# Chapter 8: Dose to the Public and Biota

## CHAPTER 8

Airborne emissions from operations at the Idaho National Laboratory (INL) Site were used to determine the potential radiological dose to members of the public using the Clean Air Act Assessment Package-1988 personal computer (CAP88-PC) program. The annual dose to the maximally exposed individual (MEI) in 2024, as determined using CAP88-PC, was 0.015 mrem (0.15 µSv), which was well below the applicable standard of 10 mrem (100 µSv) per year. In 2024, no human-made radionuclides were detected in edible portions of big game animals or waterfowl, indicating there is no dose associated with the ingestion of game animals. Therefore, the total dose to the MEI during 2024 was estimated to be 0.015 mrem (0.15 µSv). This dose is also well below the public dose limit of 100 mrem (1 µSv) established by the United States (U.S.) Department of Energy (DOE) for a member of the public.

The maximum potential population dose to the approximately 358,426 people residing within an 80 km (50 mi) radius of any INL Site facility was also evaluated as well. The population dose was calculated using reported releases, an air dispersion model known as the HYbrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) used by the National Oceanic and Atmospheric Administration (NOAA) Special Operations and Research Division, and a dose calculation model. For 2024, the estimated potential population dose was 0.012 person-rem (0.00012 person-Sv). This is approximately 0.00001% of the expected dose from exposure to natural background radiation of 139,069 person-rem (1,391 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. Additionally, maximum concentrations of radionuclides measured in waterfowl accessing INL Site ponds were used to estimate internal doses to the waterfowl. The estimated dose to waterfowl was calculated to be 0.00022 rad/d (0.0022 mGy/d). This calculation indicates the potential dose to waterfowl does not exceed the DOE limits of 0.1 rad/d (1 mGy/d).

## 8. DOSE TO THE PUBLIC AND BIOTA

DOE O 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 DOE control. 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 protecting the environment against ionizing radiation, DOE also developed technical standard DOE-STD-1153-2019, "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota" (DOE 2019). This standard provides a graded approach for evaluating radiation doses to aquatic and terrestrial biota.

Title 40 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 are calculated using U.S. Environmental Protection Agency (EPA)-approved sampling procedures, computer models, or other methods and procedures.

This chapter describes the estimated potential dose to members of the public and biota from operations at the INL Site, based on 2024 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 to determine whether 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.

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. Also, conservative doses were 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 INL Site roads 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 optically-stimulated luminescence dosimeters.

Water pathways were not considered major contributors to dose, because no surface water flows off the INL Site and radionuclides associated with INL Site releases have not 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 be released by the facilities. The 2024 INL National Emission Standards for Hazardous Air Pollutants (NESHAP) evaluation (DOE-ID 2025) reported potential radionuclide releases from 73 source locations at the INL Site. However, many of the sources resulted in doses that were insignificant, and many of these 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 five large operating stacks were modeled explicitly and included the Advanced Test Reactor (ATR) main stack (TRA-770), the Materials Test Reactor (MTR) stack (TRA-710), the Idaho Nuclear Technology and Engineering Center (INTEC) main stack (CPP-708), the Materials and Fuels Complex (MFC) Fuel Conditioning Facility stack (MFC-764), and the Transient Reactor Test Facility (TREAT) stack (MFC-720). All other releases within a facility were assigned as near ground-level releases from a single location within that facility. These other releases include other non-fugitive releases from stacks, ducts, and vents, as well as fugitive releases from ponds, soil, or other sources. Click here to see the location of all sources modeled in the dose assessment.

The radionuclides and source terms used in the dose calculations were presented previously in Table 4-1 of Chapter 4 and are summarized again in Table 8-1. Noble gases comprised the largest emission quantity but only contributed slightly to the dose. Radionuclides in the form of noble gases tend to have short half-lives and are not typically incorporated into the food supply. Radionuclides that contributed the most to the overall MEI estimated dose were uranium-238 ($^{238}U$), uranium-234 ($^{234}U$), chlorine-36 ($^{36}Cl$), tritium ($^{3}H$), cesium-137 ($^{137}Cs$), and strontium-90 ($^{90}Sr$). These radionuclides are a very small fraction of the total amount of radionuclides reported.

The following two kinds of dose estimates were made using the release data:

- ***The effective dose to the hypothetical MEI, as defined by the NESHAP regulations.*** The CAP88-PC model Version 4.1.1 (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 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 to comply with DOE O 458.1.

The dose estimates considered the 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 the soil. 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 2022), (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).

***Table 8-1. Summary of radionuclide composition of INL Site airborne effluents (2024).***

| | 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 | 1.93E+02 | 1.48E-19 | 9.10E+02 | 2.45E+00 | 1.19E-02 | 5.26E-05 | 2.88E-02 | 1.46E-05 | 1.75E-08 | 3.77E-07 | 3.40E-10 |
| CFA | 3.50E-01 | 4.21E-16 | 2.00E-05 | 1.20E-04 | 1.67E-06 | 2.54E-10 | 4.12E-08 | 1.34E-07 | 6.50E-07 | 5.98E-05 | 3.62E-15 |
| CITRC | 4.33E-01 | — | — | 3.20E-05 | 8.00E-08 | 1.81E-11 | — | — | — | — | — |
| INTEC | 1.77E-01 | 1.09E+00 | — | — | 3.20E-02 | 1.06E-04 | 2.60E-06 | 3.57E-07 | 1.68E-06 | 5.00E-08 | — |
| MFC | 2.17E+02 | 2.52E-01 | 1.71E+02 | 4.25E+01 | 1.80E-02 | 2.72E-06 | 7.50E+00 | 8.96E-02 | 6.18E-06 | 1.59E-05 | — |
| NRF | 3.90E-02 | 2.81E-01 | — | — | 5.81E-01 | 1.52E-05 | 4.53E-05 | 4.35E-10 | 2.12E-06 | 1.83E-07 | — |
| RRTR | — | — | — | — | — | — | — | — | — | — | — |
| RWMC | 4.05E+01 | — | — | — | 2.22E-02 | — | 9.02E-11 | 2.51E-11 | 5.55E-08 | 1.06E-07 | — |
| TAN | 1.45E-02 | — | — | — | — | — | 3.01E-05 | — | — | — | — |
| SMC | — | — | — | — | — | — | — | 1.34E-08 | — | — | — |
| **Total** | 4.52E+02 | 1.62E+00 | 1.08E+03 | 4.49E+01 | 6.65E-01 | 1.77E-04 | 7.53E+00 | 8.96E-02 | 1.07E-05 | 7.63E-05 | 3.40E-10 |

