicate* Scope 1 & 2 emissions were 89,391.4 metric tons of carbon dioxide equivalent (MT CO_2e) compared to 84,019.9 MT CO_2e in FY 2020, for a YOY increase of 6.4% and a 36.6% reduction from the FY 2008 baseline.	Refine a targeted list of high-value, low-cost Engineering Change Management projects with a focus on those reducing total emissions 45% by the end of FY 2024. Reduce or minimize the quantity of toxic and hazardous chemicals acquired, used, or disposed that will assist INL in pursuing agency greenhouse gas reduction targets.	**Medium** INL has committed to be carbon net-zero by the end of FY 2031. Significant progress was made toward exceeding the overall goal, but YOY Scope 1 and 2 greenhouse gases emissions may continue to vary.
Reduce Scope 3 greenhouse gas emissions.	*Preliminary data indicate* FY 2021 Scope 3 emissions were 15,586.6 metric tons of carbon dioxide equivalent (MT CO_2e) compared to 19,042.6 MT CO_2e in FY 2020, for a YOY reduction of 18.1% and a 55.8% reduction from the FY 2008 baseline.	Continue to encourage teleworking, video conferencing, and carpooling as effective ways to reduce the amount of air and ground travel, including employee commuting. Achieve a YOY 2% annual reduction for five years for a total 10% reduction.	**Medium** Significant progress was made toward exceeding the overall goal, primarily due to ongoing telework and travel restrictions. YOY Scope 3 greenhouse gases emissions may continue to vary.

3.11 References

DOE-ID, 2022, *FY 2022 Idaho National Laboratory Site Sustainability Plan*, DOE/ID-11383, Rev. 13, Idaho National Laboratory, December 2021.

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Executive Order 13834, 2018, "Efficient Federal Operations," the U.S. White House, Office of Energy and Environment, May 1, 2018.

Executive Order 13990, 2021, "Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis," the U.S. White House, Executive Office of President, January 20, 2021.

Executive Order 14008, 2021, "Tackling the Climate at Home and Abroad," the U.S. White House, Office of NEPA Policy and Compliance, January 27, 2021.

Executive Order 14057, 2021 "Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability," the U.S. White House, Executive Office of President, December 8, 2021.

ISO 14001:2015, "Environmental Management Systems – Requirements with Guidance For Use," International Organization for Standardization, September 15, 2015.

PLN-114, 2022, "Idaho National Laboratory (INL) Emergency Plan/Resource Conservation and Recovery Act (RCRA) Contingency Plan," Idaho National Laboratory, August 15, 2022.

PLN-2012, 2022, "ICP Core Emergency Plan/RCRA Contingency Plan," Rev. 64, Idaho Cleanup Project, February 21, 2022.

PLN-4267, 2021, "Idaho National Laboratory Continuity of Operations Plan," Rev. 9, Idaho National Laboratory, May 2, 2022.

Chapter 4: Environmental Monitoring Programs - Air

CHAPTER 4

An estimated total of 1,076 Ci (3.98×10^{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 2021. The highest contributors to the total release were the Advanced Test Reactor Complex at 76.9%, Materials and Fuel Complex at 17.4%, and Radioactive Waste Management Complex at 4.5%. Other INL Site facilities each contributed less than 1% to the total. The estimated maximum potential dose to a member of the public from all INL Site releases (0.067 mrem/yr) is below the regulatory standard of 10 mrem/yr (see Chapter 8 for details).

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 pathway, 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 2021.

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

Specific gamma-emitting (primarily cesium-137) radionuclides were not detected by either the Environmental Surveillance, Education, and Research Program contractor or the INL contractor during 2021. Strontium-90 was detected in eight quarterly composited samples during 2021. Plutonium-239/240 was detected in a quarterly composited sample collected along the INL Site boundary during the fourth quarter. All concentrations were within historical measurements made during the past ten years (2011-2020) and well below the DCSs for these radionuclides. Plutonium-238 and americium-241 were not detected in any quarterly composite samples during 2021.

Airborne particulates were also collected biweekly around the perimeters of the Subsurface Disposal Area at 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 2021. Detections of americium and plutonium isotopes were within levels measured in previous years. The results were three to four orders below the DCS values established for those radionuclides.

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

4. ENVIRONMENTAL MONITORING PROGRAMS: AIR

Although all Idaho National Laboratory (INL) Site facilities are carefully managed and controlled the potential to release radioactive and nonradioactive hazardous constituents in amounts above regulatory limits during an operational upset or emergency incident situation still exists. In such an event, pathway vectors, such as air, soil, plants, animals, and groundwater, may transport these constituents to nearby populations, as observed in Figure 4-1. Reviews of historical environmental data and environmental transport modeling indicate that air is a key pathway from INL Site releases to members of the general public. The ambient air monitoring network operates constantly and is a critical component of the INL Site's environmental monitoring programs. It monitors for routine and unforeseen releases, provides verification that the INL Site is in compliance with regulatory standards and limits, and can be used to assess impact to the environment over time.

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

4.1 Organization of Air Monitoring Programs

The INL contractor documents airborne radiological effluents at INL Site facilities in an annual report prepared in accordance with the 40 CFR 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities." Section 4.2 summarizes the emissions reported in *National Emission Standards for Hazardous Air Pollutants—Calendar Year 2021 INL Report for Radionuclides* (DOE-ID 2022), referred to hereafter as the National Emission Standards for Hazardous Air Pollutants (NESHAP) Report. The report also documents the estimated potential dose received by the general public due to INL Site activities.

Ambient air monitoring is conducted by the INL, ICP Core, and ESER contractors to ensure that the INL Site remains in compliance with U.S. Department of Energy (DOE) O 458.1, "Radiation Protection of the Public and the Environment."

The INL contractor collects air samples primarily on the INL Site, as observed in Figure 4-2. In 2021, the INL contractor collected approximately 1,460 air samples (including duplicate samples and blanks) for various radiological analyses. Air moisture samples were collected at four sites for tritium analysis.

The ICP Core contractor collects air samples primarily on the INL Site at Remote Handled Low-Level Waste (RHLLW) disposal facilities subject to DOE O 435.1, "Radioactive Waste Management," and downwind of facilities subject to an EPA-approved alternative for the National Emission Standards for Hazardous Air Pollutants (NESHAP) air monitoring method in accordance with 40 CFR 61.93(g). In 2021, the ICP Core contractor collected approximately 280 air samples (including duplicate samples) for various radionuclide analyses.

The ESER contractor collects air samples primarily around the INL Site encompassing a region of 23,390 km^2 (9,000 mi^2) that extends to Jackson, Wyoming, as observed in Figure 4-2. In 2021, the ESER contractor collected approximately 775 air samples (including duplicate samples and blanks) for various radionuclide analyses. The ESER contractor also collects air moisture and precipitation samples at four locations for tritium analysis.

In December 2020, DOE initiated transition of the ESER Program from DOE management to the INL contract managed by Battelle Energy Alliance, LLC (BEA). A team composed of DOE, BEA, and the ESER Program contractor, Veolia Nuclear Solutions – Federal Services (VNSFS), successfully transitioned the Program on September 30, 2021, and it is now called the Environmental Monitoring & Natural Resource Services. The ESER Program environmental surveillance scope has been integrated into the INL environmental surveillance program. Sampling activities conducted prior to September 30, 2021, were performed by VNSFS and the results are presented in this chapter under the ESER contractor. Sampling activities conducted after September 30, 2021, were performed under BEA and are presented in this chapter under the INL contractor.

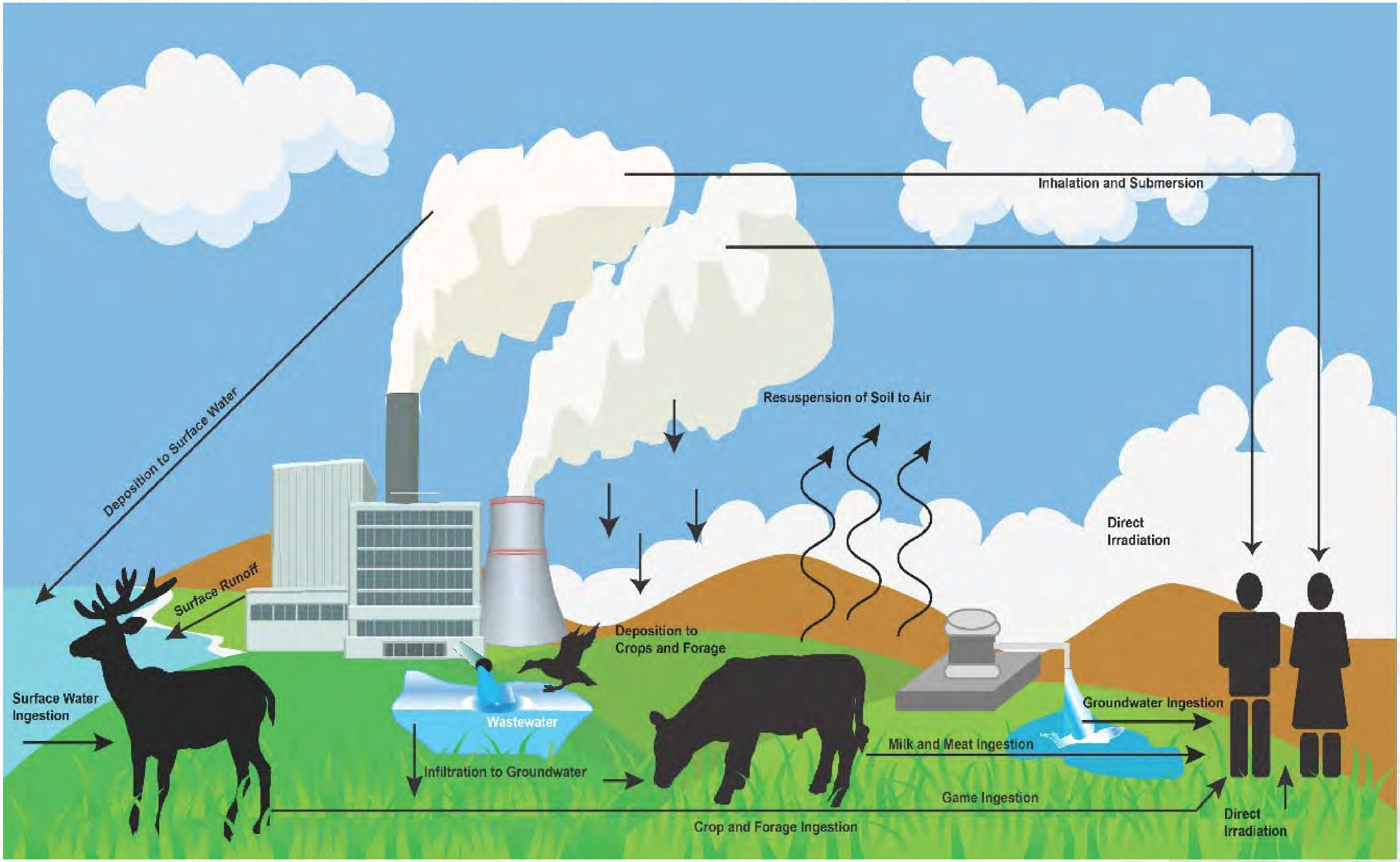


Figure 4-1. Potential exposure pathways to humans from the INL Site.

Table 4-1. Radiological air monitoring activities by organization.

	AIRBORNE EFFLUENT MONITORING PROGRAMS	ENVIRONMENTAL SURVEILLANCE PROGRAMS					
AREA/FACILITY[a]	AIRBORNE EFFLUENTS[b]	LOW-VOLUME CHARCOAL CARTRIDGES (^{131}I)	LOW-VOLUME GROSS ALPHA	LOW-VOLUME GROSS BETA	SPECIFIC RADIONUCLIDES[c]	ATMOSPHERIC MOISTURE	PRECIPITATION
ICP CORE CONTRACTOR[d]							
INTEC	●		●	●	●		
RWMC	●		●	●	●		
INL CONTRACTOR[e]							
MFC	●						
INL Site/Regional		●	●	●	●	●	
ESER CONTRACTOR[f]							
INL Site/Regional		●	●	●	●	●	●

a. ICP = Idaho Cleanup Project, INL = Idaho National Laboratory, INTEC = Idaho Nuclear Technology and Engineering Center, RWMC = Radioactive Waste Management Complex, MFC = Materials and Fuels Complex.

b. Facilities that required monitoring during 2021 for compliance with 40 CFR 61, Subpart H, "National Emissions Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities."

c. Gamma-emitting radionuclides are measured by the ICP Core contractor monthly and by the ESER contractor and the INL contractor quarterly. Strontium-90, plutonium-238, plutonium-239/240, and americium-241 are measured by the INL, ICP Core, and ESER contractors quarterly.

d. The ICP Core contractor monitors waste management facilities to demonstrate compliance with DOE O 435.1, "Radioactive Waste Management." Also, a combination of Continuous Monitoring and ambient air sampling are used to demonstrate compliance with 40 CFR 61, Subpart H.

e. The INL contractor monitors airborne effluents at MFC and ambient air outside INL Site facilities to demonstrate compliance with DOE O 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 O 458.1.

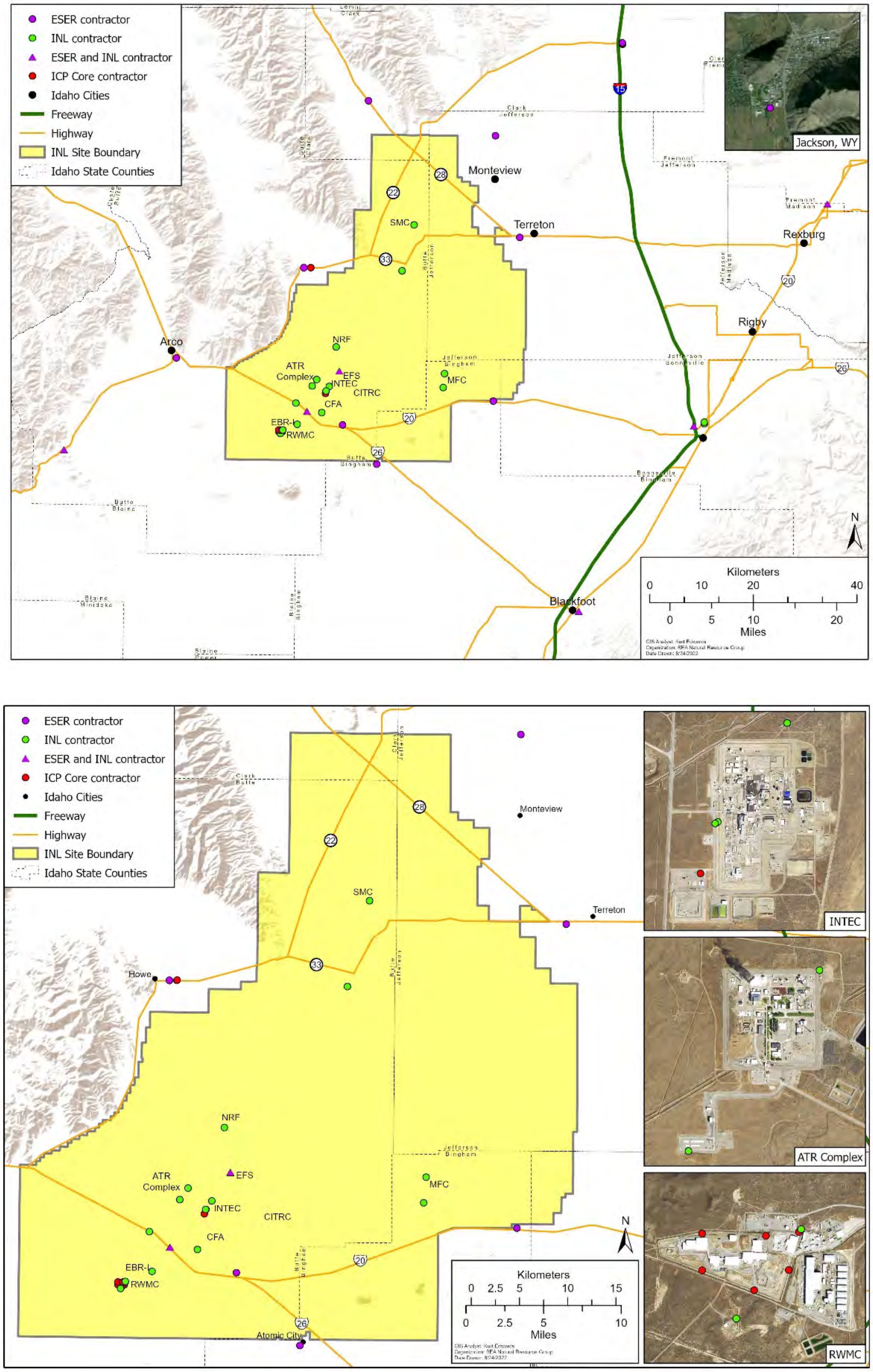


Figure 4-2. INL Site environmental surveillance radiological air sampling locations (regional [top] and on the INL Site [bottom]).

The ICP Core contractor monitors air around waste management facilities to comply with DOE O 435.1, "Radioactive Waste Management." These facilities are the Subsurface Disposal Area (SDA) at the Radioactive Waste Management Complex (RWMC) and the Idaho Comprehensive Environmental Response, Compensation, and Liability Act Disposal Facility (ICDF) near the Idaho Nuclear Technology and Engineering Center (INTEC). These locations are shown in Figure 4-2. Section 4.4 discusses air sampling by the ICP Core contractor in support of waste management activities. In 2021, the ICP Core contractor collected approximately 200 air samples (including duplicate samples) for various radiological analyses.

The National Oceanic and Atmospheric Administration (NOAA) has collected meteorological data at the INL Site since 1950. The data have historically been tabulated, summarized, and reported in several climatography reports for use by scientists to evaluate atmospheric transport and dispersion. The latest report, *Climatography of the Idaho National Laboratory*, 4th Edition (Clawson et al. 2018), was prepared by the NOAA Field Research Division of the Air Resources Laboratory and presents over 20 years (1994–2015) of quality-controlled data from the NOAA INL mesonet meteorological monitoring network (https://niwc.noaa.inl.gov/climate/INL_Climate4th_Final2.pdf). More recent data are provided by the Field Research Division to scientists modeling the dispersion of INL Site releases and resulting potential dose impact (see Chapter 8 in this annual report and *Meteorological Monitoring*, a supplement to this annual report).

4.2 Airborne Effluent Monitoring

Each regulated INL Site facility determines airborne effluent concentrations from its regulated emission sources as required under state and federal regulations. Radiological air emissions from INL Site facilities are also used to estimate the potential dose to a hypothetical maximally exposed individual (MEI), who is a member of the public (see Chapter 8 of this report). Radiological effluents and the resulting potential dose for 2021 are reported in the NESHAP Modeling Report (INL 2022) and the NESHAP Report (DOE-ID 2022).

The NESHAP Report includes three categories of airborne emissions:

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

INL Site emissions include all three airborne emission categories and are summarized in Table 4-2. The radionuclides included in this table were selected because they contribute 99.9% of the cumulative dose to the MEI estimated for each facility area. During 2021, an estimated 1,076 Ci (3.98×10^{13} Bq) of radioactivity was released to the atmosphere from all INL Site sources. The 2021 release is 34% lower than the estimated total of 1,628 Ci (6.02×10^{13} Bq) released in 2020. The reduction is primarily the result of shutdown of the Advanced Test Reactor (ATR) during most of 2021 for refurbishment of the reactor core.

The following facilities were major contributors to the total emissions, as observed in Figure 4-3:

- ***ATR Complex Emissions Sources (76.9% of total INL Site source term).*** Radiological air emissions from the ATR Complex are primarily associated with operation of the ATR. These emissions include noble gases, radioiodine, and other mixed fission and activation products. Other radiological air emissions are associated with sample analysis, site remediation, and research and development activities. The INL Radioanalytical Chemistry Laboratory, in operation since 2011, is another emission source at the ATR Complex. Activities at the lab include inorganic, general-purpose analytical chemistry, and wet chemical analysis for trace and high-level radionuclide determination. The laboratory contains high-efficiency particulate air filtered hoods that are used for the analysis of contaminated samples. There are no sources at the ATR Complex that require continuous emissions monitoring due to the low dose contribution (see Section 8.2). On a regular basis, the ATR effluent stream is sampled and analyzed for particulate, radioiodine, and noble gas radionuclides. Effluent from the Safety and Tritium Applied Research Facility (TRA-666) is sampled and analyzed for tritium.

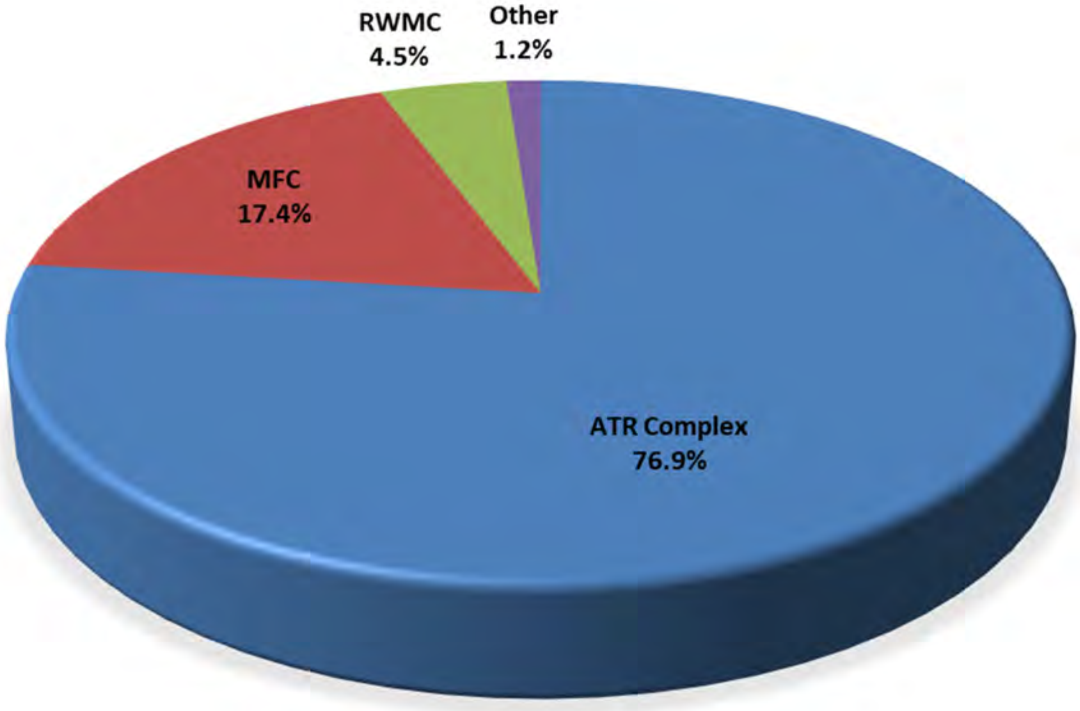


Figure 4-3. Percent contributions in Ci, by facility, to total INL Site airborne radiological releases (2021).

- ***MFC Emissions Sources (17.4% of total INL Site source term).*** Radiological air emissions are primarily associated with spent fuel treatment at the Fuel Conditioning Facility, waste characterization and fuel research development at the Hot Fuel Examination Facility, fuel research and development at the Fuel Manufacturing Facility, and post-irradiation examination at the Irradiated Materials Characterization Laboratory. To satisfy the requirements of 40 CFR 61 Subpart H, stack filters from the effluent streams of these four facilities are sampled and analyzed for particulate radionuclides on a regular basis because of their potential to discharge radionuclides into the air in quantities that could cause an effective dose in excess of 1% of the standard. Other effluent streams with a smaller potential dose (less than 1% of the standard) such as the Transient Reactor Test Facility (TREAT), are sampled and analyzed periodically to confirm the lower emissions. 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.
- ***RWMC Emissions Sources (4.5% of total INL Site source term).*** Emissions at RWMC result from various activities associated with the facility's mission to complete environmental cleanup of the area, as well as to store, characterize, and treat contact-handled transuranic waste and mixed low-level waste prior to shipment to offsite licensed disposal facilities. Various projects are being conducted to achieve these objectives: waste retrieval activities at the Accelerated Retrieval Projects (ARPs); operation of the Resource Conservation and Recovery Act (RCRA) permitted Sludge Repackage waste processing project; storage of waste within the Type II storage modules at AMWTP; storage and characterization of waste at the Drum Vent and Characterization facilities; and storage and treatment of wastes at the Transuranic Storage Area-Retrieval Enclosure (WMF-636) and the Advanced Mixed Waste Treatment Facility (WMF-676). Data from 13 emission sources (both point and diffuse) at RWMC were reported in the 2021 NESHAP Report for Radionuclides (DOE-ID 2022), including three continuously monitored point sources. WMF-676 has two continuously monitored stacks, while WMF-636 has one continuously monitored stack. Monitoring of the radionuclide emissions from the Comprehensive Environmental Response, Compensation, and Liability Act ARP facilities and the two RCRA facilities (WMF-1617 and WMF-1619) is achieved with the U.S. Environmental Protection Agency (EPA)-approved ambient air monitoring program, which has been in place since 2008. Radiological emissions at RWMC include tritium and carbon-14 associated with buried beryllium blocks at the SDA. Releases of transuranic radionuclides from ARP facilities, including americium-241 (^{241}Am), plutonium-238 (^{238}Pu), plutonium-239/240 ($^{239/240}$Pu), and plutonium-241 (^{241}Pu) have declined in recent years as waste exhumation and processing activities progress to completion.

Table 4-2. Radionuclide composition of INL Site airborne effluents (2021).[a]

		AIRBORNE EFFLUENT (Ci)[b]								
RADIONUCLIDE[c]	HALF-LIFE[d]	ATR COMPLEX[e]	CFA[e]	CITRC[e]	INTEC[e]	MFC[e]	NRF[e]	RWMC[e]	TAN[e]	TOTAL
Americium-241	432.2 y	2.25E-05	NS[f]	—[g]	3.14E-04	NS	—	1.05E-04	—	4.41E-04
Argon-41	1.83 h	3.47E+02	NS	—	—	8.09E+01	—	—	NS	4.28E+02
Bromine-82	1.47 d	—	NS	—	—	—	—	—	1.03E+01	1.03E+01
Carbon-14	5730 y	NS	NS	—	3.15E-02	—	5.50E-01	2.22E-02	—	6.04E-01
Chlorine-36	3.01E+05 y	—	—	—	5.02E-06	7.19E-03	—	—	NS	7.19E-03
Cobalt-60	5.271 y	7.08E-03	NS	—	1.64E-05	NS	—	NS	—	7.08E-03
Cesium-137	30.2 y	5.52E-03	NS	—	2.17E-04	2.60E-01	6.30E-05	NS	—	2.66E-01
Gallium-68	67.7 m	—	—	2.20E-08	—	—	—	—	—	2.20E-08
Hydrogen-3 (tritium)	12.3 y	4.55E+02	5.19E-01	—	1.61E-01	NS	NS	4.81E+01	NS	5.04E+02
Iodine-129	1.57E+07 y	NS	NS	—	7.30E-05	NS	NS	—	—	7.30E-05
Iodine-131	8.02 d	NS	NS	—	—	9.40E-02	NS	—	—	9.40E-02
Potassium-42	12.4 h	—	—	—	—	—	—	—	2.80E-01	2.80E-01
Krypton-88	2.84 h	NS	3.75E-03	—	—	9.51E+00	—	—	—	9.51E+00
Plutonium-238	87.7 y	NS	NS	—	2.12E-06	NS	—	2.37E-06	—	4.49E-06
Plutonium-239	24,065 y	8.46E-06	NS	—	1.16E-04	NS	3.80E-06	4.14E-05	—	1.70E-04
Plutonium-240	6,537 y	NS	NS	—	1.15E-04	NS	—	1.13E-05	—	1.26E-04
Plutonium-241	14.3 y	NS	NS	—	1.00E-04	NS	—	—	—	1.00E-04
Strontium-90	29.12 y	2.65E-02	NS	—	5.28E-05	NS	6.90E-05	NS	NS	2.66E-02
Uranium-234	2.46E+05 y	NS	NS	—	NS	6.52E-02	—	—	NS	6.52E-02
Uranium-235	7.04E+08 y	NS	NS	—	NS	2.19E-02	—	NS	NS	2.19E-02
Uranium-238	4.5E+09 y	NS	NS	—	NS	1.10E-01	—	NS	NS	1.10E-01
Xenon-135	9.09 h	NS	6.30E-02	—	—	NS	—	—	—	6.30E-02
Zinc-65	243.7 d	NS	NS	—	NS	3.32E-01	—	—	NS	3.32E-01

Table 4-2. continued.

		AIRBORNE EFFLUENT (Ci)[b]								
RADIONUCLIDE[c]	HALF-LIFE[d]	ATR COMPLEX[e]	CFA[e]	CITRC[e]	INTEC[e]	MFC[e]	NRF[e]	RWMC[e]	TAN[e]	TOTAL
TOTAL CI RELEASED[h]		8.02E+02	5.86E-01	2.20E-08	1.93E-01	9.13E+01	5.50E-01	4.81E+01	1.06E+01	9.54E+02
DOSE (MREM)[i]		9.69E-04	2.13E-06	3.96E-15	1.07E-04	6.48E-02	7.33E-05	4.27E-04	3.51E-04	6.67E-02

a. Radionuclide release information provided by the INL contractor (INL 2022).

b. One curie (Ci) = 3.7 × 10^{10} becquerels (Bq).

c. Includes only those radionuclides which collectively contribute 99.9% of the total dose to the MEI estimated for each INL Site facility. Other radionuclides not shown in this table account for less than 0.1% of the dose estimated for each facility.

d. Half-life units: m = minutes, h=hours, d = days, 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 and Accelerated Retrieval Projects), TAN = Test Area North (includes emissions from Specific Manufacturing Capability and Radiological Response Training Range-Northern Test Range).

f. NS = not significant. The radionuclide contribution was estimated to be < 0.1% of the total MEI dose from that facility.

g. A long dash signifies the radionuclide was not reported to be released to the air from the facility in 2021.

h. Total curies may be less than the total curies in Table 8-1 because Table 4-2 accounts only for radionuclides that collectively contribute 99.9% of the total dose to the MEI estimated for each INL Site facility.

i. The annual dose (mrem) for each facility was calculated at the location of the MEI using estimated radionuclide releases and methodology recommended by the Environmental Protection Agency. See Chapter 8 for details.

- ***Test Area North Emissions Sources (0.99% of total INL Site source term).*** Emissions sources at Test Area North (TAN) are the Specific Manufacturing Capability (SMC) project, the New Pump and Treat Facility, and the nearby Northern Test Range of the Radiological Response Training Range. Radiological air emissions from the SMC project are associated with processing of depleted uranium. Potential emissions are uranium isotopes. 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. Emissions from the Radiological Response Training Range are the result of training activities such as contamination control, site characterization, and field sampling techniques for response to radiological incidents using mostly short-lived radioactive materials.
- ***INTEC Emissions Sources (0.12% of total INL Site source term).*** Radiological air emissions at INTEC are primarily from the operation of the ICDF landfill and ponds (located outside the fenced boundary of INTEC), and storage and containment of the Three Mile Island Unit 2 (TMI-2) core debris within the Independent Spent Fuel Storage Installation (CPP-1774), which is licensed under the U.S. Nuclear Regulatory Commission (NRC). These sources contribute gaseous radionuclides, including tritium, iodine-129, and krypton-85, with contributions of particulate radionuclides cesium-137 (^{137}Cs) and ^{90}Sr from ICDF. INTEC has one stack continuously monitored for radionuclide emissions (resulting from Waste Management activities) located outside of CPP-666. Additional sources include the INTEC Main Stack (CPP-708), which emits gaseous and particulate radionuclides associated with liquid-waste operations, including effluents from the Tank Farm Facility, Process Equipment Waste Evaporator, and Liquid Effluent Treatment and Disposal facility. Other radioactive emissions are associated with remote-handled transuranic and mixed-waste management operations, dry storage of spent nuclear fuel, and maintenance and servicing of contaminated equipment.
- ***Central Facilities Area (CFA) Emissions Sources (0.049% of total INL Site source term).*** Minor emissions occur from CFA where work with small quantities of radioactive materials is routinely conducted. This includes sample preparation and verification, and radiochemical research and development. Other minor emissions result from groundwater usage via evapotranspiration from irrigation or evaporation from sewage lagoons.
- ***Critical Infrastructure Test Range Complex (CITRC) Emissions Sources (0.000000002% of total INL Site source term).*** Emissions from CITRC are primarily the result of activity related to National and Homeland Security missions. Activities at CITRC include program and project testing for critical infrastructure resilience, nonproliferation, wireless test bed operations, power line and grid testing, unmanned aerial vehicles, explosives detection, and training radiological counter-terrorism emergency response. Radionuclide releases from CITRC were less in 2021 due to the curtailment of some activities as a result of COVID-19.

The estimated radionuclide releases (Ci/yr) from INL Site facilities, shown in Table 4-2, were used to calculate the dose to the hypothetical MEI member of the public, who is assumed to reside near the INL Site perimeter. The estimated dose to the MEI in Calendar Year 2021 was 0.067 mrem/yr (0.67 µSv/yr) which is below the regulatory standard of 10 mrem/yr. Five radionuclides—cesium-137 (^{137}Cs), uranium-238 (^{238}U), uranium-234 (^{234}U), zinc-65 (^{65}Zn), and chlorine-36 (^{36}Cl)—are responsible for more than 90% of the MEI dose. Potential radiation doses to the public are discussed in more detail in Chapter 8 of this report.

4.2.1 Hydrofluorocarbon Phasedown

Hydrofluorocarbons (HFC) are the third generation of refrigerants; they were developed to replace Class II ozone depleting substances. HFCs are used in the same applications that ozone-depleting substances have historically been used in, such as refrigeration and air conditioning, foam blowing agents, solvents, aerosols, and fire suppression. HFCs are non-ozone-depleting; however, they are also potent greenhouse gases with 100-year global warming potentials (a measure of the relative climatic impact of greenhouse gases) that can be hundreds to thousands of times more potent than carbon dioxide.

Atmospheric observations of most currently measured HFCs confirm their amounts are increasing in the global atmosphere at accelerating rates. Total emissions of HFCs increased by 23% from 2012 to 2016. The four most abundant HFCs in the atmosphere—in global warming potential-weighted terms—are HFC-134a, HFC-125, HFC-23, and HFC-143a (Federal Register Volume 86, Number 95 published May 19, 2021). The American Innovation and Manufacturing Act of 2020 included reductions for the production and, therefore, the consumption of HFCs.

In addition, the INL contractor is participating in the voluntary HFC task team lead by AU-21, National Nuclear Security Administration. The goal of the task team is to better understand and address DOE’s needs and determine next steps.

The HFC task team is currently working on writing an Operating Experience Summary for the DOE complex that will provide information on operational impacts to critical systems from these regulations that will decrease the amount of HFCs manufactured in the future. HFC phasedown proactive measures being taken by the INL Site contractors are listed below.

4.2.1.1 INL Contractor

The INL contractor compiled a list of equipment at its facilities that contains HFCs and completed an impact analysis to better understand the potential impacts of this HFC phasedown. This list was obtained from a variety of sources: facility/operations personnel, laboratory personnel, fire protection personnel, research and development organizations, engineer personnel, maintenance personnel, and environmental support and services personnel. The list includes heating, ventilation, and air conditioning systems that contain 50 pounds or more of refrigerant, computer room air conditioning units that contain 50 pounds or more of refrigerant, fire protection systems, and laboratory equipment. Most of the laboratory equipment that contained HFCs were chillers used to cool specific pieces of equipment. Other laboratory equipment that contains HFCs includes environmental chambers, a microwave digester, non-rad and rad separator ion sources, non-rad and rad separator magnets, and a laser flash. The list does not include small heating, ventilation, and air conditioning equipment (units containing less than 50 pounds of refrigerant), refrigerators, drinking water fountains, or other small appliances. The INL contractor manages thousands of these small appliances at the facilities; most would be operated until failure and then replaced. Two hundred thirty-six pieces of equipment and systems were identified.

In addition, the INL contractor is participating in the voluntary HFC task team lead by AU-21, National Nuclear Security Administration. The goal of the task team is to better understand and address DOE’s needs and determine next steps.

4.2.1.2 ICP Core Contractor

An inventory of refrigeration equipment at ICP Core facilities, using those HFCs scheduled for phasedown, was conducted in December 2021. This activity identified two chillers (four circuits total) using R-134a at the Integrated Waste Treatment Unit (IWTU). The total charge for both chillers is approximately 830 lbs. These units will continue to be used for the IWTU mission. ICP Core preventative maintenance practices will minimize the potential for leaks. ICP Core possesses an inventory of recovery cylinders dedicated to these units, ensuring that refrigerant recovered during maintenance is available to recharge the equipment. Should there be a major failure resulting in a loss of R-134a rendering the units inoperable, they would be replaced or retrofitted. New equipment at ICP Core will be specified to use refrigerants that are not subject to the HFC phasedown.

4.3 Ambient Air Monitoring

Ambient air monitoring is conducted on and off the INL Site to identify regional and historical trends, to detect accidental and unplanned releases, and to determine if air concentrations are below derived concentration standards (DCSs) established by DOE for inhaled air (DOE 2011). Each radionuclide-specific DCS corresponds to a dose of 100 mrem for continuous exposure during the year. The Clean Air Act NESHAP regulatory standard is 10 mrem/yr (0.1 mSv/yr) (40 CFR 61, Subpart H).

4.3.1 Ambient Air Monitoring System Design

Figure 4-2 shows the regional and INL Site routine air monitoring locations. A total of 38 low-volume air samplers, one high-volume air sampler, eight atmospheric moisture samplers, and four precipitation samplers operated in the network in 2021, as shown in Table 4-3.

Historically, air samplers were positioned near INL Site facilities or sources of contamination, in predominant downwind directions from sources of radionuclide air emissions, at potential offsite receptor population centers, and at background locations. In 2015, the network was evaluated quantitatively, using atmospheric transport modeling and frequency of detection methods (Rood, Sondrup, and Ritter 2016). A Lagrangian Puff air dispersion model (CALPUFF) with three years of meteorological data was used to model atmospheric transport of radionuclides released from six major facilities and predict air concentrations at each sampler location for a given release time and duration. Frequency of detection is defined as the fraction of events resulting in a detection at either a single sampler or network. The frequency of detection methodology allowed for an evaluation of short-term releases that included effects of short-term variability in meteorological conditions. Results showed the detection frequency was over 97.5% for the entire network considering all sources and radionuclides. Network intensity results (e.g., the fraction of samplers in the network that have a positive detection for a given event) ranged from 3.75% to 62.7%. An evaluation of individual samplers indicated some samplers were poorly located and added little to the overall effectiveness of the network. Using this information, some monitors were relocated to improve performance of the network. In 2019, the frequency of detection method was used to evaluate the Idaho Falls facilities (INL 2019), with the result being the installation of an additional monitor at the INL Research Center (IRC).

Tritium is present in air moisture due to natural production in the atmosphere, the remnants of global fallout from historical nuclear weapons testing, and releases from INL Site facilities (Table 4-2). Historical emissions data show that most tritium is released from the ATR Complex, INTEC, and RWMC. Tritium enters the environment as tritiated water and behaves like water in the environment. The air monitoring network evaluation described in the previous paragraph was also used to locate atmospheric moisture samplers. The Experimental Field Station (EFS) and Van Buren Boulevard samplers are located onsite and appear to be in or near the areas of highest projected air concentration. Atomic City and Howe are communities located close to the INL Site boundary. Idaho Falls and Craters of the Moon are good offsite locations for measuring background concentrations because they do not appear to be impacted by modeled dispersion of tritium. Thus, one or two atmospheric moisture samplers are currently placed at each of the six locations: Atomic City, Craters of the Moon, EFS (two samplers), Howe, Idaho Falls (two samplers), and Van Buren Boulevard. Although there are more particulate air monitoring stations, additional atmospheric moisture and precipitation monitoring stations are not warranted. This is because the estimated potential dose for INL Site releases is less than 0.1 mrem/yr, which is the recommended DOE limit for routine surveillance (DOE 2015). See Chapter 8 for additional information on dose.

Historical tritium concentrations in precipitation and atmospheric moisture samples collected by the ESER contractor during the 10-year period from 2009 through 2018 were compared statistically; results indicate there are no differences between the data sets. For this reason, ESER precipitation samplers were placed at the same locations as the ESER atmospheric moisture samplers at Atomic City, EFS, Howe, and Idaho Falls. In addition, Idaho Falls can be easily and readily accessed by ESER personnel after a precipitation event. The EPA has a precipitation sampler in Idaho Falls and subsamples are collected for the ESER Program.

To support emergency response, the INL contractor maintains 16 high volume event air samplers at NOAA weather towers, as shown in Figure 4-4. These event monitors are only turned on as needed for sampling when an event occurs, such as a range fire or unplanned release of radioactivity.

Table 4-3. INL Site and regional ambient air monitoring summary (2021).

MEDIUM SAMPLED	TYPE OF ANALYSIS	FREQUENCY	NUMBER OF LOCATIONS						MINIMUM DETECTABLE CONCENTRATION (MDC)
			ONSITE			OFFSITE			
			INL[a]	ESER[b]	*TOTAL*	INL[a]	ESER[b]	*TOTAL*	
Air (low volume)	Gross alpha	Weekly	16	3	**19**	6	13	**19**	1E-15 µCi/mL
	Gross beta	Weekly	16	3	**19**	6	13	**19**	2E-15 µCi/mL
	Specific gamma[c]	Quarterly	16	3	**19**	6	13	**19**	2E-16 µCi/mL
	Plutonium-238	Quarterly	16	1-2	**17-18**	6	4	**10**	3.5E-18 µCi/mL
	Plutonium-239/240	Quarterly	16	1-2	**17-18**	6	4	**10**	3.5E-18 µCi/mL
	Americium-241	Quarterly	16	1-2	**17-18**	6	4	**10**	4.6E-18 µCi/mL
	Strontium-90	Quarterly	16	1-2	**17-18**	6	4	**10**	3.4E-17 µCi/mL

Table 4-3. continued.

MEDIUM SAMPLED	TYPE OF ANALYSIS	FREQUENCY	NUMBER OF LOCATIONS ONSITE INL[a]	ONSITE ESER[b]	ONSITE *TOTAL*	OFFSITE INL[a]	OFFSITE ESER[b]	OFFSITE *TOTAL*	MINIMUM DETECTABLE CONCENTRATION (MDC)
	Iodine-131	Weekly	16	3	**19**	6	13	**19**	1.5E-15 µCi/mL
	Total particulates	Weekly	–	3	**3**	–	13	**13**	10 µg/m^3
Air (high volume)[d]	Gross beta scan	Biweekly	–	–	**–**	–	1	**1**	1E-15 µCi/mL
	Gamma scan	Continuous	–	–	**–**	–	1	**1**	Not applicable
	Specific gamma[c]	Annually[e]	–	–	**–**	–	1	**1**	1E-14 µCi/mL
	Isotopic Uranium & Plutonium	Every 4 yrs	–	–	**–**	–	1	**1**	2E-18 µCi/mL
Air (atmospheric moisture)[f]	Tritium	3–6/Quarter	2	1	**3**	2	3	**5**	2E-13 µCi/mL (air)
Air (precipitation)[g]	Tritium	Monthly	–	0	**0**	–	1	**1**	88 pCi/L
		Weekly	–	1	**1**	–	2	**2**	

a. Low volume air samplers are operated on the INL Site by the INL contractor at the following locations: ATR Complex (two air samplers), CFA, Experimental Breeder Reactor No. 1 (EBR-I), Experimental Field Station (EFS), Highway 26 Rest Area, INTEC (two air samplers), Gate 4, MFC (two air samplers), NRF, RWMC (two air samplers), Specific Manufacturing Capability (SMC), and Van Buren Boulevard. In addition, there are two rotating duplicate samplers for QA. In 2021, the samplers were located at INTEC (Westside) and RWMC. The INL contractor also samples offsite (i.e., outside INL Site boundaries) at Blackfoot, Craters of the Moon, Idaho Falls, INL Research Center (IRC) (two air samplers), and Sugar City. This table does not include high volume 'event' monitoring by the INL contractor.

b. The ESER contractor operates low volume samplers on the INL Site at Main Gate, EFS, and Van Buren Blvd. Offsite locations include Arco, Atomic City, Blackfoot, Blue Dome, Craters of the Moon, Dubois, Federal Aviation Administration Tower, Howe, Idaho Falls, Jackson (WY), Monteview, Mud Lake, and Sugar City. In addition, there are two rotating duplicate samplers for quality assurance. In 2021, these were placed at Arco and Mud Lake.

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

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

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

f. Atmospheric moisture samples are collected onsite at EFS by the ESER and INL contractors, and at Van Buren Boulevard by the INL contractor. Samples are collected offsite at Atomic City by ESER, at Craters of the Moon by INL, at Howe by ESER, and at Idaho Falls by the ESER and INL contractors.

g. Precipitation samples are currently collected onsite at EFS by the ESER contractors. Samples are collected offsite at Atomic City, Howe, and Idaho Falls (also used as the EPA RadNet precipitation location) by the ESER contractor.

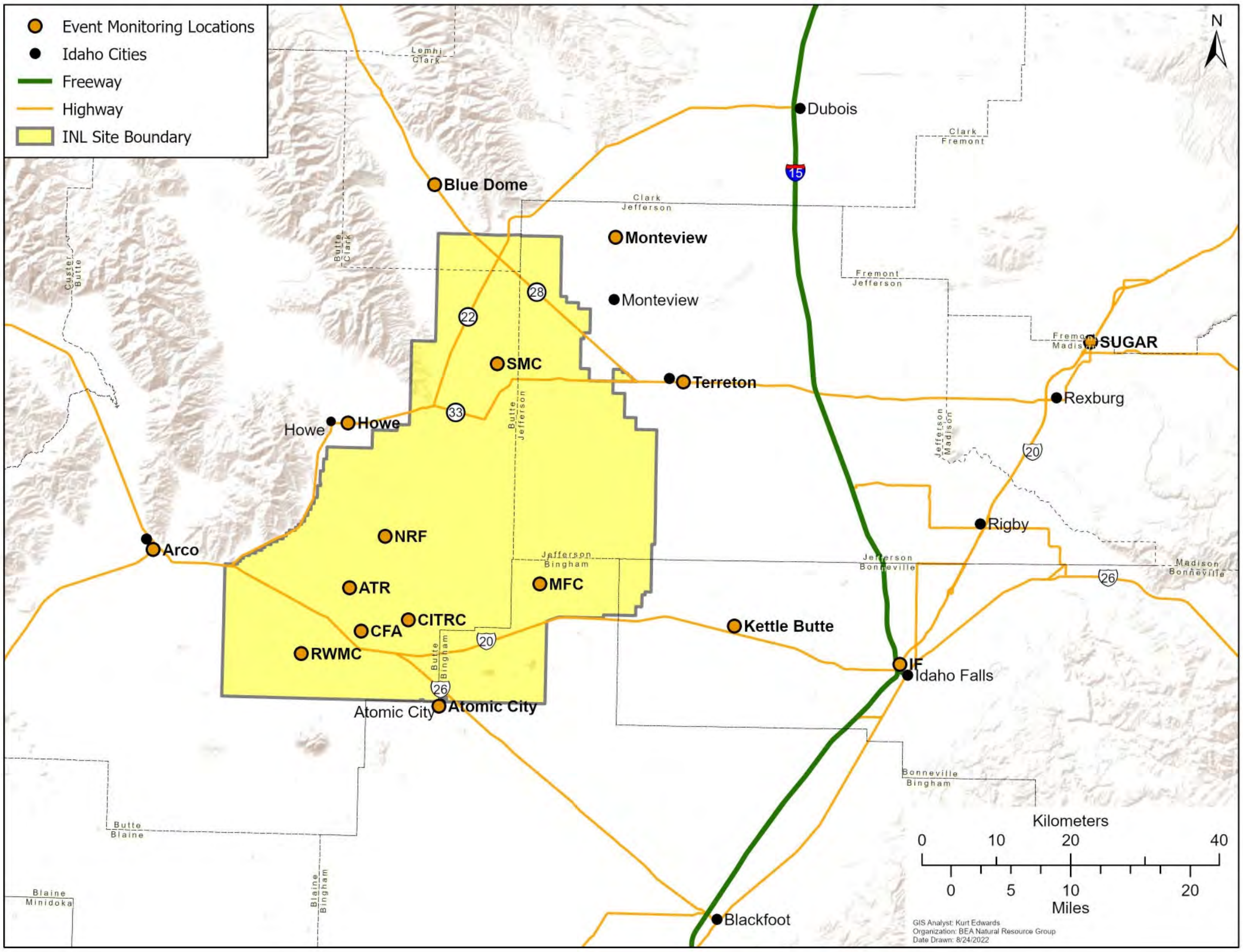


Figure 4-4. Locations of INL contractor high-volume event monitors at NOAA weather stations.

4.3.2 Air Particulate, Radioiodine, and Tritium Sampling Methods

4.3.2.1 Air Particulates

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

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

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

4.3.2.2 Radioiodine

Charcoal cartridges are collected and analyzed weekly for iodine-131 (^{131}I) by the INL and ESER contractors at the same locations described in Table 4-3. 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.

4.3.2.3 Tritium

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

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

4.3.3 Ambient Air Monitoring Results

Gaseous Radioiodines – The INL contractor collected and analyzed approximately 1,460 charcoal cartridges (including blanks and duplicates) in 2021. There were no statistically positive measurements of ^{131}I. During 2021, the ESER contractor analyzed approximately 775 cartridges (including blanks and duplicate samples), usually in batches of 10 cartridges, looking specifically for ^{131}I. Analyses of cartridges found no detectable ^{131}I.

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

Concentrations of gross alpha and gross beta radioactivity detected by ambient air monitoring conducted by INL and ESER contractors are summarized in Tables 4-4 and 4-5. Results are further discussed below:

Table 4-4. Median annual gross alpha concentrations in ambient air samples collected in 2021.

GROUP	LOCATION[a]	NO. OF SAMPLES[b]	RANGE OF CONCENTRATIONS[c] (× 10^{-15} µCi/mL)	ANNUAL MEDIAN CONCENTRATION (× 10^{-15} µCi/mL)
		ESER CONTRACTOR		
Distant	Blackfoot	39	-1.1 – 3.2	1.2
	Craters of the Moon	38	0.13 – 3.1	1.2
	Dubois	39	0.36 – 3.8	1.1
	Idaho Falls	39	-1.3 – 2.9	1.5
	Jackson	39	-0.87 – 3.4	1.4
	Sugar City	38	0.24 – 3.3	1.1
			Distant Median:	1.2
Boundary	Arco	39	0.19 – 3.2	1.3
	Atomic City	39	0.34 – 4.1	1.2
	Blue Dome	39	0.24 – 4.2	0.97
	FAA Tower	39	-1.0 – 2.8	1.1
	Howe	39	0.21 – 4.3	1.1
	Monteview	39	0.27 – 3.2	1.2
	Mud Lake	39	0.32 – 3.6	1.0
			Boundary Median:	1.2
INL Site	EFS	38	0.0 – 3.7	1.1
	Main Gate	38	0.27 – 3.4	1.2
	Van Buren	38	-0.08 – 2.7	1.1
			INL Site Median:	1.1
		INL CONTRACTOR		
Distant	Blackfoot	63	-0.48 – 6.0	1.3
	Craters of the Moon	61	-0.15 – 7.8	1.2
	Dubois	13	0.80 – 2.5	1.9
	Idaho Falls	64	0.12 – 5.8	1.4
	IRC[d]	51	-0.38 – 5.3	1.3
	IRC (North)	51	-0.22 – 6.8	1.5
	Jackson	13	1.1 – 2.8	1.3
	Sugar City	64	-0.06 – 6.4	1.6
			Distant Median:	1.3
Boundary	Arco	13	1.1 – 2.8	1.6
	Atomic City	13	1.1 – 3.5	1.9
	Blue Dome	13	0.95 – 2.5	1.5
	FAA Tower	13	0.91 – 2.6	1.9
	Howe	13	0.85 – 3.0	1.7
	Monteview	13	0.97 – 2.8	1.8
	Mud Lake	13	-0.25 – 3.7	1.9
			Boundary Median:	1.8

Table 4-4. continued.

GROUP	LOCATION[a]	NO. OF SAMPLES[b]	RANGE OF CONCENTRATIONS[c] ($\times 10^{-15}$ µCi/mL)	ANNUAL MEDIAN CONCENTRATION ($\times 10^{-15}$ µCi/mL)
INL Site	RHLLW	51	-0.28 – 7.2	1.6
	ATR Complex (NE corner)	49	-0.54 – 7.4	1.7
	Highway 26 Rest Area	51	-0.18 – 6.3	1.0
	CFA	49	-0.04 – 6.0	1.9
	EBR-I	49	-0.64 – 5.4	1.2
	EFS	61	-0.04 – 9.6	1.7
	Gate 4	51	-0.62 – 7	1.4
	INTEC (NE corner)	51	-0.1 – 8	1.5
	INTEC (west side)	48	-0.13 – 4.8	1.1
	MFC (North)	48	-0.48 – 6.2	1.4
	MFC (South)	51	-0.11 – 8.3	1.5
	NRF	51	-0.3 – 5.7	1.3
	RWMC	49	-0.37 – 5.0	1.2
	RWMC (South)	51	-0.01 – 4.7	1.4
	SMC	51	0.27 – 6.9	1.5
	Van Buren Boulevard	64	-0.5 – 9.1	1.5
			INL Site Median:	1.4

a. FAA = Federal Aviation Administration, RHLLW = Remote Handled Low-Level Waste Disposal Facility. See Figure 4-2 for locations on INL Site.

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

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

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

- ***Gross Alpha.*** Gross alpha concentrations are measured on a weekly basis in individual air samples ranged from a low of (-1.3 ± 0.09) $\times 10^{-15}$ µCi/mL collected by the ESER contractor at Idaho Falls on February 17, 2021, to a high of (9.6 ± 3.2) $\times 10^{-15}$ µCi/mL collected by the INL contractor at EFS on August 18, 2021, as shown in Table 4-4.

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

- ***Gross Beta.*** Weekly gross beta concentrations measured in air samples ranged from a low of (-8.9 ± 5.3) $\times 10^{-16}$ µCi/mL at Jackson, collected by the ESER contractor on March 17, 2021, to a high of (8.3 ± 8.5) $\times 10^{-14}$ µCi/mL collected by the INL contractor at CFA on December 9, 2021, as observed in Table 4-5. The lowest detected value (i.e., greater than 3-sigma) was (2.3 ± 0.45) $\times 10^{-15}$ µCi/mL collected by the ESER contractor at Jackson on July 15, 2021. All results were less than the maximum concentration of 1.0×10^{-13} µCi/mL which was reported in previous Annual Site Environmental Reports (2011–2019). In general, median airborne radioactivity levels for the INL Site, boundary, and distant locations tracked each other closely throughout the year. The typical temporal fluctuations for natural gross beta concentrations in air were observed, with higher values usually occurring at the beginning and end of the calendar year during winter inversion conditions (see sidebar). This pattern occurs over the entire sampling network, and is representative of natural conditions, and is not caused by a localized source, such as a facility or

Table 4-5. Median annual gross beta concentrations in ambient air samples collected in 2021.

GROUP	LOCATION[a]	NO. OF SAMPLES[b]	RANGE OF CONCENTRATIONS[c] ($\times 10^{-14}$ µCi/mL)	ANNUAL MEDIAN CONCENTRATION[c] ($\times 10^{-14}$ µCi/mL)
ESER CONTRACTOR				
Distant	Blackfoot	39	0.14 – 4.3	2.8
	Craters of the Moon	38	0.97 – 5.7	2.7
	Dubois	39	0.75 – 4.1	2.5
	Idaho Falls	39	0.44 – 3.4	2.4
	Jackson	39	-0.09 – 4.3	2.7
	Sugar City	38	0.65 – 4.0	2.4
			Distant Median:	2.6
Boundary	Arco	39	1.2 – 6.0	2.7
	Atomic City	39	0.99 – 5.8	2.8
	Blue Dome	39	0.82 – 3.9	2.6
	FAA Tower	39	0.67 – 3.8	2.5
	Howe	39	0.84 – 3.8	2.8
	Monteview	39	0.88 – 3.6	2.5
	Mud Lake	39	0.86 – 4.0	2.5
			Boundary Median:	2.6
INL Site	EFS	38	0.04 – 4.9	2.7
	Main Gate	38	0.86 – 5.3	2.7
	Van Buren	38	-1.3 – 4.2	2.5
			INL Site Median:	2.7
INL CONTRACTOR				
Distant	Blackfoot	63	1.4 – 6.1	2.6
	Craters of the Moon	61	1.6 – 5.7	2.4
	Dubois	13	1.6 – 4.6	2.8
	Idaho Falls	64	1.7 – 5.8	2.6
	IRC[d]	51	1.04 – 4.45	2.6
	IRC (North)	51	0.98 – 4.48	2.8
	Jackson	13	1.3 – 4.4	2.4
	Sugar City	64	1.0 – 6.3	2.5
			Distant Median:	2.6
Boundary	Arco	13	1.6 – 5.6	3.1
	Atomic City	13	1.5 – 6.5	3.3
	Blue Dome	13	1.6 – 5.3	3.4
	FAA Tower	13	1.6 – 5.2	2.7
	Howe	13	1.8 – 6.2	3.0
	Monteview	13	1.6 – 5.5	3.1
	Mud Lake	13	1.7 – 6.3	3.1
INL Site	RHLLW	51	1.49 – 4.51	2.7
	ATR Complex (NE corner)	49	1.26 – 5.31	2.5

Table 4-5. continued.

GROUP	LOCATION[a]	NO. OF SAMPLES[b]	RANGE OF CONCENTRATIONS[c] ($\times 10^{-14}$ µCi/mL)	ANNUAL MEDIAN CONCENTRATION[c] ($\times 10^{-14}$ µCi/mL)
	Highway 26 Rest Area	51	0.97 – 4.8	2.6
	CFA	49	1.37 – 8.3	2.8
	EBR-I	49	1.08 – 4.61	2.6
	EFS	61	1.8 – 7.7	2.7
	Gate 4	51	1.32 – 4.74	2.8
	INTEC (NE corner)	51	1.26 – 6.18	2.8
	INTEC (west side)	48	1.15 – 4.74	2.5
	MFC (North)	46	1.09 – 4.0	2.4
	MFC (South)	51	1.14 – 5.49	2.6
	NRF	51	1.28 – 4.86	2.7
	RWMC	49	1.25 – 4.41	2.6
	RWMC (South)	51	1.24 – 4.52	2.6
	SMC	51	1.22 – 4.77	2.5
	Van Buren Boulevard	64	1.4 – 5.7	2.7
			INL Site Median:	2.6

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

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

c. IRC is an in-town (Idaho Falls) facility within the INL REC.

activity at the INL Site. An inversion can lead to natural radionuclides being trapped close to the ground. In 2021, the most prominent inversion periods occurred in January, November, and December. The maximum weekly gross beta concentration is significantly below the DCS of 2.5×10^{-11} µCi/mL (see Table A-2) for the most restrictive beta-emitting radionuclide in air, ^{90}Sr.

- ***Gross Activity Statistical Comparisons.*** Statistical comparisons were made using the gross alpha and gross beta radioactivity data collected by the ESER contractor from the INL Site, boundary, and distant locations (see the supplemental report, *Statistical Methods Used in the Idaho National Laboratory Annual Site Environmental Report*, for a description of the methods used). If the INL Site were a significant source of offsite contamination, contaminant concentrations would be statistically greater at boundary locations than at distant locations. For these analyses, uncensored analytical results (i.e., values less than their analysis-specific minimum detectable concentrations) were included. There were no statistical differences between annual concentrations collected from the INL Site, boundary, and distant locations in 2021. There were a few statistical differences between weekly boundary and distant data sets collected by the ESER contractor during 2021 that can be attributed to expected statistical variation in the data and

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.

not to INL Site releases. Quarterly reports detailing these analyses are provided at https://idahoeser.inl.gov/publications.html.

The INL contractor compared gross beta concentrations from samples collected at onsite and offsite locations. Statistical evaluation revealed no significant differences between onsite and offsite concentrations. Onsite and offsite mean concentrations (2.6 ± 0.3 × 10^{-14} and 2.6 ± 0.3 × 10^{-14} µCi/mL, respectively) showed equivalence at one sigma uncertainty and are attributable to natural data variation.

Specific Radionuclides – None of the 100 INL contractor quarterly samples composited in 2021 had measurable concentrations of specific radionuclides (i.e., ^{90}Sr, ^{137}Cs, plutonium isotopes, or ^{241}Am).

The ESER contractor observed eight detections of ^{90}Sr throughout 2021. The detectable concentrations ranged from 3.3 x 10^{-17} µCi/mL at Howe during the third quarter to 2.1 x 10^{-16} µCi/mL at Mud Lake in the first quarter, as observed in Table 4-6. Plutonium-239/240 was detected in a quarterly composited sample that was collected at Arco during the fourth quarter (Table 4-6). It was not detected in a duplicate sample collected at the same location. Plutonium-238 and ^{241}Am were not detected in any sample collected by the ESER contractor. All results were within historical measurements made during the past ten years (2011-2020). In addition, the results were well below the DCSs for these radionuclides in air (i.e., 2.5 × 10^{-11} µCi/mL for ^{90}Sr, and 3.7 × 10^{-14} µCi/mL for ^{238}Pu). 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.

Table 4-6. Human-made radionuclides detected in ambient air samples collected by the ESER contractor in 2021.

RADIONUCLIDE	RESULT[a] (µCi/mL)	LOCATION	GROUP	QUARTER DETECTED
Plutonium-239/240	(55 ± 16) × 10^{-18}	Arco	Boundary	4th
Strontium-90	(48 ± 7) × 10^{-18}	Dubois	Distant	1st
Strontium-90	(59 ± 9) × 10^{-18}	Howe	Boundary	1st
Strontium-90	(50 ± 12) × 10^{-18}	Main Gate	INL Site	1st
Strontium-90	(192 ± 12) × 10^{-18}	Mud Lake	Boundary	1st
Strontium-90	(214 ± 12) × 10^{-18}	Mud Lake (duplicate)	Boundary	1st
Strontium-90	(33 ± 11) × 10^{-18}	Howe	Boundary	3rd
Strontium-90	(40 ± 10) × 10^{-18}	Arco	Boundary	4th
Strontium-90	(44 ± 11) × 10^{-18}	Atomic City	Boundary	4th

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

4.3.4 Atmospheric Moisture Monitoring Results

During 2021, the ESER contractor collected 51 atmospheric moisture samples at four locations. Table 4-7 presents the percentage of samples containing detectable tritium, the range of concentrations, and the mean concentration for each location. Tritium was detected in 17 ESER samples, with a high of (12.8 ± 2.5) × 10^{-13} µCi/mL_{air} at EFS on July 21, 2021. The highest concentration of tritium detected in an atmospheric moisture sample collected since 2011 was 28 × 10^{-13} µCi/mL at Idaho Falls in 2014. The highest observed tritium concentration in a 2021 sample collected by the ESER contractor is far below the DCS for tritium in air (as water vapor) of 2.1 × 10^{-7} µCi/mL_{air} (see Table A-5).

In 2021, the INL contractor collected 31 atmospheric moisture samples on the INL Site at EFS and Van Buren Boulevard and off the INL Site at Idaho Falls and Craters of the Moon, as observed in Table 4-7. Tritium was detected in six samples. The maximum detected concentration measured was 1.36 × 10^{-12} µCi/mL_{air} at EFS on June 30, 2021. This result is well below the DCS for tritium, as vapor, in air (2.1 × 10^{-7} µCi/mL), and is the maximum measured since 2011.

Fewer detections were observed in INL samples than in ESER samples most likely because ESER samples have more volume and were counted longer resulting in lower detection levels.

Table 4-7. Tritium concentrations[a] in atmospheric moisture samples collected on and off the INL Site in 2021.

ESER CONTRACTOR				
	ATOMIC CITY	EFS	HOWE	IDAHO FALLS
Number of samples	11	13	12	15
Number of detections	4	8	3	2
Detection percentage	36%	62%	25%	13%
Concentration range ($\times 10^{-13}$ µCi/mL$_{air}$)[b]	-2.6 ± 1.6 – 6.8 ± 2.1	0.2 ± 1.3 – 12.8 ± 2.5	-3.3 ± 1.8 – 9.1 ± 1.3	-4.7 ± 1.3 – 9.3 ± 1.8
Mean concentration ($\times 10^{-13}$ µCi/mL$_{air}$)[b]	2.1	6.0	3.1	1.7
Median concentration ($\times 10^{-13}$ µCi/mL$_{air}$)	1.5	5.9	2.5	0.2
Mean detection level ($\times 10^{-13}$ µCi/mL$_{air}$)	4.7	5.0	5.3	5.6
INL CONTRACTOR				
	CRATERS OF THE MOON	EFS	IDAHO FALLS	VAN BUREN BOULEVARD
Number of samples	6	8	8	9
Number of detections[c]	1	3	1	1
Detection percentage	17%	38%	13%	11%
Concentration range (µCi/mL$_{air}$)[b]	-7.0E-14 – 7.3E-13	-3.7E-13 – 1.4E-12	-3.5E-13 – 1.1E-12	-7.6E-14 – 1.2E-12
Mean concentration ($\times 10^{-13}$ µCi/mL$_{air}$)[b]	1.9	5.7	2.2	5.5
Median concentration ($\times 10^{-13}$ µCi/mL$_{air}$)	1.3	5.0	1.6	5.8
Mean detection level ($\times 10^{-13}$ µCi/mL$_{air}$)	7.0	9.0	8.4	8.9

a. Results ± 1σ.
b. All measurements, including negative results, are included in this table and in computation of mean annual values. A negative result indicates that the measurement was less than the laboratory background measurement.
c. An analyte is considered detected when the result is greater than or equal to three times the uncertainty (sigma).

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

4.3.5 Precipitation Monitoring Results

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

The ESER contractor collects precipitation samples weekly, when available, at Atomic City, EFS, and Howe. Precipitation is collected monthly at Idaho Falls for EPA RadNet monitoring (https://www.epa.gov/radnet) and a subsample is taken by the ESER contractor for analysis.

A total of 71 precipitation samples were collected during 2021 from the four sites. Tritium was detected in 23 samples, and detectable results ranged from 90 pCi/L at Howe in August to 391 pCi/L at Howe in November. Most detections were near the approximate detection level of 91 pCi/L. Table 4-8 shows the percentage of detections, the concentration range, the mean and median 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 range (-244 – 413 pCi/L) measured from 2011–2020.

Table 4-8. Tritium concentrations in precipitation samples collected in 2021.[a,b]

	ATOMIC CITY	EFS	HOWE	IDAHO FALLS
Number of samples	15	21	23	12
Number of detections	3	8	9	3
Detection percentage	20%	38%	39%	25%
Concentration range (pCi/L)	-83.9 ± 23.1 – 203 ± 29.7	-53.1 ± 23.5 – 262 ± 45.7	-77.2 ± 25.5 – 391 ± 31.2	-87.8 ± 24.6 – 165 ± 32.3
Mean concentration (pCi/L)	41	79	74	30
Median concentration (pCi/L)	45	69	57	38
Mean detection level (pCi/L)	90	91	91	92

a. Results ± 1σ.

b. All measurements are included in this table and in computation of mean annual values. A negative result indicates that the measurement was less than the laboratory background measurement.

The results were also comparable with tritium concentrations reported by EPA for precipitation during the 10-year period from 2002–2011 (measurements were discontinued after 2011), based on a query of available data (https://enviro.epa.gov/enviro/erams_query_v2.simple_query). Concentrations reported by EPA for Idaho Falls during that period ranged from 0-1720 pCi/L and averaged 35.1 pCi/L.

Annual tritium concentrations in atmospheric moisture and precipitation have no discernable statistical distribution, so nonparametric statistical methods were used to assess both sets of data (see *Statistical Methods Used in the Idaho National Laboratory Annual Site Environmental Report*, a supplement to this annual report.) To summarize the results, box plots were constructed of annual tritium concentrations measured in atmospheric moisture (as water) and precipitation samples collected by the ESER contractor for the past 10 years, as can be seen in Figure 4-5. The results appear to be similar for each year. A statistical comparison of both sets of data (using the non-parametric Wilcoxon Matched Pairs Test) shows there are no differences between median annual tritium concentrations measured in atmospheric moisture and in precipitation samples. Because low levels of tritium exist in the environment at all times as a result of cosmic ray reactions with atmospheric gases in the upper atmosphere and the decreasing influence of fallout from nuclear weapons testing in the atmosphere, and because tritium concentrations do not appear to differ between precipitation and atmospheric moisture samples, the source of tritium measured in precipitation and atmospheric moisture is most likely of natural origin and past nuclear tests, and not from INL Site releases.

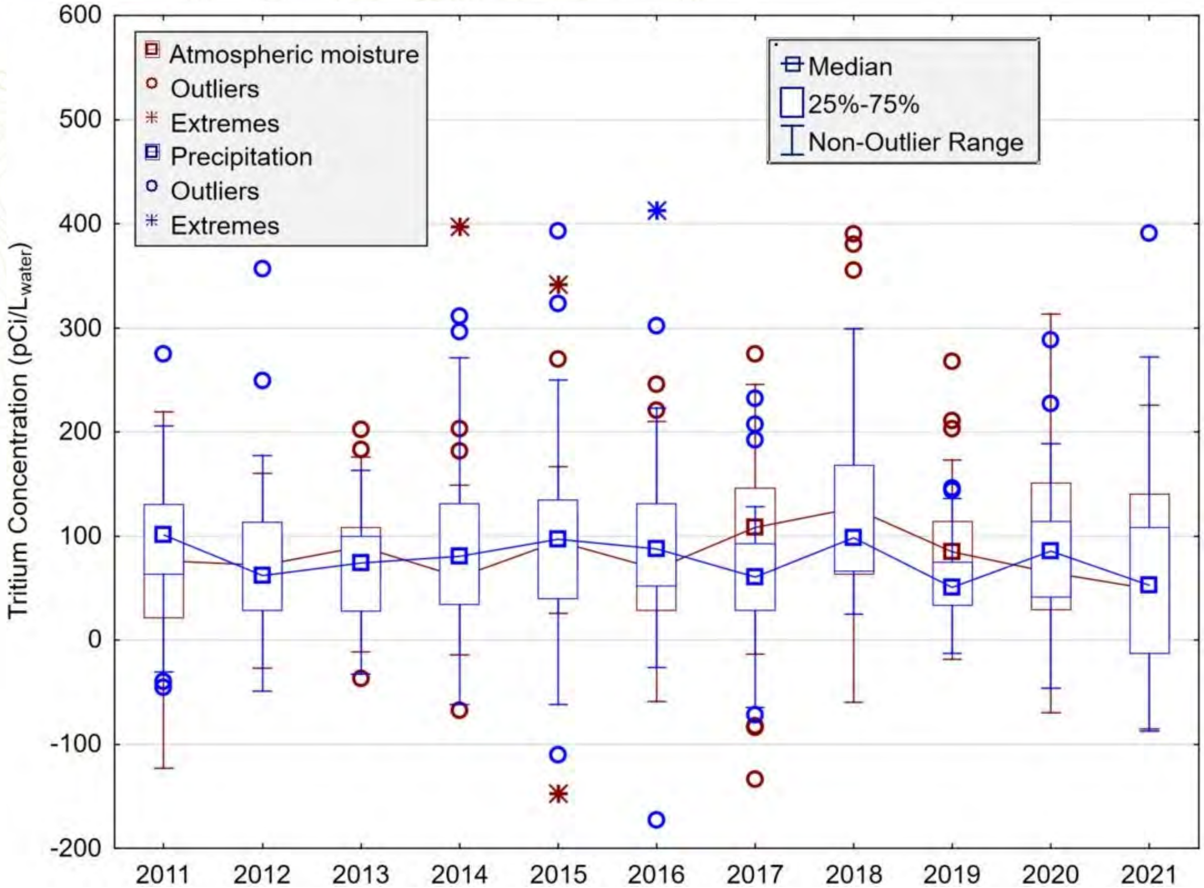


Figure 4-5. Box plots of tritium concentrations measured in atmospheric moisture and in precipitation from 2011–2021.

4.3.6 Suspended Particulates Monitoring Results

In 2021, the ESER contractor measured concentrations of suspended particulates using filters collected from the low-volume air samplers. The filters are 99% efficient for the collection of particles greater than 0.3 μm in diameter. That is, they collect the total particulate load greater than 0.3 μm in diameter.

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

The mean annual particulate concentrations ranged from 9.84 μg/m^3 at Blue Dome to 23.27 μg/m^3 at Idaho Falls. 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 Core contractor conducts environmental surveillance in and around waste management facilities to comply with DOE O 435.1, "Radioactive Waste Management." Currently, ICP Core waste management operations are performed at the SDA at RWMC and the ICDF at INTEC. These operations have the potential to emit radioactive airborne particulates. The ICP Core contractor collected samples of airborne particulate material from the perimeters of these waste management areas in 2021, as observed in Figure 4-6. Samples were also collected at a control location at Howe, Idaho, as previously seen in Figure 4-2, to compare with the results of the SDA and ICDF.

Samples were obtained using suspended particulate monitors similar to those used by the INL and ESER contractors. The air filters are 4 in. in diameter and are changed out on the closest working day to the first and 15th of each month. Gross alpha and gross beta activity were determined on all suspended particulate samples. Table 4-9 shows the median annual and range of gross alpha concentrations at each location. Gross alpha concentrations ranged from a low of (0.65 ± 0.12) × 10^{-15} µCi/mL collected at location SDA 11.3 on February 16, 2021, to a high of (4.29 ± 0.65) × 10^{-15} µCi/mL at location SDA 6.3 on September 27, 2021.

Table 4-10 shows the annual median and range of gross beta concentrations at each location. Gross beta concentrations ranged from a low of (0.68 ± 0.06) × 10^{-14} µCi/mL at location SDA 6.3 on February 16, 2021, to a high of (5.30 ± 0.45) x 10^{-14} µCi/mL at location SDA 4.3B on December 6, 2021.

Figure 4-7 compares gross alpha and gross beta sample results from 2011 through 2021 to the most restrictive DCS values ($^{239/240}$Pu for gross alpha, ^{90}Sr for gross beta) established by DOE for inhaled air (DOE 2011). The 2021 results for the SDA and ICDF are well below their respective DCS values. Results from the SDA and ICDF were compared with the results collected from the background monitoring location in Howe. The ranges of concentrations measured at the SDA and ICDF were aligned with the range measured at the Howe (background) monitoring location.

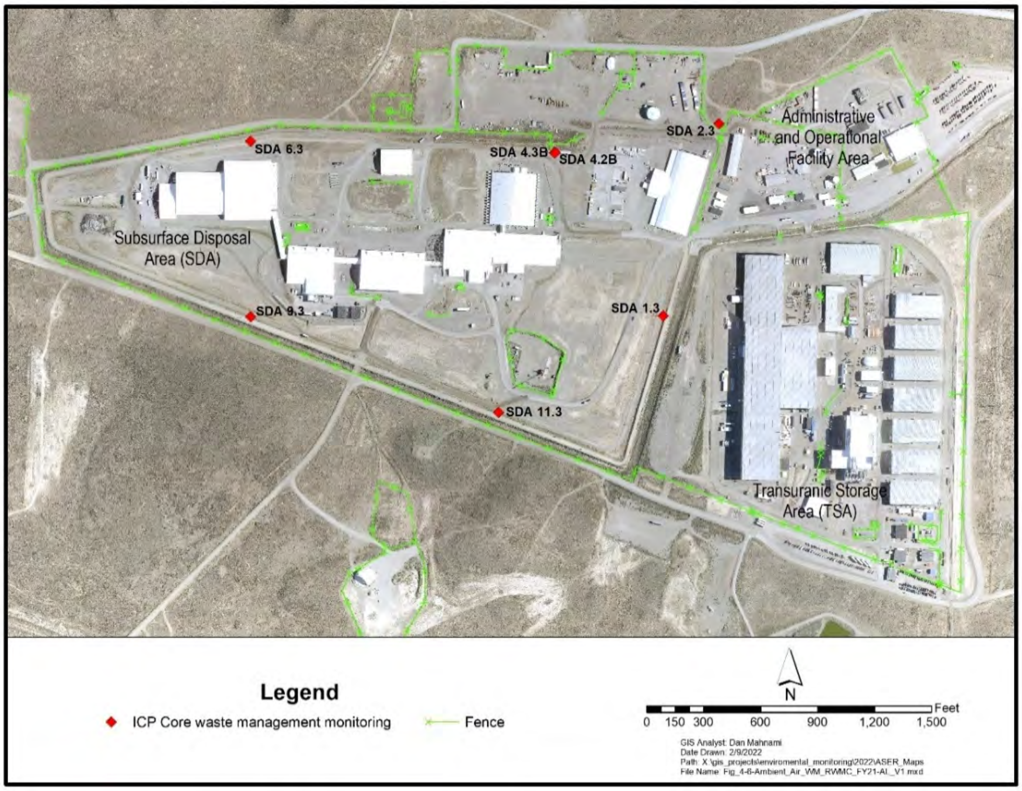
4.4.2 Specific Radionuclides

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

In 2021, only one human-made, gamma-emitting radionuclide was detected in air samples at the ICDF at INTEC. However, multiple human-made specific alpha-emitting and beta-emitting radionuclides were detected at the SDA at RWMC.

Table 4-11 shows human-made specific radionuclides detected at INTEC and the SDA in 2021. These detections are consistent with levels measured in air at the SDA in previous years. All detections were three to four orders of magnitude below the DCS stipulated in DOE (2011), as shown in Figure 4-8, and statistically false positives at the 95% confidence error are possible.

In addition to the human-made, gamma-emitting radionuclides discussed above, the ICP Core contractor also monitors for uranium. While not enumerated in Table 4-11, detections of uranium radionuclides occur routinely at concentrations that suggest a natural origin.



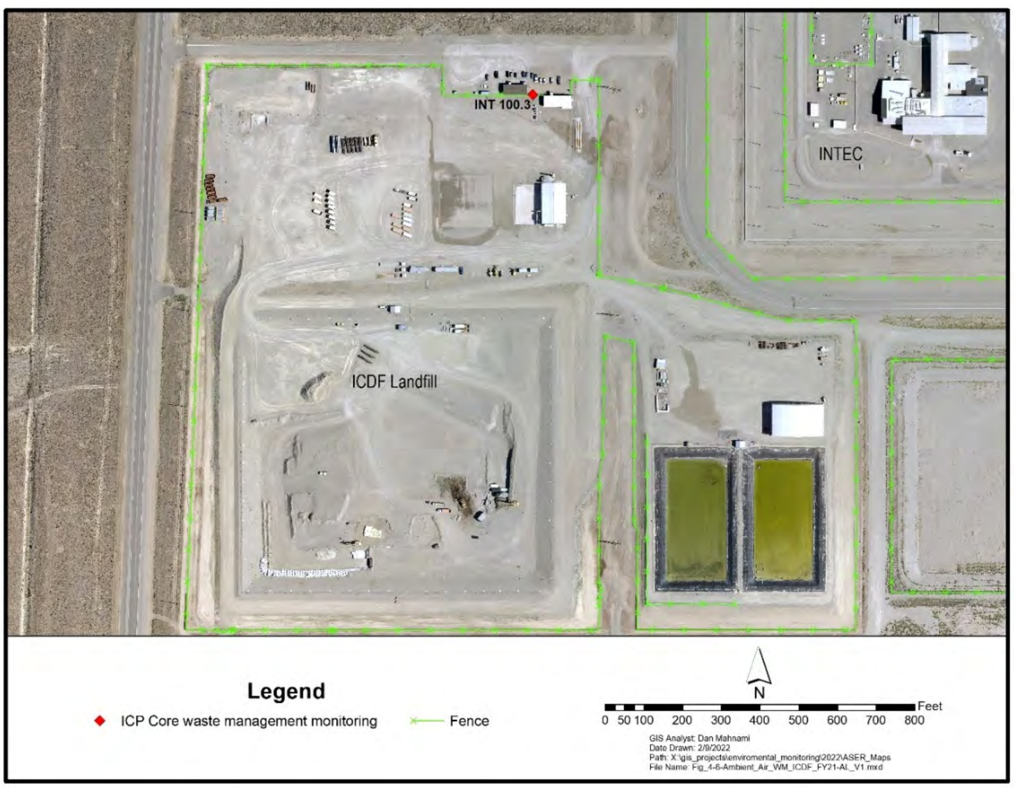


Figure 4-6. Locations of ICP Core contractor low-volume air samplers at waste management areas (SDA [top] and ICDF [bottom]).

Table 4-9. Median annual gross alpha concentration in air samples collected at waste management sites in 2021.[a]

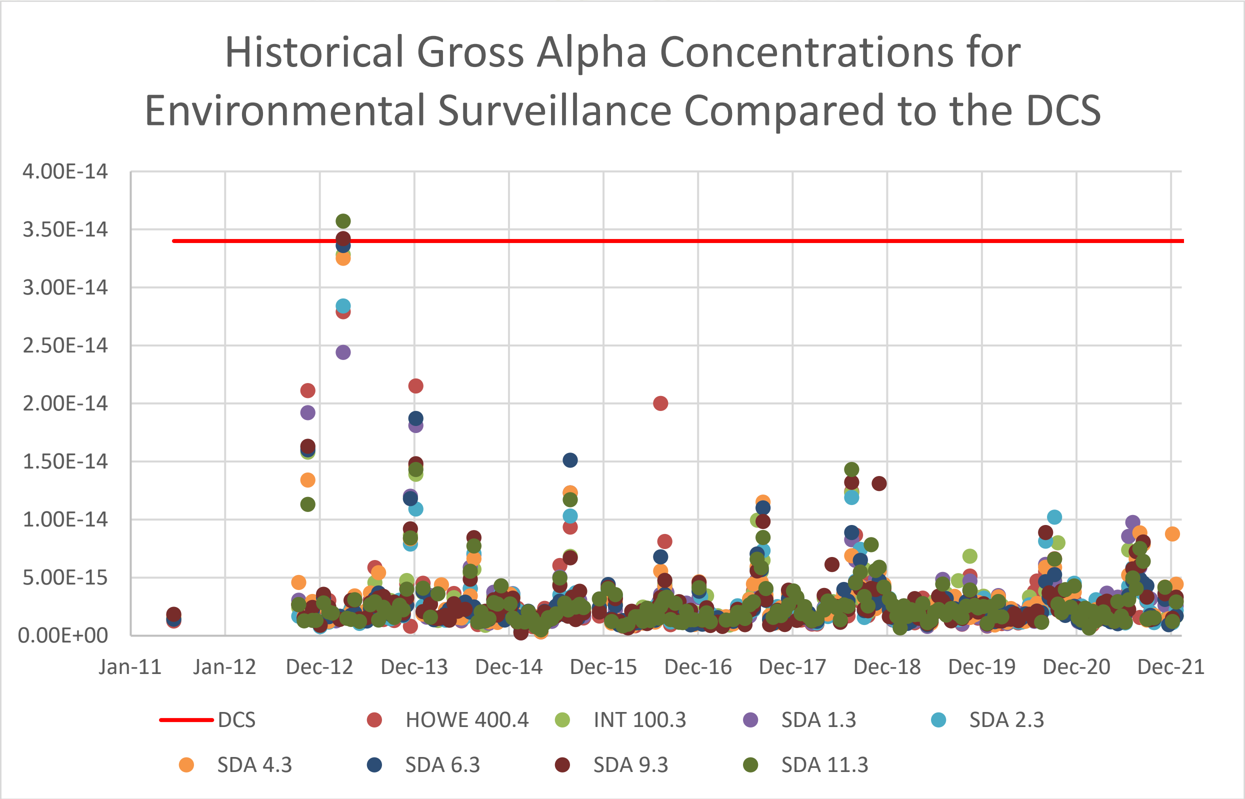
GROUP	LOCATION	NO. OF SAMPLES COLLECTED	RANGE OF CONCENTRATIONS ($\times 10^{-15}$ µCi/mL)	ANNUAL MEDIAN ($\times 10^{-15}$ µCi/mL)
SDA	SDA 1.3	17	0.88 - 3.65	2.70
	SDA 2.3	18	1.08 - 3.66	2.91
	SDA 4.3B [a]	16	0.85 - 4.18	2.94
	SDA 6.3	19	0.77 - 4.29	2.91
	SDA 9.3	19	0.85 - 3.60	2.65
	SDA 11.3	20	0.65 - 4.16	2.73
ICDF	INT 100.3	19	0.75 - 4.06	2.78
Boundary	HOWE 400.4	20	0.70 - 3.09	2.24

a. Results for SDA 4.2B, a replicate of SDA 4.3B, do not appear in the table.

Table 4-10. Median annual gross beta concentration in air samples collected at waste management sites in 2021.[a]

GROUP	LOCATION	NO. OF SAMPLES COLLECTED	RANGE OF CONCENTRATIONS ($\times 10^{-14}$ µCi/mL	ANNUAL MEDIAN ($\times 10^{-14}$ µCi/mL)
SDA	SDA 1.3	17	0.72 - 4.19	2.82
	SDA 2.3	18	0.98 - 4.99	3.47
	SDA 4.3B [a]	16	0.92 - 5.30	3.57
	SDA 6.3	19	0.68 – 4.00	2.68
	SDA 9.3	19	0.85 - 4.72	3.21
	SDA 11.3	20	0.75 - 4.52	3.01
ICDF	INT 100.3	19	0.86 - 4.61	3.17
Boundary	HOWE 400.4	20	0.95 - 4.78	3.34

a. Results for SDA 4.2B, a replicate of SDA 4.3B, do not appear in the table.



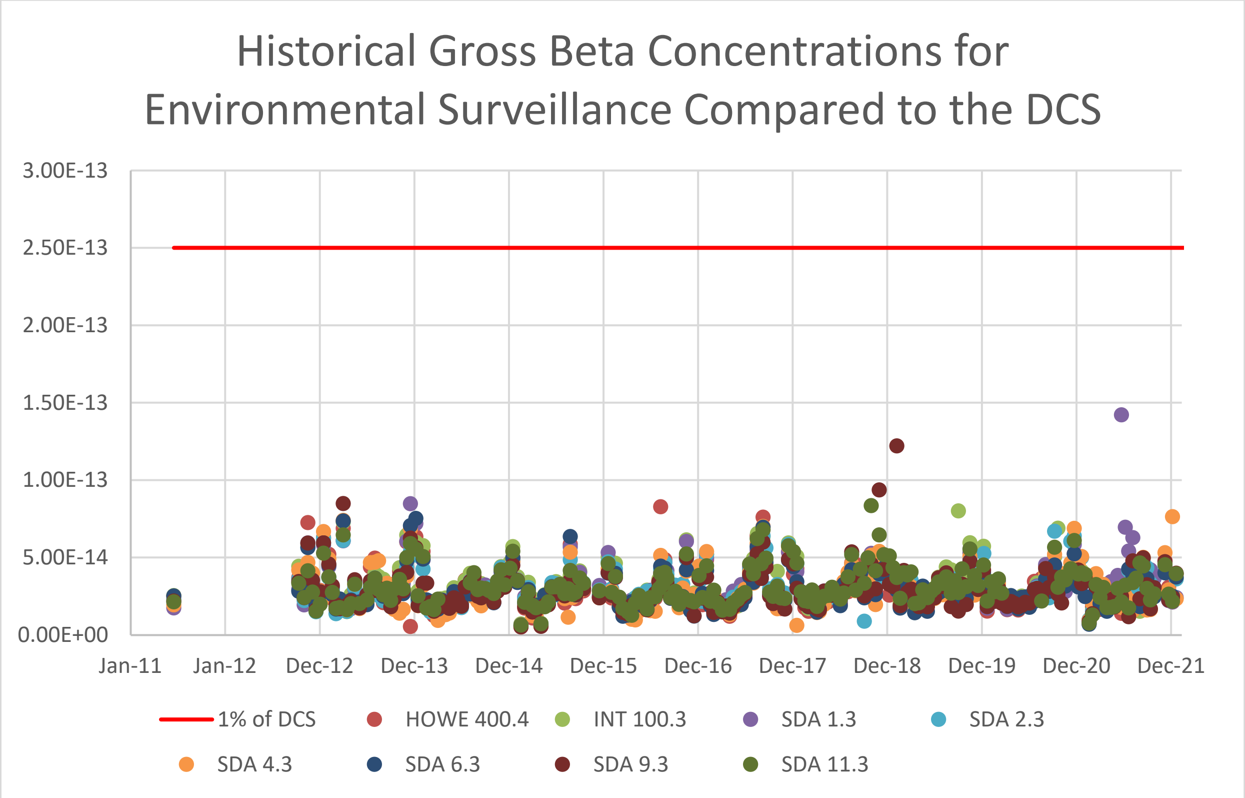


Figure 4-7. Gross alpha (top) and gross beta (bottom) results from waste management site air samples compared to their respective derived concentration standards.

