Idaho National Laboratory Site

Site Environmental Report

Calendar Year 2011

Environmental Surveillance, Education, and Research Program

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U.S. Department of Energy, Idaho Operations Office

September 2012

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Russ Mitchell, ESER, sampling soil.

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To Our Readers

The Idaho National Laboratory Site Environmental Report for Calendar Year 2011 is an overview of environmental monitoring activities conducted on and in the vicinity of the Idaho National Laboratory (INL) Site from January 1 through December 31, 2011. This report includes:

- Effluent monitoring and environmental surveillance of air, water, soil, vegetation, biota, and agricultural products for radioactivity. The results are compared with historical data, background measurements, and/or applicable standards and requirements in order to verify that the INL Site does not adversely impact the environment or the health of humans or biota.
- A summary of environmental management systems in place to protect air, water, land, and other natural and cultural resources impacted by INL Site operations.
- Ecological and other scientific research conducted on the INL Site which may be of interest to the reader.

The report addresses three general levels of reader interest:

- The first is a brief summary with a "take-home" conclusion. This is presented in the "Chapter Highlights" text box at the beginning of each chapter. There are no tables, figures, or graphs in the highlights. A lay person with little knowledge of science may comfortably read the Chapter Highlights.
- The second level is a more in-depth discussion with figures, summary tables, and summary graphs accompanying the text. The chapters of the annual report represent this level, which requires some familiarity with scientific data and graphs. A person with some scientific background can read and understand this report after reading the section entitled "Helpful Information."
- The third level includes links to supplemental and technical reports and websites that support the annual report. This level is directed toward scientists who would like to see original data and more in-depth discussions of the methods used and results. The links to these reports may be found at http://www.gsseser.com/Annuals/2010/index.htm or in the CD provided with the hard copy of this report.

In addition to the Environmental Surveillance, Education, and Research Program, which is managed by Gonzales-Stoller Surveillance, LLC, the contributors to the annual report include Battelle Energy Alliance (BEA), CH2M-WG Idaho (CWI), Department of Energy, Idaho Operations Office (DOE-ID), National Oceanic and Atmospheric Administration (NOAA), and U.S. Geological Survey (USGS). Links to their websites may be found at http://www.gsseser.com/Annuals/2010/index.htm or in the CD provided with the hard copy of this report.

Shoshone Falls

Executive Summary

The Idaho National Laboratory Site Environmental Report Calendar Year 2011 was prepared to inform the public, regulators, stakeholders, and other interested parties of the Idaho National Laboratory (INL) Site environmental performance during 2011.

Purpose of the INL Site Environmental Report

This report is published annually for the U.S. Department of Energy, Idaho Operations Office (DOE-ID) in compliance with DOE Order 231.1B, "Environment, Safety and Health Reporting." Its purpose is to

- Present the INL Site, mission, and programs
- Report compliance status with all applicable, federal, state, and local regulations
- Describe the INL Site environmental programs and activities
- Summarize results of environmental monitoring
- Discuss potential radiation doses to the public residing in the vicinity of the INL Site
- Report on ecological research conducted at the Idaho National Environmental Research Park
- Describe quality assurance methods used to ensure confidence in monitoring data.

Major INL Site Programs and Facilities

There are three primary programs at the INL Site: the INL, the Idaho Cleanup Project (ICP), and the Advanced Mixed Waste Treatment Project (AMWTP). The prime contractors at the INL Site are: Battelle Energy Alliance (BEA), the management and operations (M&O) contractor for the INL; CH2M-WG Idaho, LLC (CWI) which manages ongoing cleanup operations under the ICP; and Idaho Treatment Group, LLC, which operates AMWTP.

The INL is a science-based, applied engineering national laboratory dedicated to supporting the U.S. Department of Energy's missions in nuclear and energy research, science, and national defense. Its mission is to ensure the nation's energy security with safe, competitive, and sustainable energy systems and unique national and homeland security capabilities. Its vision is that by 2015, INL will be the pre-eminent nuclear energy laboratory with synergistic, world-class, multi-program capabilities and partnerships.

The ICP involves the safe, environmental cleanup of the INL Site, which has been contaminated with waste generated from World War II-era conventional weapons testing, government-owned research and defense reactors, laboratory research, and defense missions at other DOE sites. The 7-year, $2.9 billion cleanup project, funded through the DOE's Office of Environmental Management, focuses equally on reducing risks to workers, the public and the environment and on protecting the Snake River Plain Aquifer, the sole drinking water source for more than 300,000 residents of eastern Idaho.

DOE is committed to safely retrieve, characterize, treat, and package transuranic waste for shipment out of Idaho to permanent disposal at the Waste Isolation Pilot Plant in New Mexico.

Characterized waste containers that need further treatment before they can be shipped are sent to the AMWTP Treatment Facility where the waste can be size-reduced, sorted, and repackaged.

The INL Site comprises nine applied engineering, interim storage, and research and development facilities. The major facilities at the INL Site are the Advanced Test Reactor (ATR) Complex, Central Facilities Area (CFA); Critical Infrastructure Test Range Complex (CITRC); Idaho Nuclear Technology and Engineering Center (INTEC); Materials and Fuels Complex (MFC); Naval Reactors Facility (NRF); Radioactive Waste Management Complex (RWMC); Research and Education Campus (REC); and Test Area North (TAN).

The ATR Complex is engaged in research and development of nuclear reactor technologies. It is home to the ATR, the world's most advanced nuclear test reactor, which is also a DOE National Scientific User Facility. ATR is vital for testing materials for the nation's next generation of nuclear power plants. ATR is also used to manufacture a significant portion of the nation's medical nuclear isotopes. It is operated by the INL contractor.

For more than 50 years, the CFA has provided support facilities for the operation of the other INL facilities. The INL contractor manages CFA.

The CITRC includes the INL Site's Critical Infrastructure Test Range which provides customers with access to isolated, secure space complete with industrial-scale infrastructure components that can be used for conducting work in physical security, contraband detection, and infrastructure testing. The INL contractor manages CITRC.

INTEC was established in the 1950s as a location for extracting reusable uranium from spent nuclear fuel. Until 1992, reprocessing efforts recovered more than one-billion dollars worth of highly enriched uranium. The highly radioactive liquid created in this process was turned into a solid through a process known as calcining. Calcining converted over eight million gallons of liquid waste to a solid granular material that is now stored in bins awaiting a final disposal location outside of Idaho. Ongoing activities at INTEC include storage of spent nuclear fuel (SNF) in a modern water basin and in dry storage facilities, management of high-level waste calcine and sodium-bearing liquid waste, and the operation of the Idaho Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Disposal Facility (ICDF), which includes a landfill, evaporation ponds, and a storage and treatment facility. INTEC is operated by the ICP contractor.

The MFC focuses on research and development of nuclear fuels. Prototypes of new reactor fuels are made and evaluated at MFC. Pyroprocessing, which uses electricity to separate waste products in the recycling of nuclear fuel, is also researched here. At the Space and Security Power Systems Facility, workers make nuclear batteries (radioisotope thermoelectric generators) for use on the nation's space missions. Such batteries are crucial to the nation's deep space missions, which travel to extremely cold regions of space where sunlight is too weak to power photovoltaic cells.

The NRF is operated for Naval Reactors by Bechtel Marine Propulsion Corporation. The Naval Nuclear Propulsion Program is exempt from DOE requirements and is therefore not addressed in this annual report.

The RWMC was established in 1952 as a burial location for low-level radioactive waste. Starting in 1954, however, transuranic waste and organic sludge from Rocky Flats, Colorado, were also buried in the Subsurface Disposal Area (SDA)—the actual burial grounds at the RWMC. In 1970, the federal government stopped burying transuranic waste at the RWMC and began placing it in retrievable storage for later transfer to a federal repository, but the INL Site continues to dispose of low-level radioactive waste in the SDA. Monitoring and remediation activities associated with contamination from past waste disposal practices are also performed at the RWMC. The AMWTP, located at the RWMC, is responsible for retrieval, characterization, treatment, and packaging of transuranic waste currently stored at the INL Site. With the exception of the AMWTP, the RWMC is the responsibility of the ICP contractor.

The Research and Education Campus, located in Idaho Falls, is home to the DOE Idaho Operations Office and INL contractor administration and a wide variety of other facilities. At the INL Research Center, scientists working in dozens of laboratories conduct cutting-edge research in fields as varied as robotics, genetics, biology, chemistry, metallurgy, computational science, and hydropower. The Center for Advanced Energy Studies, which opened in 2009, is a research and eduction partnership between Boise State University, Idaho National Laboratory, Idaho State University, and University of Idaho. Other facilities house National Security programs and INL precision machining and glass shops.

TAN was established in the 1950s to support the federal government's program to build and fly a nuclear powered airplane. Although that project was cancelled in the 1960s, prior to completion, many other projects and activities, such as the Loss-of-Fluid Test Reactor were hosted at TAN. In 2008, TAN became the site's first major geographical area to have its aboveground footprint eliminated. This involved the clean-up of contaminated areas and removal of facilities no longer required for the DOE-ID mission. The main mission at TAN now is the manufacture of tank armor for the U.S. Army's battle tanks at the Specific Manufacturing Capability Project. This project is operated for the U.S. Department of Defense by the INL contractor.

Compliance with Environmental Laws, Regulations, and Policies

One measure of the achievement of the environmental programs at the INL Site is compliance with applicable environmental regulations, which have been established to protect human health and the environment. The federal laws which apply to INL Site activities include the Clean Air Act, the Clean Water Act, Safe Drinking Water Act, National Environmental Policy Act, and CERCLA. Overall, the INL Site met all federal, state, and local regulatory commitments in 2011.

The INL Site attained ISO 14001 certification of its Environmental Management System effective November 24, 2005, and continues to maintain certification. The Pollution

Prevention and Sustainability Program is part of the Environmental Management System. Its scope incorporates waste prevention and elimination, reduction of environmental releases, environmentally preferable purchasing, environmental stewardship in program planning and operational design, and recycling of solid wastes. The program is designed to minimize the environmental impact of the INL Site while enhancing support for the mission. In 2011, the INL Site reused and recycled more than 493,128.62 kilograms (1,087,162.5 pounds) of materials.

Environmental Monitoring of Air

Airborne releases are reported by DOE-ID annually in a document prepared in accordance with the Code of Federal Regulations, Title 40, "Protection of the Environment," Part 61, "National Emission Standards for Hazardous Air Pollutants (NESHAP)," Subpart H, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities." An estimated total of 3,520 curies of radioactivity, primarily in the form of short-lived noble gas isotopes, were released as airborne effluents in 2011. The highest releases were from INTEC (47 percent of total), the ATR Complex (43 percent of total), and RWMC (10 percent of total.)

The INL Site environmental surveillance programs, conducted by the INL, ICP, and the Environmental Surveillance, Education and Research (ESER) contractors, emphasize measurement of airborne radionuclides because air transport is considered the major potential pathway from INL Site releases to human receptors. During 2011, the INL contractor monitored ambient air at 17 INL Site locations and at four locations off the INL Site. The ICP contractor focused on ambient air monitoring of waste management facilities, namely INTEC and the RWMC. The ESER contractor sampled ambient air at three locations on the INL Site, at seven locations bounding the INL Site, and at six locations distant from the INL Site.

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

All radionuclide concentrations in ambient air samples were below DOE standards for air and were within historical measurements. In addition, gross alpha and gross beta concentrations were analyzed statistically and there were no differences between samples collected on the INL Site, at the INL Site boundary, and off the INL Site. Trends in the data appear to be seasonal in nature and do not demonstrate any INL Site influence. This indicates that INL Site airborne effluents were not measureable in environmental air samples. However, releases from the Fukushima reactor accident were evident in mid-March through April.

The INL and ESER contractors also collected atmospheric moisture samples at three stations on and five stations off the INL Site. In addition, the ESER contractor sampled precipitation at two stations on the INL Site and one location off the INL Site. These samples were all analyzed for tritium (^{3}H). The results were within measurements made historically and by the EPA and were below DOE standards. Tritium measured in these samples is most likely the result of natural production in the atmosphere and not the result of INL Site effluent releases.

Environmental Monitoring of Groundwater, Drinking and Surface Water for Compliance Purposes

The INL and ICP contractors monitor liquid effluents, drinking water, groundwater, and storm water runoff at the INL Site, primarily for nonradioactive constituents, to comply with applicable laws and regulations, DOE orders, and other requirements.

Wastewater is typically discharged from INL Site facilities to the ground surface. Wastewater discharges occur at percolation ponds southwest of INTEC, a cold waste pond at the ATR Complex, and a sewage treatment facility at CFA. These effluents are regulated by the state of Idaho groundwater quality and wastewater rules through wastewater reuse permits, which require monitoring of the wastewater and, in some instances, groundwater in the area. During 2011, liquid effluent and groundwater monitoring were conducted in support of wastewater reuse permit requirements. An annual report for each permitted facility was prepared and submitted to the Idaho Department of Environmental Quality. No permit limits were exceeded.

Additional liquid effluent monitoring was performed at ATR Complex, CFA, INTEC, and MFC to comply with environmental protection objectives of DOE Orders 458.1 (“Radiation Protection of the Public and the Environment”). Most results were within historical measurements. All radioactive parameters were below health-based contaminant levels.

Drinking water parameters are regulated by the state of Idaho under authority of the Safe Drinking Water Act. Drinking water was sampled in 11 drinking water systems at the INL Site in 2011. Results were below limits for all relevant drinking water standards. The CFA distribution system serves 600 workers daily and is downgradient from an historic groundwater plume of radionuclides resulting from wastewater injection by INTEC and the ATR Complex directly into the aquifer. Because of this, a dose was calculated to a worker who might obtain all their drinking water from the CFA drinking water system during 2011. The dose, 0.22 mrem, is below the EPA standard of 4 mrem/yr for public drinking water systems.

Surface water flows off of the SDA following periods of heavy precipitation or rapid snowmelt. During these times, water may be pumped out of the SDA retention basin into a drainage canal, potentially carrying radionuclides originating from radioactive waste or contaminated surface soil off the SDA. Surface water is collected when it is available. Americium-241, plutonium-239/240, and strontium were detected within historical levels. In addition, plutonium-238 was questionably detected in three samples. The detected concentrations do not pose a threat to human health or the environment, but will continue to be monitored.

Environmental Monitoring of the Eastern Snake River Plain Aquifer

The Eastern Snake River Plain Aquifer (ESRPA) beneath the eastern Snake River Plain is perhaps the single-most important aquifer in Idaho. Composed of layered basalt lava flows and some sediment, it covers an area of approximately 10,800 square miles. The highly productive aquifer has been declared a sole source aquifer by the EPA due to the nearly complete reliance on the aquifer for drinking water supplies in the area.

The U.S. Geological Survey (USGS) began to monitor the groundwater below the INL Site in 1949. Currently, the USGS performs groundwater monitoring, analyses, and studies of the ESRPA under and adjacent to the INL Site. These activities utilize an extensive network of strategically placed monitoring wells on and around the INL. In 2011, the USGS continued to monitor localized areas of chemical and radiochemical contamination beneath the INL Site produced by past waste practices, in particular the direct injection of wastewater into the aquifer at INTEC and the ATR Complex. Results for monitoring wells sampled within the plumes show decreasing concentrations of ^{3}H and ^{90}Sr over time.

Several purgeable organic compounds were detected by USGS in monitoring wells, including drinking water wells, at the INL Site. The concentration of tetrachloromethane (carbon tetrachloride) was above the EPA maximum contaminant level in one well during 2011. Concentrations of other organic compounds and trace elements detected were below their respective primary contaminant standards.

Groundwater surveillance monitoring continued for the CERCLA Waste Area Groups (WAGs) on the INL Site in 2011. At TAN (WAG 1), results of groundwater monitoring indicated that in situ bioremediation of the plume of trichloroethene has been effective. Data from groundwater in the vicinity of the ATR Complex (WAG 2) show declining concentrations of chromium, ^{90}Sr, and ^{3}H. Groundwater samples collected from aquifer and perched water monitoring wells at and near INTEC (WAG 3) had three constituents which exceeded drinking water maximum contaminant levels: ^{90}Sr, technetium-99 and nitrate. The source of ^{90}Sr is past disposal of service waste to the injection well at INTEC. Technicium-99 is from past releases from the INTEC Tank Farm. The presence of elevated nitrate is attributed to past Tank Farm releases and has remained relatively constant over the past few years at INTEC. Strontium-90, technicium-99, and nitrate show stable or declining trends. Monitoring of groundwater for the CFA landfills (WAG 4) consists of sampling wells for metals, volatile organic compounds, and anions. Five organic compounds were detected in groundwater downgradient of the CFA, at levels well below the established EPA maximum concentrations levels. Nitrate exceeded its maximum contaminant level in 2011, but concentration was within historic levels. None of the organic compounds exceeded any EPA maximum contaminant level. At the RWMC (WAG 7) carbon tetratchloride slightly exceeded its maximum contaminant level in one aquifer well north of the facility in 2011. Wells at the MFC (WAG 9) are sampled for radionuclides, metals, total organic carbon, total organic halogens and other water quality parameters. Overall, the results show no evidence of impacts from MFC activities.

Drinking water and surface water samples were sampled downgradient of the INL Site and analyzed for gross alpha and beta activity and ^{3}H. Tritium was not detected in most of the samples collected in the spring, but not the fall, of 2011. The results were well within historical measurements and below the EPA maximum contaminant level. Gross alpha and beta results were within historical measurements. The Big Lost River was also sampled and none of the detected constituents exceeded maximum contaminant limits and were below measurements made in 2010.

Monitoring of Agricultural Products and Wildlife and Direct Radiation Measurements

To help assess the impact of contaminants released to the environment by operations at the INL Site, agricultural products (milk, lettuce, wheat, and potatoes) and wildlife were sampled and analyzed for radionuclides in 2011. The agricultural products were collected on, around and distant from the INL Site by the ESER contractor. Wildlife sampling included collection of ducks from sanitation waste ponds in the vicinity of the ATR Complex and the MFC, as well as big game animals killed by vehicles on roads within the INL Site. In addition, direct radiation was measured on and off the INL Site in 2011.

Some human-made radionuclides were detected in agricultural product and wildlife samples. However, measurements were consistent with those made historically. Direct radiation measurements made at offsite, boundary, and onsite locations (except RWMC) were consistent with historical and natural background levels.

Radiation Dose to the Public and Biota from INL Site Releases

Potential radiological doses to the public from INL Site operations were calculated to determine compliance with pertinent regulations and limits. The Clean Air Act Assessment Package, 1988, PC version computer code, required by the EPA to demonstrate compliance with the Clean Air Act, was used to calculate the dose to a hypothetical, maximally exposed individual. The maximum calculated dose to the maximally exposed individual, 0.046 mrem, was well below the 10 mrem standard established by the Clean Air Act. For comparison, the dose from natural background radiation was estimated in 2011 to be 381 mrem.

The mesoscale diffusion air dispersion model, developed by the National Oceanic and Atmospheric Administration (NOAA) Air Resources Laboratory-Field Research Division, was used to evaluate dispersion patterns at the INL Site during 2011. The dispersion calculations require hourly wind data collected by NOAA using their 35-station, technologically advanced, Meteorological Monitoring Network at the INL Site. The resulting dispersion estimates were used to evaluate the dose to the population within 50 miles of the INL Site facilities. The maximum potential population dose to the approximately 305,509 people residing within an 80-km (50-mi) radius of any INL facility was calculated as 0.61 person-rem, below that expected from exposure to background radiation (116,399 person-rem).

The maximum potential individual doses from consuming waterfowl and big game animals at the INL, based on the highest concentrations of radionuclides measured in samples of these animals, were estimated to be 0.004 mrem and 0.017 mrem, respectively. When summed with the dose estimated for the air pathway, (0.046 mrem) the maximally exposed individual could potentially receive a total dose of 0.067 mrem in 2011. This is 0.067 percent of the DOE health-based dose limit of 100 mrem/yr from all pathways for the INL Site.

Tritium has been previously detected in two USGS monitoring wells located along the southern INL Site boundary. A hypothetical individual drinking water from these wells would receive a dose of less than 0.2 mrem in one year. This is an unrealistic pathway to humans as there are no drinking water wells located along the southern boundary of the INL Site. The maximum contaminant level established by EPA for ^{3}H corresponds to a dose of approximately 4 mrem.

Doses were also evaluated using a graded approach for nonhuman biota at the INL Site. Measured maximum concentrations of radionuclides measured in waterfowl tissue were used to estimate doses to those wildlife accessing ATR Complex ponds. Ducks were estimated to receive less than the standard of 1 rad/d established by DOE for aquatic biota. Based on the calculations, there is no evidence that INL Site-related radioactivity in soil or water is harming populations of plants or animals.

Environmental Research at the Idaho National Environmental Research Park

In 1975 the mostly pristine land within the INL Site's borders became the nation's second National Environmental Research Park (NERP). All lands within the Park serve as an ecological field laboratory where scientists from government agencies, universities, and private foundations may set up long-term research. This research has covered a broad range of topics and issues from studies on the basic ecology of native sagebrush steppe organisms to the potential natural pathways of radiological materials through the environment, and even to highly applied research on the design of landfill covers that prevent water from reaching buried waste. The research topics have included native plants and wildlife as well as attempts to understand and control non-native, invasive species. The NERP also provides interpretation of research results to land and facility managers to support the NEPA process natural resources management, radionuclide pathway analysis, and ecological risk assessment.

The Idaho NERP maintains several regionally and nationally important long-term ecological data sets. It is home to one of the largest data sets on sagebrush steppe vegetation anywhere. In 1950, 100 vegetation plots were established on the INL Site and were originally designed to look for the potential effects of nuclear energy research on native vegetation. Since then the plots have been surveyed about every 5 to 7 years.

In 2011 there were seven major ecological research projects taking place on the Idaho NERP. The researchers were from Idaho State University, Boise State University, Montana State University, Texas A&M, and Washington State University, Environmental Surveillance, Education, and Research Program, Wildlife Conservation Society, and U.S. Department of Agriculture.

The USGS INL Project Office drills and maintains research wells which provide information about subsurface water, rock and sediment and contaminant movement in the Eastern Snake River Plain Aquifer at and near the INL Site. In 2011 the USGS published four research reports.

Quality Assurance

Quality assurance (QA) and quality control programs are maintained by contractors conducting environmental monitoring and by laboratories performing environmental analyses to help provide confidence in the data and ensure data completeness. Programs involved in environmental monitoring developed quality assurance programs and documentation which follow requirements and criteria established by DOE. Environmental monitoring programs implemented QA program elements through QA project plans developed for each contractor.

Adherence to procedures and quality assurance project plans was maintained during 2011. Data reported in this document were obtained from several commercial, university, government, and government contractor laboratories. To assure quality results, these laboratories participated in a number of laboratory quality check programs. Quality issues that arose with laboratories used by the INL, ICP and ESER contractors during 2011 were addressed with the laboratories and have been or are being resolved.

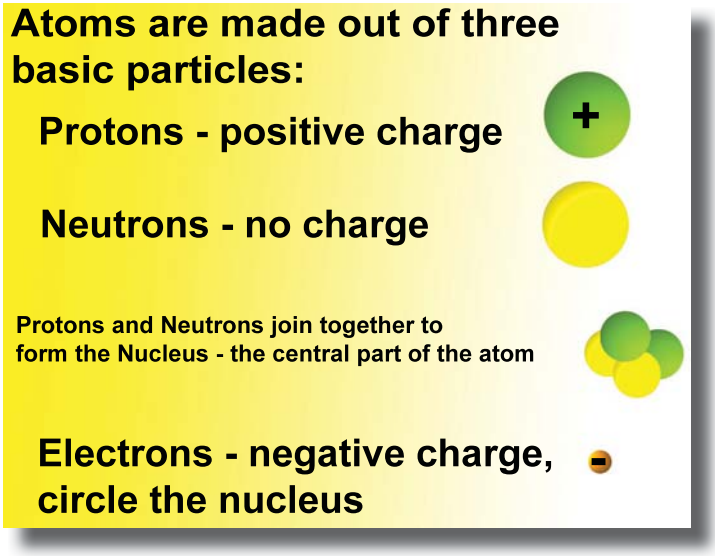
Mule Deer Doe and Fawn

Helpful Information

Much of the Annual Site Environmental Report deals with radioactivity levels measured in environmental media, such as air, water, soil, and plants. The following information is intended for individuals with little or no familiarity with radiological data or radiation dose. It presents terminology and concepts used in the Annual Site Environmental Report to aid the reader.

What is Radiation?

Matter is composed of atoms. Some atoms are energetically unstable and change to become more stable. During this transformation, unstable or radioactive atoms give off energy called "radiation" in the form of particles or electromagnetic waves. Generally, we refer to the various radioactive atoms as radionuclides. The radiation released by radionuclides has enough energy to eject electrons from other atoms it encounters. The ejected electrons and associated positively charged atoms are called "ions," and the energetic radiation that produced the ions is called "ionizing" radiation. Ionizing radiation is referred to simply as "radiation" in the rest of this report. The most common types of radiation are alpha particles, beta particles, X-rays, and gamma-rays. X-rays and gamma-rays, just like visible light and radiowaves, are packets of electromagnetic radiation. Collectively, packets of electromagnetic radiation are called photons. One may, for instance, speak of X-ray photons or gamma-ray photons.



Alpha Particles. An alpha particle is a helium nucleus without orbital electrons. It is composed of two protons and two neutrons and has a positive charge of plus two. Because alpha particles are relatively heavy and have a double charge, they cause intense tracks of ionization, but have little penetrating ability (Figure HI-1). Alpha particles can be stopped by thin layers of materials, such as a sheet of paper or piece of aluminum foil. Alpha particles can be detected in samples containing radioactive atoms of radon, uranium, plutonium, and americium.