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

b. ATR Complex = Advanced Test Reactor Complex; CFA = Central Facilities Area; CITRC = Critical Infrastructure Test Range Complex; INTEC = Idaho Nuclear Technology and Engineering Center; MFC = Materials and Fuels Complex; NRF = Naval Reactors Facility; RRTR-NTR = Radiological Response Training Range-Northern Test Range; RWMC = Radioactive Waste Management Complex (including the Advanced Mixed Waste Treatment Project [AMWTP]); TAN = Test Area North; and SMC = Specific Manufacturing Capability.

c. Noble gases ($T_{1/2}$ > 40 days) released in 2024 = $^{39}$Ar, $^{81}$Kr, and $^{85}$Kr.

d. Noble gases ($T_{1/2}$ < 40 days) released in 2024 = $^{41}$Ar, $^{83m}$Kr, $^{85m}$Kr, $^{87}$Kr, $^{88}$Kr, $^{89}$Kr, $^{219}$Rn, $^{220}$Rn,$^{131m}$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 2024 = $^{109m}$Ag, $^{110}$Ag, $^{111m}$Ag, $^{94}$Au, $^{196m}$Au, $^{137m}$Ba, $^{139}$Ba, $^{80}$Br, $^{83}$Br, $^{84}$Br, $^{117}$Cd, $^{118}$Cd, $^{60m}$Co, $^{134m}$Cs, $^{135m}$Cs, $^{138}$Cs, $^{139}$Cs, $^{140}$Cs, $^{66}$Cu, $^{165}$Dy, $^{167m}$Er, $^{158}$Eu, $^{68}$Ga, $^{75}$Ge, $^{78}$Ge, $^{117}$In, $^{117m}$In, $^{118}$In, $^{188}$Ir, $^{142}$La, $^{56}$Mn, $^{101}$Mo, $^{97}$Nb, $^{149}$Nd, $^{65}$Ni, $^{111}$Pd, $^{150}$Pm, $^{144}$Pr, $^{144m}$Pr, $^{146}$Pr, $^{88}$Rb, $^{89}$Rb, $^{90}$Rb, $^{103m}$Rh, $^{104}$Rh, $^{106}$Rh, $^{106m}$Rh, $^{126m}$Sb, $^{128m}$Sb, $^{130}$Sb, $^{77m}$Se, $^{81}$Se, $^{81m}$Se, $^{123m}$Sn, $^{127}$Sn, $^{128}$Sn, $^{101}$Tc, $^{129}$Te, $^{131}$Te, $^{133}$Te, $^{133m}$Te, $^{134}$Te, $^{206}$Tl, $^{89m}$Y, $^{91m}$Y, and $^{69}$Zn.

f. Fission products and activation products ($T_{1/2}$ > 3 hours) released in 2024 = $^{108m}$Ag, $^{110m}$Ag, $^{111}$Ag, $^{112}$Ag, $^{113}$Ag, $^{76}$As, $^{77}$As, $^{78}$As, $^{195}$Au, $^{196}$Au, $^{198}$Au, $^{133}$Ba, $^{135m}$Ba, $^{140}$Ba, $^{10}$Be, $^{207}$Bi, $^{210}$Bi, $^{210m}$Bi, $^{80m}$Br, $^{82}$Br, $^{14}$C, $^{45}$Ca, $^{109}$Cd, $^{113m}$Cd, $^{115}$Cd, $^{115m}$Cd, $^{117m}$Cd, $^{139}$Ce, $^{141}$Ce, $^{143}$Ce, $^{144}$Ce, $^{36}$Cl, $^{38}$Cl, $^{57}$Co, $^{58}$Co, $^{60}$Co, $^{51}$Cr, $^{132}$Cs, $^{134}$Cs, $^{135}$Cs, $^{136}$Cs, $^{137}$Cs, $^{64}$Cu, $^{67}$Cu, $^{166}$Dy, $^{169}$Er, $^{171}$Er, $^{172}$Er, $^{152}$Eu, $^{152m}$Eu, $^{154}$Eu, $^{155}$Eu, $^{156}$Eu, $^{157}$Eu, $^{55}$Fe, $^{59}$Fe, $^{60}$Fe, $^{72}$Ga, $^{73}$Ga, $^{152}$Gd, $^{159}$Gd, $^{68}$Ge, $^{71}$Ge, $^{77}$Ge, $^{175}$Hf, $^{178m}$Hf, $^{179m}$Hf, $^{180m}$Hf, $^{181}$Hf, $^{182}$Hf, $^{203}$Hg, $^{166}$Ho, $^{167}$Ho, $^{115}$In, $^{115m}$In, $^{189}$Ir, $^{190}$Ir, $^{192}$Ir, $^{193m}$Ir, $^{40}$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, $^{112}$Pd, $^{147}$Pm, $^{148}$Pm, $^{148m}$Pm, $^{149}$Pm, $^{151}$Pm, $^{210}$Po, $^{142}$Pr, $^{143}$Pr, $^{145}$Pr, $^{195m}$Pt, $^{84}$Rb, $^{86}$Rb, $^{87}$Rb, $^{184}$Re, $^{184m}$Re, $^{186}$Re, $^{186m}$Re, $^{187}$Re, $^{188}$Re, $^{105}$Rh, $^{103}$Ru, $^{105}$Ru, $^{106}$Ru, $^{122}$Sb, $^{124}$Sb, $^{125}$Sb, $^{126}$Sb, $^{127}$Sb, $^{128}$Sb, $^{129}$Sb, $^{46}$Sc, $^{48}$Sc, $^{79}$Se, $^{32}$Si, $^{147}$Sm, $^{151}$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, $^{184}$Ta, $^{160}$Tb, $^{161}$Tb, $^{99}$Tc, $^{99m}$Tc, $^{123m}$Te, $^{125m}$Te, $^{127}$Te, $^{127m}$Te, $^{129m}$Te, $^{131m}$Te, $^{132}$Te, $^{204}$Tl, $^{171}$Tm, $^{172}$Tm, $^{49}$V, $^{181}$W, $^{185}$W, $^{187}$W, $^{188}$W, $^{88}$Y, $^{90}$Y, $^{90m}$Y, $^{91}$Y, $^{92}$Y, $^{93}$Y, $^{65}$Zn, $^{69m}$Zn, $^{71m}$Zn, $^{72}$Zn, $^{93}$Zr, $^{95}$Zr, and $^{97}$Zr.

