Chapter 7: Environmental Surveillance 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. Iodine-131 and strontium-90 were not detected in any milk samples collected in 2023. Cesium-137 was detected in a milk sample collected in Monteview; however, a review of the result and uncertainty suggest the result is a false positive. Cesium-137 was not detected in any other milk sample collected in 2023. Human-made radionuclides were not detected in any of the other agricultural products (e.g., lettuce, grain, potatoes, alfalfa) collected in 2023.

No human-made radionuclides were detected in road-killed animal samples collected in 2023. Four human-made radionuclides (e.g., cesium-137, cobalt-60, strontium-90, zinc-65) 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.

Direct radiation measurements made at boundary and offsite locations were consistent with background levels. The average annual dose equivalent from external exposure was estimated from dosimeter measurements to be 114 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 376 mrem per year.

Direct radiation measurements taken in the vicinity of waste storage and soil contamination areas near INL Site facilities were consistent with previous measurements. Direct radiation measurements using a radiometric scanner system at the Radioactive Waste Management Complex and the Idaho Comprehensive Environmental Response, Compensation, and Liability Act Disposal Facility were historically near background levels.

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

This chapter summarizes the results of environmental surveillance monitoring of agricultural products, wildlife, soil, and direct radiation on and around the INL Site during 2023, as shown in Table 7-1. Details of these programs may be found in the "Idaho National Laboratory Site Environmental Monitoring Plan" (DOE-ID 2021). INL Site contractors monitor soil, vegetation, biota, and direct radiation on and off the INL Site to comply with applicable DOE orders and other requirements, as shown in Table 7-1. INL Site has the potential to release contaminants in the environment which may be present in agricultural products, biota, soil, and direct radiation. To improve the readability of this chapter, INL contractor data tables are included when surveillance monitoring results exceed three sigma (3σ) and/or background upper threshold limits. All sample media results for 2023 are provided in quarterly surveillance reports (INL 2024a, INL 2024b, INL 2024c, and INL 2024d).

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

AREA/FACILITY[a]	MEDIA				
	AGRICULTURAL PRODUCTS	BIOTA	ECOLOGICAL	SOIL	DIRECT RADIATION
INL CONTRACTOR					
INL Site/Regional	•	•	•	•	•
ICP CONTRACTOR					
ICDF[b]	—[d]	—	—	—	•
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.
d. — = media not sampled.

7.1 Agricultural Products and Biota Sampling

Agricultural products and game animals are sampled by the INL contractor because of the potential transfer of radionuclides to people through food chains, as was shown in Chapter 4, Figure 4-1. Sampling of agricultural foodstuffs is performed on and around the INL Site to meet the following requirements and criteria for environmental surveillance of DOE facilities:

- DOE O 458.1, "Radiation Protection of the Public and the Environment"
- "DOE Handbook Environmental Radiological Effluent Monitoring and Environmental Surveillance" (DOE 2015)
- Stakeholder inputs and values.

Figure 7-1 shows the locations where agricultural products were collected in 2023.