Beta Particles. Beta particles are electrons that are ejected from unstable atoms during the transformation or decay process. Beta particles penetrate more than alpha particles, but are less penetrating than X-rays or gamma-rays of equivalent energies. A piece of wood or a thin block of plastic can stop beta particles (Figure HI-1). The ability of beta particles to penetrate matter increases with energy. Examples of beta-emitting radionuclides include tritium (^{3}H) and radioactive strontium.

X-Rays and Gamma-Rays. X-rays and gamma-rays are photons that have very short wavelengths compared to other electromagnetic waves, such as visible light, heat rays, and radio waves. Gamma-rays and X-rays have identical properties, behavior, and effects, but differ only in their origin. Gamma-rays originate from an atomic nucleus, and X-rays originate from interactions with the electrons orbiting around atoms. All photons travel at the speed of light. Their energies, however, vary over a large range. The penetration of X-ray or gamma-ray photons depends on the energy of the photons, as well as the thickness, density and

composition of the shielding material. Concrete is a common material used to shield people from gamma-rays and X-rays (Figure HI-1). Examples of gamma-emitting radionuclides include radioactive atoms of iodine and cesium. X-rays may be produced by medical X-ray machines in a doctor's office.

How are Radionuclides Designated?

Radionuclides are frequently expressed with a one or two letter abbreviation for the element and a superscript to the left of the symbol that identifies the atomic weight of the isotope. The atomic weight is the number of protons and neutrons in the nucleus of the atom. Most radionuclide symbols used in this report are shown in Table HI-1. The table also shows the half-life of each radionuclide. Half-life refers to the time in which one-half of the atoms of a radioactive sample transforms or decays in the quest to achieve a more energetically stable nucleus. Most radionuclides do not decay directly to a stable element, but rather undergo a series of decays until a stable element is reached. This series of decays is called a decay chain.

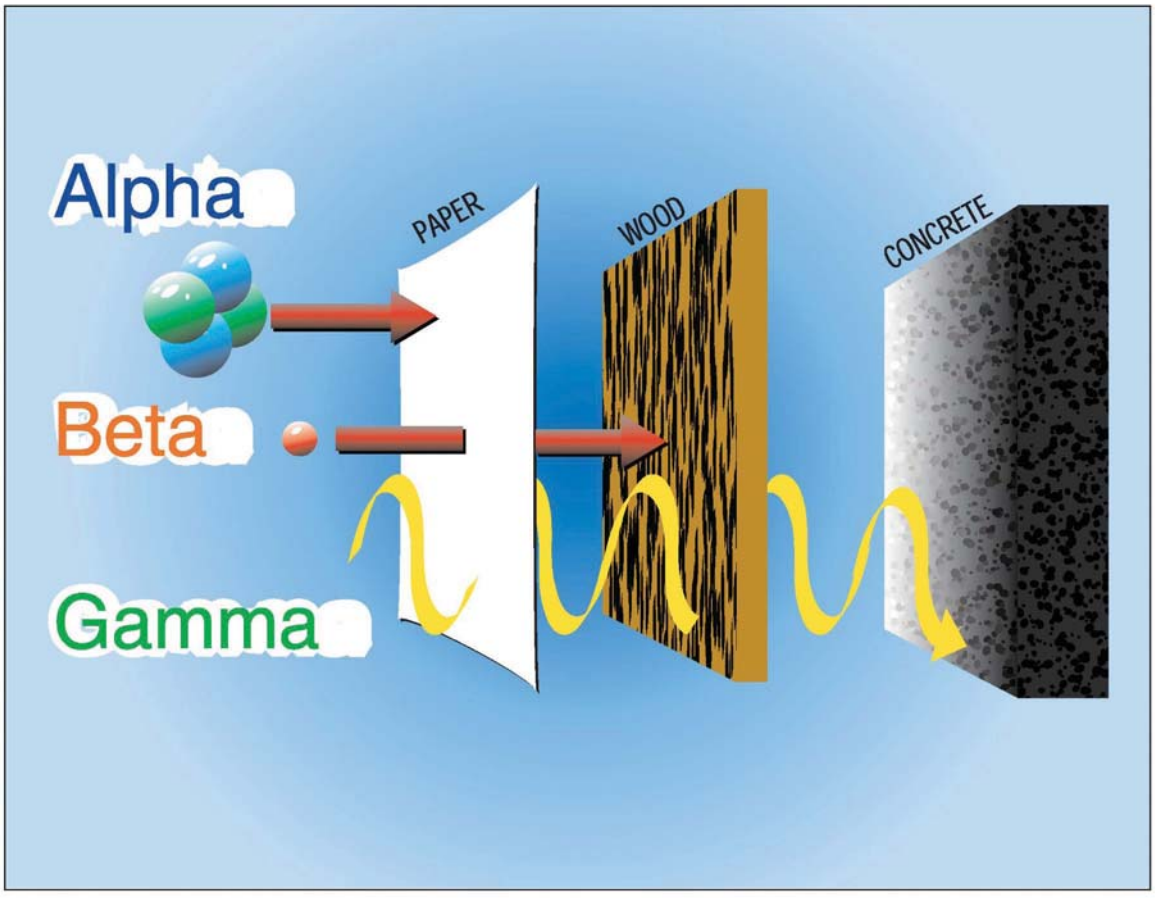


Figure HI-1. Comparison of Penetrating Ability of Alpha, Beta, and Gamma Radiation.

Table HI-1. Radionuclides and Their Half-lives.

Symbol	Radionuclide	Half-life[a,b]	Symbol	Radionuclide	Half-life
^{241}Am	Americium-241	432.2 yr	^{54}Mn	Manganese-54	312.5 d
^{243}Am	Americium-243	7,380 yr	^{59}Ni	Nickel-59	7.5×10^4 yr
^{125}Sb	Antimony-125	2.77 yr	^{63}Ni	Nickel-63	96 yr
^{41}Ar	Argon-41	1.827 hr	^{238}Pu	Plutonium-238	87.74 yr
^{137m}Ba	Barium-137m	2.552 min	^{239}Pu	Plutonium-239	2.4065×10^4 yr
^{140}Ba	Barium-140	12.74 d	^{240}Pu	Plutonium-240	6.537×10^3 yr
^{7}Be	Beryllium-7	53.3 d	^{241}Pu	Plutonium-241	14.4 yr
^{14}C	Carbon-14	5,730 yr	^{242}Pu	Plutonium-242	3.763×10^5 yr
^{141}Ce	Cerium-141	32.5 d	^{40}K	Potassium-40	1.28×10^9 yr
^{144}Ce	Cerium-144	284.3 d	^{226}Ra	Radium-226	1.62×10^3 yr
^{134}Cs	Cesium-134	2.062 yr	^{228}Ra	Radium-228	5.75 yr
^{137}Cs	Cesium-137	30.0 yr	^{220}Rn	Radon-220	55.6 s
^{51}Cr	Chromium-51	27.704 d	^{222}Rn	Radon-222	3.8235 d
^{60}Co	Cobalt-60	5.271 yr	^{103}Ru	Ruthenium-103	39.28 d
^{152}Eu	Europium-152	13.33 yr	^{106}Ru	Ruthenium-106	368.2 d
^{154}Eu	Europium-154	8.8 yr	^{90}Sr	Strontium-90	29.12 yr
^{3}H	Tritium	12.35 yr	^{99}Tc	Technetium-99	2.13×10^5 yr
^{129}I	Iodine-129	1.57×10^7 yr	^{232}Th	Thorium-232	1.405×10^{10} yr
^{131}I	Iodine-131	8.04 d	^{233}U	Uranium-233	1.585×10^5 yr
^{55}Fe	Iron-55	2.7 yr	^{234}U	Uranium-234	2.445×10^5 yr
^{59}Fe	Iron-59	44.529 d	^{235}U	Uranium-235	7.038×10^8 yr
^{85}Kr	Krypton-85	10.72 yr	^{238}U	Uranium-238	4.468×10^9 yr
^{87}Kr	Krypton-87	1.27 hr	^{90}Y	Yttrium-90	64.0 hr
^{88}Kr	Krypton-88	2.84 hr	^{65}Zn	Zinc-65	243.9 d
^{212}Pb	Lead-212	10.64 hr	^{95}Zr	Zirconium-95	63.98 d

a. From EPA (1999).

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

How are Radioactivity and Radionuclides Detected?

Environmental samples of air, water, soil, and plants are collected in the field and then prepared and analyzed for radioactivity in a laboratory. A prepared sample is placed in a radiation counting system with a detector that converts the ionization produced by the radiation into electrical signals or pulses. The number of electrical pulses recorded over a unit of time is called a "count rate." The count rate is proportional to the amount of radioactivity in the sample.

Air and water samples are often analyzed to determine the total amount of alpha and beta-emitting radioactivity present. This is referred to as a "gross" measurement, because the radiation from all alpha-emitting and beta-emitting radionuclides in the sample is quantified. Such sample analyses measure both human-generated and naturally-occurring radioactive material. Gross alpha and beta analyses are generally considered screening measurements, since specific radionuclides are not identified. The amount of gross alpha and beta-emitting radioactivity in air samples is frequently measured to screen for the presence of man-made radionuclides. If the results are higher than normal, sources other than background radionuclides may be suspected, and other laboratory techniques may be used to identify the specific radionuclides in the sample. Gross alpha and beta activity also can be examined over time and between locations to detect trends.

The low penetration ability of alpha-emitting particles makes detection by any instrument difficult. Identifying specific alpha-emitting radionuclides typically involves chemical separations in the laboratory to purify the sample prior to analysis with an alpha detection instrument. Radiochemical analysis is very time-consuming and expensive.

Beta particles are easily detected by several types of instruments, including the common Geiger-Mueller (G-M) counter. However, detection of specific beta-emitting radionuclides, such as ^{3}H and strontium-90 (^{90}Sr), requires chemical separation first.

The high-energy photons from gamma-emitting radionuclides are relatively easy to detect. Because the photons from each gamma-emitting radionuclide have a characteristic energy, gamma emitters can be simply identified in the laboratory with only minimal sample preparation prior to analysis. Gamma-emitting radionuclides, such as cesium-137 (^{137}Cs), can even be measured in soil by field detectors called "in-situ" detectors.

Gamma radiation originating from naturally occurring radionuclides in soil and rocks on the earth's surface is a primary contributor to the background external radiation exposure measured in air. Cosmic radiation from outer space is another contributor to the external radiation background. External radiation is easily measured with devices known as environmental dosimeters.

How are Results Reported?

Scientific Notation. Concentrations of radionuclides detected in the environment are typically quite small. Scientific notation is used to express numbers that are very small or very

large. A very small number may be expressed with a negative exponent, for example, 1.3×10^{-6}. To convert this number to its decimal form, the decimal point is moved left by the number of places equal to the exponent (six, in this case). The number 1.3×10^{-6} may also be expressed as 0.0000013.

When considering large numbers with a positive exponent, such as 1.0×10^{6}, the decimal point is moved to the right by the number of places equal to the exponent. In this case, 1.0×10^{6} represents one million and may also be written as 1,000,000.

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

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

Table HI-2. Multiples of Units.

Multiple	Decimal Equivalent	Prefix	Symbol
10^{6}	1,000,000	mega-	M
10^{3}	1,000	kilo-	k
10^{2}	100	hecto-	h
10	10	deka-	da
10^{-1}	0.1	deci-	d
10^{-2}	0.01	centi-	c
10^{-3}	0.001	milli-	m
10^{-6}	0.000001	micro-	μ
10^{-9}	0.000000001	nano-	n
10^{-12}	0.000000000001	pico-	p
10^{-15}	0.000000000000001	femto-	f
10^{-18}	0.000000000000000001	atto-	a

Units of Radiological Dose (Table HI-3). The amount of ionization produced by gamma or X-ray radiation in air is measured in terms of the roentgen (R). The ionization or exposure measured in air must be converted into a special unit called the equivalent dose in order to determine the impact on humans. The equivalent dose, which is often referred to as just "dose," takes into account the effect of different types of radiation on tissues. The unit used for equivalent dose is the Roentgen Equivalent Man or "rem." For the types of environmental radiation generally encountered, the unit of roentgen is approximately equal to the unit of rem. A person-rem is the sum of the doses received by all individuals in a population.

The term "rad," which is short for radiation absorbed dose, is also used in this report. The rad is a measure of the energy absorbed by any material, whereas "rem" relates to both amount of radiation energy absorbed by human tissue and its consequence.

The Système International is used to express units of radioactivity and radiation dose. The basic unit of radioactivity in this system of units is the Becquerel (Bq), which is equivalent to one nuclear disintegration per second. The number of curies must be multiplied by 3.7×10^{10} to obtain the equivalent number of becquerels. The concept of dose equivalent may also be expressed using the Système International unit sievert (Sv), where 1 Sv equals 100 rem.

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

There is always uncertainty associated with the measurement of radioactivity in environmental samples. This is mainly because radioactive decay events are inherently random. Thus, when a radioactive sample is counted again and again for the same length of time, the results will differ slightly, but most of the results will be close to the "true value" of the activity of the radioactive material in the sample. Statistical methods are used to estimate the true value of a single measurement and the associated uncertainty of the measurement. The uncertainty of a measurement is reported by following the result with an uncertainty value which is preceded by the plus or minus symbol, ± (e.g., 10 ± 2 pCi/L). For concentrations of greater than or equal to three times the uncertainty, there is 95 percent probability that the radionuclide was detected in a sample. For example, if a radionuclide is reported for a sample at a concentration of 10 ± 2 pCi/L, that radionuclide is considered to be detected in that sample because 10 is greater than 3 × 2 or 6. On the other hand, if the reported concentration of a radionuclide (e.g., 10 ± 6 pCi/L) is smaller than three times its associated uncertainty, then the sample probably does not contain that radionuclide; i.e, 10 is less than 3 × 6 or 18. Such low concentrations are considered to be undetected by the method and/or instrumentation used.

Mean, Median, Maximum, and Minimum Values. Descriptive statistics are often used to express the patterns and distribution of a group of results. The most common descriptive statistics used in this report are the mean, median, minimum, and maximum values. Mean and median values measure the central tendency of the data. The mean is calculated by adding up all the values in a set of data and then dividing that sum by the number of values in the dataset. The median is the middle value in a group of measurements. When the data are arranged from largest (maximum) to smallest (minimum), the result in the exact center of an odd number

Table HI-3. Names and Symbols for Units of Radioactivity and Radiological Dose Used in this Report.

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

Table HI-4. Units of Radioactivity.

Media	Unit
Air	Microcuries per milliliter (µCi/mL)
Liquid, such as water and milk	Picocuries per liter (pCi/L)
Soil and agricultural products	Picocuries per gram (pCi/g) dry weight
Annual human radiation exposure, measured by environmental dosimeters	Milliroentgens (mR) or millirem (mrem), after being multiplied by an appropriate dose equivalent conversion factor

of results is the median. If there is an even number of results, the median is the average of the two central values. The maximum and the minimum results represent the range of the measurements.

Statistical analysis of many of the air data reported in this annual report indicate that the median is a more appropriate representation of the central tendency of those results. For this reason, some of the figures present the median value of a data group. For example, Figure HI-2 illustrates the minimum, maximum, and median of a set of air measurements. The vertical lines drawn above and below the median represent the range of values between the minimum and maximum results.

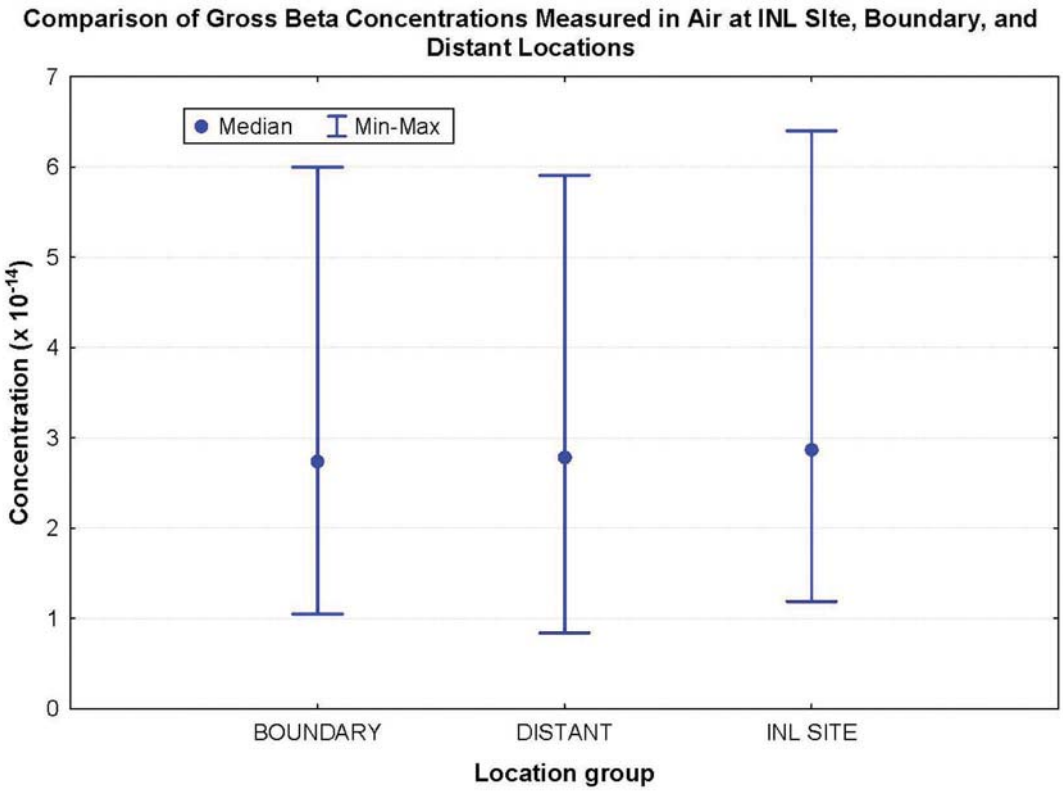


Figure HI-2. A Graphical Representation of Minimum, Median, and Maximum Results.

How are Data Represented Graphically?

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

A **pie chart** is used in this report to illustrate fractions of a whole. For example, Figure HI-3 shows the approximate contribution to dose that a typical person might receive while living in southeast Idaho. The percentages are derived from the table in the upper right-hand corner of the figure. The medical, consumer, and occupational/industrial portions are from NCRP Report No. 160 (NCRP 2009). The contribution from background (natural radiation, mostly radon) is estimated in Table 7-5 of this report.

A **column or bar chart** can show data changes over a period of time or illustrate comparisons among items. Figure HI-4 illustrates the contribution of radionuclides released into air from INL Site operations from 1975 through 1984 to the dose (mrem) calculated for the maximally exposed individual. The maximally exposed individual is a hypothetical member of the public who is exposed to radionuclides from airborne releases through various environmental

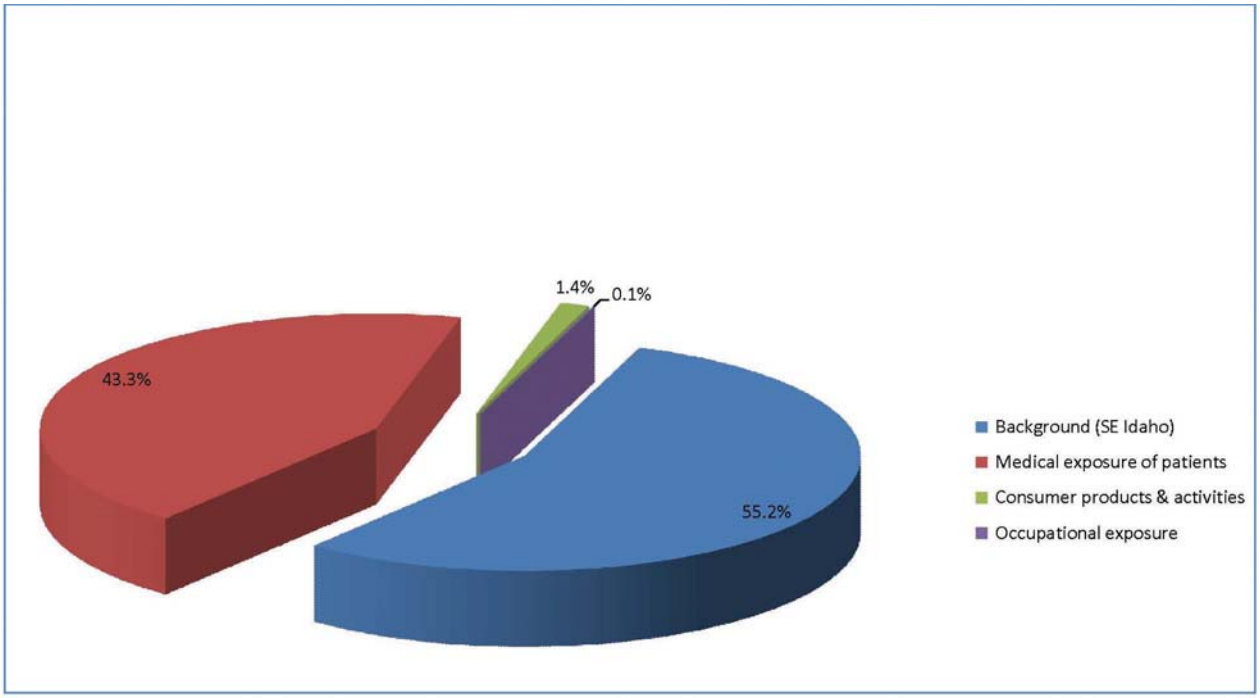


Figure HI-3. Data Presented Using a Pie Chart.

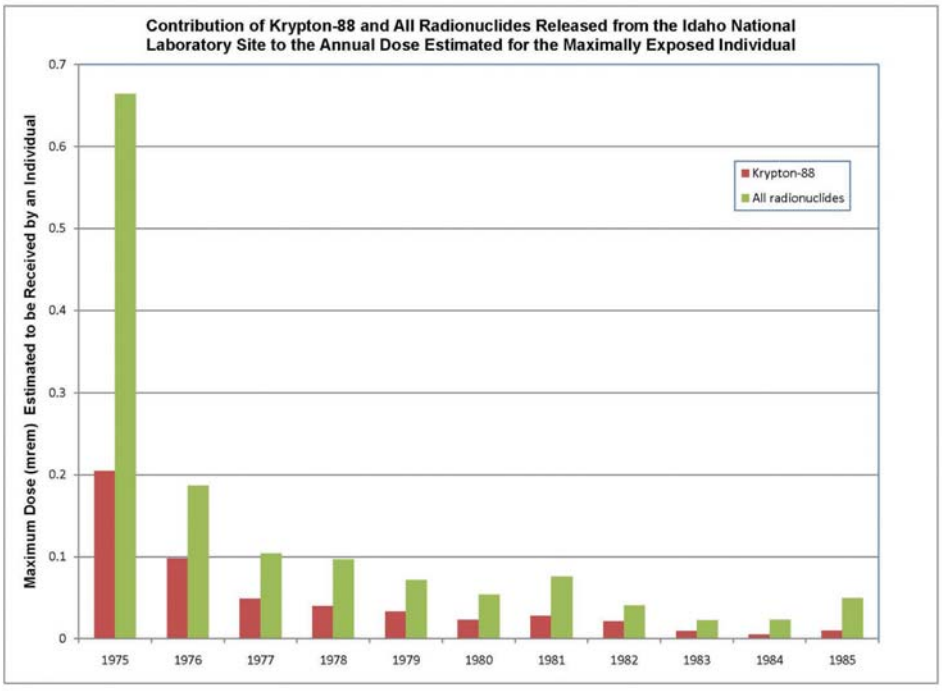


Figure HI-4. Data Plotted Using a Column Chart.

pathways and the media through which the radionculides are transported (i.e., air, water, and food). One column (red) represents the annual dose from krypton-88 (^{88}Kr) released. The second column (green) plots the annual dose from all radionuclides released into the air. The chart shows the general decreasing trend of the dose as well as the relative contribution to dose from the ^{88}Kr. The relative contribution to the total dose from ^{88}Kr varies over time. For example, it represents approximately one-third of the total dose in 1975 and a little over one-half of the dose in 1976.

A **plot** can be useful to visualize differences in results over time. Figure HI-5 shows the median, minimum, and maximum results of gross beta measurements in all air filters collected by the Environmental Surveillance, Education, and Research contractor for the previous ten years (1999 through 2008). The results are plotted by the week of the year. Thus, the median for each week represents the midpoint of measurements made at all locations during the nine-year period for that week. The plot shows that the results can vary greatly, particularly during the winter.

Contour lines are sometimes drawn on a map to discern patterns over a geographical area. For example, Figure HI-6 shows the distribution of ^{3}H in groundwater around the INTEC. Each contour line, or isopleth, represents a specific concentration of the radionuclide in groundwater. It was estimated from measurements of samples collected from wells around INTEC. Each contour line separates areas that have concentrations above the contour line value from those that have concentrations below that value. The figure shows the highest concentration gradient near INTEC and the lowest farther away. It reflects the movement of the radionuclide in groundwater from INTEC where it was injected into the aquifer in the past.

How are Results Interpreted?

To better understand data, results are compared in one or more ways, including:

- **Comparison of results collected at different locations.** For example, measurements made at INL Site locations are compared with those made at locations near the boundary of the INL Site and distant from the INL Site to find differences that may indicate an impact (Figure HI-2).
- **Trends over time or space.** Data collected during the year can be compared with data collected at the same location or locations during previous years to see if concentrations are increasing, decreasing, or remaining the same with time. See, for example, Figure HI-4. Figure HI-6 illustrates a clear spatial pattern of radionuclide concentrations in groundwater decreasing with distance from the source.
- **Comparison with background measurements.** Humans are now, and always have been, continuously exposed to ionizing radiation from natural background sources. Background sources include natural radiation and radioactivity as well as radionuclides from human activities. These sources are discussed in the following section.