g. Radioiodine released in 2024 = $^{125}$I, $^{126}$I, $^{128}$I, $^{129}$I, $^{130}$I, $^{131}$I, $^{132}$I, $^{132m}$I, $^{133}$I, $^{134}$I, and $^{135}$I.

h. Radiostrontium released in 2024 = $^{80}$Sr, $^{85}$Sr, $^{87m}$Sr, $^{89}$Sr, $^{90}$Sr, $^{91}$Sr, and $^{92}$Sr.

i. Uranium isotopes released in 2024 = $^{232}$U, $^{233}$U, $^{234}$U, $^{235}$U, $^{236}$U, $^{237}$U, and $^{238}$U.

j. Plutonium isotopes released in 2024 = $^{236}$Pu, $^{238}$Pu, $^{239}$Pu, $^{240}$Pu, $^{241}$Pu, $^{242}$Pu, and $^{244}$Pu.

k. Other actinides released in 2024 = $^{225}$Ac, $^{227}$Ac, $^{241}$Am, $^{242}$Am, $^{243}$Am, $^{252}$Cf, $^{242}$Cm, $^{243}$Cm, $^{244}$Cm, $^{248}$Cm, $^{237}$Np, $^{239}$Np, $^{231}$Pa, $^{233}$Pa, $^{234}$Pa, $^{234m}$Pa, $^{228Th}$, $^{229}$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 2024. These are typically heavy elements that are decay chain members of actinides. They include $^{214}$Bi, $^{214}$Pb, $^{226}$Ra, and $^{228}$Ra.

### 8.2.1 Maximally Exposed Individual Dose

The EPA NESHAP regulation requires a demonstration that radionuclides other than radon released to the 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). The 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 the data collected at multiple locations on the INL Site by NOAA.

The MEI that was calculated in 2024 remains at the same location as in previous years; however, it is now identified as Receptor 26 instead of Receptor 54. References to the MEI prior to 2019 (e.g., Receptor 1) continue to be referred to as Receptor 1 in the new arrangement (INL 2023).

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 2024 INL Report for Radionuclides* (DOE-ID 2025). To identify the MEI, the doses at 31 offsite locations were calculated and 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 26, which is a farmhouse and cattle operation located 3.1 km south of Highway 20 and 3 km from the east entrance of the INL Site. An effective annual dose of 0.015 mrem (0.15 µSv) was calculated for a hypothetical person living at Location 26 during 2024. Figure 8-1 compares the MEI doses calculated for years 2015–2024. 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.