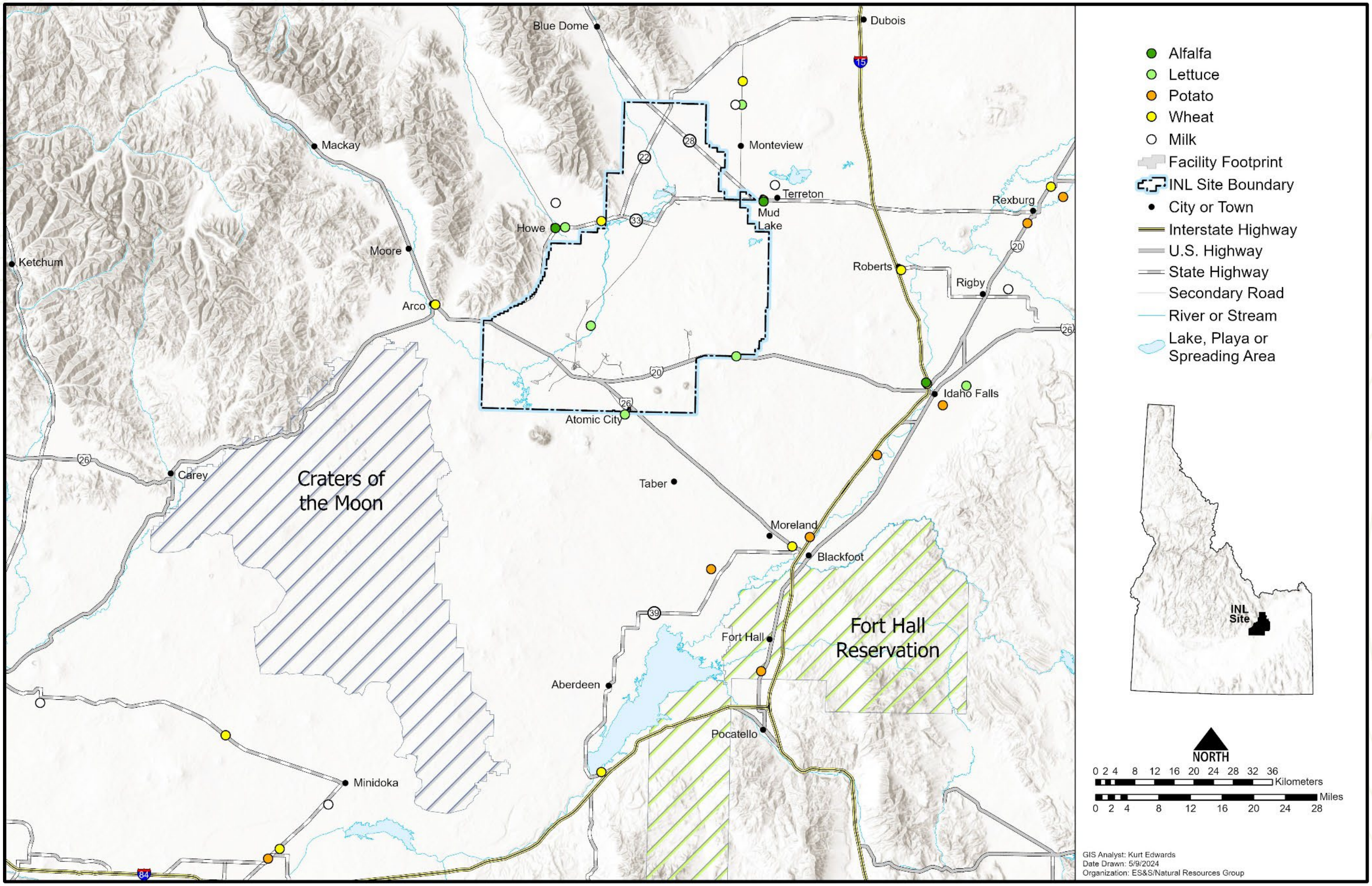

Figure 7-1. Locations of agricultural product samples collected (2023).

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). Additionally, 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 the 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 monitoring 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 Surveillance” (DOE 2015), representative samples of the pathway-significant agricultural products grown within 16 km (10 miles) of the INL Site should be collected and analyzed for radionuclides potentially present from INL 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 monitoring 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 the 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 INL contractor in areas that have no commercial or private producers.

7.2.2 Milk Results

Cow milk, and in certain localities, goat milk, is widely consumed by all age groups. Therefore, milk is frequently one of the most important foods contributing to the radiation dose to people if dairy animals are pastured near a nuclear site (INL 2023).

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 2023, the INL contractor collected 179 milk samples (including duplicates and controls) at various locations off the INL Site (Figure 7-1) and purchased milk commercially produced 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 Rigby and Terreton, Idaho, and monthly at other locations around the INL Site.

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.

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 ^{134}Cs and ^{137}Cs, can dominate the ingestion dose regionally after a severe nuclear event, such as the Chernobyl accident (Kirchner 1994) in Ukraine or the 2011 accident at Fukushima in Japan. The ingestion pathway of milk 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. None was detected in air samples collected at or beyond the INL Site boundary (see Chapter 4). Iodine-131 was not detected in any milk sample collected during 2023.

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 a 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. Potential sources of ^{137}Cs include releases from INL Site facilities and resuspension of previously contaminated soil particles. A sample collected in Monteview on April 18, 2023, resulted in a detect of ^{137}Cs (4.70 ± 1.35 pCi/L). A review of the ^{137}Cs result and uncertainty suggest the data could be a false positive. The DCS for ^{137}Cs in milk is 27,000 pCi/L. Cesium-137 was not detected in any other milk sample collected in 2023.

