Chapter 4: Environmental Monitoring Programs – Air

CHAPTER 4

An estimated total of 1,588 Ci (5.88×10^{13} Bq) of radioactivity, primarily in the form of short-lived noble gas isotopes, was released as airborne effluents from the Idaho National Laboratory (INL) Site facilities in 2024. The highest contributors to the total release were the Advanced Test Reactor (ATR) Complex at 69.6%, the Materials and Fuel Complex (MFC) at 27.6%, and the Radioactive Waste Management Complex (RWMC) at 2.55%. Other INL Site facilities contributed 0.19% to the total. The estimated maximum potential dose to a member of the public from all INL Site air emissions (0.015 mrem/yr) is below the regulatory standard of 10 mrem/yr (see Chapter 8 for details).

The INL Site environmental surveillance monitoring programs emphasize measurements of airborne contaminants in the environment because air is the most important transport pathway from the INL Site to receptors residing outside the INL Site boundary. Because of this pathway, samples of airborne particulates, atmospheric moisture, and precipitation were collected onsite, at INL Site boundary locations, and at offsite communities. These samples were analyzed for radioactivity in 2024.

INL Site contractors collect particulate filters from a network of air samplers and analyze them for gross alpha activity, gross beta activity, and the specific radionuclides described in Subsections 4.3.2 and 4.4.2. Then, the results were compared with the detection levels, background measurements, historical results, and radionuclide-specific Derived Concentration Standards (DCSs) established by the U.S. Department of Energy (DOE) to protect human health and the environment. Gross alpha and gross beta activities were used primarily for the trend analyses, which indicated observable fluctuations that correlate with seasonal variations in natural radioactivity.

The INL contractor detected amounts of americium-241 (^{241}Am), cesium-137 (^{137}Cs), strontium-90 (^{90}Sr), and zinc-65 (^{65}Zn) in some quarterly composited samples collected during 2024. All of these concentrations were within the historical measurements made during the past ten years (2014–2023), and well below the DCSs for these radionuclides.

The Idaho Cleanup Project (ICP) contractor detected amounts of ^{241}Am, plutonium-238 (^{238}Pu), and plutonium-239/240 ($^{239/240}$Pu) from some quarterly composited samples collected during 2024. These amounts were comparable to the last 5 years) and are likely due to resuspended soils contaminated from past burial practices in the Subsurface Disposal Area (SDA). The results were below the DCSs 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 rather than from INL Site releases. All measured results were below the health-based regulatory limits.

4. ENVIRONMENTAL MONITORING PROGRAMS – AIR

Although all INL Site facilities are carefully managed and controlled, the potential exists to release radioactive and nonradioactive hazardous constituents in amounts above the regulatory limits during an operational upset or emergency incident situation. In such an event, pathway vectors, such as air (see Chapter 4); soil, plants, animals (see Chapter 7); and groundwater (see Chapters 5 and 6) may transport these constituents to nearby populations. A conceptual model showing routes of exposure/pathways for these potential environmental releases can be found here. 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 complies with regulatory standards and limits, and can be used to assess the impact to the environment over time. This chapter presents the INL Site contractors results of radiological analyses of airborne effluents and ambient air samples collected both on and off the INL Site. Click here for a summary of the radiological air monitoring activities relative to INL's major radiological sources, as well as the minor onsite and offsite radiological sources. Details may be found in the INL Site Environmental Monitoring Plan (DOE-ID 2023).

4.1 Organization of Air Monitoring Programs

The INL Site contractors document airborne radiological effluents at all INL Site facilities in an annual report prepared in accordance with 40 CFR 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities." Subsection 4.2 summarizes the emissions reported in "National Emission Standards for Hazardous Air Pollutants—Calendar Year 2024 INL Report for Radionuclides" (DOE-ID 2025), 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 contractor to ensure the INL Site remains in compliance with the requirements in DOE O 458.1, "Radiation Protection of the Public and the Environment."

The INL contractor collects air samples primarily around the INL Site encompassing a region of 23,390 km^2 (9,000 mi^2), which also extends to Jackson, Wyoming. In addition, the INL contractor collects air moisture samples at eight locations and precipitation samples at four locations for tritium analysis. Subsection 4.3 summarizes the results for ambient air monitoring conducted in 2024.

The ICP 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 RWMC and the Idaho Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Disposal Facility (ICDF) near the Idaho Nuclear Technology and Engineering Center (INTEC). Subsection 4.4 discusses the air sampling process the ICP contractor performs in support of waste management activities. In 2024, the ICP contractor collected approximately 210 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 historically have been tabulated, summarized, and reported in several climatography reports and used by scientists to evaluate atmospheric transport and dispersion. The latest report, "Climatography of the Idaho National Laboratory," Fourth Edition (Clawson et al. 2018), was prepared by the Special Operations and 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. More recent data are provided by the Special Operations and Research Division to scientists modeling the dispersion of INL Site releases (see Chapter 8 in this annual report and a supplement to this annual report, "Meteorological Monitoring," for more information).