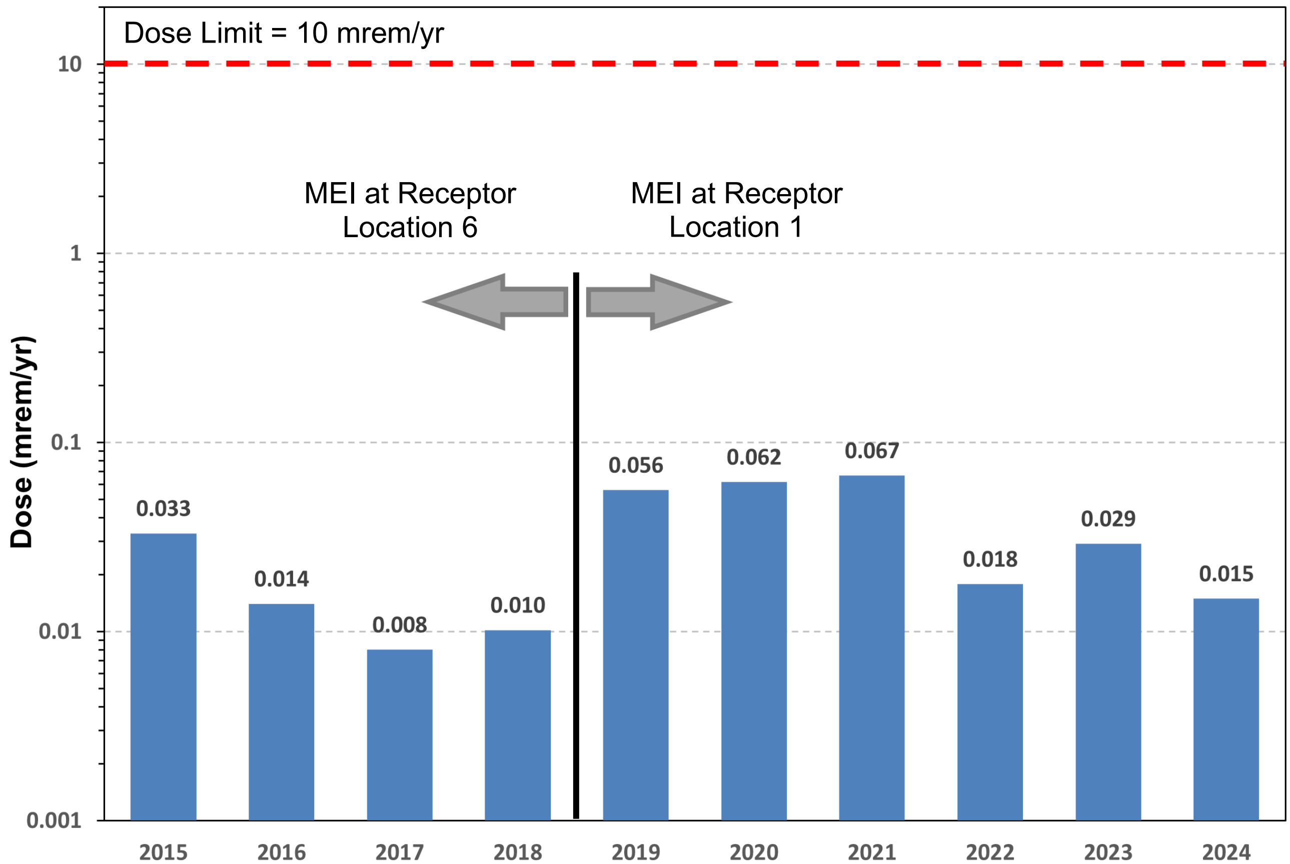


***Figure 8-1. MEI dose from INL Site airborne releases estimated for 2015–2024. See INL Site receptor locations.***

Although noble gases were the radionuclides that were released in the largest quantities in 2024, they accounted for less than 3.5% 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 60.5% of the total INL activity released was argon-41 ($^{41}$Ar), as shown in Table 4-1 of Chapter 4, yet $^{41}$Ar accounted for less than 3% of the estimated MEI dose. In contrast, radionuclides typically associated with airborne particulates, such as $^{238}$U, $^{234}$U, $^{36}$Cl, $^{137}$Cs, and $^{90}$Sr, comprised only a small fraction (e.g., less than 0.0088%) of the total amount of radionuclides reported to be released in Table 4-1 of Chapter 4, yet the radionuclides resulted in approximately 73.5% of the estimated MEI dose, as shown in Figure 8-2.

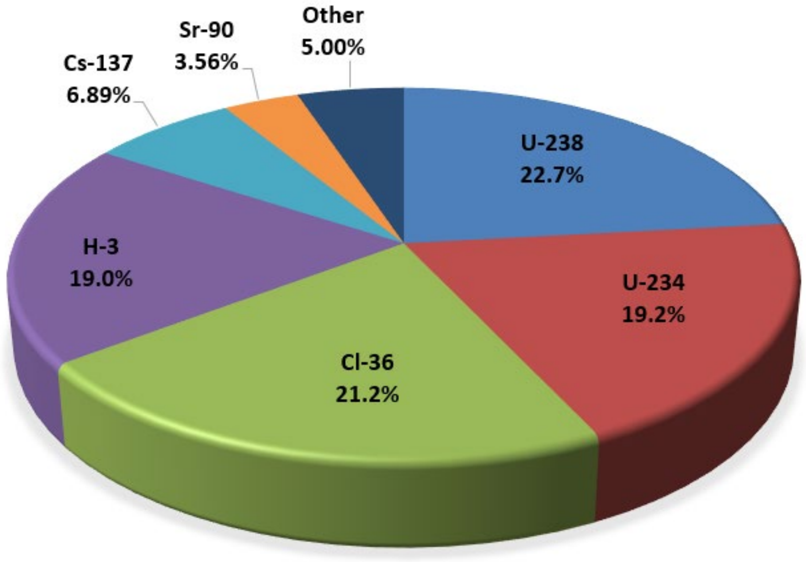


***Figure 8-2. Radionuclides contributing to the MEI dose from INL Site airborne effluents as calculated using the CAP88-PC Model (2024).***

Primary sources of the major radionuclides used to estimate the dose to the MEI, as indicated in Figure 8-3, were identified during the preparation of the annual NESHAP report (DOE-ID 2025) as follows:

- Amounts of $^{238}$U and $^{234}$U account for 22.7% and 19.2% of the MEI dose, respectively; the majority of which came from the Advanced Fuels Facility (MFC-784) at MFC.
- The second largest dose contribution was from $^{36}$Cl, accounting for 21.2%, most of which originated at the Electron Microscopy Laboratory (MFC-774) at MFC.
- Tritium accounts for 19.0% of the MEI dose with 84.4% coming from MFC-774, 10.3% coming from the beryllium blocks buried at the RWMC Subsurface Disposal Area, 2.9% from TRA-715, 2.0% from TRA-770, and the rest from other sources.
- Amounts of $^{137}$Cs and $^{90}$Sr contributed 6.9% and 3.6%, respectively. The remaining 5.00% came from other radionuclides.

The largest contribution by facility to the MEI dose overwhelmingly came from MFC at 92.8%, followed by the ATR Complex at 4.57%, and RWMC at 1.98%, as shown in Figure 8-3. This is expected for Location 26 given its proximity to MFC. Additionally, primary wind directions at the INL Site are from the southwest and northeast; thus, emissions from Test Area North (TAN), the Naval Reactors Facility (NRF), INTEC, the ATR Complex, and RWMC are off axis from a receptor near MFC.