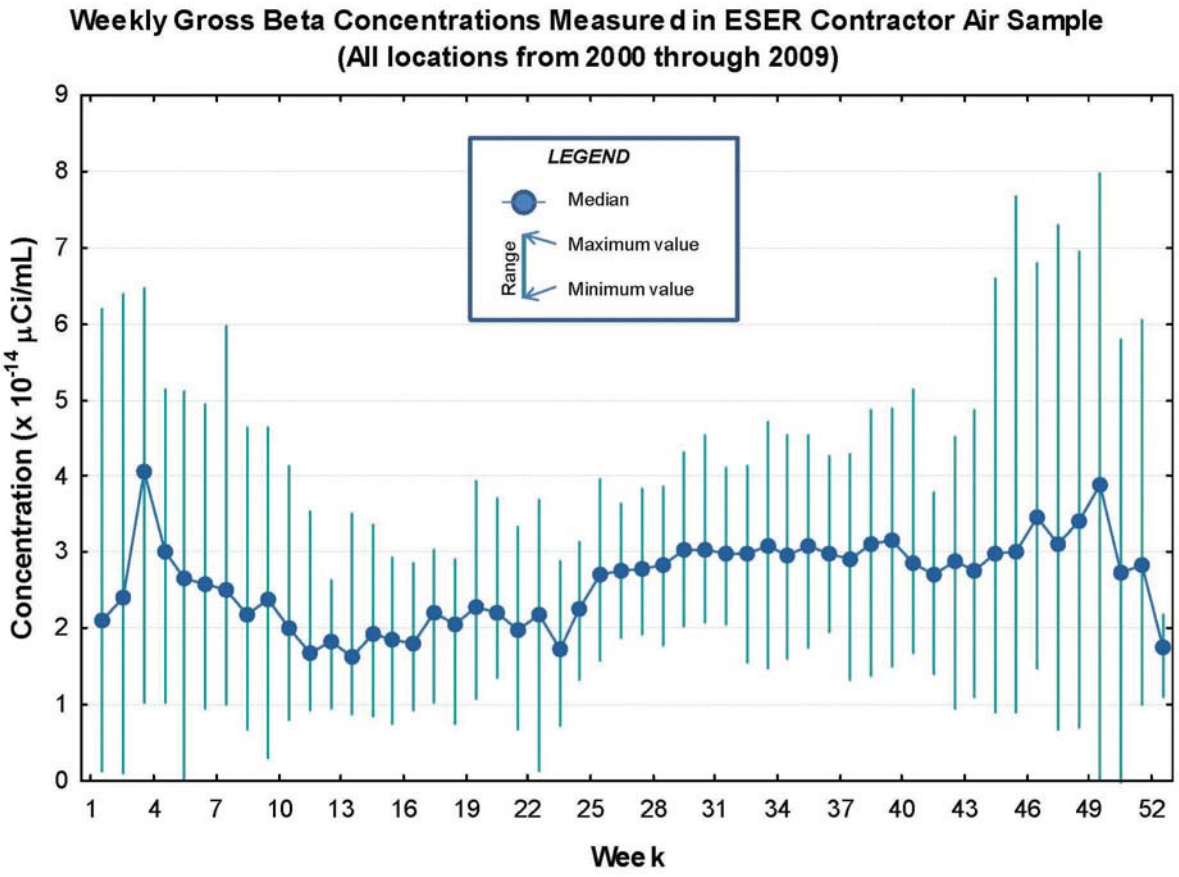


Figure HI-5. Data Plotted Using a Linear Plot.

What is Background Radiation?

Radioactivity from natural and fallout sources is detectable as "background" in all environmental media. Natural sources of radiation include: radiation of extraterrestrial origin (called cosmic rays), radionuclides produced in the atmosphere by cosmic ray interaction with matter (called cosmogenic radionuclides), and radionuclides present at the time of the formation of the earth (called primordial radionuclides). Radiation that has resulted from the activities of modern man is primarily fallout from past atmospheric testing of nuclear weapons. One of the challenges to environmental monitoring on and around the INL Site is to distinguish between what may have been released from the INL Site and what is already present in background from natural and fallout sources. These sources are discussed in more detail below.

Natural Sources. Natural radiation and radioactivity in the environment, that is natural background, represent a major source of human radiation exposure (NCRP 1987, NCRP 2009).

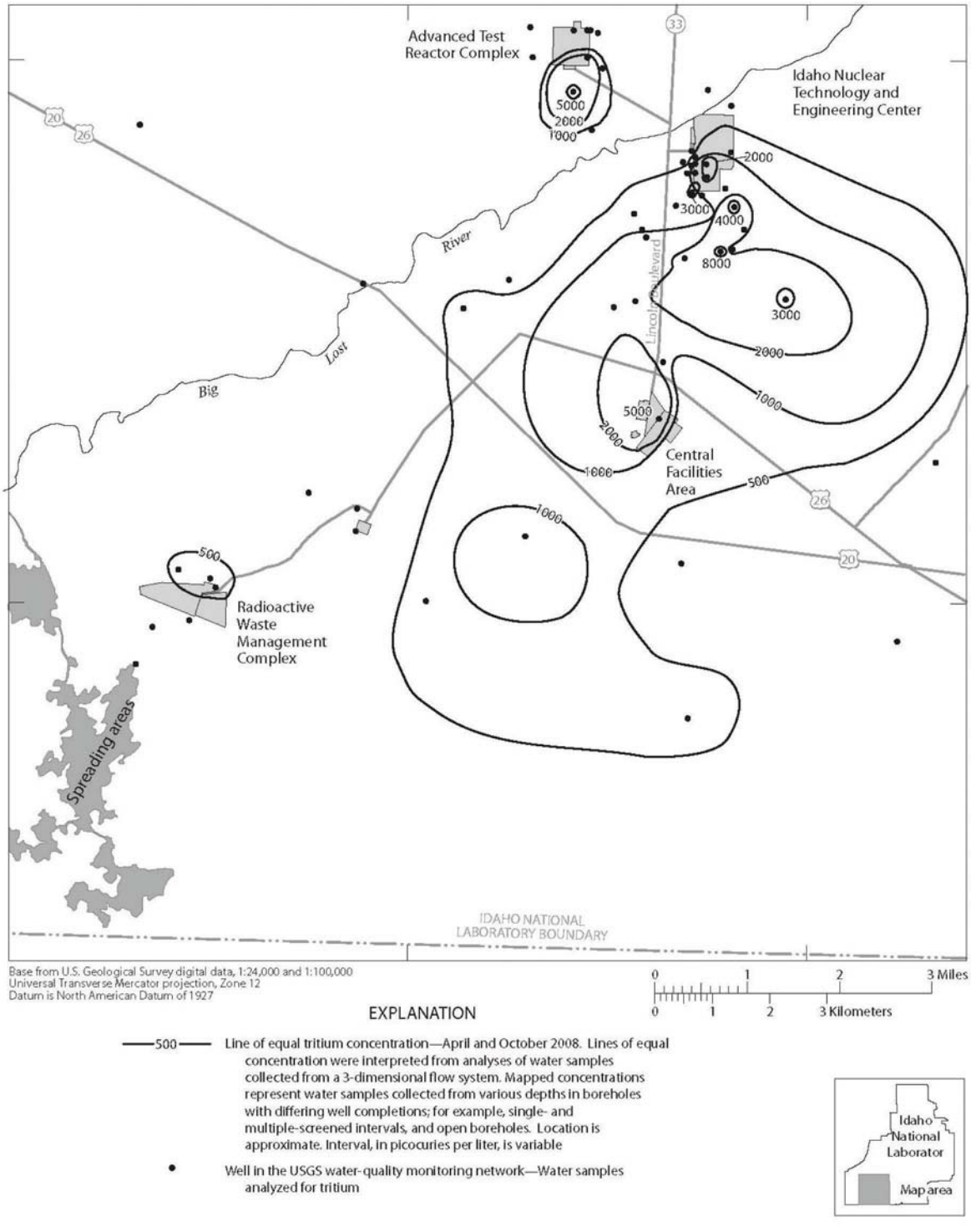


Figure HI-6. Data Plotted Using Contour Lines. Each contour line drawn on this map connects points of equal tritium concentration in water samples collected at the same depth from wells on the INL Site.

For this reason, natural radiation frequently is used as a standard of comparison for exposure to various human-generated sources of ionizing radiation. An individual living in southeast Idaho was estimated in 2011 to receive an average dose of about 381 mrem/yr from natural background sources of radiation on earth (Figure HI-7). These sources include cosmic radiation and naturally occurring radionuclides.

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

Naturally occurring radionuclides are of two general kinds: cosmogenic and primordial. Cosmogenic radionuclides are produced by the interaction of cosmic radiation within the atmosphere or in the earth. Cosmic rays have high enough energies to blast apart atoms in the earth's atmosphere. The result is the continuous production of radionuclides, such as ^{3}H (^{3}H), beryllium-7 (^{7}Be), sodium-22 (^{22}Na), and carbon-14 (^{14}C). Cosmogenic radionuclides, particularly ^{3}H and ^{14}C, have been measured in humans, animals, plants, soil, polar ice, surface rocks, sediments, the ocean floor, and the atmosphere. Concentrations are generally higher at mid-latitudes than at low- or high-latitudes. Cosmogenic radionuclides contribute only about 1 mrem/yr to the total average dose, mostly from ^{14}C, that might be received by an adult living in the United States (NCRP 2009). Tritium and ^{7}Be are routinely detected in environmental samples collected by environmental monitoring programs on and around the INL Site (Table HI-5), but contribute little to the dose which might be received from natural background sources.

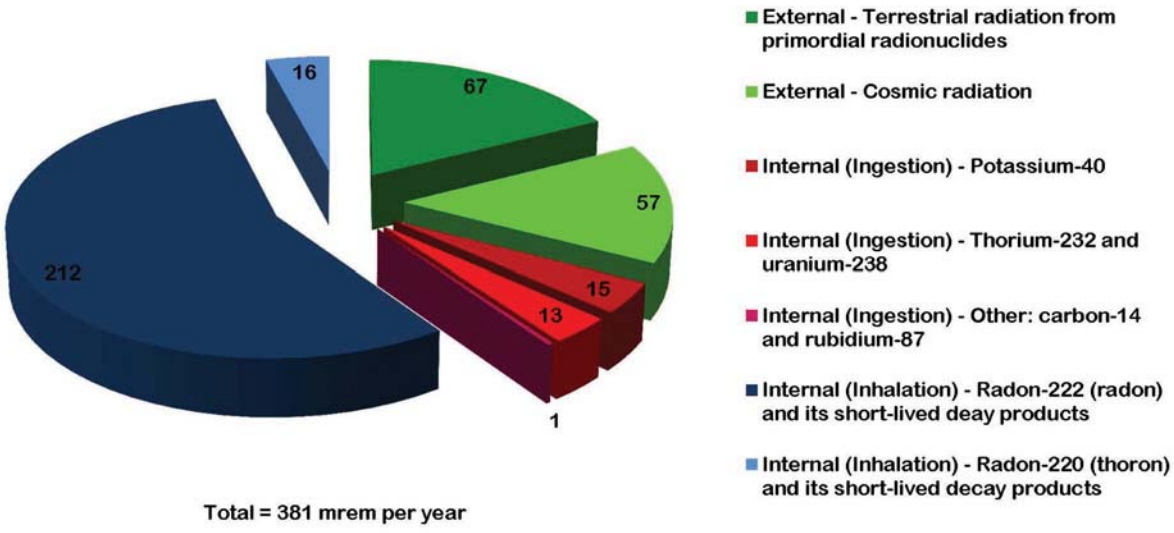


Figure HI-7. Calculated Doses (mrem per year) from Natural Background Sources for an Average Individual Living in Southeast Idaho (2011).

Table HI-5. Naturally Occurring Radionuclides that Have Been Detected in Environmental Media Collected on and around the INL Site.

Radionuclide	Half-life	How Produced?	Detected or Measured in:
Beryllium-7 (^{7}Be)	2.7×10^{6} yr	Cosmic rays	Rain, air
Tritium (^{3}H)	12.3 yr	Cosmic rays	Water, rain, air moisture
Potassium-40 (^{40}K)	1.26×10^{9} yr	Primordial	Water, air, soil, plants, animals
Thorium-232 (^{232}Th)	1.4×10^{10} yr	Primordial	Soil
Uranium-238 (^{238}U)	4.5×10^{9} yr	Primordial	Water, air, soil
Uranium-234(^{234}U)	2.5×10^{5} yr	^{238}U progeny	Water, air, soil
Radium-226 (^{226}Ra)	1,620 yr	^{238}U progeny	Water

Primordial radionuclides are those that were present when the earth was formed. The primordial radionuclides detected today are billions of years old. The radiation dose to a person from primordial radionuclides comes from internally deposited radioactivity, inhaled radioactivity, and external radioactivity in soils and building materials. Three of the primordial radionuclides, potassium-40 (^{40}K), uranium-238 (^{238}U), and thorium-232 (^{232}Th), are responsible for most of the dose received by people from natural background radioactivity. They have been detected in environmental samples collected on and around the INL Site (Table HI-5). The external dose to an adult living in southeast Idaho from terrestrial natural background radiation exposure (68 mrem/yr) has been estimated using concentrations of ^{40}K, ^{238}U, and ^{232}Th measured in soil samples collected from areas surrounding the INL Site from 1976 through 1993. Uranium-238 and ^{232}Th are also estimated to contribute 13 mrem/yr to an average adult through ingestion (NCRP 2009).

Potassium-40 is abundant and measured in living and nonliving matte. It is found in human tissue and is a significant source of internal dose to the human body (approximately 15 mrem/yr according to NCRP [2009]). Rubidium-87 (^{87}Rb), another primordial radionuclide, contributes a small amount (< 1 mrem/y) to the internal dose received by people but is not typically measured in INL Site samples.

Uranium-238 and ^{232}Th each initiate a decay chain of radionuclides. A radioactive decay chain starts with one type of radioactive atom called the “parent” that decays and changes into another type of radioactive atom called a “progeny” radionuclide. This system repeats, involving several different radionuclides. The parent radionuclide of the uranium decay chain is ^{238}U. The most familiar element in the uranium series is radon, specifically radon-222 (^{222}Rn). This is a gas that can accumulate in buildings. Radon and its progeny are responsible for most of the inhalation dose (an average of 200 mrem/yr nationwide) produced by naturally occurring radionuclides (Figure HI-7). The parent radionuclide of the thorium series is ^{232}Th. Another isotope of radon (^{220}Rn), called thoron, occurs in the thorium decay chain of radioactive atoms. Uranium-238, ^{232}Th, and their progeny often are detected in environmental samples (Table HI-5).

Global Fallout. The United States, the USSR, and China tested nuclear weapons in the atmosphere in the 1950s and 1960s, which resulted in the release of radionuclides into the upper atmosphere. This is referred to as "fallout" from weapons testing. Concerns over worldwide fallout rates eventually led to the Partial Test Ban Treaty in 1963, which limited signatories to underground testing. Not all countries stopped atmospheric testing though. France continued atmospheric testing until 1974, and China until 1980. Additional fallout, but to a substantially smaller extent, was produced by the Chernobyl nuclear accident in 1986.

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

The deposition of these radionuclides on the earth's surface varies by latitude, with most occurring in the northern hemisphere at approximately 40^{o}. Variation within latitudinal belts is a function primarily of precipitation, topography, and wind patterns.

The dose produced by global fallout from nuclear weapons testing has decreased steadily since 1970. The annual dose rate from fallout was estimated in 1987 to be less than 1 mrem (NCRP 1987). It has been over 30 years since that estimate, so the current dose is even lower.

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

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

Risk can be defined in general as the probability (chance) of injury, illness, or death resulting from some activity. There is a large amount of data showing the effects of receiving high doses of radiation, especially in the range of 50 to 400 rem (50,000 to 400,000 mrem), delivered acutely (all at once.) These are largely data resulting from studies of the survivors of the Japanese atomic bombing and of some relatively large groups of patients who were treated with substantial doses of X-rays.

It is difficult to estimate risks from low levels of radiation. Low-dose effects are those that might be caused by doses of less than 20 rem (20,000 mrem), whether delivered acutely or spread out over a period as long as a year (Taylor 1996). Most of the radiation exposures that

humans receive are very close to background levels. Moreover, many sources emit radiation that is well below natural background levels. This makes it extremely difficult to isolate its effects. For this reason, government agencies make the conservative (cautious) assumption that any increase in radiation exposure is accompanied by an increased risk of health effects. Cancer is considered by most scientists to be the primary health effect from long-term exposure to low levels of radiation.

Each radionuclide represents a somewhat different health risk. However, health physicists (radiation protection professionals) currently estimate that overall, if each person in a group of 10,000 people is exposed to 1 rem (1,000 mrem) of ionizing radiation in small doses over a lifetime, we would expect five or six more people to die of cancer than would otherwise (EPA 2010). In this group of 10,000 people, about 2,000 would be expected to die of cancer from all non-radiation causes. A lifetime exposure to 1 rem (1,000 mrem) of radiation would increase that number to about 2,005 or 2,006. For perspective, most people living on the Eastern Snake River Plain receive a little over one-third of a rem (355 mrem) every year from natural background sources of radiation.

Health physicists generally agree on limiting a person's exposure beyond background radiation to about 100 mrem per year from all sources (EPA 2010). Exceptions are occupational, medical, or accidental exposures. DOE limits the dose to a member of the public from all sources and pathways to 100 mrem and the dose from the air pathway only to 10 mrem (DOE Order 458.1). The doses estimated to maximally exposed individuals from INL Site releases are typically well below one mrem per year.

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Male Sage Grouse

Acronyms

AFV	Alternative Fuel Vehicles
AGU	American Geophysical Union
AMWTP	Advanced Mixed Waste Treatment Project
ARA	Auxiliary Reactor Area
ARVFS	Army Reentry Vehicle Facility Site
ASME	American Society of Mechanical Engineers
ATR	Advanced Test Reactor
BCG	Biota Concentration Guide
BEA	Battelle Energy Alliance
BLM	U.S. Bureau of Land Management
BLR	Big Lost River
BORAX	Boiling Water Reactor Experiment
BTEX	Benzene, Toluene, Ethylbenzene, and Xylenes
CAP88-PC	Clean Air Act Assessment Package, 1988 Personal Computer
CCA	Clean Air Act
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFA	Central Facilities Area
CFR	Code of Federal Regulations
CITRC	Critical Infrastructure Test Range Complex
CRM	Cultural Resource Management
CRMP	Cultural Resource Management Plan
CTF	Contained Test Facility
CWA	Clean Water Act
CWI	CH2M-WG Idaho, LLC
CWP	Cold Waste Pond
CY	Calendar Year
DCG	Derived Concentration Guide
DCS	Derived Concentration Standards
D&D	Decontamination and Decommissioning
DEQ	Department of Environmental Quality (state of Idaho)
DOE	U.S. Department of Energy
DOE-HQ	U.S. Department of Energy - Headquarters
DOE-ID	U.S. Department of Energy - Idaho Operations Office
DQO	Data Quality Objective
EA	Environmental Assessment
EBR-I	Experimental Breeder Reactor - No. 1
EBR-II	Experimental Breeder Reactor - No. 2
ECF	Expended Core Facility
EFS	Experimental Field Station
EIS	Environmental Impact Statement
EMS	Environmental Management System
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act

EPEAT	Electronic Product Environmental Assessment
ESA	Endangered Species Act
ESER	Environmental Surveillance, Education, and Research
FAST	Fluorinel Dissolution Process and Fuel Storage Facility
FEMP	Federal Energy Management Program
FFA/CO	Federal Facility Agreement and Consent Order
FR	Federal Register
FY	Fiscal Year
GDE	Guide
GHG	Greenhouse Gas Emissions
GP	Guiding Principles
GPS	Global Positioning System
GSA	General Services Administration
GSS	Gonzales-Stoller Surveillance, LLC
HAER	Historic American Engineering Record
HPGe	High Purity Germanium
HPSB	High Performance Sustainability Buildings
ICDF	Idaho CERCLA Disposal Facility
ICP	Idaho Cleanup Project
ICRP	Internal Commission of Radiological Protection
IDAPA	Idaho Administrative Procedures Act
IET	Initial Engine Test Facility
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center (formerly Idaho Chemical Processing Plant)
IOP	INL Oversight Program
ISB	In Situ Bioremediation
ISFSI	Independent Spent Fuel Storage Installation
ISO	International Organization for Standardization
LEED	Leadership in Energy and Environmental Design
LMA	Leaf Mass per Area Unit
LOFT	Loss-of-Fluid Test
LTV	Long-Term Vegetation
M&O	Management and Operating
MAPEP	Mixed Analyte Performance Evaluation Program
MCL	Maximum Contaminant Level
MCP	Management Control Procedure
MDIFF	Mesoscale Diffusion Model
MEI	Maximally Exposed Individual
MFC	Materials and Fuels Complex
MSAVI	Modified Soil Adjusted Vegetation Index
NA	Not Applicable
NAGPRA	Native American Graves Protection and Repatriation Act
NAPL	Non-aqueous Phase Liquid
NCRP	National Council on Radiation Protection and Measurements

ND	Not Detected
NE	Not Established
NEPA	National Environmental Policy Act
NERP	National Environmental Research Park
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NIS	Non-indigenous Plant Species
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NOAA ARL-FRD	National Oceanic and Atmospheric Administration Air Resources Laboratory - Field Research Division
NORM	Naturally Occurring Radioactive Material
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
NRF	Naval Reactors Facility
OMB	Office of Management and Budget
OP	Oversight Program
OSLD	Optically Stimulated Luminescent Dosimeters
PAH	Polycyclic Aromatic Hydrocarbon
PBF	Power Burst Facility
PCB	Polychlorinated Biphenyls
PCS	Primary Constituent Standards
PCO	Principle Coordinates
PINS	Portable Isotopic Neutron Spectroscopy
PLN	Plan
PLS	Partial Least Square
PRD	Program Requirements Document
PT	Proficiency Testing
QA	Quality Assurance
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
RESL	Radiological and Environmental Sciences Laboratory
RPD	Relative Percent Difference
RPS	Rare Plant Species
ROD	Record of Decision
RRTR	Radiological Response Training Range
RWMC	Radioactive Waste Management Complex
SCS	Secondary Constituent Standards
SDA	Subsurface Disposal Area
SHPO	State Historic Preservation Office
SMC	Specific Manufacturing Capability
SMCL	Secondary Maximum Contaminant Level
SNF	Spent Nuclear Fuel
SOX	Stand-off Experiment
SPR	Sampling Procedure

TAN	Test Area North
TCE	Trichloroethylene
TDF	Time Domain Reflectometry
TIC	Total Integrated Concentration
TLD	Thermoluminescent Dosimeter
TLS	Terrestrial Laser Scanner
TPR	Technical Procedure
TSF	Technical Support Facility
TMI	Three-Mile Island
TRU	Transuranic (waste)
TSCA	Toxic Substances Control Act
UAV	Unmanned Aerial Vehicles
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOC	Volatile Organic Compounds
WAG	Waste Area Group
WRRFT	Water Reactor Research Test Facility

Units

Bq	becquerel
C	Celsius
Ci	curie
cm	centimeter
cps	counts per second
d	Day
F	Fahrenheit
ft	feet
g	gram
gal	gallon
ha	hectare
keV	kilo-electron-volts
kg	kilogram
km	kilometer
L	liter
lb	pound
m	meter
µCi	microcurie (10^{-6} curies)
µg	microgram
µm	micrometerse
µR	microentgen
µS	microsiemens
µSv	microsieverts
Ma	million years
mCi	millicurie
MeV	mega electron volt
mg	milligram
MG	million gallons
mGy	milligrey
mi	mile
min	minute
mL	milliliter
mR	milliroentgen
mrad	millirad
mrem	millirem
mSv	millisievert
oz	ounce
pCi	picocurie (10^{-12} curies)
R	roentgen
rad	radiation absorbed dose
rem	roentgen equivalent man
Sv	sievert
yd	yard
yr	year

War on Weeds Team Mapping Noxious Weeds Using GPS Technology

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Chapter 1. Introduction

1. INTRODUCTION

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

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

The purpose of the report, as outlined in DOE Order 231.1B, is to present summary environmental data to:

- Characterize site environmental performance
- Summarize environmental occurrences and responses during the calendar year
- Confirm compliance with environmental standards and requirements
- Highlight significant facility programs and efforts.

This report is the principal document that demonstrates compliance with DOE Order 458.1 requirements and, therefore, describes the Idaho National Laboratory (INL) Site’s impact to the public and the environment with emphasis on radioactive contaminants.

1.1 Site Location

The INL Site encompasses about 2,305 square kilometers (km^2) (890 square miles [mi^2]) of the upper Snake River Plain in southeastern Idaho (Figure 1-1). Over 50 percent of the INL Site is located in Butte County. The INL Site extends 63 km (39 mi) from north to south, and is approximately 61 km (38 mi) at its broadest east-west portion. By highway, the southeast boundary is approximately 40 km (25 mi) west of Idaho Falls. Other towns surrounding the INL Site include Arco, Atomic City, Blackfoot, Rigby, Rexburg, Mud Lake, and Howe. Pocatello is almost 85 km (53 mi) to the southeast.

Federal lands surround much of the INL Site, including Bureau of Land Management lands and Craters of the Moon National Monument to the southwest, Challis National Forest to the west, and Targhee National Forest to the north. Mud Lake Wildlife Management Area, Camas National Wildlife Refuge, and Market Lake Wildlife Management Area are within 80 km (50 mi) of the INL Site. The Fort Hall Indian Reservation is located approximately 60 km (37 mi) to the southeast.