4.2 Airborne Effluent Monitoring

Each regulated INL Site facility determines the airborne effluent concentrations from its regulated emission sources as required under state and federal regulations. Radiological air emissions from INL Site facilities also are used to estimate the potential dose to a hypothetical MEI, who is a member of the public (see Figures 8-1, 8-2, and 8-3 of this report). Radiological effluents and the resulting potential dose for 2024 are reported in the NESHAP Modeling Report (INL 2025a) and the NESHAP Report (DOE-ID 2025).

The NESHAP Report includes three categories of airborne emissions:

- Sources that require continuous monitoring under the NESHAP regulation are primarily the stacks at MFC, the Advanced Mixed Waste Treatment Project, and INTEC
- Releases from all other point sources (e.g., stacks, 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 2024, an estimated 1,588 Ci (5.88×10^{13} Bq) of radioactivity was released to the atmosphere from all INL Site sources. The 2024 release is 110% lower than the estimated total of 3,341 Ci (1.24×10^{14} Bq) released in 2023. See DOE/ID-11441, "National Emissions Standards for Hazardous Air Pollutants—Calendar Year 2024 INL Report for Radionuclides," for further information about facility emissions. Figure 4.1 shows the facilities that were major contributors to the total emissions.

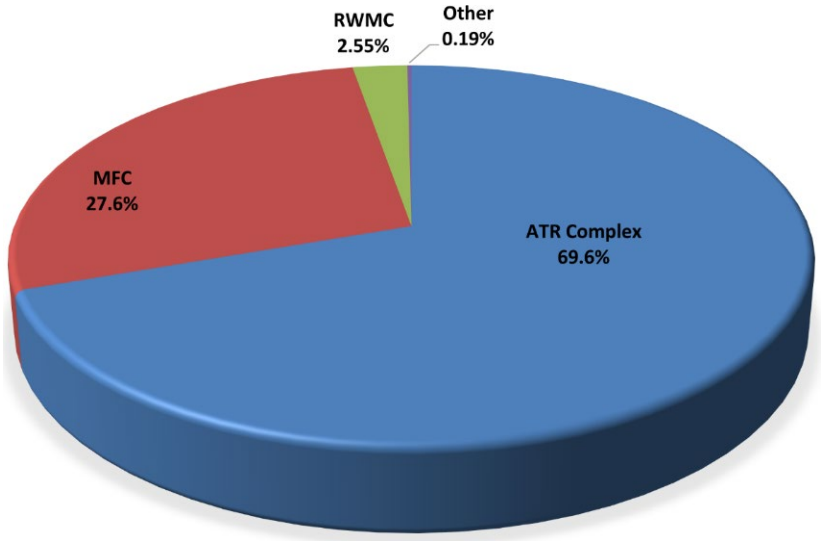

Figure 4-1. Percent contributions in Ci, by facility, to total INL Site airborne radiological releases (2024).

The estimated radionuclide releases (Ci/yr) from INL Site facilities, as shown in Table 4-1, were used to calculate the dose to the hypothetical MEI member of the public, who is assumed to reside near the INL Site perimeter. To calculate the dose to the MEI, radionuclides with very short half-lives must be converted to the first progeny with a suitable half-life for modeling, where applicable. The estimated emissions are then scaled based on the difference in activity between the parent and the progeny. The estimated dose to the MEI in calendar year 2024 was 0.015 mrem/yr (0.15 µSv/yr), which is below the regulatory standard of 10 mrem/yr. Six radionuclides—uranium-238 (^{238}U), uranium-234 (^{234}U), chlorine-36 (^{36}Cl), tritium (^{3}H), cesium-137 (^{137}Cs), and strontium-90 (^{90}Sr)—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.

4.3 Ambient Air Surveillance Monitoring

Ambient air surveillance monitoring is conducted onsite and offsite to identify regional and historical trends, detect accidental and unplanned releases, and determine whether air concentrations are below the DCSs established by DOE for inhaled air (DOE 2021). 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). All ambient air surveillance monitoring sample results for 2024 are provided in the quarterly surveillance reports (INL 2025b, INL 2025c, INL 2025d, and INL 2025e).

4.3.1 Sampling Design

The INL contractor monitors a total of 36 low-volume air samplers (including four quality assurance samplers), one high-volume air sampler, eight atmospheric moisture samplers, and four precipitation samplers that operated in the network in 2024.

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 to predict air concentrations at each sampler location for a given release time and duration. The frequency of detection is defined as the fraction of events resulting in a detection at either a single sampler or within the 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 (i.e., 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 the performance of the network. In 2019, the frequency of detection method was used to evaluate the REC facilities in Idaho Falls (INL 2019), which resulted in the installation of an additional monitor at the INL Research Center.