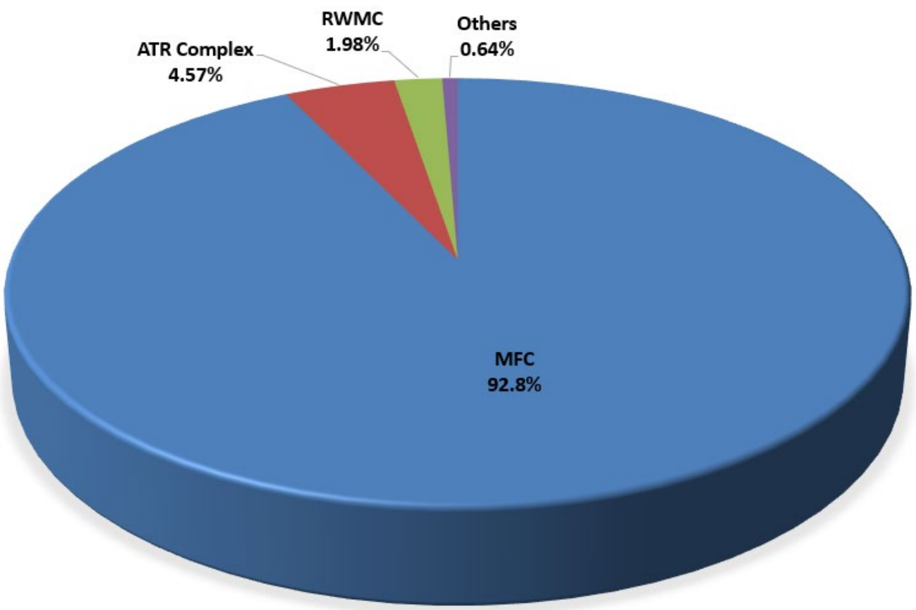


***Figure 8-3. Percent contributions, by facility, to MEI dose from the INL Site airborne effluents as calculated using the CAP88-PC Model (2024).***

The dose to the MEI is lower than in 2023 at 0.015 mrem/year, and is far below the regulatory standard of 10 mrem/yr (0.1 mSv/yr) (40 CFR 61, Subpart H).

### 8.2.2 Eighty Kilometer (50 Mile) Population Dose

The total effective population dose from airborne releases was calculated using air dispersion modeling using the NOAA HYSPLIT model (Stein et al. 2015; Draxler et al. 2013) and the DOSEMM v 190926 (Rood 2019) dose assessment model. These calculations aimed to provide a grid of total effective doses within an 80-km (50-mi) radius from any INL Site source, including Idaho Falls facilities. The data was used with geographic information system (GIS) software to compute population doses. The HYSPLIT model and its capabilities are described on the NOAA Air Resources Laboratory website.

Key contributing facilities and radionuclides were modeled, selecting those that contributed more than 0.005% of the total dose at the INL Site or more than 0.1% in Idaho Falls. Data from 34 meteorological stations were used to project the transport and dispersion of contaminants by winds and their deposition onto the ground. The HYSPLIT model predicted dispersion and deposition from releases at each facility across 17,877 grid points around the INL Site, including 27 boundary receptor locations representing actual residences.

The model outputs, which included radionuclide air concentrations and deposition amounts, were converted to dispersion and deposition factors for use in DOSEMM (Rood 2024). These factors were used to estimate air concentrations and the deposition at each grid point for the year. Then, the effective dose via inhalation, ingestion, and external exposure pathways was calculated. The radionuclide source term for radionuclide-facility combinations that were used for the site and in-town population dose assessment can be found in Overin (2025).

To estimate the population dose within an 80-km (50-mi) radius, data from the 2020 census was gathered and then projected to 2024. This was done by calculating the population change rate from 2010 to 2020 and then applying that same rate to the 2020 figures. Then, a GIS was used to import the dose values from DOSEMM and average those values within each census division. These average doses were multiplied by the estimated populations and summed to get the total population dose.

The estimated potential population dose for 2024 was 0.012 person-rem (0.00012 person-Sv) for about 358,426 people. This represents a very small 0.00001% increase as compared to the natural background radiation dose of approximately 139,069 person-rem (1,391 person-Sv). The estimated population dose for 2024 was less than population doses estimated for 2020-2023 (Figure 8-4). Table 8-2 provides the contribution to estimated annual dose from INL Site facilities by pathway in 2024.