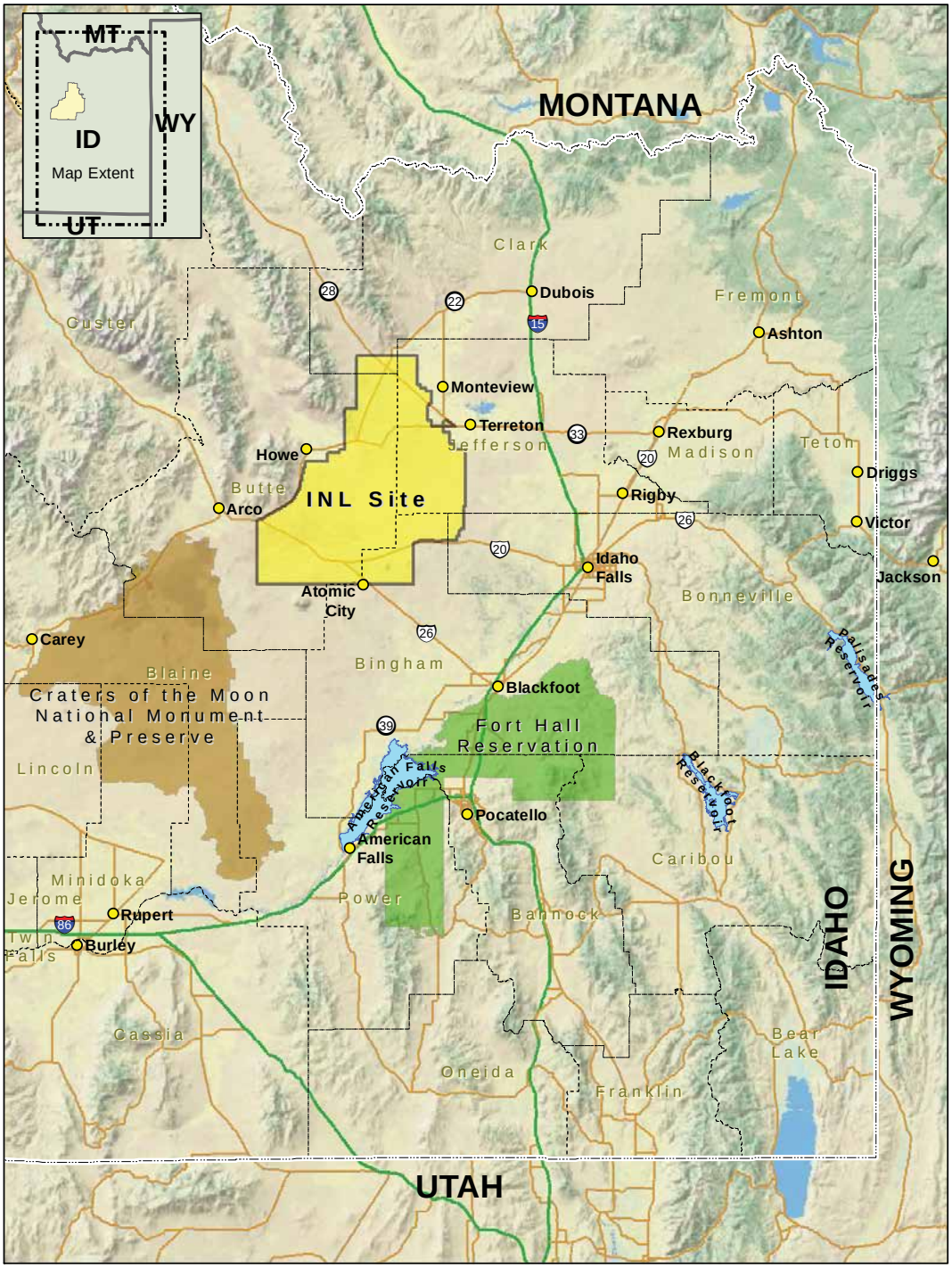

Figure 1-1. Location of the Idaho National Laboratory Site.

1.2 Environmental Setting

The INL Site is located in a large, relatively undisturbed expanse of sagebrush steppe. Approximately 94 percent of the land on the INL Site is open and undeveloped. The INL Site has an average elevation of 1,500 m (4,900 ft) above sea level and is bordered on the north and west by mountain ranges and on the south by volcanic buttes and open plain. Lands immediately adjacent to the INL Site are open sagebrush steppe, foothills, or agricultural fields. Agriculture is concentrated in areas northeast of the INL Site.

About 60 percent of the INL Site is open to livestock grazing. Controlled hunting is permitted on INL Site land but is restricted to a very small portion of the northern half of the Site.

The climate of the high desert environment of the INL Site is characterized by sparse precipitation (about 21.6 cm/yr [8.5 in./yr]), warm summers (average daily temperature of 17.1°C [62.7°F]), and cold winters (average daily temperature of -5.5°C [22.1°F]), with all averages based on 1950-2006 observations. The altitude, intermountain setting, and latitude of the INL Site combine to produce a semiarid climate. Prevailing weather patterns are from the southwest, moving up the Snake River Plain (DOE-ID 1989). Air masses, which gather moisture over the Pacific Ocean, traverse several hundred miles of mountainous terrain before reaching southeastern Idaho. Frequently, the result is dry air and little cloud cover. Solar heating can be intense, with extreme day-to-night temperature fluctuations.

Basalt flows cover most of the plain, producing rolling topography. Vegetation is visually dominated by big sagebrush (Artemisia tridentata). Beneath these shrubs are grasses and wild flowers adapted to the harsh climate. A total of 409 plant species have been recorded on the INL Site (Anderson et al. 1996).

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

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

The fractured volcanic rocks under the INL Site form a portion of the Eastern Snake River Plain Aquifer (Figure 1-2), which stretches 320 km (199 mi) from Island Park to King Hill, and stores one of the most bountiful supplies of groundwater in the nation. An estimated 247 to 370 billion m^3 (200 to 300 million acre-ft) of water is stored in the aquifer's upper portions. The aquifer is primarily recharged from the Henry's Fork and the South Fork of the Snake River, and to a lesser extent by the Big Lost River, Little Lost River, Birch Creek, and irrigation. Beneath the INL Site, the aquifer moves laterally southwest at a rate of 1.5 to 6 m/day (5 to 20 ft/day) (Lindholm 1996). The Eastern Snake River Plain Aquifer emerges in springs along the Snake River between Milner and Bliss, Idaho. Crop irrigation is the primary use of both surface water and groundwater on the Snake River Plain.

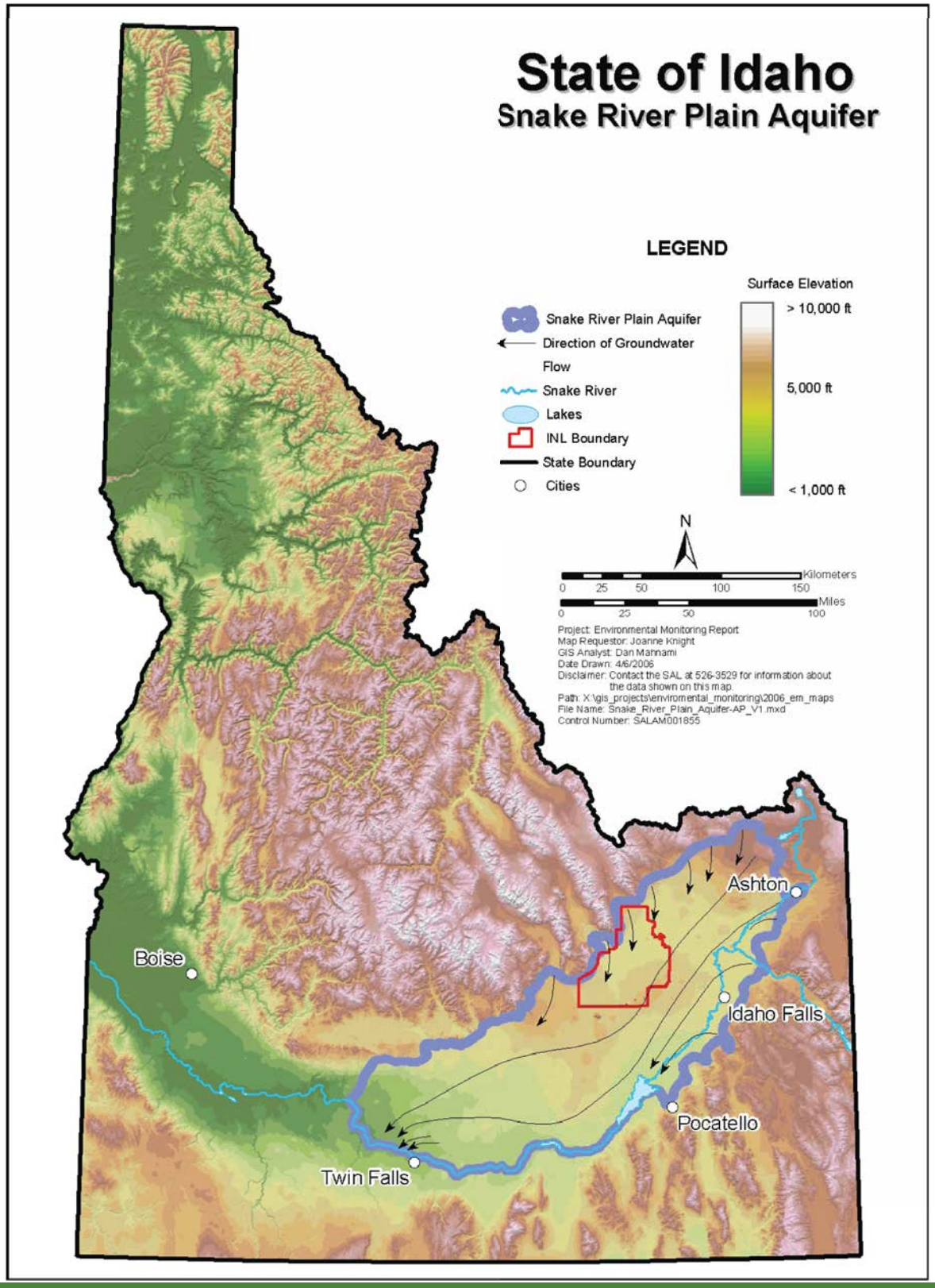

Figure 1-2. Idaho National Laboratory Site in Relation to the Eastern Snake River Plain Aquifer.

1.3 Idaho National Laboratory Site Primary Program Missions and Facilities

The INL Site mission is to operate a multi-program national research and development laboratory and to complete environmental cleanup activities stemming from past operations. The U.S. Department of Energy, Idaho Operations Office (DOE-ID) receives implementing direction and guidance primarily from two DOE Headquarters offices, the Office of Nuclear Energy and the Office of Environmental Management. The Office of Nuclear Energy is the Lead Program Secretarial Office for all DOE-ID-managed operations on the INL Site. The Office of Environmental Management provides direction and guidance to DOE-ID for environmental cleanup on the INL Site and functions in the capacity of Cognizant Secretarial Office. Naval Reactors operations on the INL Site report to the Pittsburgh Naval Reactors Office and fall outside the purview of DOE-ID and are not included in this report.

1.3.1 Idaho National Laboratory

The INL mission is to ensure the nation's energy security with safe, competitive, and sustainable energy systems and unique national and homeland security capabilities. Its vision is to be the pre-eminent nuclear energy laboratory, with synergistic, world-class, multi-program capabilities and partnerships. To fulfill its assigned duties during the next decade, INL will work to transform itself into a laboratory leader in nuclear energy and homeland security research, development, and demonstration. Highlighting this transformation will be the development of a Generation IV prototype reactor, creation of national user facilities, development of high-temperature hydrogen production, advanced fuel cycle research, expansion of the Center for Advanced Energy Studies, and proven leadership in nonproliferation and critical infrastructure protection. Battelle Energy Alliance, LLC (BEA) is responsible for management and operation of INL.

1.3.2 Idaho Cleanup Project

The Idaho Cleanup Project (ICP) involves the safe environmental cleanup of the INL Site, which was contaminated with waste generated during World War II-era conventional weapons testing, government-owned research and defense reactor operations, laboratory research, fuel reprocessing, and defense missions at other DOE sites. The 7-year, $2.9 billion cleanup project, led by CH2M-WG Idaho, LLC (CWI) and funded through the DOE Office of Environmental Management, focuses on meeting Idaho Settlement Agreement (DOE 1995) and environmental cleanup milestones while reducing risks to workers. Protection of the Snake River Plain Aquifer, the sole drinking water source for more than 300,000 residents of eastern Idaho, was the principal concern addressed in the Settlement Agreement.

ICP will treat a million gallons of sodium-bearing waste, remove targeted transuranic waste from the Subsurface Disposal Area (SDA), place spent nuclear fuel in dry storage, select a treatment for high-level waste calcine, and demolish more than 200 structures, including reactors, spent nuclear fuel storage basins, and laboratories used for radioactive experiments.

1.3.3 Advanced Mixed Waste Treatment Project

The Advanced Mixed Waste Treatment Project (AMWTP) Facility prepares and ships contact-handled transuranic waste out of Idaho. AMWTP is managed and operated by Idaho Treatment Group, LLC. Operations at AMWTP retrieve, characterize, treat, and package transuranic waste currently stored at the INL Site. The project's schedule is aligned with court-mandated milestones in the 1995 Settlement Agreement (DOE 1995) among the state of Idaho, U.S. Navy, and DOE to remove waste from Idaho. The majority of waste AMWTP processes resulted from the manufacture of nuclear weapons components at Colorado's Rocky Flats Plant. This waste was shipped to Idaho in the 1970s and early 1980s for storage, and contains industrial debris, such as rags, work clothing, machine parts, and tools, as well as soil and sludge, and is contaminated with transuranic radioactive elements (primarily plutonium). Most of the waste is "mixed waste" that is contaminated with radioactive and nonradioactive hazardous chemicals, such as oil and solvents. Since 1999, more than 45,282 m^3 (59,179 yd^3) of transuranic waste has been shipped off the INL Site.

1.3.4 Primary Idaho National Laboratory Site Facilities

Most INL Site buildings and structures are located within developed areas that are typically less than a few square miles and separated from each other by miles of undeveloped land. DOE controls all land within the INL Site (Figure 1-3).

In addition to the INL Site, DOE owns or leases laboratories and administrative offices in the city of Idaho Falls, 40 km (25 mi) east of the INL Site.

Central Facilities Area – The Central Facilities Area (CFA) is the main service and support center for INL's desert facilities. Activities at CFA support transportation, maintenance, construction, radiological monitoring, security, fire protection, warehouses, and calibration activities. It is operated by the INL contractor.

Critical Infrastructure Test Range Complex – The Critical Infrastructure Test Range Complex (CITRC) encompasses a collection of specialized test beds and training complexes that create a centralized location where government agencies, utility companies, and military customers can work together to find solutions for many of the nation's most pressing security issues. CITRC provides open landscape, technical employees, and specialized facilities for performing work in three main areas – physical security, contraband detection, and infrastructure testing. It is operated by the INL contractor.

Idaho Nuclear Technology and Engineering Center – The Idaho Chemical Processing Plant was established in the 1950s to recover usable uranium from spent nuclear fuel used in DOE and Department of Defense reactors. Over the years, the facility recovered more than $1 billion worth of highly enriched uranium that was returned to the government fuel cycle. In addition, an innovative high-level liquid waste treatment process known as calcining was developed at the plant. Calcining reduced the volume of liquid radioactive waste generated during reprocessing and placed it in a more stable granular solid form. In the 1980s, the facility underwent an ambitious modernization, and safer, cleaner, and more efficient structures replaced

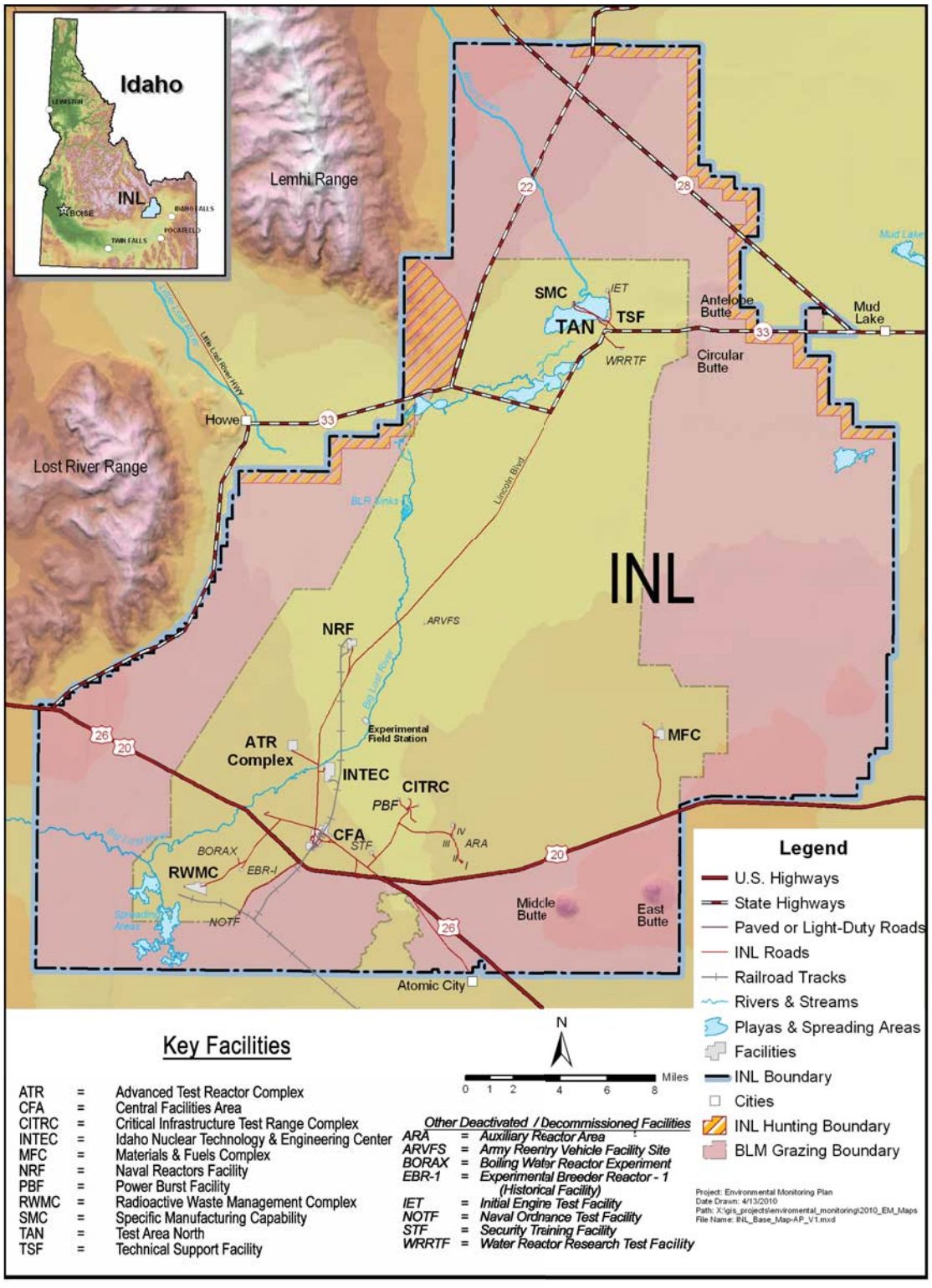

Figure 1-3. Location of the Idaho National Laboratory Site, Showing Facilities.

most major facilities. In 1992, DOE announced that the changing world political situation and the lack of demand for highly enriched uranium made reprocessing unnecessary. In 1998, the plant was renamed the Idaho Nuclear Technology and Engineering Center (INTEC). Current operations include management of sodium-bearing waste, special nuclear material disposition, spent nuclear fuel storage, environmental remediation, and demolition of excess facilities. INTEC is operated by the ICP contractor.

Materials and Fuels Complex – The Materials and Fuels Complex (MFC) is a prime testing center for advanced technologies associated with nuclear power systems. This complex is the nexus of research and development for new reactor fuels and related materials. As such, it will contribute increasingly efficient reactor fuels and the important work of nonproliferation – harnessing more energy with less risk. Facilities at MFC also support manufacturing and assembling components for use in space applications. It is operated by the INL contractor.

Naval Reactors Facility – The Naval Reactors Facility (NRF) is operated by Bechtel Marine Propulsion Corporation. Developmental nuclear fuel material samples, naval spent fuel, and irradiated reactor plant components and materials are examined at the Expended Core Facility (ECF). The knowledge gained from these examinations is used to improve current reactor designs and to monitor the performance of existing reactors. The naval spent fuel examined at ECF is critical to the design of longer-lived cores, which minimizes the creation of spent nuclear fuel requiring long-term disposition.

As established in Executive Order 12344 (1982), the Naval Nuclear Propulsion Program is exempt from the requirements of DOE Orders 436.1, 458.1, and 414.1C. Therefore, NRF is excluded from this report. The director, Naval Nuclear Propulsion Program, establishes reporting requirements and methods implemented within the program, including those necessary to comply with appropriate environmental laws. The NRF's program is documented in the NRF Environmental Monitoring Report (BMPC 2012).

Radioactive Waste Management Complex – Since the 1950s, DOE has used the Radioactive Waste Management Complex (RWMC) to manage, store, and dispose of waste contaminated with radioactive elements generated in national defense and research programs. RWMC manages solid transuranic and low-level radioactive waste. RWMC provides treatment, temporary storage and transportation of transuranic waste destined to the Waste Isolation Pilot Plant. Management of stored wastes at RWMC is the responsibility of the AMWTP contractor.

The SDA is a 39-hectare (97-acre) radioactive waste landfill that was used for more than 50 years. Approximately 14 of the 39 hectares contain waste, including radioactive elements, organic solvents, acids, nitrates, and metals from historical operations such as reactor research at INL and weapons production at other DOE facilities. A Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Record of Decision (OU-7-13/14) was signed in 2008 (DOE-ID 2008) that includes exhumation and off-site disposition of targeted waste. Through December 2011, 2.96 of the required 5.69 acres have been exhumed and 5,394.9 cubic meters of waste was shipped out of Idaho. Cleanup of RWMC is managed by the ICP contractor.

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

Research and Education Campus – The Research and Education Campus, operated by the INL contractor, is the collective name for INL's administrative, technical support, and computer facilities in Idaho Falls, and the in-town laboratories where researchers work on a wide variety of advanced scientific research and development projects. As the name implies, the Research and Education Campus uses both basic science research and engineering to apply new knowledge to products and processes that improve quality of life. This reflects the emphasis INL is placing on strengthening its science base and increasing the commercial success of its products and processes. The Center for Advanced Energy Studies, designed to promote education and world-class research and development, is also located at the Research and Education Campus. New laboratory facilities are under development, and other facilities proposed over the next 10 years include a national security building, a visitor's center, visitor housing, and a parking structure close to current campus buildings. Facilities already in place and those planned for the future are integral for transforming INL into a renowned research laboratory.

Test Area North – Test Area North (TAN) was established in the 1950s to support the government's Aircraft Nuclear Propulsion program with the goal to build and fly a nuclear-powered airplane. When President Kennedy cancelled the nuclear propulsion program in 1961, TAN began to host a variety of other activities. The Loss-of-Fluid Test (LOFT) reactor became part of the new mission. The LOFT reactor, constructed between 1965 and 1975, was a scaled-down version of a commercial pressurized water reactor. Its design allowed engineers, scientists, and operators to create or re-create loss-of-fluid accidents (reactor fuel meltdowns) under very controlled conditions. The LOFT dome provided containment for a relatively small, mobile test reactor that was moved in and out of the facility on a railroad car. The Nuclear Regulatory Commission incorporated data received from these accident tests into commercial reactor operating codes. Before closure, the LOFT facility conducted 38 experiments, including several small loss-of-coolant experiments designed to simulate the type of accident that occurred at Three Mile Island (TMI) in Pennsylvania. In October 2006, the LOFT reactor and facilities were decontaminated, decommissioned, and demolished.

Additionally, TAN housed the TMI Unit 2 Core Offsite Examination Program that obtained and studied technical data necessary for understanding the events leading to the TMI-2 reactor accident. Shipment of TMI-2 core samples to the INL Site began in 1985, and the program

ended in 1990. INL scientists used the core samples to develop a database that predicts how nuclear fuel will behave when a reactor core degrades.

In July 2008, the TAN Cleanup Project was completed. The TAN Cleanup Project demolished 44 excess facilities and the TAN Hot Shop and LOFT reactor. Environmental monitoring continues at TAN.

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

1.4 History of the INL Site

The geologic events that have shaped the modern Snake River Plain took place during the last 2 million years (Ma) (Lindholm 1996; ESRF 1996). The plain, which arcs across southern Idaho to Yellowstone National Park, marks the passage of the earth's crust over a plume of melted mantle material.

The volcanic history of the Yellowstone-Snake River Plain volcanic field is based on the time-progressive volcanic origin of the region characterized by several large calderas in the eastern Snake River Plain, with dimensions similar to those of Yellowstone's three giant Pleistocene calderas. These volcanic centers are located within the topographic depression that encompasses the Snake River drainage. Over the last 16 Ma, there was a series of giant, caldera-forming eruptions, with the most recent at Yellowstone National Park 630,000 years ago. The youngest silicic volcanic centers correspond to the Yellowstone volcanic field that are less than 2.0 Ma old and are followed by a sequence of silicic centers at about 6 Ma ago, southwest of Yellowstone. A third group of centers, approximately 10 Ma, is centered near Pocatello, Idaho. The oldest mapped silicic rocks of the Snake River Plain are approximately 16 Ma, are distributed across a 150-km-wide (93-mi-wide) zone in southwestern Idaho and northern Nevada, and are the suspected origin of the Yellowstone-Snake River Plain (Smith and Siegal 2000).

Humans first appeared on the upper Snake River Plain approximately 11,000 years ago. Tools recovered from this period indicate the earliest human inhabitants were hunters of large game. The ancestors of the present-day Shoshone and Bannock people came north from the Great Basin around 4,500 years ago (ESRF 1996).