Table 4-1. Radionuclide composition of INL Site airborne effluents (2024).[a]

AIRBORNE EFFLUENT (Ci)[b]												
RADIONUCLIDE[c]	HALF-LIFE[d]	ATR COMPLEX	CFA[e]	CITRC[e]	INTEC	MFC	NRF[e]	RRTR[e]	RWMC	SMC[e]	TAN[e]	TOTAL
Americium-243	7,350 y	NS	1.06E-05	—	—	NS	NS	—	—	—	—	1.06E-05
Argon-41	1.83 h	8.84E+02	NS	—	—	7.70E+01	—	—	—	—	—	9.61E+02
Carbon-14	5730 y	NS	NS	NS	3.19E-02	—	5.80E-01	—	NS	—	—	6.12E-01
Chlorine-36	3.01×10^5 y	—	NS	—	NS	7.19E-03	—	—	—	—	—	7.19E-03
Cobalt-60	5.271 y	5.10E-03	NS	—	5.17E-06	NS	NS	—	NS	—	—	5.11E-03
Hydrogen-3	12.3 y	1.94E+02	3.50E-01	4.33E-01	1.77E-01	2.17E+02	NS	—	4.05E+01	—	NS	4.52E+02
Iodine-129	1.57×10^7 y	NS	NS	NS	1.06E-04	NS	NS	—	—	—	—	1.06E-04
Krypton-85	10.756 y	—	NS	—	1.09E+00	NS	NS	—	—	—	—	1.09E+00
Krypton-87	76.3 min	NS	NS	—	—	9.96E+00	—	—	—	—	—	9.96E+00
Krypton-88	2.84 h	NS	NS	—	—	9.06E+00	—	—	—	—	—	9.06E+00
Plutonium-238	87.7 y	NS	NS	—	7.68E-08	NS	NS	—	NS	—	—	7.68E-08
Plutonium-239	24,065 y	NS	NS	—	4.26E-08	NS	2.02E-06	—	NS	—	—	2.06E-06
Plutonium-241	14.329 y	NS	NS	—	1.56E-06	NS	NS	—	NS	—	—	1.56E-06
Plutonium-242	3.75×10^5 y	NS	6.50E-07	—	2.97E-16	NS	NS	—	—	—	—	6.50E-07
Strontium-90	29.12 y	2.88E-02	NS	—	2.60E-06	2.42E-03	4.53E-05	—	NS	—	3.01E-05	3.13E-02
Uranium-234	2.46×10^5 y	NS	NS	—	NS	4.35E-02	—	—	—	2.38E-09	—	4.35E-02
Uranium-235	7.04×10^8 y	NS	NS	1.94E-10	NS	2.63E-03	—	—	NS	NS	—	2.63E-03
Uranium-238	4.5×10^9 y	NS	NS	1.52E-08	NS	4.34E-02	—	—	NS	1.09E-08	—	4.34E-02
Xenon-135	9.09 h	2.04E+01	NS	—	—	NS	—	—	—	—	—	2.04E+01
Xenon-138	14.1 min	NS	—	—	—	1.54E+01	—	—	—	—	—	1.54E+01
TOTAL CURIES RELEASED		1.10E+03	3.50E-01	4.33E-01	1.30E+00	3.45E+02	5.81E-01	1.50E-05	4.05E+01	1.33E-08	3.01E-05	1.49E+03
TOTAL DOSE (mrem)[h]		6.83E-04	1.22E-05	2.04E-06	3.39E-06	1.39E-02	7.69E-05	1.65E-11	2.95E-04	3.78E-10	1.10E-06	1.49E-02

a. Radionuclide release information provided by the INL contractor (INL 2025a).

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

c. Includes only those radionuclides that 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, and y = years.

e. CFA = Central Facilities Area, CITRC = Critical Infrastructure Test Range Complex, NRF = Naval Reactors Facility, RRTR = Radiological Response Training Range, SMC = Specific Manufacturing Capability, TAN = Test Area North.

f. NS = not significant. The radionuclide was estimated to not be one of the top 99.9% contributors to 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 2024.

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

Tritium, a radioactive form of hydrogen with a half-life of about 12 years, is monitored at specific locations across the INL Site as part of the air surveillance monitoring program. It combines with oxygen to form tritiated water, which behaves like regular water and can be found in surface water, precipitation, and atmospheric moisture. Tritium naturally occurs in the atmosphere due to cosmic rays interacting with atmospheric gases and can be detected in precipitation. Since the 1963 Nuclear Test Ban Treaty, tritium levels in precipitation have decreased due to radioactive decay and dilution in the oceans. The International Atomic Energy Agency has participated in surveying tritium compositions in precipitation around the globe since 1961. Long-term data suggest that tritium levels in precipitation are close to their prenuclear test values (Cauquoin et al. 2015). At the INL Site, tritium in precipitation is likely from natural sources rather than weapons testing. Tritium present in air moisture is likely due to natural atmospheric production, past global nuclear fallout, and releases from INL Site facilities. Historical emissions data show that most tritium was released from the ATR Complex, INTEC, and RWMC. Atmospheric moisture samplers are placed at seven locations: Atomic City, Craters of the Moon, EFS, Howe, Idaho Falls (two samplers), the RHLLW Disposal Facility, and Van Buren Boulevard. The INL contractor has collocated precipitation samplers at four locations: Atomic City, EFS, Howe, and Idaho Falls. The EPA has a precipitation sampler in Idaho Falls and subsamples are collected for the INL contractor.