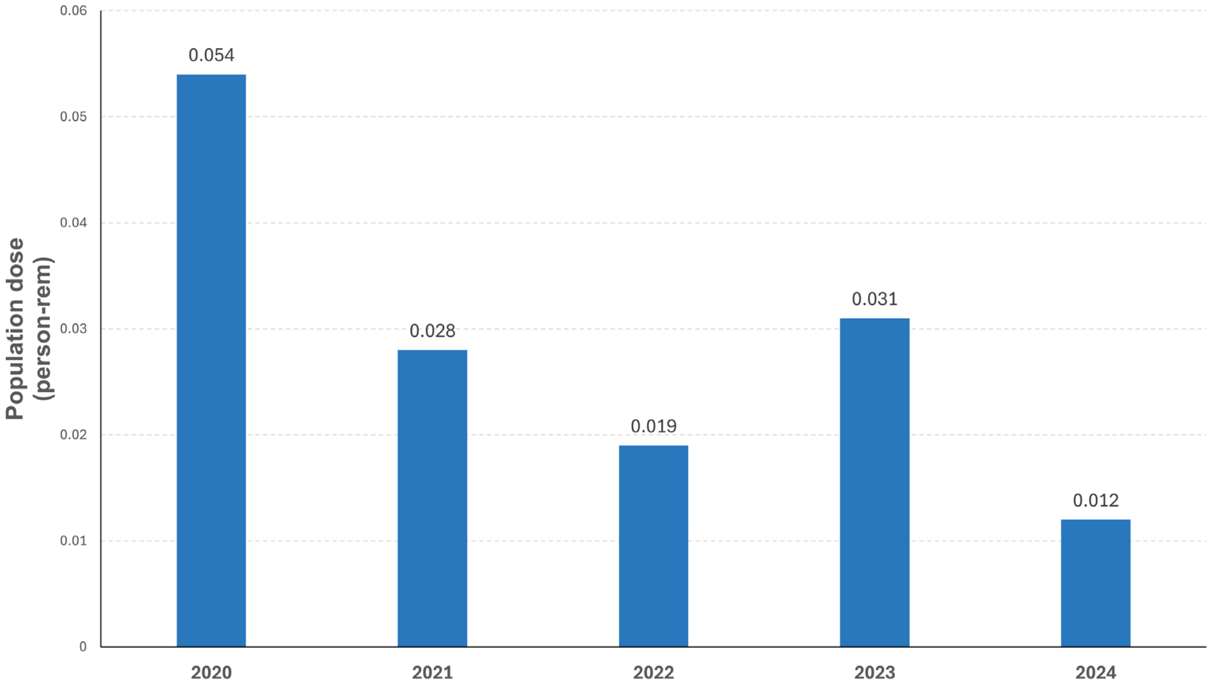


***Figure 8-4. Population dose estimated for 2020-2024.***

***Table 8-2. Contribution to estimated annual dose from INL Site facilities by pathway (2024).***

| PATHWAY[a] | ANNUAL DOSE TO MEI (mrem) | ANNUAL DOSE TO MEI (µSv) | PERCENT OF DOE 100 mrem/yr LIMIT[b] | ESTIMATED POPULATION DOSE (PERSON-rem) | ESTIMATED POPULATION DOSE (PERSON-Sv) | POPULATION WITHIN 80 km | ESTIMATED BACKGROUND RADIATION POPULATION DOSE (PERSON-rem)[c] |
|---|---|---|---|---|---|---|---|
| Air | 0.015 | 0.15 | 0.015 | 0.012 | 0.00012 | 358,426 | 139,069 |
| **TOTAL, ALL PATHWAYS** | **0.015** | **0.15** | **0.015** | **0.012** | **0.00012** | **NA[d]** | **NA** |

a. Waterfowl and big game animals had a 0.000 mrem as a result of no detected human-made radionuclides in edible portions. Therefore, they were not included as line items in the table.

b. 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.

c. The individual background dose was estimated to be 388 mrem or 0.388 rem in 2024, as shown previously in Table 7-3. The background population dose is calculated by multiplying the individual background dose by the population within an 80 km (50 mi) radius of the INL Site.

d. NA = Not applicable.

## 8.3 Dose to the Public from Ingestion of Wild Game from the INL Site

The potential dose that an individual may receive from occasionally ingesting meat from waterfowl or big 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 big game animals that may reside on or migrate through the INL Site.

### 8.3.1 Waterfowl

Waterfowl samples collected in 2024 did not have detectable concentrations of human-made radionuclides in any edible subsample. As a result, no dose from human-made radionuclides would be associated with the consumption of these animals. As in the past, the 2024 samples were not collected directly from the warm wastewater evaporation ponds at the ATR Complex but from sewage lagoons adjacent to them.

### 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 2024, none of the game samples collected from seven elk had a detectable concentration of $^{137}$Cs or other human-made radionuclides. Therefore, no dose from human-made radionuclides would be associated with the consumption of these animals.

The contribution of game animal consumption to the population dose is calculated because only a limited percentage of the population hunts game, few deceased animals have spent time on the INL Site, and most animals that 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, vegetable ingestion, and soil deposition.

## 8.4 Dose to the Public from Drinking Groundwater from the INL Site

Tritium has previously been detected in three U.S. Geological Survey 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 (3,250 ± 130 pCi/L) in 2024 is considerably less than the maximum contaminant level established by the 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 0.136 mrem (0.00136 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 INL Site Borders

The direct radiation exposure pathway from gamma radiation to the public is monitored annually using optically stimulated luminescent dosimeters. In 2024, the external radiation dose of 123 mrem measured along the INL Site boundary and offsite was statistically equivalent to the calculated background radiation dose of 131 mrem; therefore, it 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, as indicated in Figure 8-5. For 2024, the only probable pathways from INL Site activities to a realistic MEI include the air transport pathway.

The hypothetical individual, assumed to live at a farmhouse and cattle operation located 3.1 km south of Highway 20 and 3 km from the east entrance of the INL Site, as presented previously here, would receive a calculated dose from INL Site airborne releases reported for 2024 (see Subsection 8.2.1). No dose was calculated from eating waterfowl (see Subsection 8.3.1) or big game animals (see Subsection 8.3.2) in 2024.