People of European descent began exploring the Snake River Plain between 1810 and 1840; these explorers were trappers and fur traders seeking new supplies of beaver pelts. Between 1840 (by which time the fur trade was essentially over) and 1857, an estimated 240,000 immigrants passed through southern Idaho on the Oregon Trail. By 1868, treaties had been signed forcing the native populations onto the reservation at Fort Hall. During the 1870s, miners entered the surrounding mountain ranges, followed by ranchers grazing cattle and sheep in the valleys.

A railroad was opened between Blackfoot and Arco, Idaho, in 1901. By this time, a series of acts (the Homestead Act of 1862, the Desert Claim Act of 1877, the Carey Act of 1894, and

the Reclamation Act of 1902) provided sufficient incentive for homesteaders to attempt building diversionary canals to claim the desert. Most of these canal efforts failed because of the extreme porosity of the gravelly soils and underlying basalts.

During World War II, large guns from U.S. Navy warships were retooled at the U.S. Naval Ordnance Plant in Pocatello, Idaho. These guns needed to be tested, and the nearby uninhabited plain was put to use as a gunnery range, then known as the Naval Proving Ground. The U.S. Army Air Corps also trained bomber crews out of the Pocatello Airbase and used the area as a bombing range.

After the war ended, the nation turned to peaceful uses of atomic power. DOE's predecessor, the U.S. Atomic Energy Commission, needed an isolated location with ample groundwater supply on which to build and test nuclear power reactors. The relatively isolated Snake River Plain was chosen as the best location. Thus, the Naval Proving Ground became the National Reactor Testing Station in 1949.

In 1951, Experimental Breeder Reactor I became the first reactor to produce useful electricity. In 1955, the BORAX-III reactor provided electricity to Arco, Idaho – the first time a nuclear reactor powered an entire community in the U.S. The laboratory also developed prototype nuclear propulsion plants for Navy submarines and aircraft carriers. Over time, the Site evolved into an assembly of 52 reactors, associated research centers, and waste handling areas.

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

With renewed interest in nuclear power, DOE announced in 2003 that Argonne National Laboratory-West and the Idaho National Engineering and Environmental Laboratory would be the lead laboratories for development of the next generation of power reactors, and on February 1, 2005, the Idaho National Engineering and Environmental Laboratory and Argonne National Laboratory-West became the Idaho National Laboratory.

1.5 Populations Near the INL Site

1.5.1 Demography

The population of the region within 80 km (50 mi) of the INL Site is estimated, based on the 2010 census and projected growth, to be 311,334. Over half of this population (168,454) resides in the census divisions of Idaho Falls (97,061) and northern Pocatello (71,393). Another 25,730 live in the Rexburg census division. Approximately 16,869 reside in the Rigby census division and 14,848 in the Blackfoot census division. The remaining population resides in small towns and rural communities.

1.5.2 Regional Impact of the INL Site

The INL Site is the largest employer in the region. In 2009, Boise State University's College of Business and Economics evaluated the effects on the Idaho economy of all cleanup, research, and administrative operations at the INL Site (Black et al. 2009). The Impacts 2009 report details the results of this latest comprehensive research and demonstrates the significant and positive effects INL Site operations have on the immediate region and entire state.

The Impacts 2009 report analyzes three impacts of INL's contributions to the state and region. The first is INL's impact on employment, personal income, and total output for the state. Second, the report assesses the impacts of INL and its employees on state and local tax revenues. Third, the report examines the effects of INL employees' charitable contributions, educational outreach, and volunteer activities on the surrounding communities and the state. The report measures direct, secondary, and tertiary impacts of INL's operations.

Major findings of Impacts 2009 include:

- The INL Site is the second-largest employer in Idaho, with 8,016 employees. When secondary impacts on employment are analyzed, INL operations annually account for 24,000 jobs in Idaho.
- INL increased personal income in the state by nearly $2 billion and accounted for 3.5 percent of all personal income in the state. The total fiscal effects of INL accounts for over 6 percent of total tax revenue to the state. Taxes paid by INL and its employees exceed the cost of state-provided services.
- Annual property tax payments by INL employees amount to more than $17 million to local governments.
- INL provides $2.5 million to Idaho colleges and universities for continuing education of its employees.
- INL employees made charitable contributions of $33.3 million.

The research for Impacts 2009 was performed by three highly respected Boise State University economists: Dr. Geoffrey Black, chair of the Economics Department; Dr. Don Holley, former corporate economic forecaster and analyst and now a visiting professor; and John Church, former corporate economist and now special lecturer in the Economics Department and a member of the Western Blue Chip Forecast Panel (Black et al. 2009).

In their summary comments, the researchers conclude, "Idaho National Laboratory is, above all else, a world-class science and engineering center known nationally for its research and development activities in energy, security and environmental sustainability. Idaho benefits greatly from the lab's sustained presence."

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Chapter 2. Environmental Compliance Summary

Chapter 2 Highlights

Operations at the Idaho National Laboratory (INL) Site are subject to numerous federal and state environmental statutes, executive orders, and Department of Energy (DOE) orders. As a requirement of many of these regulations, the status of compliance with the regulations and releases of non-permitted hazardous materials to the environment must be documented. Overall, the INL Site met all its regulatory commitments in 2011, and programs are in place to address areas for continued improvement.

The National Emission Standards for Hazardous Air Pollutants-Calendar Year 2011 INL Report for Radionuclides report was submitted to U.S. Environmental Protection Agency, DOE Headquarters, and state of Idaho officials in June 2012, in compliance with the Clean Air Act. All Emergency Planning and Community Right-to-Know Act and Resource Conservation and Recovery Act reports were submitted as scheduled. In addition, proper notifications were made to the appropriate state and local authorities following one reportable environmental release.

The DOE Idaho Operations Office (DOE-ID) prepared two environmental assessments (EAs) in 2011 in compliance with the National Environmental Policy Act.

The U.S. Fish and Wildlife Service (USFWS) published a direct final rule in 2011 delisting wolves in Idaho, Montana, and parts of Oregon, Washington, and Utah. The Service and the states will monitor wolf populations and gather population data for at least five years in the Northern Rocky Mountain Distant Population Segment. The USFWS determined in 2010 that the Greater Sage-Grouse warrants protection of the Endangered Species Act but is not listed at this time because of the need to attend to higher priority species first. However, in a 2011 U.S. district court lawsuit settlement, the USFWS agreed to make a final listing decision on all candidate species by 2015.

The 2011 Site Sustainability Plan with the Annual Report was completed in compliance with the new Department of Energy Order 436.1, “Departmental Sustainability.” The document provides plans for providing continual energy efficiency, greenhouse gas reductions, environmental improvements, and transportation fuels efficiency at the INL Site.

The 2011 Idaho Hazardous Waste Generator Annual Report was submitted to the state of Idaho, which is authorized by Environmental Protection Agency to regulate hazardous waste under the Resource Conservation and Recovery Act. The state of Idaho approved closure

plans for two facilities in 2011. The State issued a Notice of Violation in February for alleged violations of the Resource Conservation and Recovery Act. A Consent Order was signed in June 2011, a penalty was paid, and the Notice of Violation was closed. The State also conducted an annual hazardous waste compliance inspection of the INL Site and identified some alleged violations. Corrective actions were taken to remedy the alleged violations and no penalties were assessed by the Department of Environmental Quality.

In 2011, 18 INL Site projects were screened for potential impacts to archeological resources. In addition, 46 of INL Site's sensitive cultural resources locations were revisited.

There are 41 active permits for air emissions, groundwater, wastewater, and hazardous waste compliance that have been granted to the INL Site from the city of Idaho Falls, state of Idaho, Environmental Protection Agency, and the Corps of Engineers.

2. ENVIRONMENTAL COMPLIANCE SUMMARY

This chapter reports the compliance status of the Idaho National Laboratory (INL) Site with environmental protection requirements. Operations at the INL Site are subject to numerous federal and state environmental protection requirements, such as statutes, acts, agreements, executive orders, and Department of Energy (DOE) orders. These are listed in Appendix A. The programs in place to comply with environmental protection requirements are discussed in Chapter 3.

2.1 Air Quality and Radiation Protection

2.1.1 Clean Air Act

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

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

- **New Source Performance Standards** – The New Source Performance Standards Program is a permitting performance standard for specific industry "source" categories. The standard targets sources that contribute significantly to air pollution and ensures the sources pay to meet ambient air quality standards. The criteria air pollutants are the focus of the New Source Performance Standards Program.
- **National Emissions Standards for Hazardous Air Pollutants (NESHAPs)** – The NESHAPs Program regulates emissions of hazardous air pollutants from a published list of industrial sources referred to as "source categories." The source categories must meet control technology requirements for these hazardous air pollutants. The state of Idaho has added to the federal NESHAPs list of hazardous air pollutants with the State List of Toxic Air Pollutants.
- **Stratospheric Ozone Protection Program** – The Stratospheric Ozone Protection Program limits emissions of chlorofluorocarbons, halons, and other halogenic chemicals that contribute to the destruction of stratospheric ozone.
- **Operating Permit Program** – The Operating Permit Program provides for states to issue federally enforceable operating permits to applicable stationary sources. The permits aid in clarifying operating and control requirements for stationary sources.
- **Enforcement Provisions** – Enforcement provisions establish maximum fines and penalties for CAA violations.

The state of Idaho has been delegated authority for the CAA except for one key subpart of the NESHAPs Program. Specifically, Subpart H, "National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities" (40 CFR 61, Subpart H), has not been delegated to the state of Idaho and is regulated by EPA. Subpart H applies to facilities owned or operated by DOE, including the INL Site. The Department of Energy, Idaho Operations Office (DOE-ID) submits an annual NESHAP Subpart H report to EPA, DOE Headquarters, and state of Idaho officials. The latest report is *National Emission Standards for Hazardous Air Pollutants – Calendar Year 2011 INL Report for Radionuclides* (DOE-ID 2012). Subpart H requires the use of an EPA-approved computer model to calculate the hypothetical maximum individual effective dose equivalent to a member of the public resulting from INL Site airborne radionuclide emissions. The calculations for this code are discussed further in Chapter 8, "Dose to the Public and Biota."

The Idaho Air Quality Program is primarily administered through a permitting process that sets conditions under which facilities that generate air pollutants may operate. Potential sources of air pollutants are evaluated against regulatory criteria to determine if the source is exempt from permitting. If the source is not exempted, the type of permit required depends on the type of emission or emitting source or both. Two primary types of air permits have been issued to the INL Site (Table 2-1):

- **Permit to Construct** – An air quality permit to construct is required of new or modified stationary sources, such as buildings, structures, or equipment that may emit pollutants into the air. State of Idaho air regulations and guidelines are used to apply for all permits to construct.

Table 2-1. Environmental Permits for the INL Site (2011).

Permit Type	Active Permits
Air Emissions:	
Permit to Construct	15
Title V Operating Permit	1
Groundwater:	
Injection Well	10
Well construction	1
Surface Water:	
Wastewater Reuse Permits	4
Industrial Wastewater Acceptance	1
Resource Conservation and Recovery Act:	
Part A	2
Part B	7[a]

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

- **Title V Operating Permit** – A Title V operating permit, also known as a Tier I operating permit, is required for major sources. Major sources emit, or have the potential to emit, 10 tons or more of one hazardous air pollutant or 25 or more tons per year of any combination of hazardous air pollutants. EPA promulgated regulations in July 1992 that established the Tier I requirements for state programs. Through the state implementation plan, Idaho has approved one Tier I operating permit for the INL Site.

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

DOE Order 458.1, "Radiation Protection of the Public and the Environment," establishes requirements to protect the public and the environment against undue risk from radiation associated with radiological activities conducted under the control of DOE pursuant to the Atomic Energy Act of 1954, as amended. The objectives of this Order are:

- To conduct DOE radiological activities so that exposure to members of the public is maintained within the dose limits established in this Order
- To control the radiological clearance of DOE real and personal property

- To ensure that potential radiation exposures to members of the public are as low as reasonably achievable
- To ensure that DOE sites have the capabilities, consistent with the types of radiological activities conducted, to monitor routine and non-routine radiological releases and to assess the radiation dose to members of the public
- To provide protection of the environment from the effects of radiation and radioactive material.

DOE Order 458.1 was issued in February 2011, and replaced DOE Order 5400.5 by the same title. The Order sets the public dose limit at a total effective dose not to exceed 100 mrem/yr (1 mSv/yr) above background radiation levels. Chapter 8 presents dose calculations for INL Site releases for 2011.

DOE Standard DOE-STD-1196-2011, Derived Concentration Technical Standard, was issued in April 2011, and defines the quantities used in the design and conduct of radiological environmental protection programs at DOE facilities and sites. These quantities, derived concentration standards (DCSs), represent the concentration of a given radionuclide in either water or air that results in a member of the public receiving 100 mrem (1 mSv) effective dose following continuous exposure for one year via each of the following pathways: ingestion of water, submersion in air, and inhalation. They replace the Derived Concentration Guides (DCGs), which were previously published by DOE in 1993 in DOE Order 5400.5 and represented the best available information on doses at that time. Since that publication, the radiation protection framework on which DCSs are based has evolved with more sophisticated biokinetic and dosimetric information provided by the International Commission on Radiological Protection (ICRP), thus enabling consideration of age and gender. The purpose of DOE-STD-1196-2011 is to establish DCS values reflecting the current state of knowledge and practice in radiation protection. These DCSs are based on age-specific effective dose coefficients, revised gender-specific physiological parameters for the Reference Man (ICRP 2002), and the latest information on the energies and intensities of radiation emitted by radionuclides (ICRP 2008). Previous versions of the Annual Site Environmental Report used DCGs, as defined in DOE Order 5400.5, to evaluate environmental monitoring results for the INL Site. With the issuance of DOE Order 458.1 and DOE-STD-1196-2011, this report will now evaluate environmental monitoring results according to the corresponding DCSs.

In addition to discharges to the environment, the release of property containing residual radioactive material is a potential contributor to the dose received by the public. During the 2011 reporting year, DOE Order 5400.5, not DOE Order 458.1, was the applicable order for unrestricted release of property to the public. DOE Order 5400.5 specifies limits for unrestricted release of property to the public. All INL Site contractors use a graded approach for release of material and equipment for unrestricted public use. Material has been categorized so that in some cases an administrative release can be accomplished without a radiological survey. Such material originates from non-radiological areas and includes the following:

- personal items or materials
- documents, mail, diskettes, compact disks, and other office media
- paper, cardboard, plastic products, aluminum beverage cans, toner cartridges, and other items released for recycling
- office trash
- non-radiological area housekeeping materials and associated waste
- break-room, cafeteria, and medical wastes
- medical and bioassay samples
- other items with an approved release plan.

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

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

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

2.2 Environmental Protection and Remediation

2.2.1 Comprehensive Environmental Response, Compensation, and Liability Act

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) provides the process to assess and remediate areas contaminated by the release of chemically hazardous or radioactive substances or both. Nuclear research and other operations at the INL Site left behind contaminants that pose a potential risk to human health and the environment. The INL Site was placed on the National Priorities List under CERCLA on November 29, 1989.

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

2.2.2 DOE Order 436.1, Departmental Sustainability

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

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

These programs are summarized in this chapter and elsewhere in this report. DOE Order 436.1 was issued in May 2011, and replaces most of the requirements of DOE Order 450.1A "Environmental Program Protection," and DOE Order 430.2B, "Departmental Energy, Renewable Energy and Transportation Management." The environmental monitoring requirements contained in DOE Order 450.1A have been captured in the newly issued DOE Order 458.1, as discussed above.

2.2.3 Emergency Planning and Community Right-to-Know Act

The Emergency Planning and Community Right-to-Know Act (EPCRA) is Title III of the 1986 Superfund Amendments and Reauthorization Act to CERCLA. EPCRA is intended to help local emergency response agencies better prepare for potential chemical emergencies and to inform the public of the presence of toxic chemicals in their communities. The INL Site's compliance with key EPCRA provisions is summarized in the following subsections and in Table 2-2.

Section 304 – Section 304 requires owners and operators of facilities where hazardous chemicals are produced, used, or stored to report releases of CERCLA hazardous substances or extremely hazardous substances that exceed reportable quantity limits to state and local authorities (i.e., state emergency response commissions and local emergency planning committees). There was one CERCLA-reportable chemicals release at the INL Site during 2011. On November 11, 2011, a cleanup operation involving reaction of sodium metal caused a water hammer effect that resulted in a pipe burst and subsequent release of friable asbestos. The total amount of asbestos released was calculated at 3.5 lb. (1.6 kg), which exceeded the CERCLA reportable quantity for asbestos of 1 lb. (0.5 kg). The released material was properly remediated and disposed. The release was reported to external agencies as required.

Table 2-2. INL Site EPCRA Reporting Status (2011).

EPCRA Section	Description of Reporting	2011 Status
Section 304	Extremely Hazardous Substance release notification	Required
Section 311-312	Material Safety Data Sheet/Chemical Inventory	Required
Section 313	Toxic Chemical Release Inventory Reporting	Required

Sections 311 and 312 – Sections 311 and 312 require facilities manufacturing, processing, or storing designated hazardous chemicals to make material safety data sheets describing the properties and health effects of these chemicals available to state and local officials and local fire departments. Facilities also are required to report, to state and local officials and local fire departments, inventories of all chemicals that have material safety data sheets. The INL Site satisfies the requirements of Section 311 by submitting quarterly reports to state and local officials and fire departments, identifying chemicals that exceed regulatory thresholds. In compliance with Section 312, the annual Emergency and Hazardous Chemical Inventory (Tier II) Report was provided to local emergency planning committees, state emergency response commissions, and local fire departments by the regulatory due date of March 1. This report includes the types, quantities, and locations of hazardous chemicals and extremely hazardous substances stored at INL Site facilities that exceed regulatory thresholds.

Section 313 – Section 313 requires facilities to submit a Toxic Chemical Release Inventory Form annually for each of the more than 600 Toxic Release Inventory chemicals that are manufactured, processed, or otherwise used above applicable threshold quantities. Releases under EPCRA 313 reporting include transfers to waste treatment and disposal facilities off the INL Site, air emissions, recycling, and other activities. The INL Site submitted Toxic Chemical Release Inventory Forms for ethylbenzene, lead, naphthalene, nickel, and polycyclic aromatic compounds to EPA and the state of Idaho by the regulatory due date of July 1.

Reportable Environmental Releases – There were two reportable environmental releases at the INL Site during calendar year 2011:

- On June 6, 2011, approximately 63 gal (242 L) of hydraulic fluid were released to soil and gravel from an excavator due to mechanical malfunction of the hydraulic line. The contaminated soil and gravel were removed and properly disposed. The release exceeded the reporting threshold of 25 gal (95 L) therefore notifications were made to external regulatory agencies.
- On December 8, 2011, approximately one gal (3.8 L) of an oil/water mix were released to soil from a temporary air compressor used at the Idaho Waste Treatment Unit project at Idaho Nuclear Technology and Environmental Center (INTEC). The oil-stained soil was cleaned up and properly disposed. The volume of oil was less than the reporting threshold of 25 gal

(95 L) but could not be cleaned up within twenty-four hours, as required by Idaho regulations. Therefore, the spill was reportable and notifications were made to external regulatory agencies.

2.2.4 National Environmental Policy Act

The National Environmental Policy Act (NEPA) requires federal agencies to consider and analyze potential environmental impacts of proposed actions and explore appropriate alternatives to mitigate those impacts, including a "no action" alternative. Agencies are required to inform the public of the proposed actions, impacts, and alternatives and consider public feedback in selecting an alternative. DOE implements NEPA according to procedures in the CFR (40 CFR 1500; 10 CFR 1021) and assigns authorities and responsibilities according to DOE Order 451.1B, "National Environmental Policy Act Compliance Program." Processes specific to DOE-ID are set forth in its Idaho Operations Office Management System. DOE-ID issued the Annual NEPA Planning Summary on February 1, 2011. The summary is a requirement of DOE Order 451.1B, and is prepared to inform the public and other DOE elements of:

- The status of ongoing NEPA compliance activities
- Environmental assessments expected to be prepared in the next 12 months
- Environmental impact statements expected to be prepared in the next 24 months
- The planned cost and schedule for completion of each NEPA review identified.

Ongoing NEPA Reviews of INL Site Projects – DOE-ID completed two environmental assessments (EA) in 2011:

The first EA DOE completed was the Idaho National Laboratory Stand-Off Experiment (SOX) Range Environmental Assessment. The EA described the potential impacts of creating and operating a Stand-Off Experiment Range on the INL Site where INL experts could research and develop detection systems for nuclear and non-nuclear materials of interest using high energy linear accelerators in support of U.S. national and homeland security missions. Those accelerators are used to produce high-energy x-rays which, when directed at a target object, result in the generation of signatures characteristic of the specific materials of interest. The draft EA was released for public comment on December 22, 2010. The Final EA and its related finding of no significant impact were issued on March 8, 2011. DOE determined that establishment of the SOX Range would not have a significant impact.

DOE completed the Environmental Assessment for the Replacement Capability for Disposal of Remote-Handled Low-Level Radioactive Waste Generated at the Department of Energy's Idaho Site. DOE prepared that EA to evaluate potential environmental impacts related to replacement capability options for the disposal of remote-handled low-level waste generated on the INL Site. DOE evaluated two on-site disposal facilities and one off-site disposal location (Nevada National Security Site). The Final EA and its associated finding of no significant impact were issued on December 21, 2011. DOE determined that none of the disposal options would have a significant impact. However, DOE selected an on-site disposal option to best meet DOE mission requirements.

2.2.5 Endangered Species Act

The Endangered Species Act:

- Provides a means whereby the ecosystems upon which endangered and threatened species depend may be conserved
- Provides a program for the conservation of such endangered and threatened species and their habitat
- Takes such steps as may be appropriate to achieve the purposes of the international treaties and conventions on threatened and endangered species.

The Act requires that all federal departments and agencies shall seek to conserve endangered and threatened species and shall use their authorities to further the purposes of this Act.

Personnel in the Environmental Surveillance, Education, and Research Program conduct ecological research, field surveys, and NEPA evaluations regarding ecological resources on the INL Site. Particular emphasis is given to threatened and endangered species and species of special concern identified by the U.S. Fish and Wildlife Service (USFWS) and Idaho Department of Fish and Game.

There are several species categorized under the Endangered Species Act which occur in southeastern Idaho and could be present on the INL Site. Table 2-3 presents a list of those species and the likelihood of their occurrence on the INL Site.

On October 26, 2010, the USFWS published a final rule for the Reinstatement of Protections for the Gray Wolf of the Northern Rockies in Compliance With a Court Order. The Service reinstated the gray wolf as endangered in much of its range as well as reinstating the former special rules designating the gray wolf in the southern half of Montana and Idaho as nonessential experimental populations. Wolves found on the INL Site would be considered part of the nonessential experimental population.

In May 2011, the USFWS published a direct final rule delisting wolves in Idaho, Montana, and parts of Oregon, Washington, and Utah. This final rule implements legislative language included in the Fiscal Year 2011 appropriations bill. The Service and the states will monitor wolf populations in the Northern Rocky Mountain Distant Population Segment and gather population data for at least five years.

In March 2010, the USFWS classified the Greater sage-grouse (*Centrocercus urophasianus*) as a candidate for listing under the Endangered Species Act (ESA) of 1973. This means that although the species warrants protection under the ESA, it is currently precluded from being listed due to higher agency priorities. However, in a recent (2011) U.S. district court lawsuit settlement, the FWS agreed to make a final listing decision on all candidate species by 2016. A resulting agency work plan commits the USFWS to make a determination by 2015 to either list sage-grouse as threatened or endangered, or to remove it from the candidate list.

Table 2-3. INL Species Designated Under the ESA Occurring in Counties on Which the INL Site is Located.

Species	Designation	Presence on INL Site
Greater sage-grouse (*Centrocercus urophasianus*)	Candidate	Large populations present on INL Site.
Yellow-billed cuckoo (*Coccyzus americanus*)	Candidate	Documented occasionally on south border of INL Site.
Utah valvata snail (*Valvata utahensis*)	Endangered	Not documented. Only intermittent water sources on INL Site.
Bull trout (*Salvelinus confluentus*)	Threatened	Not documented.
Canada lynx (*Lynx canadensis*)	Threatened	Not documented.
Grizzly bear (*Ursus arctos horribilus*)	Threatened	Not documented.
Ute ladies'-tresses (*Spiranthese diluvialus*)	Threatened	Not documented.

2.2.6 Migratory Bird Treaty Act

The Migratory Bird Treaty Act prohibits taking or disturbing any migratory bird, or any part, nest, or egg of any such bird without authorization from the U.S. Department of the Interior. Permits may be issued for scientific collecting, banding and marking, falconry, raptor propagation, depredation, import, export, taxidermy, waterfowl sale and disposal, and special purposes. The ICP contractor received a Special Purpose Permit for limited take, movement, and management of migratory birds and their in-use nests related to conducting cleanup operations. The permit is only applied in very limited and extreme situations where no other recourse other than relocation of nest and young is possible.

Migratory Birds Given to Rehabilitation Facilities – There were three instances where INL Site workers found injured migratory birds. Two of those birds were successfully captured and transported by ESER biologists to Idaho Department of Fish and Game personnel for subsequent transportation to the Teton Raptor Center in Wilson, Wyoming. The first instance occurred on July 14, 2011, and involved an owl at the Naval Reactors Facility. The second instance occurred on July 29, 2011, and involved an injured night hawk at the Advanced Mixed Waste Treatment Project facility. Finally, on August 23, 2011, a badly injured great-horned owl

was reported at the Advanced Test Reactor Complex. It was taken to the Idaho Fish and Game Office where it died.