Table 4-11. Human-made radionuclides detected in air samples collected at waste management sites in 2021.[a]

RADIONUCLIDE	LOCATION	RESULT (µCi/mL)	UNCERTAINTY (1 SIGMA)	PERIOD DETECTED
Americium-241	HOWE 400.4	4.91E-17	5.57E-18	09/13/2021 - 09/27/2021[b]
	INT 100.3	4.01E-18	9.09E-19	06/07/2021 - 06/21/2021[b]
	SDA 1.3	2.91E-18	8.93E-19	06/07/2021 - 06/21/2021[b]
	SDA 2.3	4.31E-18	9.63E-19	06/07/2021 - 06/21/2021[b]
	SDA 2.3	2.17E-17	3.01E-18	09/13/2021 - 09/27/2021[b]
	SDA 2.3	1.94E-17	2.8E-18	09/27/2021 - 12/20/2021
	SDA 4.3B	6.29E-17	5.67E-18	01/05/2021 - 03/30/2021
	SDA 4.3B	2.07E-17	2.37E-18	06/07/2021 - 06/21/2021[b]
	SDA 4.3B	1.95E-17	2.8E-18	09/13/2021 - 09/27/2021[b]
	SDA 4.3B	4.31E-17	5.59E-18	09/27/2021 - 12/20/2021
	SDA 6.3	2.88E-18	7.42E-19	01/05/2021 - 03/30/2021
	SDA 6.3	2.13E-18	6.31E-19	06/07/2021 - 06/21/2021[b]
	SDA 9.3	2.15E-18	6.32E-19	06/07/2021 - 06/21/2021[b]
	SDA 9.3	5.66E-18	1.87E-18	09/13/2021 - 09/27/2021[b]
Plutonium-239/240	SDA 1.3	1.13E-18	3.52E-19	09/27/2021 - 12/20/2021
	SDA 2.3	6.55E-18	1.18E-18	09/27/2021 - 12/20/2021
	SDA 4.3B	1.46E-17	2.39E-18	01/05/2021 - 03/30/2021
	SDA 4.3B	5.35E-18	1.17E-18	09/13/2021 - 09/27/2021[b]
	SDA 4.3B[c]	2.91E-17	3.37E-18	09/27/2021 - 12/20/2021
	SDA 9.3	5.06E-18	1.11E-18	09/13/2021 - 09/27/2021[b]
	SDA 9.3	6.53E-18	1.1E-18	09/27/2021 - 12/20/2021
	SDA 11.3	2.45E-18	6.97E-19	01/05/2021 - 03/30/2021
	SDA 11.3	2.34E-18	7.66E-19	09/13/2021 - 09/27/2021[b]

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

b. Samples collected in calendar year quarters 2 through 4 were not composited by the laboratory as agreed upon in the task order statement of work. Laboratory staff were not aware of the need to composite the samples due to problems associated with employee turnover.

c. Results for SDA 4.2B, a replicate of SDA 4.3B, do not appear in the table.

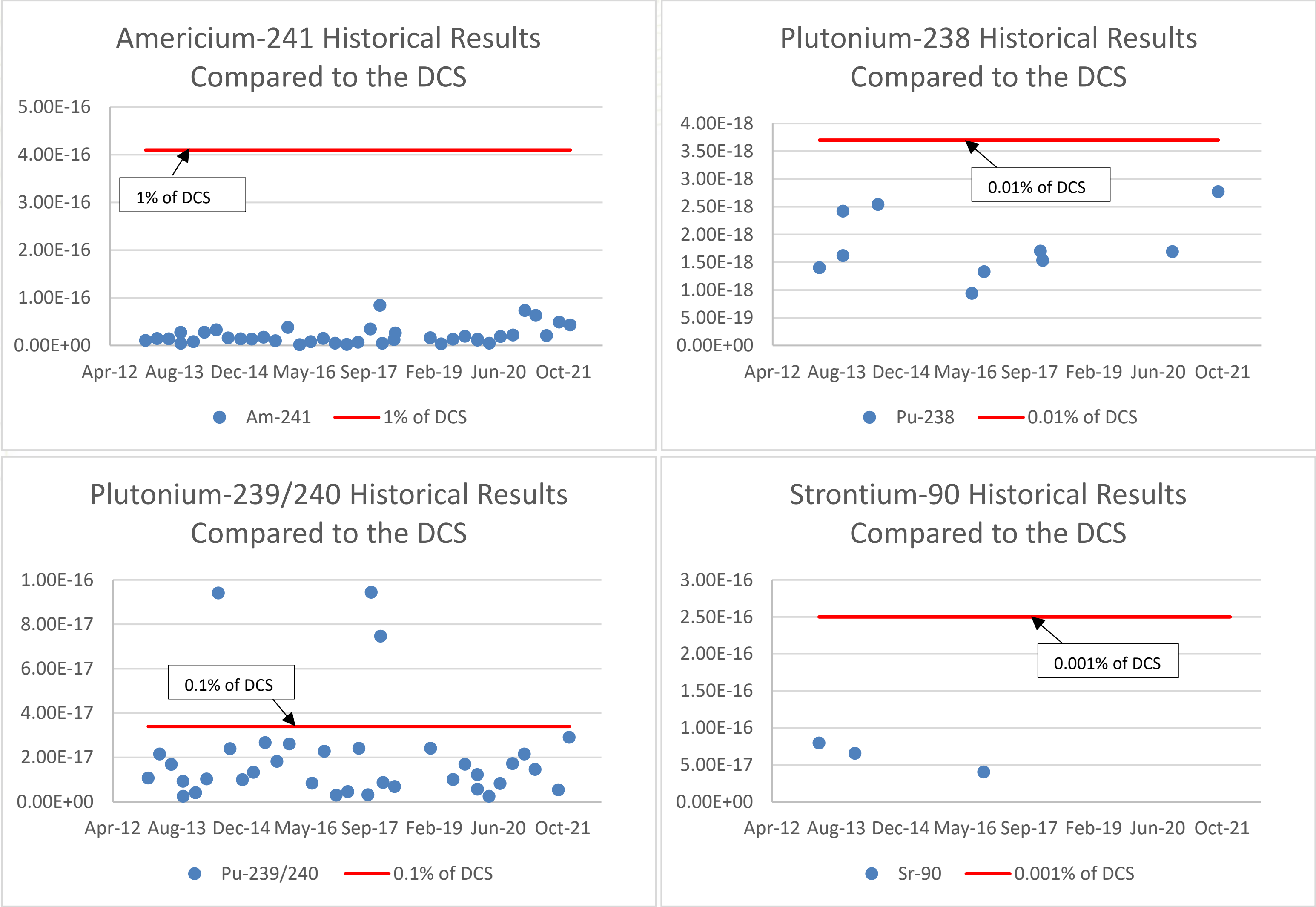


Figure 4-8. Specific human-made radionuclide detections (µCi/mL) from waste management air samples compared to various fractions of their respective derived concentration standards.

4.5 References

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Chapter 5: Environmental Monitoring Programs - Liquid Effluents Monitoring

CHAPTER 5 HIGHLIGHTS

Wastewater discharged to land surfaces and infiltration basins (percolation ponds) at the Idaho National Laboratory Site is regulated by the state of Idaho groundwater quality and recycled water rules and requires a reuse permit. Liquid effluents and surface water runoff were monitored in 2021 by the Idaho National Laboratory contractor and the Idaho Cleanup Project Core contractor for compliance with permit requirements and applicable DOE Orders established to protect human health and the environment.

During 2021, permitted reuse facilities were: Advanced Test Reactor Complex Cold Waste Ponds; Idaho Nuclear Technology and Engineering Center New Percolation Ponds and Sewage Treatment Plant; and Materials and Fuels Complex Industrial Waste Pond. Liquid effluent and groundwater at these facilities were sampled for parameters required by their facility-specific permits. No permit limits were exceeded in 2021.

Additional liquid effluent and groundwater monitoring was performed in 2021 at Advanced Test Reactor, Idaho Nuclear Technology and Engineering Center, and Materials and Fuels Complex to comply with environmental protection objectives of the U.S. Department of Energy. All parameters were below applicable health-based standards in 2021.

Surface water that runs off the Subsurface Disposal Area at the Radioactive Waste Management Complex during periods of rapid snowmelt or heavy precipitation is sampled and analyzed for radionuclides. Additionally, water sheet flows across asphalt surfaces and infiltrates around/under door seals at Waste Management Facility-636 at the Advanced Mixed Waste Treatment Project and collects in catch tanks. Specific human-made gamma-emitting radionuclides were not detected. Detected concentrations of americium-241, plutonium-239/240, and uranium isotopes did not exceed U.S. Department of Energy Derived Concentration Standards.

5. ENVIRONMENTAL MONITORING PROGRAMS: LIQUID EFFLUENTS MONITORING

Some Idaho National Laboratory (INL) Site operations retain wastewater in lined, total containment evaporative ponds constructed to eliminate liquid effluent discharges to the environment. Other INL Site operations discharge liquid effluents that may potentially contain nonhazardous levels of radioactive, or nonradioactive, contaminants to unlined infiltration basins or ponds. Effluent discharges are subject to specified discharge limits, permit limits, or maximum contaminant levels. INL and Idaho Cleanup Project (ICP) Core personnel conduct liquid effluent monitoring through liquid effluent and surface water runoff sampling and surveillance programs to ensure compliance with applicable permits, limits, and maximum contaminant levels. These programs also sample groundwater related to liquid effluent.

Table 5-1 presents the requirements for liquid effluent monitoring performed at the INL Site. A comprehensive discussion and maps of environmental monitoring, including liquid effluent monitoring and surveillance programs performed by various organizations within and around the INL Site can be found in the Idaho National Laboratory Site Environmental Monitoring Plan (DOE-ID 2021). To improve the readability of this chapter, data tables are only included when monitoring results exceed specified discharge limits, permit limits, or maximum contaminant levels. Data tables for other monitoring results are provided in Appendix B.

Table 5-1. Liquid effluent monitoring at the INL Site.

MONITORING REQUIREMENTS			
AREA/FACILITY	IDAHO REUSE PERMIT[a]	DOE O 458.1[b] LIQUID EFFLUENT MONITORING	DOE O 435.1[c] SURFACE RUNOFF SURVEILLANCE
INL CONTRACTOR			
ATR[d] Complex Cold Waste Ponds	●	●	
MFC[d] Industrial Waste Pond	●	●	
ICP CORE CONTRACTOR			
INTEC[d] New Percolation Ponds and Sewage Treatment Plant	●	●	
RWMC[d] SDA surface water runoff		●	●

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

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

c. The objective of DOE O 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 O 458.1. DOE Handbook DOE HDBK 1216 2015 suggests that potential impacts of storm-water runoff as a pathway to humans or biota should be evaluated.

d. Advanced Test Reactor – ATR; Materials and Fuels Complex – MFC; Idaho Nuclear Technology and Engineering Center – INTEC; and Radioactive Waste Management Complex – RWMC.

5.1 Liquid Effluent and Related Groundwater Compliance Monitoring

Discharge of liquid effluent to the land surface for treatment or disposal is known as 'Reuse' in the state of Idaho and is regulated by the Recycled Water Rules (IDAPA 58.01.17), Wastewater Rules (IDAPA 58.01.16), and Ground Water Quality Rule (IDAPA 58.01.11) promulgated according to the Idaho Administrative Procedures Act. The Idaho Department of Environmental Quality (DEQ) issues reuse permits for operation of the reuse systems. Reuse permits may require monitoring of nonradioactive constituents in the effluent, and groundwater in accordance with the monitoring requirements specified within each permit. Some facilities may have specified radiological constituents monitored for surveillance purposes (not required by regulations). The permits may specify annual discharge volumes, application rates, and effluent quality limits. Annual reports (ICP 2022a and 2022b; INL 2022a, 2022b, 2022c, and 2022d) were prepared and submitted to the DEQ.

During 2021, the INL and ICP Core contractors monitored, as required by the permits, the following reuse facilities shown in Table 5-2:

- ATR Complex Cold Waste Ponds (Section 5.1.1)
- INTEC New Percolation Ponds and Sewage Treatment Plant (STP) (Section 5.1.2)
- MFC Industrial Waste Pond (Section 5.1.3).

Table 5-2. 2021 status of reuse permits.

FACILITY	PERMIT STATUS AT END OF 2021	EXPLANATION
ATR Complex Cold Waste Ponds	Permit Issued	DEQ issued Reuse Permit I-161-03 October 30, 2019. The permit expires on October 29, 2029.
INTEC New Percolation Ponds	Permit Issued	DEQ issued Permit M-130-06 on June 1, 2017. The permit expires on June 1, 2024.
MFC Industrial Waste Pond	Permit Issued	DEQ issued Reuse Permit I-160-02 on January 26, 2017, with minor modifications issued March 7, 2017; May 8, 2019; and May 21, 2020.[a] The permit expires on January 25, 2027.

a. MFC Minor Modification 3, issued May 21, 2020, removed the Industrial Waste Ditch as a permit Management Unit resulting in changes to monitoring and reporting requirements. DEQ re-issued Modification 3 on September 15, 2020, to correct administrative matters.

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

5.1.1 Advanced Test Reactor Complex Cold Waste Ponds

Description. The Cold Waste Ponds (CWPs) are located approximately 137 m (450 ft) from the southeast corner of the ATR Complex compound and approximately 1.2 km (0.75 mi) northwest of the Big Lost River channel as shown in Figure 5-1. The CWPs were excavated in 1982 and consist of two unlined cells, each with dimensions of 55 × 131 m (180 × 430 ft) across the top of the berms and a depth of 3 m (10 ft). Total surface area for the two cells at the top of the berms is approximately 1.44 ha (3.55 acres). Maximum capacity is approximately 38.69 ML (10.22 MG).

The CWPs function as percolation basins for the infiltration of nonhazardous industrial liquid effluent consisting primarily of noncontact cooling tower blowdown, once-through cooling water for air conditioning units, coolant water from air compressors, and wastewater from secondary system drains and other nonradioactive drains throughout the ATR Complex. Chemicals used in the cooling tower and other effluent streams discharged to the CWP include commercial biocides and corrosion inhibitors. The Cold Waste effluent reports through collection piping to a monitoring location where flow rates to the CWP are measured using a v-notch weir and effluent samples are collected using an automated composite sampler.

Effluent Monitoring Results for the Reuse Permit. Reuse Permit I-161-03 requires monthly sampling of the effluent to the CWP (DEQ 2019). The 2021 permit reporting year monitoring results are presented in the 2021 annual reuse report (INL, 2022c) and the 2021 calendar year monitoring results are summarized in Table B-1. The total dissolved solids concentrations ranged from 203 to 1,180 mg/L. Sulfate ranged from 20.1 mg/L to 634 mg/L. 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. Due to the composition and characteristics of the effluent, the Reuse permit does not require pre-treatment or specify maximum constituent loading limits or concentration limits for the cold waste effluent discharged to the CWP. The 2021 constituent concentrations continue to remain consistent with historical results.

The permit specifies maximum annual and five-year moving average hydraulic loading rate limits of 300 MG/yr and 375 MG/yr, respectively, based on the annual reporting year of the permits. As shown in Table B-2, the 2021 annual reporting-year flow of 235.32 MG did not exceed either of these hydraulic loading limits.

Groundwater Monitoring Results for the Reuse Permit. The permit requires groundwater monitoring twice annually in April/May and September/October, at seven groundwater wells observed in Figure 5-1 to measure potential impacts from the CWP. In 2021, none of the constituents exceeded their respective primary or secondary constituent standards and are presented in Table B-3a and Table B-3b. The metals concentrations continue to remain at low levels and are consistent with historical ranges.

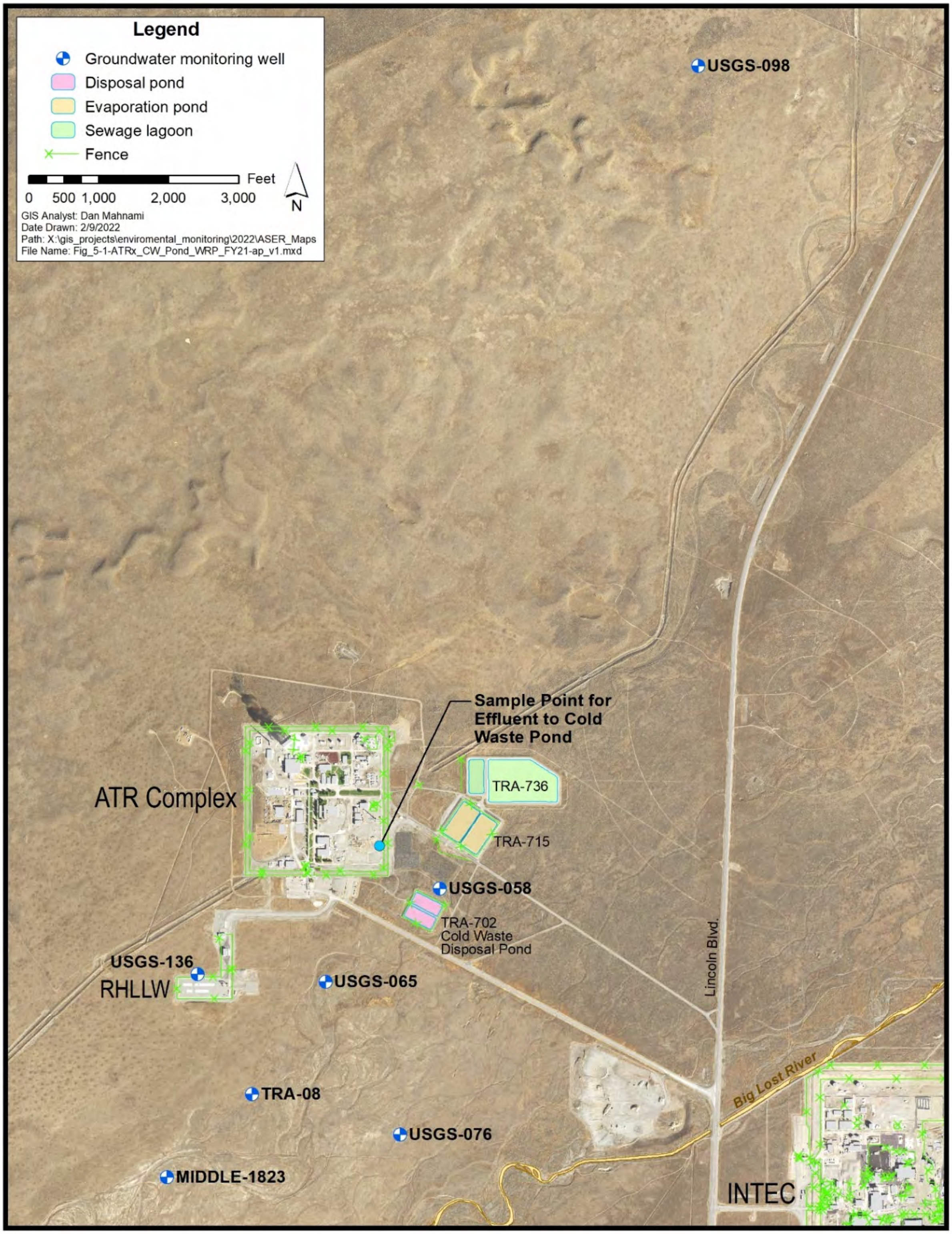

Figure 5-1. Permit monitoring locations for the ATR Complex Cold Waste Pond.

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

Description. The INTEC New Percolation Ponds are composed of two rapid infiltration ponds excavated into the surficial alluvium and surrounded by bermed alluvial material observed in Figure 5-2. The rapid infiltration system uses the soil ecosystem to treat wastewater. Each pond is 93 m x 93 m (305 ft x 305 ft) at the top of the berm and approximately 3 m (10 ft) deep. Each pond is designed to accommodate a continuous wastewater discharge rate of 11.36 ML (3 MG) per day.

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

The STP is located east of INTEC, outside the INTEC security fence, and treats and disposes of sewage, septage, and other nonhazardous industrial wastewater at INTEC. The sanitary waste is treated by natural biological and physical processes (e.g., digestion, oxidation, photosynthesis, respiration, aeration, and evaporation) in four lagoons. 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 were permitted by DEQ to operate as a reuse facility under Reuse Permit M-130-06 (DEQ 2017).

Wastewater Monitoring Results for the Reuse Permit. Monthly samples were collected from CPP-769 (influent to STP), CPP-773 (effluent from STP), and CPP-797 (effluent to the INTEC New Percolation Ponds) as seen in Figure 5-3. As required by the permit, all samples are collected as 24-hour composites, except pH, fecal coliform, and total coliform, which are collected as grab samples. The permit specifies the constituents that must be monitored at each location. The permit does not specify any wastewater discharge limits at these three locations. The 2021 reporting year monitoring results for CPP-769, CPP-773, and CPP-797 are provided in the 2021 Wastewater Reuse Report (ICP 2022a), and the 2021 calendar year monitoring results are summarized in Tables B-4, B-5, and B-6.

The permit specifies maximum daily and yearly hydraulic loading rates for the INTEC New Percolation Ponds. As shown in Table B-7, the maximum daily flow and yearly total flow to the INTEC New Percolation Ponds were below the permit limits in 2021.

Groundwater Monitoring Results for the 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 5-2.

The permit requires that groundwater samples be collected semiannually during April/May and September/October and lists which constituents must be analyzed. Contaminant concentrations in the monitoring wells are limited by primary constituent standards and secondary constituent standards specified in IDAPA 58.01.11, "Ground Water Quality Rules."

Table B-8 shows the 2021 water table elevations and depth to water table, determined prior to purging and sampling, and the analytical results for all constituents specified by the permit for the aquifer wells. Table B-9 presents similar information for the perched water wells.

Tables B-8 and B-9 show all permit-required constituents associated with the aquifer monitoring wells were below their respective primary constituent standards and secondary constituent standards in 2021. The pH values in perched water well ICPP-MON-V-212 were elevated in both May and September. The pH values associated with this well are consistently higher in the spring versus the fall, indicative of surface water recharge. Historically, each rechange of this perched water well results in decreasing pH values. Purge times are being evaluated to ensure that pH values have stabilized prior to sampling.

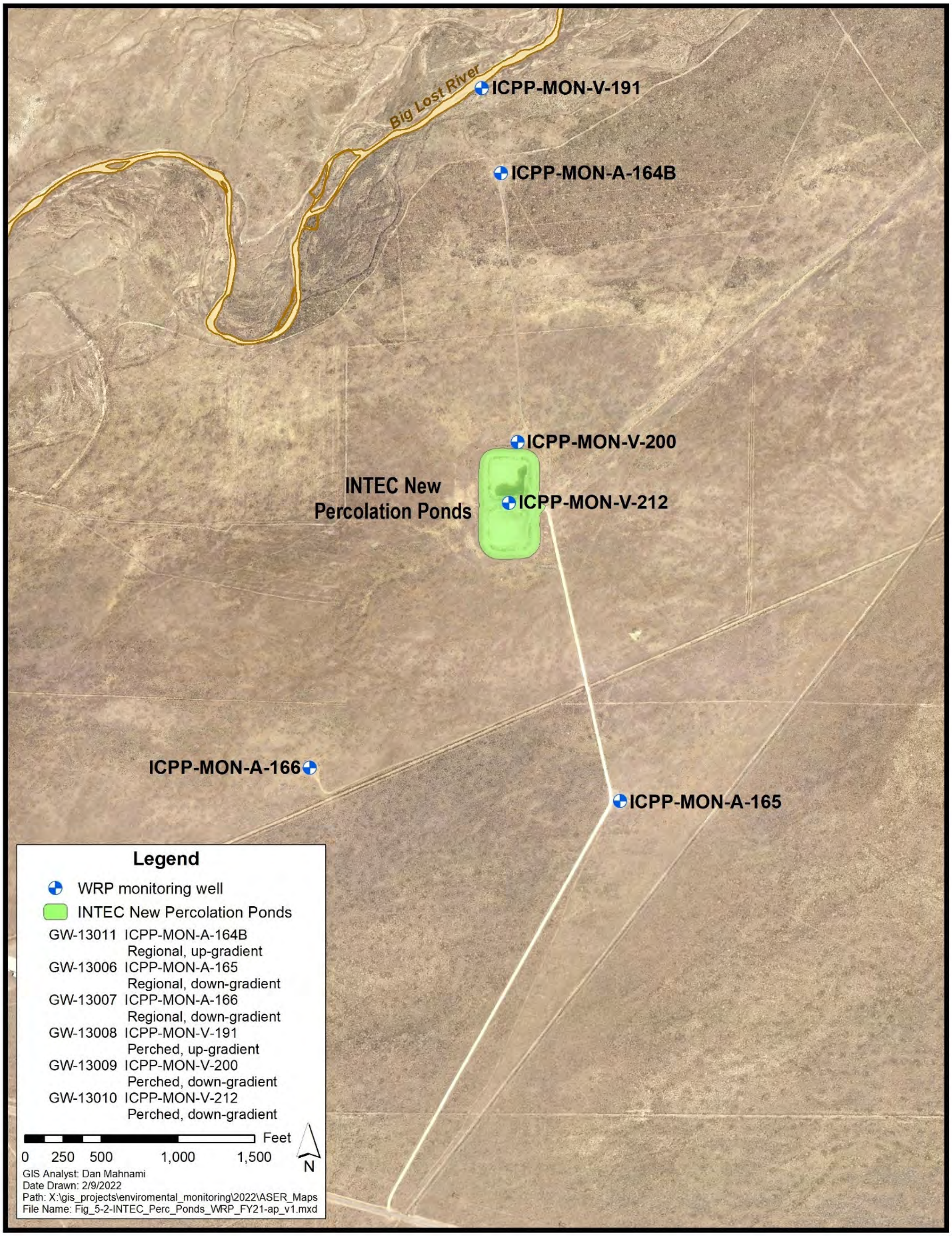

Figure 5-2. Reuse permit groundwater monitoring locations for INTEC New Percolation Ponds.

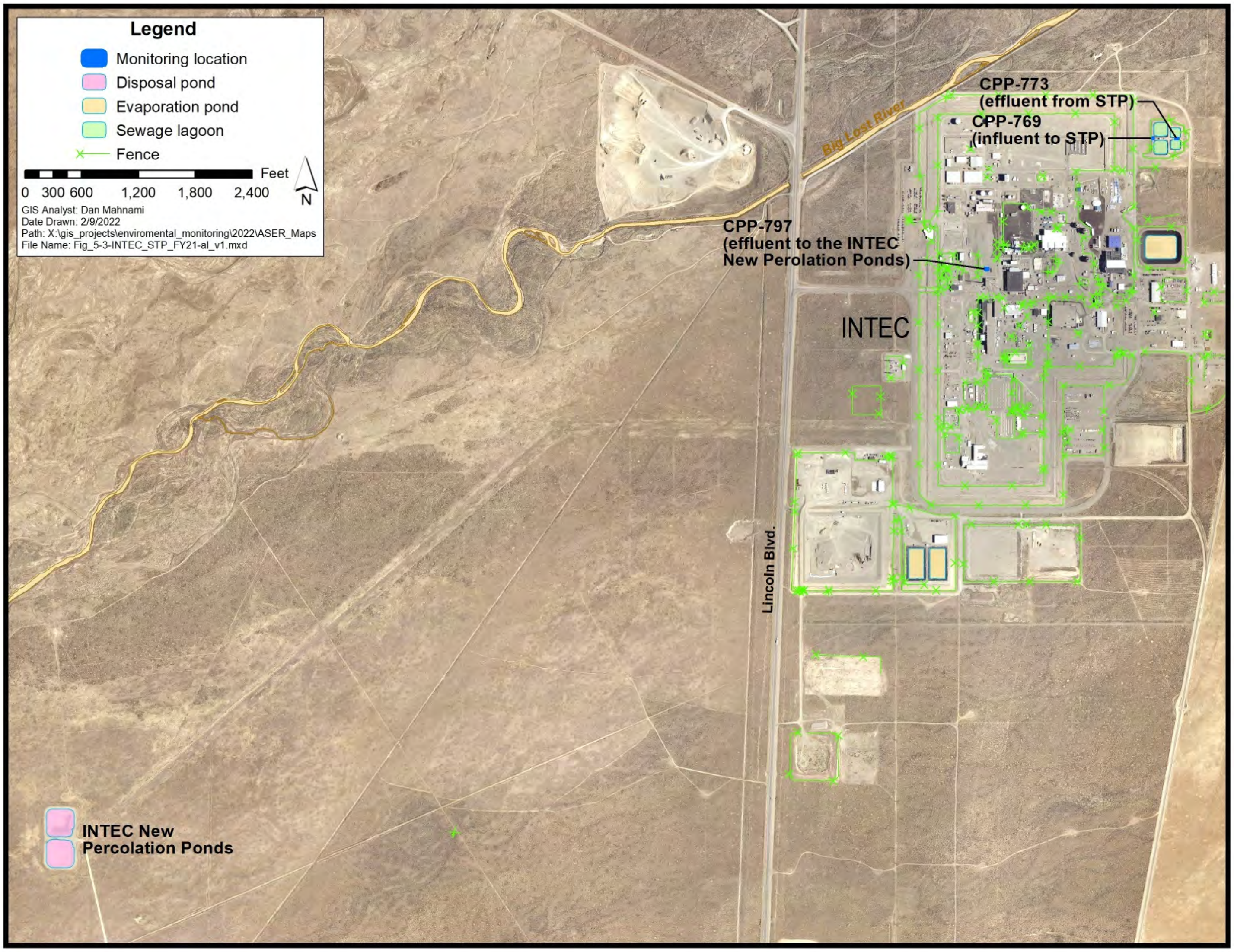

Figure 5-3. INTEC wastewater monitoring for reuse permit.

5.1.3 Materials and Fuels Complex Industrial Waste Pond

Description. The MFC Industrial Waste Pond is an unlined basin that was first excavated in 1959 and has a design capacity of 1,078.84 ML (285 MG) at a maximum water depth of 3.96 m (13 ft) identified in Figure 5-4. In previous years the pond received industrial wastewater from the storm water runoff from the nearby areas, and industrial wastewater from the Industrial Waste Ditch (IWD) (Ditch C).

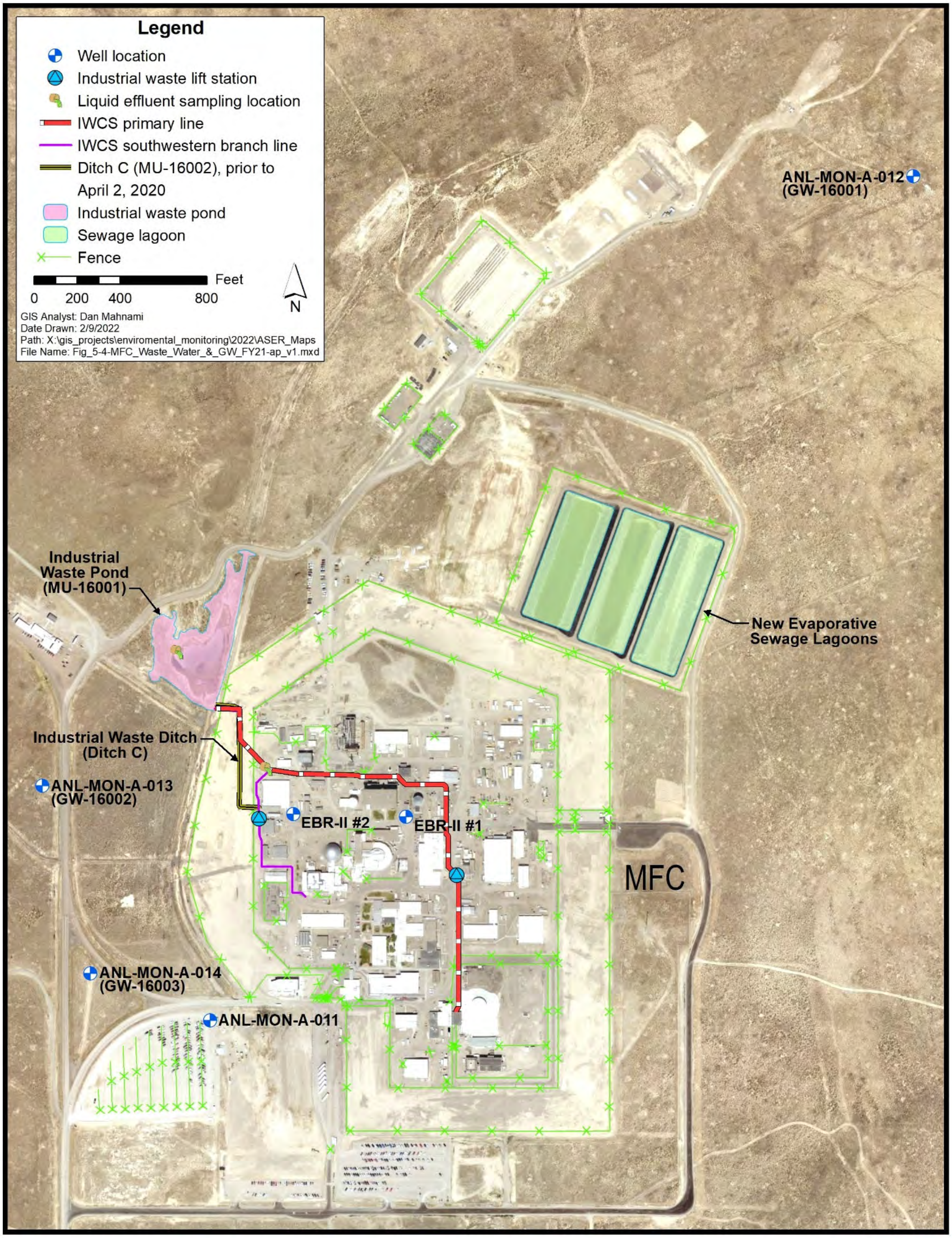

Figure 5-4. Wastewater and groundwater sampling locations MFC.

As part of the MFC Utility Corridor Upgrade Project completed in 2020, industrial wastewater discharges into the IWD (Ditch C) were eliminated. The Ditch C industrial wastewater is now collected in a new lift station and rerouted into the primary industrial waste pipeline via a new connecting pipeline. Reuse Permit I-160-02 Modification 3 issued May 21, 2020 (DEQ 2020) removed the IWD (Ditch C) Management Unit and associated monitoring from the permit as a result of permanently joining the industrial wastewater collection system pipelines together, upstream of the existing flow monitoring and sampling station, prior to discharging the combined effluent into the Industrial Waste Pond.

Now that the two MFC industrial wastewater collection system pipelines are joined together and have one flow/sample monitoring location, the system has been given more descriptive, common names. The combination of industrial wastewater pipelines/branches, lift stations, flow meter, sampling station, and associated components are now designated as the Industrial Wastewater Collection System, or IWCS. The pipeline previously known as the Industrial Waste Pipeline that captures the majority of industrial wastewater and eventually discharges into the pond is referred to as the IWCS Primary Line (PL) since it is the pipeline that collects wastewater from all sources and on which the flow meter and sampling station are located. The pipeline that collected small amounts of industrial wastewater that previously discharged into the Industrial Waste Ditch (Ditch C), but now discharges into the PL upstream of the existing sampling station via the new lift station and connecting pipeline, is referred to as the IWCS Southwestern Branch Line (SBL).

The Industrial Waste Pond functions as a percolation basin for the infiltration of nonhazardous industrial effluent. Industrial wastewater discharged to the pond via the IWCS PL consists primarily of noncontact cooling water, boiler blowdown, cooling tower blowdown and drain, air wash flows, and steam condensate. A small amount of wastewater collected within the IWCS SBL (that now discharges into the PL via a new lift station) consists of intermittent reverse osmosis effluent and laboratory sink discharge from the MFC-768 Power Plant.

Wastewater Monitoring Results for the Reuse Permit. Reuse Permit I-160-02 modification 3 requires monthly sampling of effluent discharging from the IWCS Primary Line into the Industrial Waste Pond. The 2021, permit reporting year monitoring results are presented in the 2021 annual reuse report (INL 2022d) and the calendar year results are summarized in Table B-10. Based on the composition of the industrial effluent, the reuse permit does not require pre-treatment or specify maximum constituent loading limits or concentration limits. In 2021 concentrations of iron and manganese continued to be at or near the laboratory instruments' minimum detection levels. Total Dissolved Solids ranged from 213 to 610 mg/L. The 2021 constituent concentrations continue to be within historical ranges.

The permit specifies an annual reporting year hydraulic loading limit of 17 MG/yr. As shown in Table B-11, the 2021 reporting year flow of 7.366 MG/yr was well below the permit limit.

Groundwater Monitoring Results for the Reuse Permit. The reuse permit requires groundwater monitoring twice annually, in April/May and September/October, at one upgradient well and two downgradient wells (Figure 5-4) to measure potential impacts from the pond. The analytical results are summarized in Table B-12. In 2021 none of the constituents exceeded their respective primary or secondary constituent standards, and the analyte concentrations in the downgradient wells remained consistent with background levels in the upgradient well.

5.2 Liquid Effluent Surveillance Monitoring

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

5.2.1 Advanced Test Reactor Complex

The effluent to the CWP receives a combination of process water from various ATR Complex facilities. Table B-13 lists wastewater surveillance monitoring results for those constituents with at least one detected result. Groundwater radionuclide surveillance monitoring results are summarized in Table B-14. All detected constituents including strontium-90, tritium, gross alpha, and gross beta were below the Idaho groundwater primary constituent standards, IDAPA 58.01.11.

5.2.2 Idaho Nuclear Technology and Engineering Center

In addition to the permit-required monitoring summarized in Section 5.1.3, surveillance monitoring was conducted at CPP-797 (effluent to the INTEC New Percolation Ponds) and the groundwater at the INTEC New Percolation Ponds. Table B-15 summarizes the results of radiological monitoring at CPP-797, while Table B-16 summarizes the results of radiological monitoring at groundwater Wells ICPP-MON-A-165, ICPP-MON-A-166, ICPP-MON-V-200, and ICPP-MON-V-212.

Twenty-four-hour flow proportional samples were collected from the CPP-797 wastewater effluent and composited daily into a monthly sample. Each collected monthly composite sample was analyzed for specific gamma-emitting radionuclides, gross alpha, gross beta, and total strontium activity. Potassium-40 (at a concentration of 84.6 ± 39.0 pCi/L in the March sample) was the only gamma emitting radionuclide detected in any of the twelve samples collected at CPP-797 during the 2021 reporting year. As shown in Table B-15, no total strontium activity was detected in any of the samples collected at CPP-797 in 2021. Gross alpha was not detected , while gross beta was detected in 11 of the 12 samples collected in 2021.

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 May 2021 and September 2021 and analyzed for gross alpha and gross beta. As shown in Table B-16, gross alpha was detected in three of the four monitoring wells in September 2021. Gross beta was detected in three of the monitoring wells in May 2021 and four of the monitoring wells in September 2021. All detected constituents including strontium-90, tritium, gross alpha, and gross beta were below the Idaho groundwater primary constituent standards, IDAPA 58.01.11.

5.2.3 Materials and Fuels Complex

The Industrial Waste Pond is sampled quarterly and analyzed for gross alpha, gross beta, gamma spectroscopy, and tritium as shown in Figure 5-4. Annual samples are collected and analyzed for selected isotopes of americium, strontium, plutonium, and uranium. Gross alpha, gross beta, and uranium isotopes were detected in 2021 as summarized in Table B-17, and are below applicable Derived Concentration Standards found in Table A-2.

Additionally, five ground water monitoring wells are sampled twice per year for select radionuclides, metals, anion, cations, and other water quality parameters as surveillance monitoring under the WAG 9 Record of Decision. The 2021 groundwater surveillance monitoring results are discussed in Chapter 6, Section 6.5.6 and summarized in Table 6-11. Overall, all detected results were below the Idaho groundwater primary constituent standards, IDAPA 58.01.11, and show no discernable impacts from activities at the MFC.

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.

Additionally, water sheet flows across asphalt surfaces and infiltrates around/under door seals at Waste Management Facility (WMF)-636 at the Advanced Mixed Waste Treatment Project. The resulting surface water inflow accumulates in the WMF-636 Fire Water Catch Tanks (Tanks A, B, C, and D). If the level of surface water in the Fire Water Catch Tanks reaches a predetermined level, the water is pumped into aboveground holding tanks, where it can be sampled, prior to discharge into the drainage canal surrounding the SDA.

In compliance with DOE O 435.1, the ICP Core collects surface water runoff samples at the RWMC SDA from the location shown in Figure 5-5. The WMF-636 Fire Water Catch Tanks are also shown in Figure 5-5. Surface water is collected to determine if radionuclide concentrations exceed administrative control levels or if concentrations have increased significantly, as compared to historical data. A field blank is also collected for comparison. Samples from the WMF-636 Fire Water Catch Tanks were not collected during 2021 as periodic measurements of tank levels did not indicate pumping to be necessary.

Two samples were collected from the SDA Lift Station in 2021. These samples were analyzed for a suite of radionuclides that includes americium-241 and strontium-90, as well as plutonium and uranium isotopes. There were positive detections (3σ) of americium-241, plutonium-238, and plutonium-239/240 in multiple samples taken in 2021. The maximum concentration detected for americium-241 was 1.73 (±0.014) pCi/L, which is well below the 170 pCi/L Derived Concentration Standard for americium-241. The maximum concentration detected for plutonium-238 was 0.05 (±0.01) pCi/L. Finally, the maximum concentration detected for plutonium-239/240 was 2.41 (±0.23) pCi/L, which is also well below the applicable Derived Concentration Standard (140 pCi/L). In addition to these nuclides, uranium isotopes were detected at levels consistent with historical results, which are below any applicable Derived Concentration Standard.

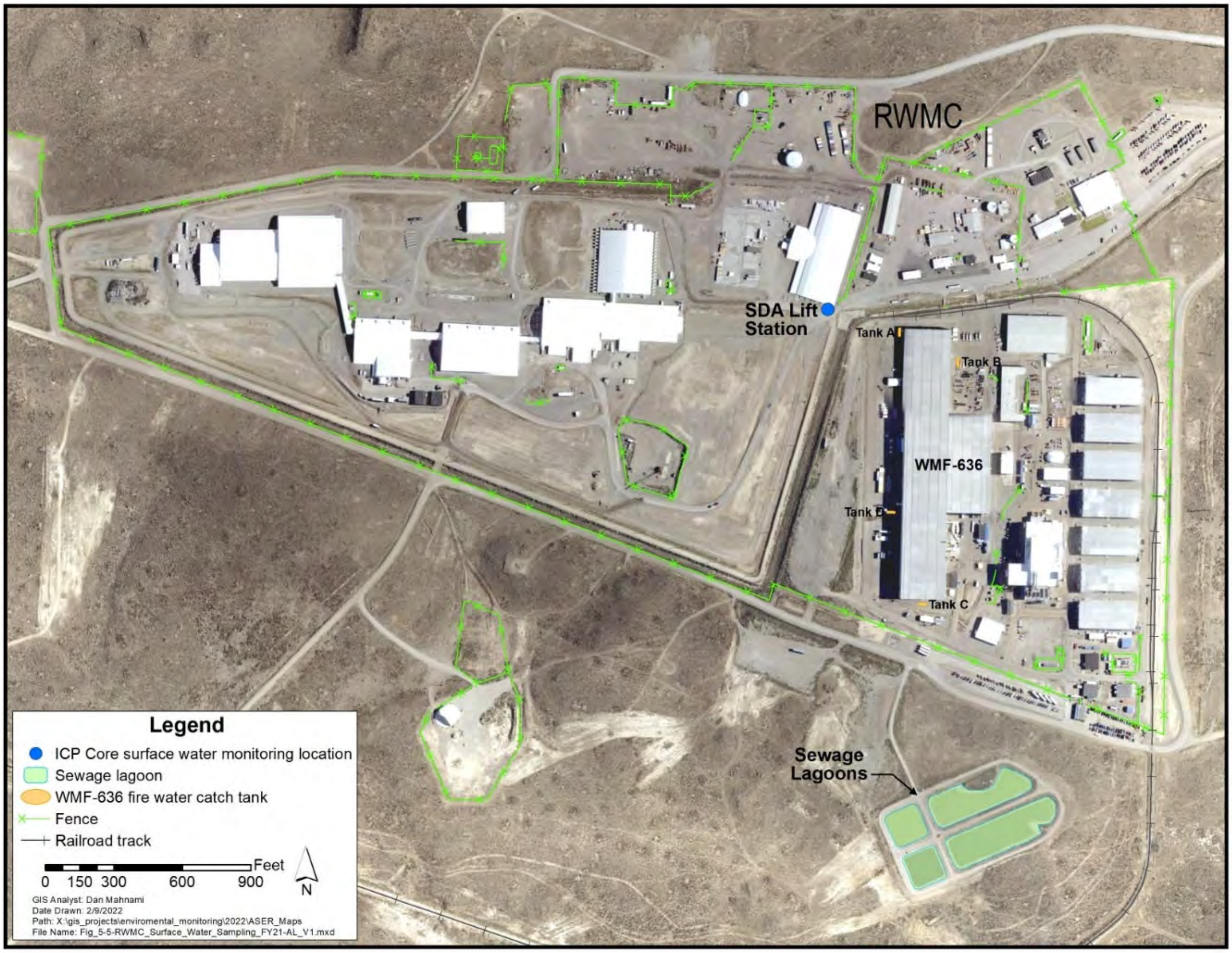

Figure 5-5. Surface water sampling location at the RWMC SDA.

Table 5-3 summarizes the specific alpha and beta results of human-made radionuclides. No human-made gamma-emitting radionuclides were detected. ICP Core will sample from the SDA Lift Station twice during 2022, when water is available, and evaluate the results to identify any potential abnormal trends or results that would warrant further investigation. ICP Core will also continue to collect samples as necessary for the discharge of accumulated water run-in contained in the WMF-636 Fire Water Catch Tanks.

Table 5-3. Radionuclides detected in surface water runoff at the RWMC SDA (2021).

LOCATION	PARAMETER	MAXIMUM CONCENTRATION[a] (pCi/L)	% DERIVED CONCENTRATION STANDARD[b]
SDA Lift Station	Americium-241	1.73 ± 0.00	1.02
	Plutonium-238	0.05 ± 0.00	0.03
	Plutonium-239/240	2.41 ± 0.23	1.72
	Uranium-234	1.29 ± 0.10	0.19
	Uranium-235	0.06 ± 0.01	0.01
	Uranium-238	1.17 ± 0.05	0.16

a. Result ±1s. Results shown are >3s.

b. See DOE-STD-1196-2011, Table A-2 (DOE 2011).

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Indian Ricegrass

Chapter 6: Environmental Monitoring Programs - Eastern Snake River Plain Aquifer Monitoring

CHAPTER 6

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 2021, USGS sampled 29 groundwater monitoring wells and one perched water well at the INL Site for analysis of 61 purgeable (volatile) organic compounds. Eleven purgeable organic compounds were detected in at least one well. Most of the detected concentrations were less than the maximum contaminant levels (MCLs) established by the U.S. Environmental Protection Agency (EPA) for public drinking water supplies. One exception was carbon tetrachloride, detected in the production well at the Radioactive Waste Management Complex (RWMC). This compound has shown a decreasing trend since 2005 and is removed from the water prior to human consumption. Trichloroethene was detected above the MCLs at a perched well at the RWMC and a well at Test Area North, where there is a known groundwater plume containing this contaminant being treated.

Groundwater surveillance monitoring required in area-specific Records of Decision under the Comprehensive Environmental Response, Compensation, and Liability Act was performed at Waste Area Groups (WAGs) 1 – 4, WAG 7, and WAG 9 in 2021.

In addition to the Advanced Test Reactor Complex and the Materials and Fuels Complex, the INL contractor also monitors ground water at the Remote-Handled Low-Level Waste Disposal Facility for the surveillance of select radiological analytes. Groundwater samples were collected from three monitoring wells at the Remote-Handled Low-Level Waste Disposal Facility in 2021. The 2021 results show no discernable impacts to the aquifer.

There are 10 drinking water systems on the INL Site monitored by INL and Idaho Cleanup Project Core contractors. All contaminant concentrations measured in drinking water systems in 2021 were below regulatory limits.

Drinking water and springs were sampled 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.

6. ENVIRONMENTAL MONITORING PROGRAMS: EASTERN SNAKE RIVER PLAIN AQUIFER

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

- 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 channel loss and playas on the north end of the INL Site.

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

- State of Idaho groundwater primary and secondary constituent standards (Ground Water Quality Rule, IDAPA 58.01.11)
- U.S. Environmental Protection Agency (EPA) health-based maximum contaminant levels (MCLs) for drinking water (40 Code of Federal Regulations [CFR] 141)
- U.S. Department of Energy Derived Concentration Standards for the ingestion of water (DOE 2011).

6.1 Summary of Monitoring Programs

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

- The United States Geological Survey (USGS) INL Project Office performs groundwater monitoring, analyses, and scientific studies to improve the understanding of the hydrogeological conditions that affect the movement of groundwater and contaminants in the eastern Snake River Plain Aquifer underlying and adjacent to the INL Site. The USGS utilizes an extensive network of strategically placed monitoring wells on the INL Site as shown in Figure 6-2 and at locations throughout the eastern Snake River Plain.

  Table 6-1 summarizes the USGS routine groundwater surveillance program. In 2021, USGS personnel collected and analyzed more than 1,200 samples for radionuclides and inorganic constituents, including trace elements, and 30 samples for purgeable organic compounds. USGS INL Project Office personnel also published four documents and two software packages covering hydrogeologic conditions and monitoring at the INL Site. The abstracts to these reports are presented in Section 6.10.

- The Idaho Cleanup Project (ICP) Core contractor conducts groundwater monitoring at various Waste Area Groups (WAGs) delineated on the INL Site identified in Figure 6-3 for compliance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as well as drinking water monitoring at the Idaho Nuclear Technology and Engineering Center (INTEC) and Radioactive Waste Management Complex (RWMC). In 2021, the ICP Core contractor monitored groundwater at Test Area North (TAN), the Advanced Test Reactor (ATR) Complex, INTEC, Central Facilities Area (CFA), and RWMC (WAGs 1, 2, 3, 4, and 7 respectively). Table 6-2 summarizes the routine monitoring for the ICP Core contractor drinking water program. The ICP Core collected and analyzed 133 drinking water samples for microbiological hazards, radionuclides, inorganic compounds, disinfection byproducts, and volatile organic compounds (VOCs) in 2021.

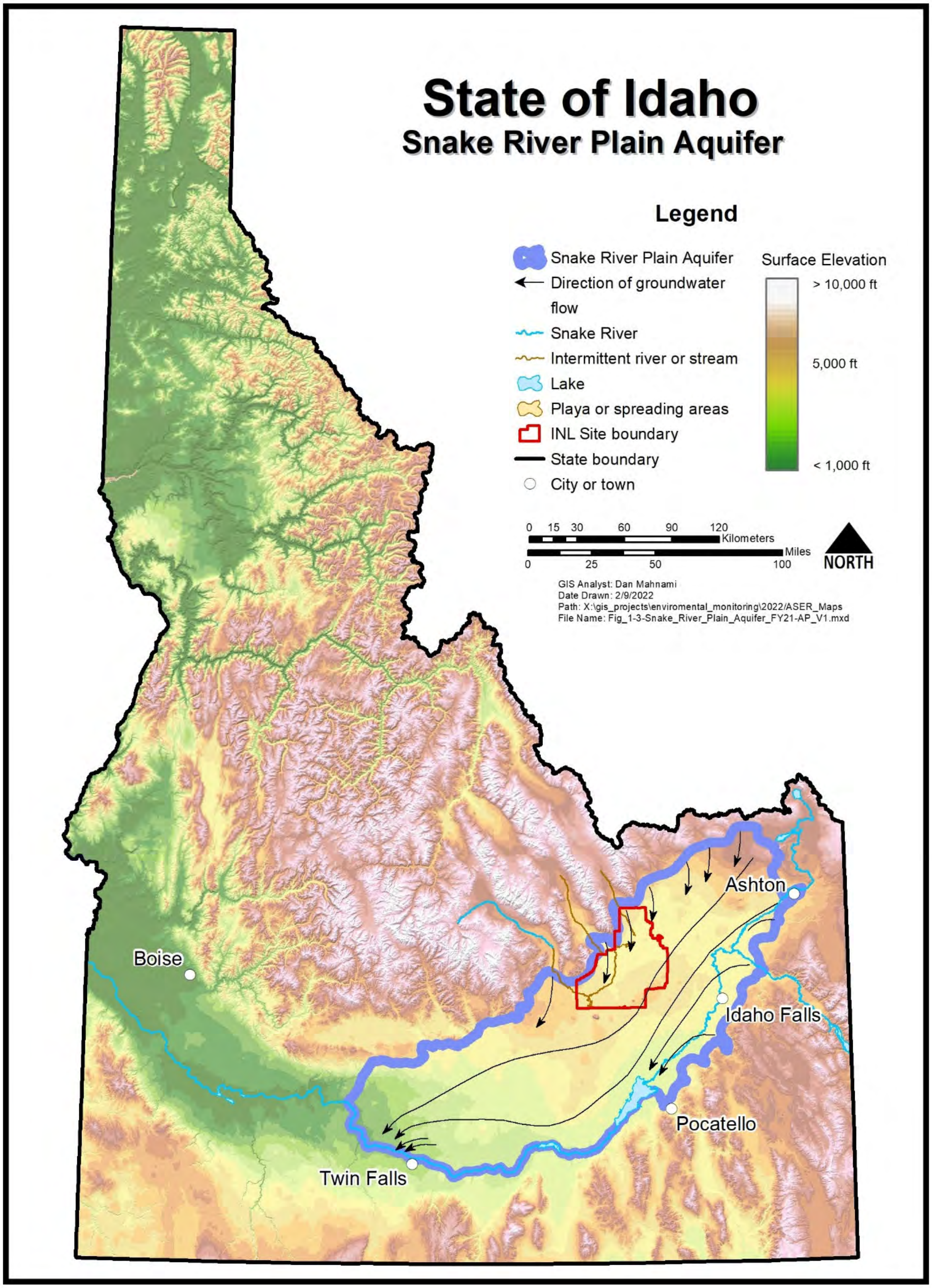

Figure 6-1. The eastern Snake River Plain Aquifer and direction of groundwater flow.

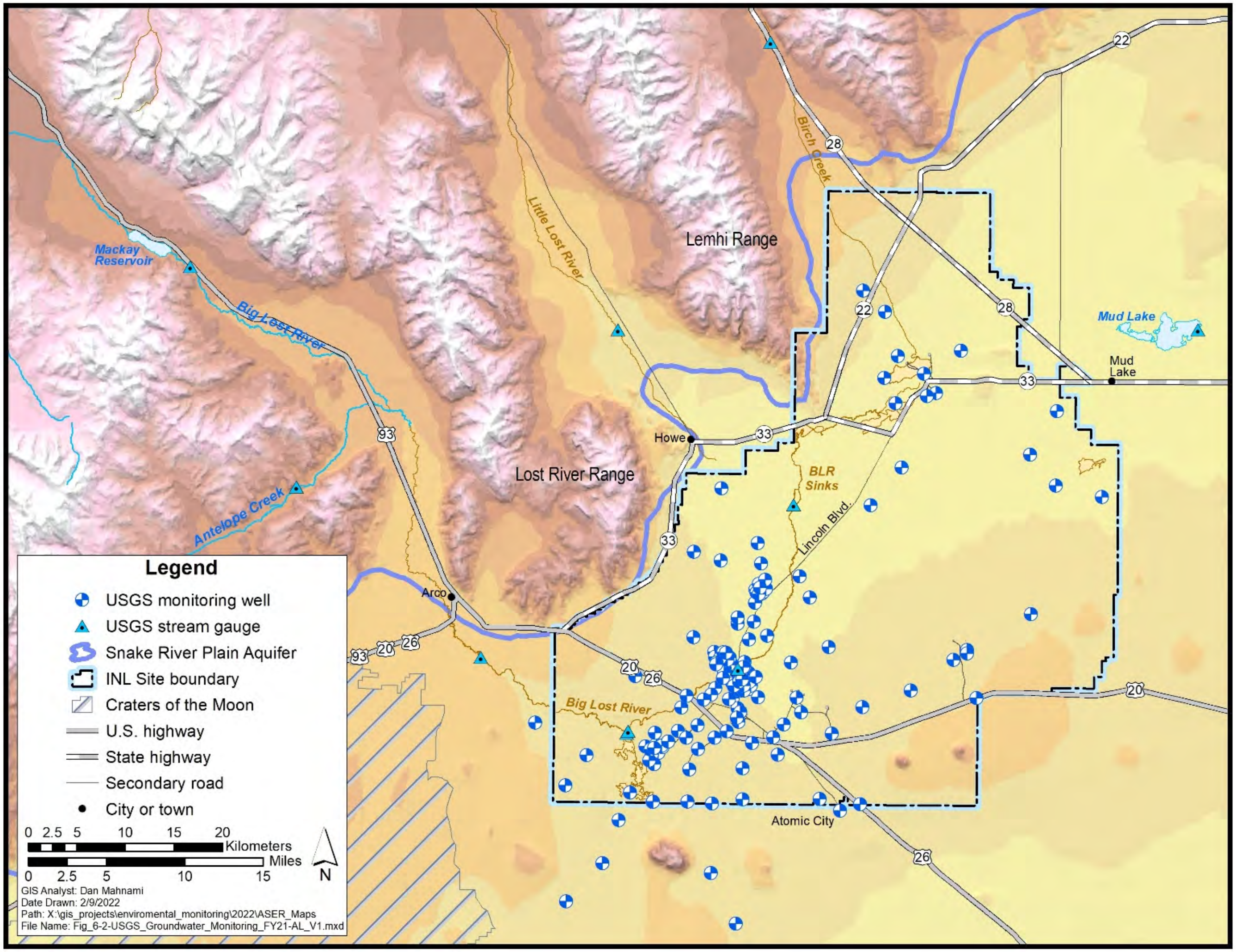

Figure 6-2. USGS groundwater monitoring locations on and off the INL Site.

Table 6-1. USGS monitoring program summary (2021).

CONSTITUENT	GROUNDWATER		SURFACE WATER		MINIMUM DETECTABLE CONCENTRATION OR ACTIVITY
	NUMBER OF SITES[a]	NUMBER OF SAMPLES	NUMBER OF SITES	NUMBER OF SAMPLES	
Gross alpha	60	68	1	1	8 pCi/L
Gross beta	60	68	1	1	3.5 pCi/L
Tritium	131	139	5	5	200 pCi/L
Gamma-ray spectroscopy	43	43	—[b]	—	—[c]
Strontium-90	63	63	—[b]	—	2 pCi/L
Americium-241	10	10	—[b]	—	0.03 pCi/L
Plutonium isotopes	10	10	—[b]	—	0.02 pCi/L
Iodine-129	31	31	—[b]	—	<1 pCi/L
Specific conductance	140	164	5	5	Not applicable
Sodium ion	129	137	—[b]	—	0.4 mg/L
Chloride ion	132	140	5	5	0.02 mg/L
Nitrates (as nitrogen)	111	119	—[b]	—	0.04 mg/L
Fluoride	6	6	—[b]	—	0.01 mg/L
Sulfate	118	126	—[b]	—	0.02 mg/L
Chromium (dissolved)	87	95	—[b]	—	1 µg/L
Purgeable organic compounds[d]	30	37	—[b]	—	Varies
Mercury	12	12	—[b]	—	0.005 µg/L
Trace elements	9	9	—[b]	—	Varies

a. Number of samples does not include 13 replicates and 5 blanks collected in 2021. Number of samples was different from the number of sites because one site for VOCs is sampled monthly, and three sites had pump problems or were dry, so they were not sampled. Number of sites does not include 24 zones from 10 wells sampled as part of the multi-level monitoring program.

b. No surface water samples collected for this constituent.

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

d. Each purgeable organic compound water sample is analyzed for 61 purgeable organic compounds.

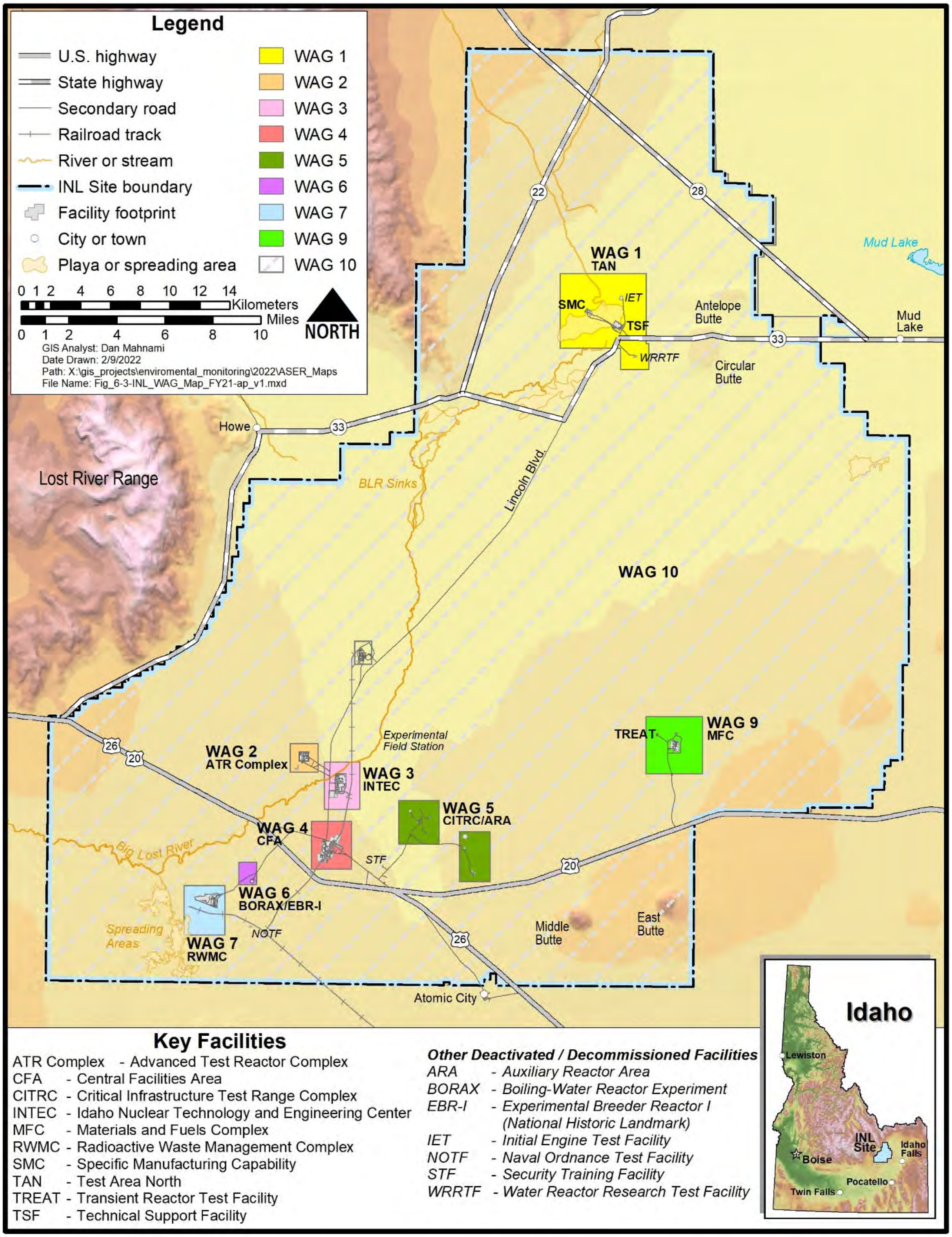

Figure 6-3. Map of the INL Site showing locations of facilities and corresponding WAGs.

Table 6-2. ICP Core contractor drinking water program summary (2021).

TYPE OF ANALYSIS	FREQUENCY (ONSITE)	MAXIMUM CONTAMINANT LEVEL
Gross alpha	2 semiannually	15 pCi/L
Gross beta	2 semiannually	50 pCi/L screening level or 4 mrem/yr
Haloacetic acids (HAA5)[a]	2 annually	0.06 mg/L
Total coliform	6 to 8 monthly	See 40 CFR 141.63(d)
E. coli	6 to 8 monthly	See 40 CFR 141.63(c)
Nitrate	2 annually	10 mg/L (as nitrogen)
Radium-226/-228	2 every 9 years	5 pCi/L
Strontium-90	2 annually	8 pCi/L
Total trihalomethanes	2 annually	0.08 mg/L
Tritium	2 annually	20,000 pCi/L
Uranium		30 µg/L
VOCs[b]	2 annually	Varies

a. Haloacetic acids = sometimes referred to as HAA5, which includes the most common haloacetic acids found in drinking water. These consist of monochloroacetic acid, dichloroacetic acid (DCA), trichloroacetic acid (TCA), monobromoacetic acid, and dibromoacetic acid.

b. VOCs = volatile organic compounds.

- The INL contractor monitors groundwater at the Materials and Fuels Complex (MFC) (WAG 9), the ATR Complex, and the Remote Handled Low-Level Waste (RHLLW) Disposal Facility and drinking water at eight INL Site facilities: ATR Complex, CFA, the Critical Infrastructure Test Range Complex (CITRC), the Experimental Breeder Reactor-I (EBR-I), the Gun Range, the Main Gate, the MFC Complex, and TAN/Contained Test Facility (CTF). Table 6-3 summarizes the routine monitoring for the INL contractor drinking water program. In 2021, the INL contractor sampled and analyzed 206 groundwater and 338 drinking water samples, which included 134 surveillance and 36 performance samples for varying constituents including radionuclides, inorganic compounds, and VOCs.
- The Environmental Surveillance, Education and Research (ESER) contractor collects drinking water samples from around the INL Site, as well as samples from natural surface waters on and off the INL Site. This includes the Big Lost River, which occasionally flows through the INL Site, and springs along the Snake River that are downgradient from the INL Site. A summary of the program may be found in Table 6-4. In 2021, the ESER contractor sampled and analyzed 26 surface and drinking water samples. Samples were not collected from the Big Lost River in 2021 due to water demands upstream inhibiting river flow onto the INL.

Table 6-3. INL contractor drinking water program summary (2021).

TYPE OF ANALYSIS	FREQUENCY (ONSITE)	MAXIMUM CONTAMINANT LEVEL
Gross alpha[a]	8 semiannually	15 pCi/L
Gross beta[a]	8 semiannually	4 mrem/yr
Tritium[a]	10 annually, 10 semiannually	20,000 pCi/L
Iodine-129[b]	1 semiannually	1 pCi/L
Parameters required by the state of Idaho under authority of the Safe Drinking Water Act	8 triennially	Varies
Nitrate[c]	10 annually	10 mg/L (as nitrogen)
Microbes (i.e., total coliform and E. coli)	14 monthly	If <40 samples/ month, no more than one positive for total coliform
Total trihalomethanes[d]	1 annual	0.08 mg/L
Haloacetic acids[d]	1 annual	0.06 mg/L
Lead/Copper[d]	35 triennially	0.015/1.3 mg/L

a. Gross alpha, beta, and tritium are sampled at all INL water systems (i.e., TAN/CTF, ATR Complex raw/drinking water, CFA, Gun Range, EBR-1, CITRC, Main Gate, and MFC).

b. Iodine-129 is only sampled at the CFA water system.

c. Nitrate and microbes are sampled at all INL water distribution systems. Nitrites were sampled in 2021.

d. Total trihalomethanes, haloacetic acids (HAA5), and lead/copper are only sampled at ATR Complex, CFA, MFC, and TAN/CTF water systems.

Table 6-4. ESER program surface and drinking water summary (2021).

MEDIUM SAMPLED	TYPE OF ANALYSIS	LOCATIONS AND FREQUENCY		MINIMUM DETECTABLE CONCENTRATION
		ONSITE	OFFSITE	
Drinking Water[a]	Gross alpha	None	9-10 semiannually	3 pCi/L
	Gross beta	None	9-10 semiannually	2 pCi/L
	Tritium	None	9-10 semiannually	100 pCi/L
Surface Water[b,c]	Gross alpha	6, when available	3-4 semiannually	3 pCi/L
	Gross beta	6, when available	3-4 semiannually	2 pCi/L
	Tritium	6, when available	3-4 semiannually	100 pCi/L

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

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

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

Details of the aquifer, drinking water, and surface water programs may be found in *the Idaho National Laboratory Site Environmental Monitoring Plan* (DOE-ID 2021b) and *Idaho National Laboratory Groundwater Monitoring and Contingency Plan Update* (DOE-ID 2021a).

6.2 Hydrogeologic Data Management

Over time, hydrogeologic data at the INL Site have been collected by 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 environmental data management and storage location for the ICP Core and INL programs. The Environmental Data Warehouse houses sampling and analytical data generated by site contractors and the USGS. It stores comprehensive information pertaining to wells, including construction, location, completion zone, type, and status.
- The ICP Core Sample and Analysis Management Program consolidates environmental sampling activities and analytical data management. The Sample and Analysis Management Program provides a single point of contact for obtaining analytical laboratory services and managing cradle-to-grave analytical data records.
- The Hydrogeologic Data Repository houses geologic and hydrologic information compiled to support remedial investigation and feasibility study (RI/FS) activities, EIS preparation, site selection and characterization, and modeling of transport in vadose and saturated zones. The information available includes (1) well construction and drill hole information; (2) maps; (3) historical data; (4) aquifer characteristics; (5) soil characterization; and (6) sediment property studies.
- The USGS Data Management Program involves putting all data in the National Water Information System, which is available online at https://waterdata.usgs.gov/id/nwis/nwis.

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

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

Presently, strontium-90 (^{90}Sr) is the only radionuclide that continues to be detected by the ICP Core contractor and USGS above the primary constituent standard in some surveillance wells between INTEC and CFA, and at TAN. Other radionuclides (e.g., gross alpha) have been detected above the 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 (2018), are shown in Figure 6-4 (Bartholomay et al. 2020). The area of contamination within the 500-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 the ATR Complex (USGS-065) and INTEC (USGS-114) have continually shown the highest tritium concentrations in the aquifer over the past 20 years shown in Figure 6-5. For this reason, these two wells are considered representative of maximum concentration trends in the rest of the aquifer. The concentration of tritium in USGS-065 near the ATR Complex decreased from 1,600 ± 90 pCi/L in 2020 to 1,380 ± 90 pCi/L in 2021; the tritium concentration in USGS-114, south of INTEC, increased slightly from 3,912 ± 173 in 2020 to 4,280 ± 150 pCi/L in 2021.

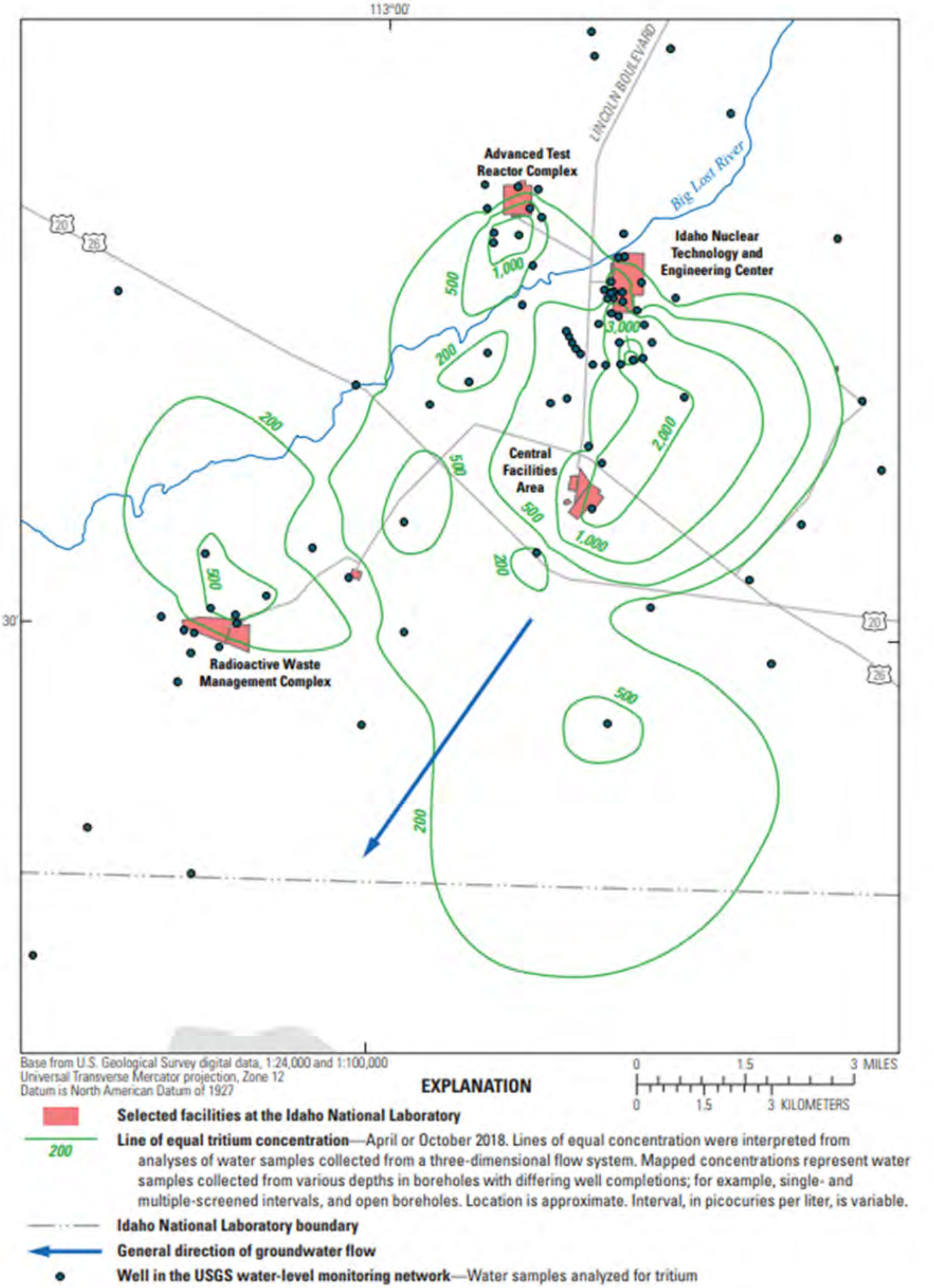

Figure 6-4. Distribution of tritium (pCi/L) in the eastern Snake River Plain Aquifer on the INL Site in 2018 (from Bartholomay et al. 2020).

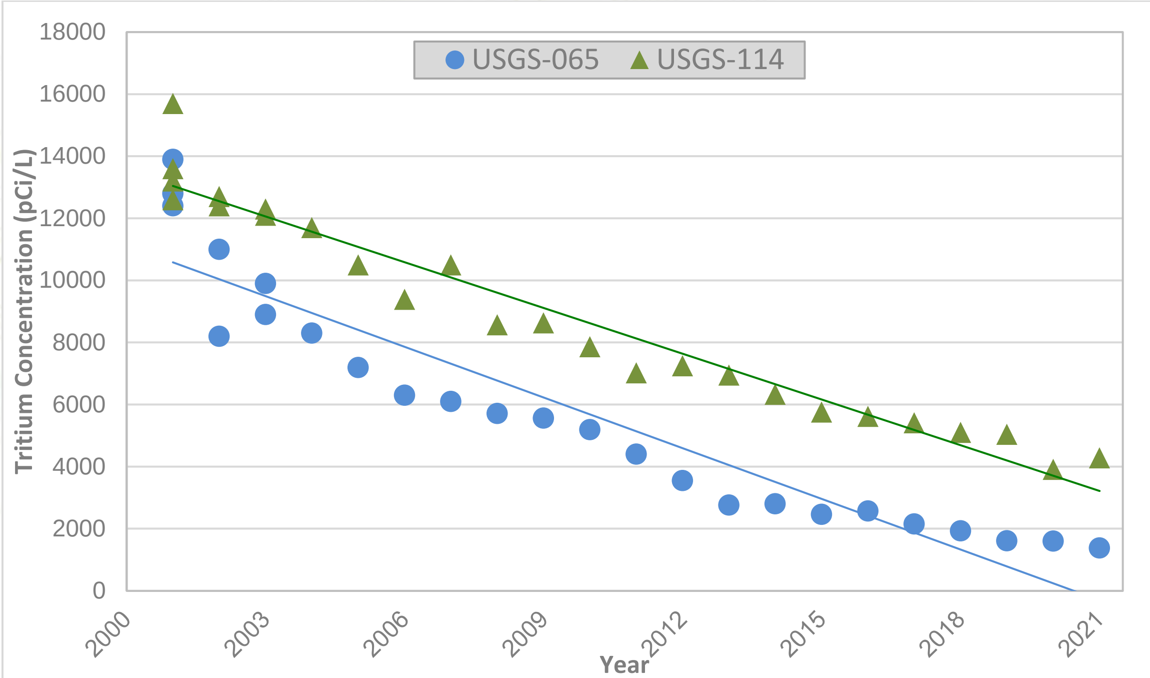

Figure 6-5. Long-term trend of tritium in wells USGS-065 and USGS-114 (2001–2021).

The Idaho primary constituent standard for tritium (20,000 pCi/L) in groundwater is the same as the EPA MCL for tritium in drinking water. The values in Wells USGS-065 and USGS-114 dropped below this limit in 1997 as a result of radioactive decay (tritium has a half-life of 12.33 years), ceased tritium disposal, advective dispersion, and dilution within the aquifer. A 2015 report by the USGS (Davis et al. 2015) indicated that water quality trends for tritium in all but one well at the INL Site showed decreasing or no trends, and the well that showed the increasing trend changed to a decreasing trend when data through 2018 were analyzed (Bartholomay et al. 2020, Figure 15).

Strontium-90 – The configuration and extent of ^{90}Sr in groundwater, based on the latest published USGS data, are shown in Figure 6-6 (Bartholomay et al. 2020). The contamination originates at INTEC from historical injection of wastewater. No ^{90}Sr was detected by USGS in the eastern Snake River Plain Aquifer near the ATR Complex during 2021. All ^{90}Sr at the ATR Complex was disposed to infiltration ponds in contrast to the direct injection that occurred at INTEC. At the 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 (e.g., 2001–2021) in Wells USGS-047, USGS-057, and USGS-113 is shown in Figure 6-7. Concentrations in Well USGS-047 have varied through time but indicate a general decrease. Concentrations in Wells USGS-057 and USGS-113 also have generally decreased during this period. The variability of concentrations in some wells was thought to be due, in part, to a lack of recharge from the Big Lost River that would dilute the ^{90}Sr. Other reasons may include increased disposal of other chemicals into the INTEC percolation ponds, which may have changed the affinity of ^{90}Sr on soil and rock surfaces, causing it to become more mobile (Bartholomay et al. 2000). A 2015 report by the USGS (Davis et al. 2015) indicated that water quality trends for ^{90}Sr in all but two perched water wells at the INL Site showed decreasing or no trends.

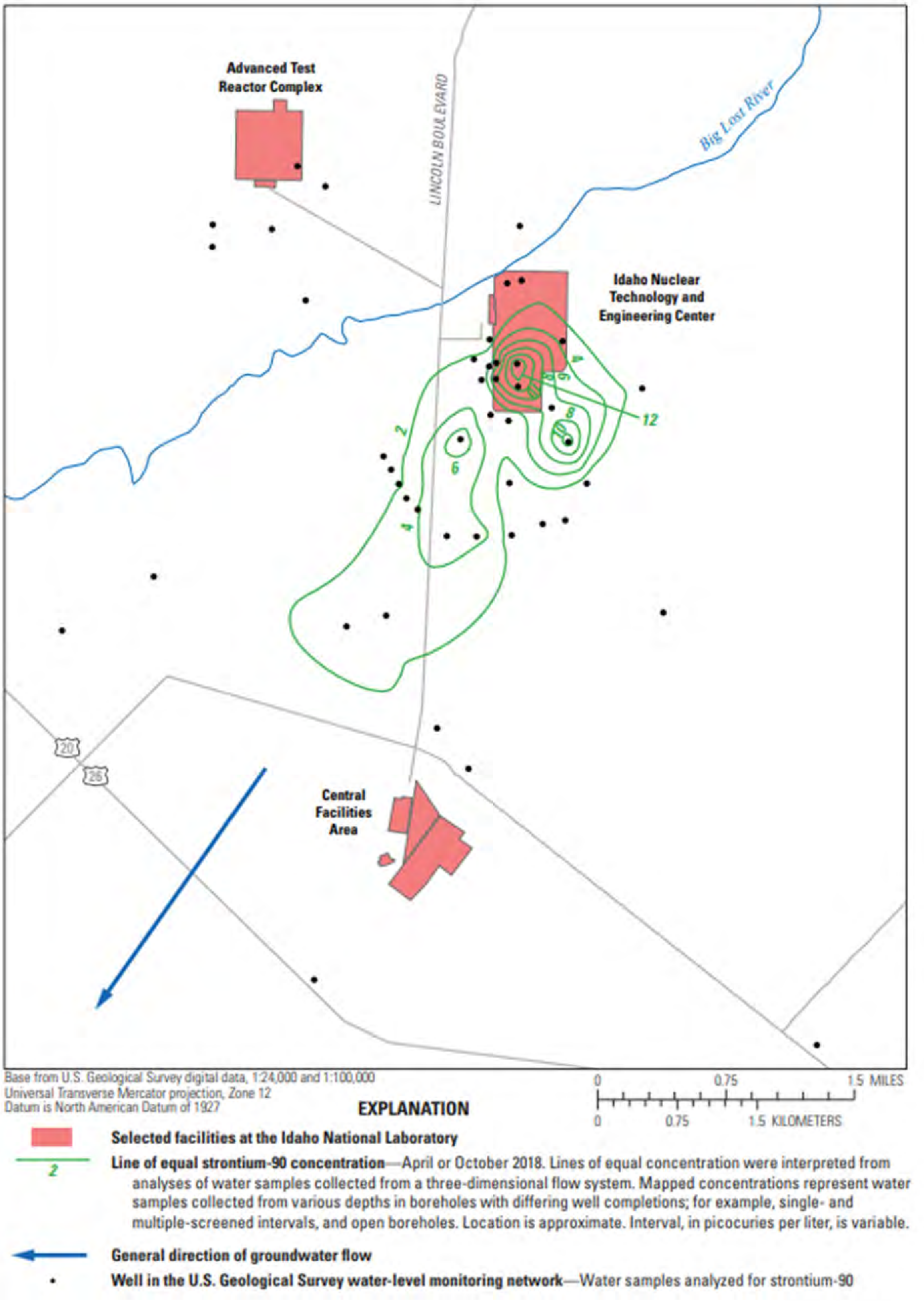

Figure 6-6. Distribution of ^{90}Sr (pCi/L) in the eastern Snake River Plain Aquifer on the INL Site in 2018 (from Bartholomay et al. 2020).

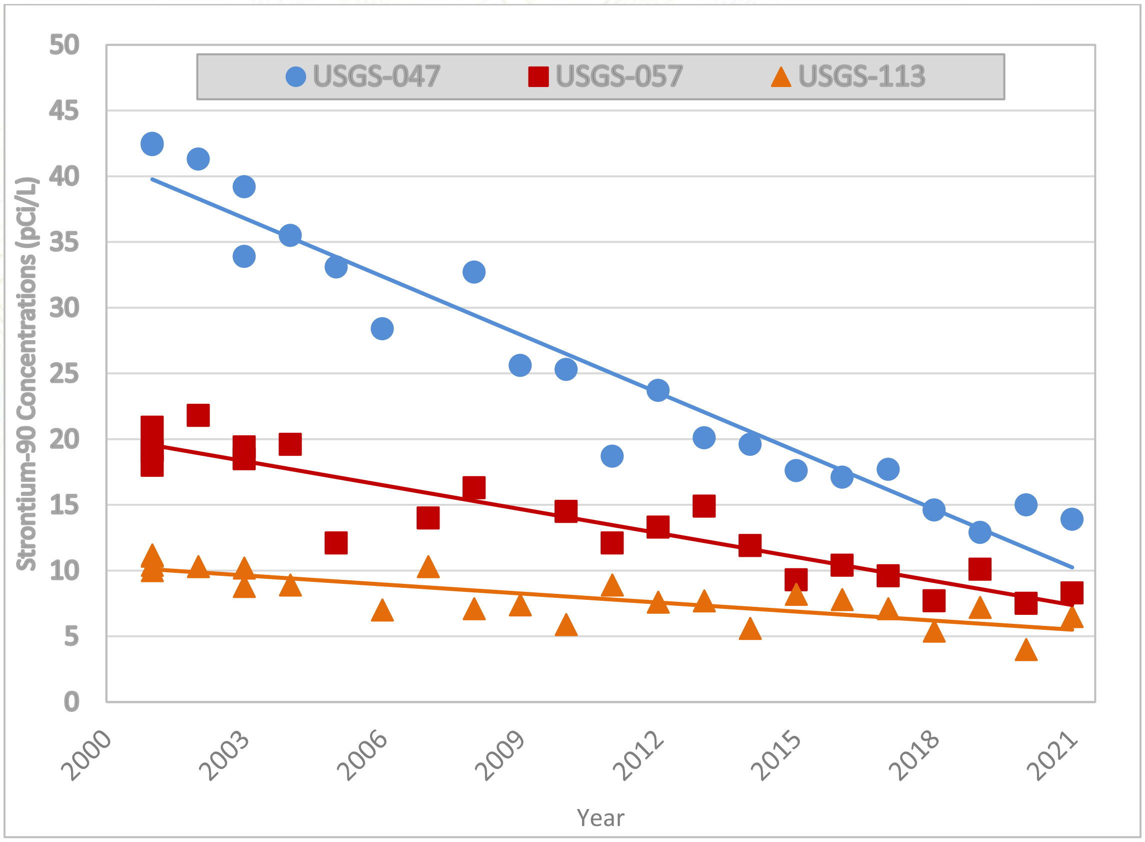

Figure 6-7. Long-term trend of ^{90}Sr in wells USGS-047, USGS-057, and USGS-113 (2000–2021).

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. These values are shown in Table 6-1. Results for wells sampled in 2021 are available at https://waterdata.usgs.gov/id/nwis/. Monitoring results for 2016–2018 are summarized in Bartholomay et al. (2020). During 2016–2018, concentrations of cesium-137 (^{137}Cs) were greater than or equal to the reporting level in one well, and concentrations of plutonium-238, plutonium-239/240, and americium-241 in all analyzed samples were less than the reporting level. In 2016–2018, reportable concentrations of gross alpha radioactivity were observed in six of the 55 wells and ranged from 6 ± 2 to 141 ± 29 pCi/L. Beta radioactivity exceeded the reporting level in most of the wells sampled, and concentrations ranged from 2.4 ± 0.8 to 1,390 ± 80 pCi/L (Bartholomay et al. 2020).

Periodically, the USGS has sampled for iodine-129 (^{129}I) in the eastern Snake River Plain Aquifer. Monitoring programs from 1977, 1981, 1986, 1990, 1991, 2003, 2007, 2011, and 2012 were summarized in Mann et al. (1988), Mann and Beasley (1994), and Bartholomay (2009, 2013). The USGS sampled for ^{129}I in wells at the INL Site in the fall of 2017 and collected additional samples in the spring of 2018. Average concentrations of 15 wells sampled in 1990–1991, 2003, 2007, 2011–2012, and 2017–2018 decreased from 1.15 pCi/L in 1990–1991 to 0.168 pCi/L in 2017–2018. 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. The concentration in that same well in 2017 decreased to 0.877 ± 0.032 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 2017–2018 USGS data (most current published date), are shown in Figure 6-8 (Maimer and Bartholomay, 2019). A follow-up sampling campaign for ^{129}I was initiated in 2021 and results will be published in an upcoming report.