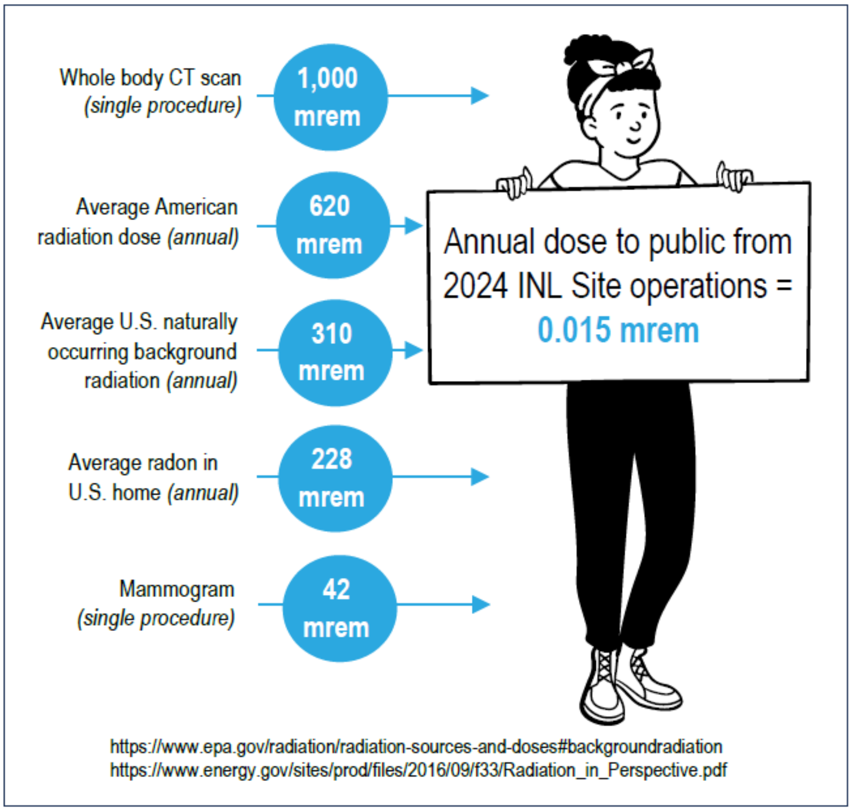


***Figure 8-5. Radiation doses associated with some common sources.***

Figure 8-5 compares other common sources of radiation dose to the INL Site operations. In 2024, the total dose from all pathways was conservatively estimated to be 0.015 mrem (0.15 μSv), as illustrated in Figure 8-5, for an offsite MEI, presented in Table 8-2. This value is significantly below the public dose limit of 100 mrem/year (1 mSv/year) set by the 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 an 80-km (50-mi) radius of INL Site facilities was calculated to be 0.012 person-rem (0.00012 person-Sv), as shown in Table 8-2. This is approximately 0.00001% of the 139,069 person-rem (1,391 person-Sv) dose given in Table 8-2 to be expected from exposure to regional natural background radiation.

## 8.7 Dose to the Public from Operations on the INL Research and Education Campus

Facilities in Idaho Falls that reported potential radionuclide emissions for inclusion in the 2024 NESHAP report include the INL Research Center (IRC) Laboratory (IF-603), DOE Radiological and Environmental Sciences Laboratory (IF-683), and the National Security Laboratory (IF-611). These facilities are located contiguously at IRC, which is part of the INL Research and Education Campus (REC) on the north side of Idaho Falls. Though programs and operations at IRC are affiliated with INL, IRC is located within the city limits of Idaho Falls and is not contiguous with the INL Site. The nearest boundary of the INL Site is about 35 km (22 mi) west of Idaho Falls. For this reason, the 2024 INL NESHAP evaluation (DOE-ID 2025) includes a dose calculation to a member of the public that is separate from the MEI at the INL Site. (Note: The REC source term was, however, included in the population dose calculation reported in Subsection 8.2.2.). Each of the IRC buildings were modeled as separate sources in 2023. Due to radionuclide tracking limitations, IF-603 and IF-611 were modeled as one source in 2024. The MEI at IRC for 2024 is approximately 147 meters south-southeast of IF-683. Using CAP88-PC, the MEI effective dose equivalent was conservatively calculated to be 0.0048 mrem/yr (0.048 µSv/yr), which is less than 0.1% 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 its associated software, RESRAD-Biota 1.8 (DOE 2019). The graded approach includes a screening method and three additional 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 riparian and 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 (e.g., Level 1 in RESRAD-Biota) provides generic limiting concentrations of radionuclides in environmental media, termed “Biota Concentration Guides (BCGs).” Each BCG 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 of less than 1 rad/d (10 mGy/d) to aquatic animals or terrestrial plants or of 0.1 rad/d (1 mGy/d) to riparian or terrestrial animals. If the sum of the measured maximum environmental concentrations divided by the BCGs (i.e., the combined sum of fractions) is less than one, no negative impact to plant or animal populations is expected. Doses are not calculated unless the screening process indicates a more detailed analysis is necessary. A failure at this 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 examination is performed using site-representative parameters (e.g., distribution coefficients, bioconcentration factors) instead of the more conservative default parameters. This is termed 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 Level 3 RESRAD-Biota. 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 the internal dose parameters. At Level 3 RESRAD-Biota, bioaccumulation—the process by which biota concentrate contaminants from their surrounding environment—can be modeled to estimate the dose to a plant or animal. Alternatively, radionuclide concentrations measured in the tissue of an organism can be input into the program 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 2024 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 the soil since the early 1970s (Jessmore, Lopez, and Haney 1994). In some 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 following facilities:

- Auxiliary Reactor Area
- ATR Complex
- Critical Infrastructure Test Range Complex
- INTEC
- Large Grid, a 24-mile radius around INTEC
- MFC
- NRF
- RWMC
- TAN.

The most recently measured maximum concentrations of radionuclides in INL Site soil were used to perform a screening level analysis 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 at the MFC Industrial Waste Pond. The radiological surveillance monitoring results are presented in the 2024 second, third, and fourth quarter reports (INL 2025a, INL 2025b, INL 2025c). The results for $^{233/234}U$ and $^{238}U$ (i.e., 0.63 pCi/L and 0.24 pCi/L, respectively) were used to represent surface water concentrations. When $^{233/234}U$ was reported, it was assumed 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 indicated in Table 8-3. 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.

In 2024, bat carcasses found at INL Site facilities were collected under a scientific collection permit and composited into samples for each location. These samples were sent to a radioanalytical laboratory and analyzed for human-made radionuclides. The analytical results, along with radionuclide concentrations in soil and water, were used as input for the RESRAD-Biota code to calculate the internal dose the bats may have received. The estimated dose was 0.0065 rad/d, which is much lower than the safety limit of 0.1 rad/d. Based on this result, it can be assumed that 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. More details can be found in the Idaho National Laboratory Site Bat Protection Plan Annual Report.

### 8.8.1 Aquatic Evaluation

The maximum radionuclide concentrations reported in ponds at the INL Site were also used for aquatic evaluation. The results shown in Table 8-4 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 (0.004) and riparian animals (0.001).

Tissue data from waterfowl collected on the ATR Complex wastewater ponds in 2024 were available too, as shown previously in Table 7-1 of Chapter 7. 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 7-1. 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 INL Site and uranium concentrations in water. The 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 8-5. The estimated dose to waterfowl was calculated by RESRAD-Biota to be 0.00022 rad/d (0.0022 mGy/d). This dose is significantly less than the standard of 0.1 rad/d (1 mGy/d). Based on these results, there is no evidence that water held in ponds at the INL Site is harming aquatic biota.