Although there are more particulate air surveillance monitoring stations, additional atmospheric moisture and precipitation monitoring stations are not needed as the estimated potential dose from INL Site releases is less than 0.1 mrem/yr, which is DOE's recommended limit for routine surveillance (DOE 2015). For more information on dose, see Chapter 8.

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

4.3.2 Sampling Methods

Air Particulates

Filters are collected weekly by the INL contractor from a network of low-volume air samplers. 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 collected air filter. Gross alpha activity is detected intermittently, but it tends to be detected more often during wildfires and when there are 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. Also gross alpha and gross beta activity are 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 analytical laboratory prior to analysis for gamma-emitting radionuclides, such as ^{137}Cs, which is a man-made radionuclide present in soil both onsite and offsite 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 typically are detected in air filter monitoring include beryllium-7 (^{7}Be) and potassium-40 (^{40}K).

The INL contractor also uses a contracted laboratory to radiochemically analyze quarterly composited samples for selected alpha- and beta-emitting radionuclides, including ^{241}Am, ^{36}Cl, ^{238}Pu, $^{239/240}Pu$, $^{233/234}U$, ^{238}U, and ^{90}Sr. In 2024, an analysis of quarterly composite samples for ^{36}Cl, $^{233/234}U$, and ^{238}U began as a result of the radionuclides being listed as contributors to the estimated MEI annual dose (see Chapter 8, Subsection 8.2.1). MFC was listed as the location with a ^{36}Cl source term that contributed >0.005%; therefore, analysis for ^{36}Cl was only performed on samples collected from MFC. Additional radionuclides 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 from global fallout.

Radioiodine

Charcoal cartridges are collected and analyzed weekly for iodine-131 (^{131}I) by the INL contractor at the same locations as the air filters. The ^{131}I isotope 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 concentration of ^{131}I in the environment could be from a recent release of fission products.

Tritium

Air is passed through an adsorbent material (molecular sieve) that captures water vapor. Once enough moisture has been collected, the molecular sieve is sent to a laboratory for analysis. The laboratory extracts water from the material by distillation and determines the tritium concentrations through liquid scintillation counting.

Precipitation samples collected by the INL contractor are also analyzed for tritium using liquid scintillation counting.

4.3.3 Ambient Air Surveillance Monitoring Results

Gaseous Radioiodines

The INL contractor collected and analyzed approximately 1,844 charcoal cartridges—including blanks and duplicates—in 2024. There were no statistically positive measurements of ^{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. This data provides useful information for trending of the total activity over time.

Results that detected gross alpha and gross beta by ambient air surveillance monitoring conducted by the INL contractor are summarized in Table 4-2.

Table 4-2. Gross alpha and gross beta detected in ambient air samples collected by the INL contractor in 2024.

RADIONUCLIDE	NUMBER OF DETECTED RESULTS[a]	LOCATION OF MINIMUM DETECTED CONCENTRATION	MINIMUM CONCENTRATION (10^{-15} µCi/mL)[b]	LOCATION OF MAXIMUM DETECTED CONCENTRATION	MAXIMUM CONCENTRATION (10^{-15} µCi/mL)
Gross Alpha	1,208 of 1,593	Craters of the Moon	0.77 ± 0.25	MFC South	7.07 ± 0.81
Gross Beta	1,579 of 1,593	EBR-I	1.08 ± 0.35	Arco	276.00 ± 3.78

a. Excludes blanks and duplicates.
b. Results ± 1σ. Results shown are ≥ 3σ and below the DCS values for these radionuclides in air.

Gross Alpha. The elevated alpha result for the air filter collected at MFC South (7.07 ±.81) × 10^{-16} µCi/mL on December 11, 2024, is likely the result of a temperature inversion.

The maximum result is less than the DCS (DOE 2022) of 1.1 × 10^{-13} µCi/mL for $^{239/240}Pu$, which is the most conservative specific radionuclide DCS that could be—although unrealistically—applied to gross alpha activity. Gross alpha results are within the historical range, as shown in Figure 4-2.