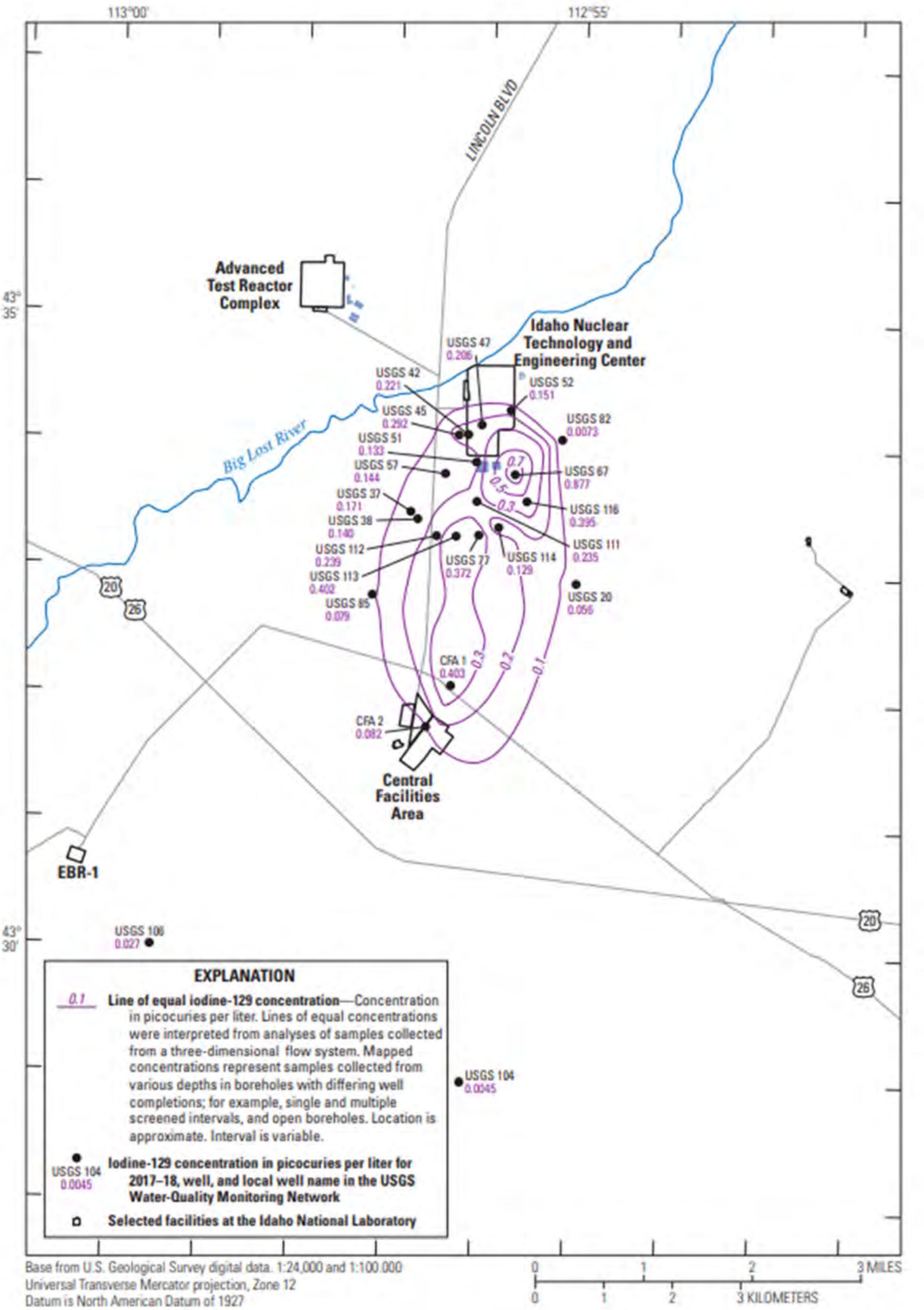

Figure 6-8. Distribution of ^{129}I in the eastern Snake River Plain Aquifer on the INL Site in 2017–2018 (from Maimer and Bartholomay 2019).

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 identified in Table 6-1. Bartholomay et al. (2020) provides a detailed discussion of results for samples collected during 2016–2018. Chromium had a concentration at the MCL of 100 µg/L in Well 65 in 2009 (Davis et al. 2013), but its concentration has been below the MCL since then and was 76.4 µg/L in 2021; this well has shown a long-term decreasing trend (Davis et al. 2015, Appendix D).

Concentrations of chloride, nitrate, sodium, and sulfate historically have been above background concentrations in many wells at the INL Site, but concentrations were below established MCLs or secondary MCLs in all wells during 2018 (Bartholomay et al. 2020).

VOCs are present in water from the eastern Snake River Plain Aquifer because of historical waste disposal practices at the INL Site. Products containing VOCs were used for degreasing, decontamination, and other activities at INL Site facilities. The USGS sampled for purgeable (volatile) organic compounds in groundwater at the INL Site during 2021. Samples from 29 groundwater monitoring wells and one perched well were collected and submitted to the USGS National Water Quality Laboratory in Lakewood, Colorado, for analysis of 61 purgeable organic compounds. USGS reports describe the methods used to collect the water samples and ensure sampling and analytical quality (Mann 1996; Bartholomay et al., 2003; Knobel et al. 2008; and Bartholomay et al. 2021). Eleven 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 identified in 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. 2020). However, concentrations for all VOCs except tetrachloromethane (also known as carbon tetrachloride) were less than the MCL for drinking water (40 CFR 141, Subpart G). The production well at the RWMC was monitored monthly for tetrachloromethane during 2021, and concentrations exceeded the MCL of 5 µg/L during 7 of the 11 months measured (no data results are available from October 2021) as shown in Table 6-6.

Concentrations have routinely exceeded the MCL for tetrachloromethane in drinking water (5 µg/L) at RWMC since 1998. (Note: VOCs are removed from production well water prior to human consumption—see Section 6.7.1.10.) Trend test results for tetrachloromethane concentrations in water from the RWMC production well indicated a statistically significant increase in concentrations has occurred from 1989 through 2015; however, Bartholomay et al. (2020) indicated that more recent data through 2018 showed no trend for the entire dataset and a decreasing trend for data collected since 2005. The more recent decreasing trend indicates that engineering practices designed to reduce VOC movement to the aquifer are having a positive effect.

Concentrations of tetrachloromethane from USGS-87 and USGS-120, south of RWMC, have had an increasing trend since 1987, but concentrations have decreased through time at USGS-88 (Davis et al. 2015; Bartholomay et al. 2020).

Trichloroethylene (trichloroethene) (TCE) exceeded the MCL of 5 µg/L from one sample collected from Well TAN-2336 at TAN identified in Table 6-5. There is a known groundwater TCE plume being treated at TAN, as discussed in more detail in Section 6.5.1. The sample collected at a perched well at RWMC, USGS 92, also had a detection of TCE above the MCL.

Table 6-5. Purgeable organic compounds in annual USGS groundwater well samples (2021).

CONSTITUENT	TAN-2336	RWMC-M7S	TAN-2271	USGS-87	USGS-88	USGS-120	USGS-132
1,1-Dichloroethane (MCL = 7 µg/L)[a]	<0.5	<0.1	0.15	<0.1	<0.1	<0.1	<0.1
1,1,1-Trichloroethane (MCL = 200 µg/L)[a]	<0.5	0.280	<0.1	0.131	<0.1	0.106	<0.1
cis-1,2-Dichoroethene[b] (MCL = 70 µg/L)[a]	10.49	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Ethylbenzene (MCL = 700 µg/L)[a]	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Tetrachloroethene[b] (MCL = 5 µg/L)[a]	<0.5	0.330	<0.1	0.187	<0.1	<0.1	<0.1
Tetrachloromethane (PCS = 2 µg/L)[c]	1	4.09	<0.2	3.71	0.67	2.27	0.409
Trichloroethene[b] (MCL = 5 µg/L)[a]	18.74	2.39	<0.1	1.24	0.48	0.725	<0.1
Trichloromethane (MCL = 5 µg/L)[a]	<0.5	0.780	<0.1	0.364	0.45	0.534	<0.1
Toluene (MCL = 1,000 µg/L)[a]	1.32	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
trans-1,2-Dichloroethene[b] (MCL = 100 µg/L)[a]	22.65	<0.1	0.40	<0.1	<0.1	<0.1	<0.1
Vinyl chloride (MCL = 2 µg/L)[a]	2.1	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
1,1-Dichloroethene (MCL = 7 µg/L)[a]	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

a. MCL = maximum contaminant level from the EPA (40 CFR 141)

b. The International Union of Pure and Applied Chemistry (IUPAC) name for ethylene is ethene. So, for example, trichloroethene is equivalent to trichloroethylene. This is the name reported in the USGS database. This nomenclature is used in this table in case the reader wants to look up the constituent in the USGS database.

c. PCS = primary constituent standard values from IDAPA 58.01.11.

Table 6-6. Purgeable organic compounds in monthly production well samples at the RWMC (2021).

CONSTITUENT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1,1,1-Trichloroethane (MCL = 200 µg/L) [a]	0.273	0.264	0.272	0.254	0.270	0.248	0.243	0.225	0.24	ND[d]	0.261	0.232
Tetrachloroethene [b] (MCL = 5 µg/L) [a]	0.361	0.349	0.385	0.387	0.311	0.330	0.346	0.291	0.35	ND	0.337	0.296
Tetrachloromethane (MCL = 5 µg/L) [a]	4.99	4.57	5.16	5.02	5.33	5.23	5.27	4.58	5.05	ND	5.30	4.71
Trichloroethene [b] (MCL = 5 µg/L) [a]	3.24	3.49	3.45	3.54	3.37	3.06	2.93	2.97	3.30	ND	2.83	2.99
Trichloromethane (PCS = 2 µg/L) [c]	1.42	1.47	1.57	1.57	1.61	1.5	1.46	1.4	1.55	ND	1.51	1.61

a. MCL = maximum contaminant level values from the EPA (40 CFR 141)

b. The International Union of Pure and Applied Chemistry (IUPAC) name for ethylene is ethene. So, for example, trichloroethene is equivalent to trichloroethylene. This is the name reported in the USGS database. This nomenclature is used in this table in case the reader wants to look up the constituent in the USGS database.

c. PCS = primary constituent standard values from IDAPA 58.01.11.

d. ND = No data are available for the RWMC Production well for October 2021.

6.5 Comprehensive Environmental Response, Compensation, and Liability Act Groundwater Monitoring During 2021

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 the 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 ARIR Home - ARIR (idaho-environmental.com). 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 (TAN) to evaluate the progress of the remedial action at TAN. The VOC groundwater plume at TAN has been divided into three zones based on the 1997 TCE concentrations with three different remedy components, which work together to remediate the entire VOC 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 (near Well TSF-05) to create conditions favorable for naturally occurring anaerobic bacteria in the aquifer to break down chlorinated solvents (principally TCE). The hot spot concentration was defined using TCE data from 1997 identified in Figure 6-9 and is not reflective of current concentrations as shown in Figure 6-10. With regulatory agency concurrence, an ISB rebound test began in July 2012 to determine if the residual TCE source in the aquifer had been sufficiently treated. Currently, the ISB rebound test has been split into two components: (1) an ISB rebound test for the area near the former injection Well TSF-05, and (2) ISB activities to treat the TCE source affecting Well TAN-28.

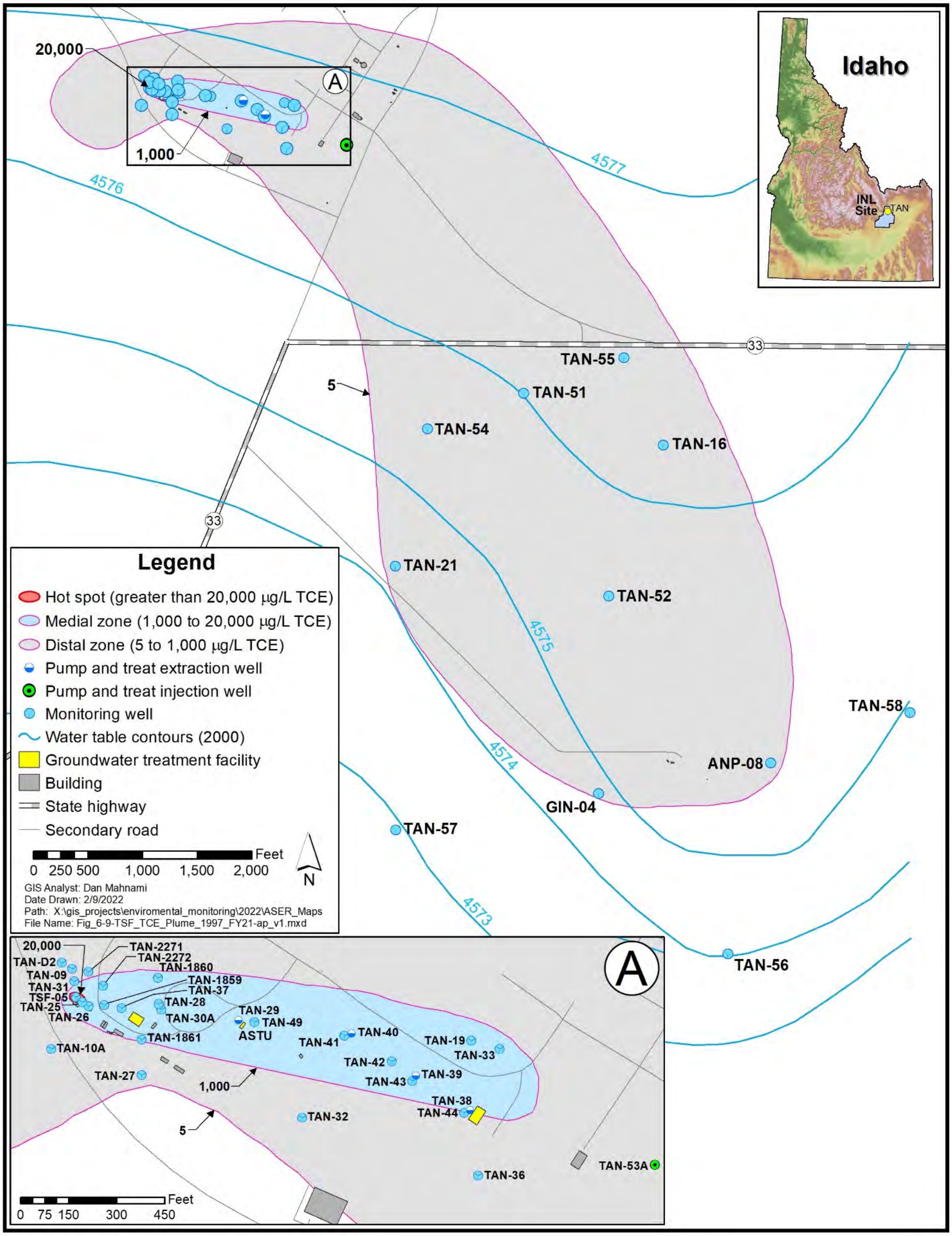

Figure 6-9. TCE plume at TAN in 1997.

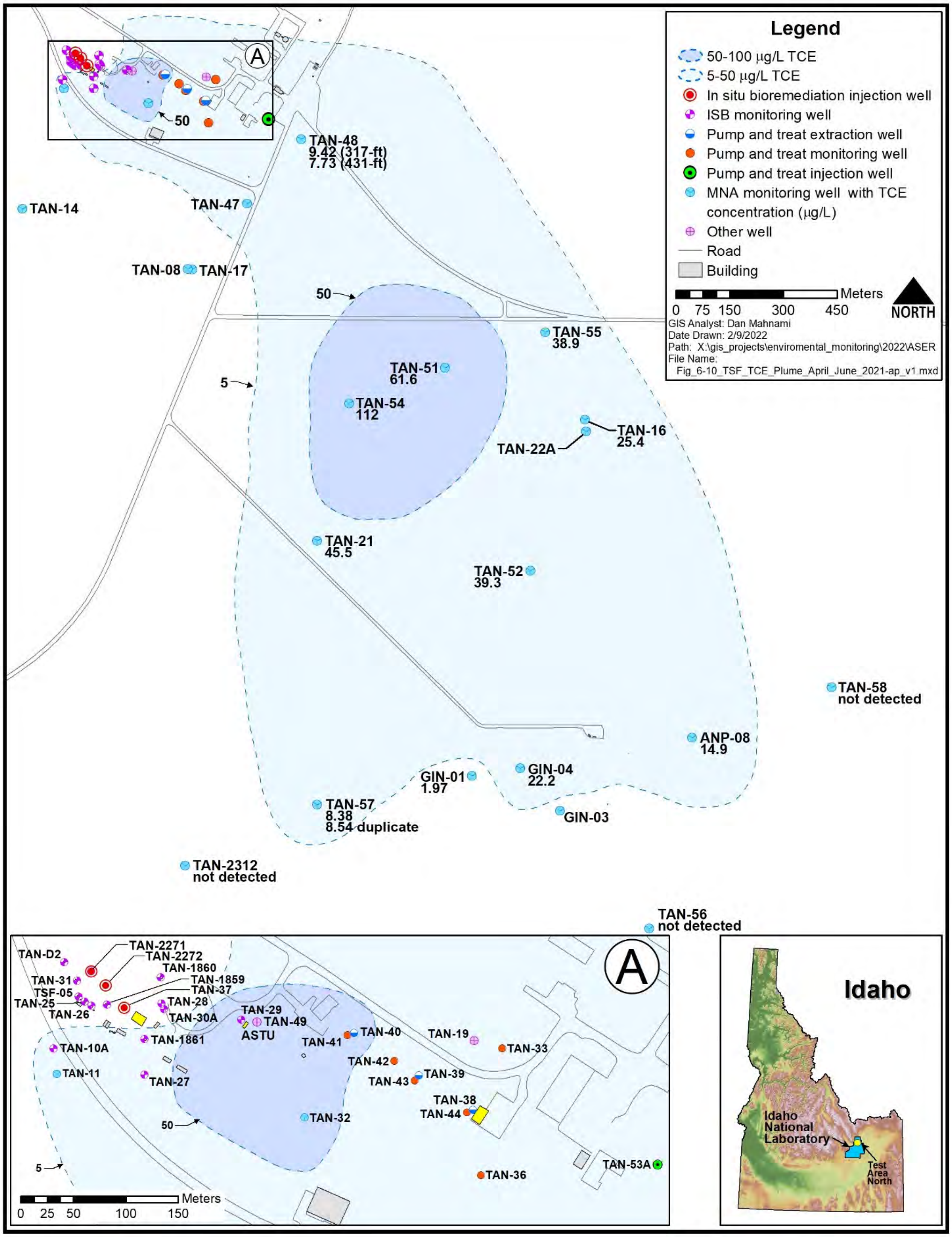

Figure 6-10. Distribution of TCE in the Snake River Plain Aquifer from April–June 2021.

In 2021, data collected during the ISB rebound test for the area near the former injection Well TSF-05 indicated that anaerobic conditions created by ISB were still present in the hot spot area, and that TCE concentrations were near or below MCLs in the wells near the former injection Well TSF-05 as shown in Figure 6-10. After background aquifer conditions are re-established, the effectiveness of the ISB part of the remedy will be evaluated (DOE-ID 2022a).

To address the source of TCE in well TAN-28, a new well, TAN-2336, was completed in July 2021 near the suspected TAN-28 TCE source. Four ISB injections were made in 2021 with two injections into both TAN-1860A and TAN-2336. TCE concentrations have declined in both TAN-28 and TAN-1860A as a result of the ISB injections to treat the TAN-28 TCE source. ISB injections will continue into the above wells until it can be determined that the TAN-28 TCE source has been successfully treated and a transition to a rebound test for the TAN-28 TCE source can be made.

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 extracts contaminated groundwater, circulates the groundwater through air strippers to remove VOCs like TCE, and reinjects treated groundwater into the aquifer. The New Pump and Treat Facility was generally operated Monday–Thursday in 2021, except for shutdowns due to maintenance. All 2021 New Pump and Treat Facility compliance samples were below the discharge limits. TCE concentrations used to define the medial zone (1,000–20,000 µg/L) are based on data collected in 1997, before remedial actions started shown in Figure 6-9, and do not reflect current concentrations as identified in Figure 6-10. In 2021, no wells were above the concentration 1,000 µg/L used historically to define the medial zone. The TCE concentrations in Wells TAN-33, TAN-36, and TAN-44 near the New Pump and Treat Facility are used as indicators of TCE concentrations migrating past the New Pump and Treat Facility extraction wells into the distal zone. In 2021, TCE concentrations for Wells TAN-33, TAN-36, and TAN-44 ranged from 14.1 to 45.0 µg/L.

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 (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 2021 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 will meet the remedial action objective of all wells below the MCL by 2095. The TCE data from the plume expansion wells suggest that plume expansion is currently within the limits allowed in the Record of Decision Amendment (DOE-ID 2001).

Radionuclide Monitoring – In addition to the VOC plume, ^{90}Sr, ^{137}Cs, tritium, and uranium-234 (^{234}U) are listed as contaminants of concern in the Record of Decision Amendment (DOE-ID 2001). Strontium-90 and ^{137}Cs are expected to naturally decline below their respective MCLs before 2095. However, wells in the source/ISB area currently show elevated ^{90}Sr and ^{137}Cs concentrations compared to levels prior to starting ISB. The elevated ^{90}Sr and ^{137}Cs concentrations are due to enhanced mobility created by elevated concentrations of competing cations (calcium, magnesium, sodium, and potassium) for adsorption sites in the aquifer. The elevated cation concentrations are due to ISB activities to treat VOCs. As competing cation concentrations decline toward background conditions, ^{90}Sr and ^{137}Cs are trending lower. The radionuclide concentrations are expected to continue to decrease, and concentration trends will continue to be evaluated to determine if the remedial action objective of declining below MCLs by 2095 will be met. All 2021 results for tritium are below the MCL of 20,000 pCi/L with the highest tritium result of 1,570 pCi/L at Well TAN-28. Sampling will be conducted for ^{234}U after ISB conditions dissipate because ISB conditions suppress uranium concentrations.

6.5.2 Summary of Waste Area Group 2 Groundwater Monitoring Results

Groundwater samples were collected from seven aquifer wells for monitoring WAG 2, ATR Complex, during 2021 shown in Figure 6-11. Aquifer samples were analyzed for ^{90}Sr, gamma-emitting radionuclides (e.g., the target analyte is cobalt-60), tritium, and chromium (filtered), in accordance with the groundwater monitoring plan (DOE-ID 2016). The data for the October 2021 sampling event will be included in the Fiscal Year 2022 Annual Report for WAG 2 (DOE-ID 2022b). The October 2021 sampling data are summarized in Table 6-7.

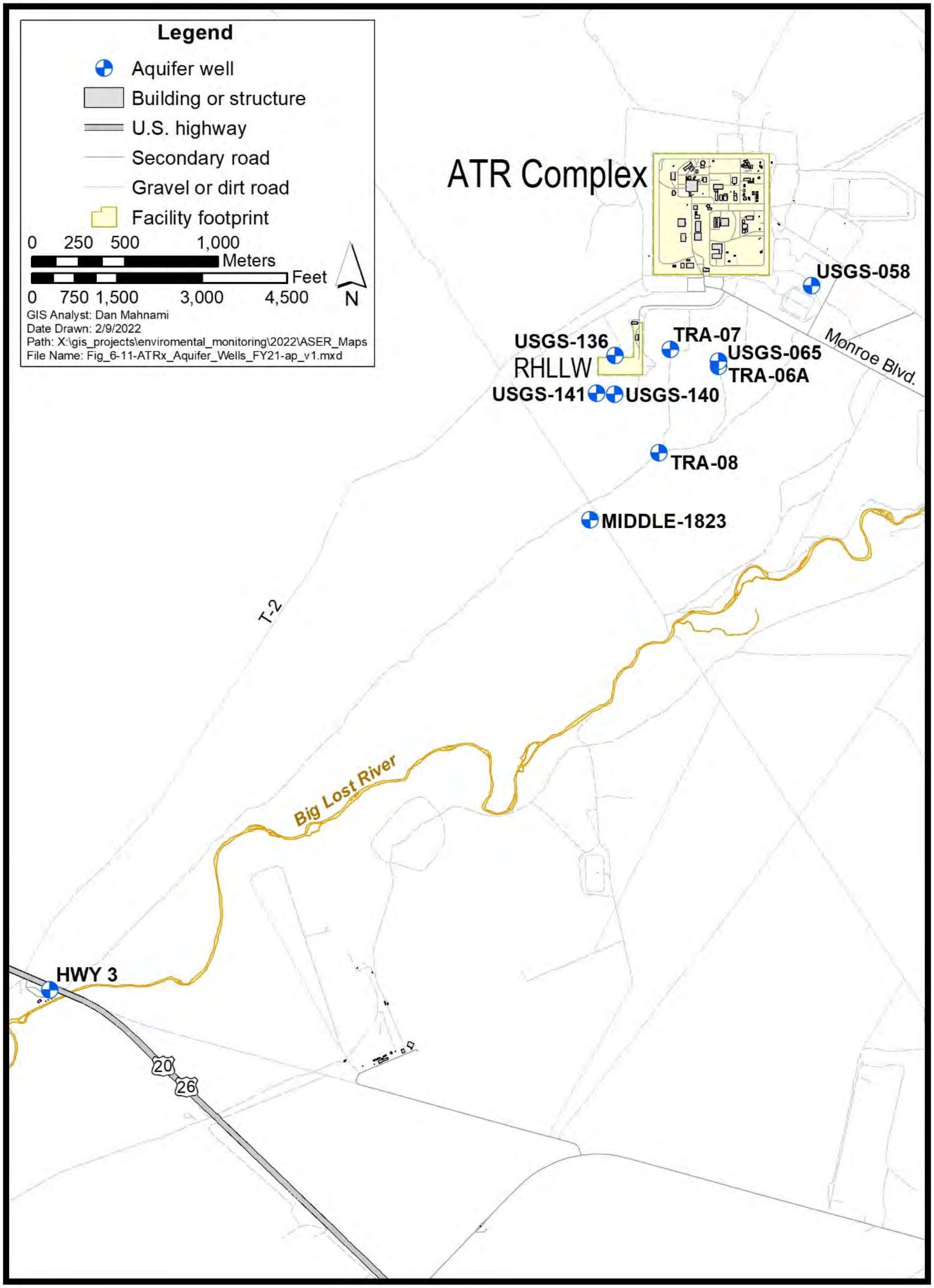

Figure 6-11. Locations of WAG 2 aquifer monitoring wells.

Table 6-7. WAG 2 aquifer groundwater quality summary (October 2021).

ANALYTE	MCL[a]	BACKGROUND[b]	MAXIMUM	MINIMUM	NUMBER OF WELLS ABOVE MCL
Chromium (filtered) (µg/L)	100	4	78.6	2.11	0
Cobalt-60 (pCi/L)	100	0	ND[c]	ND	0
Strontium-90 (pCi/L)	8	0	ND	ND	0
Tritium (pCi/L)	20,000	34	3,460	ND	0

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

No analyte occurred above its MCL in the Snake River Plain Aquifer at WAG 2. The highest chromium concentration occurred in Well TRA-07 at 78.6 µg/L and was below the MCL of 100 µg/L. The second highest chromium concentration was in Well USGS-065 at 77.2 µg/L. Compared to the previous year, the chromium concentrations decreased in both TRA-07 and USGS-065 and both wells are in long-term declining trends.

Tritium was the only radionuclide analyte detected in the aquifer and was below the MCL of 20,000 pCi/L in all sampled wells. The highest tritium concentration was 3,460 pCi/L in Well TRA-07.

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 2020 eastern Snake River Plain Aquifer water table map prepared for the vicinity of the ATR Complex was consistent with previous maps showing general groundwater flow direction to the southwest. Water levels in the vicinity of the ATR Complex declined by approximately 1.02 ft on average from October 2020 to October 2021.

6.5.3 Summary of Waste Area Group 3 Groundwater Monitoring Results

At INTEC, groundwater samples were collected from 17 eastern Snake River Plain Aquifer monitoring wells during 2021 shown in Figure 6-12. Groundwater samples were analyzed for a suite of radionuclides and inorganic constituents, and the data are summarized in the 2021 Annual Report (DOE-ID 2022c). 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), ^{129}I, and nitrates 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 2021, the highest ^{90}Sr level in eastern Snake River Plain Aquifer groundwater was at monitoring Well USGS-047 (16.4 ± 1.41 pCi/L), located south (down-gradient) 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 apart from ICPP-2021 (15.3 pCi/L) and USGS-048 (12.9 pCi/L). During the reporting period, both wells reported an elevated range of activity similar to their activity reported in 2013 (i.e., 14.5 pCi/L and 14.3 pCi/L, respectively).

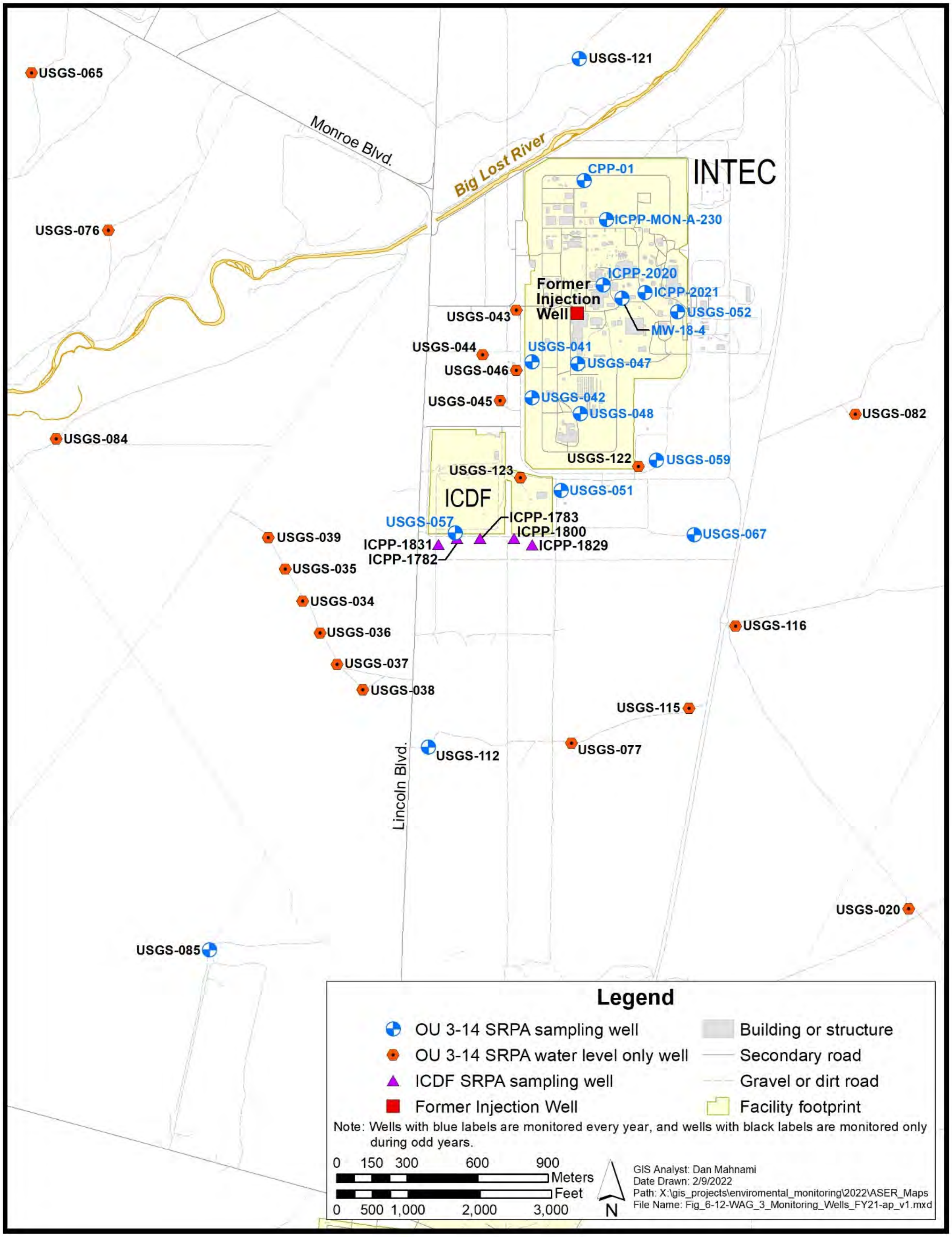

Figure 6-12. Locations of WAG 3 monitoring wells.

Table 6-8. Summary of constituents detected in WAG 3 aquifer monitoring wells (fiscal year [FY] 2021).

CONSTITUENT	EPA MCL[a]	UNITS	SNAKE RIVER PLAIN AQUIFER GROUNDWATER – APRIL 2021		
			MAXIMUM REPORTED VALUE	NUMBER OF RESULTS[b]	RESULTS >MCL[b]
Gross alpha	15	pCi/L	3.8 ± 1.3	19	0
Gross beta	NA[c]	pCi/L	573 ± 11.5	19	NA[c]
Cesium-137	200	pCi/L	ND[d]	19	0
Strontium-90	8	pCi/L	**16.4 ± 1.41**[e]	19	7
Technetium-99	900	pCi/L	**1,750 ± 101**	19	2
Iodine-129	1	pCi/L	**1.03 ± 0.139 J**[d]	19	1
Tritium	20,000	pCi/L	2,030 ± 248	19	0
Plutonium-238	15	pCi/L	–[f]	–[f]	–[f]
Plutonium-239/240	15	pCi/L	–[f]	–[f]	–[f]
Uranium-233/234	NA MCL[g]	pCi/L	2.17 ± 0.343	19	NA
Uranium-235	NA MCL	pCi/L	ND	19	NA
Uranium-238	NA MCL	pCi/L	1.01 ± 0.194	19	NA
Bicarbonate	NA	mg/L	159	19	NA
Calcium	NA	mg/L	68.1	19	NA
Chloride	250	mg/L	130 J	19	0
Magnesium	NA	mg/L	23.6 NJ[d]	19	NA
Nitrate/Nitrite (as N)	10	mg/L	**12.9 J**[d,e]	19	1
Potassium	NA	mg/L	4.83	19	NA
Sodium	NA	mg/L	31.4	19	NA
Sulfate	250	mg/L	41.3	19	0
Total dissolved solids	500	mg/L	443	19	0

a. EPA = Environmental Protection Agency; MCL = maximum contaminant level.
b. Include field duplicates.
c. NA = not applicable.
d. Data-qualifier flags:
ND = constituent not detected in sample.
J = estimated detection.
e. NJ = matrix spike sample recovery is not within specified control limits; estimated value
Bold values exceed MCL.
f. – = Gross alpha did not exceed 15 pCi/L; constituent not analyzed.
g. NA MCL = Not applicable because values are reported in pCi/L. EPA MCL is reported in mass units (µg/L).

Technetium-99 was detected above the MCL (900 pCi/L) at two monitoring wells. During 2021, the highest ^{99}Tc level in eastern Snake River Plain Aquifer groundwater was at Well ICPP-MON-A-230 (1,750 ± 101 pCi/L), located north of the INTEC Tank Farm. All wells sampled showed stable or declining trends from the previous reporting period.

Nitrate was detected in all wells sampled during this reporting period. The highest concentration was reported at Well ICPP-2021-AQ (12.9 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 drinking water MCLs (1 pCi/L) at all Snake River Plain Aquifer monitoring locations, with the exception of Well USGS-067, which is located east of INTEC's former percolation ponds, which received service wastewater until 2002. Iodine-129 was detected at four locations, with the highest detection at Well USGS-067 (1.03 ± 0.139 pCi/L). The detected ^{129}I activities at USGS-067 that have approached and exceeded the MCL have large uncertainties that overlap making all the values near the MCL essentially equivalent and potentially below the MCL.

Tritium was detected at most 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-051, southeast of INTEC (2,030 ± 248 pCi/L). Tritium concentrations have declined at nearly all locations over the past few years.

During the reporting period, no plutonium isotope analyses were performed because the current monitoring plan identifies the contingency for plutonium analysis if gross alpha exceeds 15 pCi/L. Uranium-238 (^{238}U) was detected at all eastern Snake River Plain Aquifer well locations, with the highest concentration at Well USGS-051 (1.01 ± 0.194 pCi/L). Uranium-234 was also detected in all groundwater samples, with the greatest concentrations of 2.17 ± 0.343 pCi/L at Well ICPP-MON-A-230. Uranium-234 is the daughter product (from alpha decay) of the long-lived, naturally occurring ^{238}U. All 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 (^{235}U) was not detected at any monitoring wells. 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% upper tolerance limit).

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. The wells at the CFA landfills are monitored to determine potential impacts from the landfills, while the nitrate plume south of CFA is monitored to evaluate nitrate trends. Groundwater monitoring for the CFA landfills consisted of sampling seven wells for metals (filtered), VOCs, and anions (nitrate, chloride, and sulfate) and two wells for VOCs only, in accordance with the long-term monitoring plan (DOE-ID 2018). Four wells south of CFA were sampled for nitrate, sulfate, and chloride to monitor the CFA nitrate plume. The CFA landfill and nitrate plume monitoring well locations are shown on Figure 6-13.

Analytes detected in groundwater are compared to regulatory levels identified in Table 6-9. In 2021, iron exceeded an EPA secondary maximum containment level (SMCL) within two CFA landfill wells and three wells exceeded a pH SMCL. The elevated iron concentrations probably result from the interaction of the acid preservative in the sample bottle with particles that passed through the groundwater filter. The elevated pH in the three wells was due to grout placed beneath the well screens during well construction. A complete list of the groundwater sampling results will be included in the Fiscal Year 2021 Annual Report for WAG 4 (DOE-ID 2022d).

In the CFA nitrate plume monitoring wells south of CFA, one well, CFA-MON-A-002, continued to exceed the nitrate groundwater MCL of 10 mg/L-N. The nitrate concentration in Well CFA-MON-A-002 increased from 13.2 mg/L-N in 2020 to 14.5 mg/L-N in 2021, but the concentration is still consistent with a declining trend starting in 2006.

The nitrate concentration of 7.90 mg/L-N in Well CFA-MON-A-003 is below the MCL, and, despite an increase from FY 2020 to FY 2021, shows a declining trend.

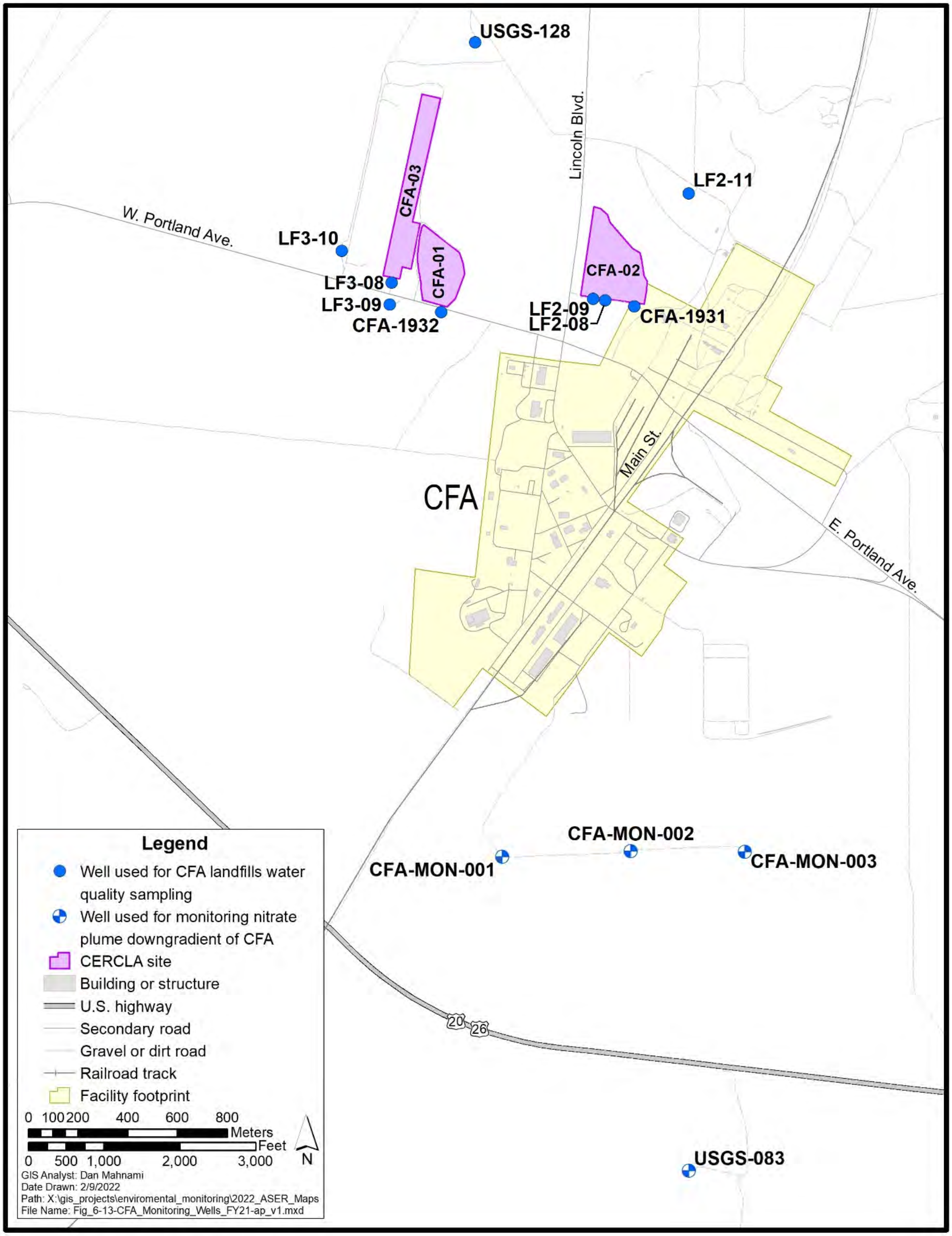

Figure 6-13. Locations of WAG 4/CFA monitoring wells.

Table 6-9. Comparison of WAG 4 groundwater sampling results to regulatory levels (August 2021).

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]	73.0	0
Sulfate (mg/L)	*250*	32.9	0
Nitrate/nitrite (mg-N/L)	10	**14.5**[d]	1
CENTRAL FACILITIES AREA LANDFILL WELLS			
ANIONS			
Chloride (mg/L)	*250*	54.5	0
Sulfate (mg/L)	*250*	39.8	0
Nitrate/nitrite (mg-N/L)	10	2.43	0
COMMON CATIONS			
Calcium (µg/L)	None	48,200	NA[e]
Magnesium (µg/L)	None	20,200	NA
Potassium (µg/L)	None	5,510	NA
Sodium (µg/L)	None	28,900	NA
INORGANIC ANALYTES			
Antimony (µg/L)	6	ND[f]	0
Aluminum (µg/L)	*50–200*	166	0
Arsenic (µg/L)	10	2.64	0
Barium (µg/L)	2,000	96.6	0
Beryllium (µg/L)	4	ND	0
Cadmium (µg/L)	5	ND	0
Chromium (µg/L)	100	67.6	0
Copper (µg/L)	*1,300/1,000*	5.04	0
Iron (µg/L)	*300*	**2,090**	2
Lead (µg/L)	15	3.02	0
Manganese (µg/L)	50	22.5	0
Mercury (µg/L)	2	ND	0
Nickel (µg/L)	None	59.5	NA
Selenium (µg/L)	50	ND	0
Silver (µg/L)	100	ND	0
Thallium (µg/L)	2	ND	0

Table 6-9. continued.

COMPOUND	MCL[a] OR SMCL[b]	MAXIMUM DETECTED VALUE	NUMBER OF WELLS ABOVE MCL OR SMCL
Vanadium (µg/L)	None	6.20	NA
Zinc (µg/L)	*5,000*	881	0
DETECTED VOLATILE ORGANIC COMPOUNDS			
Chloroform (µg/L)	80	0.90	0

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

Water level measurements taken in the CFA area decreased an average of 0.75 ft from August 2020 to August 2021. A water level contour map based on August 2021 water levels showed groundwater gradients and flow directions consistent with previous maps (DOE-ID 2021c).

6.5.5 Summary of Waste Area Group 7 Groundwater Monitoring Results

Groundwater samples collected from nine monitoring wells near the RWMC in April/May 2021 were analyzed for radionuclides, inorganic constituents, and VOCs. Of the 256, 15 met reportable criteria established in the *Field Sampling Plan for Operable Unit 7-13/14 Aquifer Monitoring* (DOE-ID 2021d). Table 6-10 lists maximum concentrations of reportable contaminants of concern in 2021, and a discussion of those results follows. No analytes were detected above their respective MCLs in samples collected from the aquifer in April/May 2021. Figure 6-14 depicts the WAG 7 aquifer well monitoring network.

- ***Carbon tetrachloride*** – Carbon tetrachloride was detected above the quantitation limit (1 µg/L) at seven monitoring locations in April/May 2021. The carbon tetrachloride concentrations decreased or remained stable in most wells near and downgradient of the RWMC, except for Well M7S, which increased slightly from the 2020 concentration, as shown in Figures 6-15 and 6-16.

Table 6-10. Summary of WAG 7 aquifer analyses for April/May 2021 sampling.

ANALYTE	NUMBER OF WELLS SAMPLED	NUMBER OF SAMPLES ANALYZED[a]	NUMBER OF REPORTABLE DETECTIONS[a,b]	CONCENTRATION MAXIMUM[a]	LOCATION OF MAXIMUM CONCENTRATION	NUMBER OF DETECTIONS GREATER THAN MCL[c]	MCL[c]
Carbon tetrachloride	9	11	7	4.27 µg/L	M15S	0	5 µg/L
Trichloroethylene	9	11	4	2.97 µg/L	M15S	0	5 µg/L
Nitrate (as nitrogen)	9	11	4	2.02 mg/L	M6S	0	10 mg/L

a. Includes field duplicate samples collected for quality control purposes and samples collected from wells with multiple ports.
b. Results that exceeded reporting criteria as established in the Operable Unit 7-13/14 Field Sampling Plan (DOE-ID 2021d).
c. MCL = maximum contaminant level. MCLs are from "National Primary Drinking Water Regulations" (40 CFR 141).

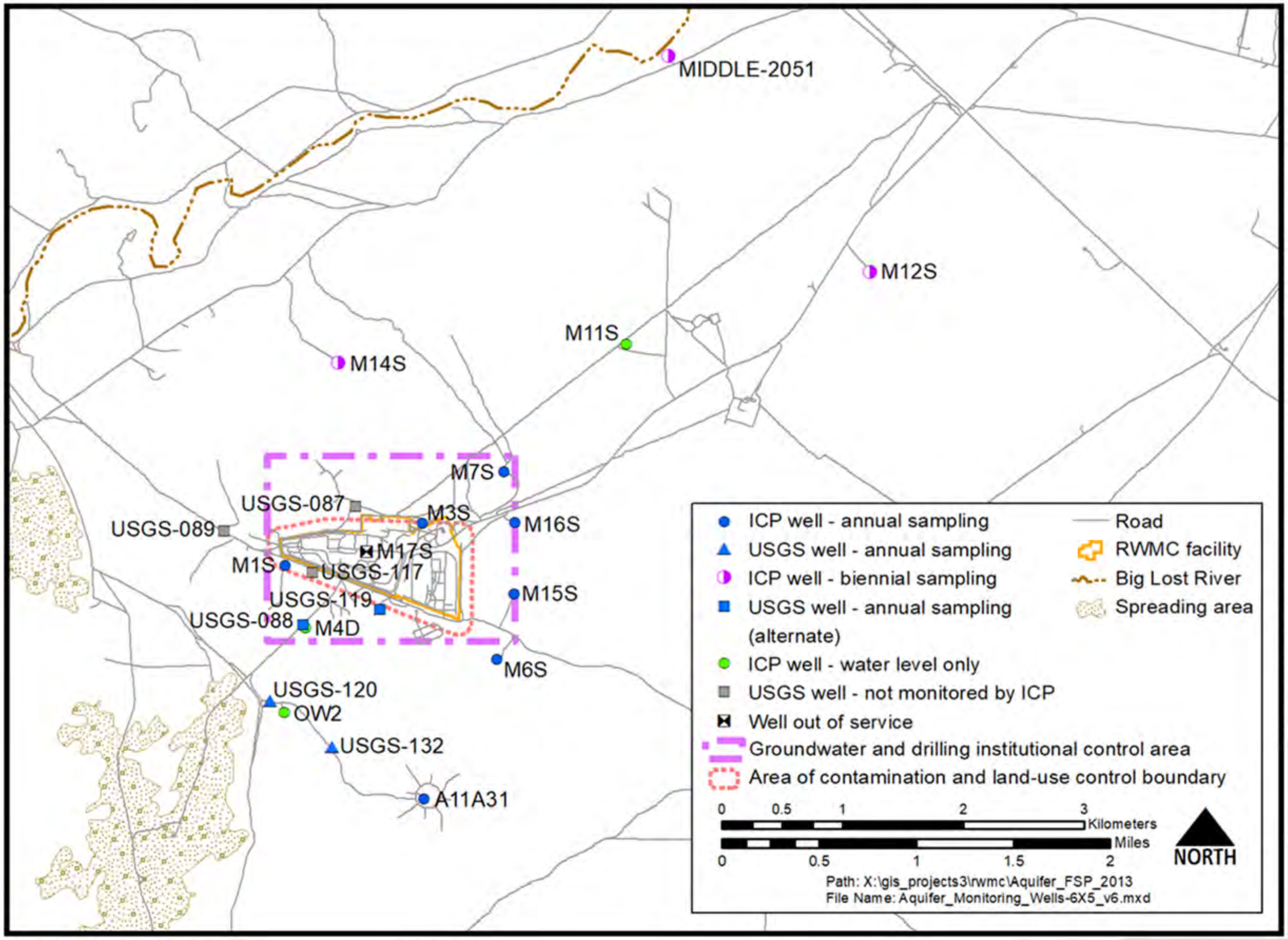

Figure 6-14. The WAG 7 aquifer well monitoring network at the RWMC (DOE-ID 2021d).

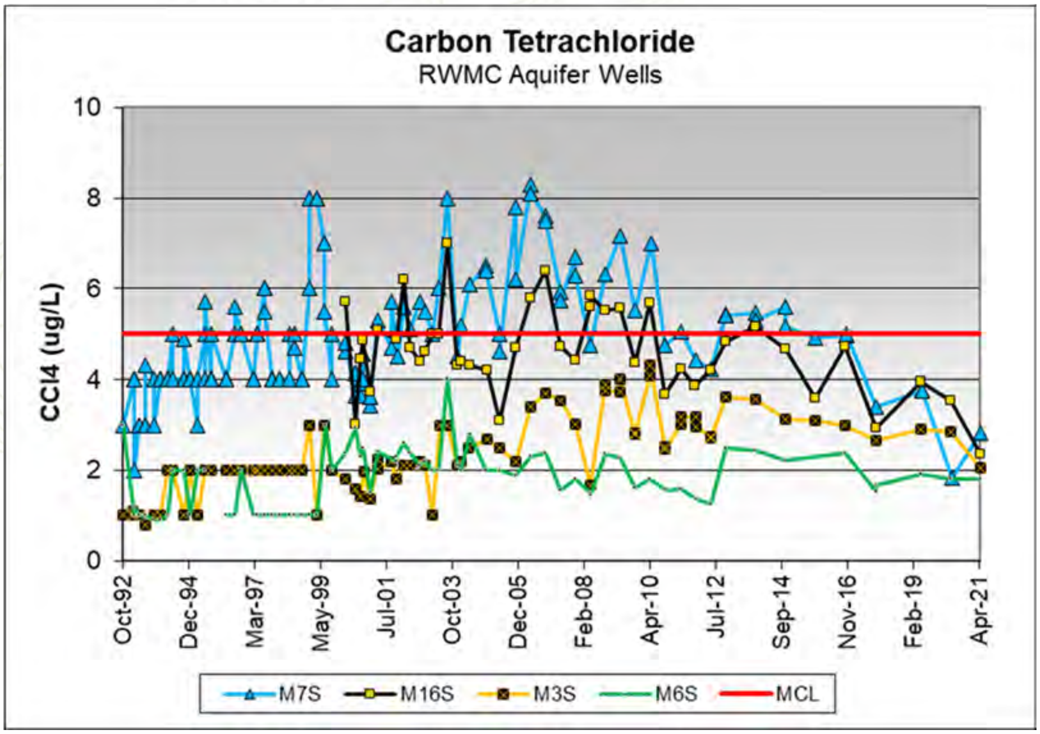

Figure 6-15. Carbon tetrachloride (CCl4) concentration trends in RWMC aquifer Wells M7S, M16S, M3S, and M6S.

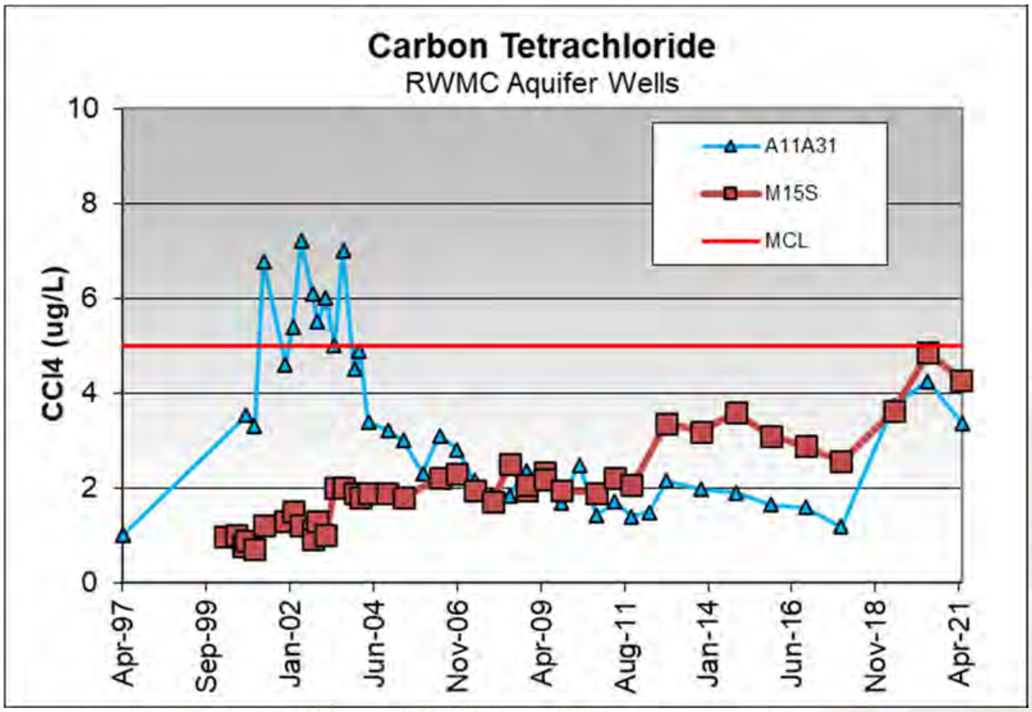

Figure 6-16. Carbon tetrachloride (CCl4) concentration trends in RWMC aquifer Wells A11A31 and M15S.

- ***Trichloroethylene*** – In April/May 2021, the concentrations of reportable trichloroethylene (>1 µg/L) either decreased or remained steady in most wells near and downgradient of the RWMC shown in Figure 6-17, except for Well M7S, which exhibited a slight increase from 2020. However, no concentrations were detected above the MCL of 5 µg/L.
- ***Radiological analytes*** – Radiological analytes were not detected above reporting thresholds in groundwater samples collected from the WAG 7 monitoring network in 2021.
- ***Inorganic analytes*** – Nitrate (as nitrogen) was the only inorganic analyte detected above its reporting threshold (background concentration of 1.05 mg/L) in 2021, which was calculated based on maximum concentrations in upgradient background wells (DOE-ID 2021d).

As in previous years, groundwater level measurements in RWMC-area monitoring wells were taken prior to sample collection for the April/May 2021 event. These measurements indicate groundwater flow toward the south beneath RWMC as shown in Figure 6-18.

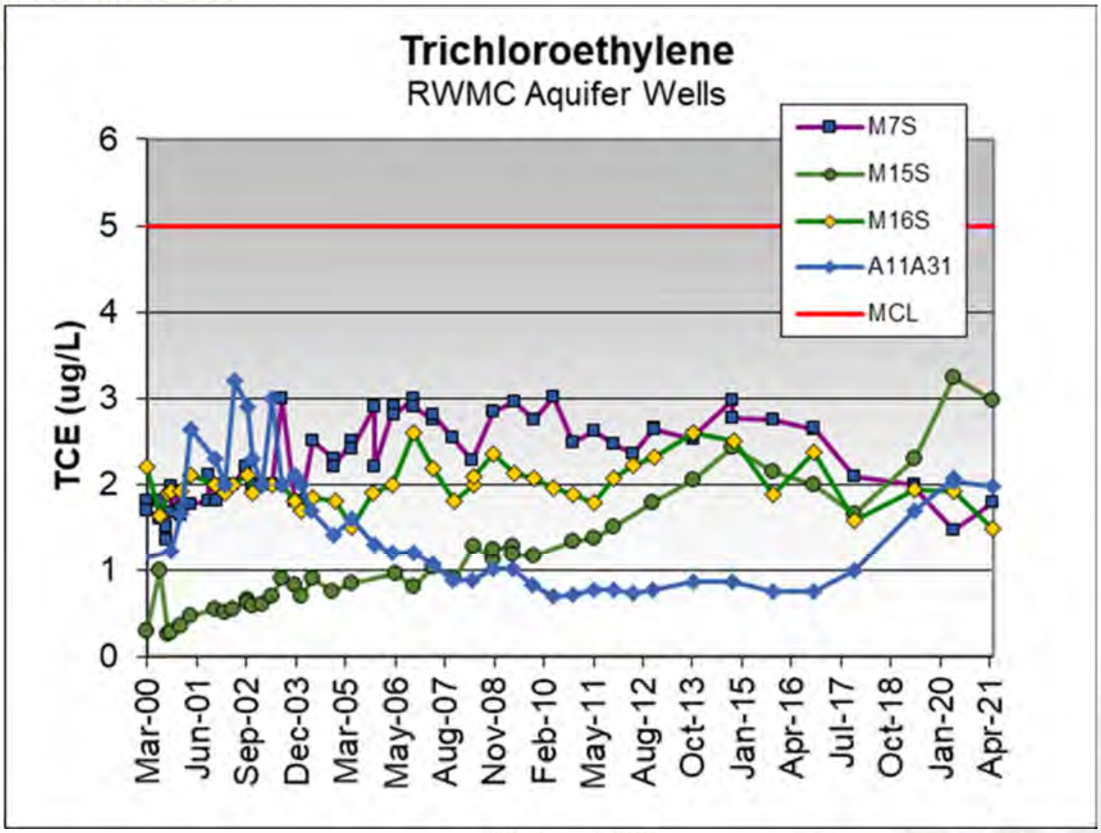

Figure 6-17. Concentration history of TCE in aquifer Wells M7S, M15S, M16S, and A11A31.

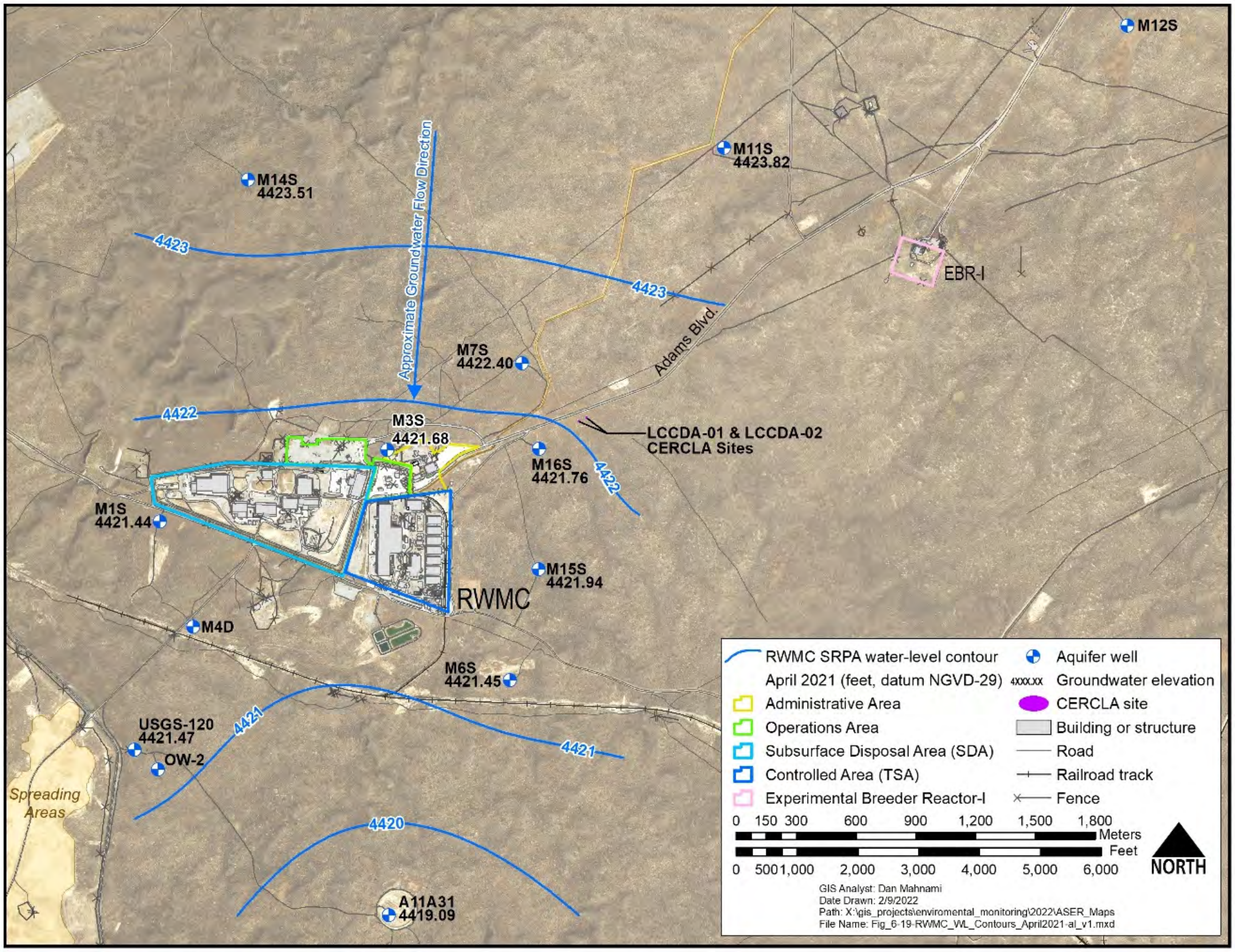

Figure 6-18. Groundwater-level contours in the aquifer near the RWMC, based on 2021 measurements.

6.5.6 Summary of Waste Area Group 9 Groundwater Monitoring Results

Five wells (four monitoring and one production) at the MFC are sampled twice per year by the INL contractor for selected radionuclides, metals, anions, cations, and other water quality parameters, as surveillance monitoring under the WAG 9 Record of Decision (Figure 6-19; ANL-W 1998). The 2021 results are summarized in Table 6-11. Overall, the data show no discernable impacts from activities at the MFC.

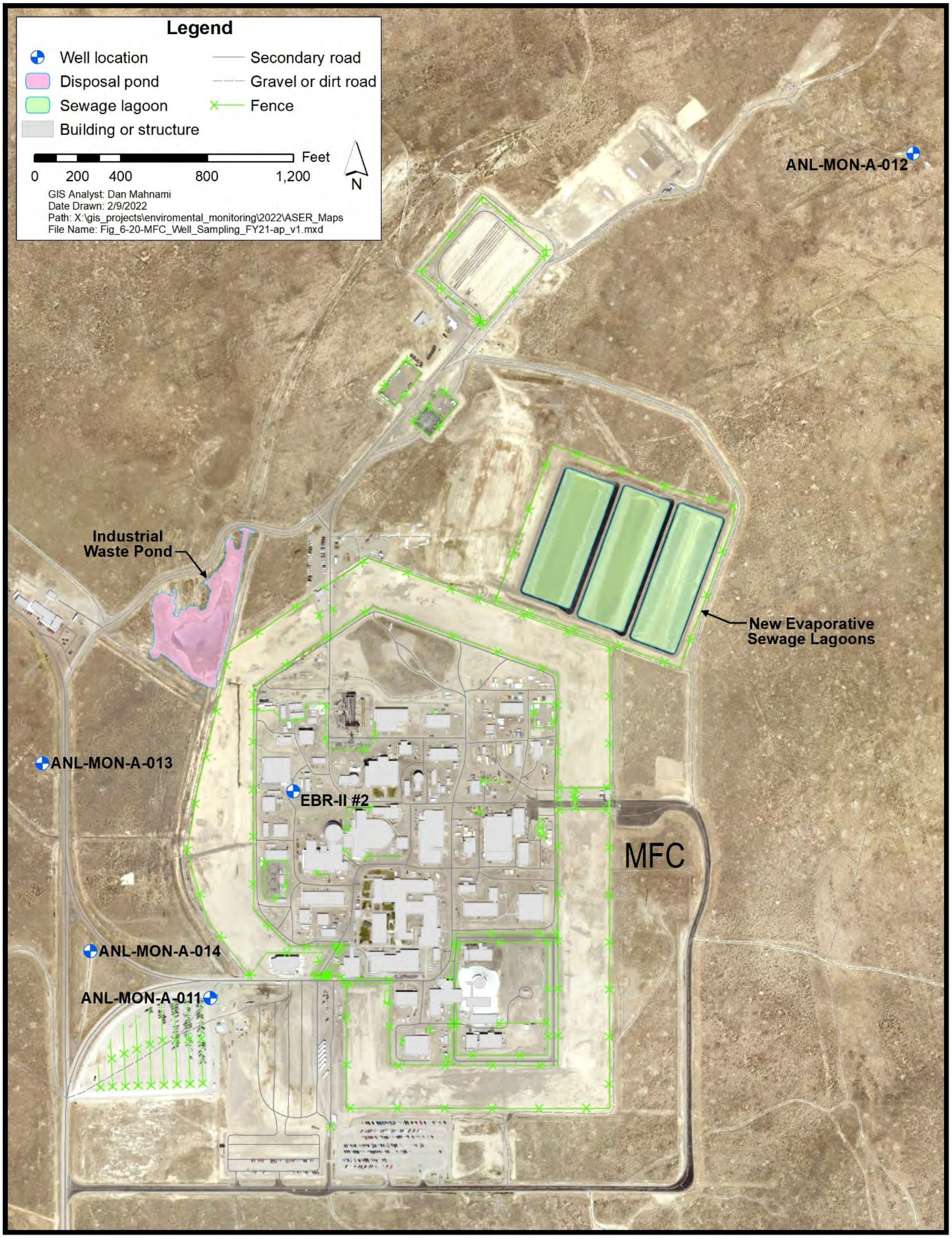

Figure 6-19. Locations of WAG 9 wells sampled in 2021.

Table 6-11. Comparisons of detected analytes to groundwater standards at WAG 9 monitoring wells (2021).

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:	4/26/2021	9/30/2021	4/20/2021	10/7/2021[c]	4/21/2021	9/29/2021	4/21/2021	9/29/2021	4/26/2021	9/30/2021	
RADIONUCLIDES[d]											
Gross alpha (pCi/L)	1.07 ± 0.297	1.76 ± 0.457	ND[e]	1.58 ± 0.317	ND	ND	ND (ND)	ND	ND	ND	15 pCi/L
Gross beta (pCi/L)	3.67 ± 0.270	2.97 ± 0.402	3.86 ± 0.360	2.78 ± 0.249	2.64 ± 0.236	3.47 ± 0.453	5.02 ± 0.245 (2.18 ± 0.181)[f]	2.09 ± 0.334	2.25 ± 0.183	1.19 ± 0.312	4 mrem/yr[g]
Uranium-233/234 (pCi/L)	1.30 ± 0.138	1.18 ± 0.163	1.44 ± 0.146	1.26 ± 0.164	1.31 ± 0.129	1.48 ± 0.202	1.30 ± 0.134 (1.52 ± 0.141)	1.46 ± 0.190	1.27 ± 0.131	1.24 ± 0.172	186,000 pCi/L (30 µg/L)
Uranium-238 (pCi/L)	0.626 ± 0.085	0.594 ± 0.108	0.727 ± 0.0947	0.570 ± 0.105	0.588 ± 0.0779	0.709 ± 0.129	0.544 ± 0.0796 (0.666 ± 0.0845)	0.787 ± 0.131	0.525 ± 0.0764	0.572 ± 0.108	9.9 pCi/L (30 µg/L)
Uranium-235 (pCi/L)	ND	ND	ND	ND	ND	ND	ND (ND)	ND	ND	ND	NA[h]
METALS[i]											
Arsenic (mg/L)	0.00267	0.00210	0.00264	0.002U	0.00276	0.00255	0.00276 (0.00334)	0.00207	0.00317	0.00219	0.05
Barium (mg/L)	0.0360	0.0356	0.0385	0.0391	0.0362	0.0377	0.0379 (0.0383)	0.0363	0.0353	0.0359	2
Calcium (mg/L)	39.9J[e]	38.0	38.9	39.1	39.8	39.2	37.8 (39.5)	38.2	41.2J	37.7	NA
Chromium (mg/L)	0.003U[e]	0.003U	0.003U	0.003U	0.003U	0.00401	0.003U (0.003U)	0.00408	0.003U	0.003U	0.01
Copper (mg/L)	0.0003U	0.000308U	0.000422	0.000520	0.000680	0.000564U	0.000447 (0.000560)	0.000401U	0.00615	0.00337U	1.3
Iron (mg/L)	0.03U	0.03U	0.03U	0.03U	0.03U	0.0484	0.03U (0.03U)	0.03U	0.0752	0.03U	0.3
Lead (mg/L)	0.0005U	0.0005U	0.0005U	0.0005U	0.0005U	0.0005U	0.0005U (0.0005U)	0.0005U	0.00133	0.00101	0.015
Magnesium (mg/L)	13.1J	12.4	11.9	12.2	12.9	12.9	11.9 (12.5)	12.2	13.4J	12.0	NA
Manganese (mg/L)	0.001U	0.001U	0.001U	0.001U	0.00124	0.001U	0.001U (0.001U)	0.001U	0.001U	0.001U	0.05
Nickel (mg/L)	0.0006U	0.0006U	0.0006U	0.0006U	0.000820	0.000609	0.0006U (0.0006U)	0.0006U	0.00371	0.00329	NA
Potassium (mg/L)	3.39	3.48	3.65	3.45	3.42	3.65	3.48 (3.53)	3.47	3.37	3.57	NA
Sodium (mg/L)	18.5	17.4	17.2	17.6	18.9	20.5	17.2 (17.9)	18.2	19.2	17.0	NA

Table 6-11. continued

WELL:	ANL-MON-A-011		ANL-MON-A-012		ANL-MON-A-013		ANL-MON-A-014		EBR-II[a] NO. 2		PCS/SCS[b]
Vanadium (mg/L)	0.00662	0.00544	0.00509	0.00454	0.00633	0.00889	0.00641 (0.00863)	0.00556	0.00817	0.00543	NA
Zinc (mg/L)	0.0033U	0.0033U	0.0033U	0.0033U	0.0033U	0.0033U	0.0033U (0.0033U)	0.0033U	0.0237	0.0183	5
ANIONS											
Chloride (mg/L)	18.4	16.5	15.8J	15.6	17.8	18.6	17.7 (16.6)	15.9	17.4	15.6	250
Nitrate-as nitrogen (mg/L)	2.50	2.43J	2.32J	2.34	2.39	2.28	2.43 (2.43)	2.49	2.50	2.39R[j]	10
Phosphorus (mg/L)	0.0593U	0.0235J	0.0974U	0.0274UJ[e]	0.0876U	0.0207J	0.0461U (0.0866U)	0.0183UJ	0.0794U	0.0282J	NA
Sulfate (mg/L)	19.6J	18.5	18.7J	18.0	19.3	20.7	19.7 (19.8)	18.3	19.3J	18.2	250
WATER QUALITY PARAMETERS											
Alkalinity (mg/L)	140	140	144	140	147	144	138 (143)	141	141	141	NA
Bicarbonate alkalinity (mg/L)	140	140	142	140	147	144	138 (143)	141	141	141	NA
Total dissolved solids (mg/L)	240	216	233	246	240	226	266 (221J)[k]	220	234	213	500

a. EBR-II = Experimental Breeder Reactor II. Also known as well ANL 2.

b. PCS = primary constituent standard; SCS = secondary constituent standard, as specified in the state of Idaho Ground Water Quality Rule, IDAPA 58.01.11.

c. ANL-MON-A-012 was initially sampled on 9/28/2021, but due to an enroute shipping delay the well was re-sampled on 10/7/21.

d. Result ± 1s uncertainty. Only analytes with at least one statistically positive result >3s uncertainty are shown. Samples were analyzed for gross alpha; gross beta; tritium; gamma-emitting radionuclides such as 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; and alpha-emitting radionuclides such as americium-241, uranium-233/234, uranium-235, and uranium-238.

e. ND = not detected; J = associated value is an estimate and may be inaccurate or imprecise; U = the analyte was not detected above the instrument detection limit or the analyte was detected at or above the applicable detection limit, but the value is not more than 5 times the highest positive amount in any laboratory blank; UJ = the sample was analyzed for but was not detected. The associated value is an estimate and may be inaccurate or imprecise.

f. Results for field duplicate samples shown in parentheses.

g. The Ground Water Quality Rule, IDAPA 58.01.11, specifies a Primary Constituent Standard (PCS) for combined beta/photon emitters of 4 millirems/year effective dose equivalent. Speciation of the individual radionuclides present would be necessary to determine the equivalent PCS in units of pCi/L. For comparison purposes, the EPA also specifies a Maximum Contaminant Level (MCL) of 4 mrem/yr for public drinking water systems and uses a screening level of 50 pCi/L. Public drinking water samples with gross beta activity greater than 50 pCi/L must be analyzed to identify the major radionuclides present.

h. NA = not applicable. A primary or secondary constituent standard has not been established for this constituent

i. Metals reported as non-filtered unless noted.

j. Due to enroute shipping delays, sample was received by the laboratory beyond the method hold-time. Validator qualified the result as “R” (rejected) due to analysis past 2-times the recommended hold time.

k. Reanalysis of the original TDS field duplicate result is reported. The reanalysis was requested to address quality control issues during data review. The reanalysis occurred beyond the allowable hold-time and the result was qualified J during the data validation process.

6.5.7 Summary of Waste Area Group 10 Groundwater Monitoring Results

In accordance with the Operable Unit 10-08 monitoring plan (DOE-ID 2021e), groundwater samples are collected every two years at the locations shown on Figure 6-20. In 2021, seven wells and three intervals from two Westbay® wells were sampled. Groundwater samples from all wells were analyzed for chloride, nitrate/nitrite as nitrogen, gross alpha, and gross beta. Sulfate and volatile organic compounds were collected from a subset of Operable Unit 10-08 monitoring wells. None of the noted analytes exceeded EPA MCLs or SMCLs (Table 6-12; DOE-ID 2022e).

Table 6-12. WAG 10 aquifer groundwater quality summary (June 2021).

ANALYTE	MCL[a] or SMCL[b]	MAXIMUM	MINIMUM	NUMBER OF WELLS ABOVE MCL
ANIONS				
Chloride (mg/L)	*250*[c]	20.4	11.3	0
Sulfate (mg/L)	*250*	25.3	4.13	0
Nitrate/nitrite (mg-N/L)	10	2.47	0.165	0
RADIONUCLIDES				
Gross alpha (pCi/L)	15	ND[d]	ND	0
Gross beta (pCi/L)	4 mrem/yr[e]	5.19	ND	0
DETECTED VOLATILE ORGANIC COMPOUNDS				
None	–	ND	ND	0

a. MCL = maximum contaminant level.

b. SMCL = secondary maximum contaminant level.

c. Numbers in *italic* text are for the secondary MCL.

d. ND = not detected.

e. The Ground Water Quality Rule, IDAPA 58.01.11, specifies a PCS for combined beta/photon emitters of 4 millirems/year effective dose equivalent. Speciation of the individual radionuclides present would be necessary to determine the equivalent PCS in units of pCi/L. For comparison purposes, the EPA also specifies a MCL of 4 mrem/yr for public drinking water systems and uses a screening level of 50 pCi/L. Public drinking water samples with gross beta activity greater than 50 pCi/L must be analyzed to identify the major radionuclides present.

6.6 Remote-Handled Low-Level Waste Disposal Facility

The INL contractor monitors groundwater at the RHLLW Disposal Facility to demonstrate compliance with DOE O 435.1, “Radioactive Waste Management,” and IDAPA 58.01.11, “Ground Water Quality Rule”. Samples were collected from three monitoring wells in 2021 and analyzed for gross alpha, gross beta, carbon-14 (^{14}C), ^{129}I, ^{99}Tc, and tritium in accordance with PLN-5501, “Monitoring Plan for the INL RHLLW Disposal Facility” as shown in Figure 6-21. Results for analytes with positive detections are summarized in Table 6-13. Tritium and gross beta were detected in all three wells, while gross alpha was positively detected in one of the three wells. Carbon-14, ^{129}I, and ^{99}Tc were not detected in any samples. All results are consistent with concentrations in the aquifer established prior to facility completion (INL 2017). The 2021 results show no discernable impacts to the aquifer from RHLLW Disposal Facility operations.

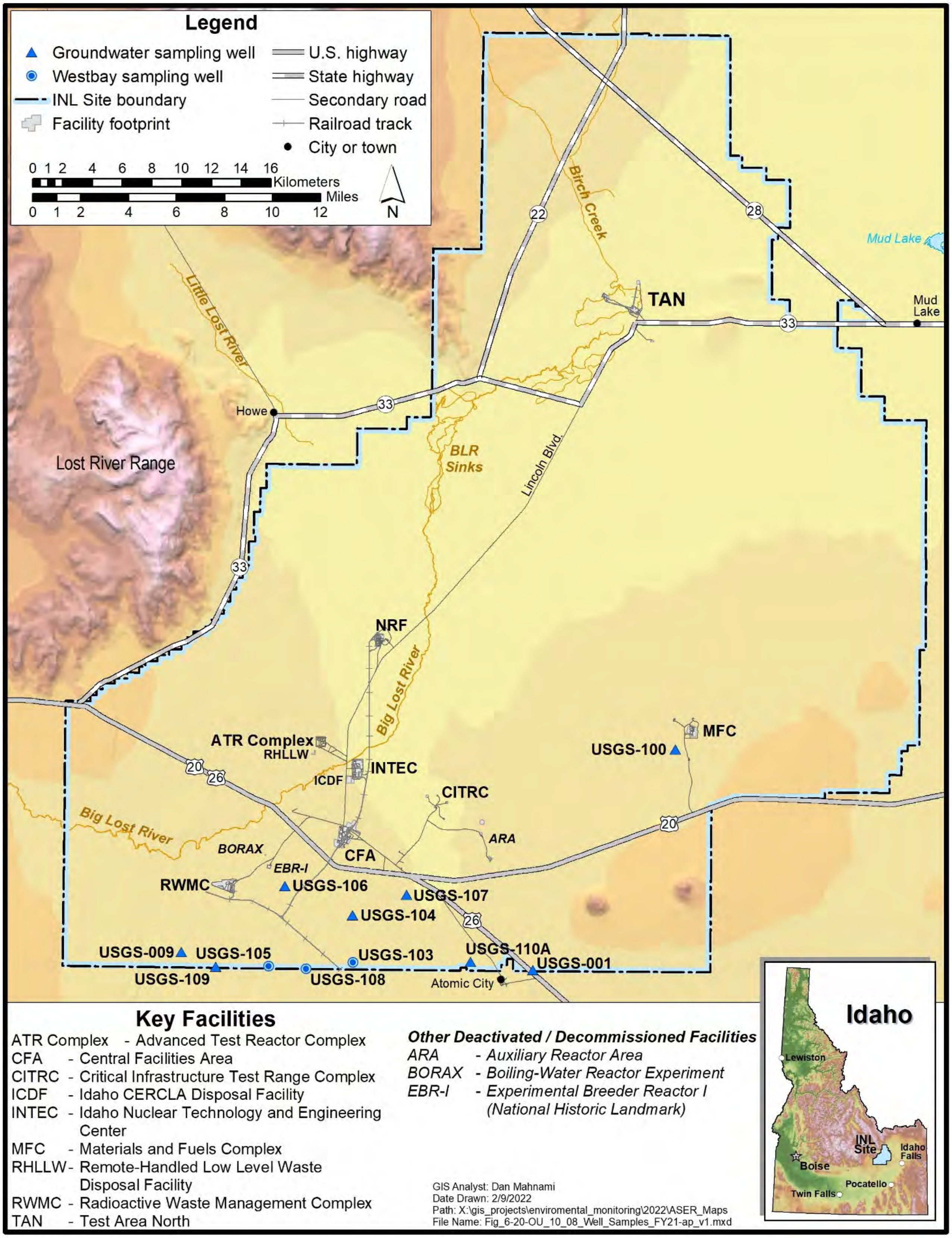

Figure 6-20. Well locations sampled for Operable Unit 10-08.

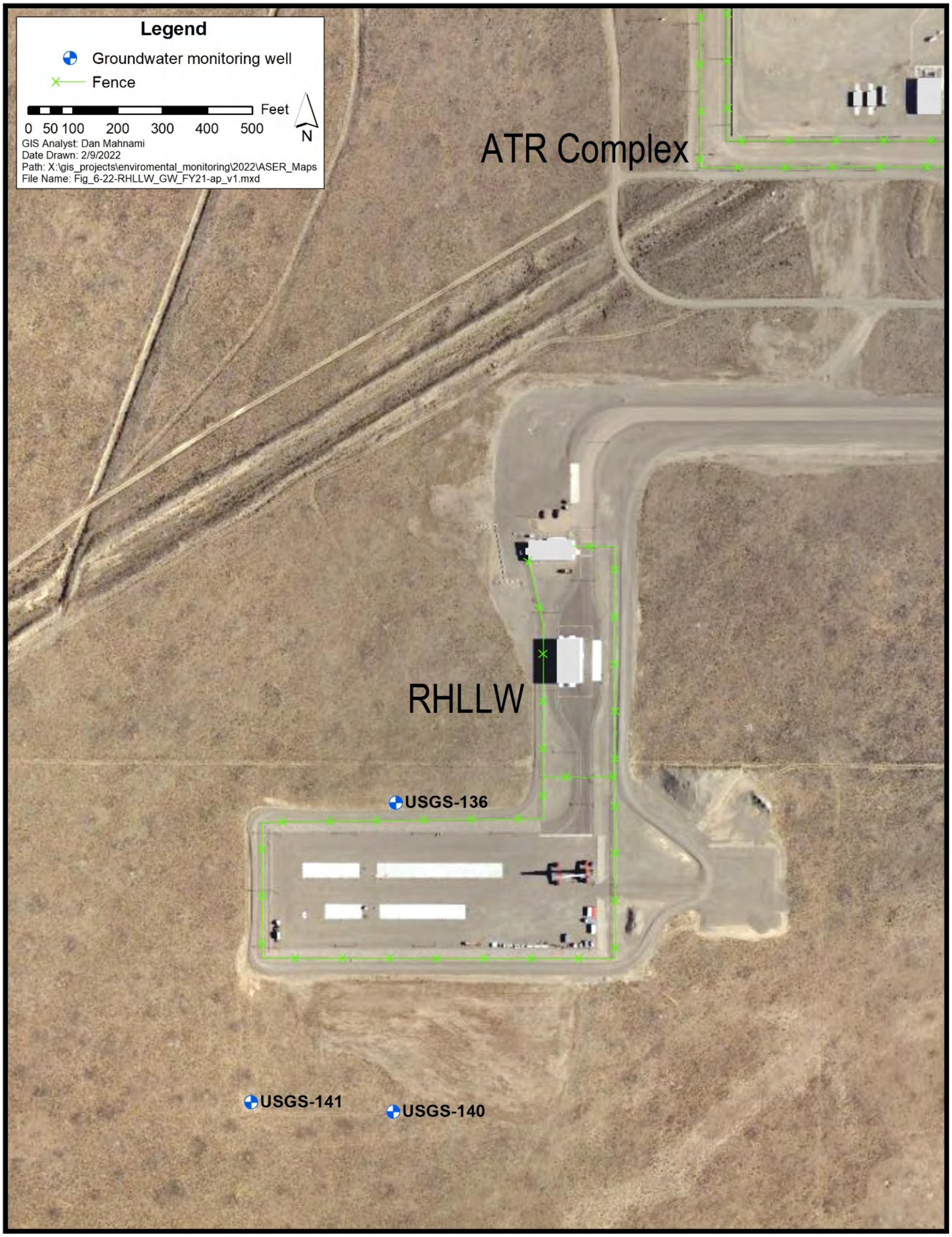

Figure 6-21. Well Locations Sampled for RHLLW Facility.

Table 6-13. Radioactivity detected in surveillance groundwater samples collected at the RHLLW Facility (2021).

WELL:	USGS-136	USGS-140	USGS-141	PCS/SCS[a]
SAMPLE DATE:	4/15/2021	4/19/2021	4/19/2021	
RADIONUCLIDES[b]				
Gross alpha (pCi/L)	ND[c]	ND (ND)[d]	1.06 ± 0.337	15 pCi/L
Gross beta (pCi/L)	2.14 ± 0.260	2.47 ± 0.260 (2.30 ± 0.254)	1.65 ± 0.254	4 mrem/yr[e]
Tritium (pCi/L)	916 ± 149	624 ± 126 (853 ± 143)	608 ± 125	20,000 pCi/L

a. PCS = Primary Constituent Standard, SCS = Secondary Constituent Standard, as specified in the state of Idaho Ground Water Quality Rule, IDAPA 58.01.11.

b. Result ± 1s. Only analytes with at least one statistically positive result >3s uncertainty are shown. Samples were analyzed for gross alpha, gross beta, carbon-14, iodine-129, technecium-99, and tritium.

c. ND = Not Detected.

d. Duplicate sample results are shown in parentheses.

e. The Ground Water Quality Rule, IDAPA 58.01.11, specifies a PCS for combined beta/photon emitters of 4 millirems/year effective dose equivalent. Speciation of the individual radionuclides present would be necessary to determine the equivalent PCS in units of pCi/L. For comparison purposes only, the EPA also specifies MCL of 4 mrem/yr for public drinking water systems and uses a screening level of 50 pCi/L. Public drinking water samples with gross beta activity greater than 50 pCi/L must be analyzed to identify the major radionuclides present.

In addition to compliance monitoring of groundwater at the RHLLW Disposal Facility, facility performance is monitored by collecting and analyzing soil-pore water samples, where sufficient water is present, from vadose-zone lysimeters installed in native materials adjacent to and below the base of the vault arrays. The baseline for the soil-pore water samples will be established over the initial three years of operation in 2019, 2020, and 2021. The third year of soil-pore water baseline sampling was collected in 2021. The 2019 - 2021 soil-porewater data will be evaluated in 2022, and the soil-pore water baseline will be established for lysimeter locations with sufficient data. Additional baseline data collection may continue in 2022 and beyond to address data gaps at locations where insufficient soil-pore water for sampling persists. Future soil-pore water sample results will be compared to the baseline measurements, where established, and used as early indicators of facility operations and key assumptions. For establishment of the baseline, soil-pore water samples are analyzed for the same target and indicator analytes as the aquifer compliance samples (e.g., gross alpha, gross beta, tritium, ^{14}C, ^{129}I, and ^{99}Tc).

6.7 Onsite Drinking Water Sampling

The INL and ICP Core contractors monitor drinking water to ensure that 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 are sampled according to a 9-year monitoring cycle, which identifies the specific classes of contaminates to monitor at each drinking water source, and the frequency (https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=30006644.txt). 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.

The INL Site has 10 drinking water systems that are monitored by the INL and ICP Core contractors. The INL contractor monitors eight of these drinking water systems and the ICP Core contractor monitors two. The Naval Reactors Facility also monitors a drinking water system. The results are not included in this annual report but are addressed in the *Naval Reactors Facility Environmental Monitoring Report for Calendar Year 2021* (FMP 2022). 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 four INL contractor transient, non-community water systems are located at EBR-I, Gun Range (Live Fire Test Range), CITRC, and the Main Gate. The four remaining INL contractor water systems are classified as non-transient, non-community water systems, and are located at CFA, MFC, the ATR Complex, and TAN/CTF. The two ICP Core contractor non-transient, non-community water systems are INTEC and the RWMC.