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 not detected in any milk sample collected during 2023. 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. The results from EPA Region 10, which includes Idaho, for a limited dataset 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 (DCS) (DOE 2022) for radionuclides in air, water, and milk. A DCS is the concentration of a radionuclide in air, water, or milk that would result in a dose of 100 mrem from ingestion, inhalation, or immersion in a gaseous cloud for one year. The DCS for ^{90}Sr in milk is 5,800 pCi/L. Therefore, the maximum observed value in milk samples (0.55 ± 0.13 pCi/L) is approximately 0.009% of the DCS for milk.

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 and from plants that contain water. Tritium was detected in the milk control sample purchased from a producer in Colorado. Concentrations varied from -51.30 ± 21.20 pCi/L in a sample from Howe in November 2023 to 111.00 ± 33.70 pCi/L in the milk control sample collected in May 2023. A negative result indicates the measurement was less than the laboratory background measurement. 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 milk is 12,000,000 pCi/L.

7.2.3 Lettuce Results

Lettuce was sampled because radionuclides in air can be deposited on soil and plants, which can then be ingested by people, as shown previously in Figure 4-1. The uptake of radionuclides by plants may occur through root uptake from soil and from deposited material absorbed into leaves. For most radionuclides, uptake by foliage is the dominant process for the contamination of plants (Amaral et al. 1994). For this reason, green, leafy vegetables, such as lettuce, have higher concentration ratios of radionuclides to soil than other kinds of plants. The INL 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 been replaced with portable lettuce

Figure 7-2. Portable lettuce planter.

planters, as shown in Figure 7-2, because the availability of lettuce from home gardens was unreliable at some key locations.

In addition, 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 the 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 2023, 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 a farm in Idaho Falls, Idaho, and a control sample was purchased at the grocery store from an out-of-state location (Washington).

The samples were analyzed for ^{90}Sr and gamma-emitting radionuclides. Strontium-90 was not detected in the lettuce samples collected during 2023. 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 Results

The DOE Handbook (DOE 2015) generally recommends representative milk and vegetation (fruits, grains, and vegetables) be included in an agriculture product monitoring program.

Grain (including wheat and barley) is sampled because it is a staple crop in the region. In 2023, the INL contractor collected grain samples at 11 locations from areas surrounding the INL Site (Figure 7-1); an additional duplicate sample was collected from Blackfoot. 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 monitoring 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 Potato Results

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 INL Site vicinity (Figure 7-1), and a duplicate sample was collected from Shelley. A control sample was purchased from outside the state of Idaho. None of the potato samples (including the duplicate) collected during 2023 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 Results

In addition to analyzing milk, the INL contractor began collecting data in 2010 on alfalfa consumed by milk cows. Samples of alfalfa were collected from locations in the cities of Blackfoot, Howe, Idaho Falls, and Mud Lake. Mud Lake is an agricultural area with a high potential for offsite contamination via the air pathway, as 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.) No ^{90}Sr or gamma-emitting radionuclides were detected in the alfalfa samples collected during 2023.

7.2.7 Big Game Animals Results

Since big game have historically been documented to uptake some level of radioactive contaminants, opportunistic sampling of road-killed game animals is important to ascertain the potential impacts of these contaminants on the animals, as well as the humans potentially consuming them (INL 2022a).

Muscle, liver, and thyroid samples were collected, under a scientific collection permit, from five big game animals. In addition, only a muscle sample was able to be collected from a sixth big game animal. 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 the isotope accumulates selectively in the thyroid gland of many animals when ingested, making them an ideal 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 or liver samples.

7.2.8 Waterfowl Results

Waterfowl are collected each year at ponds on the INL Site and at a location offsite under an Idaho Department of Fish and Game and an U.S. Fish and Wildlife scientific collection permits. In 2023, three waterfowl were collected from wastewater ponds located at the Advanced Test Reactor (ATR) Complex, two control waterfowl were collected from the South Fork of the Snake River, and one control was collected from Swan Valley. Waterfowl samples were analyzed for gamma-emitting radionuclides (^{90}Sr) and actinides (^{241}Am, ^{238}Pu, $^{239/240}$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 subsamples: (1) edible tissue (e.g., muscle, gizzard, heart, liver); (2) external portion (e.g., feathers, feet, head); and (3) all remaining tissue.