Gross Beta. The highest detected value (i.e., greater than three sigma [3σ]) was (27.6 ± 0.4) × 10^{-14} µCi/mL collected by the INL contractor at Arco on March 27, 2024. In general, median airborne radioactivity levels for the onsite, boundary, and offsite locations tracked each other closely throughout the year and are within the historical range of the past four years, as observed in Figure 4-2. The typical temporal fluctuations for natural gross beta concentrations in the air were observed, with higher values usually occurring at the beginning and end of the calendar year during winter inversion conditions (see sidebar). This pattern occurs over the entire sampling network, is representative of natural conditions, and is not caused by a localized source, such as a facility or activity at the INL Site. An inversion can lead to natural radionuclides being trapped close to

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.

the ground. The maximum weekly gross beta concentration is significantly below the DCS of 9.6 × 10^{-12} µCi/mL for the most restrictive beta-emitting radionuclide in the air, ^{90}Sr.

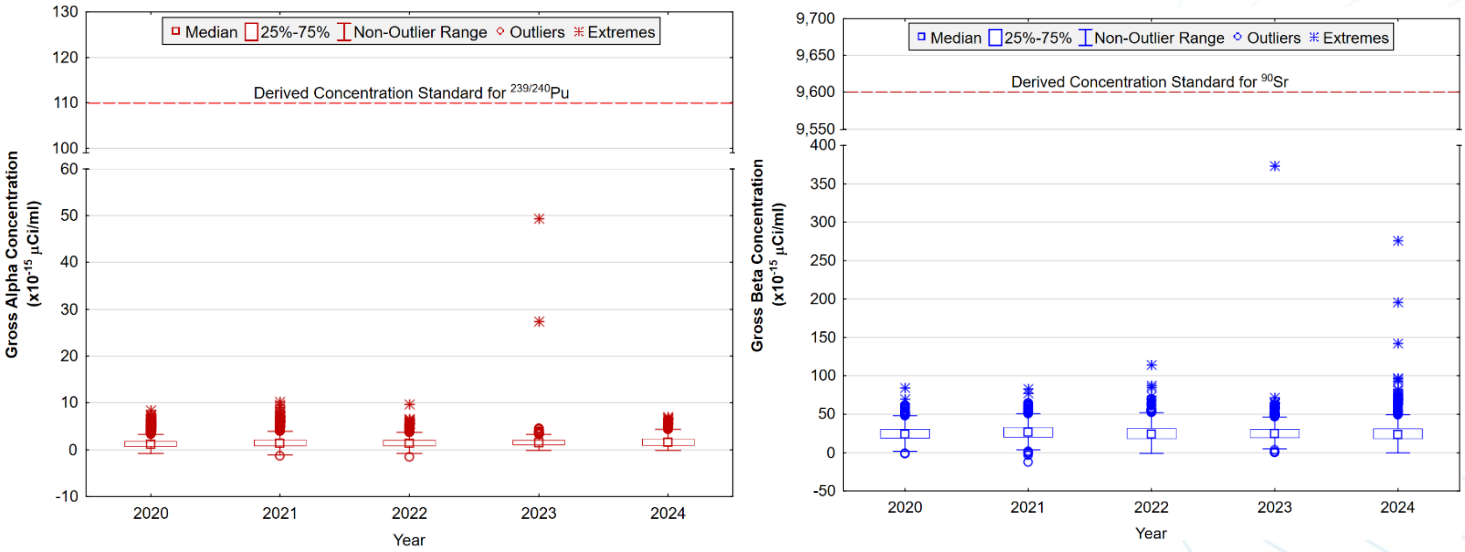

Figure 4-2. Gross alpha (left) and gross beta (right) five-year trend.

Gross Activity Statistical Comparisons. Statistical comparisons were made using the gross alpha and gross beta radioactivity data collected by the INL contractor from the onsite, boundary, and offsite locations. For these analyses, uncensored analytical results (i.e., values less than their analysis-specific minimum detectable concentrations) were included. There were a few statistical differences between the monthly and quarterly datasets collected by the INL contractor during 2024 that can be attributed to expected statistical variation in the data and not to the INL Site releases detailed in the quarterly reports.

Specific Radionuclides

The INL contractor observed a detection of ^{137}Cs and ^{65}Zn in a quarterly composited sample collected from EBR-I during the third quarter, as indicated in Table 4-3. Concentrations of ^{241}Am were detected in two quarterly composited samples. The detectable concentrations ranged from 1.86 x 10^{-17} µCi/mL at Van Buren during the first quarter to 2.90 x 10^{-17} µCi/mL at RWMC during the third quarter. Concentrations of ^{90}Sr were detected in six quarterly composited samples. The detectable concentrations ranged from 5.46 x 10^{-17} µCi/mL at RHLLW during the first quarter to 6.14 x 10^{-16} µCi/mL at Van Buren also during the first quarter as well. All results were within the historical measurements made during the past ten years from 2014–2023. All results were well below the DCSs for these radionuclides in air (i.e., 3.8 x 10^{-11} µCi/mL for ^{137}Cs, 9.6 × 10^{-12} µCi/mL for ^{90}Sr, 1.2 × 10^{-9} µCi/mL for ^{65}Zn, and 1.3 × 10^{-13} µCi/mL for ^{241}Am). In addition to the radionuclides discussed earlier, the INL contractor began surveillance monitoring for uranium during 2023. The detections of uranium radionuclides, as observed in Table 4-3, occur routinely at concentrations that suggest a natural origin (INL 2024c, INL 2024d, INL 2024e). Concentrations of ^{36}Cl were not detected in the quarterly composite samples collected from the samplers located at MFC in 2024. Natural ^{7}Be was detected in numerous INL contractor composite samples at concentrations consistent with past concentrations. Levels of atmospheric ^{7}Be result from reactions of galactic cosmic rays and solar energetic particles with nitrogen and oxygen nuclei in Earth's atmosphere.