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

The INL and ICP Core contractors monitor certain parameters more frequently than required by regulation because of low volume usage on weekends. For example, bacterial analyses are conducted monthly rather than quarterly at all eight INL contractor drinking water systems and at the two ICP Core contractor drinking water systems during months of operation. Because of known groundwater plumes near one ICP Core contractor drinking water well, additional sampling is conducted for carbon tetrachloride at RWMC.

6.7.1 Idaho National Laboratory Site Drinking Water Monitoring Results

During 2021, the INL contractor collected 168 routine/compliance samples and 36 quality control samples from eight INL Site drinking water systems. Also, part of the routine drinking water monitoring is our radiological sampling. Semi-annual sampling is done at all eight water systems for gross alpha, beta, and tritium. CFA water system was also sampled for ^{129}I due to being down gradient of the plume from the north. Table 6-14 lists detections in routine/compliance and radiological surveillance monitoring. In addition to routine samples, the INL contractor also collected 120 surveillance samples including: bacteriological, lead and copper, and perfluoroalkyl substances (PFAS).

The ICP Core contractor collected 14 routine/compliance samples and eight quality control samples from two ICP Core drinking water systems. ICP Core also collected 111 surveillance bacteriological, synthetic organic compounds and VOCs samples. Two gross alpha/beta samples were collected semiannually from both ICP Core drinking water systems. One tritium sample was also collected from each drinking water system as shown in Table 6-14.

All INL and ICP Core drinking water systems were well below regulatory limits for drinking water or there were no detections. See Table 6-14 for a summary. Since all the water systems are public water systems (PWS); their data is listed on the DEQ’s PWS Switchboard at www.deq.idaho.gov.

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 3.57 mg/L at CFA and 2.20/2.26 mg/L at MFC well #1/2 respectively. Samples for the total trihalomethanes (TTHMs), and haloacetic acids (HAA5) were collected at the ATR-Complex, MFC, and TAN/CTF as seen in Table 6-14. The ICP Core contractor sampled for nitrates at both INTEC and RWMC, and all values were less than the MCL of 10 mg/L.

The EPA is actively researching and beginning to establish regulations for a class of very widely used and dispersed man-made-chemicals called PFAS, which are considered to be an ‘emerging contaminant’ of concern and have been used in industry and consumer products worldwide since the 1950s in non-stick cookware, water-repellent clothing, stain resistant fabrics and carpets, some cosmetics, some firefighting foams, and products that resist grease, water, and oil. Many of the common PFAS have been phased out of production. These chemicals do not degrade in the environment. During production and use, PFAS can migrate into the soil, water, and air. Because of their widespread use and their persistence in the environment, PFAS are found in the blood of people and animals all over the world and are present at low levels in a variety of food products and the environment. Some PFAS can build up in people and animals with repeated exposure over time. Research involving humans suggests that high levels of certain PFAS may lead to

Table 6-14. Summary of INL Site drinking water results (2021).

CONSTITUENT	MCL (units)	ATR COMPLEX 6120020	CFA 6120008	CITRC 6120019	EBR-I 6120009	GUN RANGE 6120025	MAIN GATE 6120015	MFC 6060036	TAN CTF 6120021	RWMC PWS 6120018	INTEC PWS 6120012
RADIOLOGICAL SURVEILLANCE MONITORING											
Gross Alpha[a]	15 pCi/L	ND[b]	ND	ND-3.05	ND	ND	ND	ND-4.68	ND	2.08 – 3.15	ND
Gross Beta[a]	50 pCi/L screening or 4 mrem	ND	4.25-4.28	ND-5.65	ND-2.68	2.43-2.72	ND	1.94-10.5	2.50-2.67	ND - 2.87	1.88 – 2.88
Tritium[a]	20,000 pCi/L	ND	2,310-2,640	ND	ND	ND-284	ND	ND	ND	ND	ND
Iodine-129[c]	1 pCi/L	–	ND	–	–	–	–	–	–	–	–
COMPLIANCE MONITORING											
Nitrate	10 mg/L	ND	3.57	ND	ND	ND	ND	2.20/2.26	ND	ND	ND
Total trihalomethanes	80 ppb	ND	5.0	NA[c]	NA	NA	NA	2.8	1.3	1.5	ND
Total coliform	2 or more present	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
E. coli	Present	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
HAA5s	60 ppb	ND	ND	NA	NA	NA	NA	ND	ND	ND	NA
SOCs/VOCs[d]	SOCs varies, 5 ppb for most VOCs	ND	ND	NA	NA	NA	NA	ND	ND	ND	ND

a. Range of results (minimum – maximum) presented.

b. ND = not detected.

c. NA = not applicable based on water system classification.

d. SOCs = synthetic organic compounds and VOCs = volatile organic compounds.

numerous health impacts. A common pathway for humans to be potentially impacted by PFAS is through drinking contaminated water.

In 2021, INL and ICP Core contractors sampled 13 out of 16 wells that supply water to their ten water systems as part of a voluntary Idaho state initiative involving a select group of drinking water systems to explore the potential for the existence of PFAS in Idaho's drinking water sources. The results of this effort will be reported by DOE in the near future.

6.7.1.1 Advanced Test Reactor Complex, PWS 6120020

There are over 500 employees assigned to the ATR Complex. The water system has a continuous chlorination system to disinfect the water on a voluntary basis as an added protection. A new potable well was completed for the ATR Complex in September 2019. This gives the ATR Complex two drinking water wells. Since both are approximately 600 feet deep and less than 100 feet apart, they are designated as a wellfield. Compliance samples are collected from the wellfield at TRA-696 for most constituents. Other compliance samples are collected from the distribution system as required by the regulations. In 2021 all compliance samples were below the MCL, which includes the monthly bacteriological (i.e., total coliform and E. coli) samples. These wells can pump over 200 gpm. Water is also supplied to the RHLLW Facility which is outside the fence of the ATR Complex.

6.7.1.2 Central Facilities Area, PWS 6120008

The CFA water system has two wells that serves a little over 500 people daily. The two wells are 639 and 681 feet deep and they pump over 600 gpm. The water system is continuously disinfected on a voluntary basis as an added protection. Compliance samples are collected from the manifold at CFA-1603 for most constituents. Other compliance samples are collected from the distribution system as required by the regulations. In 2021, all constituents sampled were below the MCL, which includes the monthly bacteriological (i.e., total coliform and E. coli) samples.

6.7.1.3 CITRC Facility, PWS 6120019

At present, there are no permanent employees at CITRC. The water system has a continuous chlorination system to disinfect the water. CITRC #1 well is located at PBF 602 and is 653 feet deep and can pump 400 gpm. CITRC #2 well is located at PBF-614. The well is 1,217 feet deep and can pump 800 gpm. Compliance samples are collected from the manifold, located at PBF-638. In 2021, all compliance samples were below the MCL, which includes the monthly bacteriological (i.e., total coliform and E. coli) samples.

6.7.1.4 EBR-I, PWS 6120009

EBR-I has a public water system that is open to the public from Memorial Day to Labor Day with scheduled tours throughout the year. There are no personnel stationed at this facility. The well is 1,075 feet deep. EBR-I is one of four water systems at INL that does not automatically disinfect. The water system and well were constructed in 1949. In 2021, all compliance samples were below the MCL, which includes the monthly bacteriological (i.e., total coliform and E. coli) samples.

6.7.1.5 Gun Range Facility, PWS 6120025

There are seven employees that are permanently stationed at the Gun Range Facility. In 2010 continuous chlorination was discontinued due to an ongoing history of no bacteria (i.e., total coliform and E. coli). The well is located at B21-607 and was completed in January 1990. The well is 626 feet deep. The well pumps 20 gpm. Compliance samples are collected from the B21-607 well for most constituents. Bacteriological (i.e., total coliform and E. coli) compliance samples are collected from the distribution system as required by the regulations. In 2021, all sampled constituents were below the MCL, which includes the monthly bacteriological samples.

6.7.1.6 Main Gate Badging Facility, PWS 6120015

There are three employees permanently stationed at the Main Gate Badging Facility. The well is located at B27-605 and was completed January 1985. The well is 644 feet deep. The well pumps 20 gpm. Compliance samples are collected from the B27-605 well for most constituents. Bacteriological (i.e., total coliform and E. coli) compliance samples are collected from the distribution system as required by the regulations. In 2021 all constituents sampled for were below the MCL; which includes the monthly bacteriological samples.

6.7.1.7 Materials and Fuels Complex, PWS 6060036

There are 1,000 employees located at MFC. The water system has a continuous chlorination system to disinfect the water on a voluntary basis as an added protection. Well #1 is located at MFC-754 and Well #2 at MFC-756. Well #1 was completed in 1958 and is 747 feet deep. Well #2 was completed in 1959 and is 755 feet deep. Most compliance samples are collected from both wells. Other compliance samples, such as lead/copper, TTHMs/HAA5s, and bacteria (i.e., total coliform and E. coli), are collected from the distribution system as required by the regulations. In 2021, all sampled constituents were below the MCL, which includes the two monthly bacteriological samples.

6.7.1.8 Test Area North/Contained Test Facility (TAN/CTF), 6060021

There are more than 300 employees located at TAN/CTF. The water system has a continuous chlorination system to disinfect the water on a voluntary basis for added protection. TAN/CTF #1 Well is located at TAN 632 and was constructed in November 1957. The well is 339 feet deep. The well can pump 1,000 gpm. TAN/CTF #2 Well is located at TAN 639 and was completed in April 1958. The well is 462 feet deep and can pump 1,000 gpm. Compliance samples are collected from the manifold at TAN 1612 for most constituents. Other compliance samples are collected from the distribution system as required by the regulations. In 2021, all sampled constituents were below the MCL; which includes the monthly bacteriological (i.e., total coliform and E. coli) samples.

6.7.1.9 Idaho Nuclear Technology and Engineering Center, 6120018

Drinking water for the Idaho Nuclear Technology and Engineering Center (INTEC) is supplied by two wells, CPP-04 and ICPP-POT-A-012, located north of the facility. A disinfectant residual (e.g., chlorine) is maintained throughout the distribution system. In 2021, drinking water samples were collected from the point of entry to the distribution system (CPP-614) and from various buildings throughout the distribution system.

Eleven compliance samples were collected from various buildings throughout the distribution system at INTEC and analyzed for contaminants identified by the state of Idaho per the monitoring frequency. Sample results for these compliance samples are summarized in Table 6-14. All detected contaminants were below the MCL concentrations.

6.7.1.10 Radioactive Waste Management Complex, 6120012

The RWMC production well is located in Building WMF-603 and is the source of drinking water for RWMC. A disinfectant residual (e.g., 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 the point of entry to the distribution system (WMF-603). 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 2021, drinking water samples were collected from the point of entry to the distribution system (WMF-603) and from various buildings throughout the distribution system.

Twelve compliance samples were collected from various buildings throughout the distribution system at RWMC and analyzed for the contaminants identified by the State of Idaho per the monitoring schedule. Sample results for these compliance samples are summarized in Table 6-14. All detected contaminants were below the MCL concentrations.

6.8 Offsite Drinking Water Sampling

As part of the offsite monitoring program, drinking water samples were collected off the INL Site for radiological analyses in 2021. 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/December 2021. One upgradient location, Mud Lake, was also co-sampled with DEQ-IOP. Samples were also collected 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 results are shown in Table 6-15. DEQ-IOP results are reported quarterly and annually and can be accessed at www.deq.idaho.gov/inl-oversight.

Table 6-15. Gross alpha, gross beta, and tritium concentrations in offsite drinking water samples collected by the ESER contractor in 2021.

LOCATION	SAMPLE RESULTS (PCI/L)[a]		
GROSS ALPHA			
	SPRING	FALL	EPA MCL[b]
Atomic City	0.09 ± 0.19	2.6 ± 0.62	15 pCi/L
Control (bottled water)[c]	0.01 ± 0.19	0.14 ± 0.11	15 pCi/L
Craters of the Moon	0.32 ± 0.25	1.2 ± 0.23	15 pCi/L
Howe	0.19 ± 0.25	0.68 ± 0.21	15 pCi/L
Idaho Falls	0.02 ± 0.33	0.40 ± 0.23	15 pCi/L
Minidoka	0.27 ± 0.19	0.24 ± 0.20	15 pCi/L
Mud Lake (Well #2)	-0.09 ± 0.17	0.23 ± 0.15	15 pCi/L
Rest Area (Highway 20/26)	0.28 ± 0.25	3.3 ± 0.54	15 pCi/L
Shoshone	-0.18 ± 0.22	1.5 ± 0.25	15 pCi/L
GROSS BETA			
	SPRING	FALL	EPA MCL
Atomic City	2.6 ± 0.33	8.8 ± 1.0	4 mrem/yr (50 pCi/L)[d]
Control (bottled water)	4.4 ± 0.36	0.76 ± 0.31	4 mrem/yr (50 pCi/L)
Craters of the Moon	3.4 ± 0.39	3.4 ± 0.42	4 mrem/yr (50 pCi/L)
Howe	1.8 ± 0.37	1.7 ± 0.41	4 mrem/yr (50 pCi/L)
Idaho Falls	4.0 ± 0.46	4.7 ± 0.50	4 mrem/yr (50 pCi/L)
Minidoka	1.4 ± 0.32	4.6 ± 0.48	4 mrem/yr (50 pCi/L)
Mud Lake (Well #2)	3.3 ± 0.33	4.3 ± 0.41	4 mrem/yr (50 pCi/L)
Rest Area (Highway 20/26)	3.1 ± 0.38	5.0 ± 0.79	4 mrem/yr (50 pCi/L)
Shoshone	2.8 ± 0.37	4.5 ± 0.45	4 mrem/yr (50 pCi/L)
TRITIUM			
	SPRING	FALL	EPA MCL
Atomic City	24 ± 32	16 ± 23	20,000 pCi/L
Control (bottled water)	-50 ± 23	19 ± 23	20,000 pCi/L
Craters of the Moon	-0.17 ± 31	-6.8 ± 22	20,000 pCi/L
Howe	36 ± 31	-35 ± 23	20,000 pCi/L
Idaho Falls	42 ± 31	-44 ± 23	20,000 pCi/L

Table 6-15. continued.

LOCATION	SAMPLE RESULTS (PCI/L)[a]		
Minidoka	80 ± 31	-6.8 ± 23	20,000 pCi/L
Mud Lake (Well #2)	59 ± 31	1.2 ± 23	20,000 pCi/L
Rest Area (Highway 20/26)	116 ± 32	45 ± 24	20,000 pCi/L
Shoshone	58 ± 31	-15 ± 23	20,000 pCi/L

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

Gross alpha activity was detected statistically (above 3σ) in five of nine samples collected in fall 2021 (Atomic City, Craters of the Moon, Howe, Rest Area, and Shoshone). The results are below the screening level of 15 pCi/L for gross alpha activity, with a maximum of 3.3 ± 0.54 pCi/L, as measured at the Rest Area in November.

Gross beta activity was detected statistically in all but one drinking water sample collected during 2021. Gross beta activity was not detected in the bottled water sample (control) collected in December. The results are below the screening level of 50 pCi/L for gross beta activity, with a maximum of 8.8 ± 1.0 pCi/L, measured at Atomic City in November. If gross beta activity exceeds 50 pCi/L, an analysis of the sample must be performed to identify the major radionuclides present (40 CFR 141). Gross beta activity has been measured at these levels historically in offsite drinking water samples. For example, the maximum level reported since 2011 in past Annual Site Environmental Reports was 7.83 ± 0.61 pCi/L at Atomic City in spring of 2011.

Tritium was statistically detected in one of the drinking water samples collected in 2021. The maximum result measured was 116 ± 32 pCi/L, measured in the sample collected at the Rest Area in May. The result was within historical measurements and well below the EPA MCL of 20,000 pCi/L. The maximum tritium level was lower than the maximum measured since 2011 (209 ± 25 pCi/L) at Minidoka in spring 2018).

6.9 Surface Water Sampling

Surface water was co-sampled with DEQ-IOP in May and November 2021 at three springs located downgradient of the INL Site: Alpheus Springs near Twin Falls; Clear Springs near Buhl; and a trout farm near Hagerman shown in Figure 6-22. Results are summarized in Table 6-16.

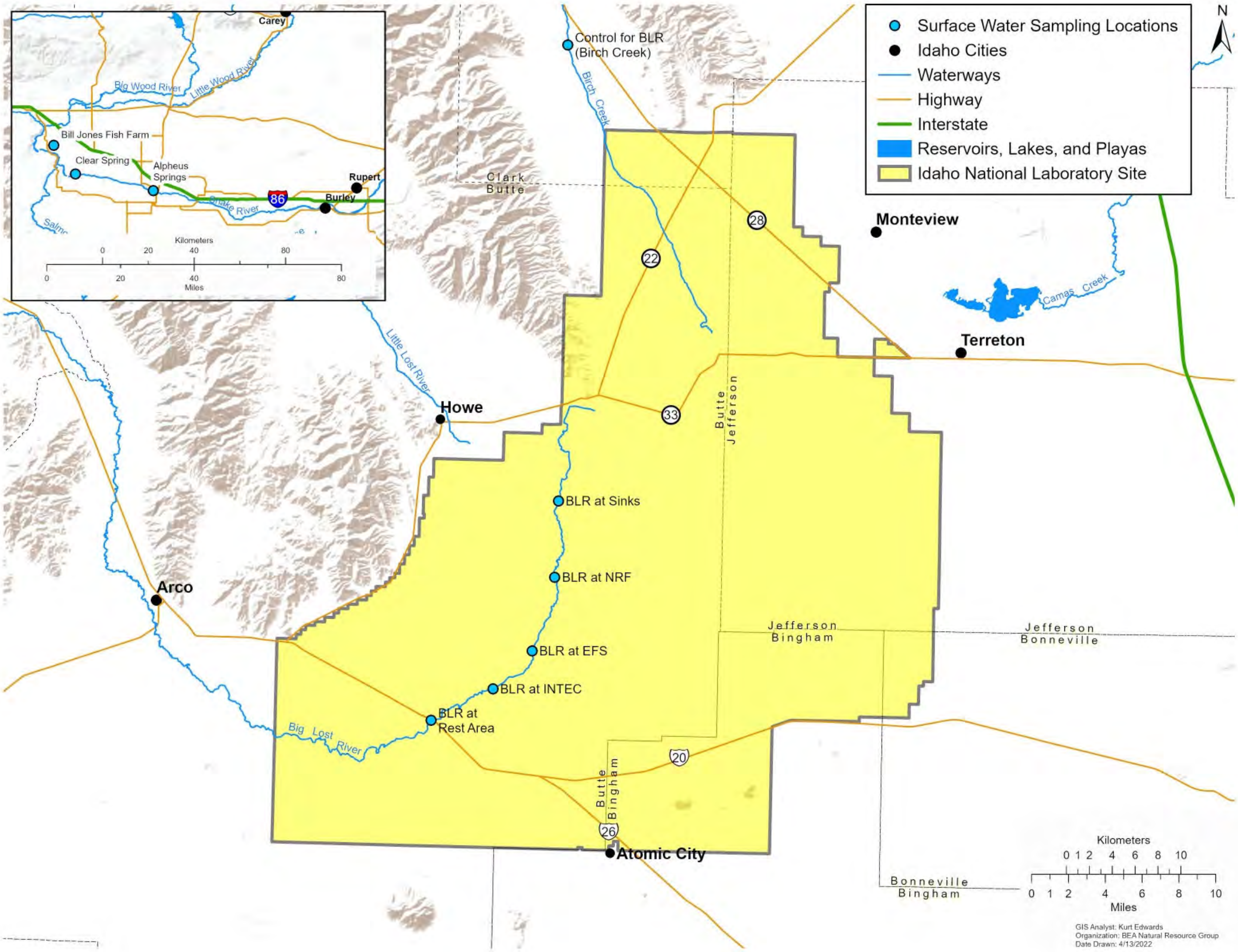

Figure 6-22. Detailed map of ESER program surface water monitoring locations.

Gross alpha activity was detected in one sample collected in November for the sample collected at Alpheus Springs (8.8 ± 0.83 pCi/L). For comparison, the maximum concentration measured since 2011 in all springs was 3.7 ± 0.68 pCi/L at Clear Springs in 2017.

Gross beta activity was detected in all surface water samples. The highest result (14 ± 1.0 pCi/L) was measured in the Alpheus Springs sample collected in the fall. Alpheus Springs has historically shown higher results, and these values are most likely due to natural decay products of thorium and uranium that dissolve into water as it passes through the surrounding basalts of the eastern Snake River Plain Aquifer. The maximum result measured since 2011 was 10.6 ± 0.56 pCi/L at Alpheus Springs in 2014.

Tritium was not detected in any of the surface water samples collected in 2021.

Table 6-16. Gross alpha, gross beta, and tritium concentrations in surface water samples collected along the Big Lost River by the ESER contractor in 2021.

LOCATION	SAMPLE RESULTS (PCI/L)[a]		
GROSS ALPHA			
	SPRING[b]	FALL[b]	EPA MCL[c]
Alpheus Springs-Twin Falls	-1.2 ± 0.28	8.8 ± 0.83	15 pCi/L
Clear Springs-Buhl	-0.25 ± 0.28	0.10 ± 0.21	15 pCi/L
JW Bill Jones Jr Trout Farm-Hagerman	0.43 ± 0.26	0.58 ± 0.21	15 pCi/L
GROSS BETA			
	SPRING	FALL	EPA MCL
Alpheus Springs-Twin Falls	9.5 ± 0.54	14 ± 1.0	4 mrem/yr (50 pCi/L)[d]
Clear Springs-Buhl	4.9 ± 0.44	5.0 ± 0.50	4 mrem/yr (50 pCi/L)
JW Bill Jones Jr Trout Farm-Hagerman	4.6 ± 0.40	4.4 ± 0.45	4 mrem/yr (50 pCi/L)
TRITIUM			
	SPRING	FALL	EPA MCL
Alpheus Springs-Twin Falls	-14 ± 24	-5.9 ± 23	20,000 pCi/L
Clear Springs-Buhl	-39 ± 23	31 ± 23	20,000 pCi/L
JW Bill Jones Jr Trout Farm-Hagerman	-56 ± 24	23 ± 23	20,000 pCi/L

a. Result ± 1s. Results ≥ 3s are considered to be statistically positive.
b. The springs and trout farm were sampled on May 10, 2021, and on November 8, 2021.
c. EPA = Environmental Protection Agency; MCL = maximum contaminant level.
d. The MCL for gross beta activity is not established. However, the EPA drinking water standard of 4 mrem/yr for public drinking water systems is applied and a screening level of 50 pCi/L is used. Samples with gross beta activity greater than 50 pCi/L must be analyzed to identify the major radionuclides present.

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 the Big Lost River Sinks (see Figure 6-22). The river then mixes with other water in the eastern Snake River Plain Aquifer. Water in the aquifer then emerges about 160 km (100 miles) away at Thousand Springs near Hagerman and other springs downstream of Twin Falls. The ESER contractor did not collect surface water samples from the Big Lost River on the INL Site because water demands upstream at the Mackay Reservoir inhibited river flow onto the INL from March to May 2021 and flow never went as far as the Lincoln Blvd bridge. No river samples were collected during 2021 at INL because of the lack of surface water flow in the Big Lost River.

6.10 U.S. Geological Survey 2021 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 eastern Snake River Plain and the eastern Snake River Plain aquifer.

At the INL Site and in the surrounding area, the USGS INL Project Office:

- Monitors and maintains a network of existing wells

- Drills new research and monitoring wells, providing information about subsurface water, rock, and sediment
- Performs geophysical and video logging of new and existing wells
- Maintains the Lithologic Core Storage Library.

Data gathered from these activities are used to create and refine hydrologic and geologic models of the aquifer, to track contaminant plumes in the aquifer, and 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: https://usgs-r.github.io/inlpubs/articles/inl-bibliography.html. Four reports and two software packages were published by the USGS INL Project Office in 2021. The abstracts of these studies and the publication information associated with each study are presented below.

6.10.1 Multilevel Groundwater Monitoring of Hydraulic Head, Water Temperature, and Chemical Constituents in the Eastern Snake River Plain Aquifer at INL

Radiochemical and chemical wastewater discharged to infiltration ponds and disposal wells since the early 1950s at INL in southeastern Idaho has affected the water quality of the eastern Snake River Plain aquifer. In cooperation with the U.S. Department of Energy in 2005, the USGS added a multilevel well-monitoring network to their ongoing monitoring program to begin describing the vertical movement and distribution of the chemical constituents in the eastern Snake River Plain aquifer (Twining et.al 2021a).

The multilevel monitoring system (MLMS) at INL has been ongoing since 2006. This report summarizes the data that was collected during 2014–2018 from 11 multilevel monitoring wells. Hydraulic head (head) and groundwater temperature data were collected, including 177 measurements from hydraulically isolated depth intervals from 448.0 to 1,377.6 feet below land surface. One port (port 3) within well USGS 134 was not monitored due to the failure of a valve.

Vertical head and temperature changes were quantified for each of the 11 MLMs. Fractured basalt zones generally had relatively small vertical head differences and showed a higher occurrence within volcanic rift zones. Poor connectivity between fractures and higher vertical gradients generally were attributed to sediment layers and (or) layers of dense basalt. Hydraulic head ranged from 4,415.5 to 4,462.6 feet above the North American Vertical Datum of 1988; groundwater temperature ranged from 10.4 to 16.8 degrees Celsius.

Normalized mean head values were analyzed for all 11 multilevel monitoring wells for the period of record (2007–2018). The mean head values suggest a moderately positive correlation among all MLMS wells and generally reflect regional fluctuations in water levels in response to seasonal climatic changes. MLMS wells within volcanic rift zones and near the southern boundary indicate a temporal correlation that is strongly positive. MLMS wells in the Big Lost Trough indicate 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.

During 2014–2018, water samples were collected from one to four discrete sampling zones, isolated by packers, in the upper 250–750 feet of the aquifer from 11 multilevel monitoring wells and were analyzed for selected radionuclides, inorganic constituents, organic constituents, and nutrients. Some additional samples were collected for VOCs from wells near the RWMC.

Nine quality-control replicate samples, three field blanks, and two equipment blanks were collected during 2014–2018 as a measure of quality assurance. Concentrations of major ions and chromium in equipment blank samples were near or less than the reporting levels, suggesting no background contamination from field equipment or source water. About 88 percent of the replicate pairs for radionuclide results were statistically comparable and 100 percent of the replicate pairs for inorganic and organic compounds were statistically comparable.

Concentrations in wells USGS 105 and 132 mostly were greater than the reporting levels, and concentrations were mostly consistent. Wells USGS 103, USGS 131, and MIDDLE 2051 had concentrations mostly greater than the two reported 2014–2018 levels and showed decreasing concentrations. The decreasing concentrations are attributed to discontinued disposal, radioactive decay, and dilution and dispersion in the aquifer.

The volatile organic compound tetrachloromethane was found in all zones sampled in well USGS 132 near the RWMC and was found in two zones in well USGS 137A. Concentrations are attributed to waste disposal at the RWMC. Questionable detections of tetrachloroethene were found in well MIDDLE 2051; the source probably was tubing fluid in the well. Tetrachloroethene was found in the tubing fluid at elevated concentrations in three wells (USGS 137A, MIDDLE 2050A, and MIDDLE 2051), and remedial efforts to remove the elevated concentrations of tetrachloroethene from tubing fluid have been successful in each of the three MLMS wells.

6.10.2 Completion Summary for Boreholes USGS 148, USGS 148A, and USGS 149 at the MFC

In cooperation with the DOE in 2019, the USGS drilled and constructed boreholes USGS 148A and USGS 149 for stratigraphic framework analyses and long-term groundwater monitoring of the eastern Idaho Snake River Plain aquifer at INL. Initially, boreholes USGS 148A and USGS 149 were continuously cored to allow the USGS and INL subcontractor to collect select geophysical and seismic data and evaluate properties of recovered core material. The USGS geophysical data and descriptions of core material are described in this report; however, data collected by the INL contractor, including seismic data, are not included as part of the report (Twining et al. 2021b).

The unsaturated zone at both borehole locations is relatively thick, depth to water was measured at approximately 663.6 feet (ft) below land surface (BLS) in USGS 148A, and at approximately 654.1 ft BLS at USGS 149. On completion of coring and data collection, both boreholes (USGS 148A and USGS 149) were repurposed as monitoring wells. Well USGS 148A was constructed to a depth of 759 ft BLS and instrumented with a dedicated submersible pump and measurement line; well USGS 149 was constructed to a depth of 974 ft BLS and instrumented with a multilevel monitoring system (Westbay^{TM}).

As collected by the USGS, geophysical data were used to characterize the subsurface geology and aquifer conditions. Natural gamma log measurements were used to assess sediment-layer thickness and location. Neutron and gamma-gamma source logs were used to confirm fractured and vesicular basalt identified for aquifer testing and multilevel monitoring well zone testing. Acoustic televiewer logs, collected for well USGS 149, were used to identify fractures and assess groundwater movement when compared with neutron measurements. Furthermore, gyroscopic deviation measurements were used to measure horizontal and vertical displacement for the USGS 148A and USGS 149 constructed boreholes.

A single-well aquifer test was done in well USGS 148A during November 6–7, 2019, to provide estimates of transmissivity and hydraulic conductivity. Estimates for transmissivity and hydraulic conductivity were 6.34×103 feet squared per day and 3.17 feet per day, respectively. The aquifer test was run overnight (21.3 hours) and measured drawdown was relatively small (0.09 ft) at sustained pumping rates ranging from 15.7 to 16.1 gallons per minute. The transmissivity estimates for well USGS 148A were slightly lower than those determined from previous aquifer tests for wells near the Materials and Fuels Complex, but well within range of other aquifer tests done at the INL Site.

Water-quality samples, collected from well USGS 148A and from four zones in well USGS 149, were analyzed for cations, anions, metals, nutrients, VOCs, stable isotopes, and radionuclides. Water samples for most of the inorganic constituents showed a similar chemistry in USGS 148A and all four zones in USGS 149. Water samples for stable isotopes of oxygen and hydrogen indicated some possible influence of irrigation on water quality. Nitrate plus nitrite concentrations indicated influence from anthropogenic sources. The VOC and radiochemical data indicated that wastewater disposal practices at the MFC or from drilling had no detectable influence on these wells.

6.10.3 Optimization of the INL Water-Quality Aquifer Monitoring Network

Long-term monitoring of water-quality data collected from wells at the INL have provided essential information for delineating the movement of radiochemical and chemical wastes in the eastern Idaho Snake River Plain aquifer. In cooperation with DOE, the USGS has maintained as many as 200 wells in the INL water-quality monitoring network since 1949. A network design tool, distributed as an R package, was developed to evaluate and optimize groundwater monitoring in the existing network based on water-quality data collected at 153 sampling sites since January 1, 1989. The objective of the optimization design tool is to reduce well monitoring redundancy while retaining sufficient data to reliably characterize water-quality conditions in the aquifer. A spatial optimization was used to identify a set of wells whose removal leads to the smallest increase in the deviation between interpolated concentration maps using the existing and reduced monitoring networks while preserving significant long-term trends and seasonal components in the data. Additionally, a temporal optimization was used to identify reductions in sampling frequencies by minimizing the redundancy in sampling events (Fisher et al. 2021).

Spatial optimization uses an islands genetic algorithm to identify near-optimal network designs removing 10, 20, 30, 40, and 50 wells from the existing monitoring network. With this method, choosing a greater number of wells to remove results in greater cost savings and decreased accuracy of the average relative difference between interpolated maps of the reduced-dataset and the full-dataset. The genetic search algorithm identified reduced networks that best capture the spatial patterns of the average concentration plume while preserving long-term temporal trends at individual wells. Concentration data for 10 analyte types are integrated in a single optimization so that all datasets may be evaluated simultaneously. A constituent was selected for inclusion in the spatial optimization problem when the observations were sufficient to: (1) establish a two-range variability model; (2) classify at least one concentration time series as a continuous record block; and (3) make a prediction using the quantile-kriging interpolation method. The selected constituents include sodium, chloride, sulfate, nitrate, carbon tetrachloride, 1,1-dichloroethylene, 1,1,1-trichloroethane, trichloroethylene, tritium, strontium-90, and plutonium-238.

In temporal optimization, an iterative-thinning method was used to find an optimal sampling frequency for each analyte-well pair. Optimal frequencies indicate that for many of the wells, samples may be collected less frequently and still be able to characterize the concentration over time. The optimization results indicated that the sample-collection interval may be increased by an average of 273 days owing to temporal redundancy.

6.10.4 Field Methods, Quality-Assurance, and Data Management Plan for Water-Quality Activities and Water-Level Measurements, INL

Water-quality activities and water-level measurements conducted by the USGS INL Project Office coincide with the USGS mission of appraising the quantity and quality of the Nation's water resources. The activities are conducted in cooperation with the DOE–Idaho Operations Office. Results of water-quality and hydraulic head investigations are presented in various USGS publications or in refereed scientific journals. The data are stored in the National Water Information System (NWIS) database. The results of the studies are used by researchers, regulatory and managerial agencies, and civic groups (Bartholomay e al. 2021).

In its broadest sense, 'quality assurance' refers to doing the job right the first time. It includes the functions of planning for products, review and acceptance of the products, and an audit designed to evaluate the system that produces the products. Quality control and quality assurance differ in that quality control ensures that things are done correctly given the 'state-of-the-art' technology, and quality assurance ensures that quality control is maintained within specified limits.

6.10.5 ObsNetQW, Assessment of a Water-Quality Aquifer Monitoring Network

The establishment of an efficient aquifer water-quality aquifer monitoring network is a critical component in the assessment and protection of groundwater quality. A periodic evaluation of the monitoring network is mandatory to ensure effective data collection and possible redesigning of existing network. This R package assesses the efficacy and appropriateness of an existing water-quality aquifer monitoring network in the eastern Idaho Snake River Plain aquifer (Fisher 2021a). This software is the companion to two USGS publications:

- Fisher, J. C., R. C. Bartholomay, G. W. Rattray, and N. V. Maimer, 2021, Optimization of the Idaho National Laboratory water-quality aquifer monitoring network, southeastern Idaho: U.S. Geological Survey Scientific Investigations Report 2021-5031 (DOE/ID-22252), 63 p., https://doi.org/10.3133/sir20215031.
- Fisher, J. C., 2020, INLDATA—Collection of datasets for the U.S. Geological Survey-Idaho National Laboratory Aquifer Monitoring Networks: U.S. Geological Survey software release, R package, Reston, Va., https://doi.org/10.5066/P9PP9UXZ.

6.10.6 INLPUBS, Bibliographic Information for the USGS INL Project Office

The R package, inlpubs, may be used to search and analyze 366 publications that cover the 74-year history of the USGS, Idaho Water Science Center, Idaho National Laboratory Project Office (INLPO). The INLPO publications were authored by 253 researchers trying to better understand the effects of waste disposal on water contained in the eastern Idaho Snake River Plain aquifer and the availability of water for long-term consumptive and industrial use. Information contained within these publications is crucial to the management and use of the aquifer by INL and the State of Idaho. USGS geohydrologic studies and monitoring, which began in 1949, were done in cooperation with the DOE–Idaho Operations Office (Fisher 2021b).

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Arrowleaf Balsamroot

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

CHAPTER 7

Radionuclides released by Idaho National Laboratory (INL) Site operations and activities have the potential to be assimilated by agricultural products and game animals, which can then be consumed by humans. These media are thus sampled and analyzed for human-made radionuclides because of the potential transfer of radionuclides to people through food chains. Strontium-90 was detected in seven of 13 milk samples at concentrations that are consistent with past measurements and is likely due to the presence of fallout radionuclides in the environment. The results were well below the Derived Concentration Standard established for strontium-90 in drinking water by the U.S. Department of Energy for the protection of human health. Human-made radionuclides were not detected in any of the other agricultural products (e.g., lettuce, grain, potatoes, alfalfa) collected in 2021.

No human-made radionuclides were detected in road-killed animal samples collected in 2021. Two human-made radionuclides (e.g., cobalt-60, strontium-90) were detected in some tissue samples of waterfowl collected on ponds in the vicinity of the Advanced Test Reactor Complex at the INL Site. The source of these radionuclides was most likely the radioactive wastewater evaporation pond, which can be accessed by waterfowl, but not the public.

Bat carcasses have been collected on the INL Site since the summer of 2015. Five human-made radionuclides (e.g., cobalt-60, zinc-65, strontium-90, cesium-137, plutonium-239/240) were detected in 2021 in some of the bats sampled. While cesium-137 and strontium-90 may be of fallout origin, the presence of cobalt-60, zinc-65, and plutonium isotopes may indicate that the bats have visited radioactive effluents ponds on the INL Site.

Soil samples were not collected on or off the INL Site in 2021.

Direct radiation measurements made at boundary and distant locations were consistent with background levels. The average annual dose equivalent from external exposure was estimated from dosimeter measurements to be 121 mrem off the INL Site. The total background dose from natural sources to an average individual living in southeast Idaho was estimated to be approximately 387 mrem per year.

Radiation measurements taken in the vicinity of waste storage and soil contamination areas near INL Site facilities were consistent with previous measurements. Direct radiation measurements using a radiometric scanner system at the Radioactive Waste Management Complex and the Comprehensive Environmental Response, Compensation, and Liability Act 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 2021. Details of these programs may be found in the *Idaho National Laboratory Site Environmental Monitoring Plan* (DOE-ID 2014a). The INL, Idaho Cleanup Project (ICP) Core, and Environmental Surveillance, Education, and Research Program (ESER) contractors monitor soil, vegetation, biota, and direct radiation on and off the INL Site to comply with applicable U.S. Department of Energy (DOE) orders and other requirements. The focus of the monitoring being conducted by INL and ICP Core contractors is on the INL Site, particularly on and around facilities, as shown in 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, as can be seen in Table 7-1.

In December 2020, DOE initiated transition of the ESER Program from DOE management to the INL contract managed by Battelle Energy Alliance, LLC (BEA). A team composed of DOE, BEA, and the ESER Program contractor, Veolia Nuclear Solutions – Federal Services (VNSFS), successfully transitioned the Program on September 30, 2021; it is now called Environmental Monitoring & Natural Resource Services. The ESER Program environmental surveillance scope has been integrated into the INL environmental surveillance program. Sampling activities conducted prior to September 30, 2021, were performed by VNSFS and the results are presented in this chapter under the ESER contractor. Sampling activities conducted after September 30, 2021, were performed under BEA and are presented in this chapter under the INL contractor.

Table 7-1. Environmental monitoring of agricultural products, biota, soil, and direct radiation on and around the INL Site.

	MEDIA				
AREA/FACILITY[a]	AGRICULTURAL PRODUCTS	BIOTA	ECOLOGICAL	SOIL	DIRECT RADIATION
ENVIRONMENTAL SURVEILLANCE, EDUCATION, AND RESEARCH PROGRAM CONTRACTOR					
INL Site/Regional	•	•	•	•	•
IDAHO NATIONAL LABORATORY CONTRACTOR					
INL Site				•	•
Regional					•
IDAHO CLEANUP PROJECT CORE CONTRACTOR					
ICDF[b]					•
RWMC[c]					•

a. INL Site = Idaho National Laboratory Site facility areas and areas between facilities.
b. ICDF = Idaho Comprehensive Environmental Response, Compensation, and Liability Act Disposal Facility.
c. RWMC = Radioactive Waste Management Complex.

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, as was shown previously in Figure 4-1. Figure 7-1 shows the locations where agricultural products were collected in 2021.

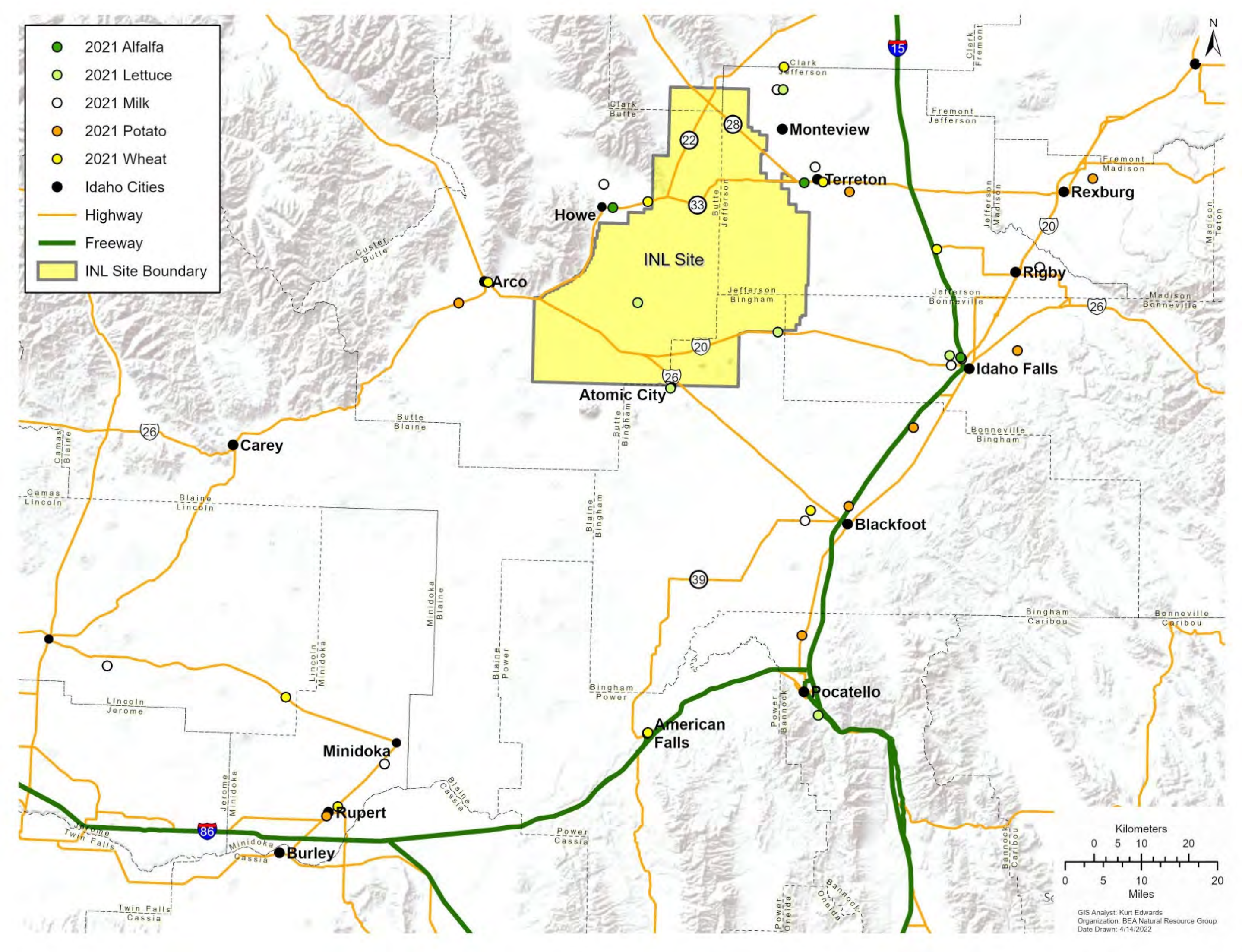


Figure 7-1. Locations of agricultural product samples collected (2021).

7.2 Sampling Design for Agricultural Products

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

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

As specified in the *DOE Handbook Environmental Radiological Effluent Monitoring and Environmental Surveillanc*e (DOE 2015), representative samples of the pathway-significant agricultural products grown within 16 km (10 miles) of the site should be collected and analyzed for radionuclides potentially present from site operations. These samples should be collected in at least two locations: (1) the place of expected maximum radionuclide concentrations, and (2) a 'background' location unlikely to be affected by radionuclides released from the INL Site.

Sample design was primarily guided by wind direction and frequencies and farming practices. Air dispersion modeling, using CALPUFF and INL Site meteorological data measured from 2006 through 2008, was performed to develop data quality objectives for radiological air surveillance for the INL Site using the methodology documented in Rood and Sondrup (2014). The same methodology was used to discern deposition patterns. The dispersion and deposition patterns resulting from these sources reflect wind patterns typical of the INL Site. Prevailing winds at most INL Site locations are from the southwest during daytime hours. During evening hours, the winds will sometimes shift direction and blow from the north or northeast but at a lower velocity. Model results show the location of maximum offsite deposition is located between the southwest INL Site boundary and Big Southern Butte. Because there are no agricultural activities in this region, sampling is focused on other agricultural areas west and northeast of the INL Site. In addition, the sampling design considers locations of interest to the public, as well as those of historical interest, which is why some samples are collected at extended distances from the INL Site.

7.2.1 Methods

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

7.2.2 Milk Results

Milk is sampled to monitor the pathway from potentially contaminated, regionally grown feed to cows, then to milk, which is then ingested by humans. During 2021, the ESER contractor collected 191 milk samples (including duplicates and controls) at various locations off the INL Site (Figure 7-1) and from commercially available milk from outside the state of Idaho (the control). The number and location of the dairies can vary from year to year as farmers enter and leave the business. Milk samples were collected weekly from dairies in Idaho Falls and Terreton, as well as monthly at other locations around the INL Site. The Blackfoot dairy is unique because milk is collected from goats. Goat's milk is of particular interest because it may contain higher concentrations of radioiodine than that found in cow's milk due to the ability of the goat to transfer iodine from forage to milk more efficiently than cows (IAEA 2010).

All milk 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, except for Blackfoot. Milk from the Blackfoot location was not analyzed in November 2021 because the family-run goat dairy at that location did not have enough samples for ^{90}Sr analysis. The Idaho Falls location was not sampled for ^{90}Sr and tritium in November due to the cows being moved to a new location in Terreton. Due to already having a location in Terreton, a Rigby dairy was sampled in November for ^{90}Sr and tritium instead and will replace the Idaho Falls sampling location.

Iodine is an essential nutrient and is readily assimilated by cows or goats that eat plants containing the element. Iodine-131 is of particular interest because it is produced by nuclear reactors or weapons, is readily detected, and, along with cesium-134 and ^{137}Cs, can dominate the ingestion dose regionally after a severe nuclear event, such as the Chernobyl accident (Kirchner 1994) or the 2011 accident at Fukushima in Japan. The ingestion of milk pathway is the main route of internal ^{131}I exposure for people. Iodine-131 has a short half-life (eight days) and therefore does not persist in the environment. Past releases from experimental reactors at the INL Site and fallout from atmospheric nuclear weapons tests and Chernobyl are no longer present. Most of the ^{131}I released in 2021 was from the Materials and Fuels Complex (approximately 0.09 Ci). None was detected in air samples collected at or beyond the INL Site boundary (see Chapter 4). Iodine-131 was also not detected in any milk sample collected during 2021.

Cesium-137 is chemically analogous to potassium in the environment and behaves similarly by accumulating in many types of tissue, most notably in muscle tissue. It has a half-life of about 30 years and tends to persist in soil. If in soluble form, it can readily enter the food chain through plants. It is widely distributed throughout the world from historic nuclear weapons detonations, which occurred between 1945 and 1980, and has been detected in all environmental media at the INL Site. Regional sources include releases from INL Site facilities and resuspension of previously contaminated soil particles. Cesium-137 was not detected in any milk sample collected in 2021.

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 either from nuclear reactors or from detonations of nuclear weapons. It has a half-life of about 29 years and can persist in the environment. Strontium tends to form compounds that are more soluble than ^{137}Cs and is therefore comparatively mobile in ecosystems. Strontium-90 was detected in seven of the 15 milk samples analyzed. Detectable concentrations ranged from 0.25 ± 0.08 pCi/L at Minidoka to 1.53 ± 0.10 pCi/L at Blackfoot as observed in Table 7-2. These levels were 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 the ingestion of grass. Results from EPA Region 10, which includes Idaho, for a limited data set of seven samples collected from 2007 through 2016, ranged from 0 to 0.54 pCi/L (EPA 2017). The maximum concentration detected in the past 10 years was 2.37 ± 0.29 pCi/L, measured at Fort Hall in November 2013.

DOE has established Derived Concentration Standards (DCSs) (DOE 2011) for radionuclides in air and water. A DCS is the concentration of a radionuclide in air or water that would result in a dose of 100 mrem from ingestion, inhalation, or immersion in a gaseous cloud for one year. There are no established DCSs for foodstuffs such as milk. For reference purposes, the DCS for ^{90}Sr in water is 1,100 pCi/L. Therefore, the maximum observed value in milk samples (1.53 ± 0.10 pCi/L) is approximately 0.14% of the DCS for drinking water.

Tritium, with a half-life of about 12 years, is an important radionuclide because it is a radioactive form of hydrogen, which combines with oxygen to form tritiated water. The environmental behavior of tritiated water is like that of water, and can be present in surface water, precipitation, and atmospheric moisture. Tritium is formed by natural processes, as well as by reactor operation and nuclear weapons testing. Tritium enters the food chain through surface water that people and animals drink, as well as from plants that contain water. Tritium was not detected in any of the milk samples analyzed during 2021, as observed in Table 7-2. Concentrations varied from -51 ± 22 pCi/L in a sample from Terreton in November 2020 to 44 ± 33 pCi/L in a sample from Idaho Falls in May 2021. These concentrations are similar to those of previous years and are consistent with those found in atmospheric moisture and precipitation samples. The DCS for tritium in water is 1,900,000 pCi/L.

7.2.3 Lettuce

Lettuce was sampled because radionuclides in air can be deposited on soil and plants, which can then be ingested by people, as shown in Figure 4-1. Uptake of radionuclides by plants may occur through root uptake from soil and/or absorption of deposited material on leaves. For most radionuclides, uptake by foliage is the dominant process for contamination of plants (Amaral et al. 1994). For this reason, green, leafy vegetables, like lettuce, have higher concentration ratios of radionuclides to soil than other kinds of plants. The ESER contractor collects lettuce samples every year from areas on and adjacent to the INL Site, as observed in Figure 7-1. The number and locations of gardens have changed from year to year depending on whether vegetables were available. Home gardens have generally been replaced with portable lettuce planters, as shown in Figure 7-2, because the availability of lettuce from home gardens was unreliable at some key locations.

Table 7-2. Strontium and tritium concentrations[a] in milk samples collected off the INL Site in 2021.

STRONTIUM-90 (pCi/L)		
LOCATION	**MAY 2021**	**NOVEMBER 2021**
Blackfoot	1.53 ± 0.10	NS[b]
Dietrich	-0.50[c] ± 0.12	0.35 ± 0.06
Howe	-0.06 ± 0.06	0.25 ± 0.18
Idaho Falls[d]	0.78 ± 0.11	NS
Minidoka	0.14 ± 0.05	0.25 ± 0.08
Monteview	0.51 ± 0.06	-0.43 ± 0.17
Rigby[d]	NS	0.43 ± 0.10
Terreton	0.16 ± 0.06	0.51 ± 0.08
AVERAGE	**0.37**	**0.23**
Control (Colorado)	-0.63 ± 0.08	0.24 ± 0.11
TRITIUM (pCi/L)		
LOCATION	**MAY 2021**	**NOVEMBER 2021**
Blackfoot	63 ± 32	NS[b]
Dietrich	19 ± 31	-48 ± 22
Howe	17 ± 31	-24 ± 22
Idaho Falls[d]	44 ± 33	NS
Minidoka	5.8 ± 31	6.1 ± 23
Monteview	-29 ± 23	-10 ± 22
Rigby[d]	NS	-3.7 ± 23
Terreton	12 ± 31	-51 ± 22
AVERAGE	**19**	**-22**
Control (Colorado)	8.2 ± 23	-40 ± 24

a. Results ± 1σ. Results greater than 3σ uncertainty are considered statistically detected.

b. NS = no sample. The Blackfoot sample is collected from a small goat farm. There was insufficient sample collected in 2021 for radiochemical analysis.

c. A negative result indicates that the measurement was less than the laboratory background measurement.

d. The Idaho Falls location moved its cows. A new dairy was sampled in Rigby to replace the one in Idaho Falls.

Figure 7-2. Portable lettuce planter.

In addition, the planters can be placed, and the 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 and potting mix, sown with lettuce seed, and self-watered through a reservoir.

Five lettuce samples were collected from portable planters at Atomic City, the Experimental Field Station, the Federal Aviation Administration Tower, Howe, and Monteview. In 2021, soil from the vicinity of the sampling locations was used in the planters. This soil was amended with potting soil as a gardener in the region would typically do when they grow their lettuce. In addition to the portable samplers, a sample was obtained from farms in Idaho Falls and Pocatello and a control sample was purchased at the grocery store from an out-of-state location (Oregon).

The samples were analyzed for ^{90}Sr and gamma-emitting radionuclides. Strontium-90 was not detected in the lettuce samples collected during 2021. 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 measurable in soils, the ability of vegetation, such as lettuce, to incorporate cesium from soil in plant tissue is much lower than for strontium (Fuhrmann et al. 2003; Ng, Colsher, and Thompson 1982; Schulz 1965). In addition, the availability of ^{137}Cs to plants depends highly on soil properties, such as clay content or alkalinity, which can act to bind the radionuclide (Schulz 1965). Soils in southeast Idaho tend to be moderately to highly alkaline.

7.2.4 Grain

Grain (including wheat and barley) is sampled because it is a staple crop in the region. In 2021, the ESER contractor collected grain samples at 10 locations from areas surrounding the INL Site (Figure 7-1), and an additional duplicate sample was collected from Roberts. A control sample was purchased from outside the state of Idaho. The locations were selected because they are typically farmed for grain and are encompassed by the air surveillance network. Exact locations may change as growers rotate their crops. No human-made radionuclides were found in any samples. Agricultural products such as fruits and grains are naturally lower in radionuclides than green, leafy vegetables (Pinder et al. 1990).

7.2.5 Potatoes

Potatoes are collected because they are one of the main crops grown in the region and are of special interest to the public. Because potatoes are not exposed to airborne contaminants, they are not typically considered a key part of the ingestion pathway. Potatoes were collected by the INL contractor at eight locations in the vicinity of the INL Site (Figure 7-1) and obtained from one location outside eastern Idaho. None of the potato samples (including duplicates) collected during 2021 contained a detectable concentration of any human-made radionuclides. Potatoes, like grain, are generally less efficient at removing radioactive elements from soil than leafy vegetables such as lettuce.

7.2.6 Alfalfa

In addition to analyzing milk, the ESER contractor began collecting data in 2010 on alfalfa consumed by milk cows. A sample of alfalfa was collected in June 2021 from locations in the Mud Lake area, Howe, and Idaho Falls. Mud Lake is an agricultural area with a high potential for offsite contamination via the air pathway are shown in Figure 8-6. (Note: The highest offsite air concentration used for estimating human doses was located southeast of the INL Site's east entrance; however, there is limited agriculture near that location.) The samples were analyzed for gamma-emitting radionuclides and ^{90}Sr. No human-made radionuclides were detected in the alfalfa samples collected during 2021.

7.2.7 Big Game Animals

Muscle, liver, and thyroid samples were collected from ten big game animals. The muscle and liver samples were analyzed for ^{137}Cs because it is an analog of potassium and is readily incorporated into muscle and organ tissues. Thyroids are analyzed for ^{131}I because it selectively concentrates in the thyroid gland when assimilated by many animal species, and is thus an excellent bio-indicator of atmospheric releases.

Iodine-131 was not detected in the thyroid samples. No ^{137}Cs or other human-made, gamma-emitting radionuclides were found in any of the muscle samples.

7.2.8 Waterfowl

Waterfowl are collected each year at ponds on the INL Site and at a location off the INL Site. Two waterfowl collected from wastewater ponds located at the Advanced Test Reactor (ATR) Complex plus three control waterfowl collected from Burton and Swan Valley were analyzed for gamma-emitting radionuclides, ^{90}Sr, and actinides americium-241 (^{241}Am), plutonium-238 (^{238}Pu), and plutonium-239/240 ($^{239/240}Pu$). These radionuclides were selected because they have historically been measured in liquid effluents from some INL Site facilities. Each sample was divided into the following three sub-samples: (1) edible tissue (e.g., muscle, gizzard, heart, liver), (2) external portion (e.g., feathers, feet, head), and (3) all remaining tissue.

Two human-made radionuclides were detected in edible, exterior, and remainder subsamples from the ducks collected at the ATR Complex ponds. These were cobalt-60 (^{60}Co), and ^{90}Sr. A Northern Shoveler collected from the sewage lagoons at ATR Complex had one of these radionuclides in edible tissue identified in Table 7-3. Three Mallards were collected as control ducks. Strontium-90 was detected in the edible tissue for all three of the control ducks.

Because more human-made radionuclides were found in ducks from the ATR Complex than other locations and at higher levels, it is assumed that the evaporation pond associated with this facility is the source of these radionuclides. The ducks were not taken directly from the two-celled Hypalon™-lined radioactive wastewater evaporation pond, but rather from an adjacent sewage lagoon. However, it is likely the ducks also spent time at the evaporation pond. Concentrations of the detected radionuclides in the waterfowl collected at the ATR Complex were for the most part lower than those collected in 2020. The ^{90}Sr detected in the control ducks is most likely from fallout from past weapons testing. The hypothetical dose to a hunter who eats a contaminated duck from the ATR Complex ponds is presented in Chapter 8, Section 8.3.1.

Table 7-3. Radionuclide concentrations detected in waterfowl collected in 2021.

RADIONUCLIDES DETECTED IN WATERFOWL TISSUE (pCi/kg)				
LOCATION	SPECIES	PORTION	RADIONUCLIDE	CONCENTRATION
ATR Complex Ponds	Northern Shoveler	Exterior	^{60}Co	49 ± 6
			^{90}Sr	196 ± 9
		Remainder	^{60}Co	7 ± 2
			^{90}Sr	112 ± 7
	Northern Shoveler	Edible	^{90}Sr	49 ± 5
		Exterior	^{60}Co	71 ± 7
			^{90}Sr	177 ± 6
		Remainder	^{90}Sr	99 ± 6
Controls	Mallard	Edible	^{90}Sr	24 ± 5
		Exterior	^{90}Sr	21 ± 4
	Mallard	Edible	^{90}Sr	73 ± 4
		Exterior	^{90}Sr	22 ± 4
		Remainder	^{90}Sr	11 ± 3
	Mallard	Edible	^{90}Sr	30 ± 3
		Exterior	^{90}Sr	30 ± 4
		Remainder	^{90}Sr	16 ± 4

7.2.9 Bats

Bat carcasses have been collected on the INL Site since the summer of 2015. Bats are typically desiccated when received and generally weigh about a few grams each. The samples collected in 2021 were analyzed for gamma-emitting radionuclides, for specific alpha-emitting radionuclides (plutonium isotopes and ^{241}Am), and for ^{90}Sr (a beta-emitting radionuclide).

The bat carcasses were divided and composited by the following areas in 2021: Test Area North, Naval Reactors Facility, Materials and Fuels Complex, Central Facilities Area/Experimental Breeder Reactor-I, and ATR Complex/Idaho Nuclear Technology and Engineering Center (INTEC).

The bat analysis results are summarized in Table 7-4. The following radionuclides were detected in at least one sample during 2021: ^{137}Cs, ^{60}Co, ^{238}Pu, $^{239/240}Pu$, ^{90}Sr, and zinc-65. Cesium-137 is fairly ubiquitous in the environment because of fallout from historical nuclear weapons tests. Strontium-90 is another fallout radionuclide. Cobalt-60 and zinc-65, which are fission products, may indicate that the bats visited radioactive effluent ponds on the INL Site, such as at the ATR Complex ponds. Plutonium-238 and $^{239/240}Pu$, which is present in radioactive waste as well as in the environment from past weapons testing, was detected in one sample collected in 2021. The potential doses received by bats are discussed in Chapter 8, Section 8.8.2.

Table 7-4. Radionuclide concentrations measured in bats collected in 2021.

BAT TISSUE CONCENTRATIONS (pCi/kg DRY WEIGHT)			
RADIONUCLIDE	MINIMUM[a]	MAXIMUM[b]	NUMBER OF DETECTIONS[c]
^{241}Am	ND[d]	ND	0
^{137}Cs	642 ± 132	2,310 ± 112	2
^{60}Co	12,000 ± 166	16,000 ± 271	2
^{238}Pu	ND	30 ± 5	1
^{239}Pu	ND	12 ± 4	1
^{90}Sr	93 ± 10	29,300 ± 190	5
^{65}Zn	1,730 ± 171	6,420 ± 339	2

a. Minimum detected concentration.
b. Maximum detected concentration.
c. Out of 5 composites analyzed.
d. ND = not detected.

7.3 Soil Sampling

In the early 1970s, the DOE Radiological and Environmental Sciences Laboratory (RESL) established a routine program for collecting surface and subsurface soils (0–5 and 5–10 cm deep) on and around the INL Site. At that time, RESL established extensive onsite soil sampling grids outside INL Site facilities. Offsite locations were also established by RESL during this process to serve as background sites. RESL analyzed all samples (onsite and offsite) for gamma-emitting radionuclides with a subset onsite analyzed for ^{90}Sr, ^{241}Am, and isotopes of plutonium. In addition, all soil from the surface component (0–5 cm) of the offsite samples was analyzed for ^{90}Sr and alpha emitting-radionuclides (^{241}Am and isotopes of plutonium).

Between 1970 and 1978, RESL extensively sampled the onsite grids outside INL Site facilities and then reduced the onsite sampling frequency to a seven-year rotation that ended in 1990 with sampling at the Test Reactor Area (now known as the Advanced Test Reactor Complex). Surface soils were sampled at distant and boundary locations off the INL Site annually from 1970 to 1975, and the collection interval for offsite soils was extended to every two years starting in 1978.

The INL contractor currently completes soil sampling on a five-year rotation at the INL Site to evaluate long-term accumulation trends and to estimate environmental radionuclide inventories. Sampling occurred in 2017 and is next scheduled for 2022. Data from previous years of soil sampling and analysis on the INL Site show slowly declining concentrations of short-lived radionuclides of human origin (e.g., ^{137}Cs), with no evidence of detectable concentrations depositing onto surface soil from ongoing INL Site releases, as discussed in INL (2016).

The ESER contractor collects soil samples in offsite locations first established by RESL every two years (in even-numbered years). Results to date indicate that the source of detected radionuclides in soil is not from INL Site operations and is most likely derived from world-wide fallout activity (DOE-ID 2014a).

7.3.1 Soil Sampling Design

The basis for the current INL contractor soil sampling design is defined in the *Data Quality Objectives Supporting the Environmental Soil Monitoring Program for the INL Site* (INL 2016), which is discussed in the 2017 Annual Site Environmental Report. Soil was not sampled by the INL contractor in 2021.

7.3.2 Offsite Soil Sampling Results

Offsite soil was not sampled by the ESER contractor in 2021.

7.3.3 Onsite Soil Sampling Results

Onsite soils were not collected in 2021.

7.4 Direct Radiation

7.4.1 Sampling Design

Thermoluminescent dosimeters (TLDs) were historically used to measure cumulative exposures in air (in milliRoentgen or mR) to ambient ionizing radiation. The TLD packets contain four lithium fluoride chips and were placed approximately 1 m (about 3 ft) above the ground at specified locations. Beginning with the May 2010 distribution of dosimeters, the INL contractor began collocating optically stimulated luminescent dosimeters (OSLDs) with TLDs. The primary advantage of the OSLD technology over the traditional TLD is that the nondestructive reading of the OSLD allows for dose verification (i.e., the dosimeter can be read multiple times without destruction of the accumulated signal inside the aluminum oxide chips). TLDs, on the other hand, are heated, and once the energy is released, they cannot be reread. The last set of INL contractor TLD results were from November 2012. The ESER contractor began the use of OSLDs in November 2011 in addition to the TLDs.

ESER TLDs were analyzed by the ICP Core contractor through 2015, after which the task was no longer performed. In 2017, the Idaho State University Environmental Assessment Laboratory (EAL) assumed responsibility for the ESER TLD monitoring effort with the transfer of the TLD analytical equipment to the Idaho State University radiological science laboratory. The EAL spent 2017 bringing the TLD reader into service, including acquiring and installing software to operate the reader. The reader was calibrated using known exposures of TLDs irradiated by the DOE RESL. In 2021, the ESER contractor TLDs were prepared and read by EAL.

Dosimeter locations are shown in Figure 7-3. The sampling periods for 2021 were from November 2020–April 2021 and May 2021–October 2021.

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.

7.4.2 Methods

TLDs are deployed in the field in May and then replaced in November. The dosimeters are sent to the EAL for analysis.

OSLDs are also placed in the field for six months at the same locations as the TLDs. The ESER OSLDs are sent to the EAL for analysis. The INL OSLDs are returned to the manufacturer for analysis. Transit control dosimeters are shipped with the field dosimeters to measure any dose received during shipment.

Background radiation levels are highly variable; therefore, historical information establishes localized regional trends to identify variances. It is anticipated that five percent of the measurements will exceed the background dose. If a single measurement is greater than the background dose, it does not necessarily qualify that there is an unusually high amount of radiation in the area. When a measurement exceeds the background dose, the measurement is compared to other values in the area and to historical data to determine if the results may require further action as described in Data Quality Objectives Supporting the Environmental Direct Radiation Monitoring Program for the Idaho National Laboratory (INL 2019). The method for computing the background value as the upper tolerance limit (UTL) is described in EPA (2009) and EPA (2013). The ProUCL software (EPA 2013) has been used to compute UTLs, given all available data in the area since 2009.

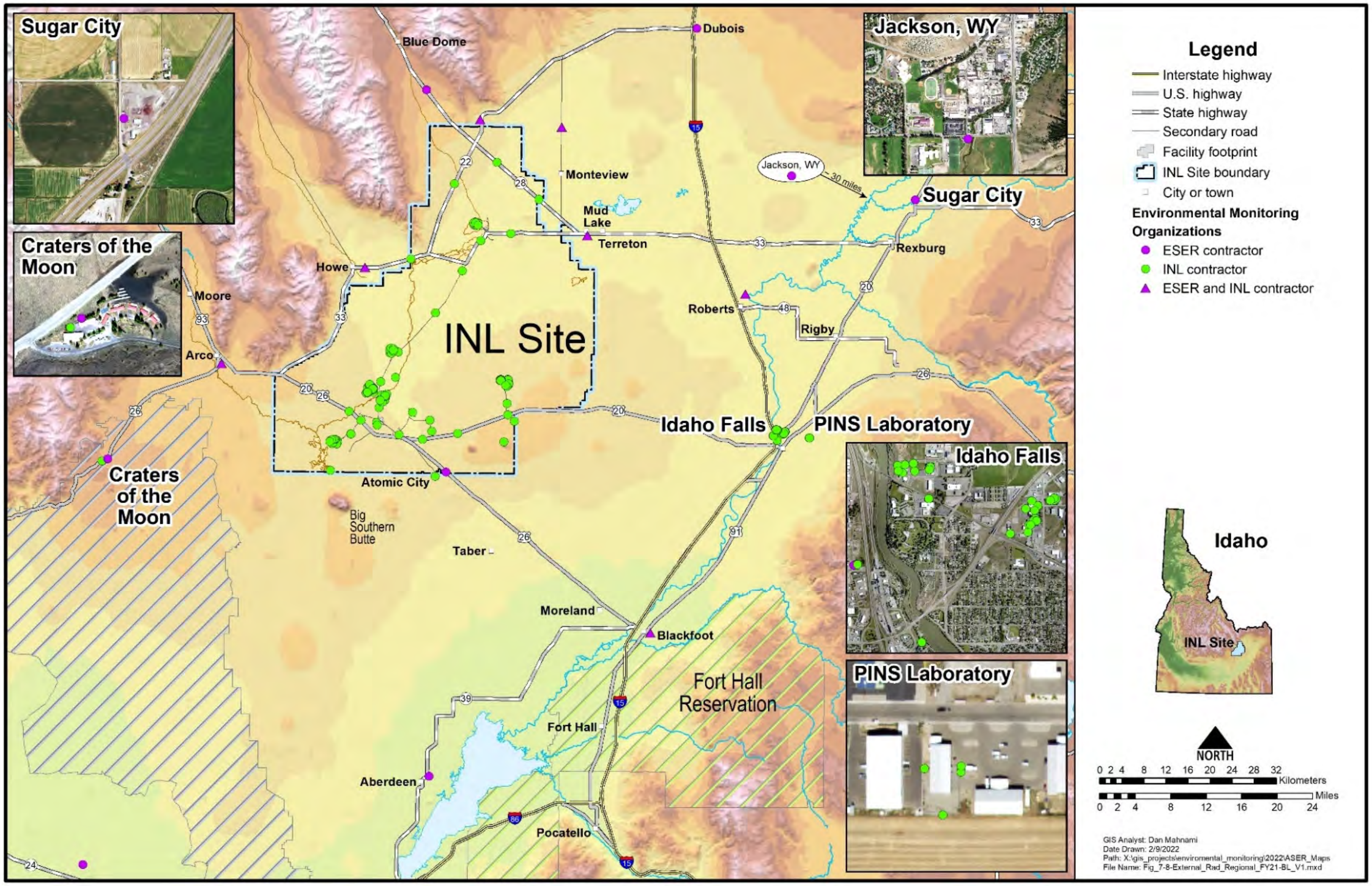


Figure 7-3. Regional direct radiation monitoring locations (2021).

7.4.3 Results

The ESER and INL contractor OSLD data measured at common locations around the INL Site in 2021 are shown in Table 7-5. Using OSLD data collected by both the ESER and INL contractors, the mean annual ambient dose was estimated at 121 mrem (1,210 µSv) for boundary and 122 mrem (1,220 µSv) for distant locations. The mean annual ambient dose for all locations combined is 122 mrem (1,220 µSv).

The 2021 direct radiation results collected by the INL contractor at sitewide and regional locations are provided in Appendix C. Results are reported in gross units of ambient dose equivalent (mrem), rounded to the nearest mrem. The 2021 reported values for field locations were primarily below the historic six-month UTL. Table 7-6 shows locations that exceeded the specific six-month UTL, which was calculated using results measured from 2009 through 2018 (INL 2019). As discussed in Section 7.3.2, a result greater than the background level UTL does not necessarily mean that radiation levels have increased since it is anticipated that 5% of the measurements will exceed the background dose. Rather it indicates that the measurement should be compared to other values in the area and to historical data to provide context and determine if the results may require further action. The facility dosimeters that exceeded the background level UTL in 2021 are located at Argonne National Laboratory (ANL) (see Figure C-6), INTEC (listed as Idaho Chemical Processing Plant (ICPP), (see Figure C-4) and the Radioactive Waste Management Complex (RWMC), (see Figure C-9). The ANL O-8 exceedance appears to be a one-time occurrence. The ANL O-21 results appears to be following a trend since 2020. The ICPP results presented in Table 7-7 appear to follow a pattern of elevated measurements observed at those locations. The locations have consistently shown higher results when compared to other locations at INTEC. The RWMC O-11A dosimeter result was only slightly above the UTL. The dosimeter result for RWMC O-13A is the highest seen for that area. The UTL exceedances for locations near ANL, INTEC, and RWMC are most likely due to operations in those areas. All 2021 environmental dosimetry results were provided to the Radiation Control Department for their consideration.

Neutron dose monitoring is conducted around buildings in Idaho Falls where sources may emit or generate neutron radiation. These buildings include the IF-675 Portable Isotopic Neutron Spectroscopy Laboratory, the IF-670 Bonneville County Technology Center, and the IF-638 Physics Laboratory. Additional neutron dosimeters are placed at the INL Research Center along the south perimeter fence and at the background location Idaho Falls O-10. All neutron dosimeters collected in 2021 were reported as ‘M’ which denotes the dose equivalents are below the minimum measurable quantity of 10 mrem. The background level for neutron dose is zero and the current dosimeters have a detection limit of 10 mrem. Any neutron dose measured is considered present due to sources inside the building. The INL contractor follows the recommendations of the manufacturer to prevent environmental damage to the neutron dosimetry by wrapping each in aluminum foil. To keep the foil intact, the dosimeter is inserted into an ultraviolet protective cloth pouch when deployed.

Table 7-5. Annual environmental radiation doses using OSLDs at all offsite locations (2017–2021).

LOCATION	2017		2018		2019		2020		2021	
	ESER[a] (mrem)	INL[b] (mrem)	ESER (mrem)	INL (mrem)	ESER[c] (mrem)	INL (mrem)	ESER (mrem)	INL (mrem)	ESER (mrem)	INL (mrem)
DISTANT										
Aberdeen	120	NA	123	NA	134	NA	125	NA	134	NA
Blackfoot	112	NA	NA	NA	NA	NA	NA	NA	NA	NA
Blackfoot (Mountain View[f])	102	110	110	125	116	113	115	121	109	115
Craters of the Moon	116	125	118	132	122	116	118	133	118	132
Dubois	98	NA	103	NA	110	NA	102	NA	106	NA
Idaho Falls	110	119	118	126	134	114	115	134	127	121
IF-IDA	NA	106	NA	119	NA	106	NA	112	NA	106
Jackson	[e]	NA	109	NA	113	NA	108	NA	113	NA
Minidoka	102	NA	109	NA	118	NA	111	NA	113	NA
Rexburg/Sugar City[g]	141	NA	151	NA	156	NA	144	NA	149	NA
Roberts[h]	119	124	130	145	134	133	129	138	134	128
MEAN	**113**	**117**	**119**	**129**	**126**	**116**	**119**	**128**	**122**	**120**
BOUNDARY										
Arco	111	122	122	134	127	118	122	127	128	128
Atomic City	117	122	122	132	135	112	124	125	130	130
Birch Creek Hydro[i]	93	94	110	119	114	110	105	113	113	108
Blue Dome	94	NA	106	NA	111	NA	99	NA	109	NA
Howe	109	115	119	129	121	119	117	117	120	111

Table 7-5. continued.

LOCATION	2017		2018		2019		2020		2021	
	ESER[a] (mrem)	INL[b] (mrem)	ESER (mrem)	INL (mrem)	ESER[c] (mrem)	INL (mrem)	ESER (mrem)	INL (mrem)	ESER (mrem)	INL (mrem)
Monteview	110	133	119	130	127	119	125	134	125	118
Mud Lake	117	131	132	143	131	130	133	139	128	129
MEAN	**107**	**120**	**119**	**131**	**124**	**120**	**118**	**126**	**122**	**121**

a. ESER = Environmental Surveillance, Education, and Research Program.

b. INL = Idaho National Laboratory.

c. The 2018 ESER OSLD results are approximately 10 mrem/yr higher than in previous years. This is due to the application of a revised standard control dose.

d. NA = Not applicable. Neither contractor samples at this location.

e. The Jackson location was not operating from May 2015 through January 2017 because a new location was identified and constructed during this period.

f. ESER has two locations at Blackfoot – one at Mountain View Middle School (MVMS) and one at Groveland, which is called “Blackfoot” by ESER. The INL has one OSLD station at MVMS, which is called “Blackfoot.” For the sake of consistency in this report, the MVMS site is called “Mountain View” for both ESER and the INL. The Blackfoot (Groveland) station was inadvertently removed by the Idaho Transportation personnel in early 2018 and is no longer used by ESER.

g. The ESER dosimeter was moved from Rexburg to Sugar City in July 2013. The INL contractor ended surveillance at Rexburg/Sugar City in May 2015.

h. INL contractor calls this location RobNOAA.

i. INL contractor calls this location Reno Ranch.

Table 7-6. Dosimetry locations above the six-month background upper tolerance limit (2021).

LOCATION	MAY 2021 SAMPLE RESULT (mrem)	NOV. 2021 SAMPLE RESULT (mrem)	BACKGROUND LEVEL UTL[a] (mrem)
ANL O-8	108.8	*	86.3
ANL O-21	101.1	103.7	86.3
ICPP O-20	316.9	325.7	197.1
ICPP O-27	224.9	203.6	197.1
ICPP O-28	214.3	209.3	197.1
ICPP O-30	225.1	233.8	197.1
RWMC O-11A	*	89.5	86.7
RWMC O-13A	*	223.3	86.7

a. The UTL is the value such that 95 percent of all the doses in the area are less than that value with 95 percent confidence. That is, only 5 percent of the doses should exceed the UTL.

* Sample did not exceed the UTL for the collection period.

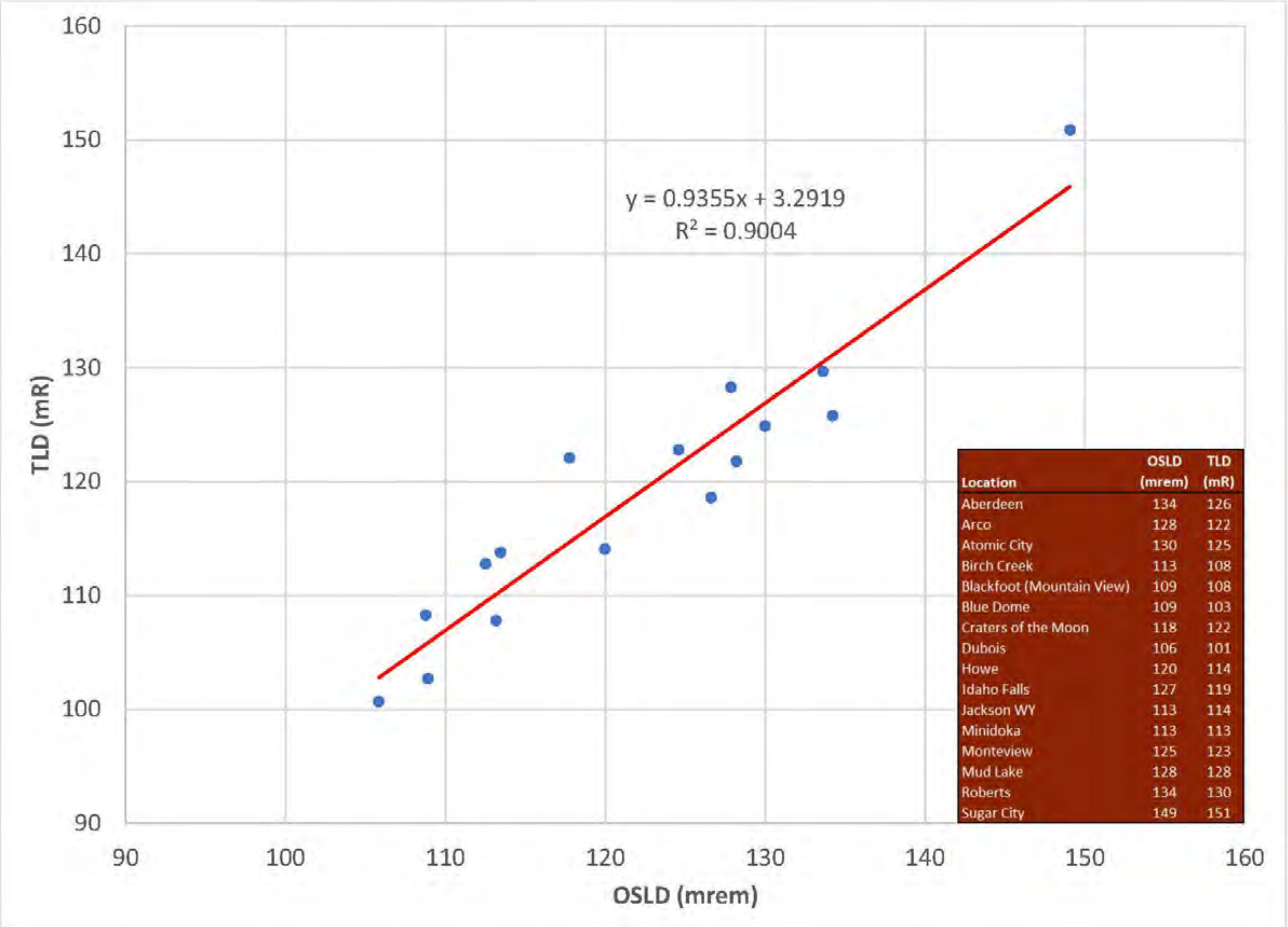
The 2021 ESER TLD data are shown in Figure 7-4. The TLD results demonstrate a strong linear relationship (r^2 = 0.90) with the 2021 ESER OSLD results, indicating a good correlation as observed in Figure 7-4. The two dosimetry systems do not measure the same radiological quantity. The TLD system is calibrated to measure the quantity and exposure expressed in units of Roentgen. The OSLD system is calibrated to measure the quantity, ambient dose equivalent (H*[10]), expressed in units of rem. However, they appear to respond in a similar fashion to penetrating radiation fields in the field.

Table 7-7 summarizes the calculated effective dose a hypothetical individual would receive on the Snake River Plain from various natural background radiation sources (e.g., cosmic and terrestrial). This table includes the latest recommendations of the National Council of Radiation Protection and Measurements (NCRP) in Ionizing Radiation Exposure of the Population of the United States (NCRP 2009).

The terrestrial natural background radiation exposure estimate is based on concentrations of naturally occurring radionuclides found in soil samples collected from 1976–1993, as summarized by Jessmore, Lopez, and Haney (1994). Concentrations of naturally occurring radionuclides in soil do not change significantly over this relatively short period. Data indicate the average concentrations of uranium-238 (^{238}U), thorium-232 (^{232}Th), and potassium-40 (^{40}K) were 1.5, 1.3, and 19 pCi/g, respectively. The calculated external dose equivalents received by a member of the public from ^{238}U plus decay products, ^{232}Th plus decay products, and ^{40}K based on the above-average area soil concentrations were 21, 28, and 27 mrem/yr, respectively, for a total of 76 mrem/yr (Mitchell et al. 1997). Because snow cover can reduce the effective dose that Idaho residents receive from soil, a correction factor must be made each year to the estimated 76 mrem/yr. In 2021, this resulted in a reduction in the effective dose from soil to a value of 73 mrem.

The cosmic component varies primarily with increasing altitude. Using Figure 3.4 in NCRP Report No. 160 (NCRP 2009), it was estimated that the annual cosmic radiation dose near the INL Site is approximately 57 mrem. Cosmic radiation may vary slightly because of solar cycle fluctuations and other factors.

Based on this information, the sum of the terrestrial and cosmic components of external radiation dose to a person residing on the Snake River Plain in 2021 was estimated to be 130 mrem/yr. This is similar to the 121 mrem/yr measured at offsite locations using 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 2021.



Location	OSLD (mrem)	TLD (mR)
Aberdeen	134	126
Arco	128	122
Atomic City	130	125
Birch Creek	113	108
Blackfoot (Mountain View)	109	108
Blue Dome	109	103
Craters of the Moon	118	122
Dubois	106	101
Howe	120	114
Idaho Falls	127	119
Jackson WY	113	114
Minidoka	113	113
Monteview	125	123
Mud Lake	128	128
Roberts	134	130
Sugar City	149	151

Figure 7-4. Comparison of TLD versus OSLD results measured by ESER in 2021.

Table 7-7. Calculated effective dose from natural background sources (2021).

SOURCE OF RADIATION DOSE	TOTAL AVERAGE ANNUAL DOSE	
	CALCULATED (mrem)	MEASURED[a] (mrem)
EXTERNAL IRRADIATION		
Terrestrial	73[b]	NA[c]
Cosmic	57[d]	NA
Subtotal	130	121
INTERNAL IRRADIATION (PRIMARILY INGESTION)[e]		
Potassium-40	15	NM[f]
Thorium-232 and uranium-238	13	NM
Others (carbon-14 and rubidium-87)	1	NM
INTERNAL IRRADIATION (PRIMARILY INHALATION)[d]		
Radon-222 (radon) and its short-lived decay products	212	NM
Radon-220 (thoron) and its short-lived decay products	16	NM
TOTAL	**387**	**NM**

a. Calculated from the average annual external exposure at all offsite locations measured using OSLDs (see Table 7-5).
b. Estimated using concentrations of naturally occurring radionuclide concentrations in soils in the Snake River Plain.
c. NA indicates terrestrial and cosmic radiation parameters were not measured individually but were measured collectively using dosimeters.
d. Estimated from Figure 3.4 of NCRP Report No. 160.
e. Values reported for average American adult in Table 3.14 of NCRP Report No. 160.
f. NM = not measured.

The component of background dose that varies the most is inhaled radionuclides. According to the NCRP, the major contributor of effective dose received by a member of the public from ^{238}U plus decay products is short-lived decay products of radon (NCRP 2009). The amount of radon in buildings and groundwater depends, in part, upon the natural radionuclide content of soil and rock in the area. The amount of radon also varies among buildings of a given geographic area depending upon the materials each contains, the amount of ventilation and air movement, and other factors. The United States average of 212 mrem/yr was used in Table 7-7 for this component of the total background dose. The NCRP also reports that the average dose received from thoron, a decay product of ^{232}Th, is 16 mrem.

People also receive an internal dose from ingestion of ^{40}K and other naturally occurring radionuclides in environmental media. The average ingestion dose to an adult living in the United States was reported in NCRP Report No. 160 to be 29 mrem/yr (NCRP 2009).

With all these contributions, the total background dose to an average individual living in southeast Idaho was estimated to be approximately 387 mrem/yr identified in Table 7-7. This value was used to calculate background radiation dose to the population living within 50 mi of INL Site facilities shown in Table 8-6.

7.5 Waste Management Surveillance Sampling

For compliance with DOE O 435.1, "Radioactive Waste Management" (2011), vegetation and soil are sampled at the Radioactive Waste Management Complex (RWMC), and direct surface radiation is measured at RWMC and the Idaho Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Disposal Facility (ICDF).

7.5.1 Vegetation Sampling at the Radioactive Waste Management Complex

At RWMC, vegetation was historically collected from four major areas identified in Figure 7-5, and a control location approximately seven miles south of the Subsurface Disposal Area (SDA) at the base of Big Southern Butte. Russian thistle was collected in even-numbered years. Crested wheatgrass and rabbitbrush were collected in odd-numbered years. In 2018, the ICP Core decided, using guidance from DOE-HDBK-1216-2015 (DOE 2015), to discontinue further biota sampling activities. This decision was based on an evaluation of biota sample data trends, which concluded that vegetation is not considered a major mode of radionuclide transport through the environment surrounding the SDA at RWMC.

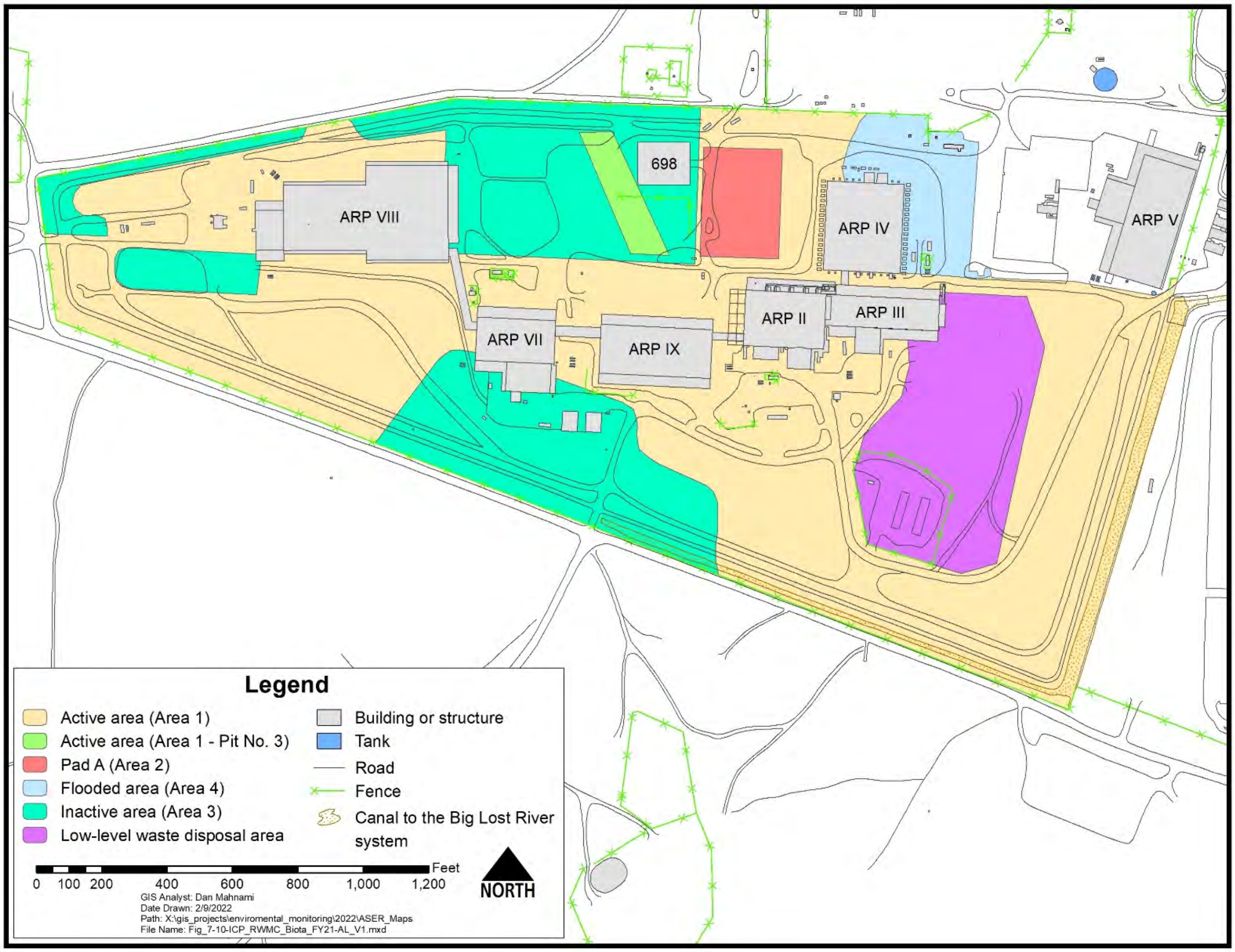


Figure 7-5. Historical vegetation sampling areas at the RWMC.