Four human-made radionuclides were detected in edible, exterior, and remainder subsamples from the ducks collected at the ATR Complex ponds. The radionuclides were ^{137}Cs, ^{60}Co, ^{90}Sr, and ^{65}Zn. A Green-winged Teal collected from the sewage lagoons at ATR Complex had four of these radionuclides in edible tissue as identified in Table 7-2. One of the radionuclides (^{137}Cs) was also detected in edible tissue of a Mallard collected from the South Fork of the Snake River.

Table 7-2. Radionuclide concentrations detected in waterfowl collected in 2023.

RADIONUCLIDES DETECTED IN WATERFOWL TISSUE (pCi/kg)				
LOCATION	SPECIES	PORTION	RADIONUCLIDE	CONCENTRATION
ATR Complex	Green-winged Teal	Edible	Cesium-137	1,650 ± 77
			Cobalt-60	370 ± 30
			Strontium-90	161 ± 32
			Zinc-65	820 ± 73
South Fork of the Snake River	Mallard	Edible	Cesium-137	13 ± 4

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 radionuclides detected in waterfowl collected at the ATR Complex were higher than those collected in 2022. All results were within historical measurements observed during the past ten years (2013-2022). The ^{137}Cs detected in the control duck 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.

7.3 Soil Sampling

The “DOE Handbook – Environmental Radiological Effluent Monitoring and Environmental Surveillance” (DOE 2015) states that soil sampling and analysis should be used to evaluate the long-term accumulation trends and to estimate environmental radionuclide inventories. It notes that soil provides an integrating medium that can account for contaminants released to the atmosphere either directly in gaseous effluents or indirectly from resuspension of onsite contamination or through liquid effluents released to a stream that is subsequently used for irrigation. However, while soil sampling is a useful approach for determining the accumulation of initially airborne radionuclides that have been deposited on the ground, such sampling generally serves a supplementary role in environmental surveillance monitoring programs (Gallegos 1995; Hardy and Krey 1971; EML 1997). In addition, soil sampling is of questionable value in attempting to estimate small increments of deposition over a period of a few years or less because of the large uncertainties in sampling and the inherent variability in soil and because it is not recommended as a routine method of environmental surveillance monitoring except in pre-operational surveys (EML 1997).

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. The next soil sampling event is scheduled for 2027. 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 (2017).

7.4 Direct Radiation

Environmental direct radiation measures exposure of the public and non-involved workers within INL Site boundaries and surrounding areas. Dosimeters are placed around INL facilities, along the INL Site perimeter, and in areas within a 50-mile radius of the INL Site boundaries.

7.4.1 Sampling Design

An array of optically stimulated luminescent dosimeters (OSLDs) are distributed throughout the Eastern Snake River Plain and on the INL Site to measure for environmental radiation. In addition, neutron dose surveillance monitoring is conducted around INL facilities and buildings where neutron radiation may be present. Offsite and boundary dosimeter locations are shown in Figure 7-3. The sampling periods for 2023 were from November 2022 to April 2023 and May 2023 to October 2023.

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

Environmental OSLDs are placed in the field for six months. After the six-month period, the OSLDs are collected and returned to the supplier 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 5% of the measurements will exceed the background dose. If a single measurement is greater than the background dose, it does not necessarily mean 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 2022b). The method for computing the background value as the upper tolerance limit (UTL) is described in EPA (2009) and EPA (2016). The ProUCL Version 5.1 software (EPA 2016) has been used to compute UTLs, given all available data in the area since 2012.