Barn Swallow Nest Destruction – On August 25, 2011, INL personnel notified DOE that they had identified a "taking" (destruction) of swallow nests with eggs at the Specific Manufacturing Capability located at the INL Test Area North. The nests had been constructed on a roll-up door, and the nests were knocked-down when the roll-up door was raised for a monthly security check (this was an "alarmed" door). DOE and INL Contractor notified the USFWS special agent in Idaho Falls. After a discussion of the events, the special agent considered this to be an unintentional taking, and that no "ticket" would be issued. Had the taking been intentional, this would be a more serious matter.

2.2.7 Executive Order 11988 – Floodplain Management

Executive Order 11988 requires each federal agency to issue or amend existing regulations and procedures to ensure that the potential effects of any action it may take in a floodplain are evaluated and that its planning programs and budget requests consider flood hazards and floodplain management. It is the intent of Executive Order 11988 that federal agencies implement floodplain requirements through existing procedures, such as those established to implement NEPA. 10 CFR 1022 contains DOE policy and floodplain environmental review and assessment requirements through the applicable NEPA procedures. In those instances where impacts of actions in floodplains are not significant enough to require the preparation of an Environmental Impact Statement (EIS) under NEPA, alternative floodplain evaluation requirements are established through the INL Site Environmental Checklist process.

For the Big Lost River, DOE-ID has accepted the *Big Lost River Flood Hazard Study, Idaho National Laboratory, Idaho* (Bureau of Reclamation 2005). This flood hazard report is based on geomorphological models and has undergone peer review. On January 12, 2006, DOE-ID directed the ICP contractor to use this floodplain determination for any activities that require the characterization of flows and hazards associated with the Big Lost River. All activities on the INL Site requiring characterization of flows and hazards are expected to use this report.

For facilities at Test Area North, the 100-year floodplain has been delineated in a U.S. Geological Survey report (USGS 1997).

2.2.8 Executive Order 11990 – Protection of Wetlands

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

States also may be subject to the jurisdiction of Sections 404 and 402 of the Clean Water Act.

The only area of the INL Site identified as potentially jurisdictional wetlands is the Big Lost River Sinks. The USFWS National Wetlands Inventory map is used to identify potential jurisdictional wetlands and non-regulated sites with ecological, environmental, and future development significance. In 2011, no actions took place or impacted potentially jurisdictional wetlands on the INL Site. Cattle grazing is conducted in the area of the Big Lost River Sinks under Bureau of Land Management permits obtained by private parties.

2.2.9 Executive Order 13514 – Federal Leadership in Environmental, Energy, and Economic Performance

Executive Order 13514, "Federal Leadership in Environmental, Energy, and Economic Performance," was signed by President Obama on October 5, 2009. This Executive Order does not rescind or eliminate the requirements of Executive Order 13423. Instead, it expands on the energy reduction and environmental performance requirements for federal agencies identified in Executive Order 13423.

The goal of Executive Order 13514 is "to establish an integrated strategy towards sustainability in the Federal Government and to make reduction of greenhouse gas emissions () a priority for Federal agencies." Towards meeting that goal, federal agencies are required to meet a series of deadlines critical to achieving the GHG reduction goals of the Executive Order.

- On November 5, 2009, each agency submitted the name of their Senior Sustainability Officer to the Council on Environmental Quality (CEQ) Chair and Office of Management and Budget (OMB) Director
- On January 4, 2010, a percentage reduction target for agency-wide reductions of Scope 1 and 2 GHG emissions, in absolute terms, by fiscal year 2020, relative to a fiscal year 2008 baseline of the agency's Scope 1 and 2 GHG, was due to the CEQ Chair and OMB Director
- On June 2, 2010, Scope 3 targets and the Strategic Sustainability Performance Plan were submitted to the CEQ Chair and the OMB Director
- On January 31, 2011, the comprehensive GHG inventory was due from each of the agencies to the CEQ Chair and OMB Director.

In addition to guidance, recommendations, and plans that are due by specific dates, Executive Order 13514 specifies numerical and non-numerical targets for agencies to reach in areas such as sustainable buildings, water efficiency, electronic products, and transportation management. Beyond targets, Executive Order 13514 requires agencies to follow specific management strategies to improve sustainability. These targets and management strategies are listed in Table 2-4.

The new DOE Order 430.2B, "Departmental Energy, Renewable Energy, and Transportation Management," contains requirements that DOE will accomplish to implement Executive Order

Table 2-4. Executive Order 13514 Targets and Management Strategies for Federal Agencies (2011).

NUMERICAL TARGETS
• Reduce petroleum consumption by 2 percent per year through FY[a] 2020 • Reduce by 2 percent annually: – Potable water intensity by FY 2020 (26 percent total reduction). – Industrial, landscaping, and agricultural water intensity by FY 2020 (20 percent total reduction) • Achieve 50 percent or higher diversion rate: – Non-hazardous solid waste by FY 2015. – Construction and demolition materials and debris by FY 2015. • Ensure at least 15 percent of existing buildings and leases meet the Guiding Principles by FY 2015, with continued progress towards 100 percent. • Ensure 95 percent of all new contracts, including non-exempt contract modifications, require products and services that are energy-efficient, water-efficient, biobased, environmentally preferable, non-ozone depleting, contain recycled-content, non-toxic or less-toxic alternatives. • Reduce Scope 1 & 2 GHG 28 percent by 2020 • Produce at least 7.5 percent of sites energy from onsite renewable sources. • Reduce building energy intensity by 3 percent annually or 30 percent by 2015.
NON-NUMERICAL TARGETS
• Increase renewable energy and renewable energy generation on agency property. • Pursue opportunities with vendors and contractors to reduce GHG[a] emissions (i.e., transportation options and supply chain activities). • Reduce building energy intensity. • Ensure all new Federal buildings that enter the planning process in 2020 and thereafter are designed to achieve zero-net-energy standards by 2030. • Use low GHG emitting vehicles, including AFVs[a], and optimize the number of vehicles in agency fleets. • Implement water management strategies including water-efficient and low-flow fixtures. • Implement source reduction to minimize waste and pollutant generation. • Decrease use of chemicals directly associated with GHG emissions. • Participate in transportation planning and recognize existing infrastructure in regions/communities. • Ensure procurement preference for EPEAT[a]-registered electronic products.
SPECIFIC MANAGEMENT STRATEGIES TO IMPROVE SUSTAINABILITY
• Develop and implement innovative, agency-specific policies and practices to reduce scope 3 GHG emissions in agency operations. • Manage existing buildings to reduce energy, water, and materials consumption. • Implement and achieve objectives in EPA's Stormwater Management Guidance. • Reduce paper use and acquire paper containing at least 30 percent postconsumer fiber. • Minimize the acquisition, use, and disposal of toxic and hazardous materials. • Employ environmentally sound practices for the disposition of all agency excess or surplus electronic products. • Procure Energy Star and FEMP[a]-designated electronic equipment. • Continue implementation of existing EMS programs.

a. FY = fiscal year; GHG = greenhouse gas; AFV = alternative fuel vehicle; EPEAT = Electronic Product Environmental Assessment Tool; FEMP = Federal Energy Management Program.

13514. DOE Order 430.2B defines an executable plan as an action plan setting forth a binding obligation of the applicable site that:

- Commits appropriate personnel resources
- Establishes a financial plan that prioritizes the use of life-cycle, cost-effective, private-sector financing and optimizes the application of appropriation and budgeted funds
- Establishes a timeline for execution coupled with specific performance measures and deliverables designed to achieve established requirements.

On May 22, 2011, DOE issued DOE Order 436.1 “Departmental Sustainability”. The order defines requirements and responsibilities for managing sustainability at DOE to ensure that the Department carries out its missions in a sustainable manner that addresses national energy security and global environmental challenges, and advances sustainable, efficient and reliable energy for the future; institutes wholesale cultural change to factor sustainability and GHG reductions into all DOE corporate management decisions; and ensures that DOE achieves the sustainability goals established in its Strategic Sustainability Performance Plan. This order cancels DOE O 450.1A and DOE O 430.2B.

DOE-ID submitted the *2011 INL Site Sustainability Plan with the Annual Report* to DOE Headquarters in December 2010 (DOE-ID 2010a). This plan contains strategies and activities for 2011 that are leading INL to continual energy efficiency, greenhouse gas reductions, environmental improvements, and transportation fuels efficiency to facilitate the INL Site in meeting the goals and requirements of Executive Order 13514, and DOE Order 436.1 before the end of fiscal year 2020.

The INL Site as a whole spent over $14.9 M in 2011 for facility and equipment energy. Of this total $12.9 M was spent for building energy, $1.1 M was spent for process energy, and $878 K was spent on equipment fuel. The managed area consumes over 9.04 trillion Btu of energy and 898 million gallons of water annually. Energy consumption at the INL Site for 2011 on a Btu/ft^2 basis has been reduced by 10.5 percent, weather adjusted, when compared to the base year of 2003.

Transportation fuel use across the INL Site totaled over 1,157,999 gallons of various types of fuels for 2011. The INL Site fleet is comprised of light duty vehicles fueled by gasoline, E85, and compressed natural gas. Heavy-duty vehicles include over-the-road buses fueled by diesel, biodiesel, and a complex assortment of trucks and equipment. Typically, 152.9 M km (9.5 M mi) are driven annually, and over 50,000 hours are logged on heavy equipment. Table 2-5 lists energy and water use reduction goals for the INL Site. A more detailed discussion of environmental management systems, waste minimization, and pollution prevention programs is provided in Chapter 3.

Table 2-5. Estimated Future Energy and Water Use Reduction for the INL Site (2011).

Performance Area	Baseline[a]	2015 Goal
Total Building Energy Use	981,300 MBtu	702,280 MBtu
Total Building Water Use	1,010.0 Mgal	810.1 Mgal

a. 2003 is the baseline year for Energy Use and 2007 is the baseline year for Water Use.

2.3 Waste Management

2.3.1 Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (RCRA) established regulatory standards for generation, transportation, storage, treatment, and disposal of hazardous waste. The Idaho Department of Environmental Quality (DEQ) is authorized by EPA to regulate hazardous waste and the hazardous components of mixed waste at the INL Site. Mixed waste contains both radioactive and hazardous materials. The Atomic Energy Act, as administered through DOE orders, regulates radioactive wastes and the radioactive part of mixed wastes. A RCRA hazardous waste permit application contains two parts – Part A and Part B. Part A of the RCRA hazardous waste permit application consists of EPA Form 8700-23, along with maps, drawings, and photographs, as required by 40 CFR 270.13. Part B of the RCRA hazardous waste permit application contains detailed, site-specific information as described in applicable sections of 40 CFR 270.14 through 270.27. The INL Site currently has two RCRA Part A permit volumes and seven Part B permit volumes (Parts A and B are considered a single RCRA permit and are comprised of several volumes).

RCRA Reports – As required by the state of Idaho, the INL Site submitted the 2011 Idaho Hazardous Waste Generator Annual Report in January 2012. The report contains information on waste generation, treatment, recycling, and disposal activities at INL Site facilities.

RCRA Closure Plan – The state of Idaho approved closure plans for the following facilities in 2011:

- Advanced Test Reactor Complex - 5.8.d TRA-632 Hot Cell Drain
- Materials and Fuels Complex Experimental Breeder Reactor - No. 2 (EBR-II) Closure.

RCRA Inspection – On February 24, 2011, an INL contractor issued a Notice of Violation (NOV) to DOE and an INL contractor for alleged violations of the RCRA/Hazardous Waste Management Act (HWMA). On June 15, 2011, a Consent Order was signed resolving the alleged violations. The penalty was paid and the NOV was closed.

On May 16 – 20, 2011, DEQ conducted an annual RCRA inspection of the INL Site. On July 11, 2011, DEQ sent a RCRA/HWMA Compliance Warning Letter to DOE and INL Site contractors stating that alleged violations were identified during this inspection. A response to the Warning Letter was provided to DEQ detailing corrective actions taken to remedy the alleged violations. No penalty was assessed by the DEQ.

2.3.2 Federal Facility Compliance Act

The Federal Facility Compliance Act requires the preparation of site treatment plans for the treatment of mixed wastes stored or generated at DOE facilities. Mixed waste contains both hazardous and radioactive components. The INL Site Proposed Site Treatment Plan was submitted to the state of Idaho and EPA on March 31, 1995. This plan outlined DOE-ID's proposed treatment strategy for INL Site mixed-waste streams, called the "backlog," and provided a preliminary analysis of potential offsite mixed low-level waste treatment capabilities. The Federal Facility Compliance Act Consent Order and Site Treatment Plan was finalized and signed by the state of Idaho on November 1, 1995 (DEQ 1995). A status of Site Treatment Plan milestones for 2011 is provided in Chapter 3.

2.3.3 Toxic Substances Control Act

The Toxic Substances Control Act (TSCA), which is administered by EPA, requires regulation of production, use, or disposal of chemicals. TSCA supplements sections of the Clean Air Act, the Clean Water Act, and the Occupational Safety and Health Act. Because the INL Site does not produce chemicals, compliance with TSCA is primarily directed toward use and management of certain chemicals, particularly polychlorinated biphenyls (PCBs). PCB-containing light ballasts are being removed at buildings undergoing demolition. The ballasts are disposed off the INL Site in a TSCA-approved disposal facility.

2.3.4 DOE Order 435.1, Radioactive Waste Management

DOE Order 435.1, "Radioactive Waste Management," was issued to ensure that all DOE radioactive waste is managed in a manner that protects the environment and worker and public safety and health. This Order, effective July 1, 1999, includes the requirements that DOE facilities and operations must meet in managing radioactive waste. Change 1 was added to the Order in August 2001. INL Site activities related to this Order are discussed in Chapters 3 and 6.

2.3.5 1995 Settlement Agreement

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

The INL Site continues to ship transuranic waste to the Waste Isolation Pilot Plant in Carlsbad, New Mexico, in compliance with the Settlement Agreement requirement to ship a running average of no fewer than 2,000 m^3 (2,616 yd^3) of transuranic waste per year out of Idaho.

The running average over the past three years is 5,517 m^3 (7,210 yd^3). In calendar year 2011, 2,500 m^3 (3,267 yd^3) of transuranic waste was shipped out of Idaho. This amount included 10.35 m^3 (13.52 yd^3) of remote-handled transuranic waste. In addition, 333 m^3 (435 yd^3) of mixed low-level waste historically managed as TRU was shipped.

In 2011, 1,476 m^3 (1,929 yd^3) of buried TRU waste was shipped.

The INL Site received one truck cask shipment containing 0.0118 metric tons heavy metal of spent nuclear fuel. Specifically, the spent nuclear fuel was received from Reed College.

2.4 Water Quality and Protection

2.4.1 Clean Water Act

The Clean Water Act (CWA), passed in 1972, established goals to control pollutants discharged to U.S. surface waters. Among the main elements of the CWA are effluent limitations for specific industry categories set by EPA and water quality standards set by states. The CWA also provided for the National Pollutant Discharge Elimination System (NPDES) permit program, requiring permits for discharges into regulated surface waters.

The INL Site complies with two CWA permits through the implementation of procedures, policies, and best management practices. The first permit covers discharges from Idaho Falls facilities to the city of Idaho Falls publicly-owned treatment works. The second permit, NPDES General Permit for Storm Water Discharges from Construction Activities, provides protective requirements for construction activities located within the INL Site storm water corridor (63 FR 31). These permits are discussed further in the following sections.

National Pollutant Discharge Elimination System Permits – The city of Idaho Falls is authorized by the NPDES permit program to set pretreatment standards for nondomestic discharges to publicly-owned treatment works. This program is set out in the Municipal Code of the city of Idaho Falls regulations in Chapter 1, Section 8. The INL Research Center is the only facility that is required to have an Industrial Wastewater Acceptance Permit. The Industrial Wastewater Acceptance Permit contains special conditions and compliance schedules, prohibited discharge standards, reporting requirements, monitoring requirements, and effluent concentration limits for specific parameters. All discharges from Idaho Falls facilities in 2011 were within compliance levels established in the acceptance permit.

Storm Water Discharge Permits for Construction Activity – DOE-ID obtained coverage for the INL Site under the General Permit for Storm Water Discharges from Construction Sites issued in June 1993. The coverage under the general permit has been renewed twice. INL Site contractors obtain coverage under the general permit for individual construction projects. Storm water pollution prevention plans are completed for individual construction projects. Only construction projects that are determined to have a reasonable potential to discharge pollutants to regulated surface water are required to have a storm water pollution prevention plan and general permit. Inspections of construction sites are performed in accordance with permit requirements.

2.4.2 Safe Drinking Water Act

The Safe Drinking Water Act establishes primary standards for water delivered by systems supplying drinking water to 15 or more connections or 25 individuals for at least 60 days per year. The INL Site drinking water supplies meet these criteria for public water systems and are classified as either nontransient noncommunity or transient noncommunity systems.

The INL Site has 12 active public water systems, one of which serves the Naval Reactors Facility. All INL Site facilities sample drinking water as required by the state of Idaho and EPA. Chapter 5 contains details on drinking water monitoring.

2.4.3 State of Idaho Wastewater Reuse Permits

Wastewater consists of spent or used water from a home, community, farm, or industry that contains dissolved or suspended matter. To protect public health and prevent pollution of surface and ground waters, state of Idaho regulations require anyone wishing to land-apply or otherwise use wastewater to obtain a Wastewater Reuse Permit according to Idaho Administrative Procedures Act (IDAPA) 58.01.17 ("Recycled Water Rules") and (IDAPA) 58.01.16 ("Wastewater Rules"). DEQ is responsible to issue Wastewater Reuse Permits. Two types of Wastewater Reuse Permits are issued – industrial and municipal. Industrial Wastewater Reuse Permits regulate reuse of wastewater from such operations as food processing facilities. Municipal Wastewater Reuse Permits regulate reuse of wastewater that contains treated sewage. All Wastewater Reuse Permits specify both standard and site-specific conditions. Land application of wastewater is one method of reusing treated wastewater. It is a natural way of recycling by which wastewater is applied to land and is absorbed by vegetation or infiltrated into the soil column. Reuse is the broader topic of which land application is but one method. Other methods of reuse include commercial toilet flushing, dust control, and fire suppression.

Applications for Wastewater Reuse Permits have been submitted to DEQ for all existing INL Site land application facilities. DEQ has issued permits for:

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

2.4.4 IDAPA 58.01.02, Water Quality Standard

In August 2007, analysis of groundwater samples from the ICPP-2018 monitoring well at INTEC detected petroleum products. An investigation of the source of the petroleum products determined it likely to be weathered diesel No. 2, the source of which was most likely the CPP-701A Diesel Tank that had leaked in 2005 and had been repaired. On April 1, 2008, DEQ gave DOE and the ICP contractor an Administrative Order to assess the extent of the contamination and to develop corrective actions if necessary. On December 9, 2008, ICP submitted a Schedule and Criteria document to outline the investigation and a subsequent groundwater monitoring plan

with proposed corrective actions in March 2009, to fulfill the requirements of the Administrative Order. Semiannual results of the perched water and aquifer wells monitoring data were submitted by ICP in the Spring 2009 Summary Report (DOE-ID 2009a), and in the Fall 2009 Summary Report (DOE-ID 2009b), including analysis for benzene, toluene, ethylbenzene, and xylenes (BTEX).

The monitoring and free product recovery activities required by the Corrective Action/ Monitoring Plan for the petroleum release associated with Well ICPP-2018 (ICP 2010) were continued during 2010 and 2011. Monitoring activities included measuring water levels in selected perched water and aquifer wells, checking for the presence of non-aqueous phase liquid (NAPL) in these wells, measuring product quantities removed, and collecting and analyzing groundwater samples.

Except for Well ICPP-2018, a measurable thickness or other physical evidence of NAPL was not observed in any of the monitored wells. Three of the four BTEX constituents-benzene, ethylbenzene, and xylene – were undetected at the applicable detection levels in all perched water and aquifer wells sampled in April 2010.

In June 2011, revisions to the Corrective Action/Monitoring Plan agreed to by CWI and DEQ during 2010 and 2011 significantly reduced the monitoring requirements. Monitoring wells ICPP-2018 and CPP-33-4-1 are now the only wells being sampled for BTEX and polycyclic aromatic hydrocarbon (PAH) compounds. Currently, the requirements include continued monitoring of product in Well ICPP-2018 using absorbent sock or passive skimmer to recover free product, and collecting and analyzing groundwater samples in both wells.

No BTEX constituents (i.e., benzene, toluene, ethylbenzene, and xylenes) were detected at the applicable detection levels in either monitoring well ICPP-2018 or CPP-33-4-1 sampled during the July 26, 2011, sampling event. Also, no PAH compounds were detected at their respective detection limit in groundwater samples obtained from these wells (ICP 2011).

2.5 Cultural and Historic Resources Protection

2.5.1 National Historic Preservation Act

Preservation of cultural resources on lands managed by DOE is mandated by a number of federal laws and their implementing regulations, including among others, the National Environmental Policy Act of 1969, the Archaeological Resource Protection Act of 1979, and most importantly, the National Historic Preservation Act (NHPA) of 1966. Cultural resources at the INL Site are numerous and include prehistoric resources representing more than 12,000 years of human occupation, historic resources representing the period from 1805 to the late 1920s, important historic World War II, post-war, and nuclear facilities like Experimental Breeder Reactor I, which was the first reactor in the world to produce usable electrical power and is recognized as a National Historic Landmark, and places and resources of importance to the Shoshone-Bannock Tribes. Many of the cultural resources located at the INL site are historic properties, potentially eligible for nomination to the National Register of Historic Places. The NHPA includes specific guidelines (Section 106) for a legal process used to determine if adverse effects to these

properties will occur and, if so, the nature and extent of these adverse effects. The Idaho State Historic Preservation Office and interested parties such as the Shoshone-Bannock Tribes then are communicated with and, when required, formally consulted to mitigate these effects. The NHPA also outlines requirements for developing a broad understanding of all INL Site cultural resources (Section 110), not only those located in active project areas.

The *INL Cultural Resource Management Plan* (DOE-ID 2011) was written specifically for INL Site resources, providing a tailored approach to comply with federal laws and regulations and implement DOE cultural resource policies and goals. The Plan is reviewed and updated annually, as needed. The programmatic cornerstones of the Plan are two signed Agreements, one between DOE-ID, the Advisory Council on Historic Preservation, and the Idaho State Historic Preservation Office, dated July 2004, Concerning Management of Cultural Resources on the INL Site (DOE-ID 2004), and a second Agreement-in-Principle between DOE-ID and the Shoshone-Bannock Tribes, dated December 3, 2007 (DOE-ID 2007).

Cultural Resources Surveys – In 2011, 18 project reviews were completed for potential impacts to cultural resources. Table 2-6 provides a summary of the cultural resource activities performed. Eight of the 2011 reviews involved field studies to identify and evaluate archaeological sites. Most of these efforts were associated with NHPA Section 106 project reviews designed to evaluate potential impacts as a result of proposed INL ground-disturbing activities and included archaeological surveys, archaeological site monitoring during ground disturbance, and small scale archaeological test excavations. Impacts related to fire-fighting efforts associated with large range fires over the past two years were also assessed. Approximately 358 acres were intensively examined during these project surveys and 28 new archaeological resources were identified and recommended for avoidance or other protective measures. Cumulatively, the total number of acres surveyed for archaeological resources on the INL Site increased to 55,430 with the addition of these surveys (approximately 10 percent of the 890 square mile laboratory) and the total number of resources identified rose to 2,727.

One project review in 2011 involved small scale archaeological test excavations at seven prehistoric archaeological sites located within the preferred alignment of a proposed new multipurpose haul road (DOE-ID 2010b, INL CRM 2010). Test excavations were necessary in order to determine if ground disturbance associated with road construction would result in adverse impacts to sensitive subsurface cultural deposits. No subsurface cultural materials were identified within the areas of potential effect for road construction, and consultation with the Idaho State Historic Preservation Office (SHPO) led to a finding of no adverse effects for this Section 106 review.

One final project review involved the decontamination and demolition (D&D) of a nuclear reactor facility, EBR-II. The review was conducted to determine potential effects to EBR-II from D&D activities. It was determined that these activities would have an adverse impact on this historic property and consultation was initiated with the Idaho SHPO. Agreed upon mitigation included the completion of an Historic American Engineering Record report and a new interactive display at the Experimental Breeder Reactor No. 1 National Historic Landmark.

Table 2-6. Cultural Resource Surveys Performed at the INL Site (2011).

Project #	Project Name	INL CRMO Activities	Acres Surveyed	Cultural Resources Identified
BEA-11-01:	Infrastructure Recapitalization and New Expended Core Facilities at NRF	Archaeological survey, site monitoring, and reporting	15	3 isolates 1 site
BEA-11-02:	Rocky Mountain Power Pole Replacement	Cultural resource permit oversight and monitoring of ground disturbance	10	1 isolate 2 sites
BEA-11-03:	Wireless Test Bed Projects	Environmental Checklist review and limited field survey	1	None
BEA-11-04:	Fire Surveys (Jefferson Fire, Middle Butte Fire)	Archaeological survey and site monitoring	40	6 isolates 7 sites
BEA-11-05:	Quantifiable Bat Count Study (Stoller)	Environmental Checklist review	None	None
BEA-11-06:	Wind EA	Review of draft documentation	None	None
BEA-11-07:	New Targets at CFA Firing Range	Environmental Checklist review	None	None
BEA-11-08:	Look Ahead Sensor Testing	Environmental Checklist review	None	None
BEA-11-09:	Traffic Signs	Environmental Checklist review	None	None
BEA-11-10:	USGS Wells	Environmental Checklist review	None	None
BEA-11-11:	Mountain States Transmission Intertie	Cultural resource permit oversight and feedback to BLM on various aspects of project Environmental	292 acres	7 isolates 1 site

Table 2-6. Cultural Resource Surveys Performed at the INL Site (2011) (continued).