7.5.2 Soil Sampling at the Radioactive Waste Management Complex

Waste management surveillance soil sampling has been conducted triennially at the SDA at RWMC since 1994. The last triennial soil sampling event was conducted in 2015. In 2017, the results of soil sampling from 1994–2015 were reviewed for each constituent of interest and compared to their respective environmental concentration guide; these guidelines were established in 1986 in *Development of Criteria for the Release of Idaho National Engineering Laboratory Sites Following Decontamination and Decommissioning* (EGG-2400 1986). All results were well below their respective environmental concentration guide.

The footprint at RWMC has changed drastically since this soil sampling began. The area where soil sampling has been performed at the SDA at RWMC is now a heavily disturbed area. Structures cover a majority of the area and fill has been brought in where subsidence has occurred. Gravel has been applied for road base. The DOE Handbook, *Environmental Radiological Effluent Monitoring and Environmental Surveillance* (DOE 2015) states, “Except where the purpose of soil sampling dictates otherwise, every effort should be made to avoid tilled or disturbed areas and locations near buildings when selecting soil sampling locations.”

In 2017, a decision was made to discontinue soil monitoring based on several factors: (1) the limited availability of undisturbed soils; and (2) sufficient historical data being collected previously to satisfy the characterization objectives; and (3) the conclusion that planned activities in the SDA do not have the potential to change surface soil contaminant concentrations prior to installation of the surface cover over the entire SDA under the CERCLA program.

7.5.3 Surface Radiation Survey at the Radioactive Waste Management Complex and the Idaho CERCLA Disposal Facility

Surface radiation surveys are performed to characterize gamma radiation levels near the ground surface at waste management facilities. Comparing the data from these surveys year to year helps to determine whether radiological trends exist in specific areas. This type of survey is conducted at the SDA at RWMC and at the ICDF to complement air sampling. The SDA contains legacy waste, of which some is in the process of being removed for repackaging and shipment to an off-Site disposal facility. The ICDF consists of a landfill and evaporation ponds, which serve as the consolidation points for CERCLA-generated waste within the INL Site boundaries.

A vehicle-mounted Global Positioning Radiometric Scanner (GPRS) system (Radiation Solutions, Inc., Model RS-701) was used to conduct this year’s soil surface radiation (gross gamma) surveys to detect trends in measured levels of surface radiation. The RS-701 system consists of two sodium iodide (NaI) scintillator gamma detectors, housed in two separate metal cabinets, and a Trimble global positioning system receiver, mounted on a rack attached to the front bumper of a four-wheel drive vehicle. The detectors are approximately 24 in. above ground. The detectors and the global positioning system receiver are connected to a system controller and to a laptop computer located inside the cabin of the field vehicle. The GPRS system software displays the gross gamma counts and spectral second-by-second data from the detectors, along with the corresponding 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 field vehicle is driven 5 mph (7 ft/second), and the GPRS system collects latitude, longitude, and gamma counts per second from both detectors. Data files generated during the radiological surveys are saved and transferred to the ICP Core spatial analysis laboratory for mapping after the surveys are completed. The maps indicate areas where survey counts were at or near background levels and areas where survey counts are above background levels. No radiological trends were identified in 2021 in comparison to previous years.

Figure 7-6 shows a map of the area that was surveyed at RWMC in 2021. 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 2021 results are comparable to measurements in previous years. Most of 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 were generally at or below 4,000 counts per second. Most of the 2021 RWMC gross gamma radiation measurements were at or near background levels. The 2021 maximum gross gamma radiation measurement on the SDA was 27,874 counts per second, as compared to the maximum 2020 measurement of 34,716 counts per second. In previous years, maximum readings were measured in a small area at the western end of the soil vault row (SVR)-7, but measurements were lower for this location in 2021. The maximum readings in 2021 were observed directly west of Accelerated Retrieval Project VIII (WMF-1621). This is likely attributed to waste operations and waste transport vehicles located on the concrete pad during the time of the survey.

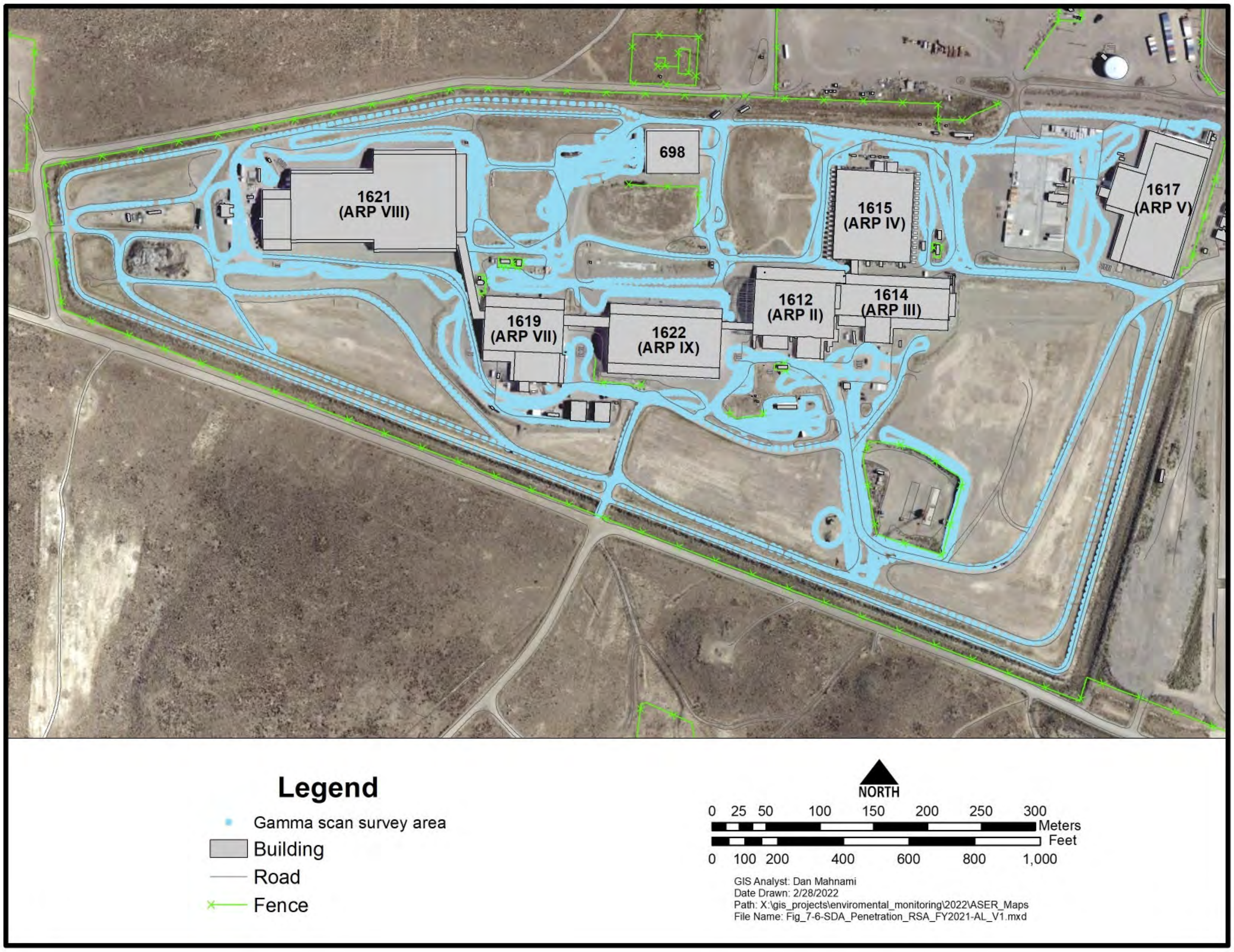


Figure 7-6. SDA surface radiation survey area (2021).

The area that was surveyed at the ICDF is shown in Figure 7-7. The readings at the ICDF vary from year to year. These variations are related to the disposal and burial of new CERCLA remediation wastes in accordance with the ICDF waste placement plan (EDF-ER-286 2017). In 2021, the readings were either at background levels or slightly above background levels (approximately 3,000 counts per second), which is expected until the facility is closed and capped.

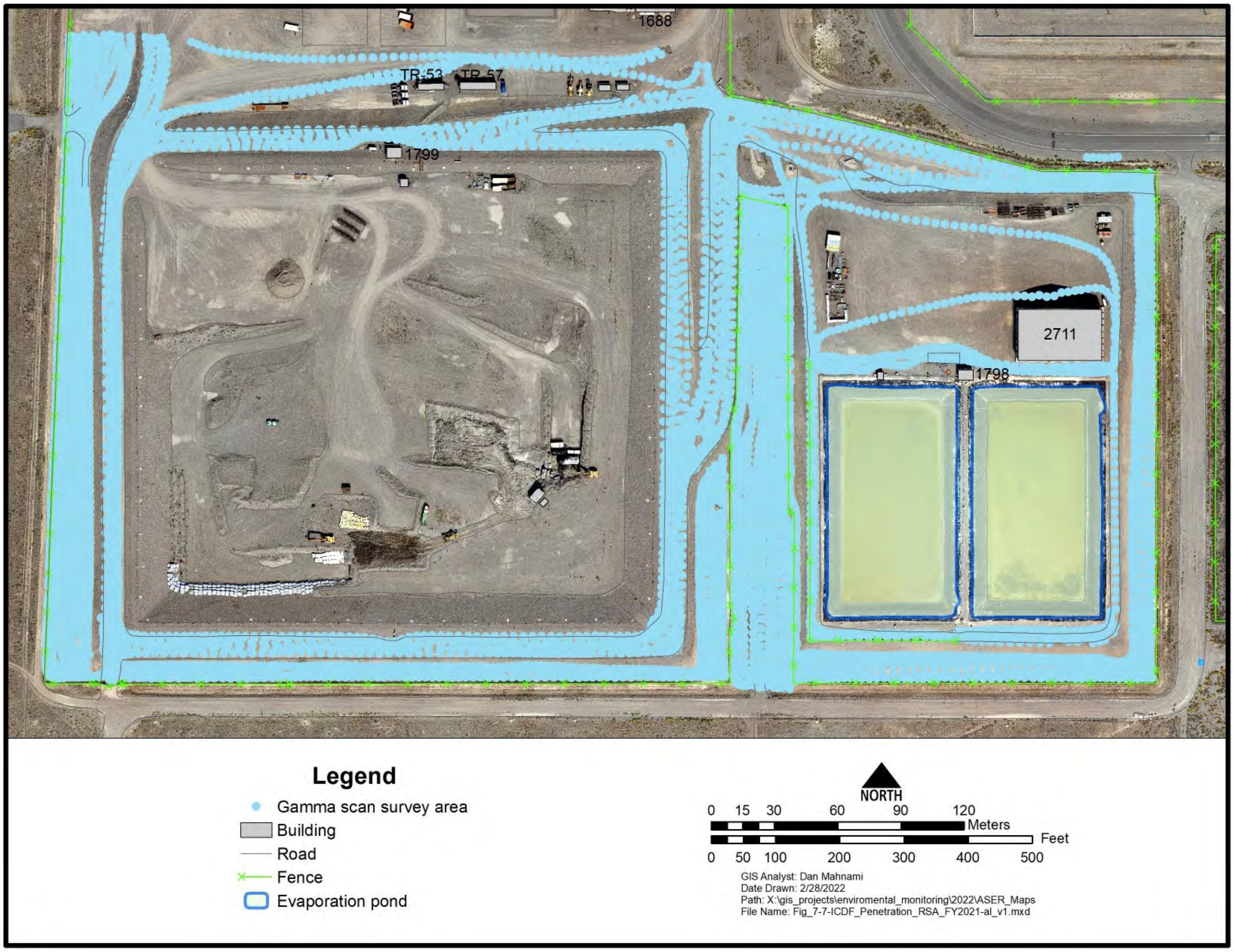


Figure 7-7. ICDF surface radiation survey area (2021).

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Slender Buckwheat

Chapter 8:
Dose to the Public and Biota

CHAPTER 8

Airborne emissions from Idaho National Laboratory (INL) Site operations were used to determine potential radiological dose to members of the public using the Clean Air Act Assessment Package (CAP) 88-PC computer program. The annual dose to the maximally exposed individual in 2021, as determined using CAP88-PC, was 0.067 mrem (0.67 µSv), which was well below the applicable standard of 10 mrem (100 µSv) per year. A maximum potential dose from ingestion of game animals was also estimated using the highest radionuclide concentrations in the edible tissue of waterfowl collected at Advanced Test Reactor (ATR) ponds in 2021. The maximum potential dose to an individual who consumes waterfowl was calculated to be 0.002 mrem (0.02 µSv). It was determined there is no dose associated with the consumption of big game animals. Therefore, the total dose (from air emissions and ingestion of the waterfowl) to the maximally exposed individual during 2021 was estimated to be 0.069 mrem (0.69 µSv). This dose is also far below the public dose limit of 100 mrem (1 mSv) established by the U.S. Department of Energy (DOE) for a member of the public.

The maximum potential population dose to the approximately 353,435 people residing within an 80 km (50 mi) radius of any INL Site facility was also evaluated. The population dose was calculated using reported releases, an air dispersion model (HYSPLIT) used by the National Oceanic and Atmospheric Administration Air (NOAA) Resources Laboratory-Field Research Division, and a dose calculation model (DOSEMM). For 2021, the estimated potential population dose was 2.85 x 10^{-2} person-rem (2.85 x 10^{-4} person-Sv). This dose is approximately 0.00002 percent of that expected from exposure to natural background radiation of 136,779 person-rem (1,368 person-Sv).

The potential doses to aquatic and terrestrial biota from contaminated soil and water were evaluated using a graded approach. Initially, the potential doses were screened using maximum concentrations of radionuclides detected in soil and effluents at the INL Site. Results of the screening calculations indicate that contaminants released from INL Site activities do not have an adverse impact on plants or animal populations. In addition, maximum concentrations of radionuclides measured in waterfowl accessing INL Site ponds and in bats collected at or near INL facilities, were used to estimate internal doses to the waterfowl and bats. These calculations indicate that the potential doses to waterfowl and to bats do not exceed the DOE limits for biota.

No reportable unplanned radiological effluent or emission releases occurred from the INL Site in 2021, therefore, no doses or impacts were manifested.

8. DOSE TO THE PUBLIC AND BIOTA

U.S. Department of Energy (DOE) Order 458.1, “Radiation Protection of the Public and the Environment,” contains requirements for protecting the public and the environment against undue risk from radiation associated with radiological activities conducted under the control of the DOE. In addition to requiring environmental monitoring to ensure compliance with the order, DOE O 458.1 establishes a public dose limit. DOE sites must perform dose evaluations using mathematical models that represent various environmental pathways to demonstrate compliance with the public dose limit and to assess collective (population) doses. In the interest of protection of the environment against ionizing radiation, DOE also developed the technical standard DOE-STD-1153-2019, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE 2019). The Standard provides a graded approach for evaluating radiation doses to aquatic and terrestrial biota.

Title 40 Code of Federal Regulations (CFR) Part 61 Subpart H, "National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities," establishes federal radiation dose limits for the maximally exposed member of the public from all airborne emissions and pathways. It requires that doses to members of the public from airborne releases be calculated using U.S. Environmental Protection Agency (EPA) approved sampling procedures, computer models, or other procedures approved by EPA.

This chapter describes the estimated potential dose to members of the public and biota from operations at the Idaho National Laboratory (INL) Site, based on 2021 environmental monitoring measurements or calculated emissions.

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 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 shown in Figure 4-1.

Airborne radioactive materials are carried from the source and dispersed by winds. The concentrations from routine releases are too small to measure at locations around the INL Site, so atmospheric dispersion models were used to estimate the downwind concentration of air pollutants and the potential doses from these projected offsite concentrations. Conservative doses were also calculated from the ingestion of meat from wild game animals that access the INL Site. Ingestion doses were calculated from the concentrations of radionuclides measured in game animals killed by vehicles on roads at the INL Site and waterfowl harvested from INL Site wastewater ponds that had detectable levels of human-made radionuclides. External exposure to radiation in the environment—primarily from naturally-occurring radionuclides—was measured directly using thermoluminescent dosimeters and optically-stimulated luminescence dosimeters.

Water pathways were not considered major contributors to dose, because no surface water flows off the INL Site and no radionuclides associated with INL Site releases have been measured in public drinking water wells.

8.2 Dose to the Public from INL Site Air Emissions

The potential doses from INL Site air emissions were estimated using the amounts reported to be released or could potentially be released by the facilities. The 2021 INL National Emission Standards for Hazardous Air Pollutants (NESHAP) evaluation (DOE-ID 2022) reported potential radionuclide releases from 66 source locations at the INL Site. However, many of the sources resulted in doses that were insignificant, and many sources are located relatively close together, such that the sampling network response from a release would be the same for all nearby sources. Therefore, insignificant sources were not explicitly modeled, and some sources were consolidated with nearby sources. Emissions from four large operating stacks were modeled explicitly and included the Advanced Test Reactor (ATR) main stack (TRA-770), the Idaho Nuclear Technology and Engineering Center (INTEC) main stack (CPP-708), the Experimental Breeder Reactor-II main stack (MFC-764), and the Transient Reactor Test Facility (TREAT) stack. All other releases within a facility were assigned as near ground-level releases from a single location within the facility. These other releases include other non-fugitive releases from stacks, ducts and vents, and fugitive releases from ponds, soil, or other sources. Figure 8-1 shows the location of all sources modeled in the dose assessment. Releases from the TREAT stack were assumed collocated with releases from Materials and Fuels Complex (MFC). Releases from the Radiological Response Training Range–Northern Test Range were assumed collocated with releases from Specific Manufacturing Capability (SMC). Releases from the Radiological Response Training Range–Southern Test Range are typically collocated with releases from Radioactive Waste Management Complex (RWMC), but Radiological Response Training Range–Southern Test Range did not operate in 2021. Emissions from the Safety and Tritium Applied Research facility (TRA-666) at the ATR Complex are typically routed to and out the Material Test Reactor (MTR) stack. During calendar year 2021, TRA-666 began a building ventilation system modification project and emissions were routed to a much shorter temporary stack for most of the year. Therefore, all TRA-666 emissions for calendar year 2021 were conservatively reported as a ground-level release and no emissions were reported for the MTR stack.

The radionuclides and source terms used in the dose calculations were presented previously in Table 4-2 and are summarized in Table 8-1. The category of noble gases comprised the largest emission quantity, but only contributed slightly to the dose. Radionuclides that were categorized as noble gases tend to have short half-lives and are not typically incorporated into the food supply. Radionuclides that contributed most to the overall estimated dose to the maximally exposed individual (MEI) were cesium-137 (^{137}Cs), uranium-238 (^{238}U), uranium-234 (^{234}U), zinc-65 (^{65}Zn), and chlorine-36 (^{36}Cl). These radionuclides are a very small fraction of the total amount of radionuclides reported.

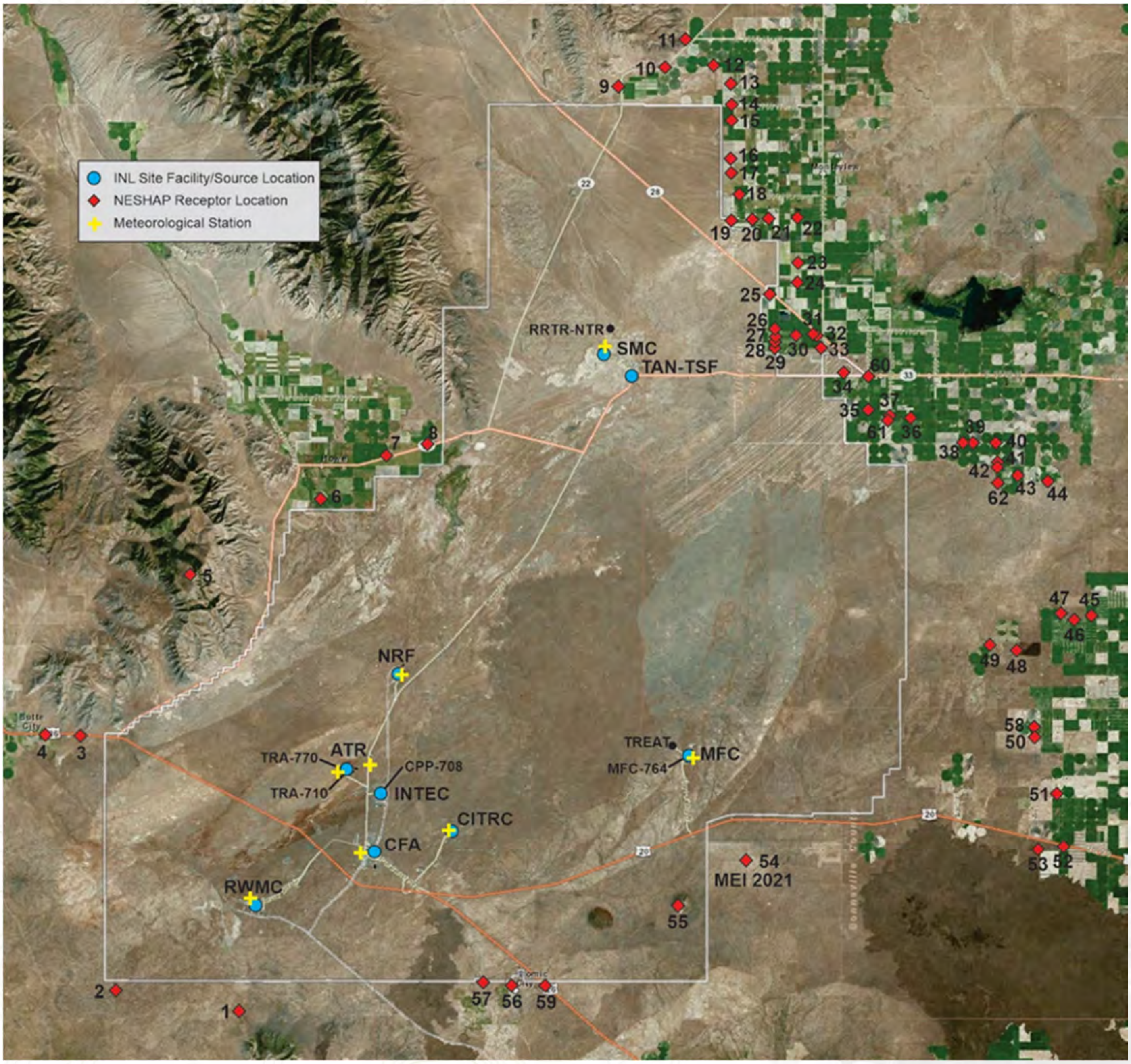

Figure 8-1. INL Site major facility airborne source locations. TRA-770, CPP-708, TREAT, and MFC-764 were modeled as stack releases. *The remaining sources were modeled as ground-level releases. Releases from Radiological Response Training Range–Northern Test Range were assumed collocated with releases from SMC. Releases from TREAT were assumed collocated with releases from MFC. Sixty-two specific receptor locations, including the MEI (location 54), modeled by CAP88-PC are also shown.*

Table 8-1. Summary of radionuclide composition of INL Site airborne effluents (2021).

TOTAL CURIES[a] RELEASED											
FACILITY[b]	TRITIUM	NOBLE GASES[c] ($T1/2$ > 40 DAYS)	NOBLE GASES[d] ($T1/2$ < 40 DAYS)	FISSION AND ACTIVATION PRODUCTS[e] ($T1/2$ < 3 HOURS)	FISSION AND ACTIVATION PRODUCTS[f] ($T1/2$ > 3 HOURS)	TOTAL RADIOIODINE[g]	TOTAL RADIOSTRONTIUM[h]	TOTAL URANIUM[i]	PLUTONIUM[j]	OTHER ACTINIDES[k]	OTHER[l]
ATR Complex	4.55E+02	1.48E-19	3.72E+02	2.16E-01	1.70E-02	8.82E-05	2.65E-02	2.07E-09	8.46E-06	2.43E-05	3.12E-10
CFA	5.19E-01	6.65E-06	8.00E-02	7.98E-04	8.72E-07	3.51E-11	1.41E-11	1.27E-10	1.43E-11	2.74E-11	3.94E-15
CITRC	0.00E+00	0.00E+00	0.00E+00	2.20E-08	6.00E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
INTEC	1.61E-01	1.09E+00	0.00E+00	0.00E+00	3.17E-02	7.30E-05	5.28E-05	3.15E-07	3.33E-04	3.14E-04	0.00E+00
MFC	3.65E-01	6.32E-02	1.80E+02	6.73E+00	6.52E-01	9.41E-02	1.14E-03	1.97E-01	2.71E-07	8.54E-09	0.00E+00
NRF	1.10E-02	5.30E-03	0.00E+00	0.00E+00	5.50E-01	1.72E-05	6.90E-05	0.00E+00	3.80E-06	0.00E+00	0.00E+00
RWMC	4.81E+01	0.00E+00	0.00E+00	0.00E+00	2.22E-02	0.00E+00	4.29E-08	1.43E-08	5.51E-05	1.05E-04	0.00E+00
TAN	3.26E-02	5.72E-06	1.45E-10	8.55E-11	1.06E+01	0.00E+00	1.02E-06	1.09E-07	0.00E+00	0.00E+00	0.00E+00
Total	**5.04E+02**	**1.16E+00**	**5.52E+02**	**6.95E+00**	**1.19E+01**	**9.42E-02**	**2.77E-02**	**1.97E-01**	**4.01E-04**	**4.43E-04**	**3.12E-10**

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 Advanced Mixed Waste Treatment Project and Radiological Response Training Range-Southern Test Range); TAN = Test Area North (including Specific Manufacturing Capability and Radiological Response Training Range-Northern Test Range).

c. Noble gases ($T_{1/2}$ > 40 days) released in 2021 = ^{39}Ar, ^{42}Ar, ^{81}Kr and ^{85}Kr (^{39}Ar, ^{42}Ar and ^{81}Kr release is negligible).

d. Noble gases ($T_{1/2}$ < 40 days) released in 2021 = ^{41}Ar, ^{79}Kr, ^{83m}Kr, ^{85m}Kr, ^{87}Kr, ^{88}Kr, ^{89}Kr, ^{219}Rn, ^{220}Rn, ^{127}Xe, ^{131m}Xe, ^{133}Xe, ^{133m}Xe, ^{135}Xe, ^{135m}Xe, ^{137}Xe and ^{138}Xe.

e. Fission products and activation products ($T_{1/2}$ < 3 hours) released in 2021 = ^{106}Ag, ^{109m}Ag, ^{110}Ag, ^{78}As, ^{137m}Ba, ^{139}Ba, ^{141}Ba, ^{211}Bi, ^{80}Br, ^{83}Br, ^{84}Br, ^{117}Cd, ^{60m}Co, ^{138}Cs, ^{139}Cs, ^{140}Cs, ^{165}Dy, ^{158}Eu, ^{68}Ga, ^{75}Ge, ^{78}Ge, ^{114}In, ^{117}In, ^{142}La, ^{56}Mn, ^{97}Nb, ^{149}Nd, ^{65}Ni, ^{150}Pm, ^{144}Pr, ^{144m}Pr, ^{88}Rb, ^{89}Rb, ^{90}Rb, ^{103m}Rh, ^{106}Rh, ^{106m}Rh, ^{126m}Sb, ^{130}Sb, ^{81}Se, ^{81m}Se, ^{127}Sn, ^{128}Sn, ^{129}Te, ^{131}Te, ^{133}Te, ^{134}Te, ^{208}Tl, ^{89m}Y, ^{91m}Y and ^{69}Zn.

f. Fission products and activation products ($T_{1/2}$ > 3 hours) released in 2021 = ^{108m}Ag, ^{110m}Ag, ^{111}Ag, ^{112}Ag, ^{73}As, ^{76}As, ^{77}As, ^{133}Ba, ^{140}Ba, ^{10}Be, ^{207}Bi, ^{210}Bi, ^{210m}Bi, ^{82}Br, ^{14}C, ^{45}Ca, ^{109}Cd, ^{113m}Cd, ^{115}Cd, ^{115m}Cd, ^{139}Ce, ^{141}Ce, ^{143}Ce, ^{144}Ce, ^{36}Cl, ^{57}Co, ^{58}Co, ^{60}Co, ^{51}Cr, ^{134}Cs, ^{135}Cs, ^{136}Cs, ^{137}Cs, ^{64}Cu, ^{67}Cu, ^{159}Dy, ^{166}Dy, ^{169}Er, ^{152}Eu, ^{154}Eu, ^{155}Eu, ^{156}Eu, ^{157}Eu, ^{55}Fe, ^{59}Fe, ^{60}Fe, ^{72}Ga, ^{73}Ga, ^{153}Gd, ^{159}Gd, ^{68}Ge, ^{71}Ge, ^{77}Ge, ^{175}Hf, ^{178m}Hf, ^{179m}Hf, ^{181}Hf, ^{182}Hf, ^{203}Hg, ^{166m}Ho, ^{114m}In, ^{115m}In, ^{192}Ir, ^{194}Ir, ^{40}K, ^{42}K, ^{140}La, ^{141}La, ^{52}Mn, ^{53}Mn, ^{54}Mn, ^{93}Mo, ^{99}Mo, ^{22}Na, ^{24}Na, ^{92m}Nb, ^{93m}Nb, ^{94}Nb, ^{95}Nb, ^{95m}Nb, ^{96}Nb, ^{147}Nd, ^{57}Ni, ^{59}Ni, ^{63}Ni, ^{66}Ni, ^{185}Os, ^{191}Os, ^{32}P, ^{33}P, ^{205}Pb, ^{210}Pb, ^{107}Pd, ^{109}Pd, ^{146}Pm, ^{147}Pm, ^{148}Pm, ^{148m}Pm, ^{149}Pm, ^{151}Pm, ^{210}Po, ^{143}Pr, ^{145}Pr, ^{83}Rb, ^{84}Rb, ^{86}Rb, ^{87}Rb, ^{184}Re, ^{184m}Re, ^{186}Re, ^{186m}Re, ^{187}Re, ^{188}Re, ^{102}Rh, ^{102m}Rh, ^{105}Rh, ^{103}Ru, ^{105}Ru, ^{106}Ru, ^{35}S, ^{122}Sb, ^{124}Sb, ^{125}Sb, ^{126}Sb, ^{127}Sb, ^{128}Sb, ^{129}Sb, ^{46}Sc, ^{47}Sc, ^{48}Sc, ^{79}Se, ^{32}Si, ^{151}Sm, ^{153}Sm, ^{156}Sm, ^{113}Sn, ^{117m}Sn, ^{119m}Sn, ^{121}Sn, ^{121m}Sn, ^{123}Sn, ^{125}Sn, ^{126}Sn, ^{179}Ta, ^{182}Ta, ^{183}Ta, ^{157}Tb, ^{158}Tb, ^{160}Tb, ^{161}Tb, ^{97m}Tc, ^{99}Tc, ^{99m}Tc, ^{123m}Te, ^{125m}Te, ^{127}Te, ^{127m}Te, ^{129m}Te, ^{131m}Te, ^{132}Te, ^{204}Tl, ^{168}Tm, ^{170}Tm, ^{171}Tm, ^{48}V, ^{49}V, ^{181}W, ^{185}W, ^{187}W, ^{188}W, ^{88}Y, ^{90}Y, ^{91}Y, ^{92}Y, ^{93}Y, ^{65}Zn, ^{69m}Zn, ^{72}Zn, ^{93}Zr, ^{95}Zr and ^{97}Zr.

g. Radioiodine released in 2021 = ^{125}I, ^{126}I, ^{128}I, ^{129}I, ^{130}I, ^{131}I, ^{132}I, ^{133}I, ^{134}I and ^{135}I.

h. Radiostrontium released in 2021 = ^{80}Sr, ^{85}Sr, ^{89}Sr, ^{90}Sr, ^{91}Sr and ^{92}Sr.

i. Uranium isotopes released in 2021 = ^{232}U, ^{233}U, ^{234}U, ^{235}U, ^{236}U, ^{237}U and ^{238}U.

j. Plutonium isotopes released in 2021 = ^{236}Pu, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu and ^{244}Pu.

k. Other actinides released in 2021 = ^{227}Ac, ^{241}Am, ^{243}Am, ^{242}Cm, ^{243}Cm, ^{244}Cm, ^{237}Np, ^{239}Np, ^{231}Pa, ^{233}Pa, ^{234}Pa, ^{234m}Pa, ^{227}Th, ^{228}Th, ^{229}Th, ^{230}Th, ^{231}Th, ^{232}Th and ^{234}Th.

l. Other = radioisotopes of elements that are not noble gases, activation or fission products, radioiodine, radiostrontium, or actinides released in 2021. These are typically heavy elements that are decay chain members of actinides. They include ^{212}Bi, ^{214}Bi, ^{211}Pb, ^{212}Pb, ^{214}Pb, ^{212}Po, ^{215}Po, ^{216}Po, ^{223}Ra, ^{224}Ra, ^{226}Ra and ^{207}Tl.

a.

The following two kinds of dose estimates were made using the release data:

- ***The effective dose to the hypothetical MEI, as defined by the NESHAP regulations.*** The Clean Air Act Assessment Package-1988 personal computer (CAP88-PC) model Version 4.1 (EPA 2020) was used to predict the maximum concentration and dose at offsite receptor locations. The receptor location with the highest estimated dose is the MEI location.
- ***The collective effective dose (population dose) for the population within 80 km (50 mi) of any INL Site facility.*** For this calculation, the HYbrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model (Stein et al. 2015) was used to model atmospheric transport, dispersion, and deposition of radionuclides released to the air from the INL Site. The population dose was estimated using the Dose Multi-Media (DOSEMM) model (Rood 2019) using dispersion and deposition factors calculated by HYSPLIT in order to comply with DOE O 458.1.

The dose estimates considered air immersion dose from gamma-emitting radionuclides, internal dose from inhalation of airborne radionuclides, internal dose from ingestion of radionuclides in plants and animals, and external dose from gamma-emitting radionuclides deposited on soil previously shown in Figure 4-1. The CAP88-PC computer model uses dose and risk tables developed by the EPA. Population dose calculations were made using: (1) DOE effective dose coefficients for inhaled radionuclides (DOE 2011); (2) EPA dose conversion factors for ingested radionuclides (EPA 2002); and (3) 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 NESHAP regulation requires demonstrating that radionuclides other than radon released to air from any DOE nuclear facility do not result in a dose to the public of greater than 10 mrem/yr (0.1 mSv/yr) (40 CFR 61, Subpart H). EPA requires the use of an approved computer model such as CAP88-PC to demonstrate compliance with 40 CFR 61, Subpart H. CAP88-PC uses a modified Gaussian plume model to estimate the average dispersion of radionuclides released from up to six sources. It uses average annual wind files based on data collected at multiple locations on the INL Site by the National Oceanic and Atmospheric Administration (NOAA).

The dose to the MEI from INL Site airborne releases of radionuclides was calculated to demonstrate compliance with NESHAP and is published in the *National Emissions Standards for Hazardous Air Pollutants – Calendar Year 2021 INL Report for Radionuclides* (DOE-ID 2022). In order to identify the MEI, the doses at 62 offsite locations shown in Figure 8-1, 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 location was determined to be location 54, a farmhouse and cattle operation located 3.1 km south of Highway 20, 3 km from INL Site's east entrance. This is the same MEI location as the previous year, but different from the MEI location for several years prior to that which was location 1 (a.k.a. Frenchmans Cabin), located 2.3 km south of the INL boundary, south of RWMC. Although the dose in 2021 was slightly higher at location 55 (e.g., East Butte) than at location 54, location 55 does not currently qualify as a NESHAP receptor location. Privately owned communication (e.g., TV, radio, cell) towers are located on top of East Butte, but there are currently no dwellings or places of business, and this site is visited only occasionally by maintenance workers. Nevertheless, doses are calculated at this point should the occupancy situation change. An effective annual dose of 0.067 mrem (0.67 μSv) was calculated for a hypothetical person living at location 54 during 2021. The 2021 dose at the former MEI (location 1) was 0.015 mrem/yr and it was the 29th highest receptor location in terms of dose.

Figure 8-2 compares the MEI doses calculated for years 2012–2021. All the doses are well below the whole-body dose limit of 10 mrem/yr (0.1 mSv/yr) for airborne releases of radionuclides established by 40 CFR 61, Subpart H. The highest dose estimated during the past ten years was in 2021.

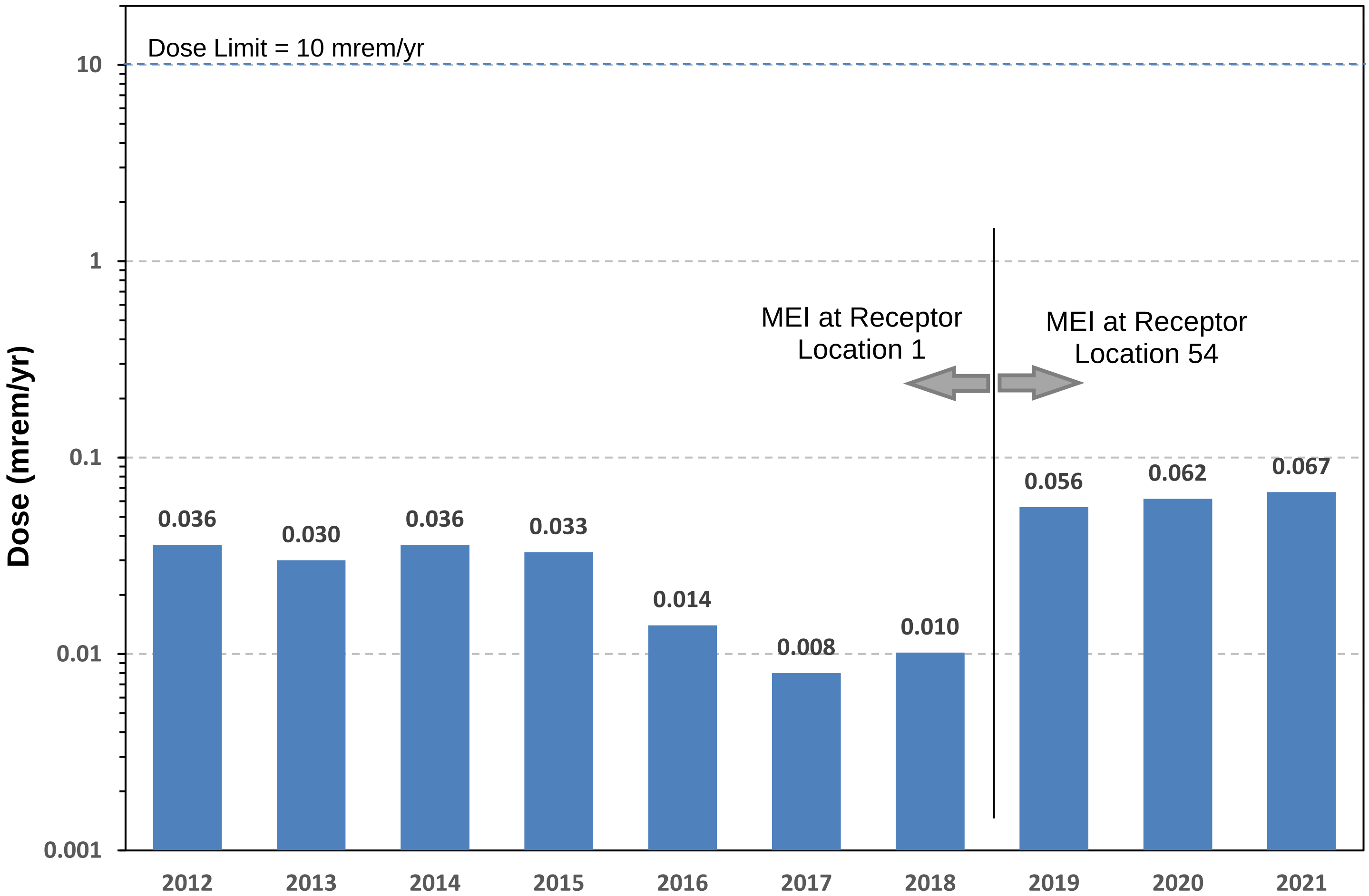

Figure 8-2. MEI dose from INL Site airborne releases estimated for 2012–2021. *See Figure 8-1 for INL Site receptor locations.*

Although noble gases were the radionuclides released in the largest quantities in 2021, they accounted for less than 1% of the cumulative MEI dose from all pathways largely because of their relatively short half-lives and because they only affect the immersion dose (i.e., they are excluded from the food supply). For example, about 40% of the total INL activity released was argon-41 (^{41}Ar) as shown in Table 4-2, yet ^{41}Ar accounted for less than 1% of the estimated MEI dose. In contrast, radionuclides typically associated with airborne particulates, such as ^{137}Cs, ^{238}U, ^{234}U, ^{65}Zn and ^{36}Cl, comprised only a small fraction (e.g., less than 0.08%) of the total amount of radionuclides reported to be released previously reported in Table 4-2, yet resulted in approximately 92.36% of the estimated MEI dose are shown in Figure 8-3. The dose from ^{137}Cs (e.g., half-life 30.2 years) comes largely from deposition on the ground where it can enter the food chain and is a source of direct radiation. The direct radiation comes from gamma photons emitted from the short-lived decay product barium-137m. Uranium-234 and ^{238}U are isotopes of natural uranium with half-lives of 245,500 years and 4.5 billion years, respectively. During decay, both isotopes emit alpha particles which are less penetrating than other forms of radiation, and ^{238}U emits a weak gamma ray. As long as it remains outside the body, uranium poses a small health hazard, mostly from gamma-rays. If inhaled or ingested, the radioactivity poses increased risks of cancer due to alpha particle emissions. Chlorine-36 also has a very long half-life that decays by emitting a relatively low-energy beta particle and a small amount of gamma radiation that poses a hazard only if ingested. Zinc-65 is the longest-lived zinc radioisotope with a half-life of 244 days. Zinc-65 causes direct radiation dose and dose from inhalation and ingestion.

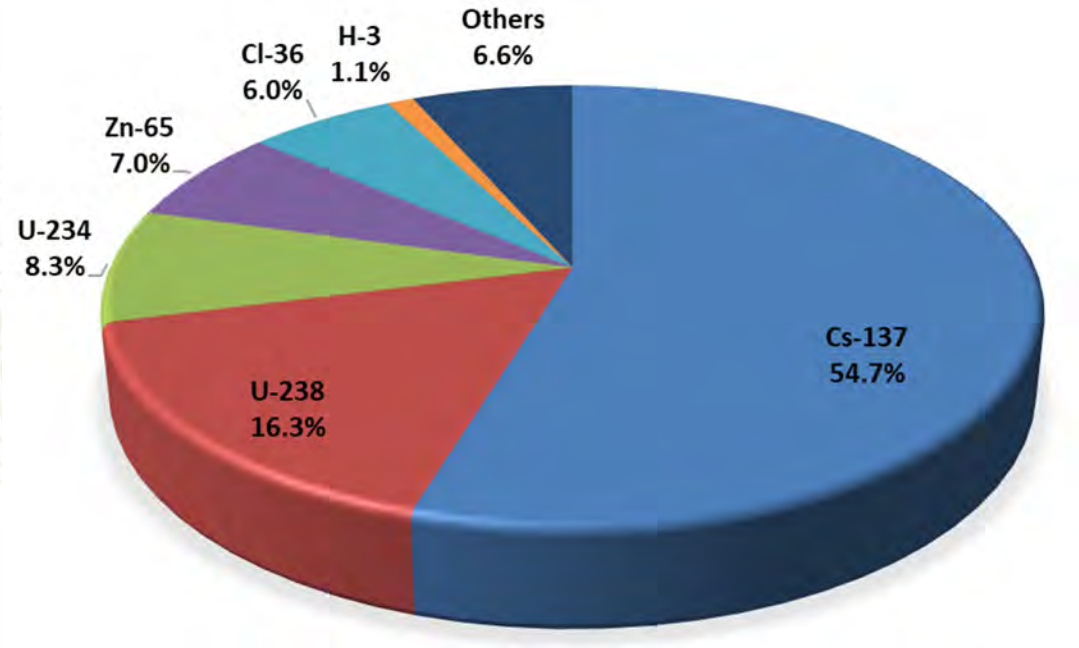

Figure 8-3. Radionuclides contributing to dose to MEI from INL Site airborne effluents as calculated using the CAP88-PC Model (2021).

Primary sources of the major radionuclides used to estimate the dose to the MEI are identified in Figure 8-3 were identified during preparation of the annual NESHAP report (DOE-ID 2021) as follows:

- The largest dose contribution was from ^{137}Cs (54.7%) and the majority came from the Radiochemistry Laboratory (MFC-1702) located at MFC.
- ^{238}U and ^{234}U account for 16.3% and 8.3% of the MEI dose respectively; most came from the Advanced Fuel Facility (MFC-784) at MFC.
- ^{65}Zn and ^{36}Cl account for 7.0% and 6.0% of the MEI dose respectively; the majority came from the Electron Microscopy Laboratory (MFC-774) at MFC.
- Tritium accounts for only 1.1% of the MEI dose with 21.1% coming from the ATR Complex warm waste ponds (TRA-715), 50.6% coming from beryllium blocks at RWMC, 17.3% from the ATR stack, and the rest from other sources.

The largest contribution by facility to the MEI dose came overwhelmingly from MFC at 97.1%, followed by the ATR Complex at 1.45%, and RWMC at 0.64% as shown in Figure 8-4. This is expected for location 54 given the proximity to MFC. Additionally, primary wind directions at the INL Site are from the southwest and northeast and thus emissions from Test Area North, the Naval Reactors Facility, INTEC, ATR, and RWMC are off axis from a receptor near MFC.

Although the dose increased slightly in 2021, the MEI dose of 0.067 mrem/year is still far below the regulatory standard of 10 mrem/yr (0.1 mSv/yr) (40 CFR 61, Subpart H).

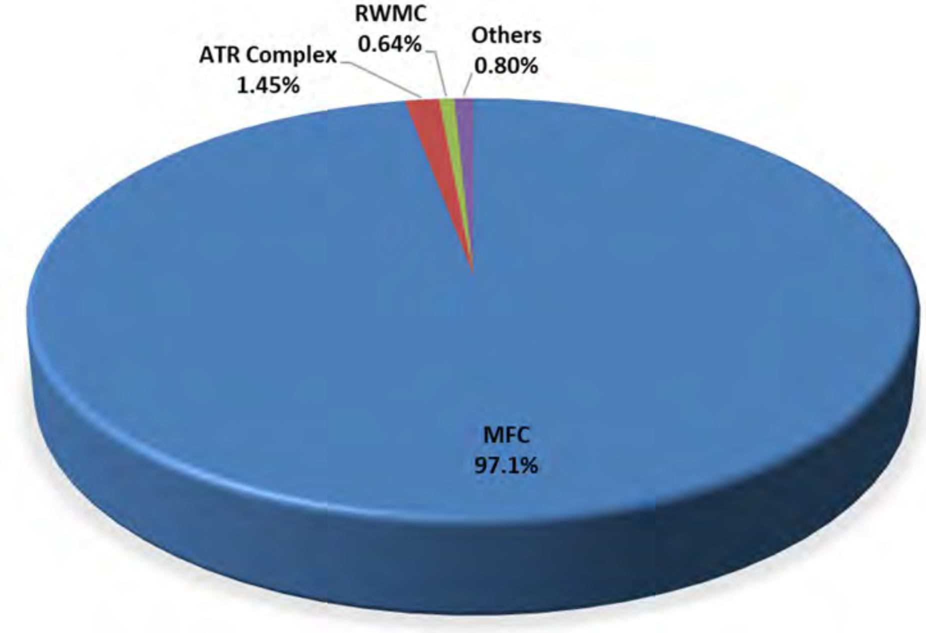

Figure 8-4. Percent contributions, by facility, to MEI dose from the INL Site airborne effluents as calculated using the CAP88-PC Model (2021).

8.2.2 Eighty Kilometer (50 Mile) Population Dose

The total effective population dose from airborne releases was calculated using air dispersion modeling performed by the NOAA Air Research Laboratory Field Research Division using their HYSPLIT model (Stein et al. 2015; Draxler et al. 2013), and the DOSEMM v 190926 (Rood 2019) dose assessment model. The HYSPLIT model and its capabilities are described on the NOAA Air Resources Laboratory website (see https://www.arl.noaa.gov/hysplit/).

The objective of these calculations were to provide a grid of total effective dose across a model domain that encompasses an 80-km (50-mi) radius from any INL Site source, as observed in Figure 8-5. In addition to INL Site sources, releases from the Idaho Falls facilities located at the INL Research Center (IRC) within Idaho Falls city limits were also included. These data were then used with geographical information system software to compute population dose.

The radionuclide source term for facilities that contributed significantly to the annual dose were the same as those used by the CAP88-PC (EPA 2020) modeling performed for the annual NESHAP report (DOE-ID 2022). These sources and radionuclides were included in the HYSPLIT/DOSEMM modeling. Radionuclides and facilities that yielded greater than 0.01% of the total dose at the location of the INL Site MEI were selected to be modeled, as observed in Tables 8-2 and 8-3, respectively. For Idaho Falls facilities, radionuclides that result in a dose greater than 0.1% of the total dose at the MEI in Idaho Falls were included. The radionuclide source term used for the Idaho Falls facilities modeling is shown in Table 8-4.

During 2021, the NOAA Air Resources Laboratory Field Research Division continuously gathered meteorological data at 34 meteorological stations on and around the INL Site (see *Meteorological Monitoring*, a supplement to this Annual Site Environmental Report). The transport and dispersion of contaminants by winds and deposition onto the ground was projected by the HYSPLIT model using hourly averaged observations from the meteorological stations throughout 2021 together with regional topography. The model predicted dispersion and deposition resulting from releases from each facility at each of 17,877 grid points projected on and around the INL Site. The Cartesian grid was designed to encompass the region within 80 km (50 mi) of INL Site facilities, as shown in Figure 8-5. In addition, 27 boundary receptor locations, representing actual residences around the INL Site, were included in the modeling. These 27 receptor locations are a subset of the 62 receptor locations used for the NESHAP evaluation.

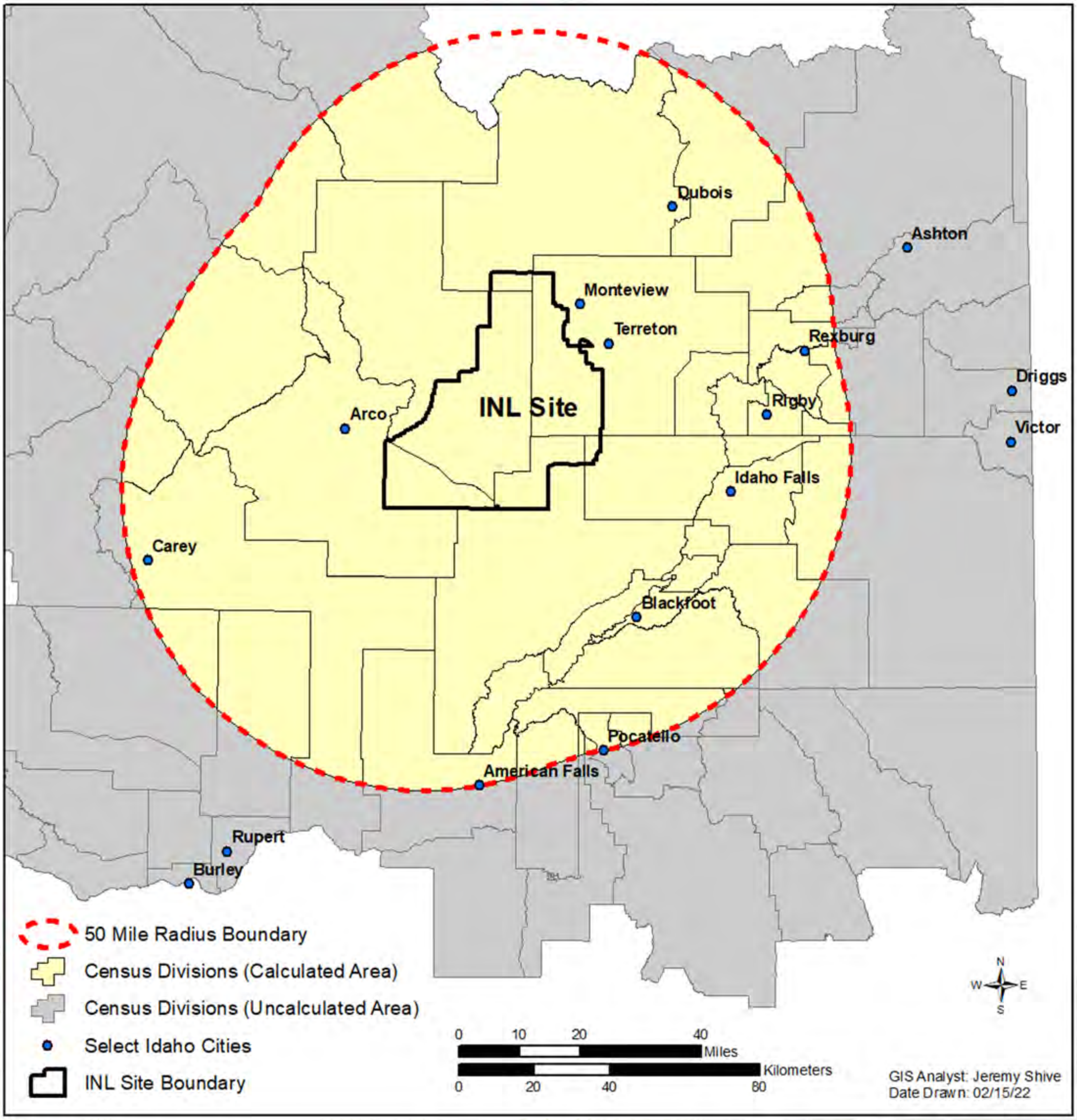

Figure 8-5. Region within 80 km (50 miles) of INL Site facilities. *Census divisions used in the 50-mile population dose calculation are shown.*

Table 8-2. Particulate radionuclide source term (Ci yr^{-1}) for radionuclide-facility combinations that contributed greater than 0.01% of the total dose for INL Site facilities[a] at the MEI location (2021).

RADIONCULIDE	ATRC	ATRC-ATR	ATRC-MTR	CFA	INTEC	INTEC-MS	MFC	MFC-MS	MFC-TREAT	NRF	RWMC	SMC	TAN	TOTAL (Ci yr^{-1})
Americium-241	2.19E-05	5.79E-07	–	7.50E-12	3.14E-04	2.66E-13	2.77E-11	–	–	–	1.05E-04	–	–	4.41E-04
Bromine-82	–	–	–	8.29E-07	–	–	–	–	–	–	–	1.03E+01	–	1.03E+01
Chlorine-36	–	–	–	–	5.02E-06	–	7.19E-03	–	–	–	–	2.71E-09	–	7.19E-03
Cobalt-60	7.07E-03	4.93E-06	–	2.11E-11	1.64E-05	–	1.97E-12	–	–		4.43E-17	–	–	7.09E-03
Cesium-137	5.48E-03	4.38E-05	–	3.75E-08	2.17E-04	5.99E-10	2.60E-01	–	–	6.30E-05	4.43E-18	–	–	2.66E-01
Plutonium-239	8.46E-06	–	–	1.28E-11	1.16E-04	9.81E-14	2.29E-07	1.74E-08	8.20E-09	3.80E-06	4.14E-05	–	–	1.70E-04
Plutonium-240	1.28E-14	–	–	1.25E-12	1.15E-04	8.83E-14	3.58E-11	–	–	–	1.13E-05	–	–	1.26E-04
Strontium-90	2.65E-02	–	–	2.10E-12	5.28E-05	5.49E-10	2.23E-06	9.05E-08	–	6.90E-05	4.29E-08	–	1.02E-06	2.66E-02
Tellurium-129m	–	–	–	7.17E-14	–	–	4.32E-02	–	–	–	–	–	–	4.32E-02
Uranium-234	1.41E-10	–	–	6.57E-12	1.76E-07	–	6.52E-02	–	–	–	–	1.65E-08	–	6.52E-02
Uranium-235	3.09E-10	–	–	2.41E-13	1.02E-08	–	2.19E-02	–	–	–	2.48E-10	1.15E-09	–	2.19E-02
Uranium-238	1.57E-09	–	–	3.57E-13	1.29E-07	–	1.10E-01	–	–	–	1.40E-08	9.16E-08	–	1.10E-01
Zinc-65	9.52E-06	–	–	9.45E-14	6.53E-17	–	3.32E-01	–	–	–	–	4.27E-08	–	3.32E-01

ATRC = Advanced Test Reactor Complex; ATRC-ATR = Advanced Test Reactor Complex-Advanced Test Reactor; ATRC-MTR = Advanced Test Reactor Complex-Material Test Reactor; CFA = Central Facilities Area; INTEC = Idaho Nuclear Technology and Engineering Center, INTEC-MS = Idaho Nuclear Technology and Engineering Center-Main Stack; MFC = Materials and Fuels Complex; MFC-MS = Materials and Fuels Complex-Main Stack; MFC-TREAT = Materials and Fuels Complex-Transient Reactor Test Facility; NRF = Naval Reactors Facility, RWMC = Radioactive Waste Management Complex (including Advanced Mixed Waste Treatment Project); SMC = Specific Manufacturing Capability; TAN = Test Area North (including Technical Support Facility).

Table 8-3. Noble gases, iodine, tritium and carbon-14 source term (Ci yr^{-1}) for radionuclide-facility combinations that contributed greater than 0.01% of the total dose for INL Site facilities[a] at the MEI location (2021).

RADIONUCLIDE	ATRC	ATRC-ATR	ATRC-MTR	CFA	INTEC	INTEC-MS	MFC	MFC-TREAT	NRF	RWMC	SMC	TAN	TOTAL (Ci yr^{-1})
Argon-41	5.40E-05	3.47E+02	–	4.70E-05	–	–	–	8.09E+01	–	–	8.69E-11	–	4.28E+02
Krypton-87	3.40E-05	3.11E+00	–	7.08E-05	–	–	–	1.05E+01	–	–	1.74E-20	–	1.36E+01
Krypton-88	5.21E-03	–	–	3.75E-03	–	–	–	9.51E+00	–	–	–	–	9.52E+00
Krypton-89	–	–	–	–	–	–	–	3.42E+01	–	–	–	–	3.42E+01
Xenon-138	1.18E-04	1.13E+01	–	5.90E-05	–	–	–	1.62E+01	–	–	–	–	2.75E+01
Iodine-129	1.31E-10	–	–	1.29E-18	6.91E-05	3.92E-06	4.91E-05	–	1.20E-05	–	–	–	1.34E-04
Iodine-131	1.75E-06	5.10E-07	–	2.51E-12	–	–	9.40E-02	–	5.20E-06	–	–	–	9.40E-02
Carbon-14	4.32E-10	–	–	2.00E-09	3.15E-02	–	–	–	5.50E-01	2.22E-02	–	–	6.04E-01
Hydrogen-3	7.48E+01	3.80E+02	–	5.19E-01	1.59E-01	1.28E-03	3.65E-01	–	1.10E-02	4.81E+01	–	3.26E-02	5.04E+02

ATRC = Advanced Test Reactor Complex; ATRC-ATR = Advanced Test Reactor Complex-Advanced Test Reactor; ATRC-MTR = Advanced Test Reactor Complex-Material Test Reactor; CFA = Central Facilities Area; INTEC = Idaho Nuclear Technology and Engineering Center; INTEC-MS = Idaho Nuclear Technology and Engineering Center-Main Stack; MFC = Materials and Fuels Complex; MFC-TREAT = Materials and Fuels Complex-Transient Reactor Test Facility; NRF = Naval Reactors Facility; RWMC = Radioactive Waste Management Complex (including Advanced Mixed Waste Treatment Project); SMC = Specific Manufacturing Capability; TAN = Test Area North (including Technical Support Facility).

Table 8-4. Radionuclide source term (Ci yr^{-1}) for radionuclides that contributed greater than 0.1% of the total dose for INL in-town facilities[a] (2021).

RADIONUCLIDE	IF-603	IF-611	IF-683 (RESL)	ANNUAL RELEASE (Ci yr^{-1})
Actinium-227	–	–	5.39E-09	5.39E-09
Americium-241	–	–	1.02E-07	1.02E-07
Americium-243	–	–	1.04E-09	1.04E-09
Barium-133	–	–	3.59E-07	3.59E-07
Cobalt-60	2.00E-17	–	1.16E-08	1.16E-08
Cesium-134	9.37E-07	–	2.57E-08	9.63E-07
Cesium-137	9.40E-08	–	7.18E-08	1.66E-07
Europium-152	–	–	4.49E-08	4.49E-08
Europium-154	1.50E-13	–	7.69E-08	7.69E-08
Iodine-125	–	–	4.88E-08	4.88E-08
Iodine-129	–	–	1.10E-10	1.10E-10
Neptunium-237	–	–	6.48E-09	6.48E-09
Protactinium-231	–	–	1.15E-09	1.15E-09
Plutonium-238	–	–	7.83E-08	7.83E-08
Plutonium-239	–	–	1.32E-07	1.32E-07
Radium-226	–	–	7.53E-08	7.53E-08
Strontium-90	–	–	7.04E-08	7.04E-08
Uranium-232	–	–	3.18E-08	3.18E-08
Uranium-233	–	–	1.64E-07	1.64E-07
Xenon-133	–	4.63E-01	–	4.63E-01
Xenon-135	–	1.24E-04	–	1.24E-04
Zinc-65	4.70E-08	–	8.41E-08	1.31E-07

a. All three sources are located at the INL Research Center and were assumed to be released from the Radiological and Environmental Sciences Laboratory (RESL) stack location.

Outputs from the NOAA HYSPLIT model were radionuclide air concentrations and deposition amounts for a unit release (1 Ci/s) for each significant INL Site source calculated at 17,877 grid nodes across the model domain. These values were converted to dispersion and deposition factors for use in DOSEMM (Rood 2019).

The dispersion factor, often referred to as the X/Q value (concentration divided by source), was calculated by dividing the concentration in air (Ci/m^3) by the unit release rate (1 Ci/s) resulting in dispersion factor units of s/m^3. The deposition factor was calculated by dividing the total deposition (Ci/m^2) by the release time (seconds) and then by the unit release rate (1 Ci/s) to yield deposition factors in units in 1/m^2. Dispersion and deposition factors were calculated for each month of the year and were read into DOSEMM along with the annual radionuclide release rates from each source. Although annual release quantities were provided, monthly release quantities could have been used if available to account for seasonal variations in atmospheric dispersion.

Using DOSEMM, the actual estimated radionuclide emission rate (Ci/s) for each radionuclide and each facility was multiplied by the air dispersion and deposition factors that were calculated by HYSPLIT to yield an air concentration (Ci/m^3) and deposition (Ci/m^2) at each of the grid points over the time of interest (in this case, one year). The products were then used to calculate the effective dose (mrem) via inhalation, ingestion, and external exposure pathways at each grid point and at each boundary receptor location using the methodology described in Rood (2019).

Figure 8-6 displays the summation of all doses calculated from the modeling of all releases from all facilities (including INL in-town facilities) as isopleths, ranging in value from 0.0008 to 0.8 mrem (0.008 to 8 μSv). The highest dose to an INL Site boundary receptor was estimated to be 0.00659 mrem (0.0659 μSv) at a farmhouse and cattle operation (receptor location 6, which is the same as receptor location 54 in Figure 8-1). The farmhouse and cattle operation are also the location of the MEI used for the NESHAP dose assessment in 2021, which reported an estimated dose of 0.067 mrem (0.67 μSv) to the MEI (see Section 8.2.1). The lower dose of the HYSPLIT/DOSEMM model are attributed to the generally lower HYSPLIT dispersion factors when compared to those from CAP88-PC and 1-year buildup time in soil in DOSEMM for external exposure compared to 100-year buildup time in CAP88-PC (Rood 2022). The HYSPLIT dispersion factors reflect differences in plume trajectory, turbulent diffusion, terrain complexities, plume depletion and sector averaging between the HYSPLIT and CAP88-PC models.

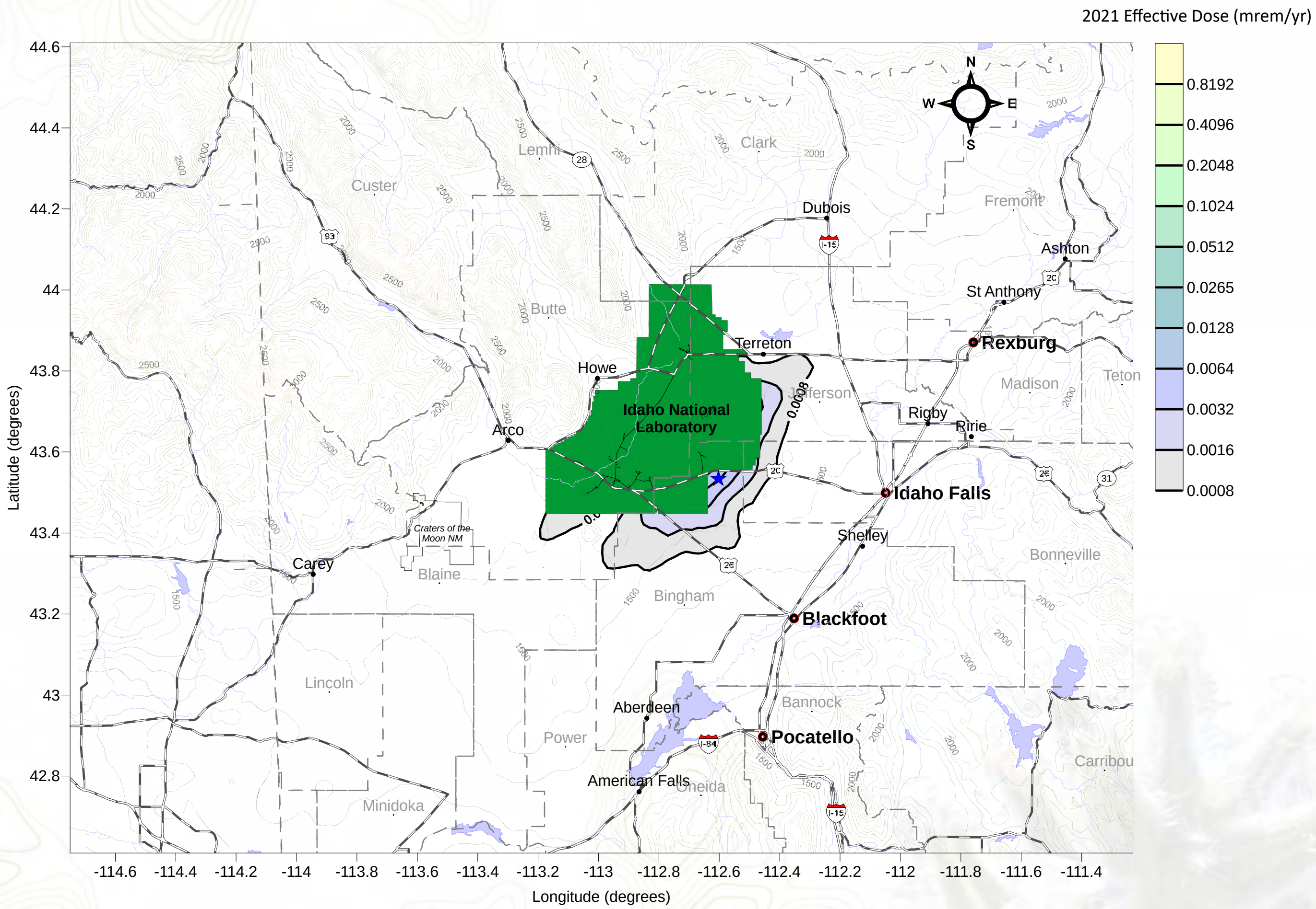

Figure 8-6. ***Effective dose (mrem) isopleth map with boundary receptor locations displayed (2021).*** *The maximum receptor dose is projected at receptor 6, which is a farmhouse and cattle operation, as depicted as a blue star east of the INL east entrance. This is the same location as receptor 54 in Figure 8-1.*

To calculate the 80 km (50 mi) population dose, the number of people living in each census division was first estimated with data from the 2010 census extrapolated to 2021. The extrapolation of the population for each census division was performed by calculating the change in the population during the last ten-year period between censuses (i.e., 2000-2010) and dividing the result by ten to yield the rate of change per year. The rate of change per year was adjusted for the 2021 time period and applied to the 2010 population in order to estimate the number of people living in each census division. It was necessary to use 2010 census data for 2021 because full 2020 census results were not available in time for publication of this report. The next step involved the use of the Geographic Information System. The grid and dose values from DOSEMM were imported into the Geographic Information System. The doses within each census division were averaged and multiplied by the population within each of the divisions or portion of divisions within the 80 km (50 mi) area defined in Figure 8-5. These doses were then summed over all census divisions to obtain the 80 km (50 mi) population dose, as observed in Table 8-5. The estimated potential population dose was 2.85 x 10^{-2} person-rem (2.85 x 10^{-4} person-Sv) to a population of approximately 353,435. When compared with the approximate population dose of 136,779 person-rem (e.g., 1,368 person-Sv) estimated to be received from natural background radiation, as observed in Table 8-6, this represents an increase of about 0.00002 percent.

The estimated population dose for 2021 is lower than that calculated for 2020 (5.41 x 10^{-2} person-rem).

Table 8-5. Dose to population within 80 km (50 miles) of INL Site facilities (2021).

CENSUS COUNTY DIVISION[a,b]	POPULATION[c]	POPULATION DOSE	
		PERSON-rem	PERSON-Sv
Aberdeen	3,798	3.34E-04	3.34E-06
Alridge	586	7.44E-06	7.44E-08
American Falls	11,027	1.59E-03	1.59E-05
Arbon (part)	30	1.03E-06	1.03E-08
Arco	2,710	8.08E-04	8.08E-06
Atomic City (division)	2,697	9.21E-03	9.21E-05
Blackfoot	16,482	7.28E-04	7.28E-06
Carey (part)	1,131	1.18E-04	1.18E-06
East Clark	85	7.90E-06	7.90E-08
East Madison (part)	327	8.26E-06	8.26E-08
Firth	3,291	1.04E-04	1.04E-06
Fort Hall (part)	4,702	1.50E-04	1.50E-06
Hailey-Bellevue (part)	6	6.18E-08	6.18E-10
Hamer	2,370	3.90E-03	3.90E-05
Howe	403	3.55E-04	3.55E-06
Idaho Falls	119,106	3.77E-03	3.77E-05
Idaho Falls, west	1,669	7.20E-04	7.20E-06
Inkom (part)	676	1.01E-05	1.01E-07
Island Park (part)	102	1.04E-05	1.04E-07
Leadore (part)	6	1.27E-07	1.27E-09
Lewisville-Menan	4,488	3.32E-04	3.32E-06
Mackay (part)	1,300	1.54E-05	1.54E-07
Moreland	11,092	7.24E-04	7.24E-06
Pocatello	67,708	1.81E-03	1.81E-05
Rexburg	33,528	1.25E-03	1.25E-05

Table 8-5. continued.

CENSUS COUNTY DIVISION[a,b]	POPULATION[c]	POPULATION DOSE	
		PERSON-rem	PERSON-Sv
Rigby	24,160	7.46E-04	7.46E-06
Ririe	2,212	3.12E-05	3.12E-07
Roberts	1,657	2.64E-04	2.64E-06
Shelley	9,465	3.06E-04	3.06E-06
South Bannock (part)	343	8.46E-06	8.46E-08
St. Anthony (part)	2,777	1.72E-04	1.72E-06
Sugar City	8,291	5.62E-04	5.62E-06
Swan Valley (part)	7,268	1.02E-04	1.02E-06
Ucon	7,119	2.65E-04	2.65E-06
West Clark	823	6.09E-05	6.09E-07
TOTAL	**353,435**	**2.85E-02**	**2.85E-04**

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 estimate 2020 values based on 2010 Census Report for Idaho since the 2020 Census Report was not available at the time of this report.

Table 8-6. Contribution to estimated annual dose from INL Site facilities by pathway (2021).

PATHWAY	ANNUAL DOSE TO MEI		PERCENT OF DOE 100 mrem/yr LIMIT[a]	ESTIMATED POPULATION DOSE		POPULATION WITHIN 80 km	ESTIMATED BACKGROUND RADIATION POPULATION DOSE (PERSON-rem)[b]
	(mrem)	(µSv)		(PERSON-rem)	(PERSON-Sv)		
Air	0.067	0.67	0.067	0.028	0.00028	353,435	136,779
Waterfowl	0.002	0.02	0.002	NA[c]	NA	NA	NA
Big game animals	0.000	0.00	NA	NA	NA	NA	NA
TOTAL, ALL PATHWAYS	**0.069**	**0.69**	**0.069**	**0.028**	**0.00028**	**NA**	**NA**

a. The DOE public dose limit from all sources of ionizing radiation and exposure pathways that could contribute significantly to the total dose is 100 mrem/yr (1 mSv/yr) total effective dose equivalent. It does not include dose from background radiation.

b. The individual background dose was estimated to be 387 mrem or 0.387 rem in 2021, as shown previously in Table 7-8. The background population dose is calculated by multiplying the individual background dose by the population within 80 km (50 mi) of the INL Site.

c. NA = Not applicable.

8.3 Dose to the Public from Ingestion of Wild Game from the Idaho National Laboratory Site

The potential dose that 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 may briefly reside at wastewater disposal ponds at the ATR Complex and MFC, and game animals that may reside on or migrate through the INL Site.

8.3.1 Waterfowl

The maximum potential dose of 0.002 mrem (0.02 µSv) calculated for an individual consuming contaminated waterfowl based on 2021 sample results is lower than the dose estimated for 2020 (0.078 mrem [0.78 µSv]). As in the past, the 2021 samples were not collected directly from the warm wastewater evaporation ponds at the ATR Complex but from sewage lagoons adjacent to them. The dose calculation assumes the waterfowl resided at all the ponds while they were in the area.

8.3.2 Big Game Animals

A study on the INL Site from 1972–1976 conservatively estimated the potential whole-body dose that could be received from an individual eating the entire muscle (27,000 g [952 oz]) and liver mass (500 g [17.6 oz]) of an antelope with the highest levels of radioactivity found in these animals. This dose was 2.7 mrem (27 µSv) (Markham et al. 1982). Game animals collected at the INL Site during the past few years have generally shown much lower concentrations of radionuclides. In 2021, none of the game samples collected (e.g., eight 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 are calculated because only a limited percentage of the population hunts game, few of the animals killed have spent time on the INL Site, and most of the animals that do migrate from the INL Site would have reduced concentrations of radionuclides in their tissues by the time they were harvested (Halford, Markham, and White 1983). The total population dose contribution from these pathways would, realistically, be less than the sum of the population doses from the inhalation of air, submersion in air, ingestion of vegetables, and deposition on soil.

8.4 Dose to the Public from Drinking Groundwater from the Idaho National Laboratory Site

Tritium has previously been detected in three U.S. Geological Survey monitoring wells located on the INL Site along the southern boundary (Mann and Cecil 1990; Bartholomay, Hopkins, and Maimer 2015; Twining et al. 2021). These wells, located in an uninhabited area, have shown a historical downward trend in tritium detections. The maximum concentration from all wells on the INL Site (4,280 ± 150 pCi/L) in 2021 is considerably less than the maximum contaminant level established by EPA for drinking water (20,000 pCi/L). An individual drinking water from a well with the maximum concentration would hypothetically receive a dose of 0.202 mrem (0.00202 mSv) in one year. Because these wells are not used for drinking water, this is an unrealistic scenario and the groundwater ingestion pathway is not included in the total dose estimate to the MEI.

8.5 Dose to the Public from Direct Radiation Exposure along Idaho National Laboratory Site Borders

The direct radiation exposure pathway from gamma radiation to the public is monitored annually using thermoluminescent dosimeters and optically-stimulated luminescent dosimeters, as previously shown in Figure 7-8.

In 2021, 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 O 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 2021, the only probable pathways from INL Site activities to a realistic MEI include the air transport pathway and ingestion of game animals.

The hypothetical individual, assumed to live at a farmhouse and cattle operation located 3.1 km south of Highway 20, and 3 km from INL Site's east entrance presented in Figures 8-1 and Figure 8-6, would receive a calculated dose from INL Site airborne releases reported for 2021 (Section 8.2.1) and from consuming a duck contaminated at the ATR Complex wastewater ponds (Section 8.3.1). No dose was calculated from eating big game animals in 2021 (Section 8.3.2).

The dose estimate for an offsite MEI is presented in Table 8-6. The total all-pathways dose was conservatively estimated to be 0.069 mrem (0.69 µSv) for 2021. This represents about 0.017 percent of the annual dose expected to be received from background radiation (387 mrem [3.8 mSv], as shown in Table 7-7) and is well below the 100 mrem/yr (1 mSv/yr) public dose limit above background established by DOE. As discussed in the Helpful Information section of this report, the 100 mrem/yr limit is far below the exposure levels expected to result in acute health effects.

The dose received by the entire population within 80 km (50 mi) of INL Site facilities was calculated to be 2.85 x 10^{-2} person-rem (2.85 x 10^{-4} person-Sv) identified in Table 8-5. This is approximately 0.00002 percent of the dose (136,779 person-rem, [1,368 person-Sv], Table 8-6) expected from exposure to natural background radiation in the region.

8.7 Dose to the Public from Operations on the Idaho National Laboratory Research and Education Campus

Facilities in the city of Idaho Falls that reported potential radionuclide emissions for inclusion in the 2021 NESHAP report include the IRC Laboratory (IF-603), DOE RESL (IF-683), and the National Security Laboratory (IF-611). These facilities are located contiguously at the IRC, part of the Research and Education Campus on the north side of the city of Idaho Falls. Though programs and operations at the IRC are affiliated with the INL, the IRC is located within the city limits of Idaho Falls and is not contiguous with the INL Site, the nearest boundary of which is approximately 35 km (22 mi) west of Idaho Falls. For this reason, the 2021 INL NESHAP evaluation (DOE-ID 2022) includes a dose calculation to a member of the public that is separate from the INL Site MEI. (Note: the Research and Education Campus source term was, however, included in the population dose calculation reported in Section 8.2.2.) The IRC MEI for calendar year 2021 is approximately 115 meters south-southeast of RESL. The effective dose equivalent to the MEI was conservatively calculated, using CAP88-PC, to be 0.0062 mrem/yr (0.062 µSv/yr), which is less than 0.1 percent of the 10-mrem/yr federal standard.

8.8 Dose to Biota

8.8.1 Introduction

The impact of environmental radioactivity at the INL Site on nonhuman biota was assessed using *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE 2019) and the associated software, RESRAD-Biota 1.8 (DOE 2019). The graded approach includes a screening method and three more detailed levels of analysis for demonstrating compliance with standards for the protection of biota. The threshold of protection is assumed at the following absorbed doses: 1 rad/d (10 mGy/d) for aquatic animals, 0.1 rad/d (1 mGy/d) for terrestrial animals, and 1 rad/d (10 mGy/d) for terrestrial plants.

The first step in the graded approach uses conservative default assumptions and maximum values for all currently available data. This general screening level (Level 1 in RESRAD-Biota) provides generic limiting concentrations of radionuclides in environmental media, termed "Biota Concentration Guides." Each biota concentration guide is the environmental concentration of a given radionuclide in soil or water that, under the assumptions of the model, would result in a dose rate less than 1 rad/d (10 mGy/d) to aquatic animals or terrestrial plants or 0.1 rad/d (1 mGy/d) to terrestrial animals. If the sum of the measured maximum environmental concentrations divided by the biota concentration guides (e.g., 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 the EPA (1998). RESRAD-Biota cannot perform these calculations.

8.8.2 Terrestrial Evaluation

The division of the INL Site into evaluation areas based on potential soil contamination and habitat types is of particular importance for the terrestrial evaluation portion of the 2021 biota dose assessment. For the INL Site, it is appropriate to consider specific areas that have been historically contaminated above background levels. Most of these areas have been monitored for radionuclides in soil since the early 1970s (Jessmore, Lopez, and Haney 1994). In some of these areas, structures have been removed and areas cleaned to a prescribed, safe contamination level, but the soil may still have residual, measurable concentrations of radionuclides. These areas are associated with the facilities shown in Figure 1-4 and include:

- Auxiliary Reactor Area
- ATR Complex
- Critical Infrastructure Test Range Complex
- INTEC
- Large Grid, a 24-mile radius around INTEC
- MFC
- Naval Reactors Facility
- RWMC
- Test Area North.

For the initial terrestrial evaluation, the most recently measured maximum concentrations of radionuclides in INL Site soil were used, as discussed in Table 8-7. The table includes laboratory analyses of soil samples collected in 2005, 2006, 2012, 2015, and 2017 (soil samples were not collected on the INL Site in 2016, 2018, 2019, 2020, or 2021).

Using the maximum radionuclide concentrations for all locations in Table 8-7, a screening level analysis was made of the potential terrestrial biota dose. The soil concentrations are conservative because background concentrations were not subtracted. The analysis also assumed that animals have access to water in facility effluents and ponds. The maximum radionuclide concentrations reported in ponds at the INL Site were for the MFC Industrial Waste Pond presented in Table C-17. The results for uranium-233/234 ($^{233/234}U$) and ^{238}U in Table C-17, 1.83 pCi/L and 0.58 pCi/ respectively, were thus used to represent surface water concentrations. When $^{233/234}U$ was reported, it was assumed that the radionuclide present was ^{233}U since doses due to ingestion and inhalation are more conservative for ^{233}U than for ^{234}U (EPA 2002).

The combined sum of fractions was less than one for both terrestrial animals (0.21) and plants (0.002) and passed the general screening test, as pointed out in Table 8-8. Based on the results of the graded approach, there is no evidence that INL Site-related radioactivity in soil is harming terrestrial plant or animal populations.

Tissue data from bats collected at or near INL facilities were also available and are previously presented in Table 7-4. Concentrations of radionuclides in tissue were input into the RESRAD-Biota computer model at the Level 3 step to calculate the internal dose to bats. The results of the dose evaluation to bats using radionuclide concentrations measured in tissue are shown in Table 8-9. The maximum dose received by bats at the INL Site was estimated to be 0.001 rad/d (0.01 mGy/d) in 2021. The calculated doses are well below the threshold of 1 rad/d (10 mGy/d). Based on these results, members of the bat population at the INL Site receive an absorbed dose that is within the DOE standard established for the protection of terrestrial animals.

8.8.3 Aquatic Evaluation

Maximum radionuclide concentrations reported in Table B-17 (results for the MFC Industrial Waste Pond) were also used for aquatic evaluation. Potassium-40 reported in ponds was assumed to be of natural origin and was not included in the 2021 calculations. The results shown in Table 8-10 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 (0.01) and riparian animals (0.003).

Table 8-7. Concentrations of radionuclides in INL Site soils, by area.

LOCATION[a]	RADIONUCLIDE	DETECTED CONCENTRATION (pCi/g)[b]	
		MINIMUM	MAXIMUM
ARA/CITRC	Cesium-134	4.0E-02	6.0E-02
	Cesium-137	1.3E-01	3.0
	Strontium-90	2.1E-01	3.7E-01
	Plutonium-238	------	3.9E-03
	Plutonium-239/240	1.3E-02	1.8E-02
	Americium-241	5.5E-03	8.5E-03
ATR Complex	Cesium-137	2.0E-1	6.1E-01
	Strontium-90	------[c]	5.8E-02
	Plutonium-238	5.9E-03	4.3E-02
	Plutonium-239/240	1.7E-02	2.2E-02
EFS	Cesium-137	1.5E-01	6.8E-01
INTEC	Cesium-134	------	8.0E-02
	Cesium-137	3.0E-02	3.5
	Strontium-90	4.9E-01	7.1E-01
	Plutonium-238	2.5E-02	4.3E-02
	Plutonium-239/240	1.1E-02	2.9E-02
	Americium-241	6.1E-03	8.1E-03
MFC	Cesium-134	4.0E-02	6.0E-02
	Cesium-137	1.3E-01	4.9E-01

Table 8-7. continued.

LOCATION[a]	RADIONUCLIDE	DETECTED CONCENTRATION (pCi/g)[b]	
		MINIMUM	MAXIMUM
	Cobalt-60	------	5.0E-02
	Plutonium-239/240	1.5E-02	2.9E-02
	Americium-241	4.3E-03	1.2E-02
RWMC	Cesium-137	1.4E-02	4.5E-02
	Plutonium 239/240	------	2.4E-02
	Cesium-134	------	6.0E-02
	Cesium-137	------	3.3E-01
	Plutonium-239/240	5.7E-03	1.6E-02
	Americium-241	4.3E-03	9.7E-03
TAN/SMC	Cesium-134	4.0E-02	6.0E-02
	Cesium-137	1.1E-01	3.1
	Plutonium-239/240	1.3E-02	1.7E-02
	Americium-241	3.2E-03	5.7E-03
All	Cesium-134	3.0E-02	9.0E-02
	Cesium-137	1.4E-02	3.5
	Cobalt-60	------	5.0E-02
	Strontium-90	1.0E-02	7.1E-01
	Plutonium-238	2.2E-03	4.3E-02
	Plutonium-239/240	5.7E-03	9.5E-01
	Americium-241[d]	3.2E-03	6.2E-01

a. ATR Complex = Advanced Test Reactor Complex; ARA/CITRC = Auxiliary Reactor Area/Critical Infrastructure Test Range Complex; EFS = Experimental Field Station; MFC = Materials and Fuels Complex; INTEC = Idaho Nuclear Technology and Engineering Center; RWMC = Radioactive Waste Management Complex; TAN/SMC = Test Area North/Specific Manufacturing Capability. See Figure 1-4.

b. Legend:

a.	Results measured in 2013-2014 using in situ gamma spectroscopy.
b.	Results measured by laboratory analyses of soil samples collected in 2005.
c.	Results measured by laboratory analyses of soil samples collected in 2006.
d.	Results measured by laboratory analyses of soil samples collected in 2012.
e.	Results measured by laboratory analyses of soil samples collected in 2015.
f.	Results measured by laboratory analyses of soil samples collected in 2017.

c. '-----' indicates that only one measurement was taken and is reported as the maximum result.

d. The data were the results of laboratory analysis for Americium-241 in soil samples.

Table 8-8. RESRAD biota assessment (screening level) of terrestrial ecosystems on the INL Site (2021).