***Table 8-3. RESRAD-Biota assessment (screening level) of terrestrial ecosystems on the INL Site (2024).***

| TERRESTRIAL ANIMAL | | | | | | |
|---|---|---|---|---|---|---|
| | WATER | | | SOIL | | |
| NUCLIDE | CONCENTRATION (pCi/l) | BCG[a] (pCi/l) | RATIO | CONCENTRATION (pCi/g) | BCG (pCi/g) | RATIO |
| Americium-241 | — | 2.02E+05 | — | 1.2 | 3.89E+03 | 3.08E-04 |
| Cobalt-60 | — | 1.19E+06 | — | 0.05 | 6.92E+02 | 7.23E-05 |
| Cesium-134 | — | 3.26E+05 | — | 0.08 | 1.13E+01 | 7.08E-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 | — | 1.6 | 6.11E+03 | 2.62E-04 |
| Strontium-90 | — | 5.45E+04 | — | 0.71 | 2.25E+01 | 3.16E-02 |
| Uranium-233 | 0.63 | 4.01E+05 | 1.57E-06 | — | 4.83E+03 | — |
| Uranium-238 | 0.24 | 4.06E+05 | 5.91E-07 | — | 1.58E+03 | — |
| **SUMMED** | **—** | **—** | **2.16E-06** | **—** | **—** | **2.08E-01** |
| **TERRESTRIAL PLANT** | | | | | | |
| | WATER | | | SOIL | | |
| NUCLIDE | CONCENTRATION (pCi/l) | BCG (pCi/l) | RATIO | CONCENTRATION (pCi/g) | BCG (pCi/g) | RATIO |
| Americium-241 | — | 7.04E+08 | — | 1.2 | 2.15E+04 | 5.57E-05 |
| Cobalt-60 | — | 1.49E+07 | — | 0.05 | 6.13E+03 | 8.16E-06 |
| Cesium-134 | — | 2.28E+07 | — | 0.08 | 1.09E+03 | 7.36E-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 | — | 1.6 | 1.27E+04 | 1.26E-04 |
| Strontium-90 | — | 3.52E+07 | — | 0.71 | 3.58E+03 | 1.98E-04 |
| Uranium-233 | 0.63 | 1.06E+10 | 5.95E-11 | — | 5.23E+04 | — |
| Uranium-238 | 0.24 | 4.28E+07 | 5.60E-09 | — | 1.57E+04 | — |
| **SUMMED** | **—** | **—** | **5.66E-09** | **—** | **—** | **2.05E-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 8-4. RESRAD-Biota assessment (screening level) of aquatic ecosystems on the INL Site (2024).*

| AQUATIC ANIMAL | | | | | | |
|---|---|---|---|---|---|---|
| | WATER | | | SEDIMENT | | |
| NUCLIDE | CONCENTRATION (pCi/l) | BCG[a] (pCi/l) | RATIO | CONCENTRATION (pCi/g) | BCG (pCi/g) | RATIO |
| Uranium-233 | 0.63 | 2.00E+02 | 3.16E-03 | 0.0315 | 1.06E+07 | 2.97E-09 |
| Uranium-238 | 0.24 | 2.23E+02 | 1.07E-03 | 0.012 | 4.28E+04 | 2.80E-07 |
| **Summed** | — | — | **4.23E-03** | — | — | **2.83E-07** |
| **RIPARIAN ANIMAL** | | | | | | |
| | WATER | | | SEDIMENT | | |
| NUCLIDE | CONCENTRATION (pCi/l) | BCG (pCi/l) | RATIO | CONCENTRATION (pCi/g) | BCG (pCi/g) | RATIO |
| Uranium-233 | 0.63 | 6.76E+02 | 9.32E-04 | 0.0315 | 5.28E+03 | 5.97E-06 |
| Uranium-238 | 0.24 | 7.56E+02 | 3.17E-04 | 0.012 | 2.49E+03 | 4.82E-06 |
| **SUMMED** | — | — | **1.25E-03** | — | — | **1.08E-05** |

a. BCG = Biota Concentration Guide. Each radionuclide-specific BCG represents the limiting radionuclide concentration in an environmental medium which would not result in recommended dose standards for biota to be exceeded.

*Table 8-5. RESRAD-Biota assessment (Level 3 analysis) of aquatic ecosystems on the INL Site using measured waterfowl tissue data (2024).*

| WATERFOWL DOSE (rad/d) | | | | | |
|---|---|---|---|---|---|
| NUCLIDE | WATER[a] | SOIL[b] | SEDIMENT | TISSUE[c] | SUMMED |
| Americium-241 | — | 8.45E-07 | — | — | 8.45E-07 |
| Cobalt-60 | — | 4.97E-06 | — | 1.06E-05 | 1.55E-05 |
| Cesium-134 | — | 4.78E-06 | — | — | 4.78E-06 |
| Cesium-137 | — | 7.58E-05 | — | — | 7.85E-05 |
| Plutonium-238 | — | 1.76E-10 | — | — | 1.76E-10 |
| Plutonium-239 | — | 3.27E-09 | — | — | 3.27E-09 |
| Strontium-90 | — | 5.14E-07 | — | 7.29E-07 | 1.24E-06 |
| Uranium-233 | 9.30E-05 | NA | 5.93E-07 | NA | 9.36E-05 |
| Uranium-238 | 3.12E-05 | NA | 2.08E-07 | NA | 3.14E-05 |
| **TOTAL** | **1.24E-04** | **8.69E-05** | **8.01E-07** | **2.76E-04** | **2.23E-04[d]** |

a. Only uranium isotopes were measured in the MFC 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 8-3). Note: NA = uranium isotopes were not analyzed in soil.

c. Internal doses to waterfowl were calculated using maximum concentrations in edible tissue. Note: NA = uranium isotopes were not analyzed in tissue samples.

d. DOE biota dose rate criteria for riparian animals is 0.1 rad/day.

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