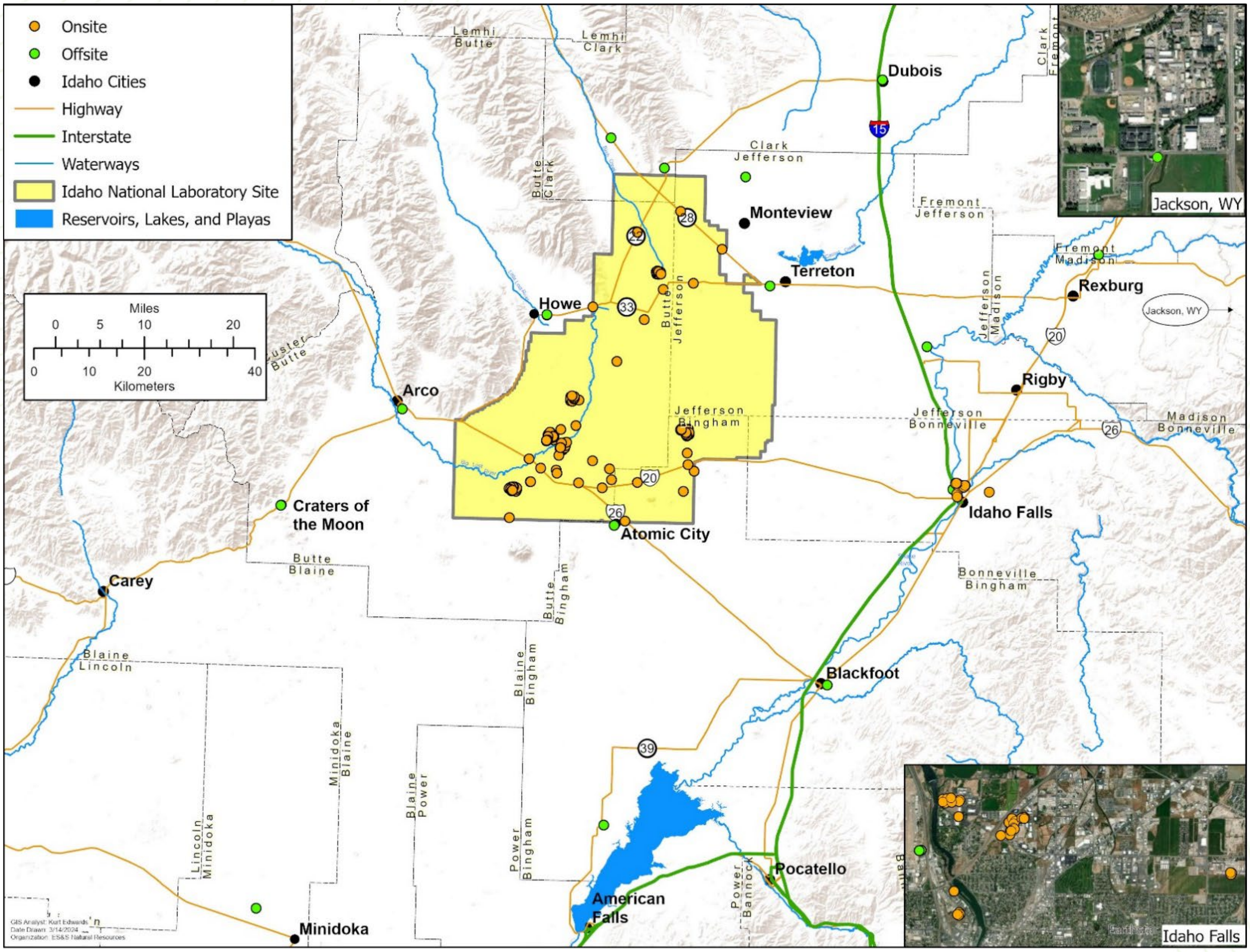

Figure 7-3. INL contractor OSLD locations (2023).

7.4.3 Direct Radiation Results

The 2023 direct radiation results collected by the INL contractor at boundary, offsite, and onsite locations are provided in Appendix B. The building number for the Lindsay Building changed from IF-652A to IF-695. During sample collection in May 2023, dosimeters were missing from the Idaho Nuclear Technology and Engineering Center (ICPP O-14) and the Lindsay Building (IF-652A O-3). Similarly, dosimeters were not found at Materials and Fuels Complex (ANL O-15) and the Portable Isotopic Neutron Spectroscopy Laboratory (IF-675S O-34) when sample collection was performed in November 2023. Results are reported in gross units of ambient dose equivalent (mrem). The 2023 reported values for field locations were primarily below the historic six-month UTL. Table 7-3 lists locations that exceeded their specific six-month UTL. As anticipated, 2% exceeded the UTL for 2023 (Section 7.4.2). The results listed in Table 7-3, showed similarity when compared to historical data suggesting no further action was required.

Table 7-3. Dosimetry locations above the six-month background UTL (2023).