Table 4-3. Human-made radionuclides detected in ambient air samples collected by the INL contractor in 2024.

RADIONUCLIDE	NUMBER OF DETECTED RESULTS	LOCATION OF MINIMUM DETECTED CONCENTRATION	MINIMUM CONCENTRATION (µCi/mL)[a]	LOCATION OF MAXIMUM DETECTED CONCENTRATION	MAXIMUM CONCENTRATION (µCi/mL)
Americium-241	2 of 148	Van Buren	(1.86 ± 0.53) E-17	RWMC	(2.90 ± 0.55) E-17
Cesium-137	1 of 148	NA[b]	ND[c]	EBR-I	(3.09 ± 0.84) E-16
Strontium-90	6 of 148	RHLLW	(5.46 ± 1.80) E-17	Van Buren	(6.14 ± 0.47) E-16
Uranium-233/234	23 of 148	Blackfoot	(1.62 ± 0.50) E-17	MFC-North	(5.20 ± 1.27) E-17
Uranium-238	32 of 148	Howe	(1.26 ± 0.41) E-17	EBR-I	(4.99 ± 1.04) E-17
Zinc-65	1 of 148	NA	ND	EBR-I	(7.92 ± 1.36) E-16

a. Results ± 1σ. Results are ≥ 3σ and below the DCS values.
b. NA = Not applicable.
c. ND = Not detected.

4.3.4 Atmospheric Moisture Surveillance Monitoring Results

During 2024, the INL contractor collected 76 atmospheric moisture samples at Atomic City, Craters of the Moon, EFS, Howe, Idaho Falls, RHLLW facility, and Van Buren. Table 4-4 shows a total of four tritium detections in 2024. The observed tritium concentrations are far below the DCS for tritium in air (as water vapor) of 1.3×10^{-7} $\mu Ci/mL_{air}$.

Table 4-4. Tritium detected in atmospheric moisture samples collected by the INL contractor in 2024.

RADIONUCLIDE	NUMBER OF DETECTED RESULTS	LOCATION OF MINIMUM DETECTED CONCENTRATION	MINIMUM CONCENTRATION (pCi/mL_{air})[a]	LOCATION OF MAXIMUM DETECTED CONCENTRATION	MAXIMUM CONCENTRATION (pCi/mL_{air})
Tritium	4 of 76	Craters of the Moon	(3.60 ± 1.17) E-13	Idaho Falls	(8.23 ± 2.61) E-13

a. Results ± 1σ. Results are below the DCS value for tritium in air (as water vapor) 1.3×10^{-7} uCi/mL_{air}.

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. Tritium releases from non-fugitive sources are highly localized and although they may be detected immediately adjacent to the facility, they are unlikely to be detected at current air surveillance monitoring stations because of atmospheric dispersion.

4.3.5 Precipitation Surveillance Monitoring Results

The INL contractor collects precipitation samples weekly, when available, at Atomic City, EFS, and Howe. Precipitation is collected monthly at Idaho Falls for EPA RadNet monitoring and a subsample is taken by the INL contractor for analysis. A total of 69 precipitation samples were collected during 2024 from the four sites. Tritium was not detected in any of the samples. The DCS value is 2.6×10^{6} pCi/L for tritium in water and within the historical range (-173 to 413 pCi/L) measured from 2014–2023. Then the results were compared with tritium concentrations reported by the EPA for precipitation during the 10-year period from 2002–2011 (measurements discontinued after 2011) based on the query of available data. Concentrations reported by EPA for Idaho Falls during that period ranged from -84–1718 pCi/L and averaged 35.1 pCi/L.

Annual tritium concentrations in atmospheric moisture and precipitation have no discernible statistical distribution, so nonparametric statistical methods were used to assess both datasets (see "Statistical Methods Used in the Idaho National Laboratory Annual Site Environmental Report," a supplement to this annual report). To summarize these results, box plots were constructed illustrating the annual tritium concentrations measured in atmospheric moisture (as water) and precipitation samples collected by the INL contractor for the past 10 years, as observed in Figure 4-3. The results appear to be similar for each year. A statistical comparison of both datasets using the non-parametric Wilcoxon Matched Pairs Test shows there are no differences between the median annual tritium concentrations measured in atmospheric moisture and in the 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.