Project #	Project Name	INL CRMO Activities	Acres Surveyed	Cultural Resources Identified
		Impact Statement under preparation		
BEA-11-12:	Pioneer Excavations	Archaeological research excavations in support of Section 110 goals	None	None
BEA-11-13:	Small CWI projects	Environmental Checklist review	None	None
BEA-11-14:	Electrical Grid Test Facility Siting	Feedback to initial facility siting including field tour	None	None
BEA-11-15:	T17 Fire	Archive search and planning for field surveys in 2012	None	None
BEA-11-16:	Motion Cameras at MFC	Environmental Checklist review	None	None
BEA-11-17:	Ground Disturbance at PBF	Environmental Checklist review and monitoring of ground disturbance	None	None
BEA-11-18:	EBR-II D&D	Assessment of impacts of D&D activities and resulting mitigation of adverse impacts through documentation and public outreach	None	None

INL Cultural Resources Management Office investigations in 2011 also were conducted to further DOE-ID obligations under Section 110 of the National Historic Preservation Act to develop a broad understanding of all INL Site archaeological resources, not only those located in active project areas. For a second year, the INL Cultural Resources Management program (CRMP) collaborated with researchers from the Center for the Study of the First Americans at Texas A & M University to pursue ongoing scholarly research on long-term human occupation of the INL Site region through targeted excavations at deeply stratified archaeological sites on the INL. In 2011, excavations were focused at an important prehistoric campsite located on the banks of the Big Lost River (Figure 2-1). Deeply stratified cultural deposits at this site extend more than two meters below surface and hold promise for providing information to contribute to a clearer understanding of local and regional human adaptations over much of the 13,000 year period of human occupation. Research, artifact analyses, and field studies will continue through 2012.

Cultural Resources Monitoring – The INL Cultural Resources Management Office implements a yearly program of cultural resource monitoring that involves routine visits to monitor current conditions at known archaeological resources of high sensitivity across the entire INL Site. In 2011, 46 sensitive cultural resource localities were revisited, including: two locations with Native American human remains, one of which is a cave, three additional caves, one of which is listed on the National Register of Historic Places, 29 prehistoric archaeological sites, four historic homesteads, one historic stage station, one Civilian Conservation Corps historic snow fence, five historic roads and trails, and Experimental Breeder Reactor I, which is a designated National Historic Landmark. Representatives from the Shoshone-Bannock Tribes are important partners in these efforts. Results of 2011 INL Site cultural resources monitoring are documented in Idaho National Laboratory Cultural Resources Monitoring Report for FY-2011 (INL CRM 2011).

2.5.2 Native American Graves Protection and Repatriation Act

The INL Site is located on the aboriginal territory of the Shoshone and Bannock people. The Shoshone-Bannock Tribes have a government-to-government relationship with DOE-ID that is strengthened and maintained through an Agreement-in-Principle between the Tribes and DOE-ID, regular Cultural Resource Working Group meetings, and stipulations outlined in the “INL Cultural Resource Management Plan” (DOE-ID 2011).

The Native American Graves Protection and Repatriation Act (NAGPRA) establishes a systematic process to determine the rights of lineal descendants, American Indian tribes, and Native Hawaiian organizations to related human remains, funerary objects, sacred objects, and objects of cultural patrimony with which they are affiliated. Federal agencies, such as DOE, must follow this process for items that are discovered on lands under their jurisdiction. The AIP reinforces Shoshone-Bannock tribal interest in cultural resources on INL Site lands that include, but are not limited to, natural resources, sacred sites, traditional cultural properties, camps, burial areas and associated funerary objects, and items of cultural patrimony to them. The INL CRMP establishes a communication protocol that encourages regular and ongoing interaction between DOE-ID, their contractor, and the Tribes. This interaction ranges from day-to-day discussions and monthly Cultural Resource Working Group meetings to formal government-to-government

consultation in certain instances, such as when NAGPRA items are discovered on INL Site lands. Disposition or resolution of NAGPRA issues is reached through the formal consultation process and may include repatriation, the formal return of human remains and cultural objects to the Tribes.

No NAGPRA issues arose at INL in 2011.

2.6 Summary of Environmental Permits

Table 2-1 summarizes active permits for the INL Site through year-end 2011 that were issued for sitewide or individual facility operations or both that have been referenced in previous sections of this chapter.

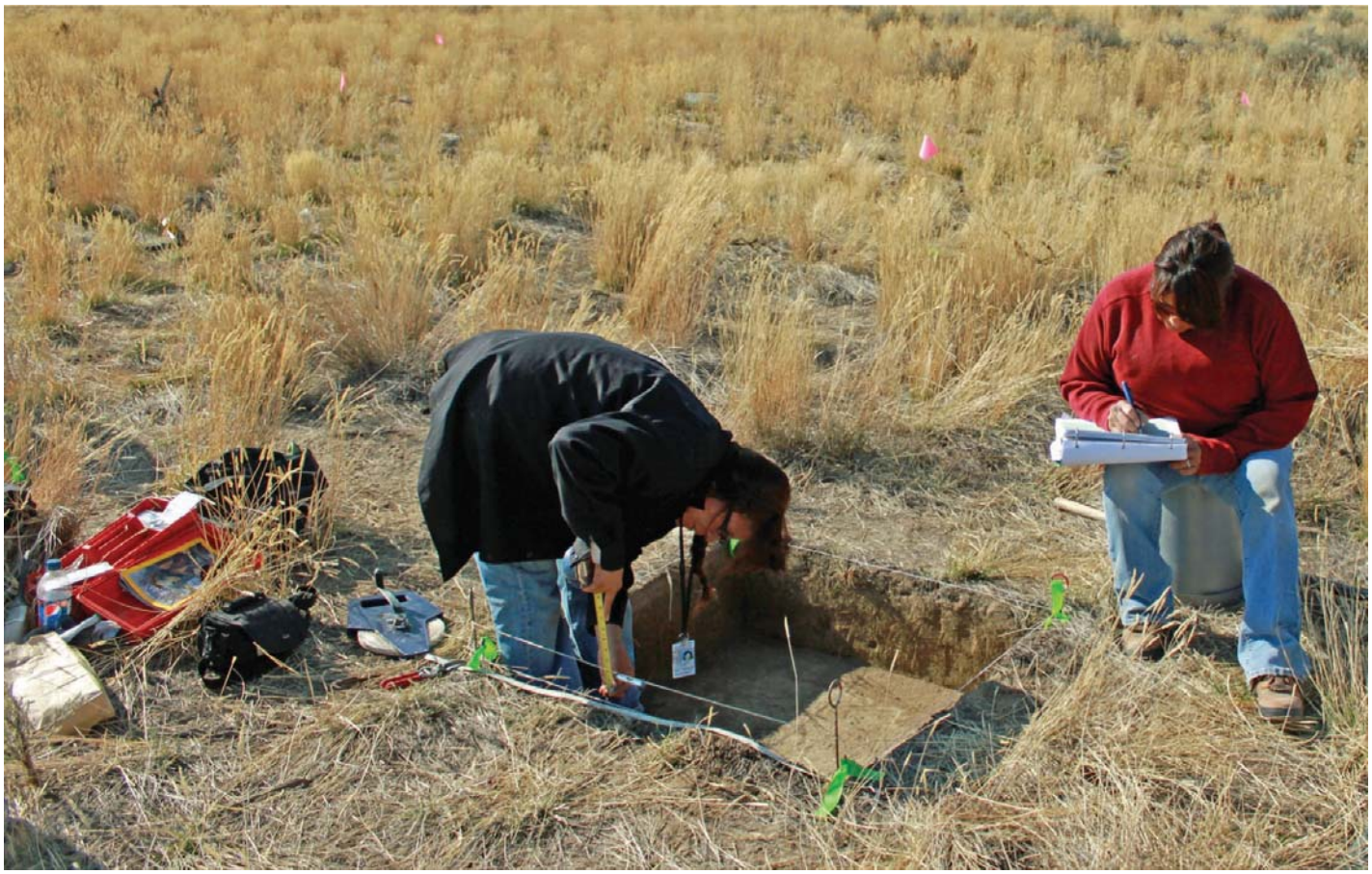

Figure 2-1. Shoshone-Bannock Tribal Staff Aid INL Archaeologists in Test Excavations.

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Chapter 3. Environmental Program Information

Chapter 3 Highlights

Environmental monitoring programs at the Idaho National Laboratory (INL) Site involve sampling environmental media, including ambient air; drinking water, surface water, and groundwater; soils; vegetation; agricultural products and wildlife; and measuring direct radiation. More than 6,100 samples were collected and analyzed in 2011 for a wide array of constituents, including pH, inorganics, volatile organics, gases, gross alpha and beta activity, and specific radionuclides, such as tritium, strontium, americium, and plutonium isotopes.

The Department of Energy Headquarters Office of Independent Oversight within the Office of Health, Safety, and Security conducted an independent assessment of the INL Site environmental monitoring programs in 2010, at the request of the Department of Energy Idaho Operations Office. Many of the recommendations of the assessment team for individual programs were implemented in 2011. INL Site contractors also continued to develop the technical basis for the sitewide environmental monitoring program.

Significant progress continues on INL Site cleanup activities. Among the 2011 accomplishments are:

- 5,517 m^3 (7,210 yd^3) of treated transuranic waste was sent from the Advanced Mixed Waste Treatment Project to the Waste Isolation Pilot Plant in Carlsbad, New Mexico, for disposal
- 333 m^3 (435 yd^3) of mixed low-level waste, historically managed as stored transuranic waste, was also shipped off the INL Site from the Advanced Mixed Waste Treatment Project
- More than 1,089 m^3 (1,424 yd^3) of mixed low-level waste and 1,855 m^3 (2,426 yd^3) of low-level waste were shipped off the INL Site from the Radioactive Waste Management Complex (RWMC) for treatment or disposal or both. Approximately 40 m^3 (52 yd^3) of newly generated, low-level waste was disposed of at the RWMC.

Contractors in charge of nuclear energy and cleanup operations at the INL Site had environmental management systems in place that were compliant with Department of Energy Order 436.1 requirements. Two INL Site contractors successfully went through International Organization for Standardization 14001 semi-annual audits without any nonconformances, and a third contractor was audited by a qualified auditor who concluded that there were no major nonconformances.

In 2011, the Pollution Prevention Program successfully accomplished the goals of the INL Site Pollution Prevention Plan through projects such as the Federal Electronics Challenge, Earth Day, and the INL's recycling initiative.

3. ENVIRONMENTAL PROGRAM INFORMATION

This chapter highlights the Idaho National Laboratory (INL) Site environmental programs that help maintain compliance with major acts, agreements, and orders. Much of the regulatory compliance activity is performed through the various environmental monitoring programs (Section 3.1), environmental restoration (Section 3.2), waste management and disposition (Section 3.3), and the Environmental Management System (EMS) (Section 3.4). Section 3.5 summarizes other significant INL Site environmental programs and activities.

3.1 Environmental Monitoring Programs

Facility effluents and environmental media are monitored for radioactive and nonradioactive constituents to ensure INL Site operations protect human health and the environment and comply with applicable environmental protection laws, regulations, and permits. INL Site environmental monitoring consists of effluent monitoring and environmental surveillance, which are defined as follows:

- Effluent monitoring is the collection and analysis of samples or measurements of liquid and gaseous effluents for the purpose of:

  - Characterizing and quantifying contaminants

  - Assessing radiation exposure of members of the public

  - Providing means to control effluents at or near the point of discharge

  - Demonstrating compliance with applicable standards and permit requirements.

- Environmental surveillance is the measurement of contaminants in the environment to assess any potential incremental effects that INL Site operations may have on human health and the environment. Routine surveillance of all exposure pathways (Figure 3-1) is performed on specific environmental media (air, water, agricultural products, animal tissue, soil, and direct radiation).

At the INL Site, several organizations conduct environmental monitoring:

- The INL contractor (Battelle Energy Alliance, LLC [BEA]) and the Idaho Cleanup Project (ICP) contractor (CH2M-WG Idaho, LLC [CWI]) perform monitoring activities on the INL Site.
- The Environmental Surveillance, Education, and Research (ESER) contractor, Gonzales-Stoller Surveillance, LLC (GSS), performs monitoring activities off the INL Site.
- Two federal agencies also perform monitoring activities on and around the INL Site under interagency agreements with the Department of Energy, Idaho Operations Office (DOE-ID). The National Oceanic and Atmospheric Administration conducts meteorological monitoring and research, and the U.S. Geological Survey (USGS) conducts groundwater monitoring and research.

Tables 3-1 through 3-6 present a summary of the environmental surveillance programs conducted by the ESER, INL, and ICP contractors and the USGS in 2011. In addition to the monitoring constituents listed in Table 3-6, the USGS collected samples twice a year from 12 wells in cooperation with the Naval Reactors Facility (NRF), one time last year from three wells in cooperation with NRF, and collected an expanded list of constituents from nine multi-depth sampling wells. This expanded constituent list changes from year to year in response to USGS program remedial investigation/feasibility study requirements. The constituents collected during 2011, for the multi-depth wells were major anions and cations, trace elements, nutrients, total organic carbon, selected radionuclides, and selected stable isotopes. These data are available from the USGS by request. For a more detailed description of INL Site monitoring activities, see the *Idaho National Laboratory Environmental Monitoring Plan* (DOE-ID 2010a).

Results of the environmental monitoring programs for 2011 are presented in Chapter 4 (air), Chapter 5 (compliance monitoring for liquid effluents, groundwater, drinking water, and surface water), Chapter 6 (Eastern Snake River Plain Aquifer), and Chapter 7 (agricultural, wildlife, soil, and direct radiation). Chapter 8 discusses radiological doses to humans and biota, and Chapter 9 presents 2011 results on ecological research programs at the INL Site. Quality assurance activities of the various organizations conducting environmental monitoring are described in Chapter 10. A summary of historical environmental monitoring activities, meteorological monitoring, field measurements of cesium-137 in soil, and statistical methods used in this report are provided as supplemental reports.

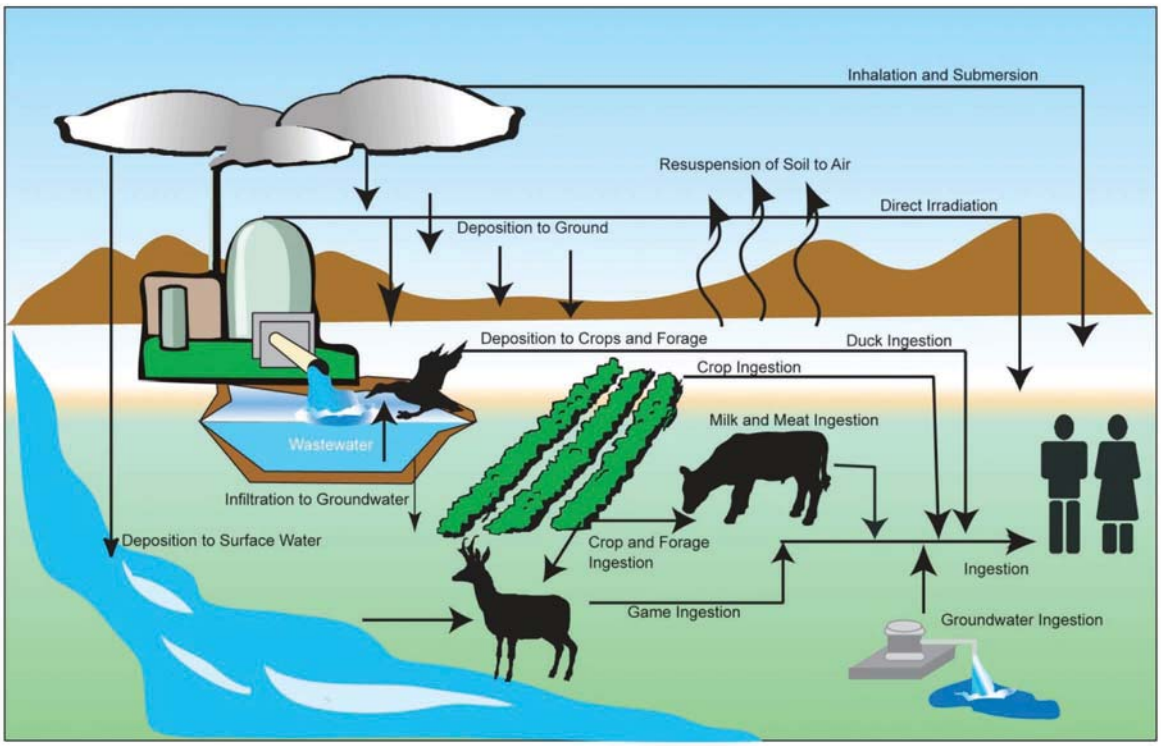

Figure 3-1. Potential Exposure Pathways to Humans from the Idaho National Laboratory Site.

Table 3-1. Environmental Surveillance, Education, and Research Program Summary (2011).

Medium Sampled	Type of Analysis	Locations and Frequency		Minimum Detectable Concentration
		Onsite	Offsite	
Air (low volume)	Gross alpha	4 weekly[a]	14 weekly[a]	1×10^{-15} µCi/mL
	Gross beta	4 weekly	14 weekly	1×10^{-14} µCi/mL
	Specific gamma	4 quarterly	14 quarterly	3×10^{-16} µCi/mL
	Plutonium-238	2 quarterly	5-6 quarterly	2×10^{-18} µCi/mL
	Plutonium-239/240	2 quarterly	5-6 quarterly	2×10^{-18} µCi/mL
	Americium-241	2 quarterly	5-6 quarterly	2×10^{-18} µCi/mL
	Strontium-90	2 quarterly	5-6 quarterly	6×10^{-17} µCi/mL
	Iodine-131	4 weekly	14 weekly	2×10^{-15} µCi/mL
	Total particulates	4 quarterly	14 quarterly	10 µg/m^3
Air (high volume)[b]	Gross beta	None	1, twice per week	1×10^{-15} µCi/mL
	Gamma scan	None	If gross β > 1 pCi/m^3	1×10^{-14} µCi/mL
	Isotopic U and Pu	None	1 annually	2×10^{-18} µCi/mL
Air (atmospheric moisture)	Tritium	None	4 locations, 3 to 6 per quarter	2×10^{-13} µCi/mL (air)
Air (precipitation)	Tritium	1 weekly/ 1 monthly[c]	1 monthly	100 pCi/L
Animal tissue (big game and waterfowl)[d]	Specific gamma	Varies annually	Varies annually	5 pCi/g
	Iodine-131	Varies annually	Varies annually	3 pCi/g
Alfalfa	Specific gamma	None	1 annually	0.1 pCi/g
Agricultural products (milk)	Cesium-137	None	1 weekly	1 pCi/L
	Iodine-131	None	1 weekly/9 monthly	3 pCi/L
	Strontium-90	None	9 semiannually	5 pCi/L
	Tritium	None	9 semiannually	150 pCi/L
Agricultural products (potatoes)	Specific gamma	None	8 –10 annually	0.1 pCi/g
	Strontium-90	None	8 –10 annually	0.2 pCi/g
Agricultural products (wheat)	Specific gamma	None	10 –12 annually	0.1 pCi/g
	Strontium-90	None	10 –12 annually	0.2 pCi/g
Agricultural products (lettuce)	Specific gamma	1 annually	7 – 9 annually	0.1 pCi/g
	Strontium-90	1 annually	7 – 9 annually	0.2 pCi/g
Drinking Water[e]	Gross alpha	None	9-10 semiannually	3 pCi/L
	Gross beta	None	9-10 semiannually	2 pCi/L
	Tritium	None	9-10 semiannually	150 pCi/L
Surface Water[f]	Gross alpha	5 annually	3-4 semiannually	3 pCi/L
	Gross beta	5 annually	4 annually	2 pCi/L
	Tritium	5 annually	4 annually	150 pCi/L

Table 3-1. Environmental Surveillance, Education, and Research Program Summary (2011) (continued).

Medium Sampled	Type of Analysis	Locations and Frequency		Minimum Detectable Concentration
		Onsite	Offsite	
Soil	Specific gamma	None	14 biennially[g]	0.001 pCi/g
	Plutonium-238	None	14 biennially	0.005 pCi/g
	Plutonium-239/240	None	14 biennially	0.1 pCi/g
	Americium-241	None	14 biennially	0.005 pCi/g
	Strontium-90	None	13 biennially	0.05 pCi/g
Direct radiation exposure[h] (thermoluminescent dosimeters (TLDs))	Ionizing radiation	None	17 semiannually	5 mR

a. Onsite includes three locations and a duplicate sampler at one location; off INL Site includes 13 locations and a duplicate sampler at one location.
b. Filters are collected by Environmental Surveillance, Education, and Research personnel for the Environmental Protection Agency (EPA) RadNet program and sent to the EPA for analysis. Data are reported by the Environmental Protection Agency's RadNet at http://www.epa.gov/narel/radnet/.
c. A portion of the monthly sample collected at Idaho Falls is sent to the Environmental Protection Agency for analysis, and data are reported by RadNet.
d. Only big game animals (pronghorn, elk or mule deer) that are victims of road kills or natural causes are sampled on the INL Site. No big game animal controls are collected. Waterfowl are usually collected on ponds within the Advanced Test Reactor Complex, Materials and Fuels Complex, and control areas.
e. Samples are co-located with the State of Idaho Department of Environmental Quality (DEQ) INL Oversight Program at Shoshone and Minidoka water supplies. An upgradient sample is collected at Mud Lake Well #2. The number of samples includes a duplicate sample.
f. Onsite locations are the Big Lost River (if running) at the public rest stop on highway 20/26, at two locations along Lincoln Boulevard, at EFS, and at the Big Lost River Sinks. A duplicate sample is also collected on the Big Lost River. Offsite samples are co-located with the DEQ INL Oversight Program at Alpheus Spring, Clear Springs, and at a fish hatchery at Hagerman. A duplicate sample is also collected at one location.
g. A duplicate sample is also collected at one location.
h. ESER began co-locating optically stimulated luminescence dosimeters (OSLDs) with TLDs in November 2011 with the goal replacing the TLDs with the more state-of-the-art technology in November 2012.

Table 3-2. Idaho National Laboratory Contractor Air and Environmental Radiation Surveillance Summary (2011).

Medium Sampled	Type of Analysis	Locations and Frequency		Detectable Concentration
		Onsite[a]	Offsite[a]	
Air (low volume)	Gross alpha	19 weekly	4 weekly	1×10^{-15} µCi/mL
	Gross beta	19 weekly	4 weekly	5×10^{-15} µCi/mL
	Specific gamma	19 semiannually	4 semiannually	Varies by analyte[b]
	Iodine-131	19 weekly	4 weekly	2×10^{-15} µCi/mL
Air (atmospheric moisture)	Tritium	2 to 4 per quarter	2 to 4 per quarter	1×10^{-11} µCi/mL (water)
Soil	In situ gamma	Varies annually	None	Varies by analyte
Direct radiation exposure[d] (thermoluminescent dosimeters (TLDs) and optically stimulated luminescence dosimeters (OSLDs)	Ionizing radiation	51 semiannually	13 semiannually	5 mR
Direct radiation exposure (mobile radiation surveys)	Gamma radiation	Facilities and INL Site roads[c]	Not collected	Not applicable

a. Low volume air sampling locations onsite include ARA, CFA, EBR-I, Gate 4, INTEC, CPP, NRF, PBF, TRA, RTC, RWMC, SMC, TAN, MFC, EFS, Highway 26 Rest Area, Van Buren and two duplicate locations. Locations offsite include Blackfoot, Craters of the Moon, Idaho Falls and Rexburg. A blank also is analyzed.

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

c. The perimeter at each INL Site facility and an area outside the northeast corner of INTEC are surveyed each year. All INL Site roadways over which waste is transported are surveyed annually.

d. The INL contractor began co-locating OSLDs with TLDs in November 2010. The TLDs will be replaced by OSLDs in November 2012.

Table 3-3. Idaho National Laboratory Contractor Drinking Water Program Summary (2011).

Medium/Contaminant Type	Type of Analysis	Frequency (onsite)	Maximum Contaminant Level
Drinking water/ radiological	Gross alpha	6 annually, 9 semiannually	15 pCi/L
	Gross beta	6 annually, 9 semiannually	4 mrem/yr
	Radium-226/228	6 annually, 9 semiannually	5 pCi/L
	Tritium	6 annually, 9 semiannually	20,000 pCi/L
	Uranium	9 annually	0.03 pCi/L
	Iodine-129	2 semiannually	1 pCi/L
Drinking water/primary and secondary drinking water parameters	Parameters required by the state of Idaho under authority of the Safe Drinking Water Act	9 triennally	Varies
Drinking water/nitrates	Nitrate	9 annually	10 mg/L (as nitrogen)
Drinking water/microbial	Microbes	13 quarterly 12 monthly 1 monthly during summer	If <40 samples/ month, no more than one positive for total coliform
Drinking water/volatile organic compounds	Volatile organic compounds	2 annually	Varies

Table 3-4. Idaho Cleanup Project Contractor Environmental Surveillance Program Air, Surface Water, Vegetation, and Radiation Survey Summary (2011).