TERRESTRIAL ANIMAL						
	WATER			SOIL		
NUCLIDE	CONCENTRATION (pCi/l)	BCG[a] (pCi/l)	RATIO	CONCENTRATION (pCi/g)	BCG (pCi/g)	RATIO
Cobalt-60	–	1.19E+06	–	0.05	6.92E+02	7.23E-05
Cesium-134	–	3.26E+05	–	0.09	1.13E+01	7.97E-03
Cesium-137	–	5.99E+05	–	3.5	2.08E+01	1.69E-01
Plutonium-238	–	1.89E+05	–	0.043	5.27E+03	8.16E-06
Plutonium-239	–	2.00E+05	–	0.95	6.11E+03	1.55E-04
Strontium-90	–	5.45E+04	–	0.71	2.25E+01	3.16E-02
Uranium-233	1.83	4.01E+05	4.57E-06	–	4.83E+03	4.57E-06+00
Uranium-238	0.58	4.06E+05	1.43E-06	–	1.58E+03	–
SUMMED	–	–	**6.00E-06**	–	–	**2.08E-01**
TERRESTRIAL PLANT						
	WATER			SOIL		
NUCLIDE	CONCENTRATION (pCi/l)	BCG (pCi/l)	RATIO	CONCENTRATION (pCi/g)	BCG (pCi/g)	RATIO
Cobalt-60	–	1.49E+07	–	0.05	6.13E+03	8.16E-06
Cesium-134	–	2.28E+07	–	0.09	1.09E+03	8.28E-05
Cesium-137	–	4.93E+07	–	3.5	2.21E+03	1.59E-03
Plutonium-238	–	3.95E+09	–	0.043	1.75E+04	2.46E-06
Plutonium-239	–	7.04E+09	–	0.95	1.27E+04	7.49E-05
Strontium-90	–	3.52E+07	–	0.71	3.58E+03	1.98E-04
Uranium-233	1.83	1.06E+10	1.73E-10	–	5.23E+04	–
Uranium-238	0.58	4.28E+07	1.35E-08	–	1.57E+04	–
SUMMED	–	–	**1.37E-08**	–	–	**1.95E-03**

a. BCG = Biota Concentration Guide. Each radionuclide-specific BCG represents the limiting radionuclide concentration in an environmental medium which would not result in recommended dose standards for biota to be exceeded.

Table 8-9. RESRAD biota assessment (level 3 analysis) of terrestrial ecosystems on the INL Site using measured bat tissue data (2021).

BAT DOSE (rad/d)					
NUCLIDE	WATER	SOIL	SEDIMENT	TISSUE[a]	SUMMED
Cobalt-60	–	6.21E+-06	–	1.24E-04	1.30E-04
Cesium-134	–	1.05E-04	–	9.77E-05	1.05E-04
Cesium-137	–	9.91E-05	–	1.01E-04	2.01E-04
Plutonium-238	–	7.99E-07	–	7.98E-07	7.99E-07
Plutonium-239/240	–	1.13E-08	–	7.17E-05	7.17E-05
Strontium-90	–	4.27E-06	–	8.78E-04	8.83E-04
Uranium-233/234	4.56E-07	–	–	4.56E-07	4.56E-07
Uranium-238	1.29E-07	–	–	1.27E-07	1.29E-07
Zinc-65[b]	–	–	–	9.26E-06	9.26E-06
TOTAL	5.85E-07	2.15E-04	–	**1.28E-03**	**1.40E-03**

a. Calculated using maximum concentrations measured in bat tissues.

b. The half-life of ^{65}Zn is 244.06 days. For this reason, the concentration measured in composited tissue is probably lower (by as much two times) than the original concentrations in the live bats.

Table 8-10. RESRAD biota assessment (screening level) of aquatic ecosystems on the INL site (2021).

AQUATIC ANIMAL						
	WATER			SEDIMENT		
NUCLIDE	CONCENTRATION (pCi/l)	BCG[a] (pCi/l)	RATIO	CONCENTRATION (pCi/g)	BCG (pCi/g)	RATIO
Uranium-233	1.83	2.00E+02	9.17E-03	0.0915	1.06E+07	8.63E-09
Uranium-238	0.581	2.23E+02	2.60E-03	0.02905	4.28E+04	6.78E-07
Summed	–	–	**1.18E-02**	–	–	**6.87E-07**
RIPARIAN ANIMAL						
	WATER			SEDIMENT		
NUCLIDE	CONCENTRATION (pCi/l)	BCG (pCi/l)	RATIO	CONCENTRATION (pCi/g)	BCG (pCi/g)	RATIO
Uranium-233	1.83	6.76E+02	2.71E-03	0.0915	5.28E+03	1.73E-05
Uranium-238	0.581	7.56E+02	7.69E-04	0.02905	2.49E+03	1.17E-05
SUMMED	–	–	**3.48E-03**	–	–	**2.90E-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.

Tissue data from waterfowl collected on the ATR Complex wastewater ponds in 2021 were also available, as shown previously in Table 7-3. Concentrations of radionuclides in tissue can be input into the RESRAD-Biota code at the Level 3 step to calculate the internal dose to biota. To confirm that doses to waterfowl from exposure to radionuclides in the vicinity of the ATR Complex are not harmful, a Level 3 analysis was performed using the maximum tissue concentrations from Table 7-3. The waterfowl were assumed in the model to be riparian animals, accessing both aquatic and terrestrial environments in the area. External dose was calculated using the maximum radionuclide concentrations measured in soils around the ATR Complex and uranium concentrations in water. Concentrations of uranium in sediment were estimated by the RESRAD-Biota code from the concentrations in water.

Results of the dose evaluation to waterfowl using radionuclide concentrations measured in tissue are shown in Table 8-11. The estimated dose to waterfowl was calculated by RESRAD-Biota to be 4.48×10^{-4} rad/d (4.48×10^{-2} mGy/d). This dose is significantly less than the standard of 1 rad/d (10 mGy/d). Based on these results, there is no evidence that water held in ponds at the INL Site is harming aquatic biota.

8.9 Unplanned Releases

In 2021, the INL Site had no events that resulted in emissions exceeding reporting thresholds. All radiological emissions were accounted for in the dose received by the maximally exposed individual.

Table 8-11. RESRAD biota assessment (level 3 analysis) of aquatic ecosystems on the INL Site using measured waterfowl tissue data (2021).

WATERFOWL DOSE (rad/d)					
NUCLIDE	WATER[a]	SOIL[b]	SEDIMENT	TISSUE[c]	SUMMED
Cesium-134	–	5.37E-06	–	–	5.37E-06
Cesium-137	–	7.58E-05	–	–	7.58E-05
Cobalt-60	–	4.97E-06	–	2.38E-06	1.16E-04
Plutonium-238	–	1.76E-10	–	–	1.76E-10
Plutonium-239	–	1.94E-09	–	–	1.94E-09
Strontium-90	–	5.14E-07	–	1.12E-05	1.17E-05
Uranium-233	2.70E-04	NA	1.72E-06	2.72E-04	2.72E-04
Uranium-238	7.55E-05	NA	5.03E-07	7.60E-05	7.60E-05
TOTAL	3.46E-04	8.67E-05	2.23E-06	3.62E-04	4.48E-04

a. Only uranium isotopes were measured in the Material and Fuels Complex Industrial Waste Pond. Hence, doses were not calculated for other radionuclides in water and sediment.

b. External doses to waterfowl were calculated using soil concentrations. Maximum concentrations of radionuclides measured in soil at the INL Site were used (Table 8-7). Note: NA=uranium isotopes were not analyzed for in soil.

c. Internal doses to waterfowl were calculated using maximum concentrations in edible tissue shown in Table 7-3. Note: NA=uranium isotopes were not analyzed for in tissue samples.

8.10 References

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Chapter 9: Natural and Cultural Resources Conservation and Monitoring

CHAPTER 9

Ecological information is used to ensure compliance with applicable rules and regulations and to provide information to ensure that the Idaho National Laboratory (INL) Site Mission and goals can be achieved with few to no impacts to natural resources. There are three key areas of emphasis: (1) Conservation Planning; (2) Land Stewardship; and (3) Natural Resource Monitoring and Research.

The U.S. Department of Energy's Idaho Operations Office addresses conservation by developing conservation or protection plans to protect species and the valuable ecosystems they inhabit. These efforts include: (1) Candidate Conservation Agreement for Greater Sage-grouse (*Centrocercus urophasianus*) on the Idaho National Laboratory Site; (2) the INL Site Bat Protection Plan; (3) the Sagebrush Steppe Ecosystem Reserve; (4) the Migratory Bird Conservation Plan; and (5) the Avian Protection Plan and Bird Management Policy.

Land Stewardship consists of identifying ways to manage ecosystems on the INL Site through planning, restoration, rehabilitation, and preparing the INL Site for climate change. Areas where the U.S. Department of Energy's Idaho Operations Office is actively employing land stewardship activities include: (1) wildland fire protection planning, management, and recovery; (2) restoration and revegetation; (3) carbon sequestration; (4) weed management; (5) ecological support for National Environmental Policy Act; and (6) meeting conditions of Executive Order 14008 "Tackling the Climate Crisis at Home and Abroad."

Natural resource monitoring and research has been conducted for more than 70 years with some studies dating back to the 1950's. The focus of this work is to better understand the INL Site's ecosystem and biota, and to determine the impact on species from activities conducted at the INL Site. The INL Site was designated as a National Environmental Research Park in 1975 and serves as an outdoor laboratory for environmental scientists to study Idaho's native plants and wildlife in an intact and relatively undisturbed ecosystem. Other routine monitoring activities include: (1) breeding bird surveys, (2) midwinter raptor survey, (3) long-term vegetation transects, and (4) vegetation mapping.

The INL Cultural Resource Management Office (CRMO) coordinates cultural resource-related activities at the INL Site and implements the INL Cultural Resource Management Plan (DOE-ID 2016) with oversight by DOE-ID's Cultural Resource Coordinator. Cultural resource identification and evaluation studies in fiscal year (FY) 2021 included: (1) archaeological field surveys; (2) monitoring, and site updates related to INL Site project activities; and (3) meaningful collaboration with members of the Shoshone-Bannock Tribes and public stakeholders.

9. NATURAL RESOURCES CONSERVATION AND MONITORING

The environmental setting of the Idaho National Laboratory (INL) Site is characterized as a sagebrush steppe ecosystem. Approximately 94% of the land on the INL Site is undeveloped (DOE-ID and USFWS 2014) with approximately 60% open to livestock grazing. The sagebrush ecosystem is considered one of the most imperiled ecosystems in the United States (Noss et al. 1995), as these ecosystems are being lost at an alarming rate. In fact, only about 56% of its historic range is currently occupied (Knick et al. 2003; Schroeder et al. 2004). Threats to this system include wildland fire, invasive species, and infrastructure development. Therefore, natural resources on the INL Site are a high conservation priority for the survival of species that are dependent upon this ecosystem, some of which may be at the risk of local extirpation or even regional loss (Davies et al. 2011). Conservation, management, recovery, and revegetation plans are developed to provide management guidance and promote stewardship of the natural resources while meeting the INL Site's mission.

Ecological data collected on plants and key wildlife species provides the U.S. Department of Energy's Idaho Operations Office (DOE-ID) with an understanding of how species use the INL Site and context for analyzing trends. These data are often used in National Environmental Policy Act (NEPA) documents and enables DOE-ID to make informed decisions for project planning and to maintain up-to-date information on potentially sensitive species on the INL Site. These data also support DOE-ID's compliance with environmental regulations, agreements, policies, and executive orders, including:

- Endangered Species Act (ESA), 1973
- National Environmental Policy Act (NEPA), 1969
- Migratory Bird Treaty Act, 1918
- Executive Order 13186; Responsibilities of Federal Agencies to Protect Migratory Birds
- Migratory Bird Treaty Act Special Purpose Permit with U.S. Fish and Wildlife Service (USFWS)
- Bald and Golden Eagle Protection Act, 1940
- Memorandum of Understanding between the U.S. Department of Energy and the USFWS regarding implementation of Executive Order 13186, Responsibilities of Federal Agencies to Protect Migratory Birds" (Federal Register 2013)
- Candidate Conservation Agreement (CCA) for Greater Sage-grouse on the INL Site (DOE-ID and USFWS 2014)
- Idaho National Laboratory Comprehensive Land Use and Environmental Stewardship Report (INL 2016)
- Idaho National Laboratory Site Bat Protection Plan (DOE-ID 2018)
- Executive Order 13751, "Safeguarding the Nation from the Impacts of Invasive Species"
- Sagebrush Steppe Ecosystem Reserve Management Plan (1999) (EA ID-074-02-067)
- Executive Order 14008, "Tackling the Climate Crisis at Home and Abroad"
- DOE Order 420.1C Chg. 3, "Facility Safety"
- 2001 Federal Wildland Fire Management Policy (NIFC 2001)
- National Fire Protection Association (NFPA) 1143, "Standard for Wildland Fire Management"
- NFPA 1144, "Standard for Reducing Structure Ignition Hazards from Wildland Fire"
- Idaho National Engineering and Environmental Laboratory Wildland Fire Management Environmental Assessment (DOE 2003).

9.1 Conservation Planning

The INL Site provides breeding and foraging habitat for a variety of species, including 43 species of birds and eight species of mammals that are listed as 'Species of Greatest Conservation Need' or 'Rare,' 'Imperiled,' or 'Critically Imperiled' within the state of Idaho. Conservation planning is a way to identify species that have the potential to become listed under the ESA and can be used when consulting with USFWS in their determination process.

9.1.1 Candidate Conservation Agreement for Greater Sage-grouse on the INL Site

Populations of greater sage-grouse (*Centrocercus urophasianus*) (hereafter, sage-grouse) have declined in recent decades (Connelly et al. 2004), and the species' range-wide distribution across western North America has been reduced to nearly half of its historical distribution (Schroeder et al. 2004, Connelly et al. 2011a). Although the rate of decline has slowed over the past two decades (Connelly et al. 2004, Garton et al. 2011, Western Association of Fish and Wildlife Agencies 2015), statewide, sage-grouse numbers have dropped 53% from 2016 to 2019, and birds north of the

Snake River have been disappearing in even greater numbers (Ellsworth 2020). Because of sage-grouse reliance on broad expanses of sagebrush (*Artemisia* spp.), there is concern for the future of sage-grouse. Sagebrush habitats have been greatly altered during the past 150 years and are currently at risk from a variety of pressures (Connelly et al. 2004; Davies et al. 2011; Knick et al. 2011). Healthy stands of sagebrush are necessary for sage-grouse to survive throughout the year; however, young sage-grouse also require a diverse understory of native forbs and grasses during the summer months. Sagebrush habitats that consist of a diversity of vegetation provide protection from predators and supply high-protein insects necessary for rapidly growing chicks (Connelly et al. 2011b).

Sage-grouse populations have been monitored on the INL Site for over 30 years. These efforts show that the overall numbers of sage-grouse on the INL Site are decreasing. When sage-grouse were petitioned for listing under the ESA, DOE-ID recognized the need to reduce the potential for impacts to existing and future mission activities. In 2014, DOE-ID entered into the CCA with the USFWS to identify threats to the species and its habitat and develop conservation measures and objectives to avoid or minimize threats to sage-grouse. This voluntary agreement established a Sage-grouse Conservation Area (SGCA) shown in Figure 9-1, and DOE-ID committed to deprioritize the SGCA when planning infrastructure development and to establish mechanisms for reducing human disturbance of breeding and nesting sage-grouse (DOE and USFWS 2014).

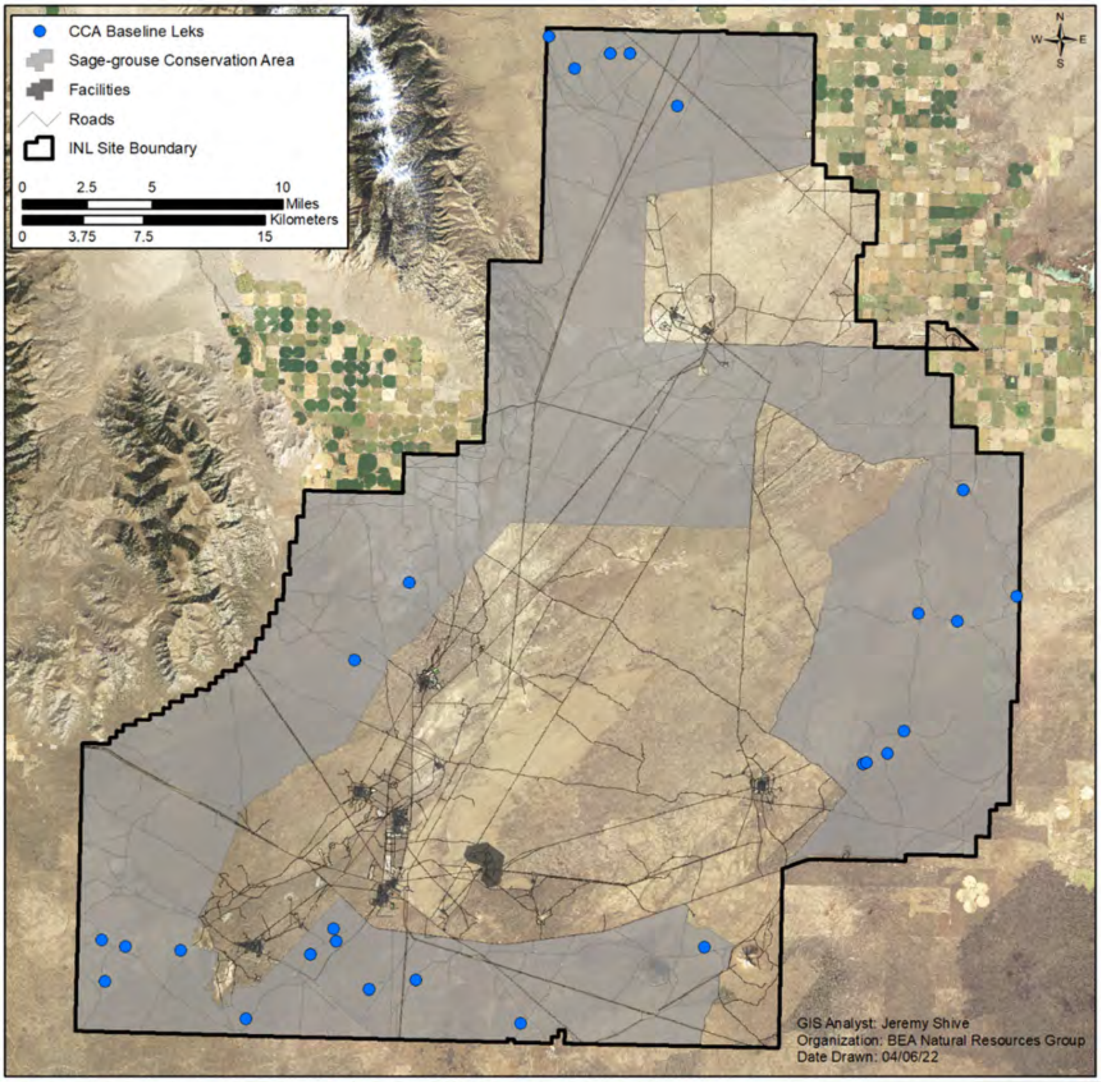

Figure 9-1. Area defined by the CCA for greater sage-grouse on the INL Site as a SGCA and location of baseline leks used for determining the population trigger.

To guard against sage-grouse population declines outside the natural range of variation, the CCA established population and habitat triggers. The sage-grouse population trigger baseline for the INL Site equals the number of males counted in 2011 during peak male attendance on 27 active leks within the SGCA (i.e., 316 males). The population trigger will be tripped if the three-year running average of males on those 27 baseline leks decreases ≥ 20% (i.e., ≤ 253 males). The baseline value of the habitat trigger is equivalent to the amount of area within the SGCA that was characterized as sagebrush-dominated (Artemisia spp.) habitat at the beginning of 2013. The habitat trigger will trip if there is a reduction of ≥ 20% (15,712 ha [38,824 ac]) of sagebrush habitat within the SGCA. Total sagebrush habitat area and distribution are monitored using aerial imagery and a geographic information system. If a trigger is tripped, an automatic response by both DOE and USFWS would be initiated, as delineated in the CCA.

INL contractor wildlife biologists monitor sage-grouse populations, sagebrush habitats, and activities that are considered threats to sage-grouse survival on the INL Site. For the most recent annual results, please refer to Implementing the Candidate Conservation Agreement for Greater Sage-Grouse on the Idaho National Laboratory Site 2021 Full Report (INL 2021), found at https://idahoeser.inl.gov.

9.1.1.1 Population

Each spring, crews enter the field to monitor sage-grouse that have congregated on leks for breeding purposes. Baseline and all other active leks are monitored multiple times from March 20th until peak male attendance has been determined and recorded. Inactive leks are also surveyed every five years to determine if the lek status has changed. During CY 2021, the peak male abundance on baseline leks was 227–the same number observed in 2020. This value remains the lowest recorded since 2011 when tracking baseline leks began.

9.1.1.2 Sagebrush Habitat Condition and Distribution

Two monitoring tasks are designed to identify vegetation changes across the landscape and assist in maintaining an accurate record of the condition and distribution of sagebrush habitat within the SGCA to facilitate annual evaluation of the habitat trigger: (1) Sagebrush Habitat Condition, and (2) Sagebrush Habitat Amount and Distribution.

Monitoring sagebrush condition provides data used to compare sagebrush habitat on the INL Site across years. Data collected to support this task may also be used to document gains in habitat as non-sagebrush map polygons transition back into sagebrush classes, or to document losses when compositional changes occur within sagebrush polygons that may require a change in the assigned map class.

Sagebrush habitat amount and distribution tracks losses to sagebrush habitat following events that alter vegetation communities, such as wildlife fires and land development. As updates are made to map classes (e.g., vegetation polygon boundaries), the total area of sagebrush habitat available will be compared to the baseline value established for the habitat trigger to determine status with respect to the habitat threshold.

Together, these two monitoring tasks provide the basis for maintaining an accurate map and estimate of condition and quantity of sagebrush habitat on the INL Site. The condition of sagebrush habitat remained high in 2021. Sagebrush cover was within its historical range of variability. Herbaceous cover exceeded its range of variability. The abundance of non-natives was generally low. The total area of sagebrush habitat in the SGCA on the INL Site remained unchanged from 2020 to 2021, with 77,486 ha (191,472.1 ac). This represents a total loss to date of approximately 1.4%.

9.1.1.3 Threats and Associated Conservation Measures

The CCA identifies and rates eight threats that potentially impact sage-grouse and its habitats on the INL Site, including wildland fire, infrastructure development, and raven predation. Conservation measures have been assigned to each threat and consist of actions aimed towards mitigating impacts to the sage-grouse and its habitat by INL Site activities. This is accomplished through the avoidance and minimization of threats by utilizing best management practices (BMPs), such as setting seasonal and time-of-day restrictions. This restriction provides an additional 1 km (0.6 mile) of protection around every lek whether it occurs within the SGCA or not. DOE-ID also recognizes that sagebrush-dominated communities outside of the SGCA serve as important habitats for sage-grouse, so BMPs were developed and applied to the entire INL Site, which guides infrastructure development and other land-use decisions.

9.1.2 Bat Protection Plan

Bats represent over 30% of mammal species described for the INL Site. Large undisturbed areas of shrub-steppe habitat, basalt outcrops, lava caves, juniper uplands, and ponds and landscape trees at industrial facilities provide complex and abundant foraging and a roosting habitat for a variety of resident and transient bat species. Beginning in the early 1980s, the INL Site has supported bat research either through program funding or through outside funded projects managed under the National Environmental Research Park (NERP). These efforts promoted general bat conservation and provided critical conservation data to DOE-ID decision-makers, as well as state and federal resource agencies. The result of numerous publications, reports, conservation assessments, and theses has been the recognition of the INL Site and surrounding desert as a crucial bat habitat.

During CY 2021 a total of 1,021,503 files of echolocation calls from 18 passive acoustic monitoring stations were collected: (1) 394,117 files from facilities, and (2) 627,386 files from caves.

Over the past two decades, newly identified threats to bat populations (e.g., white-nose syndrome and large-scale commercial wind energy development) have caused widespread multiple mortality events in bats and resulted in precipitous declines of numerous common bat species and elevated conservation concern for bats across the United States, including additional listings under the ESA. Because of these threats, regional agency initiatives were developed to address them, as well as potential for impacts to the INL Site mission. In 2011, DOE-ID and the Naval Reactors Laboratory Field Office/Idaho Branch Office decided to increase attention given to bat resources and initiate the development of a comprehensive INL Site-wide bat protection and monitoring program. In 2018, the INL Site Bat Protection Plan was finalized. The Bat Protection Plan provides a framework for eliminating mission impacts associated with protected bat species, monitoring the status of bat populations, providing current data for environmental analyses, and engaging resource agency stakeholders, such as the USFWS, Bureau of Land Management (BLM), and Idaho Department of Fish and Game (IDFG) on bat issues. The Bat Protection Plan was updated in 2020 and provides the most current INL Site bat data. This report can be found at https://idahoeser.inl.gov.

9.1.3 Sagebrush Steppe Ecosystem Reserve

On July 19, 2004, DOE-ID signed a Finding of no Significant Impact for an Environmental Assessment (EA) and Management Plan that outlined a framework to collaboratively manage the Idaho National Engineering and Environmental Laboratory (INEEL) Sagebrush Steppe Ecosystem Reserve (SSER) with the BLM, USFWS, and IDFG. The SSER includes 29,945 ha (74,000 ac) of high desert land in the north central portion of the INL Site (Figure 9-2). In the 1999 Proclamation establishing the SSER, then Secretary of Energy Bill Richardson recognized that the "*Reserve is a valuable ecological resource unique to the intermountain west and contains lands that have had little human contact for over 50 years. The Sagebrush Steppe Ecosystem across its entire range was listed as a critically endangered ecosystem by the National Biological Service in 1995, having experienced greater than a 98% decline since European Settlement...*" Because the SSER represents a unique ecological resource, "*conservation management of the area is intended to maintain the current plant community and provide the opportunity for study of an undisturbed sagebrush steppe ecosystem…*" The Proclamation also specified that traditional rangeland uses will be allowed to continue under the SSER management designation and that the Public Land Orders, which withdrew INEEL lands, would supersede SSER management objectives if the land were needed to support INEEL's nuclear energy research mission (DOE-ID 2004).

A mission statement and four primary management goals were developed to guide management of the SSER. The mission statement reads: "The INEEL Sagebrush Steppe Ecosystem Reserve shall be managed as a laboratory where all native ecosystem components, cultural resources, and Native American Tribal values are conserved. Management will concentrate on providing opportunities for scientific investigation of the resources present on the Reserve." This mission statement is consistent with INL's designation as a NERP (see Section 9.3.5). The four SSER management goals included: (1) maintaining and protecting existing high-quality biological, cultural, and tribal resources; (2) providing for long-term resource management, plan implementation, and development of educational opportunities; (3) restoring degraded ecological resources; and (4) facilitating and managing scientific research.

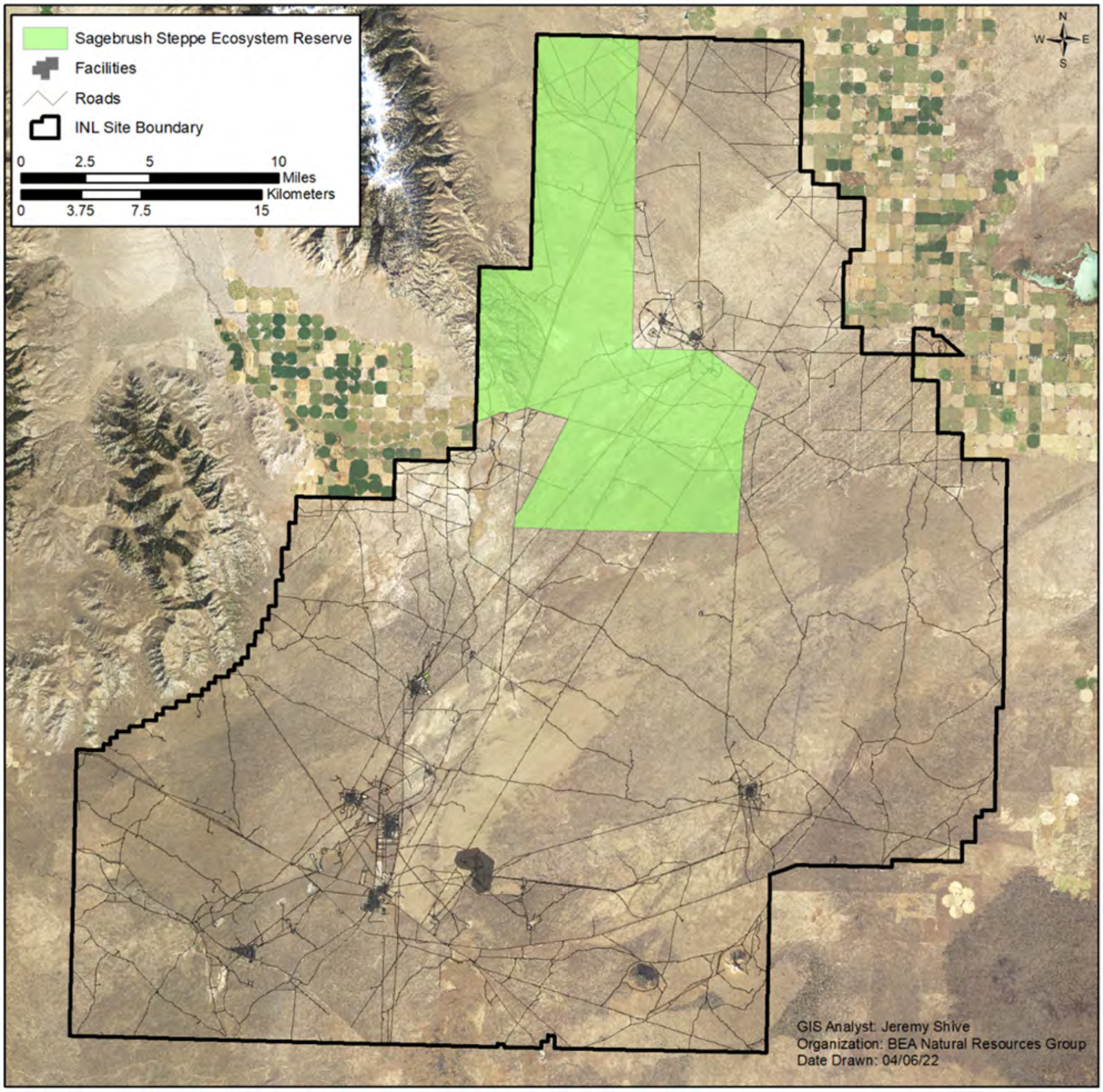

Figure 9-2. The SSER within the boundary of the INL Site.

Specific actions to guide management of the SSER according to its mission and management goals were provided in the INEEL Sagebrush Steppe Ecosystem Reserve Final Management Plan (DOE-ID 2004). The primary actions included in the preferred alternative for managing the SSER were: (1) establishment of a Reserve Management Committee; (2) reduction in road access and use; (3) implementation of an integrated weed management plan; (4) limitation of restoration actions to locally collected plant materials; (5) no changes in livestock class or increase in stocking levels; (6) no construction of wells for livestock watering purposes; (7) minimization of anthropogenic structures for raptor perching; and (8) responding to wildland fire suppression and post-fire restoration in a manner that is consistent with INL's Wildland Fire EA.

Implementation of the SSER Management Plan and associated actions was contingent on funding allocations from the cooperating agencies where it was recognized that innovative funding sources would likely be required for timely implementation. To date, the cooperating agencies have been unable to identify funding resources sufficient to establish the SSER managing committee and fully implement the SSER Management Plan. As such, DOE-ID is currently evaluating actions to improve the management of the SSER. However, the INL continues to consider the mission and goals of the SSER Management Plan in their planning processes and land management decisions on the INL Site. When federal actions are proposed by DOE-ID on or including portions of the SSER, the restrictions on travel, infrastructure development, and other activities described in the SSER Management Plan are documented and applied to any proposed actions through the INL NEPA process. Additionally, the SSER is utilized for scientific research through the INL NERP. There is currently one NERP project where Boise State University researchers are utilizing the SSER as a portion of their study area for investigating sagebrush habitat utilization and forage selection by sage-grouse.

9.1.4 Migratory Bird Conservation Plan

Most activities at the INL Site are conducted within fenced, industrial complexes that are up to several hundred acres in size. General actions from day-to-day operations that may affect migratory birds include moving equipment such as trailers and nuclear fuel casks, mowing vegetated areas for wildland fire protection, and maintenance of utilities and infrastructure. Therefore, it is not unusual to encounter a variety of animals, including migratory birds, while conducting these activities. DOE-ID has developed a Migratory Bird Conservation Plan (DOE-ID 2022) that provides a framework for protecting and conserving migratory birds and their habitat while accomplishing critical DOE-ID and Naval Reactors Laboratory Field Office/Idaho Branch Office missions.

DOE-ID maintains a Special Purpose Permit issued by USFWS and an IDFG Scientific Collection Permit that allows for the destruction or relocation of a pre-determined number of migratory bird nests. All practicable minimization and avoidance efforts identified in the Migratory Bird Conservation Plan are to be implemented before parties exercise their ability to take migratory birds under these permits. The conservation plan identifies measures that are designed to eliminate or minimize impacts to migratory birds and to protect their habitat. These measures include the protection of native vegetation, avoiding disturbing nesting birds, reducing the potential for conflicts with missions, and enhancing native habitat as practical. Conservation measures are implemented through the NEPA program, which assesses the potential impacts to migratory birds during implementation of a project or activity. The plan also identifies BMPs that are implemented across the INL Site. BMPs include routine surveys conducted during nesting season (e.g., April 1st to October 1st) of structures, equipment, and vegetated areas to ensure project activities do not disturb or otherwise interfere with active nests. If an active nest with eggs or chicks is discovered, all work that could result in abandonment or destruction of the nest is suspended and the appropriate environmental personnel contacted for assistance and guidance. Until a determination is made whether to remove the nest, actions are conducted to ensure the nest is not abandoned due to work activities.

During 2019, DOE-ID established a Migratory Bird/Wildlife Conservation Working Group to provide a forum for discussing, resolving, and collaborating on all activities related to migratory bird and other wildlife matters arising on the INL Site. A primary task is to promote the conservation of migratory birds, share ideas to minimize the impact of nesting birds to operations in INL critical areas, and ensure compliance with permit requirements. Accomplishments to date include the development of online Migratory Bird Awareness Training for environmental staff, facility maintenance, operations, and program managers. Mitigation actions, such as incorporating critical equipment inspections into daily operations orders to identify nesting activities, use of window dressings to reduce mortality from window collisions, and effectively exchanging information regarding the use of relocating bird eggs or young to licensed rehabilitators, are used as options in lieu of unavoidable destruction and take situations. Additional efforts are being made to track and map active nests using the Global Positioning System. These efforts will aid in identifying areas where the installation of deterrents or other actions may benefit critical facility activities.

9.1.5 Avian Protection Plan and Bird Management Policy

The INL contractor has developed an Avian Protection Plan and Bird Management Policy (MCP-3367) in keeping with Avian Power Line Interaction Committee requirements (Avian Power Line Interaction Committee 2006). This plan includes documenting, tracking, and correcting conditions that resulted in a migratory bird's death. When birds are electrocuted, power poles are either retrofitted or modified with avian protection devices during the next scheduled power outage. These efforts help to reduce future electrocutions. Avian interactions are also considered when siting new line locations and when replacing existing poles to reduce risks to migratory birds through proactive and innovative resolutions.

9.2 Land Stewardship

9.2.1 Fire Protection Planning, Management, and Recovery

The INL fire department provides wildland fire suppression services on the rangeland within the Site boundary as well as a five-mile buffer outside of the INL Site boundary. The fire department employs pre-incident strategies, such as the identification of special hazards, mitigation procedures, and mapping necessary to facilitate response to fires. DOE-ID maintains mutual aid agreements with regional agencies, including the BLM, to assist in response to high challenge wildland fires. Additionally, the INL contractor implements PLN-14401, "Idaho National Laboratory Wildland Fire Management Plan," which incorporates essential elements of various federal and state fire management standards, policies, and agreements. A balanced fire management approach has been adopted to ensure the protection of improved laboratory assets in a manner that minimizes effects on natural, cultural, and biological resources. The INL contractor has established a Wildland Fire Management Committee (WFMC) to review seasonal fuel management activities and the potential impact of all fires greater than 40.5 ha (100 ac).

A primary responsibility of the WFMC is to determine if a post-fire recovery plan is warranted for a given fire. Once an ecological resources post-fire recovery plan is requested, the INL Natural Resources Group completes an ecological resource assessment to evaluate the resources potentially impacted by a wildland fire and drafts a recovery plan for treatment prioritization and implementation by the WFMC. After the 2019 Sheep Fire, WFMC members expressed an interest in a recovery plan where implementation is phased over five years and is flexible, where actions can be implemented individually depending on specific resource concerns and funding availability. The resulting plan was organized into four natural resource recovery objectives: (1) soil stabilization for erosion; (2) cheatgrass and noxious weed control within the larger burned area; (3) native herbaceous recovery; and (4) sagebrush habitat restoration. Multiple treatment options were provided in the plan for improving post-fire recovery. Because the structure and organization of the plan, as well as the options of prioritizing treatment actions, were useful to the WFMC, subsequent post-fire ecological recovery plans continue to utilize this framework. There are two post-fire ecological resource recovery plans that are actively being implemented on the INL Site—one plan for four fires that burned in 2020 and one additional plan for the 2019 Sheep Fire.

In 2020, the WFMC requested an ecological assessment and fire recovery plan for four fires ranging in size from 11 ha (27 ac) to 678 ha (1,675 ac): the Howe Peak Fire, the Telegraph Fire, the Cinder Butte Fire, and the Lost River Fire identified in Figure 9-3. Under approved emergency stabilization actions listed in the existing Wildland Fire EA (DOE 2003), the INL contractor completed several activities during the fall of 2020, including recontouring containment lines on the fires where they were used, reseeding containment lines with native grass seed, and spraying noxious weeds, especially in disturbed soils on and around containment lines. Upon completion and review of the ecological resource recovery plan (Forman et al. 2021), additional recovery actions that were prioritized by INL's WFMC included: (1) monitoring temporary fire suppression access roads for natural recovery; (2) installing signs; and (3) replanting those roads if necessary, and ongoing noxious weed inventory and treatment across all four fires. Additionally, sagebrush restoration was recommended on the Telegraph Fire because it would improve habitat value in proximity to an active sage-grouse lek and it would provide some habitat connectivity across the burned area. A total of 41,300 sagebrush seedlings are scheduled to be planted in the Telegraph Fire footprint in 2022.

The Sheep Fire burned more than 40,000 ha (98,842 ac) of land on the INL Site in July 2019 (Figure 9-3). Under the direction of the WFMC, the Sheep Fire Ecological Resources Post-Fire Recovery Plan (Forman et al. 2020) was completed. Soil stabilization efforts were finished on the Sheep Fire containment lines in 2020 and the WFMC prioritized restoration/treatment actions within two post-fire recovery objectives: noxious weed/cheatgrass control and big sagebrush habitat restoration. Noxious weed treatment continued throughout the Sheep Fire footprint in 2021. Cheatgrass treatment was completed along sections of accessible two-track roads in a swath extending 6 m (20 ft) on each side of the road for a total of 13.7 km (8.5 mi). DOE-ID and agency stakeholders collaborated to seed sagebrush on portions of the Sheep Fire during the winter of 2019/2020. The seeding was completed across a target area of approximately 10,100 ha (25,000 ac) in and adjacent to the SGCA. Because of poor initial germination and establishment from the aerial seeding, a total of 45,000 seedlings were planted in the Sheep Fire in October 2021 and an additional 45,000 seedlings are scheduled to be planted in October 2022.

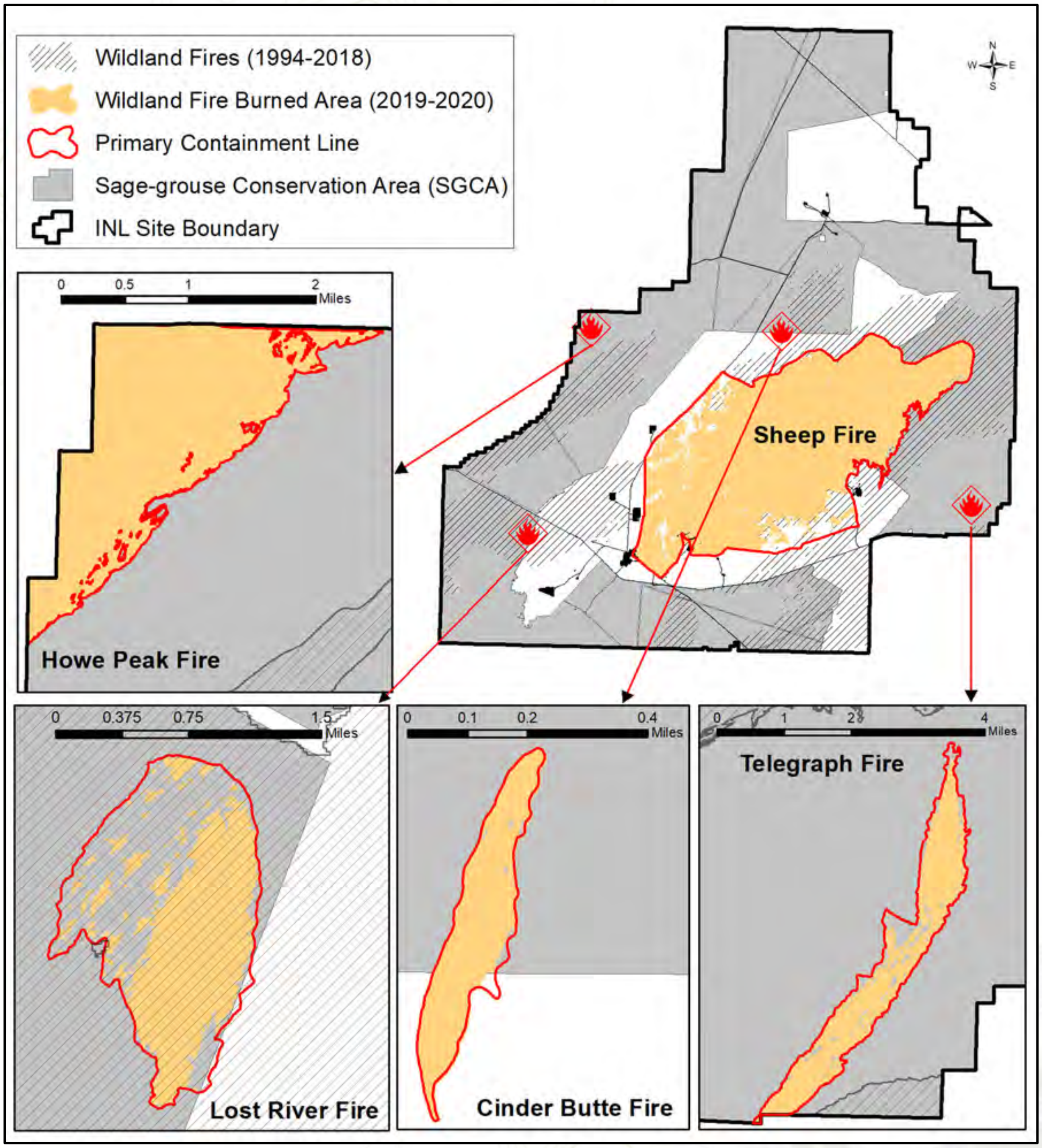

Figure 9-3. Wildland fires on the INL Site since 1994. *Additional detail provided for 2019 and 2020 fires.*

Emergency wildland fire response and associated soil stabilization actions are addressed in the INL Wildland Fire EA (DOE 2003). However, each non-emergency post-fire recovery action is currently subject to NEPA review. Although this approach was adequate at the time the EA was signed, there have been changes in fire frequency and land cover over the past twenty years, making it less effective. Because of the changing ecological conditions at the INL Site and the number of post-fire recovery actions that were recommended by the WFMC after the Sheep Fire and the 2020 fires, the INL contractor is in the process of updating the fire management plan, the framework for the ecological resource's recovery plan, and the NEPA analysis necessary to implement changes to both plans. These updates will facilitate a more comprehensive and efficient response in fire suppression and in post-fire restoration in the future.

9.2.2 Restoration and Revegetation

9.2.2.1 Revegetation for Soil Stabilization

Revegetation with native species is required on the INL Site for activities that disturb or remove soil and vegetation where the area will not be physically stabilized and maintained as sterile. These areas are left exposed and vulnerable to erosion and invasive or noxious weed infestation. Areas requiring revegetation are assessed for appropriate revegetation methods based on site condition and disturbance size. A baseline condition of areas that may be disturbed are collected prior to disturbance, partly to assess the native species present. The native species observed inform an appropriate seed mix that is to be used during revegetation efforts following the disturbance. Revegetation methods on the INL Site include but are not limited to hand broadcasting seed, seedbed preparation, soil augmentation, drill seeding, and planting nursery stock. In calendar year (CY) 2021, one revegetation project was initiated by INL's Facility and Site Services on approximately 0.4 ha (4.75 ac) to address soil stabilization. Revegetation projects on the INL are revisited one- and five-years after planting to monitor success and determine if further actions need to be taken. There were no revegetation projects assessed in CY 2021.

9.2.2.2 Sagebrush Habitat Restoration

Sagebrush habitat restoration on the INL Site is conducted in response to DOE-ID's goal of no net loss of sagebrush. The potential to lose sagebrush habitat on the INL Site occurs in two instances. The first is due to wildland fire, as discussed in Section 9.2.1, which has the potential to remove large tracts of sagebrush habitat that can take more than 100 years to recover naturally. The second instance where sagebrush habitat is lost is due to infrastructure expansion and mission critical project activities. The INL contractor implements multiple BMPs to minimize sagebrush habitat loss, such as co-locating infrastructure, but in some cases, removal of sagebrush habitat is necessary to support the INL mission. The INL contractor carries out a compensatory sagebrush mitigation strategy for projects that must remove sagebrush habitat. This strategy outlines an approach for projects to provide funds for sagebrush to be restored in designated priority areas where they can provide the greatest habitat benefit. Sagebrush habitat restoration has been conducted using multiple methods, including planting containerized sagebrush seedlings and aerially applying sagebrush seed. Due to the semiarid nature of the local ecosystem, the INL contractor has found that planting sagebrush seedlings results in higher survivorship than trying to establish sagebrush from seed. In CY 2021, 45,000 sagebrush seedlings provided by the INL contractor, and 38,750 sagebrush seedlings provided by IDFG were planted across 391.6 ha (967.7 ac). As a result of sagebrush habitat restoration on the INL Site since 2015, 155,750 sagebrush seedlings have been planted across 610 ha (1,507.4 ac). Seedlings planted on the INL Site are monitored one- and five-years following planting.

9.2.3 Carbon Sequestration

The maintenance and enhancement of healthy rangeland vegetation on the INL Site is guided by several plans, such as INL Wildland Fire Ecological Recovery Plans (Forman et al. 2020, and Forman et al. 2021) and the Sitewide Noxious Weed Management Plan (PLN-611). These plans all include components that promote carbon sequestration on the INL Site. Planned activities are ongoing and will continue through 2023. Rangelands store most of their carbon long-term in the soil in the form of organic carbon through deep-rooted native perennial grasses and shrubs. Keeping INL rangeland soils intact is an important action for preserving this natural carbon storage. INL can maintain and promote carbon sequestration because access is restricted to the general public, resulting in the ecosystem being relatively undisturbed and natural over most of its acreage. Below-ground carbon stores are lost when annual invasive grasses, like cheatgrass, displace deep-rooted perennial plants. Combatting this threat requires preventative management and targeted restoration. Benefits include conserving wildlife habitat for the imperiled sage-grouse and other sagebrush-dependent species, reduced wildfire risk, and enhanced plant and soil carbon storage. Cheatgrass and other annual grasses also have an increased risk of further carbon loss due to fire. INL plans to address controlling annual grass invasion, which is critical to protect currently stored carbon and disrupt the devastation of the invasive fire cycle.

9.2.4 Weed Management

The INL contractor maintains and funds a noxious and invasive weed management program to target, control the spread of, and eliminate invasive and noxious weeds that threaten the mission of the INL Site. Noxious weeds carry federal and state designations that require the control and containment of their populations. Applying liquid pesticide through spraying is the primary method used to control and eliminate noxious and invasive weeds on the INL Site. In addition to spraying pesticides, the INL contractor uses a sterilant in facility footprints and heavy traffic areas to prevent the introduction and spread of invasive and noxious weeds in those areas. In some cases where the application of pesticides is not appropriate, INL staff will remove noxious weeds by hand. Following the removal of large infestations of noxious weeds, INL contractor will revegetate the area with appropriate native species to prevent invasive weeds from returning and promote soil stabilization.

In 2021, 903.9 L (238.8 gal) of pesticides mixed with water and 793.8 kg (1,750 lbs) of granular pesticide were applied to 267.5 ha (661 ac) of INL property by Facility and Site Services and other INL Site contractors to prevent and control noxious weeds and other invasive plant species. An additional 7.7 ha (19 ac) of weeds were controlled via shoveling and hand-pulling. Twenty different pesticide products were applied. The areas treated included a range from backcountry locations where wildland fire has provided a vector for noxious weeds to roadside locations that are monitored regularly for infestations. Noxious weed species targeted and controlled in 2021 were rush skeletonweed (*Chondrilla juncea*), scotch thistle (*Onopordum acanthium*), musk thistle (*Carduus nutans*), Russian knapweed (*Acroptilon repens*), spotted knapweed (*Centaurea stoebe*), black henbane (*Hyoscyamus niger*), leafy spurge (*Euphorbia esula*), and Canada thistle (*Cirsium arvense*).

Coordination between INL Site contractors, and adjacent land management agencies has been crucial in controlling noxious weeds on the INL Site. In CY 2021, INL pesticide applicators took part in four joint spray days with surrounding county and land management agencies to work together and target larger known infestations. Pesticide applicators at INL also attend periodic regional meetings to continually improve the program by learning from other applicators and to keep up on the latest techniques and technologies for managing weeds.

9.2.5 Ecological Support for National Environmental Policy Act

Actions undergoing any level of NEPA review receive ecological support at the INL Site. The Natural Resources Group prepares an ecological resource review document to support Environmental Impact Statement (EIS) or EA proposed actions. These ecological resource review documents are typically derived from analyzing existing ecological data from vegetation and wildlife monitoring programs on the INL Site in conjunction with field-based surveys of the proposed area of impact. In CY 2021, there were no newly proposed actions undergoing NEPA review at the EIS or EA level.

Individual actions performed under Categorical Exclusions at the INL Site are addressed in Environmental Compliance Permits (ECPs). These are the lowest level of NEPA review. There were 186 ECPs initiated in CY 2021. Ecological support for ECPs is carried out predominantly though a Biological Resource Review (BRR) process for activities outside of facility footprints with the potential to disturb wildlife, vegetation, or soils. The BRR is intended to assess the biological impacts and fulfill any regulatory compliance requirements associated with the project. This is typically done in two parts. The first is collecting a baseline condition of the INL Site prior to conducting activities. The second is conducting a follow up survey of project activities to assess project impacts. The BRR also acts as a tracking mechanism for multiple monitoring requirements that must be reported at the end of the year. Some monitoring requirements that are documented in the BRR include identifying noxious weed locations, areas requiring soil stabilization, areas where compensatory sagebrush mitigation may be required, nesting birds, and native plant species that should be utilized for revegetation. There were 23 BRRs initiated in support of ECPs in CY 2021.

9.2.6 Executive Order 14008 Tackling the Climate Crisis at Home and Abroad

Executive Order 14008, *Tackling the Climate Crisis at Home and Abroad,* stresses the importance to "protect America's natural treasures, increase reforestation, improve access to recreation, and increase resilience to wildfires and storms…". Under this Order, a goal was identified to preserve 30% of America's lands and waters by 2030. To meet this goal, Federal land management agencies issued an initial report, Conserving and Restoring America the Beautiful, which identified several focus areas to meet this goal.

To assist in meeting the conservation of 30% of United States lands and waters established in the Executive Order, and goals and principles identified in America the Beautiful, DOE developed a Conservation Action Plan, which identified seven focus areas for early action including:

- Creating more parks and safe outdoor opportunities in nature-deprived communities
- Supporting tribal-led conservation and restoration priorities
- Expanding collaborative conservation of fish and wildlife habitats and corridors
- Increasing access to outdoor recreation
- Incentivizing and rewarding the voluntary conservation efforts of fishers, ranchers, farmers, and forest owners
- Creating jobs by investing in restoration and resilience
- Other actions supportive of the America the Beautiful campaign.

The following are long-term and ongoing projects that are conducted on the INL Site meeting some of these focus areas.

9.2.6.1 Tribal Led Conservation and Restoration Priorities

The lands now designated as the INL Site are included in the ancestral homelands of the Shoshone and Bannock people. Archaeological sites on the INL Site and far beyond are viewed by the Shoshone-Bannock Tribes as concrete evidence of their cultural heritage and a direct link to their ancestors. This landscape is populated by plants, animals, and water that are not only important for subsistence and medicine, but are sacred. Landmarks, such as Middle Butte, define home and territory, figure in stories that tell how the world came to be the way it is, and provide a living link between contemporary Shoshone and Bannock people and their ancestral homelands. DOE-ID has a long-term relationship with the Shoshone-Bannock Tribes documented in an Agreement in Principle that formalizes tribal involvement in DOE-ID planning and implementation of environmental restoration, long-term stewardship, cultural resources protections, waste management operations, and nuclear energy programs. In CY 2021, the Tribes initiated a bat management program on the Fort Hall Reservation. ESER Program biologists provided advice to the Tribes on deploying and operating detectors to monitor bat populations that reside on and migrate across Reservation lands.

9.2.6.2 Expand Collaborative Conservation of Fish and Wildlife Habitats and Corridors

Sagebrush steppe ecosystems are facing accelerated declines and have been identified as one of the most endangered ecosystems in the world due to threats from grazing, invasive plants, and altered fire regimes (Schroeder et al. 2004; Noss 1995). Significant alterations to the sagebrush ecosystem have resulted in altered ecological processes and components of the remaining systems (Chambers et al. 2017). This ecosystem is home to a variety of species and provides a critical winter habitat for wildlife species, such as sage-grouse and pronghorn. Species that rely on sagebrush during portions of their life cycle are at risk of local extirpation or regional extinctions (Davies et al. 2011). IDFG has identified sagebrush steppe as one of the most important ecosystems for wildlife in Idaho, and the INL Site remains one of the best remaining examples of an intact sagebrush steppe ecosystem in the region. DOE-ID is working to restore these important habitats that were impacted by fires or other disturbances by planting sagebrush seedlings (Section 9.2.2), reducing invasive species (Section 9.2.4), and developing conservation plans for key species, such as sage-grouse (Section 9.1.1) and bats (Section 9.1.2). DOE-ID has also set aside 29,945 ha (74,000 ac) of sagebrush steppe habitat as an ecosystem reserve (Section 9.1.3).

9.2.6.3 Outdoor Recreation Opportunities

As a component of conservation, the INL Site provides outdoor recreation opportunities to staff and the public as well as valuable research opportunities to university researchers under the NERP (Section 9.3.5) program. The INL provides more than 64 km (40 mi) of designated jogging/walking trails for INL Site employees and limited hunting opportunities are available to the general public. Hunting for elk and pronghorn only are established by the IDFG on 8,704 ha (21,508 ac) along the Site boundary in northern portions of the INL Site (Figure 9-4). A valid hunting license and an IDFG-issued INL Site hunting permit are required to access these areas.

9.2.6.4 Collaboration with Other Agency Stakeholders to Conserve Habitat

DOE-ID and the INL contractor collaborate with agency stakeholders by attending allotment reviews, providing vegetation monitoring data, reviewing EAs for activities that may impact the INL Site, and sharing resources for fire recovery of sagebrush ecosystems and sagebrush habitat restoration.

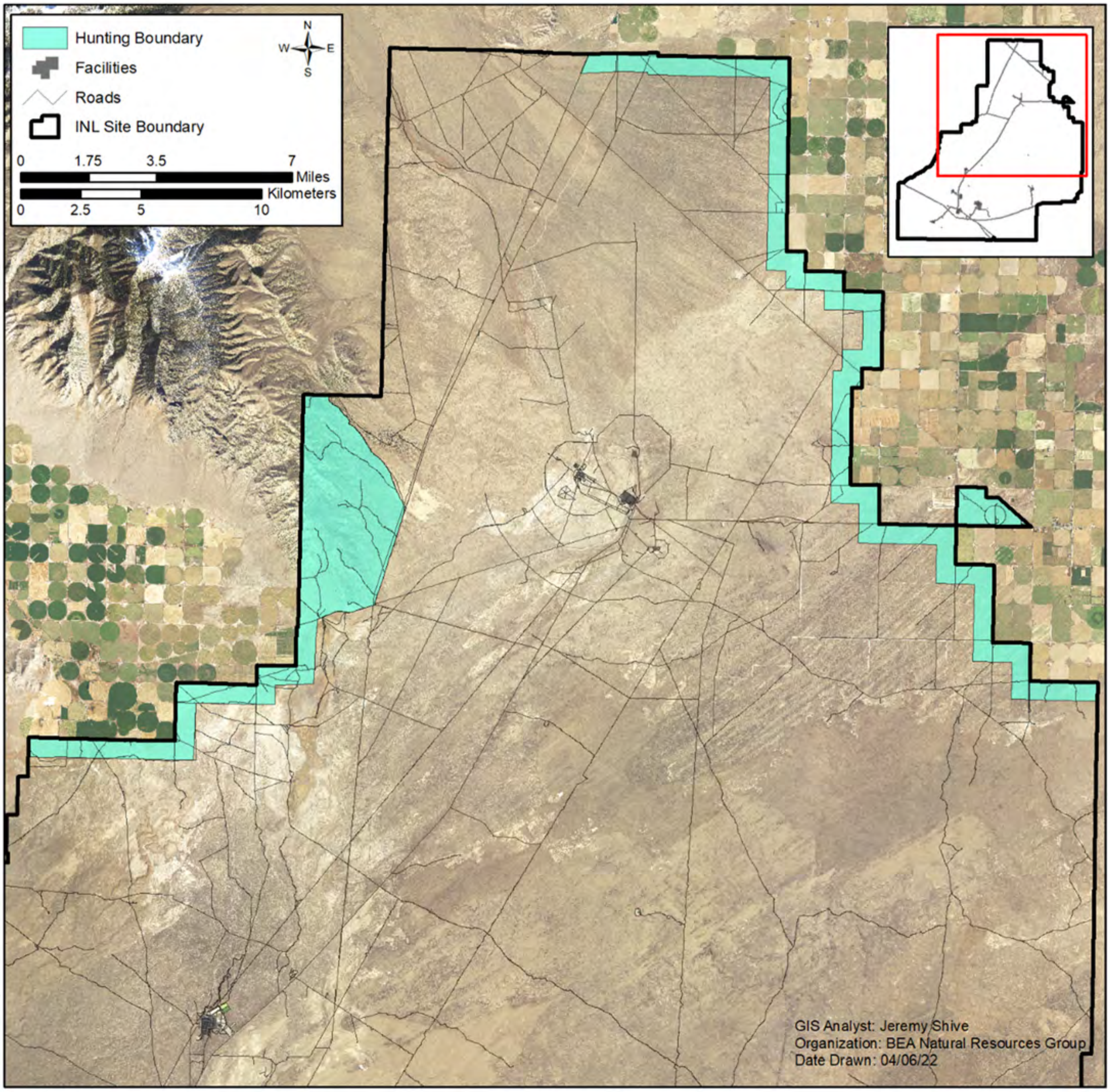

Figure 9-4. Designated elk and pronghorn hunting boundary on the INL Site.

9.3 Natural Resource Monitoring and Research

9.3.1 Breeding Bird Surveys

The North American Breeding Bird Survey (BBS) was developed by the USFWS and the Canadian Wildlife Service to document trends in bird populations. Pilot surveys began in 1965 and immediately expanded to cover the United States east of the Mississippi and Canada, and by 1968, included all of North America (Sauer and Link 2011). The BBS program in North America is managed by the United States Geological Survey (USGS) and currently consists of over 5,100 routes, with approximately 2,500 of these being sampled each year (Sauer and Link 2011).

BBS data provide long-term species abundance and distribution trends for > 420 species of birds across a broad-geographic scale (Sauer and Link 2011). 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 for birds (Sauer and Link 2011). The BBS provides a wealth of information about population trends of birds in North America and is the foundation for broad conservation assessments extending beyond local jurisdictional boundaries (Sauer and Link 2011).

Five official USGS BBS routes (i.e., remote routes) are on the INL Site and have been surveyed nearly each year since 1985 (except 1992 and 1993). In 1985, the DOE-ID also established eight additional routes around INL Site facilities to monitor birds near human activity centers (i.e., facility routes) as shown in Figure 9-5. These routes are also surveyed annually using the same techniques and methods as those indicated by USGS. Surveys are conducted from late May until early July and are scheduled to be conducted as close to the same day each year. All birds seen and heard during the survey are recorded regardless of breeding status (e.g., flyovers). BBS data can benefit INL Site managers directly by providing information on local breeding bird populations, which may be useful as they consider new activities and comply with NEPA. For the most recent BBS results, visit https://idahoeser.inl.gov.

During CY 2021, a total of 2,752 birds from 49 species were documented during these BBS surveys, which is 39.1% lower than the 34-year mean of 4,577 from the same number of species.

9.3.2 Midwinter Raptor Survey

Midwinter eagle surveys were initiated during 1979 by the USGS 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 wintering habitat. In 1983, two midwinter eagle survey routes were established on the INL Site, one that encompasses the northern portion of the INL Site and one that encompasses the south as identified in Figure 9-6. Initially, the counts focused on eagle populations; however, biologists recognized the importance of collecting data on raptor abundances during this survey and started recording all raptors including owls, hawks, and falcons in 1985. In 1992, the list of recorded species expanded to include corvids and shrikes.

In early January of each year, teams of biologists and ecologists drive along each of two established routes. The methods that were used to conduct the survey consisted of each member of the team (excluding the driver) continually scanning the landscape to detect any target species perched, hovering, or soaring. If a target species was detected, the vehicle stopped, and, using binoculars and/or spotting scopes, each species was identified (if more than one species is observed) and the number of individuals per species was counted. A total of 273 birds representing seven species were observed during the 2021 midwinter raptor surveys. Common ravens and rough-legged hawks are typically the most observed species during this survey, and during CY 2021 made up 47% and 37% of the observations, respectively.

9.3.3 Long-term Vegetation Transects

The long-term vegetation (LTV) transects and associated permanent plots were established on what is now the INL Site in 1950 for the purposes of assessing impacts of nuclear energy research and production on surrounding ecosystems (Singlevich et al. 1951). Initial sampling efforts focused on potential fallout from nuclear reactors and the effects of radionuclides on the flora and fauna of the Upper Snake River Plain. After several years of sampling, however, the concentrations and any related effects of radionuclides on the sagebrush steppe ecosystem of the INL Site were determined to be negligible (Harniss 1968). Because the LTV plots were widely distributed across two transects that bisect the INL Site, as shown in Figure 9-7, and vegetation abundance data had been collected periodically since their establishment, their utility as a basis for monitoring vegetation trends in terms of species composition, abundance, and distribution was eventually recognized. Vegetation data collection has continued on the LTV plots on a regular basis—about once every five years. Eighty-nine LTV plots are still accessible, and most have now been sampled consistently between 1950–2016, making the resulting dataset one of the oldest, largest, and most comprehensive for sagebrush steppe ecosystems in North America.

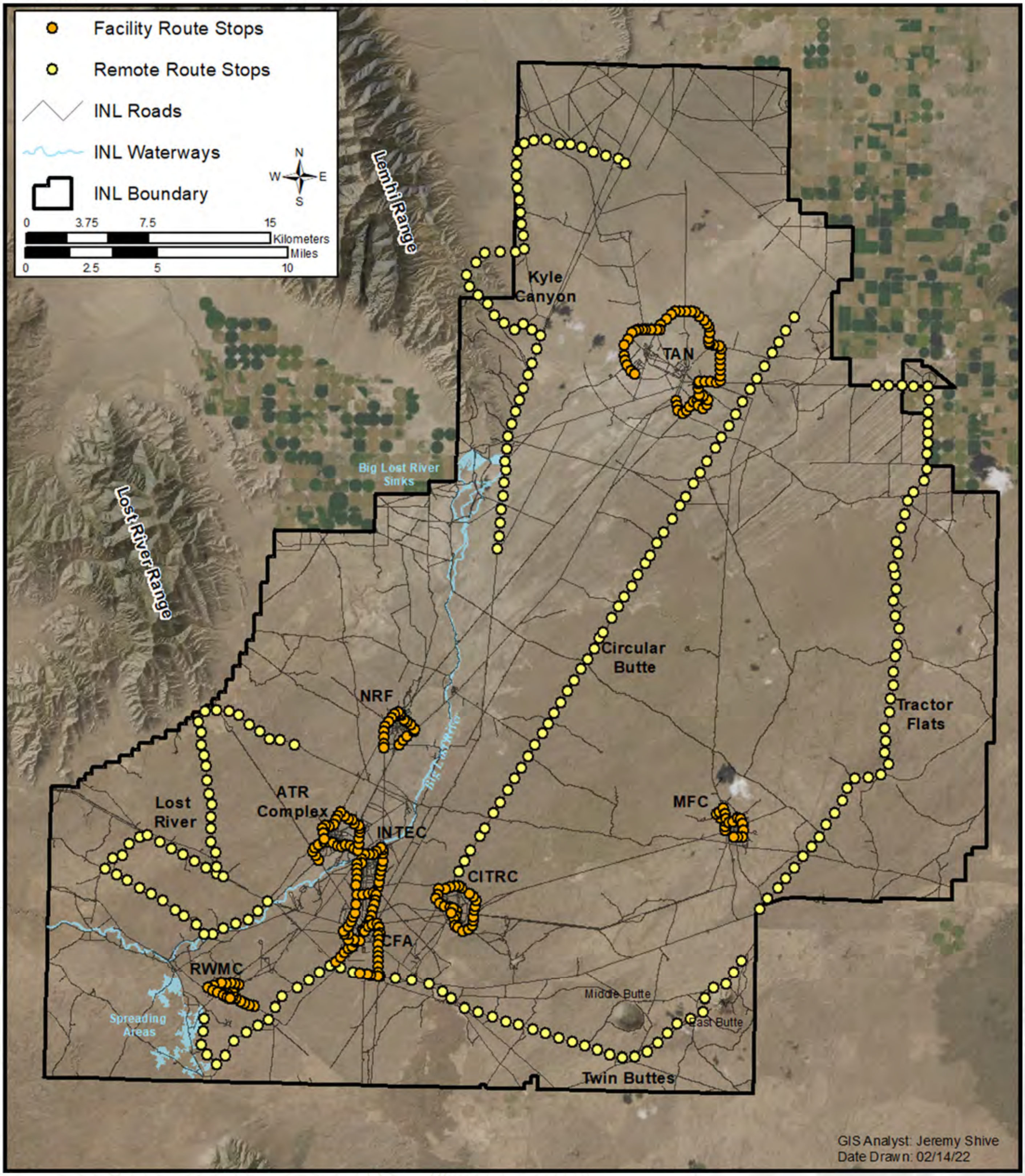

Figure 9-5. Remote and facility BBS routes on the INL Site.

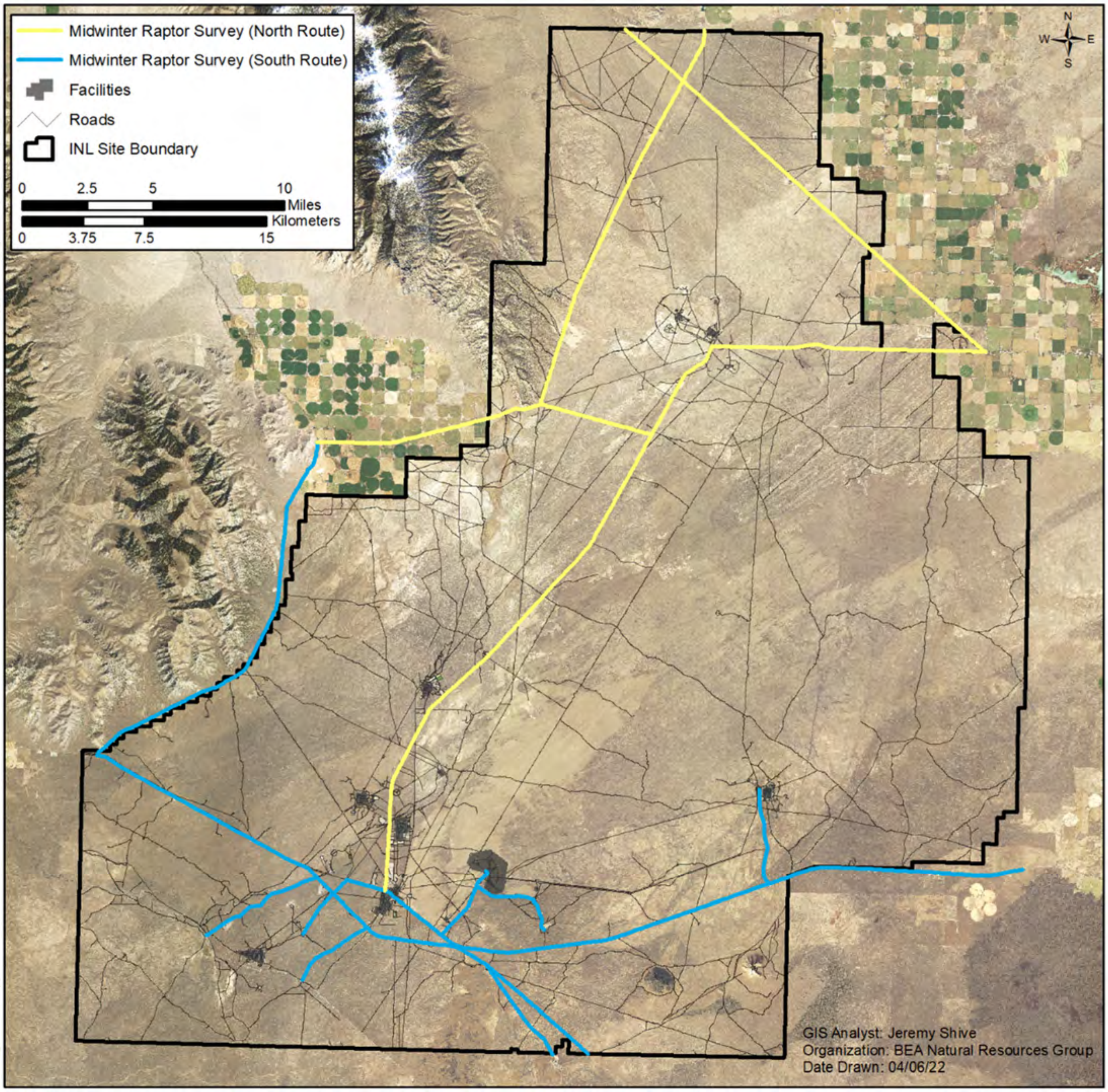

Figure 9-6. North and south midwinter raptor survey routes on the INL Site.

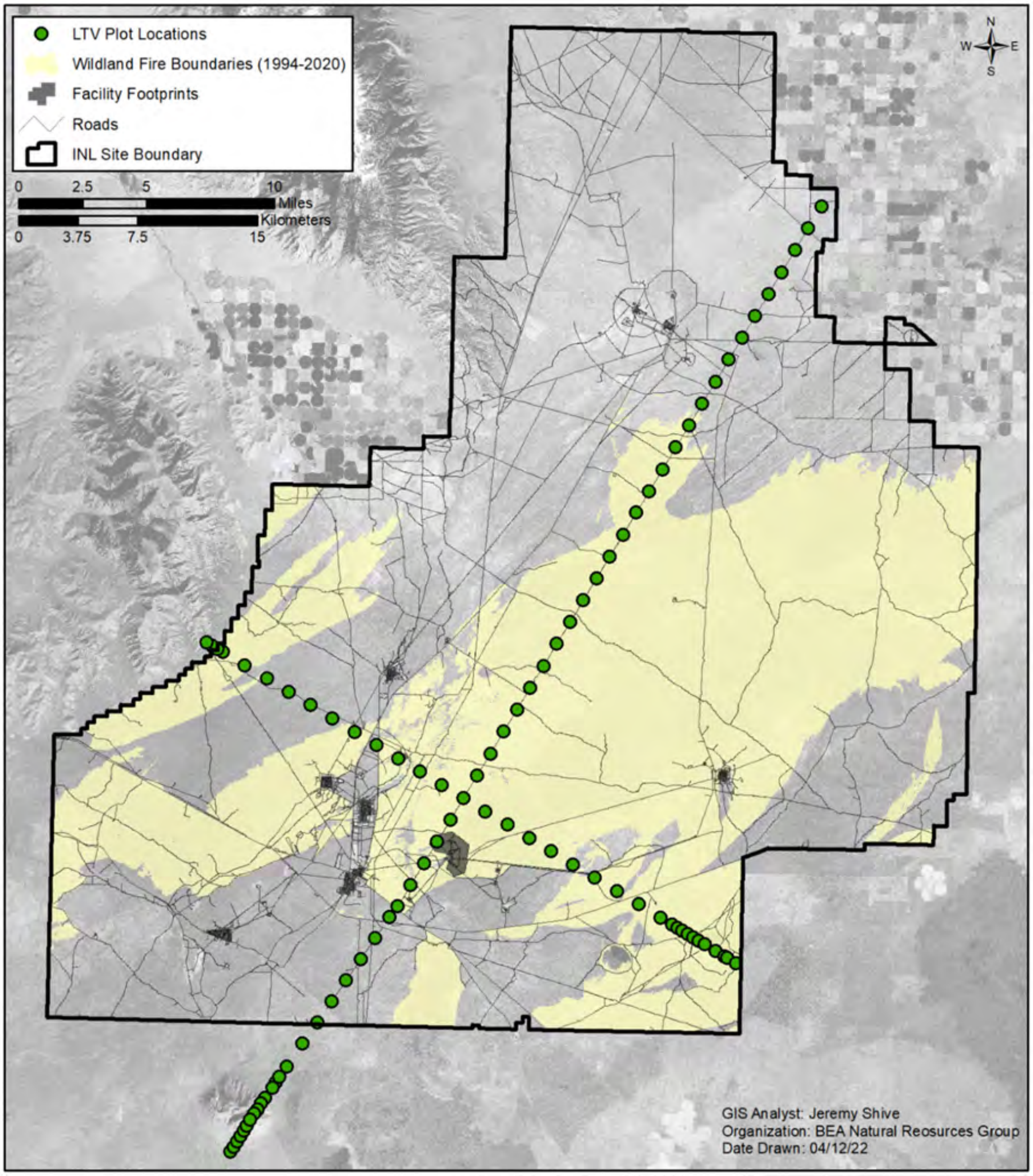

Figure 9-7. Locations for the long-term vegetation transect plots established on the INL Site in 1950 and sampled regularly over the past 70 years.

As the mission of the INL Site has grown and changed over the past 70 years, so too has the purpose and utility of the LTV project. Although the LTV project was initiated to address energy development at the INL Site, it is unique in its capacity to allow investigators to observe long-term vegetation change and the potential impacts of that change at the INL Site and across the region. Abiotic and biotic conditions (e.g., conditions created by the physical environment and by other living organisms) have been characterized by rapid change over the past few decades. These changes include shifts in land cover, land use, and weather patterns. Several large wildland fires have removed sagebrush from a large portion of the Upper Snake River Plain over the past twenty years; approximately 99,000 ha (250,000 ac) have burned on the INL Site since 1994 shown in Figure 9-7. Soil disturbance associated with fighting wildland fires and disturbance associated with general increases in the use of remote backcountry areas are notable throughout the Intermountain West. Concurrently, many of the hottest and driest years during the 70-year INL Site weather record occurred during the past decade. All of these factors contribute to increasing stress on native plant communities and potentially set the stage for a period of dramatic change in vegetation across the region. The LTV project is documenting this change and may provide some context for understanding resistance and resilience in local sagebrush steppe.

Data were last collected across the 89 active LTV plots for the 13th time between June and August of 2016. Plots were sampled for cover and density by species according to methodologies developed in 1950, with supplemental sampling protocols added in 1985. (See Forman and Hafla [2018] for details of the project sample design.) Notable changes between the 2011 and 2016 sample periods include decreases in shrub cover and particularly big sagebrush (*Artemisia tridentata*); increases in native grass cover; and declines in the densities of introduced annual grasses and forbs. In terms of long-term trends, big sagebrush cover was at its lowest point in the 66-year history of the data set, and native, perennial grasses were near the upper end of their historical range of variability. Introduced annuals, primarily cheatgrass (*Bromus tectorum*), exhibited fluctuations with greater magnitudes of change from one sample period to the next over the past two decades when compared with earlier sample periods. The 14th comprehensive data collection effort for the LTV plots is scheduled to occur again during the 2022 growing season.

9.3.4 Vegetation Map

The vegetation map published in 2011 represented a substantial improvement over previous maps of the INL Site in terms of resolution, accuracy, and statistical rigor (Shive et al. 2011). Since completion, the vegetation map has been used extensively to support the inventory and monitoring of ecological resources, prioritizing potential habitat for other sensitive species, identifying restoration and/or weed control opportunities, and characterizing affected environments for NEPA analyses. There have been many changes in vegetation distribution and composition since the map was completed. The most discrete changes were caused by four relatively large wildland fires that burned approximately 52,820 ha (130,521 ac) from 2010–2012, representing approximately 23% of the INL Site. More gradual changes in plant community composition, like increases in the abundance and distribution of non-native annual grasses and forbs, have also been occurring over the past decade.

A comprehensive update to the current vegetation map was initiated in 2017 and involved three steps: (1) a plant community classification to define vegetation classes; (2) manual map delineations of those classes; and (3) an accuracy assessment of the completed map. A total of 16 unique vegetation classes resulted from the plant community classification, where 12 represented natural vegetation classes and four were ruderal classes (e.g., classes dominated by non-native species). Within the native classes there was one woodland class, six shrubland classes, two shrub grasslands, and three grasslands. Within the ruderal classes there was one shrubland, two grasslands, and a class characterized by mixed weedy forbs that tend to dominate areas with a specific hydrologic regime, namely playas.

The Big Sagebrush – Green Rabbitbrush (Threetip Sagebrush) Shrubland class contained the largest amount of total area of the INL Site mapped with 851.2 km^2 (210,330.9 ac) and also the greatest number of map polygons with 2,388 presented in Figure 9-8. The second largest mapped area was the combined Green Rabbitbrush/Thickspike Wheatgrass Shrub Grassland and Needle and Thread Grassland class with 570.8 km^2 (141,035 ac). The three largest map classes cover 73.2% of the vegetated area on the INL Site, suggesting the majority of vegetation communities are dominated by big sagebrush or species most commonly associated with post-fire communities where big sagebrush was previously present. The Cheatgrass Ruderal Grassland contained the second largest number of polygons with 1,435. However, the mean area for the Cheatgrass Ruderal Grassland class was much smaller at 0.06 km^2 (15.9 ac) and many of the polygons mapped were isolated individual patches rather than larger contiguous areas.

Some plant community classes were combined prior to the map accuracy assessment because those classes were known to be hard to map with imagery. This resulted in 13 map classes that were evaluated through an independent map accuracy assessment. Overall map accuracy across all classes was 77.3% with a Kappa value of 0.75. These results indicate the new vegetation map is not only the highest spatial resolution (i.e., 1:6,000), but also the most accurate map ever produced for the INL Site. The Juniper Woodland class had the highest individual class accuracy (i.e., user's and producer's accuracy) of 100%, but was limited in distribution and spatial extent. The Big Sagebrush – Green Rabbitbrush (Threetip Sagebrush) Shrubland class contained the largest amount of mapped area and was also the second most accurate map class with a user's accuracy of 93.9%. For more information about vegetation classification and mapping results, visit the Vegetation Community Classification and Mapping of the INL Site 2019.pdf.

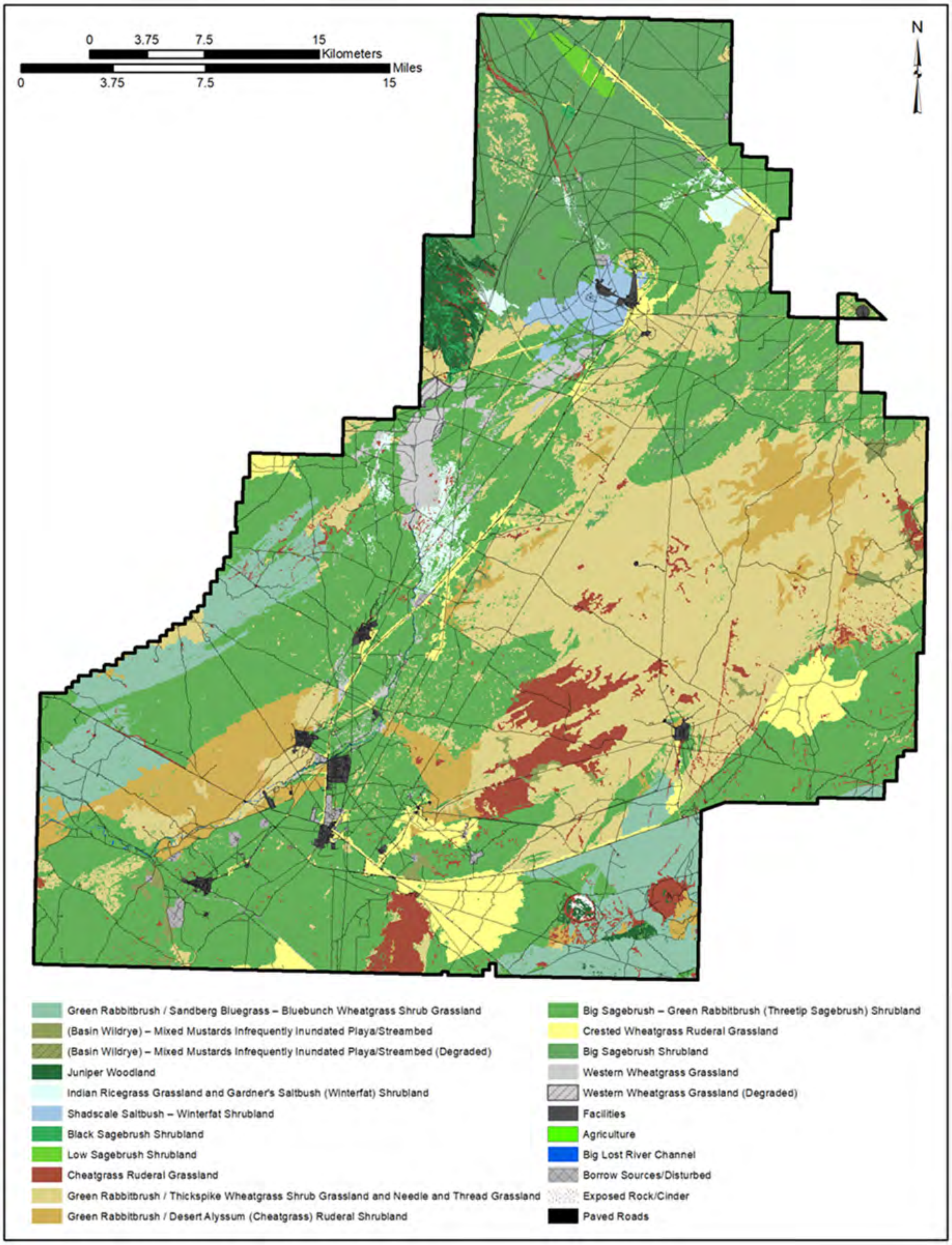

Figure 9-8. INL Site vegetation community classification map published in 2019.

9.3.5 National Environmental Research Park

The INL Site was designated as a NERP in 1975. According to the Charter for the NERP, NERPs are intended to be outdoor laboratories where research can be carried out to achieve agency and national environmental goals, as shown in Figure 9-9. Those environmental goals are stated in the NEPA, Energy Reorganization Act, and Non-nuclear Energy Research and Development Act. Environmental goals stated in these acts have been used to define the purpose of the Idaho NERP as a place that can be used for research to sufficiently understand our environment so that we may enjoy its bounty without detracting from its value and eventually to evolve an equilibrium use of our natural resources. The desirability of conducting research on the Idaho NERP is enhanced by having access to relatively undisturbed sagebrush steppe habitat and restricted public access. In 2021, the INL contractor facilitated university-led research on three ongoing ecological research projects through the NERP: (1) documenting ants and associated arthropods on the INL Site; (2) tracking rattlesnake movements through gestation and dispersal of young; and (3) addressing ecohydrology in sagebrush steppe.

Figure 9-9. Idaho NERP.

Entomological studies facilitated through the Idaho NERP include an array of research on taxa relationships, new species descriptions, and documentation of species new to the INL Site. A list of ants found at the INL Site was developed by Clark and Blom (2007) and has been used as a basis for studying ecological relationships between some of the ant taxa and a variety of ant guests. In the ecological context, guests are generally defined as animals living within the nest or colony of another species. One ant guest taxon, a desert beetle (*Philolithus elatus*), was not previously known from the INL Site (Stafford et al. 1986) but has recently been collected from harvester ant (*Pogonomyrmex salinus)* nests; it is currently the subject of study and description (Clark et al. in prep). An undescribed species of Jerusalem cricket (*Stenopelmatus* sp.) also has been found in ant nests at the INL Site and work to formally describe this species continues. Field observations indicate a predatory crab spider (*Xysticus* sp.) that has not been documented previously on the INL Site and now noted to be feeding on *Pogonomyrmex salinus*. Additionally, researchers continued to make incidental observations and field records for flea beetles (*Disonycha latifrons)* that feed on green rabbitbrush (*Chrysothamnus viscidifloris*) and *Moneilema* sp. (not yet found at the Site), a rare cactus feeding beetle. Voucher specimens collected at the INL Site have been deposited in the insect collection at the Orma J. Smith Museum of Natural

History and College of Idaho and are available for research. The Principal Investigator leading this research effort is William Clark from the College of Idaho; his work on invertebrates at the INL Site spans several decades and will continue into the foreseeable future.

More ecological studies have been conducted on the Great Basin Rattlesnake (*Crotalus oreganus* ssp. *lutosus)* than any other reptile species on the INL Site. This species occurs in large numbers in several areas on the INL Site and is best known for their large aggregations of sometimes several hundred individuals at underground overwintering sites (hibernacula). During their activity season, *C. o. lutosus* make a lengthy migration away from and back to a hibernaculum. While adult male and non-pregnant female rattlesnakes travel several kilometers during their active season to forage and find mates, pregnant individuals move less and generally remain within 1 km of their hibernaculum. These pregnant snakes spend most of their active season gestating under rocks until they give birth. The selection of an appropriate gestation site is important for pregnant snakes to avoid predators such as badgers and hawks, but also to provide proper thermoregulatory opportunities because embryonic development is influenced by temperature. In 2018 and 2019, a project was conducted on the INL Site to locate gestation rocks used by pregnant *C. o. lutosus* and to measure their attributes to determine if pregnant rattlesnakes were selecting specific rocks. Initial results indicate that gestation rocks fall within a specific size range and have attributes that are a subset of the available rocks; this suggests pregnant snakes are likely making choices to use specific rocks. From a management and conservation perspective, once identified, the persistence and non-destruction of gestation rocks could be important for maintaining Great Basin Rattlesnake populations because these rocks have specific characteristics that allow yearly success in reproduction. The Principal Investigator for this project is Dr. Vincent Cobb from Middle Tennessee State University and his work is ongoing for manuscripts describing results from this study.

The INL Site and other landscapes with sagebrush steppe vegetation are experiencing a simultaneous change in climate and plant community composition that are impacting habitat for wildlife, wildfire risks, and ecosystem services forage. 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. Since the early 2000s, investigators have utilized an existing INL ecohydrology research facility, the former Protective Cap Biobarrier Experiment, to study vegetation change with respect to precipitation regime, vegetation type, and soil depth. The focus of current research is to compare the impacts of grass invasion and shifts in timing of precipitation on functioning of the whole ecosystem, including biogeochemistry, carbon storage, and other attributes that relate to resistance and resilience in a changing environment. The experiment site was burned in its entirety by the 2019 Sheep Fire, which created an exceptional opportunity to test the underlying basis for the theory on resistance to exotic annual-grass invasion (cheatgrass) and resilience of sagebrush steppe. The long-term treatments conveniently create a gradient of pre-fire climate differences, and the cessation of treatment application has induced large differences in simulated drought conditions on the experiment. Researchers continue to sample the differences in cheatgrass among the treatments along with the corresponding soil nutrients and water. The research team includes Dr. Matthew Germino from the USGS Forest and Rangeland Ecosystem Science Center and Drs. Toby Maxwell and Marie-Anne DeGraff from Boise State University; their research continues to utilize a facility that has been in operation since 1994 and they will continue to collect data for at least the next few years.