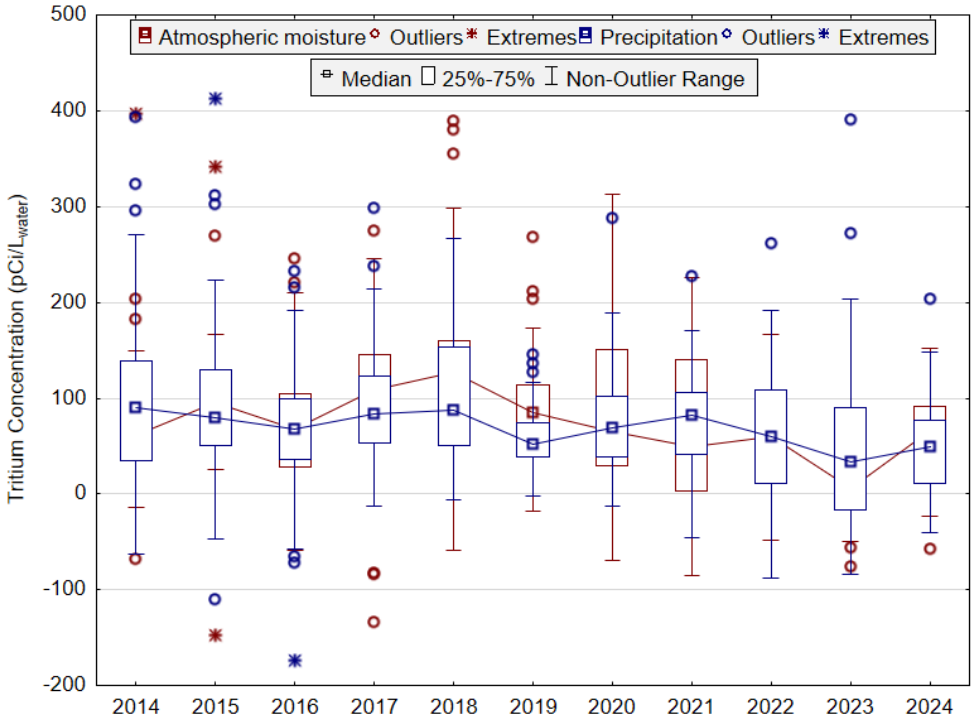

Figure 4-3. Box plots of tritium concentrations measured in atmospheric moisture and in precipitation from 2014–2024.

4.4 Waste Management Environmental Air Surveillance Monitoring

4.4.1 Gross Activity

The ICP contractor conducts environmental surveillance monitoring in and around waste management facilities to comply with DOE O 435.1, "Radioactive Waste Management." Currently, ICP 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 contractor collected samples of airborne particulate material from the perimeters of these waste management areas in 2024. Also, samples were collected at a control location at Howe to compare with the results of the SDA and ICDF.

Samples were obtained using suspended particulate monitors similar to those used by the INL contractor. The 4-in.-diameter air filters are changed out on the closest working day to the first and the fifteenth of each month. Gross alpha and gross beta activity were determined on all suspended particulate samples. Table 4-5 shows the range of detected gross alpha and beta concentrations for 2024.

Table 4-5. Gross alpha and gross beta detected in ambient air samples collected by the ICP contractor in 2024.

RADIONUCLIDE	NUMBER OF DETECTED RESULTS	LOCATION OF MINIMUM DETECTED CONCENTRATION	MINIMUM CONCENTRATION (µCi/mL)[a]	LOCATION OF MAXIMUM DETECTED CONCENTRATION	MAXIMUM CONCENTRATION (µCi/mL)
Gross Alpha	167 of 182	SDA 9.3	1.71E-19	SDA 4.2C	1.82E-15
Gross Beta	167 of 182	SDA 9.3	2.89E-18	SDA 11.3	2.88E-14

a. Results ±1σ. Results are ≥3σ and below the derived concentration standard values for these radionuclides in air.

The 2024 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 background monitoring location in Howe.

4.4.2 Specific Radionuclides

Air filters are collected by the ICP contractor, 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 2024, no human-made, beta-emitting, gamma-emitting, or alpha-emitting radionuclides were detected in air samples at ICDF at INTEC. No gamma-emitting or beta-emitting radionuclides were detected in air samples at the RWMC SDA.

Table 4-6 shows human-made specific radionuclides detected in the SDA in 2024. These detections are consistent with levels measured in the air at the SDA in the last 5 years. All detections were three to four orders of magnitude below the DCS, as stipulated in DOE 2022. Statistically, false positives at the 95% confidence error are possible.