LOCATION	NOV. 2022 – APRIL 2023 SAMPLE RESULT (mrem)	MAY 2023 – OCT. 2023 SAMPLE RESULT (mrem)	BACKGROUND LEVEL UTL[a] (mrem)
ANL O-23	—[b]	88.6 ± 4.4	87.5
ANL O-26	—	89.1 ± 4.5	87.5
ICPP O-15[c]	177.6 ± 8.3	165.3 ± 8.3	146.9
IF-603W O-4	—	62.3 ± 3.1	61.8
TRA O-10[c]	130.7 ± 6.5	139.2 ± 7.0	121.0
TRA O-11[c]	—	123.4 ± 6.2	121.0

a. The UTL is the value such that 95% of all the doses in the area are less than that value with 95% confidence. It is anticipated that 5% of the doses should exceed the UTL.
b. — = Sample did not exceed the UTL for the collection period.
c. Elevated levels expected due to the work being performed in the area.

Neutron dose surveillance monitoring is conducted around buildings in Idaho Falls where sources may emit or generate neutron radiation. These buildings include IF-675, the Portable Isotopic Neutron Spectroscopy Laboratory; IF-695 (formerly IF-652A), the Lindsay Building; IF-670, the Bonneville County Technology Center; and IF-638, the INL Research Center 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. Onsite locations with neutron badges include the Transient Reactor Test Facility and the Remote-Handled Low-Level Waste Facility. Neutron dosimeters were missing from the Lindsay Building (IF-652A O-3) during May 2023 sample collection, and at the Portable Isotopic Neutron Spectroscopy Laboratory (IF-675S O-34) and the Transient Reactor Test Facility (TREAT O-4) for November 2023 sample collection. All neutron dosimeters collected in 2023 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 7-4 summarizes the calculated effective dose a hypothetical individual would receive on the Snake River Plain from various natural background radiation sources (e.g., cosmic, 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 the soil do not change significantly over this relatively short period. Data indicate the average concentrations of ^{238}U, ^{232}Th, and ^{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 2023, this resulted in a reduction in the effective dose from soil to a value of 62 mrem/yr.

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.

Table 7-4. Calculated effective dose from natural background sources (2023).

SOURCE OF RADIATION DOSE	TOTAL AVERAGE ANNUAL DOSE	
	CALCULATED (mrem)	MEASURED[a] (mrem)
EXTERNAL IRRADIATION		
Terrestrial	62[b]	NA[c]
Cosmic	57[d]	NA
Subtotal	**119**	**114**
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	**376**	

a. Calculated from the average annual external exposure at all offsite locations measured using OSLDs.
b. Estimated using concentrations of naturally occurring radionuclide concentrations in soils in the Snake River Plain.
c. NA indicates terrestrial and cosmic radiation parameters were not measured individually but were measured collectively using dosimeters located offsite and at the boundary of the INL Site.
d. Estimated from Figure 3.4 of NCRP Report No. 160.
e. Values reported for the average American adult in Table 3.14 of NCRP Report No. 160.
f. NM = not measured.

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 2023 was estimated to be 119 mrem/yr. This is similar to the 114 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 offsite locations in 2023.

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 on 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 7-4 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 U.S. was reported in the 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 376 mrem/yr, as identified in Table 7-4. This value was used to calculate background radiation dose to the population living within 50 miles of INL Site facilities (Table 8-5).

7.5 Waste Management Surveillance Sampling

For compliance with DOE O 435.1, “Radioactive Waste Management,” vegetation and soil were at the Radioactive Waste Management Complex (RWMC), and direct surface radiation is measured at the RWMC and the Idaho Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Disposal Facility (ICDF). Soil sampling was conducted at the Subsurface Disposal Area (SDA) at the RWMC from 1994 to 2017. Soil surveillance monitoring was discontinued based on several factors including the limited availability of undisturbed soils and sufficient historical data being collected previously to satisfy the characterization objectives.

7.5.1 Vegetation Sampling at the Radioactive Waste Management Complex

At the RWMC, vegetation was historically collected from four major areas and a control location approximately seven miles south of the 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 contractor 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.

7.5.2 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 offsite 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.

Surface Radiation mapping did not occur in 2023 because of issues stemming from attrition of technical staff but will occur in 2024, twice at the SDA to characterize potential changes resulting from closure activities at those facilities. An automated annual reminder has been put into place to ensure completion of subsequent drive over surveys. Historically, the average background values were around 4,000 counts per second at RWMC with most readings being at or near background. At ICDF, background values were around 3,000 counts per second with most readings being at or near background.

7.6 References

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Northwest indian paintbrush