9.4 INL Cultural Resource Management

The INL Cultural Resource Management Office (CRMO) resides within the INL contractor, Battelle Energy Alliance. Cultural resource professionals within the INL CRMO coordinate cultural resource-related activities at the INL Site and implement the INL Cultural Resource Management Plan (DOE-ID 2016) with oversight by DOE-ID's Cultural Resource Coordinator. Provisions to protect the unique cultural resources of the lands and facilities at the INL Site are included in Environmental Policies issued by Battelle Energy Alliance and other INL Site contractors and in company procedures that guide work completion. Cultural resource identification and evaluation studies in fiscal year (FY) 2021 included: (1) archaeological field surveys; (2) monitoring, and site updates related to INL Site project activities; and (3) meaningful collaboration with members of the Shoshone-Bannock Tribes and public stakeholders.

9.4.1 INL Section 106 Project Reviews

The INL CRMO resides within DOE-ID INL Management and Operations Contractor, Battelle Energy Alliance. Cultural resource professionals within the INL CRMO coordinate cultural resource-related activities at the INL Site and implement the INL Cultural Resource Management Plan (DOE-ID 2016) with oversight by DOE-ID's Cultural Resource Coordinator. Provisions to protect the unique cultural resources of the lands and facilities at the INL Site are included in Environmental Policies issued by Battelle Energy Alliance and other INL Site contractors and in company procedures that guide work completion. Cultural resource identification and evaluation studies in FY 2021 included archaeological field surveys, monitoring, and site updates related to INL Site project activities, and meaningful collaboration with members of the Shoshone-Bannock Tribes and public stakeholders.

9.4.2 INL Section 110 Research

Cultural resource identification and evaluation studies in FY 2021 were many and varied. Class III inventories for Section 110 surveys related to areas identified by the Shoshone-Bannock Tribes and INL CRMO research interests. There are currently two active multi-year Section 110 research proposals including: *Pluvial Lake Terreton: Building a Multidisciplinary Dataset to Understand Human Land Use During the Terminal Pleistocene* (INL 2017a) and *Decoding the Southern Idaho Cultural Landscape Through Volcanic Glass Source Analysis* (INL 2017b). The INL CRMO staff is coordinating these research efforts with the Shoshone-Bannock Tribes.

Decoding the Southern Idaho Cultural Landscape Through Volcanic Glass Source Analysis

In order to fully characterize the geographic distribution of Southern Idaho obsidian source groups, the INL CRMO has compiled a comprehensive Idaho obsidian reference collection. On March 16, 2021, INL CRMO staff provided the Fort Hall Business Council a progress report on source characterization efforts. Several more obsidian and fine-grained volcanic sources were added to the reference collection in FY 2021. The current dataset contains over 2,000 samples of geologic obsidian from 155 locations that correspond to 30 geochemically distinct source groups, a few of which have not been previously defined or recognized by archaeologists. This is the most comprehensive reference database of obsidian sources yet compiled for Southern Idaho. In FY 2022, the INL CRMO will publish results of analyses conducted in FY 2020 and FY 2021, including sources defined in the reference collection and provenance determinations for legacy collections of Terminal Pleistocene/Early Holocene projectile points held at the Earl Swanson Archaeological Repository.

Owl Cave Research

To better understand the Shoshone and Bannock peoples' use of the landscape within the Pioneer Basin, the physiographic region encompassing the INL, INL CRMO archaeologist graduate interns began investigations at the oldest and only stratigraphic site in the region. Working in conjunction with Museum of Idaho collection managers, INL researchers inventoried and classified the entire stone tool collection for the purpose of establishing the collection's extent and potential for future research. In addition to organizing lithic artifacts INL researchers reviewed and digitized notes on features, units, and layers to evaluate the potential for undisturbed stratigraphic sections of the site, resulting in a three-dimensional model of excavations, artifacts, and features at Owl Cave. Finally, a selection of obsidian stone tools of differing functional type and stratigraphic context were subjected to x-ray fluorescence analysis with the results of all these efforts to be published in a peer-reviewed journal article in FY 2022.

Built Environment Comprehensive Inventory

In FY 2021, the INL CRMO contracted the Center for the Environmental Management of Military Lands (CEMML), housed at Colorado State University, to complete a comprehensive survey of built environment resources at the INL Site constructed prior to 1980. While select INL Site campuses were surveyed in the late 1990s, those records did not capture the necessary depth of detail to provide sound evaluations of eligibility for the National Register of Historic Places (NRHP). As the years passed, additional resources have reached 50 years of age, a requirement for listing on the NRHP. For the past two decades, historic-age resources were surveyed on a project-by-project basis only. CEMML's comprehensive inventory will provide both an up-to-date record of historic-age built resources across the INL and a planning document for future growth. During FY 2021, CEMML conducted fieldwork at the Central Facilities Area, the Critical Infrastructure Test Range Complex, the Materials and Fuels Complex, the Idaho Nuclear Technology and Engineering Center, and the Advanced Test Reactor Complex. The inventory reports will be submitted to INL CRMO during FY 2022.

To support the needs of the evolving INL Site campuses, the INL CRMO also began updating the Precontact, Historic, and Post-World War II Contexts to provide a fuller understanding of the human history of what would become the INL Site, as well as to better situate the resources preserved within their temporal and thematic contexts.

9.4.3 Cultural Resource Monitoring

Field work in FY 2021 also included a broad, yearly program involving routine visits to monitor current conditions at previously recorded archaeological resources across the INL Site. In FY 2021, INL CRMO, Shoshone-Bannock Tribes Heritage Tribal Office, and DOE-ID staff monitored site condition at six locations on the INL Site. The data acquired during the FY 2021 monitoring efforts of these sites allowed for a complete evaluation of the current condition as compared to the initial recordings, but also establish a more detailed baseline for future monitoring efforts.

9.4.4 Stakeholder, Tribal, Public, and Professional Outreach

In FY 2021, the CRMO staff continued public outreach components amidst the continuation of the COVID-19 pandemic. Educational exhibits at the EBR-I National Historic Landmark within the boundaries of the INL Site are important tools for public outreach. Unfortunately, due to the COVID-19 pandemic and necessary restrictions, face-to-face employee and public tours at EBR-I were not possible in FY 2021. However, visitors could download a free app that provided a virtual tour of the EBR-I museum. Following the success of the virtual tours of the EBR-I museum, the INL CRMO developed and conducted two virtual archaeology tours for over 100 INL employees and members of the public. These tours included discussions of DOE-ID’s archaeological responsibilities, Eastern Idaho precontact history, and specific examples of historic sites and nuclear history at the site.

In addition to tours, INL CRMO archaeologists working with the Museum of Idaho to provide professional expertise and assistance in teaching a brief archaeology summer course for local public-school teachers on July 28-29, 2021. This included providing instruction on Idaho’s precontact period, archaeological survey and excavation techniques, and the protection of cultural resources. This outreach effort included 16 public school teachers in history, science, and social studies curriculum.

In FY 2021, INL CRMO archaeologists, Shoshone-Bannock Heritage Tribal Office staff, and the DOE-ID Cultural Resource Coordinator facilitated access to the INL Site for members of the Fort Hall Business Council. Council members visited Middle Butte Cave and two archaeological sites adjacent to the Big Lost River. During this visit, CRMO staff demonstrated current protocols for in-field x-ray fluorescence analysis of obsidian artifacts that reduce the need for surface collection and curation. Additionally, an INL CRMO archaeologist and an undergraduate intern led two archaeology workshops for about 25 Shoshone-Bannock middle school science, technology, engineering, and mathematics students.

Goodale’s Cutoff, a spur trail of the Oregon Trail, intersects the southwest corner of the INL Site. In conjunction with the development of the historic context statement for Goodale’s Cutoff in FY 2021, interpretive panels were finalized and approved for display at the Big Lost River Rest Area. The design has been approved by DOE-ID, the Idaho SHPO, and the Shoshone-Bannock Tribes. Production and installation are scheduled for FY 2022.

9.4.5 INL Archives and Special Collections

During FY 2021, the INL archives and special collections retained a full-time intern to assist the INL archivist. Together, they completed the scanning, editing, and metadata entry for 554 large format architectural drawings and photographs requested by CEMML, completed scanning of 3,989 seismographs for INL seismology, and added relevant metadata to 1,691 of the scans. Archives staff reviewed over 600 records retention schedules and created a list of record series that may contain historically significant information to retain in the INL archives.

Three new internal acquisitions and one external acquisition were accessioned into the INL archives. Included within these new collections are approximately 95,000 historical photographs for which a folder level inventory was completed.

Archives staff completed 11 accessions of existing but not formally accessioned collections, which were comprised of items that were present in the archive prior to 2019, including: (1) 991 architectural and engineering drawings; (2) 1,532 archival photographs; (3) 44 slides; (4) 170 glass plate negatives; (5) 304 audio media/visual media/booklets/manuals;

and (6) 1,063 contractor newsletters. Archives staff also created item-level inventories for 1,740 historical publications (1989-1999), contractor newsletters (1968-1999), reports, booklets, historical photographs, compact discs, video home system, film reels, and slides.

Archives staff updated, corrected, and completed, 13 existing accessions for 633 architectural and engineering drawings that were present in the archives prior to 2019.

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Chapter 10: Quality Assurance of Environmental Surveillance Programs

CHAPTER 10

Quality assurance (QA) consists of planned and systematic activities that give confidence in effluent monitoring and environmental surveillance program results (NCRP 2012). Environmental surveillance programs should provide data of known quality for the assessments and decisions being made. Quality assurance and quality control programs were maintained by INL contractors and laboratories performing environmental analyses.

The subcontracted laboratories (e.g., ALS-Fort Collins, GEL-Charleston, SwRI) were rigorously assessed and audited by the U.S. Department of Energy (DOE) Consolidated Audit Program-Accreditation Program, an approved third-party accrediting body. Each laboratory maintained their accreditation for 2021. The accreditation qualifies the laboratories to receive, analyze, and report data to a DOE program. Idaho State University-Environmental Assessment Laboratory was audited in 2021 by the Idaho National Laboratory (INL) quality team and is listed in the Battelle Energy Alliance Qualified Suppliers List.

In addition to the quality assurance processes implemented by the INL contractors, the laboratories also utilize trained personnel, procedures, and quality assurance processes to ensure quality data. Data quality reviews were performed by the laboratory and any unusual conditions were addressed and identified in the case narrative prior to reporting to INL.

Field sampling elements, laboratory measurements (see Section 10.2), and performance evaluation samples were reviewed and evaluated for each INL contractor laboratory. Results are summarized in Section 10.4. Together this information was used to assess the quality of data provided to INL contractors, and to follow-up and/or conduct a corrective action to improve processes when necessary. This multi-faceted approach to quality assurance and quality control added value to each INL Site contractor's monitoring program by providing confidence that all laboratory data reported in this report are reliable and of acceptable quality.

10. QUALITY ASSURANCE OF ENVIRONMENTAL SURVEILLANCE PROGRAMS

This chapter describes specific measures taken to ensure adequate data quality and summarizes performance.

10.1 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 O 414.1D, "Quality Assurance"
- 10 Code of Federal Regulations (CFR) 830, Subpart A, "Quality Assurance Requirements"
- U.S. Environmental Protection Agency (EPA) QA/G-4, Guidance on Systematic Planning Using the Data Quality Objective Process

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

- EPA Intergovernmental Data Quality Task Force, Uniform Federal Policy for Implementing Quality Systems, (Evaluating, Assessing, and Documenting Environmental Data Collection/Use and Technology Programs) (EPA 2005)
- American Society of Mechanical Engineers NQA-1-2012, "Quality Assurance Requirement for Nuclear Facility Applications."

These regulations specify 10 criteria of a quality program, presented in the gray text box on page 10-1. Additional quality assurance program requirements in 40 CFR 61, Appendix B, Method 114, must be met for all new point sources of radiological air emissions as required by 40 CFR 61, Subpart H.

Each Idaho National Laboratory (INL) Site contractor incorporates appropriate QA requirements to ensure that environmental samples are representative and complete, and that data are reliable and defensible.

10.2 Program Elements and Supporting QA Process

According to the National Council on Radiation Protection and Measurements (NCRP 2012), QA is an integral part of every aspect of an environmental surveillance 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 surveillance process can lead to misinterpretation of data and/or errors in decisions based on these data. Every step in radiological effluent monitoring and environmental surveillance should be evaluated for integrity, and actions should be taken to evaluate and manage data uncertainty.

Meeting requirements of state regulations and DOE orders is an important part of developing a successful and defensible environmental surveillance program. Gathering of quantitative and qualitative environmental surveillance data is unique to each surveillance program. All data from planning, sample collection and handling, sample analysis, data review and evaluation, and reporting must be of known defensible accuracy, precision, completeness, and representativeness. Approved, detailed procedures are maintained, adequate training given, and documents controlled to ensure that data are of known and acceptable precision and accuracy.

The main elements of environmental surveillance programs implemented at the INL Site, as well as the QA processes/activities that support them, are shown in Figure 10-1 and discussed below.

10.2.1 Planning

Environmental surveillance activities are conducted by a variety of organizations including:

- Idaho National Laboratory contractor
- Idaho Cleanup Project Core contractor
- Environmental Surveillance, Education, and Research Program
- U.S. Geological Survey
- National Oceanic and Atmospheric Administration.

Each INL Site contractor 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.

Sitewide Monitoring Plans. The *Idaho National Laboratory Site Environmental Monitoring Plan* (DOE-ID 2021) and *Idaho National Laboratory Groundwater Monitoring and Contingency Plan Update* (DOE-ID 2021) summarize the various monitoring programs at the INL Site, including 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 plans include the rationale for monitoring, the types of media monitored, where the monitoring is conducted, and information regarding access to analytical results.

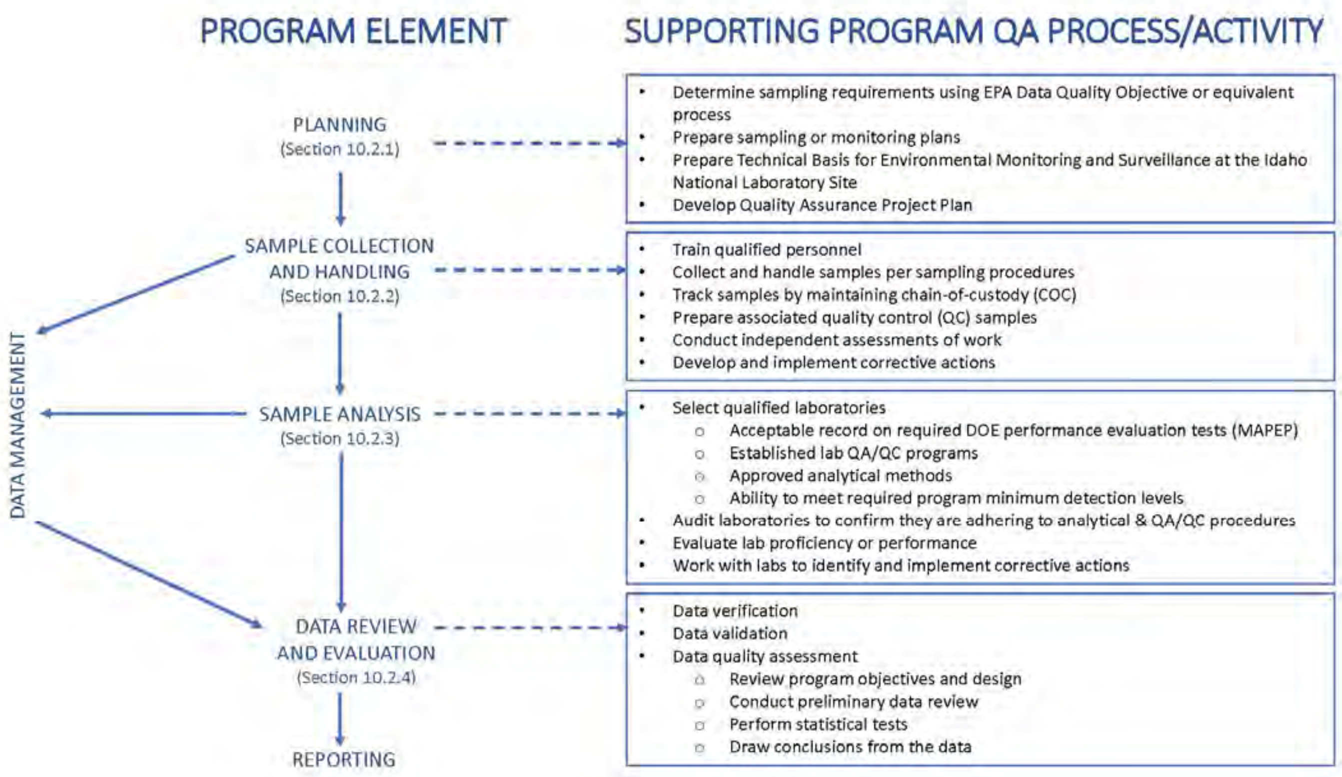

Figure 10-1. Flow of environmental surveillance program elements and associated QA processes and activities.

Quality Assurance Project Plan. Implementation of QA elements for sample collection and data assessment activities are documented by each INL Site contractor using the approach recommended by the EPA. The EPA policy on QA plans is based on the national consensus standard ANSI/ASQC E4-1994, "Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs." DQOs are project-dependent and are determined based on the needs of the data users' and the purpose for which that data are generated. DQOs, sampling and analysis plans, and *Technical Basis for Environmental Monitoring and Surveillance at the INL Site* (DOE/ID-11485) are integrated into the INL contractors QA Project Plans. Quality elements applicable to environmental surveillance and decision-making are specifically addressed in *EPA Requirements for Quality Assurance Project Plans* (EPA QA/R-5) (EPA 2001).

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.

These elements are categorized as follows:

- Project management
- Data generation and acquisition
- Assessment and oversight
- Data verification/validation and usability.

A QA Project Plan documents the planning, implementation, and assessment procedures for a particular project, as well as any specific QA and QC activities. It integrates all technical and quality aspects of the project to provide a 'blueprint' for obtaining the type and quality of environmental data and information needed for a specific decision or use. Each environmental surveillance program at the INL Site prepares a QA Project Plan.

10.2.2 Sample Collection and Handling

Defensible laboratory data is a critical component of any environmental program. Field sample collection and handling, coupled with a chain-of-custody showing unique sample identification, weight, volume, holding time, approved procedures, and request of laboratory analysis, are important steps of good defensible quality data. The QC elements used to obtain defensible quality data are described below.

Strict adherence to program procedures is an implicit foundation of QA. In 2021, samples were collected and handled according to documented program procedures. Samples were collected by trained personnel. Sample integrity was maintained through a system of sample custody records. Work execution assessments were routinely conducted by personnel independent of the work activity. Deficiencies were addressed by corrective actions, which are tracked in contractor-maintained corrective action tracking systems.

Field quality control sample elements, as shown in Figure 10-2, were also collected or prepared to check the quality of sampling processes. These included the collection of trip blanks, field blanks, equipment blanks, split samples, sample duplicates, and performance evaluation (PE) samples that are defined as follows:

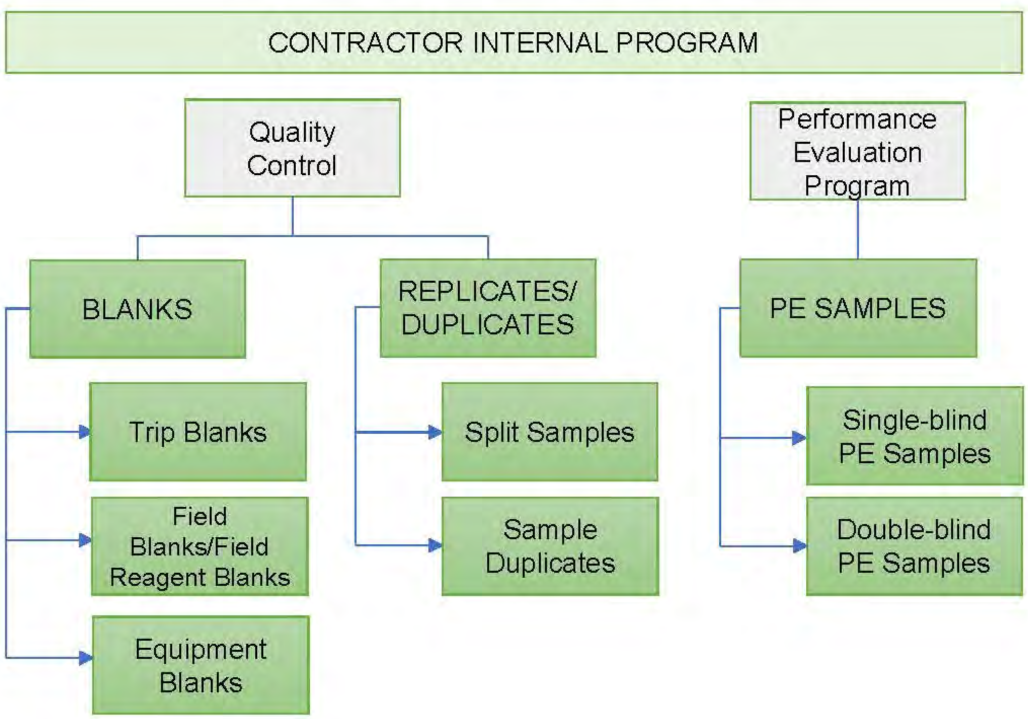

Figure 10-2. Field quality control sampling elements.

Blanks. The primary purpose of blanks (a sample of analyte-free media) is to trace sources of artificially introduced contamination. The INL contactors may utilize various types of blanks based on the samples being collected for a program or project.

- ***Trip Blank.*** The blank sample results can be used to identify and isolate the source of contamination introduced in the field or the laboratory. A trip blank is a clean sample of matrix 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.

- ***Field Blank (also called Field Reagent Blank).*** A field blank is collected to assess the potential introduction of contaminants and the adequacy of field and laboratory protocols during sampling and laboratory analysis. In air sampling, a field blank is a clean, analyte-free filter that is carried to the sampling site, exposed to sampling conditions, returned to the laboratory, and treated as an environmental sample. In water sampling, field blanks are prepared at the field site where environmental water samples are collected. A sample of analyte-free water is poured into the container in the field where environmental water samples are collected, preserved, and shipped to the laboratory with field samples. Results include relevant ambient conditions during sampling and laboratory sources of contamination.

- ***Equipment Blank.*** An equipment blank is a volume of laboratory-grade water that is used to rinse sampling equipment. The rinse water is collected and tested to verify that the sampling equipment is not contaminated. Equipment blank samples verify the effectiveness of the decontamination (cleaning) procedures on sampling equipment.

Replicate/Duplicate Samples. Field duplicate samples are used to assess precision. Duplicates also provide information on analytical variability caused by sample heterogeneity, collection methods, and laboratory procedures:

- ***Split Samples.*** A sample collected and later divided from the same container into two portions that are analyzed separately. Split samples are used to assess analytical precision.

- ***Sample Duplicate or Field Replicates (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 estimating the precision resulting from the sampling process.

PE Samples. PE samples are prepared samples that contain known values of analyte(s) of interest to the specific project, INL Site contractor program, or laboratory. PE samples are used to assess analytical method specific laboratory performance and to check that the laboratory can be within criteria set by the specific project or program for known value sample recovery. The samples are matched as closely as possible to the specific media, analytes of interest, and expected concentration or activity levels appropriate for the specific project, program, or use in decision-making. In some cases, the PE sample matrix may differ from the field samples (i.e., using deionized water with a known amount of analyte to simulate an atmospheric moisture sample). The PE samples are generally submitted with batches of field samples so they are processed simultaneously in the laboratory. Types of PE samples are described below:

- ***Single-blind PE Samples.*** The value of a single-blind PE sample is known to the INL contractor sending the sample but unknown to the laboratory receiving the sample.

- ***Double-blind PE Samples.*** The value of a double-blind PE sample is unknown to both the laboratory receiving the sample and the INL contractor. While the program specifies PE sample matrix and boundaries of the value's range (i.e., the known value must fall between a pre-determined minimum and maximum value that corresponds to the specific project or program), the actual value is unknown to both the INL Site contractor and the laboratory.

10.2.3 Sample Analysis

Laboratories used for routine analyses of radionuclides in environmental media were selected by INL contractors based on each laboratory's capabilities to meet program objectives, such as the ability to meet required detection levels, and past results in PT programs. Programs exist to help contract holders conduct and assess a laboratory's ongoing performance. Requirements for participation in specific programs are at the discretion of the contract holder. One program, the U.S. Department of Energy Consolidated Audit Program-Accreditation Program (DOECAP-AP), accredits laboratories in meeting requirements outlined in the Quality System Manual (QSM) (QSM 2021). No major findings were identified by the DOECAP-AP, an approved third-party auditors, that would influence the defensibility or quality of laboratory data in 2021. For more information on DOECAP-AP, visit the DOE Analytical Services Program webpage at www.energy.gov/ehss/analytical-services-program.

Laboratory data quality is continually verified by QC samples, as observed in Figure 10-3, and include: calibration verifications, blanks, replicates/duplicates, and intra-laboratory PE samples.

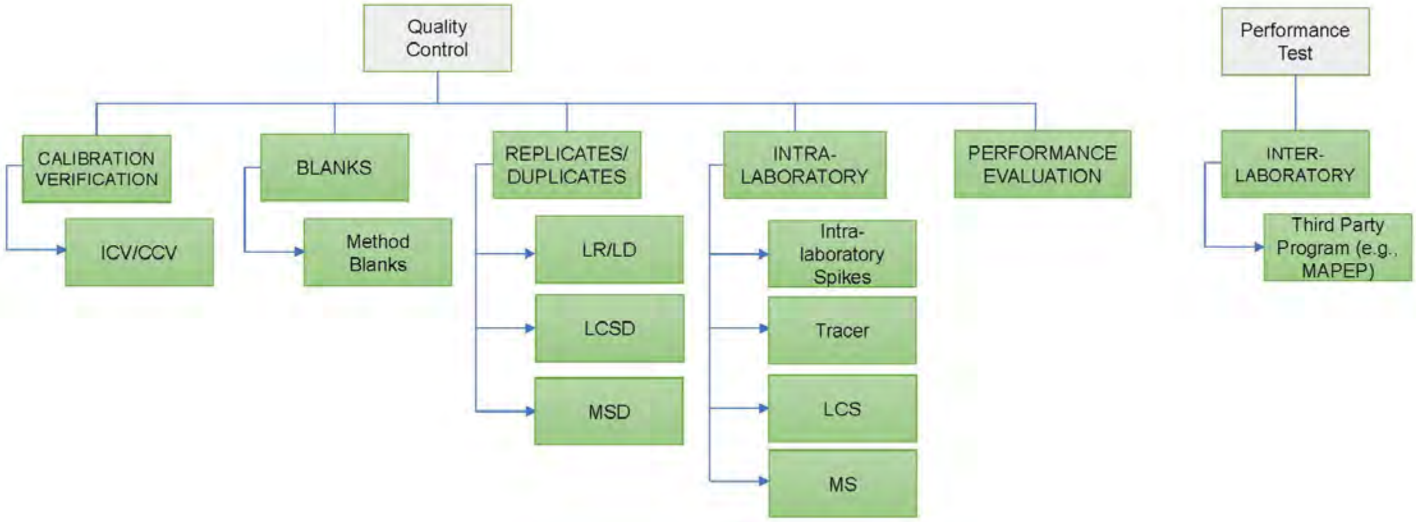

Figure 10-3. Laboratory measurement elements.

The types of QC samples used to assess the quality of laboratory analytical processes and their results are described below.

Calibration Verification. The calibration verification is used to check that the instrument is still within the original calibration of the instrumentation being used for analyses of the samples sent to the laboratory for the requested method and analytes requested on the chain-of-custody.

- ***Initial Calibration Verification (ICV) and Continuing Calibration Verification (CCV).*** The primary purpose of the ICV/CCV is to check the original calibration of the instrumentation being used to analyze samples for that method and targeted analytes. The ICV/CCV is from an external source different than that used in calibration.

Blanks. The primary purpose of blanks (e.g., a sample of analyte-free media) is to trace sources of artificially introduced contamination. Laboratory blanks assess the potential of contamination being introduced during the analytical laboratory process whereas field blanks are used to identify potential contamination that occurred during sample collection.

- ***Method Blank.*** A method blank is an analyte-free matrix such as distilled water for liquids or cleaned sand for solids and/or soils that is processed in the same way as the INL Site contractor program samples. The main function of the method blank is to document contamination resulting from the analytical laboratory process.

Replicate/Duplicate. Replicate/duplicate samples are used to assess precision. Replicates/duplicates also provide information on analytical variability caused by sample heterogeneity, collection methods, and laboratory procedures.

- ***Laboratory Replicate/Duplicate.*** Two aliquots from the same field sample are prepared by the laboratory and analyzed separately using identical procedures to assess the precision of a method in a given sample matrix.

- ***Laboratory Control Sample Duplicate (LCSD) analysis (accuracy and precision).*** The LCSD is used to determine the accuracy and precision, as well as bias of a method in each sample matrix.

- ***Matrix Spike Duplicate (MSD) analysis (accuracy and precision).*** The MSD is used to determine the accuracy and precision, as well as the bias of a method in each sample matrix.

Intra-laboratory samples. Intra-laboratory known value samples can be used to verify competency of the laboratory analysis method and analyst performing the sample preparation and analysis.

- ***Intra-laboratory PE.*** This is an internal laboratory quality program using their own known value sample program to test their laboratory for method performance.

- ***Tracer.*** Tracers are added to samples to determine the overall chemical yield for the analytical preparation steps. Tracers are the same element with a different isotope that are chemically similar. An example would be using ^{242}Pu as a tracer when analyzing for ^{238}Pu and ^{239}Pu.
- ***Laboratory Control Sample (LCS).*** The primary purpose of the LCS (accuracy) is to demonstrate that the laboratory can perform the overall analytical approach in a matrix free of interferences (e.g., reagent water, clean sand, or another suitable reference matrix) and its analytical system is in control but does not reflect analytical performance on analyzing real world samples.
- ***Laboratory Matrix Spike (MS).*** The purpose of the MS (accuracy) sample is to determine if the method is applicable to the sample matrix in question.

Performance Evaluation. This is either a single-blind or double-blind PE sample ideally using a similar matrix as the field samples being submitted by the INL contractor (see Section 10.2.2).

Inter-laboratory PT samples. This is an external PT and inter-laboratory comparison program accredited under the International Organization for Standardization/International Electrotechnical Commission (ISO/IEC 17043:2010[E]). *The Department of Defense (DoD) Department of Energy (DOE) Consolidated Quality Systems Manual (QSM) for Environmental Laboratories* (QSM 2021) requires that laboratories receiving and analyzing samples for DOE contracts successfully participate in a PT program for one year before becoming an accredited laboratory to receive samples for analyses for all analytes, matrices, and methods included in the laboratory's scope of work. The inter-laboratory program requires that participating laboratories must analyze at least two sets of samples during a calendar year.

The analytical laboratory may use several of the laboratory QC measurement elements identified above. Results of the laboratory QC are presented to the INL contractors as a data package and provide assurance that the data reported is useable and defensible.

10.2.4 Data Review and Evaluation

Data generated from INL Site contractors are routinely evaluated in order to understand and sustain the quality of data. This allows the program to determine if the DQO's established in the planning phase were achieved and whether the laboratory is performing within its 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 also may be reviewed—sample preservation and temperature, defensible chain-of-custody documentation and sample integrity, analytical hold-time compliance, correct test method application, 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 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 INL Site contractor's environmental monitoring plans; confirms the usability of the data for the intended end use via validation of analyses performed and data reduction and reporting; and ensures that 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, if available, consistency 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.

The programs include results of individual program QC data, as well as the Mixed Analyte Performance Evaluation Program (MAPEP) PT. Individual QC programs include the use of several elements, as shown in Figure 10-2 and Figure 10-3, respectively, to evaluate the performance of a laboratory. These elements were previously discussed in Sections 10.2.2 and 10.2.3. Not all QC measurement elements are required unless specifically called out in each INL Site contractor program's contract with the laboratory, or as required by the specific analytical method.

Figure 10-4 shows a visual decision tree of the process used for reviewing PE sample results along with sample data. When QC sample results fall within the acceptable range for the INL contractors, review of the remaining data continues. If no issues are identified, the data package is approved. If a non-agreement (not acceptable) is encountered, the INL Site contractor reviews all available QC data to determine the course of action needed. Some of the items that may be reviewed include the following:

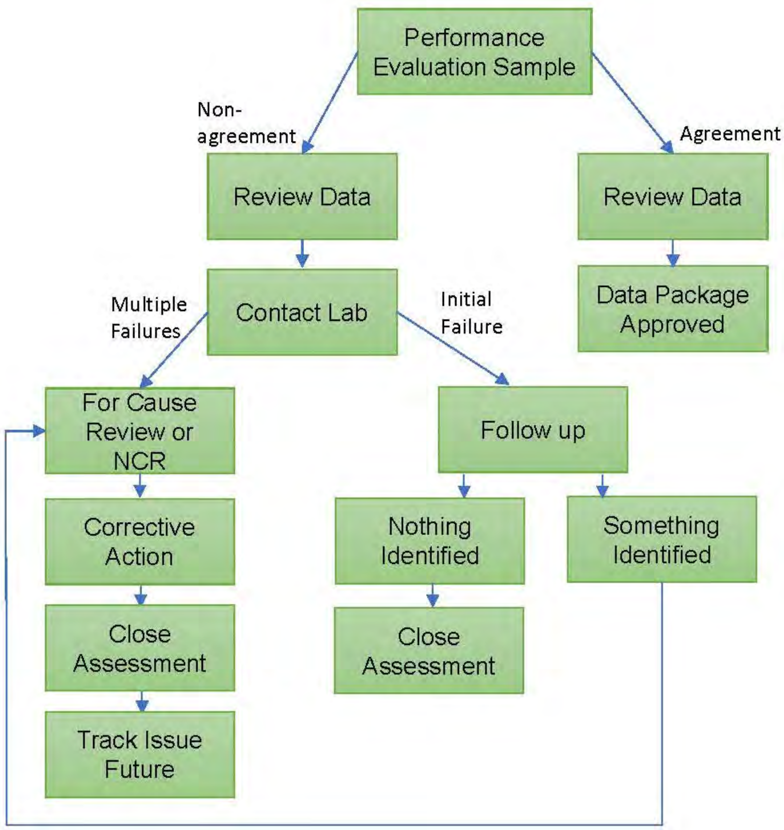

Figure 10-4. Environmental surveillance field sampling data QA review process.

- Did the PE sample provider prepare the sample (single-blind or double-blind) within the range specified by their customer? If yes, begin looking into the other QC data reported by the laboratory. If no, the PE sample may not be an accurate representation of the project-specific field conditions or field results. If the equipment is calibrated for the field concentration range, and the PE sample is not within that range, then the accuracy and representativeness of the PE sample may be called into question.

- Did the laboratory perform all required program- and method-specific QC analyses? Are these QC results within acceptable parameters or not?
- What does a review of the long-term project results indicate? Are all project-specific and analytic-method-specific QC results within specification? If not, does the laboratory have a history of out-of-specification QC results for a specific analyte, or is the new result a one-time anomaly?
- What does a review of long-term PE blind sample results indicate? Is the current 'not acceptable' result a one-time anomaly, or does the long-term data indicate a reoccurring or ongoing concern with accurate PE measurements of a specific analyte?
- What does a review of the long-term MAPEP PT results indicate?
- Do past DOECAP-AP third-party audits, provide insight into any ongoing analytical or QC concerns for this laboratory?
- What information is available from other laboratory accreditation bodies to provide insight into the laboratory's capabilities? Has the laboratory maintained its accreditations? Does the laboratory remain in good standing with these governing scientific bodies (i.e., Is there any reason to believe, based on the opinions/accreditation of the scientific professionals at these bodies, that the laboratory is not capable of accurately measuring the specific analytes in question)?
- Was there a complete dissolution of the sample?
- Was there an issue with the Laboratory Information Management System, or equivalent system, data reduction, or calculation issue?
- Was there incomplete purification of a sample from an interfering analyte? An example would be too much calcium present in a sample for ^{90}Sr analysis.

Upon review of the entire body of QC evidence described above, using both objective and subjective professional judgement, the INL Site contractor will determine if the 'not acceptable' result is a one-time anomaly or if the laboratory needs to implement any follow-up or corrective actions.

A 'For-Cause-Review' or 'Non-Conformance Report' is requested when either multiple blind PE sample issues occur consecutively, or as a result of a follow-up action. The For-Cause-Review would review laboratory data to investigate anything that may have been misreported (e.g., sample units, weights, calculations); whereas a Non-Conformance Report would generate a more rigorous laboratory review. Both the For-Cause-Review and Non-Conformance Report will result in a Corrective Action (CA) being issued which will resolve the problem and prevent future issues from occurring. Upon acceptance of the CA, the assessment would be closed and the issues discussed in the CA will be monitored in future data packages.

A follow-up action occurs after a single failure and may result in the laboratory not identifying any issues leading to the 'not acceptable' result. At this point the data package is good defensible data if the laboratory passed all of their qualifying criteria for the data package and that the following are within the laboratory quality criteria, as applicable: initial calibration verification, continuing calibration verification, method blank, LCS, MS, laboratory replicate, radioactive tracer recovery, and field blank(s). If a laboratory qualifying criteria is not met, the laboratory will re-prepare and re-analyze the samples; however, if enough of a sample is not available, the laboratory may flag their data if their radioactive tracer, LCS, laboratory replicate, or MS are not within their criteria. When the follow-up action identifies issue(s), either a For-Cause-Review or Non-Conformance Report may be requested.

If a laboratory were to have two consecutive sets of PE samples that were not within the acceptable criteria, the specific environmental laboratory project manager would be asked to demonstrate whether the issue in question was investigated, corrective measures were implemented, and additional PE samples were analyzed with results within the acceptable criteria. If the laboratory cannot identify any issues, the INL Site contractor will work with the laboratory to assist in the investigative process. For example, whether additional PE samples may be provided to the analytical laboratory determine if any problems arise from sample preparation, data calculations, data entry into a database, etc. As a result, the laboratory will provide an acceptable CA to the INL Site contractor. The issue will be monitored for future PE samples. Depending on the severity, the contractor may hold onto samples until the issue is resolved and send a letter-of-concern to the laboratory. Based on the outcome of the investigation, the INL Site contractors may terminate the contract and seek another laboratory.

The PE samples that received a 'not acceptable' performance evaluation were reviewed as per the process discussed in Section 10.2.4. The 'not acceptable' findings are discussed in Sections 10.4.3.1, 10.4.3.2, and 10.4.4.3.

10.3 Inter-laboratory Program Performance Testing Evaluations

The MAPEP is an inter-laboratory program that uses PT evaluations to test the ability of the laboratories to correctly analyze for radiological, non-radiological, stable organic, and stable inorganic constituents' representative of those at DOE sites.

In 2021, all laboratories used by the INL Site contractors participated in two separate MAPEP PT program series. The matrices along with the radioanalytes of interest that received a MAPEP 'not acceptable' evaluation are discussed below. A 'not acceptable evaluation' is assigned to MAPEP results that are > +/-30% of the reference value. The analytical laboratory is responsible for reviewing their individual MAPEP results and to correct potential quality concerns identified by MAPEP. Additional information on MAPEP is available at: https://www.id.energy.gov/resl/mapep/mapep.html.

10.3.1 ALS-Fort Collins

For 2021, there were no analytes or sample matrices of interest that were outside the reference value criteria stated above.

10.3.2 GEL Laboratories

GEL Laboratories received "not acceptable" evaluations for ^{90}Sr in vegetation, ^{226}Ra in water and gross alpha in an air filter. Results for ^{90}Sr were not acceptable for vegetation in the first MAPEP series of 2021. A review of historical MAPEP results indicates this was a single event. Strontium-90 in vegetation will be monitored for future MAPEP results to identify consecutive "not acceptable" evaluations.

The 'not acceptable' evaluation for ^{226}Ra in water occurred in the second MAPEP series of 2021. Results for ^{226}Ra were acceptable in the first MAPEP series of 2021. Review of historical MAPEP results indicate the ^{226}Ra 'not acceptable' in 2021 was a single event and not a consecutive or ongoing non-agreement for MAPEP water media. Future ^{226}Ra MAPEP results will continue to be monitored for trends, and to determine if consecutive 'not acceptable' evaluations occur that require corrective actions by the laboratory.

GEL Laboratories received a 'not acceptable' evaluation for gross alpha in the second MAPEP series of 2021. The result for gross alpha was 'acceptable' in the first MAPEP series of 2021. Gross alpha in air filters is not a regular analyte and matrix of interest to the ICP Core contractor at this laboratory, although there was a single, non-routine sampling event in 2021 that analyzed for gross alpha in a stationary engine air filter. Although the MAPEP result for this analyte and matrix were not discussed with the laboratory, the data package contained other QC measures and underwent third-party validation. The gross alpha air filter 'not acceptable' was a single event for the 2021 MAPEP and will be followed for trending.

10.3.3 ISU-EAL

ISU-EAL received 'not acceptable' evaluations for several matrices and radioanalytes of interest. The matrices and respective radioanalytes include:

- air filter: gross alpha/gross beta
- water: gross alpha/gross beta, ^{57}Co, ^{60}Co
- vegetation: ^{57}Co, ^{60}Co, ^{134}Cs, ^{137}Cs, and ^{65}Zn.

The laboratory director identified issues with sample preparation and data management that is unique to MAPEP. A corrective action plan was developed by the analytical laboratory to prevent any future problems. The ISU-EAL performance will be monitored for future MAPEP PT program samples to identify consecutive ‘not acceptable’ evaluations.

10.3.4 SwRI

The SwRI was used for special sample analysis by the ICP Core contractor and was not used for routine environmental sampling and reporting.

10.4 Intra-laboratory Performance Evaluation Results

The INL Site contractors submitted blank and duplicate/replicate samples to identify potential contamination and estimate the variability of an analysis. Section 10.2.2 has a more in-depth description of blanks and duplicate/replicate samples. The results for blank and duplicate/replicate samples submitted by each contractor are discussed in Sections 10.4.1 and 10.4.2.

10.4.1 Blanks

The INL contractors submitted blank samples along with the field samples to test for the introduction of contamination during the process of field collection, laboratory preparation, and laboratory analysis. Section 10.2.2 provides a discussion on the various types of blank samples.

10.4.1.1 ESER Contractor Blank Results

In 2021, the ESER contractor submitted blank samples for air, milk, atmospheric moisture, and precipitation. ISU-EAL and GEL reported 616 separate analytes. The criteria were met by 601 out of 616 blank analytes. This meets the criteria in the quality assurance plan.

10.4.1.2 INL Contractor Blank Results

In 2021, the INL contractor submitted blank samples for air and atmospheric moisture. ALS-FC reported 294 separate analytes. The criteria were met by 284 out of 294 blank analytes. This meets the criteria in the quality assurance plan.

10.4.1.3 ICP Core Contractor Blank Results

In 2021, the ICP submitted 146 separate radioanalytes in field blank samples for water with GEL and ALS-Fort Collins, of which 138 did not report detectable activity in the sample. Field blanks were discontinued in 2018 for air filters.

10.4.1.4 USGS Blank Results

In 2021, the USGS INL Project office submitted five blank QA samples for routine groundwater monitoring. A request was made for six separate analytes for analysis by the PE sample provider. Of the requested analytes, none of the blank samples had detections above 3σ (Bartholomay and others, 2021; Rattray, 2014). This meets the criteria in the quality assurance plan.

10.4.2 Duplicate/Replicate Samples

The criteria for acceptable precision may vary by specific project or program based on the characteristics of the media being sampled and the decision-making purpose of the results. Section 10.2.2 provides a discussion on the various types of duplicate/replicate samples.

10.4.2.1 ESER Duplicate/Replicate Results

In 2021, the ESER contractor requested 258 field duplicate analyte pairs for air, milk, agricultural products, and water (drinking water and surface water). The QC criteria for acceptability specifies the relative percent difference determined from field duplicates should be +/- 20% for 98% of the analyses and the QC criteria were met by 253 out of 258 separate analytes and meets the criteria in the quality assurance plan.

10.4.2.2 INL Contractor Duplicate/Replicate Results

Air

In 2021, the INL contractor requested analysis of 563 field duplicate pairs. The air QC criteria for laboratories supporting the program is that at least 90% of the samples submitted annually, must be successfully analyzed and reported according to specified procedures. The results for 547 of 563 (97%) passed the precision criteria for field duplicate samples.

Water

In 2021, the INL contractor water programs requested the analysis of 107 field duplicate analyte pairs. The water QC criteria for acceptability specifies the relative percent difference determined from the field duplicates should be 35% or less for 90% of the analyses. The results for 105 of the 107 (98.1%) duplicate pairs were less than 35% for 2021.

10.4.2.3 ICP Core Contractor Duplicate/Replicate Results

Air

In 2021, the ICP Core contractor requested the analysis of 153 field duplicate pairs for the environmental surveillance air program, of which 143 were determined to be 'acceptable.' Accordingly, total precision for air samples across all projects was 93.5%, which does not indicate an issue with the ICP Core contractor samples.

Water

In 2021, the ICP Core Contractor requested 110 field duplicate pairs for radiological analysis of various environmental monitoring water projects across the site, of which 103 were determined to be 'acceptable.' Accordingly, the total precision for water samples across all projects was 93.6%, which does not indicate an issue with ICP Core contractor samples.

10.4.2.4 USGS Duplicate/Replicate Results

In 2021, the USGS INL Project Office collected sample-replicate pairs from 15 groundwater monitoring wells. A request was made for a total of 41 field sample-replicate analyte pairs by the PE sample provider. The sample-replicate pair variability was determined by calculating normalized absolute difference for the radionuclide results. Evaluation of the 41 sample-replicate pairs, where eight of these pairs had a detection above 3σ, show 100% of the results had a calculated normalized absolute difference < 1.96. These results are in concordance with our stated QA requirements for sample-replicate pairs (Bartholomay and others, 2021; Rattray 2014).

10.4.3 PE Samples

All laboratories used by the INL Site contractors were provided single- or double-blind PE samples throughout the 2021. The sample matrices sent to the laboratories included: air filter, water (e.g., drinking water, atmospheric moisture, surface water, groundwater, effluent, precipitation), milk, soil, and agricultural products. The methods of analysis included: gamma spectroscopy, alpha spectroscopy, beta spectroscopy, and liquid scintillation. In 2021, INL Site contractor monitoring programs issued 253 individual performance tests; 226 were within acceptable criteria. Upon evaluation of all QC evidence available, it was determined that performance tests that did not meet acceptance criteria did not affect the defensibility or usability of the INL Site contractor's results. Additional information regarding the 2021 performance tests that did not meet acceptance criteria is presented in Sections 10.4.3.1, 10.4.3.2, and 10.4.3.3.

10.4.3.1 ESER Blind PEs

A total of 53 analytes were analyzed by GEL Laboratories and ISU-EAL in 2021. GEL Laboratories received a non-agreement for americium-241 (^{241}Am), ^{238}Pu, ^{239}Pu, and ^{90}Sr for two sets of quarterly air filter composites for 2021. GEL Laboratories received a non-agreement for ^{90}Sr in one of two milk samples in 2021. ISU-EAL had an 'acceptable' agreement for all blind PE samples analyzed in 2021.

The GEL project manager was contacted after each non-agreement PE recovery analysis was received. GEL researched the first set of quarterly air filter composite results and did not find anything that would contribute to the low recovery results. GEL was contacted again by the ESER program regarding the second non-agreement PE recovery analysis.

GEL created an NCR to conduct a more rigorous assessment of the issue. A PE set of two quarterly composite samples with known values were sent to GEL to assist with their evaluation of preparing and analyzing the quarterly composites sent to them for alpha spectroscopy (e.g., ^{241}Am, ^{238}Pu, ^{239}Pu) and ^{90}Sr analysis. GEL Laboratories is compiling the analysis results for their internal assessment and will report the results when available. Quarterly air filter composite samples will not be shipped to GEL for analyses until this issue is resolved. The non-agreement for one of the ^{90}Sr in milk, was just outside the reference value. The second milk sample was within the known reference value; no trend was identified for 2021.

10.4.3.2 INL Contractor Blind PEs

A total of 106 analytes were analyzed by ALS and GEL Laboratories for air, milk, and water in 2021. ALS received a 'not acceptable' evaluation for ^{241}Am, ^{238}Pu, and $^{239/240}$Pu for quarterly air filter composites and GEL received a 'not acceptable' evaluation for ^{241}Am and ^{226}Ra in water.

A total of four PE quarterly composite samples were submitted to ALS during 2021. At least one non-agreement was received for ^{241}Am, ^{238}Pu, $^{239/240}$Pu, and ^{90}Sr. The INL contractor contacted ALS regarding the non-agreement results and is awaiting a response from ALS.

Seventy PE water results were analyzed by GEL in 2021, seven received a non-agreement including three gamma spectroscopy results for ^{241}Am and four gamma spectroscopy results for radium-226 (^{226}Ra). Americium-241 and ^{226}Ra emit gamma and alpha radiation. Gamma spectroscopy results for ^{241}Am and ^{226}Ra are used as a screening tool for these project-specific systems in which these analytes are not expected. Additional analysis of field samples for ^{241}Am and ^{226}Ra, using analyte-specific methods, can be performed if the program determines the gamma spectroscopy screening results exceed certain thresholds. The thresholds were not exceeded in the field samples. Review of the ^{226}Ra PE results indicate the PE sample provider prepared all four PE non-agreement samples at levels less than the contractual detection limits of the laboratory. Two of the four ^{226}Ra non-agreement results were correctly noted by the laboratory and that the results were below the contractual minimum detection limit. The PE provider's non-agreement conclusion (not being within 30% of the known values) is considered correct because the PE samples were prepared at levels below the required detection limits. The other two ^{226}Ra PE results were reported as suspected false-positives by the laboratory, meaning the laboratory detected 'something' but the results were less than 3-times the uncertainty and below the minimum required detection level. The 2021 PE provider's non-agreement results were submitted to GEL Laboratory for evaluation. No findings or gamma spectroscopy QC deficiencies requiring CA were reported by GEL. The INL contractor will continue to evaluate future PE sample results for trends and concerns that may require CAs by the laboratory.

10.4.3.3 ICP Core Blind PEs

A total of 99 analytes were analyzed in 2021 for both GEL Laboratories and ALS-Fort Collins. GEL Laboratories received a non-agreement for tritium, ^{90}Sr, and technetium-99 for water samples in 2021. At ICP Core, when a laboratory has a non-agreement assigned, the Sample and Analysis Management office informs the project managers and participating laboratories of the results and requests the laboratory to investigate. For the discrepancies in agreement for 2021, GEL investigated the results and reported back that there were no specific findings that required CAs. GEL reported there was an error in the initial aliquot of the ^{90}Sr sample. A new aliquot was prepared and re-analyzed and the results met the acceptance criteria. Based on the review of all of the quality data presented, there is no indication that there is an issue with the accuracy or defensibility of the field data results.

10.5 Conclusions

The quality elements presented in Figure 10-1 were implemented in 2021. Field sampling elements, as provided in Figure 10-2, laboratory measurements, as outlined in Figure 10-3, and PE samples were reviewed and evaluated for each INL Site contractor laboratory and are summarized in Section 10.4. INL Site contractors scrutinized all recognized performance matters to understand potential impacts on the quality and value of results provided and reconciled issues of concern. It has been determined that all laboratory data presented in this report are reliable and of applicable quality.

10.6 References

10 CFR 830, 2022, Subpart A, “Quality Assurance Requirements,” *Code of Federal Regulations*, Office of the Federal Register. Available electronically at https://www.ecfr.gov/cgi-bin/text-idx?SID=074233709c29153b42bc0e7e25e68307&mc=true&node=sp40.10.61.a&rgn=div6.

40 CFR 61, 2022, Appendix B, “Test Methods, Method 114, Test Methods for Measuring Radionuclide Emissions from Stationary Sources,” *Code of Federal Regulations*, Office of the Federal Register. Available electronically at https://www.ecfr.gov/cgi-bin/text-idx?SID=11c3269295aab799456dcba14addb85a&mc=true&node=pt40.10.61&rgn=div5#ap40.10.61_1359.c.

40 CFR 61, 2022, Subpart H, “National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities,” *Code of Federal Regulations*, Office of the Federal Register. Available electronically at https://www.ecfr.gov/cgi-bin/text-idx?SID=11c3269295aab799456dcba14addb85a&mc=true&node=pt40.10.61&rgn=div5#ap40.10.61_1359.c.

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Rattray, G. W., 2014, *Evaluation of quality-control data collected by the U.S. Geological Survey for routine water-quality activities at the Idaho National Laboratory and vicinity, southeastern Idaho, 2002-08: U.S. Geological Survey Scientific Investigations Report 2014-5027* (DOE/ID--22228), 66 p. Available electronically at https://doi.org/10.3133/sir20145027.

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:

- 10 CFR 830, 2022, Subpart A, "Quality Assurance Requirements," Code of Federal Regulations, Office of the Federal Register. Available electronically at https://www.ecfr.gov/current/title-10/chapter-III/part-830/subpart-A
- 10 CFR 1021, 2022, "National Environmental Policy Act Implementing Procedures," *Code of Federal Regulations*, Office of the Federal Register. Available electronically at https://www.energy.gov/sites/prod/files/10CFRPart1021.pdf.
- 10 CFR 1022, 2022, "Compliance with Floodplain and Wetland Environmental Review Requirements," *Code of Federal Regulations*, Office of the Federal Register. Available electronically at https://www.energy.gov/sites/prod/files/10CFRPart1022.pdf.
- 36 CFR 79, 2022, "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. Available electronically at https://ecfr.io/Title-36/pt36.1.79.
- 36 CFR 800, 2022, "Protection of Historic Properties," U.S. Department of the Interior, National Park Service, *Code of Federal Regulations*, Office of the Federal Register. Available electronically at https://ecfr.io/Title-36/cfr800_main.
- 40 CFR 50, 2022, "National Primary and Secondary Ambient Air Quality Standards," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register. Available electronically at https://ecfr.io/Title-40/pt40.2.50.
- 40 CFR 61, 2022, "National Emission Standards for Hazardous Air Pollutants," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register. Available electronically at https://ecfr.io/Title-40/pt40.10.61.
- 40 CFR 61, Subpart H, 2022, "National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities," *Code of Federal Regulations*, Office of the Federal Register. Available electronically at https://ecfr.io/Title-40/pt40.10.61#sp40.10.61.h.
- 40 CFR 84, 2022, "Phasedown of Hydrofluorocarbons," Code of Federal Regulations, Office of the Federal Register. Available electronically at https://www.ecfr.gov/current/title-40/chapter-I/subchapter-C/part-84.
- 40 CFR 112, 2022, "Oil Pollution Prevention," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register. Available electronically at https://ecfr.io/Title-40/cfr112_main.
- 40 CFR 122, 2022, "EPA Administered Permit Programs: the National Pollutant Discharge Elimination System," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register. Available electronically at https://ecfr.io/Title-40/pt40.24.122.
- 40 CFR 141, 2022, "National Primary Drinking Water Regulations," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register. Available electronically at https://ecfr.io/Title-40/pt40.25.141.
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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 the protection of the public, for the airborne pathway only.

Derived Concentration Standards are established to support DOE O 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 the 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 (2022) and the Idaho groundwater quality values from IDAPA 58.01.11 (2022). Table A-7 lists the environmental permits for the INL Site.

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}	1.4×10^{-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]	1.0×10^{-10}	3.3×10^{-7}
Tritium (tritiated water)	2.1×10^{-7}	1.9×10^{-3}	Iodine-131[f]	4.1×10^{-10}	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]	2.0×10^{-9}	6.0×10^{-6}
Argon-41[d]	1.4×10^{-8}	__	Iodine-135[f]	9.7×10^{-9}	3.0×10^{-5}
Chromium-51	9.4×10^{-8}	7.9×10^{-4}	Xenon-131m[d,e]	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,e]	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,e]	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	1.2×10^{-7}	3.2×10^{-4}	Barium-139	5.8×10^{-8}	2.4×10^{-4}
Rubidium-89	1.5×10^{-7}	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}	4.0×10^{-5}
Strontium-90	2.5×10^{-11}	1.1×10^{-6}	Cerium-144	7.1×10^{-11}	5.5×10^{-6}
Yttrium-91m[e]	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[e]	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 O 458.1. They are based on a committed effective dose equivalent of 100 mrem/yr (1 mSv) for ingestion or inhalation of a radionuclide for one year. Inhalation values shown represent the most restrictive lung retention class.
b. Based on the most restrictive human-made alpha emitter ($^{239/240}Pu$).
c. Based on the most restrictive human-made beta emitter (^{90}Sr).
d. The DCS for air immersion is used because there is no inhaled air DCS established for the radionuclide.
e. An "m" after the number refers to a metastable form of the radionuclide.
f. Particulate aerosol form in air.

Table A-3. Environmental Protection Agency maximum contaminant levels for public drinking water systems and state of Idaho groundwater quality standards for radionuclides and inorganic contaminants.

CONSTITUENT	MAXIMUM CONTAMINANT LEVEL	GROUNDWATER QUALITY STANDARD
Gross alpha (pCi/L)	15	15
Gross beta (mrem/yr)	4	4
Beta/gamma emitters	Concentrations resulting in 4 mrem total body or organ dose equivalent	4 mrem/yr effective dose equivalent
Radium-226 plus -228 (pCi/L)	5	5
Strontium-90 (pCi/L)	8	8
Tritium (pCi/L)	20,000	20,000
Uranium (µg/L)	30	—
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[a]	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)	10	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 public water system must follow.

Table A-4. Environmental Protection Agency maximum contaminant levels for public drinking water systems and state of Idaho groundwater quality standards for organic contaminants.

CONSTITUENT	MAXIMUM CONTAMINANT LEVEL (mg/L)	GROUNDWATER QUALITY STANDARD (mg/L)
Benzene	0.005	0.005
Carbon tetrachloride	0.005	0.005
m-Dichlorobenzene	__	0.6
o-Dichlorobenzene	0.6	0.6
p-Dichlorobenzene	0.075	0.075
1,2-Dichloroethane	0.005	0.005
1,1-Dichloroethylene	0.007	0.007
cis-1,2-Dichloroethylene	0.07	0.07
trans-1,2-Dichloroethylene	0.1	0.1
Dichloromethane	0.005	0.005
1,2-Dichloropropane	0.005	0.005
Ethylbenzene	0.7	0.7
Monochlorobenzene	0.1	0.1
Styrene	0.1	0.1
Tetrachloroethylene	0.005	0.005
Toluene	1.0	1.0
1,2,4-Trichlorobenzene	0.07	0.07
1,1,1-Trichloroethane	0.2	0.2
1,1,2-Trichloroethane	0.005	0.005
Trichloroethylene	0.005	0.005
Vinyl chloride	0.002	0.002
Xylenes (total)	10.0	10.0
Bromate	0.01	__
Bromodichloromethane[a]	__	0.1
Bromoform[a]	__	0.1
Chlorodibromomethane[a]	__	0.1
Chloroform[a]	__	0.002
Chlorite	1.0	__
Haloacetic acids (HAA5)	0.06	__
Total Trihalomethanes (TTHMs)	0.08	0.1

a. These four compounds do not have individual MCLs. They are combined to give an MCL of 0.08 mg/L for total trihalomethanes.

Table A-5. Environmental Protection Agency maximum contaminant levels for public drinking water systems and state of Idaho groundwater quality standards for synthetic organic contaminants.

CONSTITUENT	MAXIMUM CONTAMINANT LEVEL (mg/L)	GROUNDWATER QUALITY STANDARD (mg/L)
Alachlor	0.002	0.002
Atrazine	0.003	0.003
Carbofuran	0.04	0.04
Chlordane	0.002	0.002
Dibromochloropropane	0.0002	0.0002
2,4-Dichlorophenoxyacetic acid	0.07	0.07
Ethylene dibromide	0.00005	0.00005
Heptachlor	0.0004	0.0004
Heptachlor epoxide	0.0002	0.0002
Lindane	0.0002	0.0002
Methoxychlor	0.04	0.04
Polychlorinated biphenyls	0.0005	0.0005
Pentachlorophenol	0.001	0.001
Toxaphene	0.003	0.003
2,4,5-TP (silvex)	0.05	0.05
Benzo(a)pyrene	0.0002	0.0002
Dalapon	0.2	0.2
Di(2-ethylhexyl) adipate	0.4	0.4
Di(2-ethylhexyl) phthalate	0.006	0.006
Dinoseb	0.007	0.007
Diquat	0.02	0.02
Endothall	0.1	0.1
Endrin	0.002	0.002
Glyphosate	0.7	0.7
Hexachlorobenzene	0.001	0.001
Hexachlorocyclopentadiene	0.05	0.05
Oxamyl (vydate)	0.2	0.2
Picloram	0.5	0.5
Simazine	0.004	0.004
2,3,7,8-TCDD (dioxin)	3×10^{-8}	3×10^{-8}

Table A-6. Environmental Protection Agency national secondary drinking water regulations and state of Idaho groundwater quality standards for secondary contaminants.

CONSTITUENT	SECONDARY STANDARD[a]	GROUNDWATER QUALITY STANDARD
Aluminum (mg/L)	0.05 to 0.2	0.2
Chloride (mg/L)	250	250
Color (color units)	15	15
Copper (mg/L)	1.0	—
Corrosivity	Noncorrosive	—
Foaming agents (mg/L)	0.5	0.5
Iron (mg/L)	0.3	0.3
Manganese (mg/L)	0.05	0.05
Odor (threshold odor number)	3	3
pH	6.5 to 8.5	6.5 to 8.5
Silver (mg/L)	0.1	0.1
Sulfate (mg/L)	250	250
Total dissolved solids (mg/L)	500	500
Zinc (mg/L)	5	5

a. The Environmental Protection Agency 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. The Environmental Protection 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.

Table A-7. Environmental permits for the INL Site (2021).

PERMIT TYPE	ACTIVE PERMITS
AIR EMISSIONS	
Synthetic Minor	1
GROUNDWATER	
Injection Well	2
Well construction	3[a]
SURFACE WATER	
Reuse Permits	3
Industrial Wastewater Acceptance	1
RESOURCE CONSERVATION AND RECOVERY ACT	
Part A	2[b]
Part B	7[b]
ECOLOGICAL	
Migratory Bird Treaty Act Special Purpose Permit	2
Wildlife Collection/Banding/Possession Permit	3

a. Construction of wells USGS-150, USGS-151, and USGS-152 have been cored and are currently on hold. Additional construction is planned for USGS-151 and USGS-152 during FY 2023. Borehole USGS-150 is planned for abandonment in fiscal year 2023. Permits are only required for construction of wells, not operation.

b. Part A and B are considered a single RCRA Permit that comprises several volumes.

Appendix B: Chapter 5 Addendum

Table B-1. Advanced Test Reactor Complex cold waste pond effluent permit-required monitoring results (2021).[a,b]

PARAMETER	MINIMUM	MAXIMUM	MEDIAN
pH (standard units)	6.70	7.74	7.21
Conductivity (µS/cm)	381	1475	393
Chromium, filtered (mg/L)	0.00313	0.01410	0.00369
Chromium, total (mg/L)	0.00319	0.01450	0.00354
Iron, filtered (mg/L)	0.033U[c]	0.0783	0.033U
Iron, total (mg/L)	0.033U	0.0817	0.033U
Nitrate + nitrite as nitrogen (mg/L)	0.920	4.35	0.970
Solids, total dissolved (mg/L)	203	1180	227
Sulfate (mg/L)	20.1	634	23.0

a. Reuse Permit I-161-03 does not specify maximum effluent constituent loading or concentration limits.

b. Duplicate samples collected in July 2021 are included in the statistical summary.

c. U qualifier indicates the result was below the detection limit.

Table B-2. Hydraulic loading rates for the Advanced Test Reactor Complex cold waste pond (2021).

	YEARLY TOTAL FLOW
2021 flow[a]	235.32 MG[b]
Annual permit limit[c]	375 MG
5-yr moving annual average permit limit	300 MG

a. Annual flow is reported for the 2021 permit reporting year.

b. MG = million gallons.

c. The reuse permit specifies an annual limit based on a twelve-month reuse year from November 1st – October 31st.

Table B-3a. Advanced Test Reactor Complex cold waste pond industrial wastewater reuse permit monitoring well results (2021).[a]

WELL NAME	USGS-098 (GW-0161-01)		USGS-065 (GW-161-02)		USGS-076 (GW-161-04)		TRA-08 (GW-161-05)		MIDDLE-1823 (GW-161-06)		USGS-136 (GW-161-08)		STANDARD[b] PCS/SCS
SAMPLE DATE:	04/27/2021	10/04/2021	05/03/2021	10/06/2021	04/29/2021	10/04/2021	05/03/2021	10/06/2021	04/29/2021	10/05/2021	05/04/2021	10/05/2021	
Water table depth (ft) bls[c]	427.81	429.40	475.62	477.09	483.67	485.16	489.40	490.92	493.79	494.83	488.94	490.47	NA[d]
Water table elevation (ft)[e]	4,461.40	4,459.81	4,452.95	4,451.48	4,449.54	4,448.05	4,449.66	4,448.14	4,449.08	4,448.04	4,449.79	4,448.26	NA
Borehole correction factor (ft)[f]	2.53	2.53	NA	NA	NA	NA	0.63	0.63	NA	NA	0.22	0.22	NA
Nitrite + nitrate as nitrogen (mg/L)	1.13	1.15	1.53	1.53	1.09 (1.09)[g]	1.10	1.06	1.09	1.05	1.08	1.18	1.26	10 (PCS)
pH (s.u.)	7.29	6.98	8.20	7.32	7.70	7.37	7.82	7.34	7.84	7.44	7.28	7.30	6.5 to 8.5 (SCS)
Conductivity (µS/cm)	384	394	581	599	417	427	409	422	414	422	431	430	NA
Temperature (°F)	55.6	53.6	57.7	55.8	58.1	54.5	56.8	55.9	59.7	56.3	55.0	55.2	NA
Sulfate (mg/L)	23.0J[h]	22.9J	140J	140	33.8J (33.8J)	32.8J	43.2	43.2	32.3J	32.3J	31.9J	32.4J	250 (SCS)
Total dissolved solids (mg/L)	249	219	407	403	251 (223)	253	244	320	236	241	239	254	500 (SCS)
Chromium, total (mg/L)	0.00636	0.00666	0.0813	0.0821	0.0106 (0.0102)	0.0107	0.0184	0.0213	0.00941	0.0106	0.0150	0.0167	0.1 (PCS)
Chromium, filtered (mg/L)	0.00636	0.00653	0.0789	0.0808	0.0107 (0.0106)	0.0103	0.0183	0.0192	0.00974	0.0104	0.0143	0.0156	0.1 (PCS)
Iron, filtered (mg/L)	0.03U[i]	0.03U	0.03U	0.03U	0.03U (0.0347)	0.03U	0.03U	0.03U	0.03U	0.03U	0.03U	0.03U	0.3 (SCS)

a. Reuse Permit I-161-03 was issued October 30, 2019.

b. 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.

c. bls = below land surface.

d. NA = not applicable.

e. Water table elevation above mean sea level (ft). Elevation data provided using the North American Vertical Datum of 1988 (NAVD 88).

f. The borehole correction factors were determined from gyroscopic surveys conducted by U. S. Geological Survey to reconcile discrepancies in water level measurements from well deviations.

g. Results shown in parenthesis are from the field duplicate samples.

h. J flag indicates the associated value is an estimate and may be inaccurate or imprecise.

i. U qualification indicates the analyte was not detected above the instrument detection limit or the analyte was detected at or above the applicable detection limit but the value is not more than 5 times the highest positive amount in any laboratory blank and is U qualified as a result of data validation.

Table B-3b. Advanced Test Reactor Complex cold waste pond industrial wastewater reuse permit monitoring well results (2021).

WELL NAME	USGS-058[a] (GW-161-07)		STANDARD (PCS/SCS)[b]
SAMPLE DATE:	05/04/2021	10/06/2021	
Water table depth (ft) bgs[c]	471.52	473.01	NA[d]
Water table elevation (ft)[e]	4,450.37	4,448.88	NA
Borehole correction factor (ft)[f]	NA	NA	NA
pH (s.u.)	7.35	7.34	6.5 to 8.5 (SCS)
Conductivity (µS/cm)	418	430	NA
Temperature (°F)	59.5	57.6	NA
Total dissolved solids (mg/L)	226	377	500 (SCS)
Sulfate (mg/L)	34.2J[g]	32.3J	250 (SCS)

a. Reuse permit I-161-03 only requires water table elevation, water table depth, pH, conductivity, temperature, total dissolved solids and sulfate reported for USGS-058.

b. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in the Ground Water Quality Rule, Idaho Administrative Procedure Act 58.01.11.200.01.a and b.

c. bgs = below ground surface.

d. NA = not applicable.

e. Water table elevation above mean sea level (ft). Elevation data provided using the North American Vertical Datum of 1988 (NAVD 88).

f. The borehole correction factors were determined from gyroscopic surveys conducted by U. S. Geological Survey to reconcile discrepancies in water level measurements from well deviations.

g. J flag indicates the associated value is an estimate and may be inaccurate or imprecise.

Table B-4. Idaho Nuclear Technology and Engineering Center sewage treatment plant influent monitoring results at CPP-769 (2021).

PARAMETER	MINIMUM	MAXIMUM	MEAN
Biochemical oxygen demand (5-day) (mg/L)	74.5	265	145
Nitrate + nitrite, as nitrogen (mg/L)	0.02440 U[a]	1.89	0.160
Total kjeldahl nitrogen (mg/L)	29.4	140	80.3
Total phosphorus (mg/L)	0.54	11.4	6.40
Total suspended solids (mg/L)	56.0	254	108.5

a. U flag indicates the analyte was analyzed for but not detected above the method detection limit.

Table B-5. Idaho Nuclear Technology and Engineering Center sewage treatment plant effluent monitoring results at CPP-773 (2021).

PARAMETER	MINIMUM	MAXIMUM	MEAN
Biochemical oxygen demand (5-day) (mg/L)	4.06 U[a]	19.3	11.9
Nitrate + nitrite, as nitrogen (mg/L)	0.02080U	6.36	2.52
pH (standard units)[b]	6.93	9.01	8.20
Total coliform (MPN[c]/100 mL)[b]	33.6	2,827	1,542.1
Total kjeldahl nitrogen (mg/L)	6.36	27	13.5
Total phosphorus (mg/L)	2.43	5.0	3.87
Total suspended solids (mg/L)	1.7	39	19

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.
c. MPN = most probable number.

Table B-6. Idaho Nuclear Technology and Engineering Center new percolation ponds effluent monitoring results at CPP-797 (2021).

PARAMETER	MINIMUM	MAXIMUM	MEAN
Chloride (mg/L)	15.6	143.0	59.2
Chromium (mg/L)	0.00555	0.00788	0.00625
Coliform, fecal (MPN/100 mL)[a]	1	5	1
Coliform, total (MPN/100 mL)[a]	65.0	2419.2	1173.4
Fluoride (mg/L)	0.185	0.269	0.223
Manganese, total (mg/L)	0.002U[b]	0.00200U	0.002U
Nitrate + nitrite, as nitrogen (mg/L)	0.815	1.69	1.14
pH (standard units)[a]	7.65	9.22	8.40
Selenium (mg/L)	0.00150U	0.002U	0.002U
Total dissolved solids (mg/L)	191	417	280
Total phosphorus (mg/L)	0.343	1.220	0.651

a. As required by the permit, the results for this parameter were obtained from a grab sample.
b. U flag indicates the analyte was analyzed for but not detected above the method detection limit.

Table B-7. Hydraulic loading rates for the Idaho Nuclear Technology and Engineering Center new percolation ponds (2021).

	MAXIMUM DAILY FLOW	YEARLY TOTAL FLOW
2021 flow	1,314,000 gallons	203 MG[a]
Permit limit	3,000,000 gallons	1,095 MG

a. MG = million gallons.

Table B-8. Idaho Nuclear Technology and Engineering Center new percolation ponds aquifer monitoring well groundwater results (2021).

PARAMETER	ICPP-MON-A-165 (GW-13006)		ICPP-MON-A-166 (GW-13007)		ICPP-MON-A-164B (GW-13011)		STANDARD PCS/SCS[a]
SAMPLE DATE:	05/18/2021	09/21/2021	05/18/2021	09/21/2021	05/17/2021	09/20/2021	
Water table depth (ft below brass cap)	503.80	505.47	510.98	512.66	502.89	504.53	NA[b]
Water table elevation (at brass cap in ft)[c]	4,449.11	4,447.44	4,448.56	4,446.88	4,449.28	4.447.64	NA
Chloride (mg/L)	37.5J[d]	35.7J	16.4J	16.6J	9.09J	9.90J	250
Chromium (mg/L)	0.0076	0.0193	0.00511	0.00484	0.0102	0.0124	0.1
Coliform, fecal (MPN[e]/100 mL)	<1	<1	<1	<1	<1	<1	<1 CFU[f]/100 mL
Coliform, total (MPN/100 mL)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1 CFU/100 mL[g]
Dissolved oxygen (mg/L)	7.94	8.05	5.37	4.57	4.51	5.31	NA
Electrical conductivity (µmhos/cm)	477	466	332	329	377	412	NA
Fluoride (mg/L)	0.215	0.174	0.298	0.234	0.212	0.151	4
Manganese, dissolved (mg/L)[h]	NR[i]	NR	NR	NR	NR	NR	0.05
Manganese, total (mg/L)	ND (<0.001)[j]	0.00165J	0.00942	0.0818	ND (<0.001)	ND (<0.001)	0.05
Nitrate / nitrite, as nitrogen (mg/L)	1.25	1.03	0.379	0.333	0.860	0.938	10
pH (standard units)	7.97	7.77	7.97	7.69	8.18	7.88	6.5–8.5
Selenium (mg/L)	ND (<0.0015)	ND (<0.0015)	ND (<0.0015)	ND (<0.0015)	ND (<0.0015)	ND (<0.0015)	0.05
Temperature (°F)	54.81	53.87	54.25	53.58	55.60	54.63	NA
Total dissolved solids (mg/L)	279	287	207	203	209	231	500
Total phosphorus (mg/L)	0.0253J	ND (<0.020)	0.0663	ND (<0.020)	0.0782	ND (<0.020)	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. J flag indicates the parameter was positively identified, but the reported value is an estimate. This is because the matrix spike recovery was outside U.S. Environmental Protection Agency Method Recovery Criteria.
e. MPN = most probable number.
f. CFU = colony forming unit.
g. 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.
h. The result of the dissolved concentrations of this parameter are used for SCS compliance determinations.
i. NR = parameter was not a monitoring requirement since the analytical result for total manganese did not exceed the standard in IDAPA 58.01.11.200.01.b manganese standard of 0.05 mg/L.
j. ND = Parameter not detected in sample. Value in parentheses is the detection limit.

Table B-9. Idaho Nuclear Technology and Engineering Center new percolation ponds perched water monitoring well groundwater results (2021).

PARAMETER	ICPP-MON-V-191 (GW-13008)		ICPP-MON-V-200 (GW-13009)		ICPP-MON-V-212 (GW-13010)		STANDARD PCS/SCS[a]
SAMPLE DATE:	05/17/2021	09/20/2021	05/17/2021	09/20/2021	05/17/2021	09/20/2021	
Depth to water (ft below brass cap)	Dry[b]	Dry	108.17	117.84	235.11	236.5	NA[c]
Water table elevation (at brass cap in ft)[d]	NA	NA	4,844.93	4,835.26	4,723.39	4,722.00	NA
Chloride (mg/L)	NA	NA	75.8J[e]	79.9 J	68.5J	72.3J	250
Chromium (mg/L)	NA	NA	0.00631	0.00843	0.0235	0.0344	0.1
Coliform, fecal (MPN[f]/100 mL)	NA	NA	<1	<1	<1	<1	<1 CFU[g]/100 mL
Coliform, total (MPN/100 mL)	NA	NA	<1.0	<1.0	<1.0	<1.0	1 CFU/100 mL[h]
Dissolved oxygen (mg/L)	NA	NA	7.02	4.88	4.27	5.95	NA
Electrical conductivity (µmhos/cm)	NA	NA	619	623	543	542	NA
Fluoride (mg/L)	NA	NA	0.264	0.193	0.212	0.173	4
Manganese, dissolved (mg/L)[i]	NA	NA	NR[j]	NR	NR	NR	0.05
Manganese, total (mg/L)	NA	NA	ND (<0.001)[k]	0.00226J[l]	0.0166	0.0152	0.05
Nitrate/nitrite, as nitrogen (mg/L)	NA	NA	0.900	1.21	1.48	1.35	10
pH (standard units)	NA	NA	7.97	8.00	10.16	9.82	6.5–8.5
Selenium (mg/L)	NA	NA	ND (<0.0015)	ND (<0.0015)	ND (<0.0015)	ND (<0.0015)	0.05
Temperature (°F)	NA	NA	59.58	58.82	62.24	62.08	NA
Total dissolved solids (mg/L)	NA	NA	324	357	301	296	500
Total phosphorus (mg/L)	NA	NA	0.423	0.291	0.0607	0.0720	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. ICPP-MON-V-191 was dry in May and September 2021.
c. NA = not applicable.
d. Water table elevations referenced to North American Vertical Datum of 1988 (NAVD 88).
e. J flag indicates the parameter was positively identified, but the reported value is an estimate. This is because the matrix spike recovery was outside United States Environmental Protection Agency Method Recovery Criteria.
f. MPN = most probable number.
g. CFU = colony forming units.
h. 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.
i. The results of dissolved concentrations of this parameter are used for SCS compliance determinations.
j. NR = not required since the analytical result for total manganese did not exceed the standard in Idaho Administration Procedures Act 58.01.11.200.01.d for manganese of 0.05 mg/L.
k. ND = Parameter not detected in sample. Value in parentheses is the detection limit.
l. J flag indicates that the parameter was positively identified, but the reported value is an estimate. This is because the value is less than the laboratory reporting limit.

Table B-10. Materials and Fuels Complex industrial waste pond effluent monitoring results for the reuse permit (2021).[a,b,c]

PARAMETER	MINIMUM	MAXIMUM	MEDIAN
pH (standard units)	7.15	8.59	7.30
Conductivity[d] ((µS/cm)	384	1157	479
Chloride[d] (mg/L)	12.0J[e]	224J	34.7
Nitrate + nitrite as nitrogen (mg/L)	2.73	4.06	3.07
Iron (mg/L)	0.03U[f]	0.0867	0.0394
Iron, filtered(mg/L)	0.03U	0.03U	0.03U
Manganese (mg/L)	0.002U	0.00426J	0.00208
Manganese, filtered (mg/L)	0.002U	0.00393J	0.002U
Sodium[d] (mg/L)	18.6	150	32.6
Sodium[d], filtered (mg/L)	18.5	153	32.8
Total dissolved solids (mg/L)	213	610	289

a. Liquid effluent results for permit-required constituents collected at the sampling station located on the Industrial Wastewater Collection System (IWCS) primary line prior to discharge into the pond. The results represent effluent contributions from both the IWCS Primary Line (PL) and Southwestern Branch Line (SBL), which are combined upstream of the sampling station.

b. Duplicate samples were collected in July 2021. The duplicate results are included in the data summary.

c. Reuse permit I-160-02 does not specify maximum constituent loading or concentration limits.

d. Conductivity, chloride and sodium are not required effluent monitoring parameters in the reuse permit.

e. J flag indicates the associated value is an estimate and may be inaccurate or imprecise.

f. U qualifier indicates the result was below the detection limit.

Table B-11. Materials and Fuels Complex effluent hydraulic loading to the industrial waste pond (2021).

	YEARLY TOTAL FLOW
2021 flow[a]	7.366 MG[b]
Annual permit limit[c]	17 MG

a. Annual flow is reported for the 2021 permit reporting year.

b. MG = million gallons.

c. The reuse permit specifies an annual limit based on a twelve-month reuse year from November 1st – October 31st.

Table B-12. Materials and Fuels Complex industrial waste pond summary of groundwater quality data collected for the reuse permit (2021).

WELL NAME	ANL-MON-A-012 (GW-16001)		ANL-MON-A-013 (GW-16002)		ANL-MON-A-014 (GW-16003)		PCS/SCS[a]
SAMPLE DATE:	04/20/2021	10/07/2021	04/21/2021	09/29/2021	04/21/2021	09/29/2021	
Water table depth (ft bls)[b]	658.46	661.28[c]	646.89	649.78	646.02	648.95	NA[d]
Water table elevation (ft above mean sea level)[e]	4,474.24	4,471.42	4,473.48	4,470.59	4,472.06	4,469.13	NA
Temperature (°F)	50.9	55.6	55.2	55.6	57.6	53.6	NA
pH (s.u)	7.23	6.99	7.12	6.97	7.36	6.99	6.5 to 8.5 (SCS)
Conductivity (µmhos/cm)	411	399	431	472	422 (421)[f]	437	NA
Nitrite + nitrate as N (mg/L)	2.62	2.58	2.65	2.52	2.66 (2.68)	2.93	10 (PCS)
Nitrate nitrogen (mg/L)[g]	2.32J[h]	2.34	2.39	2.28	2.43 (2.43)	2.49	10 (PCS)
Total dissolved solids (mg/L)	233	246	240	226	266 (221J)[i]	220	500 (SCS)
Iron, total (mg/L)	0.03U[j]	0.03U	0.03U	0.0484	0.03U (0.03U)	0.03U	0.3 (SCS)
Iron, filtered (mg/L)	0.03U	0.03U	0.03U	0.03U	0.03U (0.03U)	0.03U	0.3 (SCS)
Manganese, total (mg/L)	0.001U	0.001U	0.00124	0.001U	0.001U (0.001U)	0.001U	0.05 (SCS)
Manganese, filtered (mg/L)	0.001U	0.001U	0.001U	0.001U	0.001U (0.001U)	0.001U	0.05 (SCS)

a. Primary Constituent Standard (PCS) or Secondary Constituent Standard (SCS) specified in the Ground Water Quality Rule, IDAPA 58.01.11.200.01.a and b.

b. bls = below land surface.

c. ANL-MON-A-012 was initially gauged for water level and sampled on 9/28/21, but due to an enroute shipping delay the well was re-sampled on 10/7/21. The water table depth and water table elevation for 9/28/21 were measured at 661.35 ft bls and 4,471.35 ft respectively.

d. NA = not applicable.

e. Elevations are given in the National Geodetic Vertical Datum of 1929.

f. Duplicate sample results are shown in parentheses.

g. Nitrate nitrogen is not required by the reuse permit. It was analyzed for surveillance and historical trending purposes.

Table B-12. continued.

WELL NAME	ANL-MON-A-012 (GW-16001)		ANL-MON-A-013 (GW-16002)		ANL-MON-A-014 (GW-16003)		PCS/SCS[a]
SAMPLE DATE:	04/20/2021	10/07/2021	04/21/2021	09/29/2021	04/21/2021	09/29/2021	

h. J qualification indicates the associated value is an estimate and may be inaccurate or imprecise.

i. Reanalysis of the original TDS result is reported. The reanalysis was requested to address quality control issues during data review. The reanalysis occurred beyond the allowable hold-time and the result was qualified J during the data validation process.

j. U qualification indicates the analyte was not detected above the instrument detection limit or the analyte was detected at or above the applicable detection limit, but the value is not more than 5 times the highest positive amount in any laboratory blank.

Table B-13. Advanced Test Reactor Complex cold waste ponds effluent surveillance monitoring results (2021).[a]

PARAMETER	MINIMUM	MAXIMUM	DCS[b] (pCi/L)
Gross beta (pCi/L ± 1s)[c,d]	ND[d,e]	11.5 (± 0.948)	NA[f]
Potassium-40[g] (pCi/L ± 1s)	ND	30.6 (± 7.62)	16,000
pH (standard units)[h]	6.70	7.74	NA

a. Monthly samples were analyzed for gross alpha, gross beta, tritium, and gamma-emitting radionuclides including 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. DOE Derived Concentration Standards for ingested water.

c. Result ±1s. Results are shown only for statistically positive detections >3s.

d. Gross beta was positively detected in March, April, and June 2021. Results were non-detect for the other nine months of 2021.

e. ND = not detected.

f. NA = not applicable. DCS values are not established.

g. Potassium-40 was detected in February 2021. All other monthly results in 2021 were non-detect.

h. Median pH was 7.21. For perspective, the Idaho Ground Water Quality Rule Secondary Constituent Standard (SCS) for pH is 6.5 – 8.5.

Table B-14. Radioactivity detected in surveillance groundwater samples collected at the Advanced Test Reactor Complex (2021).[a]

MONITORING WELL	SAMPLE DATE	GAMMA EMITTERS[a] (PCI/L)	GROSS ALPHA (PCI/L)	GROSS BETA (PCI/L)	STRONTIUM-90 (PCI/L)	TRITIUM (PCI/L)
PCS/SCS[b]		NA	15	4 mrem/yr[c]	8	20,000
USGS-098	04/27/2021	ND[d]	ND	2.05 (±0.248)[e]	ND	ND
	10/04/2021	ND	ND	2.55 (±0.364)	ND	ND
USGS-058	05/04/2021	ND	ND	1.37 (±0.181)	ND	ND
	10/06/2021	ND	ND	1.65 (±0.251)	ND	ND
USGS-065	05/03/2021	ND	ND	2.20 (±0.251)	ND	1,130 (±169)
	10/06/2021	ND	2.04 (±0.447)	2.75 (±0.325)	ND	1,190 (±190)
TRA-08	05/03/2021	ND	1.28 (±0.420)	2.77 (±0.343)	ND	396 (±115)
	10/06/2021	ND	ND	1.30 (±0.159)	0.477 (±0.158)	566 (±138)
USGS-076	04/29/2021	ND	ND	1.29 (±0.205)	ND	424 (±101)
		(ND)[f]	(ND)	(1.82 [±0.240])	(ND)	(361 [±96.5])
	10/4/2021	ND	ND	1.58 (±0.444)	ND	ND
MIDDLE-1823	04/29/2021	ND	ND	1.86 (±0.246)	ND	545 (±109)
	10/05/2021	ND	ND	2.86 (±0.380)	ND	ND
USGS-136	05/04/2021	ND	0.981 (±0.234)	2.43 (±0.281)	ND	871 (±152)
	10/05/2021	ND	1.70 (±0.366)	2.11 (±0.297)	ND	888 (±150)

a. Gamma-emitting radionuclides including 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. Primary Constituent Standards (PCS) in the Ground Water Quality Rule, IDAPA 58.01.11.200.01.a, are provided for perspective.

c. Gross Beta PCS = 4 mrem/yr effective dose, IDAPA 58.01.11.200.01.a. For perspective, the EPA public drinking water system regulations also specify a Maximum Contaminant Limit (MCL) of 4 mrem/yr for Gross Beta and use a screening level of 50 pCi/L to determine when speciation of individual beta/photon emitters is necessary.

d. ND = not detected.

e. Results shown are for statistically positive detections >3s, along with the reported 1s uncertainty.

f. Results from field duplicate samples shown in brackets.

Table B-15. Liquid effluent radiological monitoring results for the Idaho Nuclear Technology and Engineering Center (2021).

SAMPLE DATE	GAMMA EMITTERS[a] (PCI/L)	GROSS ALPHA[b] (PCI/L)	GROSS BETA[b] (PCI/L)	TOTAL STRONTIUM (PCI/L)
EFFLUENT TO IDAHO NUCLEAR TECHNOLOGY AND ENGINEERING CENTER NEW PERCOLATION PONDS (CPP-797)				
January 2021	ND[c]	ND	6.42 (±1.08)	ND
February 2021	ND	ND	2.37 (±0.746)	ND
March 2021	84.6 (±39.0)J[d,e]	ND	5.38 (±1.06)	ND
April 2021	ND	ND	3.56 (±0.828)	ND
May 2021	ND	ND	ND	ND
June 2021	ND	ND	3.41 (±0.622)	ND
July 2021	ND	ND	4.47 (±0.921)	ND
August 2021	ND	ND	8.35 (±1.01)	ND
September 2021	ND	ND	4.55 (±0.712)	ND
October 2021	ND	ND	6.42 (±0.976)	ND
November 2021	ND	ND	5.08 (±9.98)	ND
December 2021	ND	ND	5.77 (±4.77)	ND

a. Gamma-emitting radionuclides include americium-241, antimony-125, cerium-144, cesium-134, cesium-137, cobalt-58, cobalt-60, europium-152, europium-154, europium-155, manganese-54, niobium-95, potassium-40, radium-226, ruthenium-103, ruthenium-106, silver-108m, silver-110m, uranium-235, zinc-65, and zirconium-95.

b. Detected results are shown along with the reported 1-sigma uncertainty.

c. ND = no radioactivity was detected. The result was not statistically positive at the 95% confidence interval and was below its minimum detectable activity.

d. J flag indicates the associated value is an estimate.

e. Potassium-40 was the only gamma-emitting radionuclide detected.