Table 4-6. Human-made radionuclides detected in ambient air samples collected by the ICP contractor in 2024.

RADIONUCLIDE	NUMBER OF DETECTED RESULTS	LOCATION OF MINIMUM DETECTED CONCENTRATION	MINIMUM CONCENTRATION (µCi/mL)[a]	LOCATION OF MAXIMUM DETECTED CONCENTRATION	MAXIMUM CONCENTRATION (µCi/mL)
Americium-241	5 of 54	SDA 9.3	1.64E-17	SDA 4.2C	3.47E-16
Plutonium-238	1 of 27	SDA 4.2C	7.37E-18	–	–
Plutonium-239/240	3 of 27	SDA 2.3	1.02E-16	SDA 4.2C	1.34E-16
Uranium-233-234	19 of 27	SDA 6.3	1.42E-17	SDA 9.3A	7.62E-17
Uranium-238	17 of 27	SDA 9.3	1.37E-17	SDA 11.3A	8.25E-17

a. Results ±1σ. Results are ≥3σ and below the derived concentration standard values for these radionuclides in air.

In addition to the human-made, gamma-emitting radionuclides discussed above, the ICP contractor monitors for uranium. Detections of uranium radionuclides occur routinely at concentrations that suggest a natural origin, as shown in Table 4-6.

4.5 Hydrofluorocarbon Phasedown

Hydrofluorocarbons (HFCs) are the third generation of refrigerants; they were developed to replace Class II ozone-depleting substances. HFCs are used in the same applications in which ozone-depleting substances have historically been used, such as refrigeration and air conditioning, foam-blowing agents, solvents, aerosols, and fire-suppression systems. HFCs are non-ozone-depleting; however, they are also potent greenhouse gases with 100-year global warming potentials (e.g., 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 HFC emissions 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 consumption of HFCs. This is not a phaseout of HFC production, it is a phasedown. The end goal is an 80% reduction in production by 2036 as compared to the 2013 production baseline (OE-3 2021-06). This will decrease the availability of HFCs and increase their overall cost but the HFCs still will be available. The EPA recently finalized regulations restricting the use of some HFCs in certain applications; the compliance dates vary depending on the application. As with the phasedown regulations, the EPA is not prohibiting or restricting the use of existing equipment.

4.5.1 INL Contractor

The INL contractor compiled a list of equipment at its facilities containing 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, engineering personnel, maintenance personnel, and environmental support and services personnel. The list includes heating, ventilating, and air conditioning (HVAC) systems that contain 50 pounds or more of refrigerant and computer room-air conditioning units that contain 50 pounds or more of refrigerant, fire-protection systems, and laboratory equipment. Most of the laboratory equipment containing HFCs were chillers used to cool specific pieces of equipment. Other laboratory equipment containing HFCs includes environmental chambers, a microwave digester, non-rad- and rad-

separator ion sources, non-rad- and rad-separator magnets, and a laser flash. This list does not include small HVAC equipment in 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. The INL contractor identified 236 pieces of equipment and systems.

A list of equipment containing HFCs was obtained in March 2022. This list includes 46 HVAC systems that contain 50 pounds or more of refrigerant, 26 computer room-air conditioning units, six fire-protection systems, and 158 chillers, condensing units, etc., for laboratory equipment. There are currently no changes to operations because this is a phasedown—not a phaseout—and the EPA is not prohibiting the use of HFCs in existing equipment.

Additionally, the INL contractor is participating in the voluntary HFC Task Team led 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 wrote an Operating Experience Summary for the DOE Complex that provides information on operational impacts to critical systems from these regulations, which will decrease the amount of HFCs manufactured in the future (OES-2022-03, HFC Phasedown Impacts Critical Operations). The task team is currently exploring methods for documenting and sharing the review of alternatives within the DOE Complex.

The INL contractor issued a program description document (PDD) to implement the regulations for the use of HFCs and to inform applicable employees (e.g., engineers, environmental compliance professionals, project managers) of the requirements. Issuance included a required read by the applicable employees. The PDD will be listed in STD-139, "INL Engineering Standards" (INL 2021).

The INL contractor is in the process of implementing the HFC management regulations. This includes compiling a list of all HVAC equipment with a full charge of 15 pounds or more of HFC and creating a computer-based training for HVAC technicians.

4.5.1 ICP Contractor

An inventory of refrigeration equipment at ICP facilities, using HFCs scheduled for phasedown, was conducted in December 2021. This activity identified two chillers with four total circuits using HFC-134a at the Integrated Waste Treatment Unit (IWTU). The total charge for both chillers is approximately 830 lb. These units will continue to be used throughout the IWTU mission. ICP preventative maintenance practices will minimize the potential for leaks. ICP 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 the loss of HFC-134a that renders the units inoperable, they would be replaced or retrofitted. New equipment at ICP will be specified to use refrigerants that are not subject to the HFC phasedown.

4.6 References

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