Table B-16. Groundwater radiological monitoring results for the Idaho Nuclear Technology and Engineering Center (2021).

MONITORING WELL	SAMPLE DATE	GROSS ALPHA[a] (pCi/L)	GROSS BETA[a] (pCi/L)
ICPP-MON-A-165	05/18/2021 09/21/2021	ND[b] 4.23 (±1.26)	3.99 (±0.677) 4.35 (±0.745)
ICPP-MON-A-166	05/18/2021 09/21/2021	ND 3.98 (±1.17)	ND 3.51(±0.788)
ICPP-MON-V-200	05/17/2021 09/20/2021	ND 9.23 (±1.87)	3.82 (±0.753) 6.68 (±0.994)
ICPP-MON-V-212	05/17/2021 09/20/2021	ND ND	16.6 (±1.06) 55.0 (±2.40)

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 B-17. Radiological Monitoring Results for Materials and Fuels Complex industrial waste pond (2021).[a]

PARAMETER[b] (pCi/L)	MINIMUM	MAXIMUM	DCS[c] (pCi/L)
Gross alpha	ND[d]	3.36 (±1.05)	NA[e]
Gross beta	ND	6.02 (± 0.780)	NA
Uranium-238[f]	0.581 (± 0.133)	0.581 (± 0.133)	750
Uranium-233/234[f]	1.83 (± 0.259)	1.83 (± 0.259)	660

a. Samples were analyzed for gross alpha; gross beta; plutonium-241; strontium-90; tritium; gamma-emitting radionuclides including 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, zirconium-95; alpha-emitting radionuclides including americium-241, uranium-233/234, uranium-235, uranium-238, plutonium-236, plutonium-238, plutonium-239/240, and plutonium-242.

b. Results shown are for statistically positive detections >3s, along with the reported 1s uncertainty. Only parameters with at least one positively detected result are shown.

c. DCS = DOE Derived Concentration Standard for ingested water (DOE-STD-1196-2011).

d. ND indicates the result was below the detection limit.

e. NA = not applicable.

f. Parameter was analyzed in August only; therefore, the minimum and maximum are the same.

Appendix C: Onsite Dosimeter Measurements and Locations

LOCATION	mrem[a]	
	NOV. 2020 – APRIL 2021	MAY 2021 – OCT. 2021
ARA[b] I&II O-1	71	68
PBF[c] SPERT O-1	66	66

a. Millirem (mrem) in ambient dose equivalent.
b. Auxiliary Reactor Area (ARA).
c. Power Burst Facility Special Power Excursion Reactor Test (PBF SPERT).

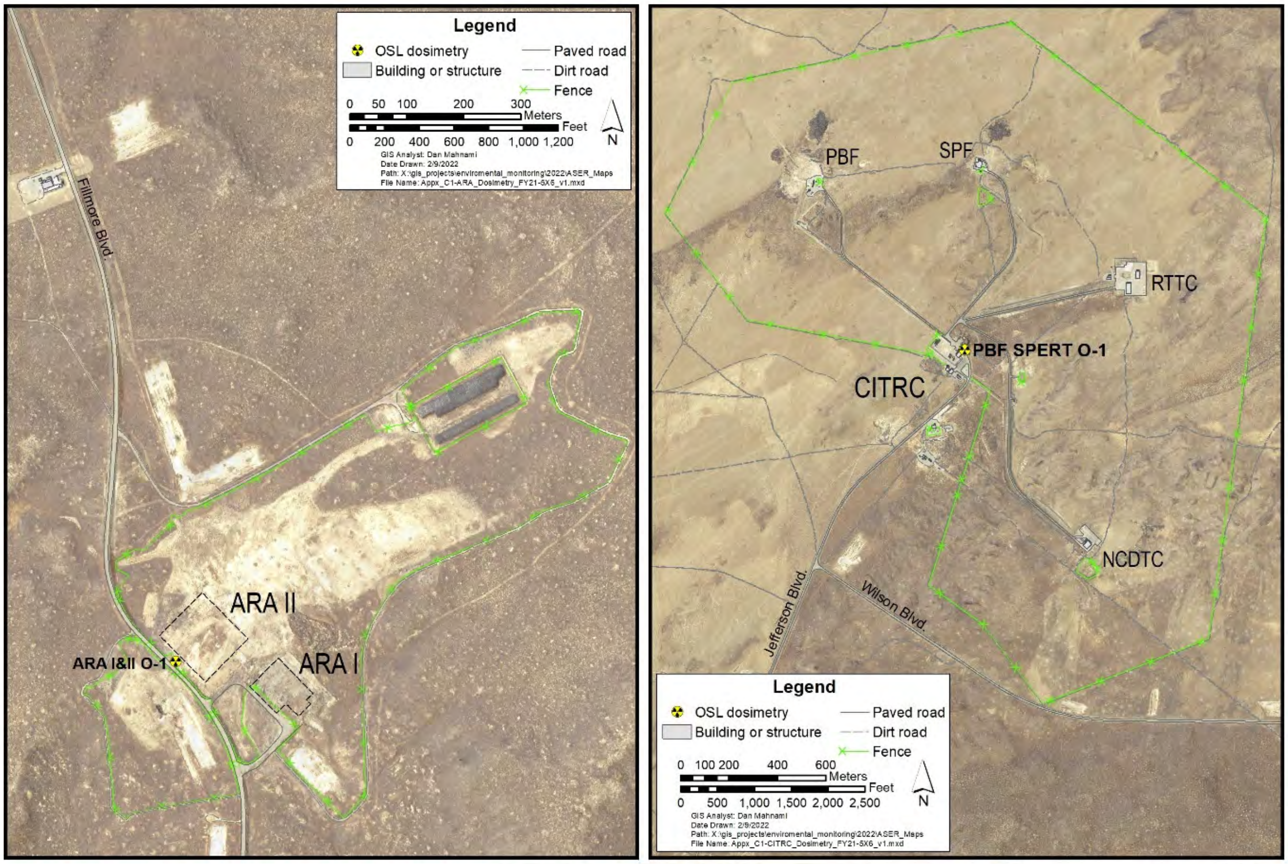


Figure C-1. Environmental radiation measurements at Auxiliary Reactor Area (ARA) and Critical Infrastructure Test Range Complex (CITRC) (2021).

LOCATION	mrem[a]		LOCATION	mrem[a]	
	NOV. 2020 – APRIL 2021	MAY 2021 – OCT. 2021		NOV. 2020 – APRIL 2021	MAY 2021 – OCT. 2021
RHLLW[b] O-1	72	73	TRA O-14	72	70
RHLLW O-2	70	65	TRA O-15	70	75
RHLLW O-3	65	59	TRA O-16	89	80
RHLLW O-4	79	71	TRA O-17	76	83
RHLLW O-5	72	68	TRA O-18	75	90
RHLLW O-6	71	72	TRA O-19	90	98
TRA[c] O-1	71	70	TRA O-20	69	72
TRA O-6	74	81	TRA O-21	82	85
TRA O-7	70	85	TRA O-22	67	68
TRA O-8	81	87	TRA O-23	74	71
TRA O-9	80	94	TRA O-24	74	73
TRA O-10	117	121	TRA O-25	68	68
TRA O-11	123	110	TRA O-26	73	73
TRA O-12	80	85	TRA O-27	72	77
TRA O-13	70	78	TRA O-28	78	71

a. Millirem (mrem) in ambient dose equivalent.
b. Remote-Handled Low-Level Waste (RHLLW).
c. Test Reactor Area (TRA).

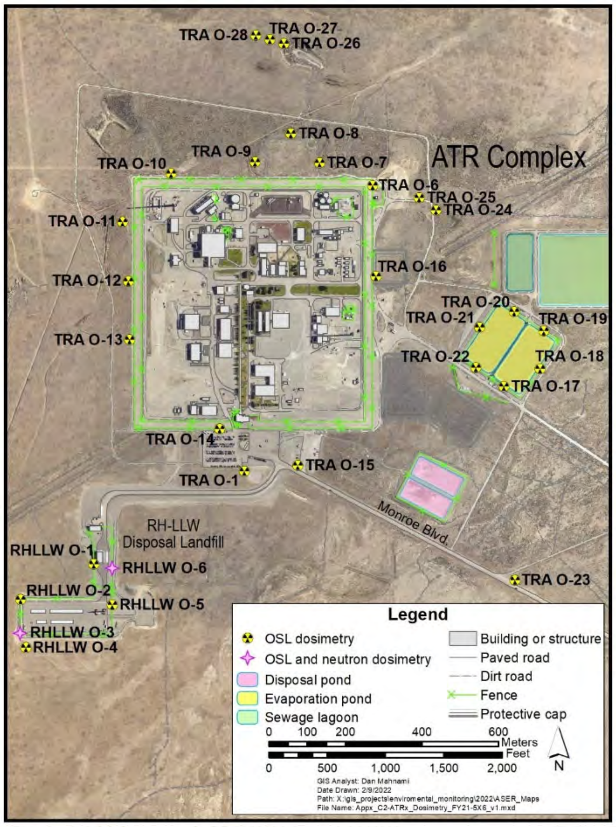


Figure C-2. Environmental radiation measurements at Advanced Test Reactor (ATR) Complex and Remote-handled Low-level Waste Disposal Facility (RHLLW) (2021).

LOCATION	mrem[a]	
	NOV. 2020 – APRIL 2021	MAY 2021 – OCT. 2021
CFA[b] O-1	75	76
LincolnBlvd[c] O-1	68	70

a. Millirem (mrem) in ambient dose equivalent.
b. Central Facilities Area (CFA).
c. Lincoln Boulevard (LincolnBlvd).

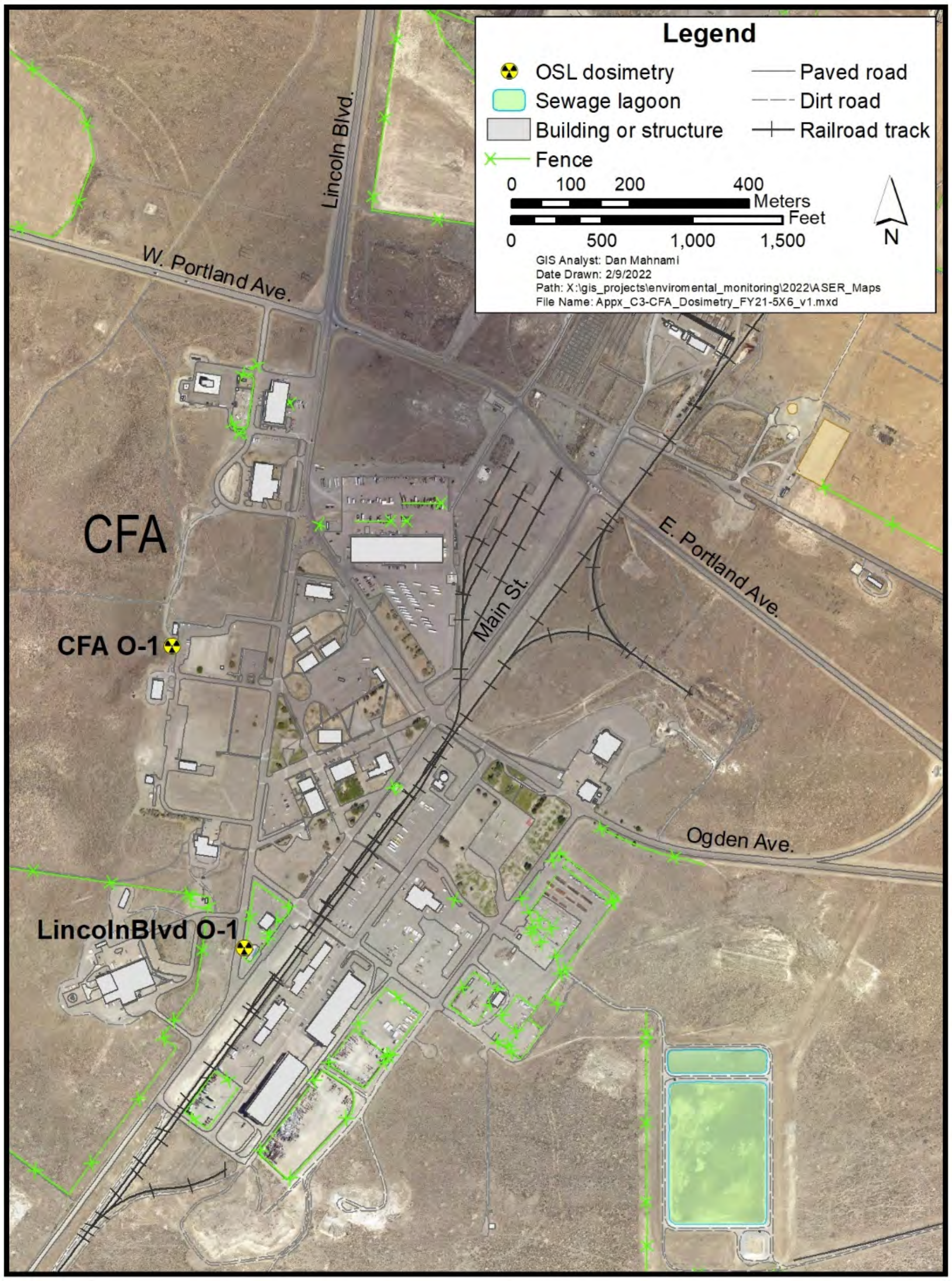


Figure C-3. Environmental radiation measurements at Central Facilities Area (CFA) and Lincoln Boulevard (2021).

LOCATION	mrem[a] NOV. 2020 – APRIL 2021	mrem[a] MAY 2021 – OCT. 2021	LOCATION	mrem[a] NOV. 2020 – APRIL 2021	mrem[a] MAY 2021 – OCT. 2021
ICPP[b] O-9	91	97	ICPP O-26	76	85
ICPP O-14	108	114	ICPP O-27	225	204
ICPP O-15	159	146	ICPP O-28	214	209
ICPP O-17	74	71	ICPP O-30	225	234
ICPP O-19	94	105	TreeFarm O-1	132	144
ICPP O-20	317	326	TreeFarm O-2	96	96
ICPP O-21	92	91	TreeFarm O-3	93	100
ICPP O-22	95	98	TreeFarm O-4	147	146
ICPP O-25	100	101			

a. Millirem (mrem) in ambient dose equivalent.
b. Idaho Chemical Processing Plant (ICPP).

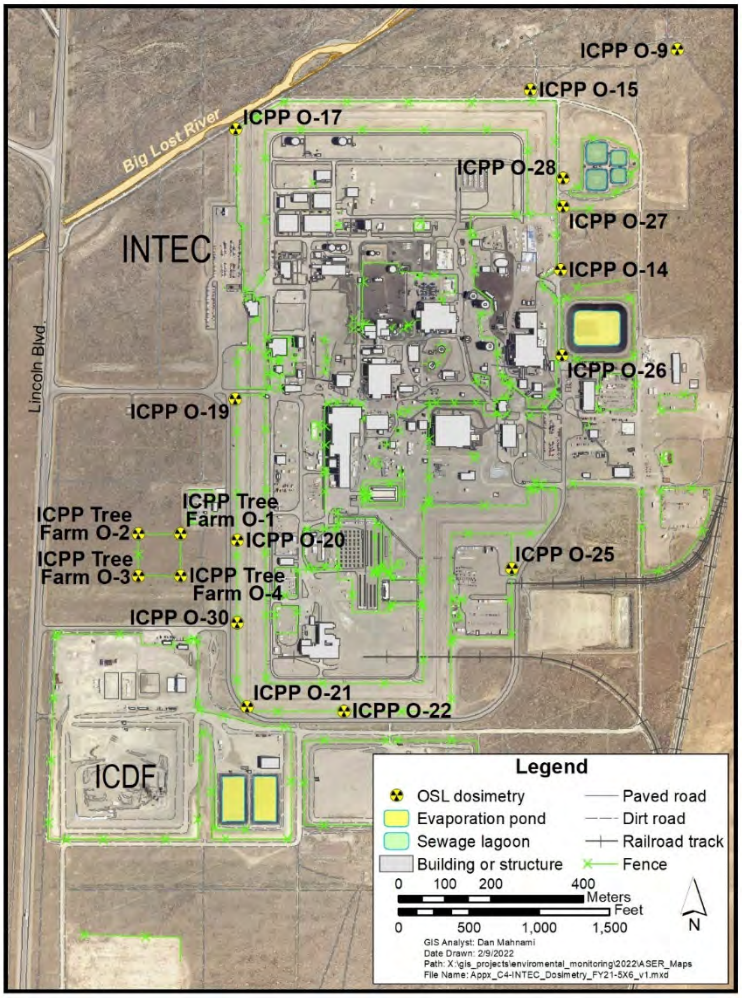


Figure C-4. Environmental radiation measurements at Idaho Nuclear Technology and Engineering Center (INTEC) (2021).

LOCATION	mrem[a] NOV. 2020 – APRIL 2021	mrem[a] MAY 2021– OCT. 2021	LOCATION	mrem[a] NOV. 2020 – APRIL 2021	mrem[a] MAY 2021 – OCT. 2021
IF[b]-603N O-1	56	57	IF-670N O-31	57	56
IF-603E O-2	50	50	IF-670E O-32	53	55
IF-603S O-3	54	54	IF-670S O-33	55	57
IF-603W O-4	54	61	IF-670D O-34	58	56
IF-627 O-30	55	56	IF-670W O-35	63	64
IF-638N O-1	54	54	IF-689 O-7	53	59
IF-638E O-2	54	48	IF-689 O-8	55	58
IF-638S O-3	61	62	IF-IRC[c] O-39	57	58
IF-638W O-4	62	58			

a. Millirem (mrem) in ambient dose equivalent.
b. Idaho Falls (IF).
c. INL Research Center (IRC).

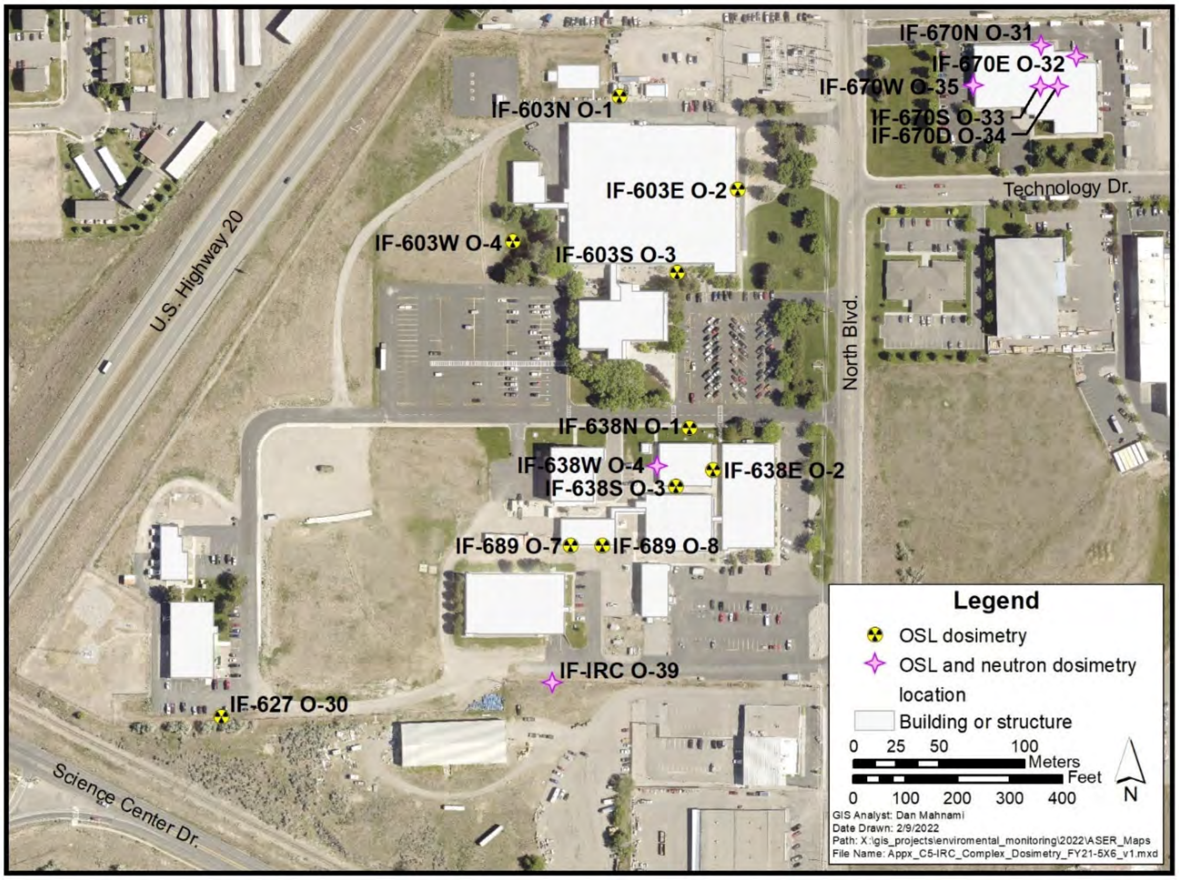


Figure C-5. Environmental radiation measurements at Idaho National Laboratory Research Center Complex (IRC) (2021).

LOCATION	mrem[a] NOV. 2020 – APRIL 2021	mrem[a] MAY 2021 – OCT. 2021	LOCATION	mrem[a] NOV. 2020 – APRIL 2021	mrem[a] MAY 2021 – OCT. 2021
ANL[b] O-7	63	72	ANL O-24	60	61
ANL O-8	109	60	ANL O-25	72	80
ANL O-12	57	56	ANL O-26	69	65
ANL O-14	67	73	TREAT[c] O-1	58	61
ANL O-15	77	80	TREAT O-2	59	67
ANL O-16	67	69	TREAT O-3	68	72
ANL O-18	67	63	TREAT O-4	63	65
ANL O-19	60	64	TREAT O-5	59	67
ANL O-20	76	79	TREAT O-6	67	73
ANL O-21	101	104	TREAT O-7	68	71
ANL O-22	75	78	TREAT O-8	63	73
ANL O-23	69	69			

a. Millirem (mrem) in ambient dose equivalent.
b. Argonne National Laboratory (ANL).
c. Transient Reactor Test (TREAT) Facility.

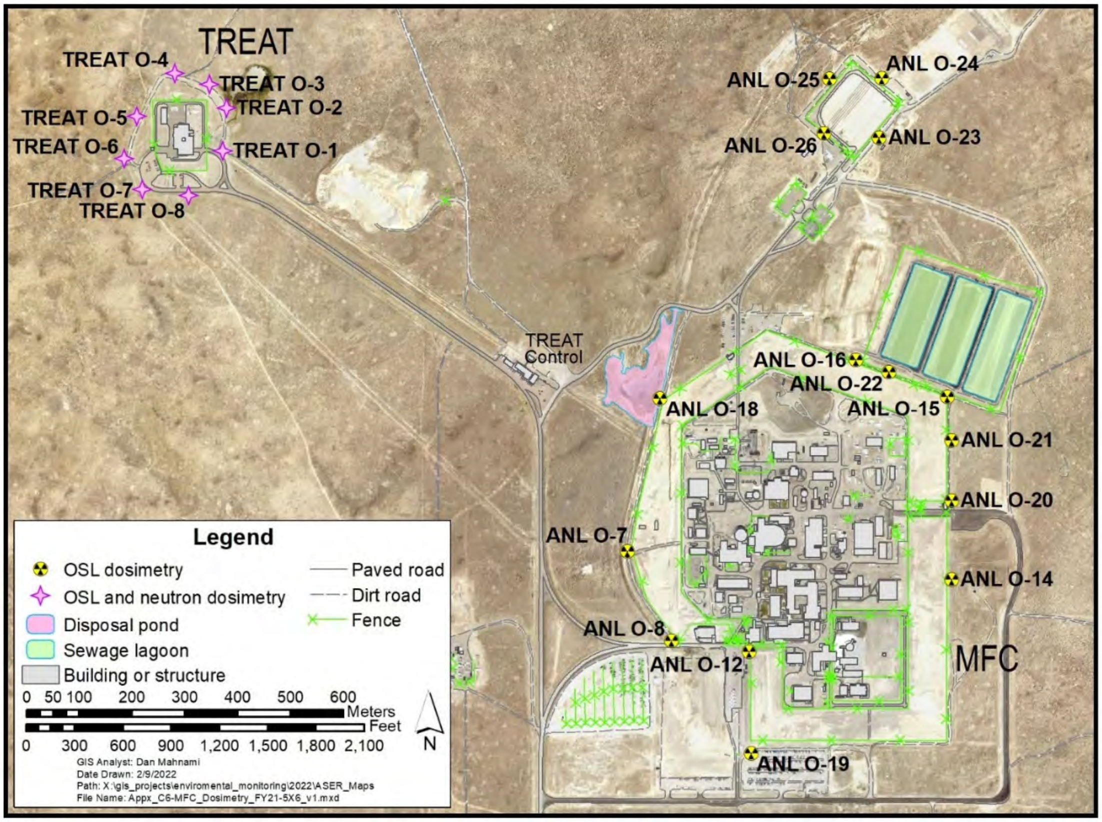


Figure C-6. Environmental radiation measurements at Materials and Fuels Complex (MFC) and Transient Reactor Test (TREAT) Facility (2021).

LOCATION	mrem[a]		LOCATION	mrem[a]	
	NOV. 2020 – APRIL 2021	MAY 2021 – OCT. 2021		NOV. 2020 – APRIL 2021	MAY 2021 – OCT. 2021
NRF[b] O-11	73	68	NRF O-21	71	76
NRF O-16	68	71	NRF O-22	60	70
NRF O-18	70	79	NRF O-23	61	62
NRF O-19	67	68	NRF O-24	59	68
NRF O-20	71	68			

a. Millirem (mrem) in ambient dose equivalent.
b. Naval Reactors Facility (NRF).

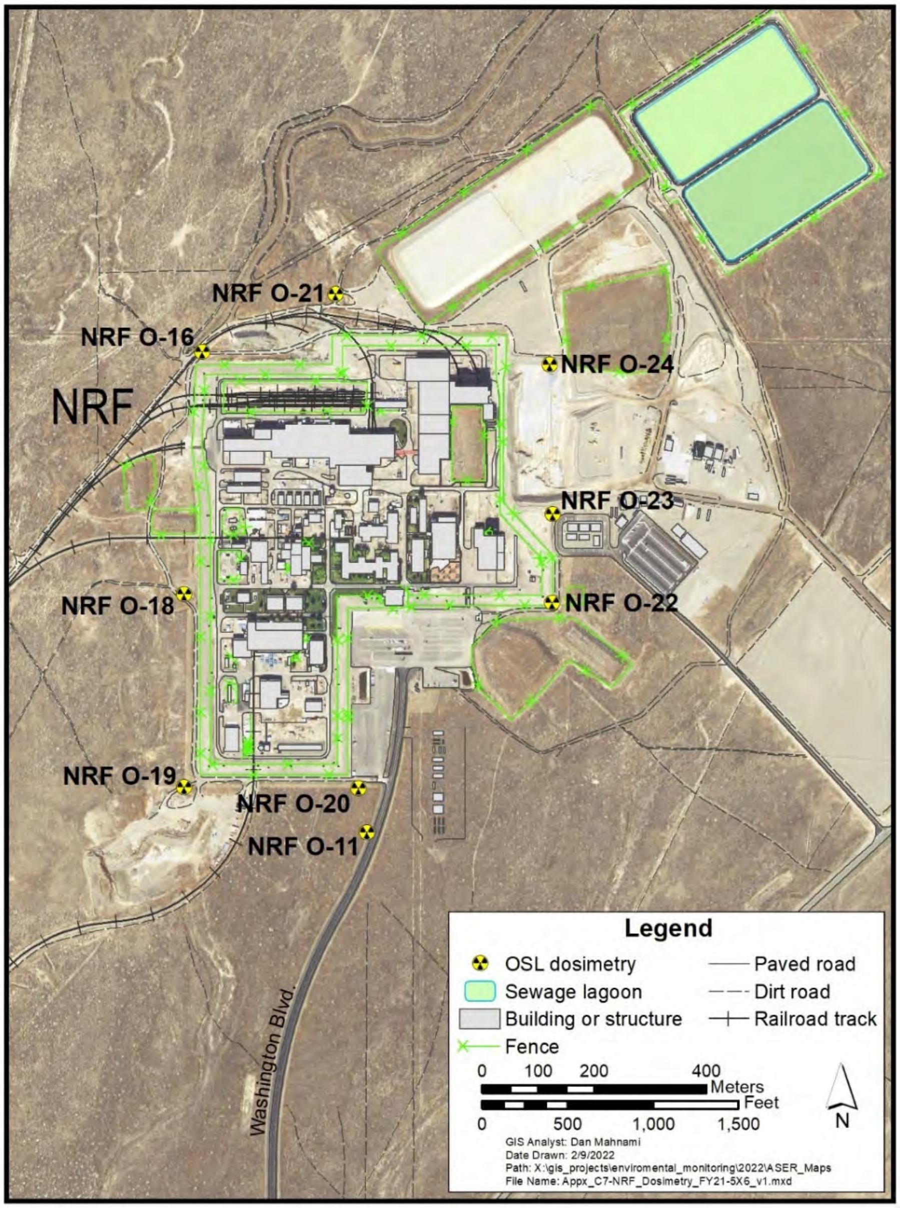


Figure C-7. Environmental radiation measurements at Naval Reactors Facility (NRF) (2021).

LOCATION	mrem[a]	
	NOV. 2020 – APRIL 2021	MAY 2021 – OCT. 2021
IF[b]-675E O-31	52	52
IF-675D O-33	50	54
IF-675S O-34	59	62
IF-675W O-35	56	55

a. Millirem (mrem) in ambient dose equivalent.
b. Idaho Falls (IF).

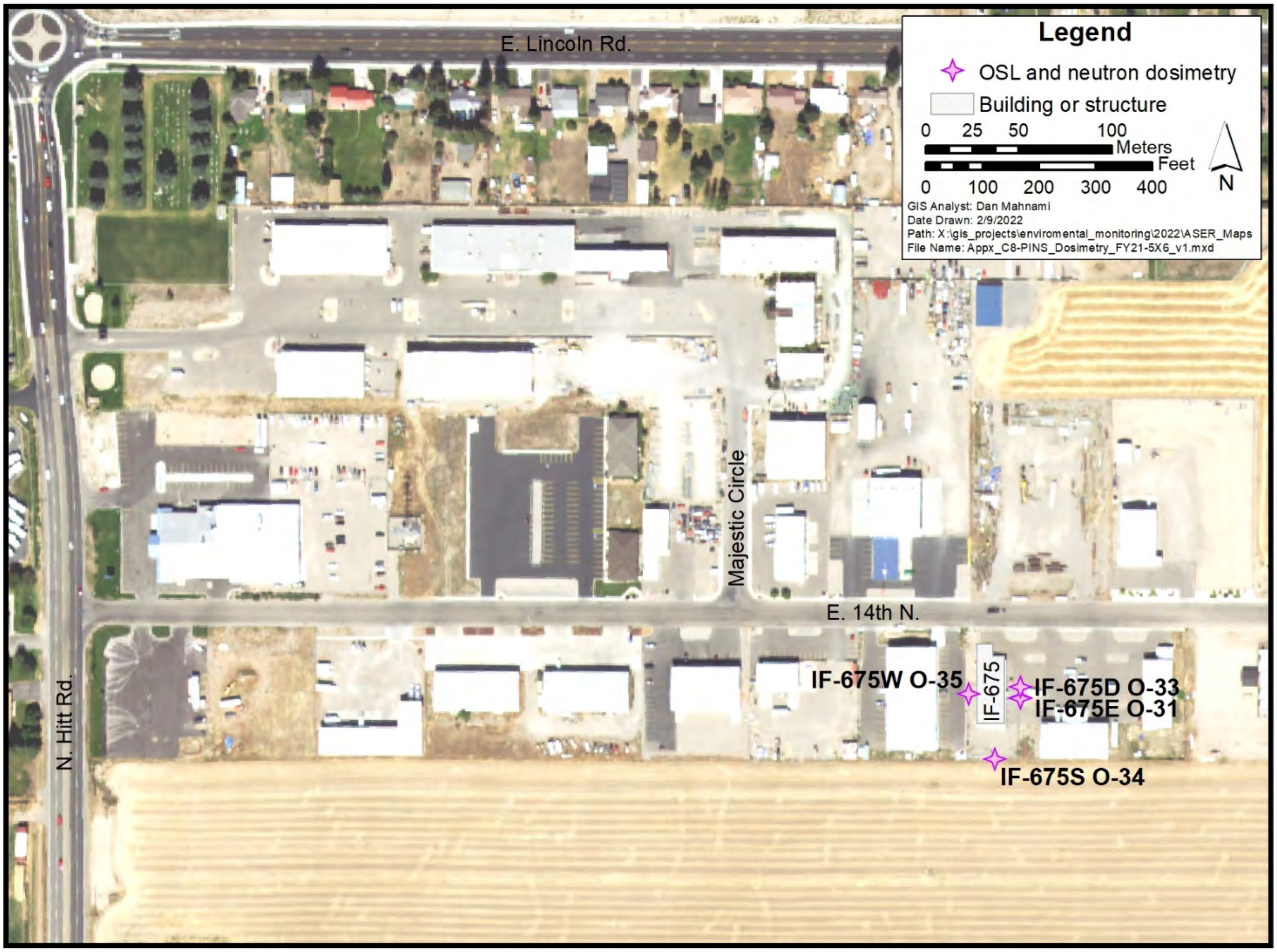


Figure C-8. Environmental radiation measurements at IF-675 Portable Isotopic Neutron Spectroscopy (PINS) Laboratory (2021).

LOCATION	mrem[a] NOV. 2020 – APRIL 2021	mrem[a] MAY 2021 – OCT. 2021	LOCATION	mrem[a] NOV. 2020 – APRIL 2021	mrem[a] MAY 2021 – OCT. 2021
RWMC[b] O-3A	68	70	RWMC O-25A	72	69
RWMC O-5A	64	65	RWMC O-27A	63	67
RWMC O-7A	66	62	RWMC O-29A	70	72
RWMC O-9A	69	82	RWMC O-39	69	73
RWMC O-11A	76	90	RWMC O-41	135	143
RWMC O-13A	76	223	RWMC O-43	64	68
RWMC O-19A	61	66	RWMC O-46	68	64
RWMC O-21A	76	74	RWMC O-47	68	65
RWMC O-23A	73	70			

a. Millirem (mrem) in ambient dose equivalent.
b. Radioactive Waste Management Complex (RWMC).

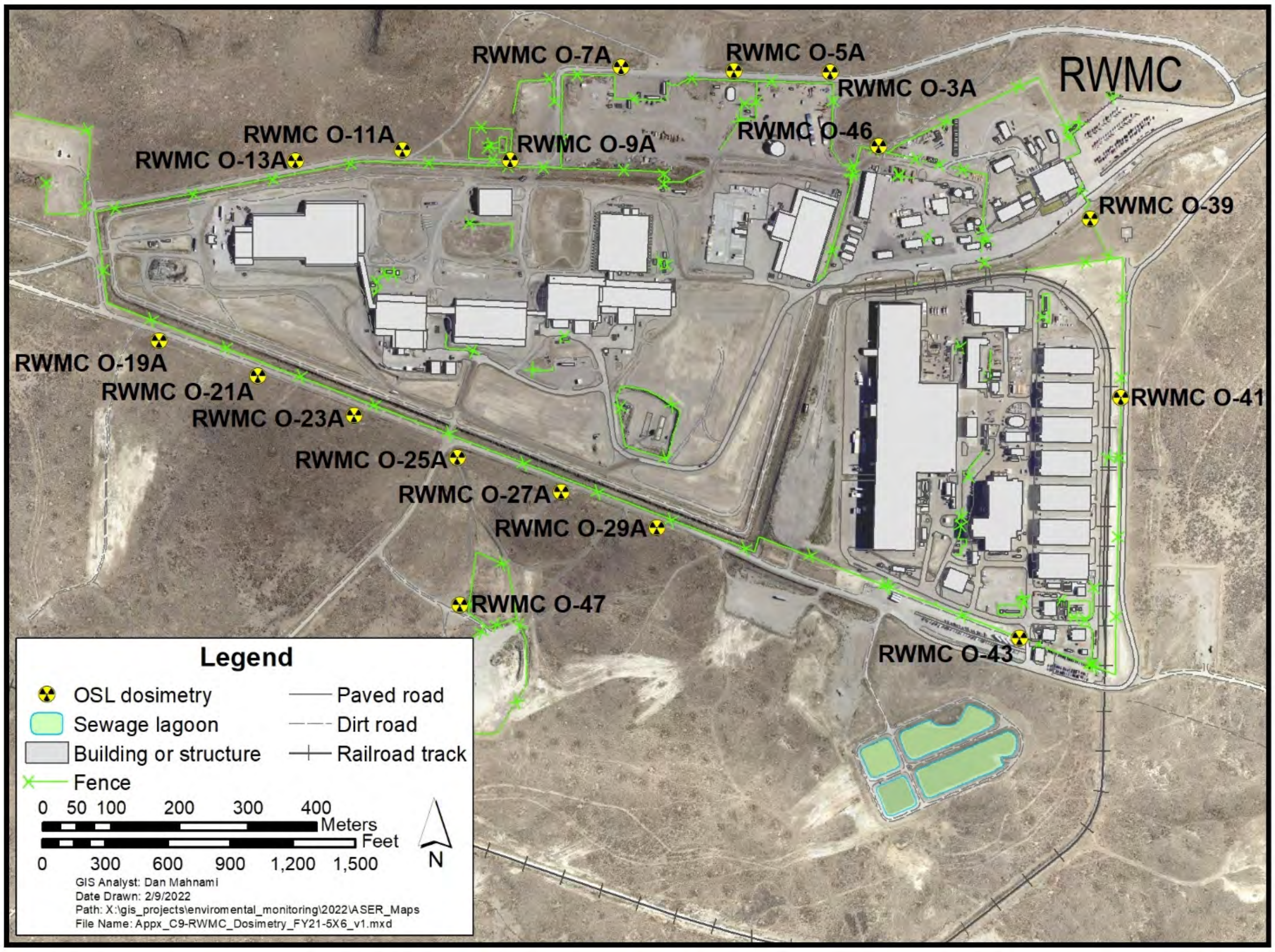


Figure C-9. Environmental radiation measurements at Radioactive Waste Management Complex (RWMC) (2021).

LOCATION	mrem[a]		LOCATION	mrem[a]	
	NOV. 2020 – APRIL 2021	MAY 2021 – OCT. 2021		NOV. 2020 – APRIL 2021	MAY 2021 – OCT. 2021
TAN LOFT[b] O-6	67	69	TAN LOFT O-10	68	58
TAN LOFT O-7	71	77	TAN LOFT O-11	69	75
TAN LOFT O-8	67	63	TAN LOFT O-12	63	63
TAN LOFT O-9	53	61	TAN LOFT O-13	68	70

a. Millirem (mrem) in ambient dose equivalent.
b. Test Area North, Loss-of-Fluid Test (TAN LOFT).

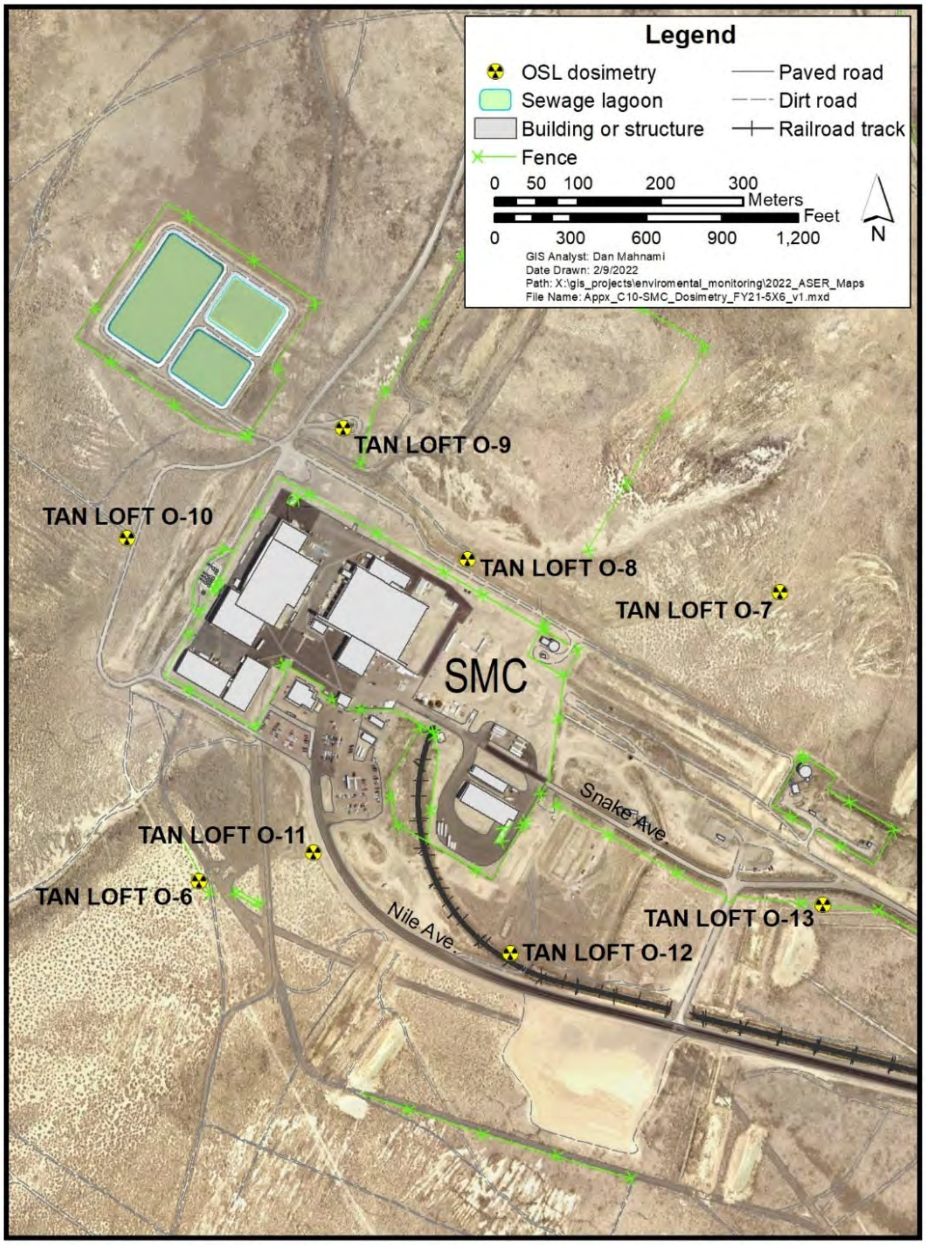


Figure C-10. Environmental radiation measurements at Specific Manufacturing Capability (SMC) (2021).

LOCATION	mrem[a]		LOCATION	mrem[a]	
	NOV. 2020 – APRIL 2021	MAY 2021 – OCT. 2021		NOV. 2020 – APRIL 2021	MAY 2021 – OCT. 2021
EFS[b] O-1	65	67	Hwy33 T17 O-3	60	58
Gate4 O-1	65	59	LincolnBlvd[d] O-3	78	74
Haul E O-1	68	65	LincolnBlvd O-5	71	73
Haul W O-2	69	65	LincolnBlvd O-9	68	70
Hwy[c]20 Mile O-266	59	65	LincolnBlvd O-15	74	76
Hwy20 Mile O-270	63	65	LincolnBlvd O-25	67	66
Hwy20 Mile O-276	59	66	Main Gate O-1	70	70
Hwy22 T28 O-1	54	60	Rest O-1	60	63
Hwy28 N2300 O-2	52	52	VanB[e] O-1	68	70

a. Millirem (mrem) in ambient dose equivalent.
b. Experimental Field Station (EFS).
c. Highway (Hwy).
d. Lincoln Boulevard (LincolnBlvd).
e. Van Buren (VanB).

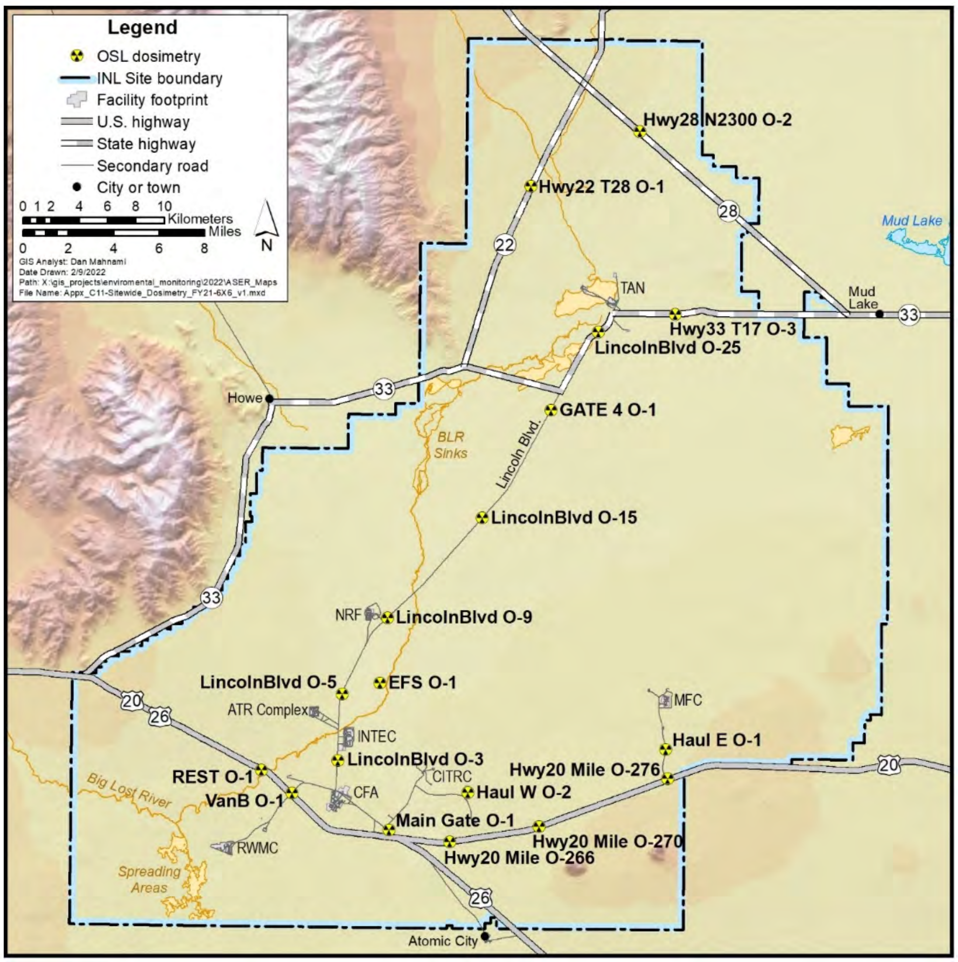


Figure C-11. Environmental radiation measurements at sitewide locations (2021).

LOCATION	mrem[a]		LOCATION	mrem[a]	
	NOV. 2020 – APRIL 2021	MAY 2021 – OCT. 2021		NOV. 2020 – APRIL 2021	MAY 2021 – OCT. 2021
Arco O-1	65	63	Mud Lake O-5	61	69
Atomic City O-2	58	72	Reno Ranch O-6	52	57
Blackfoot O-9	57	57	RobNOAA[c]	63	65
Craters O-7	62	70	RRL[d]3 O-1	63	67
Howe O-3	54	58	RRL5 O-1	75	84
Idaho Falls O-10	59	62	RRL6 O-1	62	65
IF[b]-IDA O-38	53	53	RRL17 O-1	57	57
Monteview O-4	58	60	RRL24 O-1	56	55

a. Millirem (mrem) in ambient dose equivalent.
b. Idaho Falls (IF).
c. Roberts National Oceanic and Atmospheric Administration (RobNOAA).
d. Resident Receptor Location (RRL).

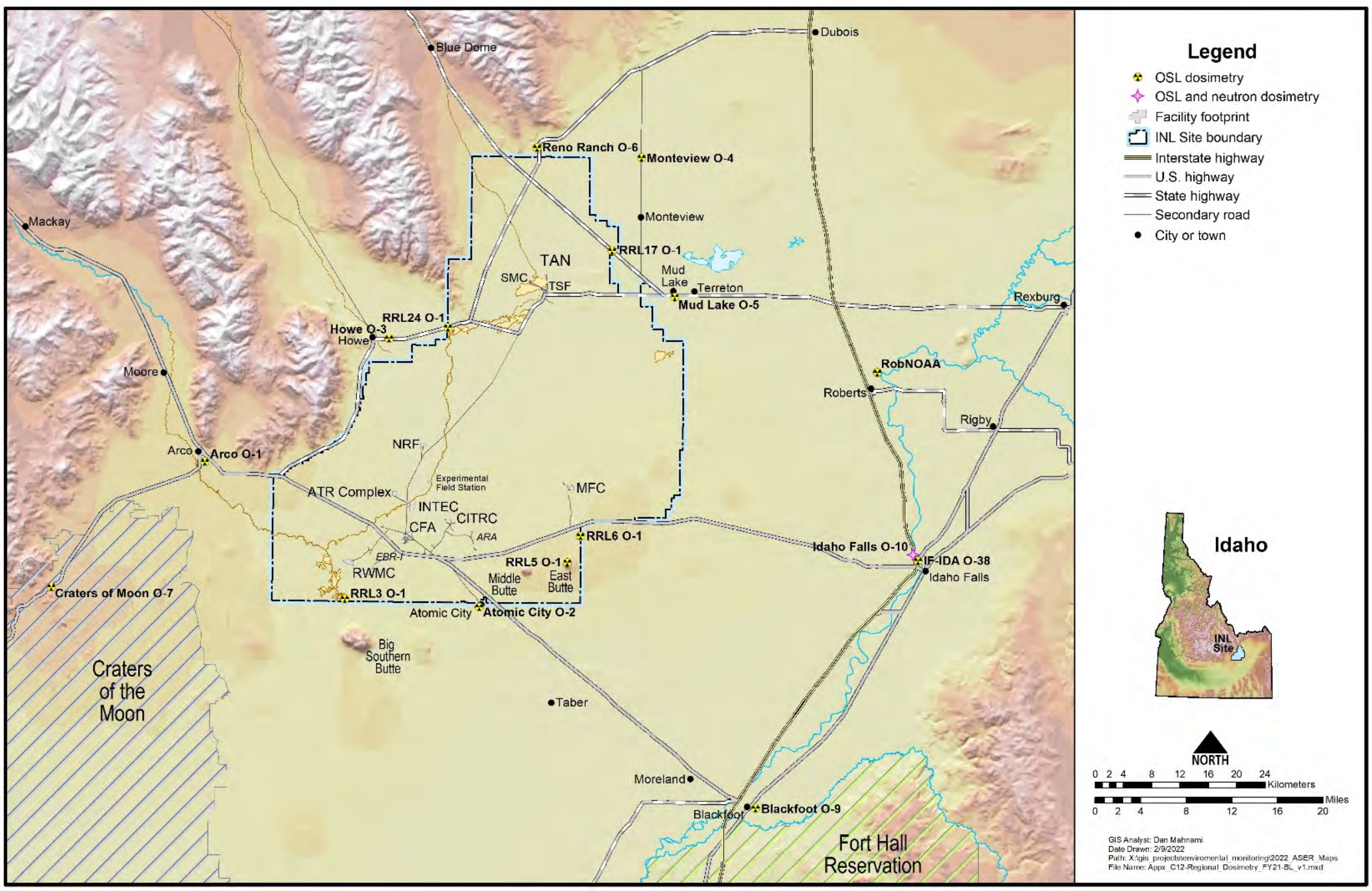
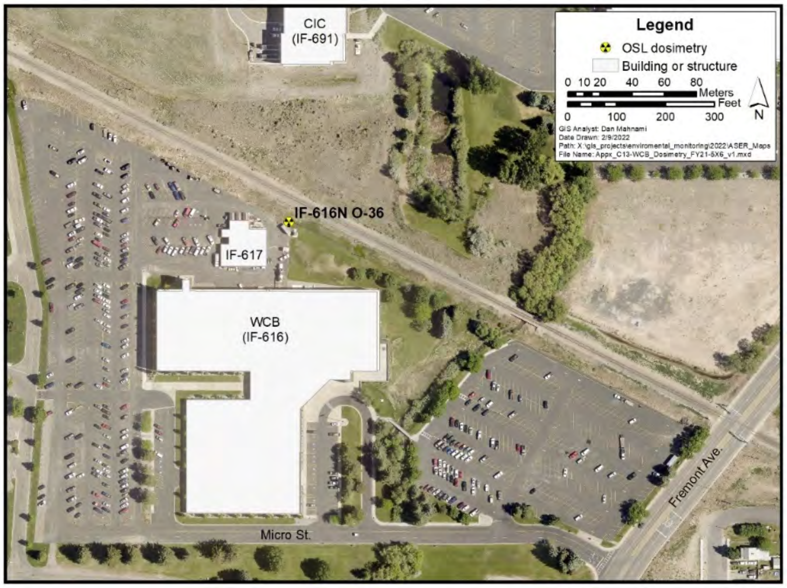


Figure C-12. Environmental radiation measurements at regional locations (2021).

LOCATION	mrem[a]		LOCATION	mrem[a]	
	NOV. 2020 – APRIL 2021	MAY 2021 – OCT. 2021		NOV. 2020 – APRIL 2021	MAY 2021 – OCT. 2021
IF[b]-616N O-36	55	58	IF-665 O-4	51	59
IF-665 O-1	56	53	IF-665 O-5	58	62
IF-665 O-2	59	59	IF-665W O-37	57	58
IF-665 O-3	56	54			

a. Millirem (mrem) in ambient dose equivalent.
b. Idaho Falls (IF).



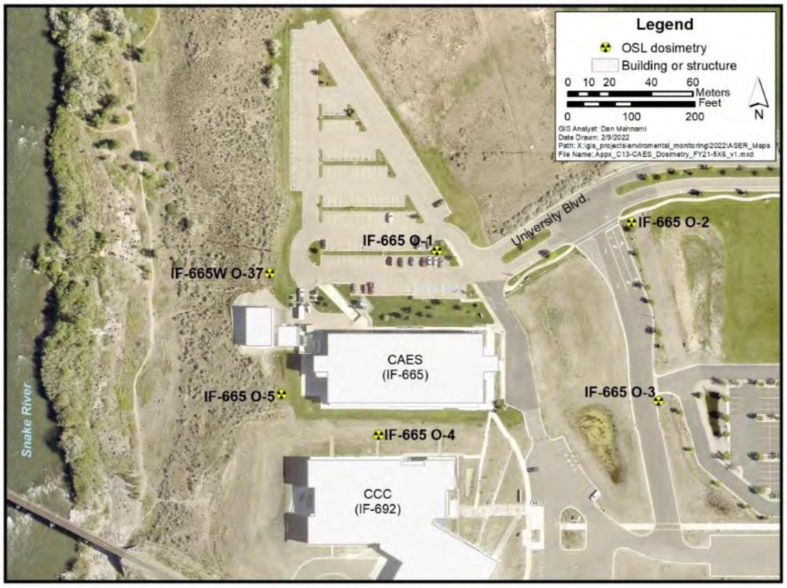


Figure C-13. Environmental radiation measurements at Willow Creek Building (WCB) and Center for Advanced Energy Studies (CAES) (2021).

LOCATION	mrem[a]	
	NOV. 2020 – APRIL 2021	MAY 2021 – OCT. 2021
EBR1[b] O-1	58	60
EBR1 O-2	87	88
EBR1 O-3	295	288

a. Millirem (mrem) in ambient dose equivalent.
b. Experimental Breeder Reactor I (EBR-I).

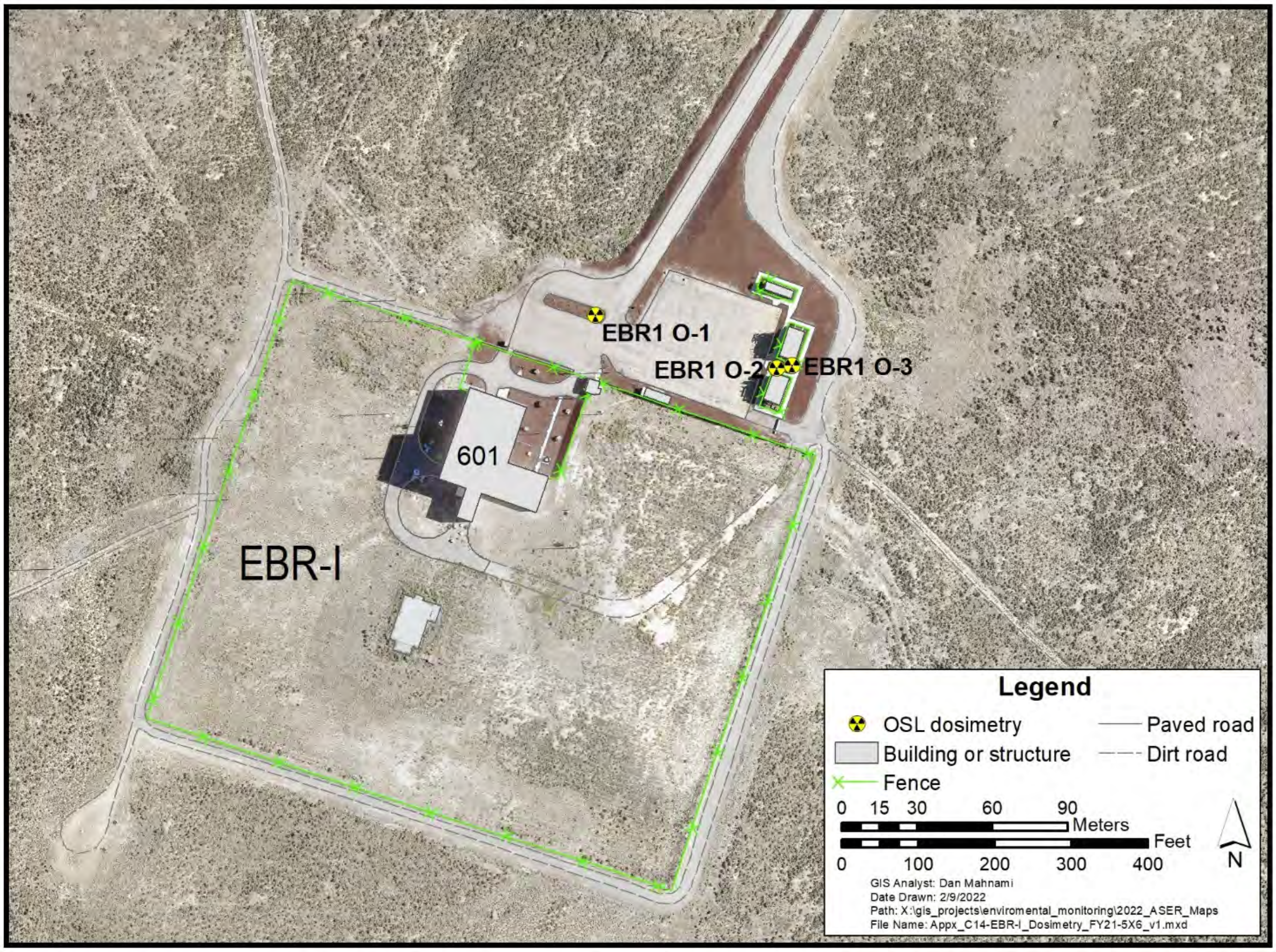


Figure C-14. Environmental radiation measurements at Experimental Breeder Reactor I (EBR-I) (2021).

LOCATION	mrem[a]	
	NOV. 2020 – APRIL 2021	MAY 2021 – OCT. 2021
IF[b]-688B O-1	51	51
IF-688B O-2	52	Lost

a. Millirem (mrem) in ambient dose equivalent.
b. Idaho Falls (IF).

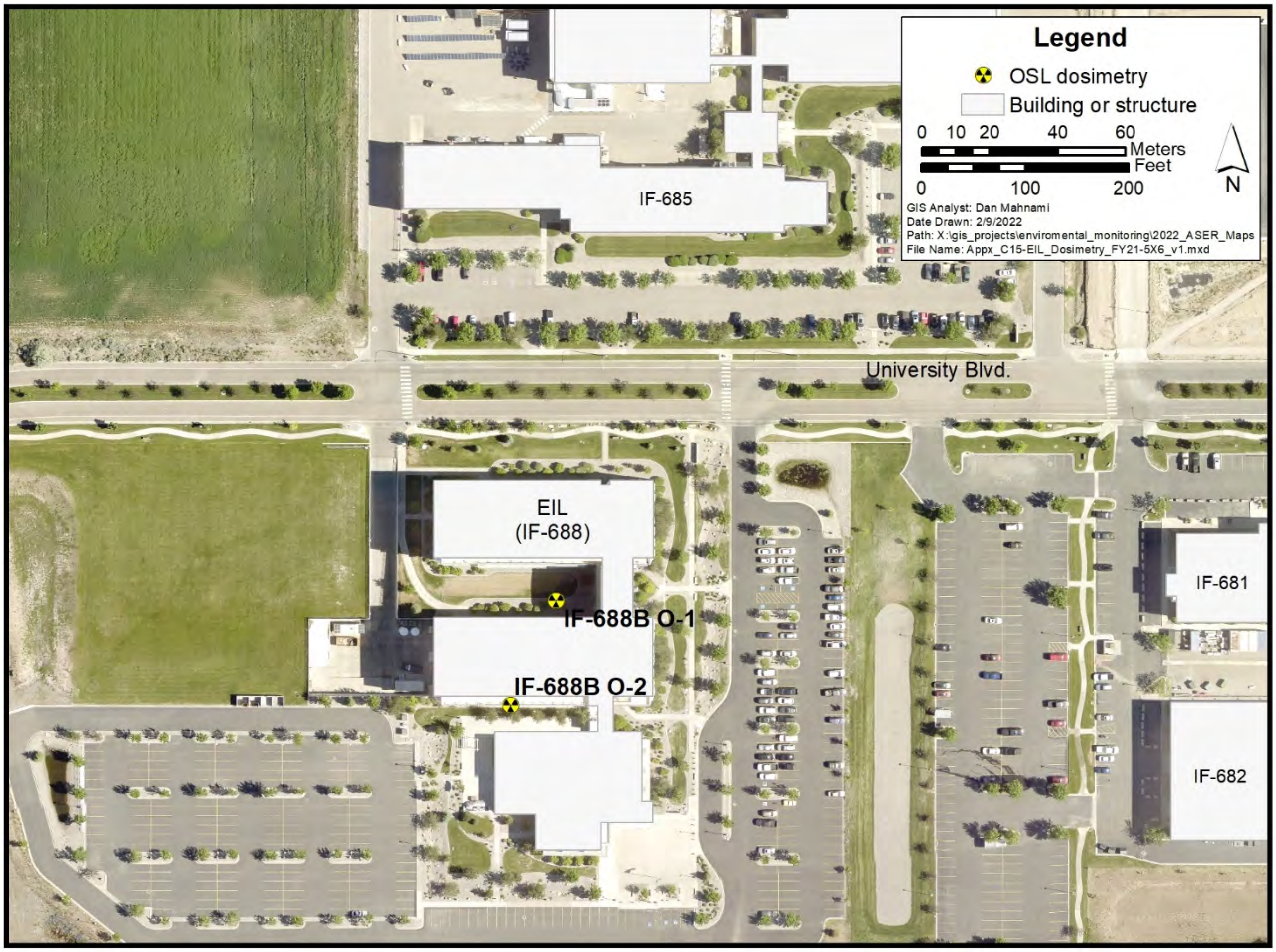


Figure C-15. Environmental radiation measurements at Energy Innovation Laboratory (EIL) (2021).

Mountain Bluebird

Appendix D: Glossary

A

accuracy: A measure of the degree to which a measured value or the average of a number of measured values agrees with the 'true' value for a given parameter; accuracy includes elements of both bias and precision.

actinides: The elements of the periodic table from actinium to lawrencium, including the naturally occurring radionuclides thorium and uranium, and the human-made radionuclides plutonium and americium.

alpha radiation: The emission of alpha particles during radioactive decay. Alpha particles are identical in makeup to the nucleus of a helium atom and have a positive charge. Alpha radiation is easily stopped by materials as thin as a sheet of paper and has a range in air of approximately an inch. Despite its low penetration ability, alpha radiation is densely ionizing and, therefore, very damaging when ingested or inhaled.

ambient dose equivalent: Since the effective dose cannot be measured directly with a typical survey instrument or a dosimeter, approved simulation quantities are used to approximate the effective dose (see **dose, effective**). The ambient dose equivalent is the quantity recommended by the International Commission on Radiation Units and Measurements to approximate the effective dose received by a human from external exposure to ambient ionizing radiation.

anthropogenic radionuclide: Radionuclide produced as a result of human activity (human-made).

aquifer: A geologic formation, group of formations, or part of a formation capable of yielding a significant amount of groundwater to wells or springs.

aquifer well: A well that obtains its water from below the water table.

B

background radiation: Radiation from cosmic sources; naturally occurring radioactive materials, including radon (except as a decay product of source or special nuclear material), and global fallout as it exists in the environment from the testing of nuclear explosive devices. It does not include radiation from source, byproduct, or special nuclear materials regulated by the U.S. Nuclear Regulatory Commission. The typically quoted average individual exposure from background radiation in southeastern Idaho is 360 millirems per year.

basalt: The most common type of solidified lava; a dense, dark grey, fine-grained, igneous rock that is composed chiefly of plagioclase, pyroxene, and olivine, often displaying a columnar structure.

becquerel (Bq): A quantitative measure of radioactivity. This is an alternate measure of activity used internationally. One becquerel of activity is equal to one nuclear decay per second. There are 3.7×10^{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.

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 the protection of populations of aquatic and terrestrial biota to be exceeded.

blank: Used to demonstrate that cross contamination has not occurred. (See **field blank**, **laboratory blank**, **equipment blank,** and **reagent blank**.)

blind sample: Contains a known quantity of some of the analytes of interest added to a sample media being collected. A blind sample is used to test for the presence of compounds in the sample media that interfere with the analysis of certain analytes.

butte: A steep-sided and flat-topped hill.

C

calibration: The adjustment of a system and the determination of system accuracy using known sources and instrument measurements of higher accuracy.

chain of custody: A method for documenting the history and possession of a sample from the time of collection, through analysis and data reporting, to its final disposition. An item is considered to be in a person's custody if the item is (1) in the physical possession of that person, (2) within direct view of that person, or (3) placed in a secured area or container by that person.

comparability: A measure of the confidence with which one data set or method can be compared to another.

composite sample: A sample of environmental media that contains a certain number of sample portions collected over a time period. The samples may be collected from the same location or different locations. They may or may not be collected at equal intervals over a predefined period (e.g., quarterly).

completeness: A measure of the amount of valid data obtained from a measurement system compared to the amount that was expected under optimum conditions.

confidence interval: A statistical range with a specified probability that a given parameter lies within the range.

contaminant: Any physical, chemical, biological, radiological substance, matter, or concentration that is in an unwanted location.

contaminant of concern: Contaminant in a given media (usually soil or water) above a risk level that may result in harm to the public or the environment. At the INL Site, a contaminant that is above a 10^{-6} (1 in 1 million) risk value.

control sample: A sample collected from an uncontaminated area that is used to compare INL Site analytical results to those in areas that could not have been impacted by INL Site operations.

cosmic radiation: Penetrating ionizing radiation, both particulate and electromagnetic, that originates in outer space. Secondary cosmic rays, formed by interactions in the earth's atmosphere, account for about 45 to 50 millirem of the 300 millirem of natural background radiation that an average member of the U.S. public receives in a year.

curie (Ci): The original unit used to express the decay rate of a sample of radioactive material. The curie is a unit of activity of radioactive substances equivalent to 3.70×10^{10} disintegrations per second: it is approximately the amount of activity produced by 1 gram of radium-226. It is named for Marie and Pierre Curie who discovered radium in 1898. The curie is the basic unit of radioactivity used in the system of radiation units in the United States, referred to as "traditional" units. (See also **becquerel**).

D

data gap: A lack or inability to obtain information despite good faith efforts to gather desired information.

data validation: A systematic review of a data set to identify outliers or suspect values. More specifically, data validation refers to the systematic process of independently reviewing a body of analytical data against established criteria to provide assurance that the data are acceptable for their intended use. This process may use appropriate statistical techniques to screen out impossible or highly unlikely values.

data verification: The scientific and statistical evaluation of data to determine if data obtained from environmental operations are of the right type, quality, and quantity to support their intended use. Data verification also includes documenting those operations and the outcome of those operations (e.g., data do or do not meet specified requirements). Data verification is not synonymous with data validation.

decay products: Decay products are also called “daughter products.” They are radionuclides that are formed by the radioactive decay of parent radionuclides. In the case of radium-226, for example, nine successive different radioactive decay products are formed in what is called a “decay chain.” The chain ends with the formation of lead-206, which is a stable nuclide.

derived concentration standard (DCS): The concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by a single pathway (e.g., air inhalation or immersion, water ingestion), would result in an effective dose of 100 mrem (1 mSv). DOE O 458.1, “Radiation Protection of the Public and the Environment,” establishes this limit and DOE Standard DOE-STD-1196-2011, “Derived Concentration Technical Standard,” provides the numerical values of DCSs.

deterministic effect: A health effect, the severity of which varies with the dose and for which a threshold is believed to exist. Deterministic effects generally result from the receipt of a relatively high dose over a short time period. Skin erythema (reddening) and radiation-induced cataract formation is an example of a deterministic effect (formerly called a nonstochastic effect).

diffuse source: A source or potential source of pollutants that is not constrained to a single stack or pipe. A pollutant source with a large areal dimension.

diffusion: The process of molecular movement from an area of high concentration to one of lower concentration.

direct radiation: External radiation from radioactive plumes or from radionuclides deposited on the ground or other surfaces.

dispersion: The process of molecular movement by physical processes.

dispersion coefficient: An empirical concentration, normalized to a unit release rate, used to estimate the concentration of radionuclides in a plume at some distance downwind of the source. The National Oceanic and Atmospheric Administration prepared the dispersion coefficients for this report, using data gathered continuously at meteorological stations on and around the INL Site and the HYSPLIT transport and dispersion model.

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 substance: A substance listed in the appendices to 40 CFR 355, "Emergency Planning and Notification."

F

fallout: Radioactive material made airborne as a result of aboveground nuclear weapons testing and deposited on the earth's surface.

field blank: A blank used to provide information about contamination that may be introduced during sample collection, storage, and transport. A known uncontaminated sample, usually deionized water, is exposed to ambient conditions at the sampling site and subjected to the same analytical or measurement process as other samples.

fissile material: Although sometimes used as a synonym for fissionable material, this term has acquired a more restricted meaning. Namely, any material that is fissionable by thermal (slow) neutrons. The three primary fissile materials are uranium-233, uranium-235, and plutonium-239.

fission: The splitting of the nucleus of an atom (generally of a heavy element) into at least two other nuclei and the release of a relatively large amount of energy. Two or three neutrons are usually released during this type of transformation.

fission products: The nuclei (fission fragments) formed by the fission of heavy elements, plus the nuclides formed by the subsequent decay products of the radioactive fission fragments.

fissionable material: Commonly used as a synonym for fissile material, the meaning of this term has been extended to include material that can be fissioned by fast neutrons, such as uranium-238.

floodplain: Lowlands that border a river and are subject to flooding. A floodplain is comprised of sediments carried by rivers and deposited on land during flooding.

G

gamma radiation: A form of electromagnetic radiation, like radio waves or visible light, but with a much shorter wavelength. It is more penetrating than alpha or beta radiation, and capable of passing through dense materials such as concrete.

gamma spectroscopy: An analysis technique that identifies specific radionuclides that emit gamma radiation. It measures the particular energy of a radionuclide's gamma radiation emissions. The energy of these emissions is unique for each radionuclide, acting as a fingerprint to identify a specific radionuclide.

gross alpha activity: The total radioactivity due to alpha particle emission as inferred from measurements on a dry sample. See **alpha radiation.**

gross beta activity: The total radioactivity due to beta particle emission as inferred from measurements on a dry sample. See **beta radiation.**

groundwater: Water located beneath the surface of the ground (subsurface water). Groundwater usually refers to a zone of complete saturation containing no air.

H

half-life: The time in which one-half of the activity of a particular radioactive substance is lost due to radioactive decay. Measured half-lives vary from millionths of a second to billions of years. Also called physical or radiological half-life.

hazardous air pollutant: Any hazardous chemical as defined under 29 CFR 1910.1200, "Hazard Communication," and 40 CFR 370.2, "Definitions." See **hazardous substance**.

hazardous material: Material considered dangerous to people or the environment.

hazardous substance: Any substance, including any isomers and hydrates, as well as any solutions and mixtures containing these substances, designated as such under Section 311 (b) (2)(A) of the *Clean Water Act*; any toxic pollutant listed under Section 307 (a) of the *Clean Water Act*; any element, compound, mixture, solution, or substance designated pursuant to Section 102 of the *Comprehensive Environmental Response, Compensation and Liability Act*; any hazardous waste having the characteristics identified under or listed pursuant to Section 3001 of the *Solid Waste Disposal Act*; any hazardous air pollutant listed under Section 112 of the *Clean Air Act*; and any imminently hazardous chemical substance or mixture to which the U.S. Environmental Protection Agency Administrator has taken action pursuant to Section 7 of the *Toxic Substances Control Act*. The term does not include petroleum, including crude oil or any fraction thereof that is not otherwise specifically listed or designated in the first paragraph, and it does not include natural gas, natural gas liquids, liquefied natural gas, or synthetic gas usable for fuel (or mixtures of natural gas and such synthetic gas).

hazardous waste: A waste that is listed in the tables of 40 CFR 261 ("Identification and Listing Hazardous Waste") or that exhibits one or more of four characteristics (e.g., corrosivity, reactivity, ignitability, and toxicity) above a predefined value.

high-level radioactive waste: Waste material resulting from the reprocessing of spent nuclear fuel, including both liquid and solid materials containing enough radioactivity to require permanent isolation from the environment.

hot spot: (1) In environmental surveillance, a localized area of contamination or higher contamination in an otherwise uncontaminated area. (2) In geology, a stationary, long-lived source of magma coming up through the mantle to the earth's surface. The hot spot does not move but remains in a fixed position. As the crust of the earth moves over a hot spot, volcanic eruptions occur on the surface.

I

infiltration: The process by which water on the ground surface enters the soil or rock.

influent waste: Raw or untreated wastewater entering a treatment facility.

inorganic: Relating to or belonging to the class of compounds not having a carbon basis; hydrochloric and sulfuric acids are called inorganic substances.

ionizing radiation: Any radiation capable of displacing electrons from atoms or molecules, thereby producing ions. Some examples are alpha, beta, gamma, x-rays, neutrons, and light. High doses of ionizing radiation may produce severe skin or tissue damage.

isopleth: A line on a map connecting points having the same numerical value of some variable.

isotope: Two or more forms of an element having the same number of protons in the nucleus (or the same atomic number) but having different numbers of neutrons in the nucleus (or different atomic weights). Isotopes of a single element possess almost identical chemical properties. Examples of isotopes are plutonium-238, plutomium-239, and plutonium-241; each acts chemically like plutonium but have 144, 145, and 147 neutrons, respectively.

L

laboratory blank: A sample, usually deionized water, that is intended to contain none of the analytes of interest and is subjected to the same analytical or measurement process as other samples to establish a zero baseline or laboratory background value. Laboratory blanks are run before and after regular samples are analyzed to measure contamination that may have been introduced during sample handling, preparation, or analysis. A laboratory blank is sometimes used to adjust or correct routine analytical results.

liquid effluent: A liquid discharged from a treatment facility.

M

matrices/matrix/media: Refers to the physical form (solid, liquid, or gas) or composition (soil, filter, groundwater, or air) of a sample.

maximally exposed individual (MEI): A hypothetical member of the public whose location and living habits tend to maximize his or her radiation dose, resulting in a dose higher than that received by other individuals in the general population.

millirem (mrem): A unit of radiation dose that is equivalent to one one-thousandth of a rem.

millisievert (mSv): The International System of Units (SI) for radiation dose and effective dose equivalent. The SI equivalent of the millirem (1 millisievert = 100 millirem).

minimum detection concentration (MDC): The lowest concentration to which an analytical parameter can be measured with certainty by the analytical laboratory performing the measurement. While results below the MDC are sometimes measurable, they represent values that have a reduced statistical confidence associated with them (less than 95 percent confidence).

multi-media: Covering more than one environmental media (e.g., an inspection that reviews groundwater, surface water, liquid effluent, and airborne effluent data).

N

natural background radiation: Radiation from natural sources to which people are exposed throughout their lives. It does not include fallout radiation. Natural background radiation is comprised of several sources, the most important of which are:

- ***Cosmic radiation:*** Radiation from outer space (primarily the sun)
- ***Terrestrial radiation:*** Radiation from radioactive materials in the crust of the earth
- ***Inhaled radionuclides:*** Radiation from radioactive gases in the atmosphere, primarily radon-222.

natural resources: Land, fish, wildlife, biota, air, water, groundwater, drinking water supplies, and other such resources belonging to, managed by, held in trust by, appertaining to, otherwise controlled by the United States, any state or local government, any foreign government, or Native American tribe.

noble gas: Any of the chemically inert gaseous elements of the helium group in the periodic table.

non-community water system: A public water system that is not a community water system. A non-community water system is either a transient non-community water system or a non-transient non-community water system.

non-transient non-community water system: A public water system that is not a community water system and that regularly serves at least 25 of the same persons over six months per year. These systems are typically schools, offices, churches, factories, etc.

O

organic: Relating or belonging to the class of chemical compounds having a carbon basis; hydrocarbons are organic compounds.

optically stimulated luminescence dosimeter (OSLD): Used to measure direct penetrating gamma radiation through the absorption of energy from ionizing radiation by trapping electrons that are excited to a higher energy band. The trapped electrons in the OSLD are released by exposure to green light from a laser.

P

perched water well: A well that obtains its water from a water body above the water table.

performance evaluation sample: Sample prepared by adding a known amount of a reference compound to reagent water and submitting it to the analytical laboratory as a field duplicate or field blank sample. A performance evaluation sample is used to test the accuracy and precision of the laboratory's analytical method.

person-rem: Sum of the doses received by all individuals in a population.

pH: A measure of hydrogen ion activity. A low pH (0 – 6) indicates an acid condition; a high pH (8 – 14) indicates a basic condition. A pH of 7 indicates neutrality.

playa: A depression that is periodically inundated with water and will retain such water over time. An intermittent or seasonal water body.

plume: A body of contaminated groundwater or polluted air flowing from a specific source. The movement of a groundwater plume is influenced by such factors as local groundwater flow patterns, the character of the aquifer in which groundwater is contained, and the density of contaminants. The movement of an air contaminant plume is influenced by the ambient air motion, the temperatures of the ambient air and of the plume, and the density of the contaminants.

PM_{10}: Particle with an aerodynamic diameter less than or equal to 10 microns.

pollutant: (1) Pollutant or contaminant as defined by Section 101(33) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), shall include, but not be limited to, any element, substance, compound, or mixture, including disease causing agents, which after release into the environment and upon exposure, ingesting, inhalation, or assimilation into an organism, either directly from the environment or indirectly by ingestion through food chains, will or may reasonably be anticipated to cause death, disease, behavioral abnormalities, cancer, genetic mutation, physiological malfunctions (including malfunctions in reproduction), or physical deformation, in such organisms or their offspring. The term does not include petroleum, including crude oil or any fraction thereof which is not otherwise specifically listed or designated as a hazardous substance under Section 101(14) (A) through (F) of CERCLA, nor does it include natural gas, liquefied natural gas, or synthetic gas of pipeline quality (or mixtures of natural gas and such synthetic gas). For purposes of the National Oil and Hazardous Substances Pollution Contingency Plan, the term pollutant or contaminant means any pollutant or contaminant that may present an imminent and substantial danger to public health or welfare of the United States. (2) Any hazardous or radioactive material naturally occurring or added to an environmental media, such as air, soil, water, or vegetation.

polychlorinated biphenyl: Any chemical substance that is limited to the biphenyl molecule that has been chlorinated to varying degrees or any combination of substances that contain such substance.

precision: A measure of mutual agreement among individual measurements of the same property. Precision is most often seen as a standard deviation of a group of measurements.

public water system: A system for the provision to the public of water for human consumption through pipes or other constructed conveyances, if such system has at least 15 service connections or regularly serves an average of at least 25 individuals daily at least 60 days out of the year. Includes any collection, treatment, storage, and distribution facilities under control of the operator of such system and used primarily in connection with such system and any collection or pretreatment storage facilities not under such control that are used primarily in connection with such system. Does not include any special irrigation district. A public water system is either a community water system or a non-community water system.

purgeable organic compound: An organic compound that has a low vaporization point (volatile).

Q

quality assurance (QA): Those planned and systematic actions necessary to provide adequate confidence that a facility, structure, system, or component will perform satisfactorily and safely in service. Quality assurance includes quality control. If quality is the degree to which an item or process meets or exceeds the user's requirements, then quality assurance is those actions that provide the confidence that quality was in fact achieved.

quality control (QC): Those actions necessary to control and verify the features and characteristics of a material, process, product, service, or activity to specified requirements. The aim of quality control is to provide quality that is satisfactory, adequate, dependable, and economic.

quality factor: The factor by which the absorbed dose (rad or gray) must be multiplied to obtain a quantity that expresses, on a common scale for all ionizing radiation, the biological damage (rem or sievert) to the exposed tissue. It is used because some types of radiation, such as alpha particles, are more biologically damaging to live tissue than other types of radiation when the absorbed dose from both is equal. The term, 'quality factor,' has now been replaced by 'radiation weighting factor' in the latest system of recommendations for radiation protection.

R

rad: Short for radiation absorbed dose; a measure of the energy absorbed by any material.

radioactivity: The spontaneous transition of an atomic nucleus from a higher energy to a lower energy state. This transition is accompanied by the release of a charged particle or electromagnetic waves from the atom. Also known as activity.

radioactive decay: The decrease in the amount of any radioactive material with the passage of time due to the spontaneous emission from the atomic nuclei of either alpha or beta particles, often accompanied by gamma radiation.

radioecology: The study of the behavior and the effects of radioactive materials on the environment. Also includes the use of radioisotopes to study the structure and function of ecosystems and their component parts.

radionuclide: A type of atom that emits energy in the form of photons or particles (radiation) during transformation.

radiotelemetry: The tracking of animal movements through the use of a radio transmitter attached to the animal of interest.

reagent blank: A sample of any reagent used for sample preparation subjected to the same analytical or measurement process as a normal sample. A reagent blank is used to show that the reagent used in sample preparation does not contain any of the analytes of interest.

rehabilitation: The planting of a variety of plants in an effort to restore an area's plant community diversity after a loss (e.g., after a fire).

relative percent difference: A measure of variability adjusted for the size of the measured values. It is used only when the sample contains two observations, and it is calculated by the equation:

$$RPD = \frac{|R1 - R2|}{(R1 + R2)/2} \times 100$$

where R1 and R2 are the duplicate sample measurement results.

release: Spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing of a hazardous substance, pollutant, or contaminant into the environment.

rem (Roentgen Equivalent Man): A unit in the traditional system of units that measures the effects of ionizing radiation on humans.

reportable quantity: Any *Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)* hazardous substance, the reportable quantity for which is established in Table 302.4 of 40 CFR 302, "Designation, Reportable Quantities, and Notification," the discharge of which is a violation of federal statutes and requires notification of the regional U.S. Environmental Protection Agency administrator.

representativeness: A measure of a laboratory's ability to produce data that accurately and precisely represent a characteristic of a population, a parameter variation at a sampling point, a process condition, or an environmental condition.

reprocessing: The process of treating spent nuclear fuel for the purpose of recovering fissile material.

resuspension: Windblown reintroduction to the atmosphere of material originally deposited onto surfaces from a particular source.

rhyolite: A usually light-colored, fine-grained, extrusive igneous rock that is compositionally similar to granite.

risk: In many health fields, risk means the probability of incurring injury, disease, or death. Risk can be expressed as a value that ranges from zero (no injury or harm will occur) to one (harm or injury will definitely occur).

risk assessment: The identification and quantification of the risk resulting from a specific use or occurrence of a chemical, taking into account the possible harmful effects on individuals or society of using the chemical in the amount and manner proposed and all the possible routes of exposure. Quantification ideally requires the establishment of dose-effect and dose-response relationships in likely target individuals and populations.

roentgen (R): The amount of ionization produced by gamma radiation in air. The unit of roentgen is approximately numerically equal to the unit of rem.

S

shielding: The material or process used for protecting workers, the public, and the environment from exposure to radiation.

sievert (Sv): A unit for assessing the risk of human radiation dose, used internationally. One sievert is equal to 100 rem.

sigma uncertainty: The uncertainty or margin of error of a measurement is stated by giving a range of values likely to enclose the true value. These values follow from the properties of the normal distribution, and they apply only if the measurement process produces normally distributed errors, e.g., the quoted standard errors are easily converted to 68.3 percent (one sigma), 95.4 percent (two sigma), or 99.7 percent (three sigma) confidence intervals, which are usually denoted by error bars on a graph or by the following notations:

- measured value ± uncertainty
- measured value (uncertainty).

sink: Similar to a playa with the exception that it rapidly infiltrates any collected water.

spent nuclear fuel: Uranium metal or oxide and its metal container that have been used to power a nuclear reactor. It is highly radioactive and typically contains fission products, plutonium, and residual uranium.

split sample: A single sample, usually divided by the analytical laboratory, split into two separate samples. Each sample is prepared and analyzed independently as an indication of analytical variability and comparability.

spreading areas: At the INL Site, a series of interconnected low areas used for flood control by dispersing and evaporating or infiltrating water from the Big Lost River.

stabilization: The planting of rapidly growing plants for the purpose of holding bare soil in place.

standard: A sample containing a known quantity of various analytes. A standard may be prepared and certified by commercial vendors, but it must be traceable to the National Institute of Standards and Technology.

standard deviation: In statistics, the standard deviation (SD), also represented by the Greek letter sigma σ, is a measure of the dispersion of a set of data from its mean.

stochastic effect: An effect that occurs by chance and which may occur without a threshold level of dose, whose probability is proportional to the dose and whose severity is independent of the dose. In the context of radiation protection, the main stochastic effect is cancer.

storm water: Water produced by the interaction of precipitation events and the physical environment (buildings, pavement, ground surface).

surface radiation: Surface radiation is monitored at the INL Site at or near waste management facilities and at the perimeter of Site facilities. (See **direct radiation**.)

surface water: Water exposed at the ground surface, usually constrained by a natural or human-made channel (stream, river, lake, ocean).

surveillance: Monitoring of parameters to observe trends but which is not required by a permit or regulation.

T

thermoluminescent dosimeter (TLD): A device used to measure radiation dose to occupational workers or radiation levels in the environment. A dosimeter is made of one or more lithium fluoride chips that measure cumulative exposure to ionizing radiation. Lithium fluoride absorbs the energy of radiation and releases it as light when heated.

total effective dose (TED): The sum of the effective dose (for external exposures) and the committed effective dose.

total organic carbon: A measure of the total organic carbon molecules present in a sample. It will not identify a specific constituent (e.g., benzene), but will detect the presence of a carbon-bearing molecule.

toxic chemical: Chemical that can have toxic effects on the public or environment above the 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 non-community water system: A water system that is not a community water system and serves an average of 25 persons less than six months per year. These systems are typically campgrounds or highway rest stops.

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 to wet conditions that cannot adapt to an absence of flooding. Wetlands generally include playa lakes, swamps, marshes, bogs, and similar areas as sloughs, prairie potholes, wet meadows, prairie river overflows, mudflats, and natural ponds.

Smoke at Middle Butte


Idaho National Laboratory