Medium Sampled	Type of Analysis	Location and Frequency		Minimum Detectable Concentration[b]
		RWMC[a]	INTEC[a]	
Air (low volume)	Gross alpha	8 bimonthly	1 bimonthly	7×10^{-13} µCi/mL
	Gross beta	8 bimonthly	1 bimonthly	2×10^{-12} µCi/mL
	Specific gamma	8 monthly	1 monthly	Varies by analyte
	Specific alpha	8 quarterly	1 quarterly	8×10^{-18} µCi/mL
	Strontium-90	8 quarterly	1 quarterly	1×10^{-16} µCi/mL
Surface water runoff	Specific gamma	1 quarterly[c]	None	Varies by analyte
	Plutonium isotopes	1 quarterly[c]	None	0.02 pCi/L
	Uranium-233/234	1 quarterly[c]	None	0.06 pCi/L
	Uranium-235	1 quarterly[c]	None	0.04 pCi/L
	Uranium-238	1 quarterly[c]	None	0.04 pCi/L
	Americium-241	1 quarterly[c]	None	0.02 pCi/L
	Strontium-90	1 quarterly[c]	None	0.3 pCi/L
Vegetation	Specific gamma	4 annually[d]	None	Varies by analyte
	Plutonium isotopes	4 annually[d]	None	0.0006 pCi/g
	Uranium-233/234	4 annually[d]	None	0.002 pCi/g
	Uranium-235	4 annually[d]	None	0.001 pCi/g
	Uranium-238	4 annually[d]	None	0.001 pCi/g
	Americium-241	4 annually[d]	None	0.0006 pCi/g
	Strontium-90	4 annually[d]	None	0.012 pCi/g
Mobile radiation surveys	Gamma radiation	1 annually	None	Not applicable

a. INTEC = Idaho Nuclear Technology and Engineering Center
RWMC = Radioactive Waste Management Complex.
b. Detection limits vary with each laboratory analysis, but approximate values are provided.
c. Samples were collected monthly during the first quarter of 2011 per DOE-ID request.
d. Rabbitbrush and crested wheatgrass samples were collected in 2011.

Table 3-5. Idaho Cleanup Project Contractor Drinking Water Program Summary (2011).

Medium Sampled	Type of Analysis	Location and Frequency		Maximum Contaminant Level Action Level
		RWMC[a]	INTEC[a]	
Drinking water systems	**Microbiological Contaminants**	2 monthly	3 monthly	<40 samples/month, no more than one positive for total coliform
	Inorganic Chemicals			
	Antimony	1 triennially	1 triennially	0.006 mg/L
	Arsenic	1 triennially	1 triennially	0.010 mg/L
	Barium	1 triennially	1 triennially	2 mg/L
	Beryllium	1 triennially	1 triennially	0.004 mg/L
	Cadmium	1 triennially	1 triennially	0.005 mg/L
	Chromium	1 triennially	1 triennially	0.1 mg/L
	Copper	1 triennially	1 triennially	1.3 mg/L (TT)[b]
	Mercury	1 triennially	1 triennially	0.002 mg/L
	Nickel	1 triennially	1 triennially	Not Applicable
	Lead	1 triennially	1 triennially	0.015 mg/L (TT)[b]
	Selenium	1 triennially	1 triennially	0.05 mg/L
	Thallium	1 triennially	1 triennially	0.002 mg/L
	Nitrate (as nitrogen)	1 annually	1 annually	10 mg/L
	Nitrite (as nitrogen)	1 triennially	1 triennially	1 mg/L
	Radionuclides			
	Gross alpha	1 semiannually	1 semiannually	15 pCi/L
	Gross beta	1 semiannually	1 semiannually	4 mrem/yr
	Strontium-90	1 annually	1 annually	4 mrem/yr
	Tritium	1 annually	1 annually	4 mrem/yr
	Synthetic Organic Chemicals			
	2-4-5-TP	1 triennially	1 triennially	0.050 mg/L
	2-4-D	1 triennially	1 triennially	0.070 mg/L
	Atrazine	1 triennially	None	0.003 mg/L

Table 3-5. Idaho Cleanup Project Contractor Drinking Water Program Summary (2011) (continued).

Medium Sampled	Type of Analysis	Location and Frequency		Maximum Contaminant Level Action Level
		RWMC[a]	INTEC[a]	
	Dalapon	1 triennially	1 triennially	0.2 mg/L
	Dinoseb	1 triennially	1 triennially	0.007 mg/L
	Di(2-ethylhexyl)adipate	1 triennially	None	0.4 mg/L
	Di(2-ethylhexyl)phthalate (DEHP)	1 triennially	None	0.006 mg/L
	Picloram	1 triennially	1 triennially	0.5 mg/L
	Volatile Organic Chemicals[c]	2 quarterly	1 triennially	Varies
	Disinfectants and Disinfection Byproducts			
	Haloacetic Acids (HAA5)	1 triennially	1 triennially	0.60 mg/L
	Total Trihalomethanes (TTHMs)	1 triennially	1 triennially	0.08 mg/L

a. INTEC = Idaho Nuclear Technology and Engineering Center
RWMC = Radioactive Waste Management Complex.

b. Lead and copper are regulated by a treatment technique (TT) that requires systems to control the corrosiveness of their water. If more than 10% of samples exceed the action level, water systems must take additional steps.

c. Each volatile organic chemical sample is analyzed for 21 volatile organic chemicals.

Table 3-6. U.S. Geological Survey Monitoring Program Summary (2011).

Constituent	Groundwater		Surface Water		Minimum Detectable Concentration or activity
	Number of Sites[a]	Number of Samples	Number of Sites	Number of Samples	
Gross alpha	50	50	4	4	1.5 pCi/L
Gross beta	50	50	4	4	3.4 pCi/L
Tritium	156	154	7	7	200 pCi/L
Gamma-ray spectroscopy	92	92	4	4	—[b]
Strontium-90	109	108	—[c]	—	2 pCi/L
Americium-241	25	25	—[c]	—	0.03 pCi/L
Plutonium isotopes	25	25	—[c]	—	0.02 pCi/L
Iodine-129	31	31	—[c]	—	<1aCi/L
Specific conductance	157	157	7	7	Not applicable
Sodium ion	145	143	—[c]	—	0.1 mg/L
Chloride ion	155	153	7	7	0.1 mg/L
Nitrates (as nitrogen)	117	116	—[c]	—	0.05 mg/L
Fluoride	4	4	—[c]	—	0.1 mg/L
Sulfate	105	103	—[c]	—	0.1 mg/L
Chromium (dissolved)	81	80	—[c]	—	0.005 mg/L
Purgeable organic compounds[d]	30	41	—[c]	—	Varies
Total organic carbon	51	51	—[c]	—	0.1 mg/L
Trace elements	13	13	—[c]	—	Varies

a. Number of samples does not include 16 replicates and 3 equipment blanks collected in 2011. Number of samples was less than the number of sites because several sites were dry or had unresolved pump problems. Number of sites does not include 46 zones from 9 wells sampled as part of the multi-level program.

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

c. No surface water samples collected for this constituent.

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

3.1.1 Sitewide Monitoring Committees

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

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

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

3.1.2 DOE Headquarters Independent Assessment

In 2010, at DOE-ID's request, the DOE Headquarters Office of Independent Oversight within the Office of Health, Safety, and Security conducted an independent assessment of the INL Site environmental monitoring program. The scope for the assessment included:

- Review of INL Site environmental monitoring activities to ensure that the sitewide environmental monitoring program as a whole is comprehensive and meets the objectives of DOE Order 450.1A, Sections 4(c)(2)(a-d) which address protection of public health and the environment for specific media, and (c)(5-6) which address monitoring and meeting data quality objectives
- Review of the INL (BEA), ICP (CWI), and ESER (GSS) contractor environmental monitoring activities to ensure compliance with the requirements of DOE Order 450.1A, Sections 4(c)(2)(a-d) and (c)(5-6) and DOE Order 5400.5 for their contract responsibilities
- Determination of whether current monitoring activities meet selected stakeholder (Idaho Department of Fish and Game, state of Idaho, INL Oversight) expectations
- Review of the effectiveness of communication and timely access to monitoring data between site contractors and with DOE-ID on monitoring activities
- Review of the effectiveness of INL self-assessments of environmental monitoring activities

- Confirmation of the effectiveness of data storage and access, including foreseeable technological issues related to data storage, retrievability, and contractor planning to address such issues
- Confirmation that data quality objectives are appropriate and are being met
- Determination of whether monitoring is adequate for the expanding research and development activities of INL in the city of Idaho Falls
- Review of the INL Site Annual Site Environmental Report production process to ensure that the information reported is comprehensive, technically sound, written in a manner that is understandable to the public and site stakeholders, and that appropriate efforts are being made to ensure the quality and defensibility of data reported.

The Office of Health, Safety, and Security Assessment Team issued a final report detailing positive attributes of the existing program and recommended program enhancements (Table 3-7). DOE-ID directed INL Site contractors to address the overarching recommendation to develop a technical basis for the sitewide monitoring program. In 2011, the INL contractor continued to lead a team consisting of the ICP contractor and the ESER contractor to develop the technical basis. The contractors are also addressing other recommendations applicable to their individual programs. The full Assessment Report is available at http://www.hss.doe.gov/indepoversight/reports/eshevals.html.

3.2 Environmental Restoration

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

The INL Site is divided into ten waste area groups (WAGs) (Figure 3-2) as a result of the FFA/CO, and each WAG is further divided into smaller cleanup areas called operable units. Field investigations are used to evaluate potential release sites within each WAG and operable unit when existing data are insufficient to determine the extent and nature of contamination. After each investigation is completed, a determination is made whether a “No Action” or “No Further Action” listing is possible, or if it is appropriate to proceed with an interim cleanup action, the Operable Unit-10-08 Plug-In Remedy action, or further investigation using a remedial investigation/feasibility study. The remedial investigation/feasibility study is used to determine the nature and extent of the problem presented by the past release of contamination and to develop and evaluate options for remedial action. Results from the remedial investigation/feasibility study form the basis for risk assessments and alternative cleanup actions. This information, along with the regulatory agencies’ proposed cleanup plan, is presented to the public in a document called a proposed plan. Proposed plans present cleanup alternatives and recommend a preferred cleanup alternative to the public. After consideration of public comments, DOE, the Environmental Protection Agency, and the state of Idaho develop a record of decision (ROD)

Table 3-7. Summary of Results from the 2010 Office of Health, Safety, and Security Assessment of the INL Site Environmental Monitoring Program (DOE 2010).

Positive Attributes	Recommended Program Enhancements
• Database management protocols are comprehensive and provide effective mechanisms for collection, analysis, and retrieval of vast amounts of environmental sampling data generated by INL Site contractors. • Technical and professional staffs are well qualified and knowledgeable. • INL Site contractors have good working relationships with external stakeholders and regulators. • Plan and procedure infrastructure in support of the environmental monitoring and surveillance programs is comprehensive. • Monitoring of potential Endangered Species Act listed species is proactive. • Research and collaboration with institutions of higher learning enhances the knowledge base and the effectiveness of environmental monitoring activities.	• The current programmatic design does not provide a complete definition of the technical basis for all environmental monitoring and surveillance activities being conducted at the INL Site. • Some aspects of the program were not sufficiently coordinated and communicated among contractors. • Some information in published environmental reports was not fully accurate and clear. • Implementation of certain quality assurance protocols and media specific monitoring and surveillance actions were not fully effective.

selecting a cleanup approach from the alternatives evaluated. Cleanup activities then can be designed, implemented, and completed.

Since the FFA/CO was signed in December 1991, the INL Site has cleaned up release sites containing asbestos, petroleum products, acids and bases, radionuclides, unexploded ordnance and explosive residues, polychlorinated biphenyls, heavy metals, and other hazardous materials. Twenty-four RODs have been signed and are being implemented. Comprehensive remedial investigation/feasibility studies have been completed for WAGs 1, 2, 3, 4, 5, 7, 8, 9, and 6/10 (6 is combined with 10). Closeout activities at WAGs 1 (excluding Operable Unit 1-07B), 2, 4, 5, and 8 have been completed. The WAG 10, Operable Unit 10-08 ROD (Sitewide Groundwater, Miscellaneous Sites and Future Sites [DOE-ID 2009]) was the last ROD and was finalized in September 2009.

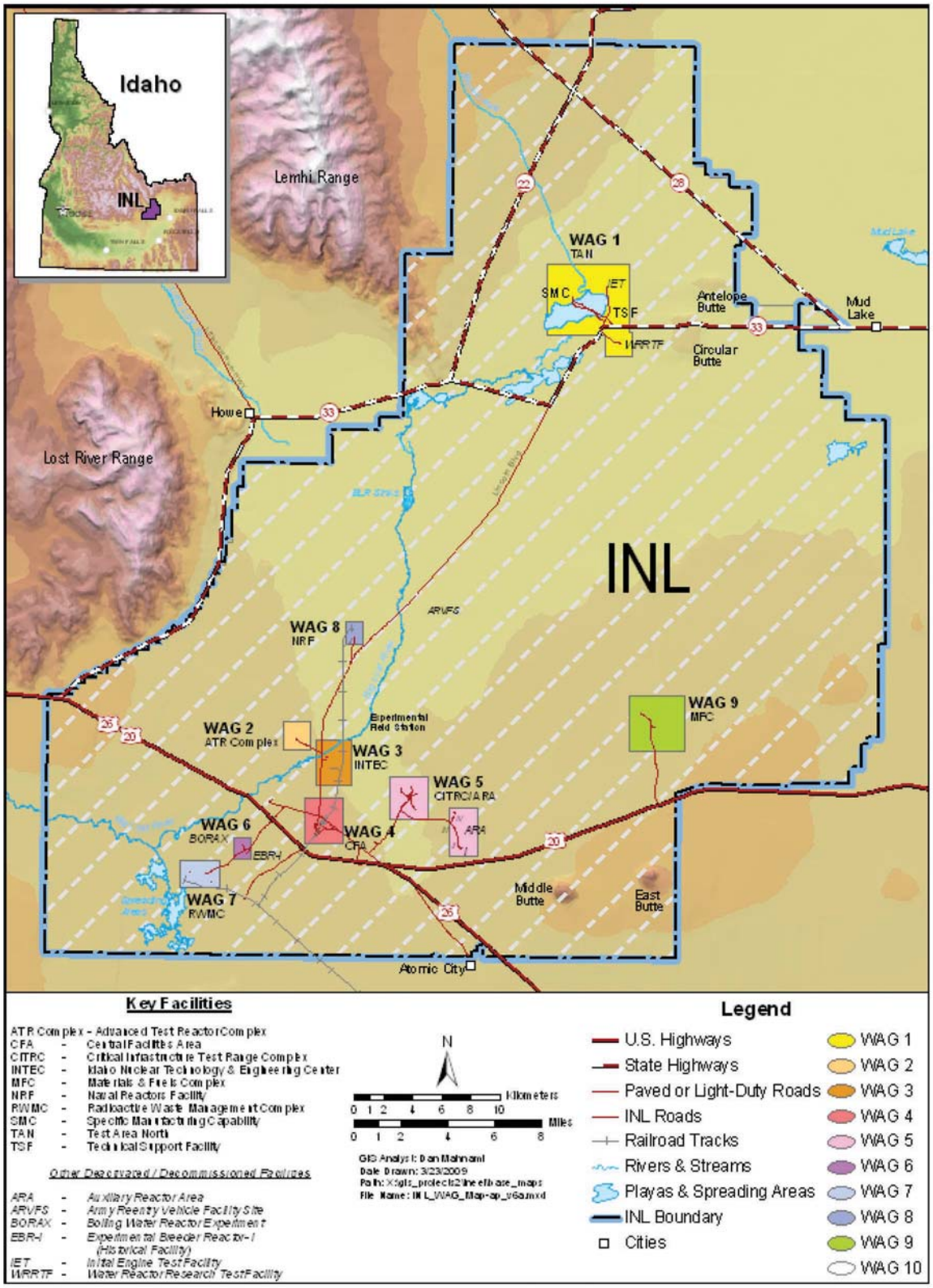

Figure 3-2. Map of the Idaho National Laboratory Site Showing Locations of the Facilities and Corresponding Waste Area Groups.

Documentation associated with the FFA/CO is publicly available in the CERCLA Administrative Record and can be accessed at http://ar.inel.gov/. The location of each WAG is shown in Figure 3-2. Cleanup progress for each WAG is summarized in the following subsections. CERCLA-related groundwater and ecological monitoring activities are summarized in Chapters 6 and 7, respectively.

3.2.1 Waste Area Group 1 – Test Area North

Groundwater cleanup for Operable Unit 1-07B continued throughout 2011. The in situ bioremediation nutrient injection system continued to reduce contaminant concentrations in the aquifer. The New Pump and Treat Facility generally operated 4 days per week to maintain trichloroethylene concentrations in the medial zone below specified targets. The project finalized an In-Situ Bioremediation (ISB) Rebound Test Plan and a revised groundwater monitoring plan in 2011 to address issues from the 2010 Five Year Review. The ISB Rebound Test is expected to begin in FY-2012 or FY-2013. In addition, the Air Stripping Treatment Unit operated from the end of January to the end of July 2011 and was then placed into standby. All institutional controls were maintained in 2011.

3.2.2 Waste Area Group 2 – Advanced Test Reactor Complex

All active remediation in WAG 2 is complete. Some elements of the remedy, including monitoring perched water and groundwater under the facility area and maintenance of caps and covers, will continue until the risk posed by contamination left in place is acceptable. All institutional controls and operations and maintenance requirements were maintained in 2011.

3.2.3 Waste Area Group 3 – Idaho Nuclear Technology and Engineering Center

Operations continued at the Idaho CERCLA Disposal Facility (ICDF) during 2011, disposing of contaminated soil and debris in the landfill cell and liquid waste to the ICDF evaporation ponds. The ICDF disposes of contaminated soils and debris from CERCLA remediation operations to reduce risk to the public and the environment.

Remedial actions required by the WAG 3, Operable Unit 3-14 ROD implemented in 2011 included the reduction of approximately 10.5 MG of anthropogenic recharge to the northern perched water zones, and the installation of drainage ditches and low permeability pavement over the recharge control zone. Approximately 525 ft of high density polyethylene drainage culvert and 47,000^2 ft of low permeability pavement in the recharge control zone were installed that directs all surface runoff toward the Operable Unit 3-14 evaporation pond on the east side of the Idaho Nuclear Technology and Engineering Center (INTEC). These actions were taken at the Tank Farm Facility to reduce water infiltration that can transport contaminants from the perched water to the aquifer. Perched and groundwater monitoring under and near the facility will continue until the risk posed by contamination left in place is below target levels. All institutional controls and operations and maintenance requirements were maintained in 2011.

3.2.4 Waste Area Group 4 – Central Facilities Area

Remediation of WAG 4 was completed in 2004. Soil gas and groundwater monitoring and maintenance of caps and covers will continue until the risk posed by contamination left in place is acceptable. All institutional controls were maintained in 2011.

3.2.5 Waste Area Group 5 – Critical Infrastructure Test Range/Auxiliary Reactor Area

Cleanup activities at WAG 5 are complete. The Remedial Action Report (DOE-ID 2005) was completed in 2005. All institutional controls and operations and maintenance requirements were maintained in 2011.

3.2.6 Waste Area Group 6/10 – Experimental Breeder Reactor I/Boiling Water Reactor Experiment, Miscellaneous Sites, Eastern Snake River Plain Aquifer

The WAG 10, Operable Unit 10-08 ROD (Sitewide Groundwater, Miscellaneous Sites, and Future Sites) was the last INL Site ROD identified and was finalized in September 2009 (DOE-ID 2009). Operable Unit 10-08 addresses Eastern Snake River Plain Aquifer concerns not covered by other WAGs and future sites that may be discovered. Groundwater monitoring will continue in 2011 to confirm that there is no unacceptable threat to human health or the environment from commingled plumes or along the southern INL Site boundary. A Final Long-Term Ecological Monitoring Report for Operable Unit 10-04 was submitted to the regulatory agencies, which covered six years of monitoring data. Remediation of unexploded ordnance in accordance with the Operable Units 6-05 and 10-04 ROD, continued in 2011. All institutional controls and operations and maintenance requirements were maintained in 2011.

3.2.7 Waste Area Group 7 – Radioactive Waste Management Complex

WAG 7 includes the Subsurface Disposal Area, a 39-hectare (97-acre) radioactive waste landfill that is the major focus of remedial decisions at the Radioactive Waste Management Complex. Waste is buried in approximately 14 of the 39 hectares (35 of the 97 acres) within 21 unlined pits, 58 trenches, 21 soil vault rows, and on Pad A, an above-grade disposal area (Figure 3-3). Disposal requirements have changed in accordance with laws and practices current at the time of disposal. Initial operations were limited to shallow, landfill disposal of waste generated at the INL Site. Beginning in 1954, the Rocky Flats Plant near Boulder, Colorado, was authorized to send waste to the Radioactive Waste Management Complex for disposal. The Rocky Flats Plant was a nuclear weapons production facility with peak operations during the Cold War era. A variety of radioactive waste streams was disposed of, including process waste (e.g., sludge, graphite molds and fines, roaster oxides, and evaporator salts), equipment, and other waste incidental to production (e.g., contaminated gloves, paper, clothing, and other industrial trash). Much of the Rocky Flats Plant waste was contaminated with transuranic isotopes and solvents (e.g., carbon tetrachloride). In 1970, burial of transuranic waste was prohibited. In 1984, disposal practices were modified to eliminate disposal of mixed waste. Since 1984, only low-level waste was disposed of in the Subsurface Disposal Area. This was discontinued at the end of fiscal year 2008, and only the Naval Reactors remote handled, low-level waste is still being disposed in the Subsurface Disposal Area. Disposal of waste from offsite generators was discontinued in the early 1990s.

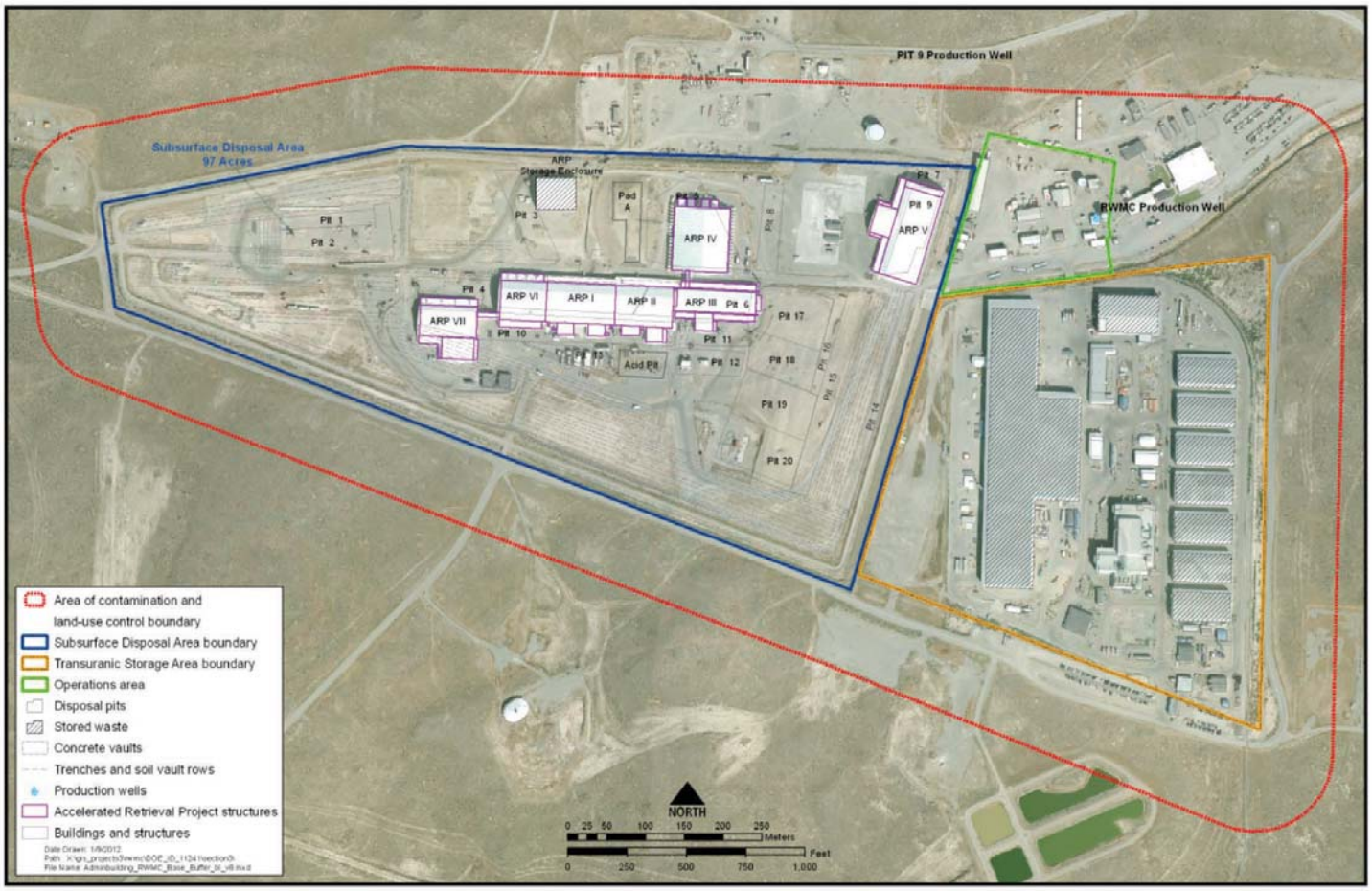

Figure 3-3. Radioactive Waste Management Complex Subsurface Disposal Area (2011).

The Operable Unit 7-13/14 ROD (DOE-ID 2008) was signed in 2008. The ROD is consistent with DOE's obligations for removal of transuranic waste under the *Agreement to Implement U.S. District Court Order Dated May 25, 2006*, between the state of Idaho and DOE, effective July 3, 2008 (DOE 2008). The ROD calls for exhuming a minimum of 6,238 m^3 (8,159 yd^3) of targeted waste from a minimum combined area of 2.3 ha (5.69 acres). Targeted waste for retrieval contains transuranic elements, such as plutonium, as well as uranium and collocated organic solvents, such as carbon tetrachloride. Targeted waste retrievals in specific areas of the Subsurface Disposal Area commenced in 2005 under the Accelerated Retrieval Project I. The retrieved targeted waste is packaged, certified, and shipped out of Idaho. The first targeted excavation in Pit 4 East was completed in early 2008. A second excavation commenced in July 2007, in other parts of Pit 4 East and Pit 6 and was completed in June 2009, and a third excavation in another part of Pit 6 commenced in December 2008, and was completed in October 2009. A fourth excavation in Pit 5 commenced in January 2010, and was completed in January 2011. A fifth excavation in Pit 9 commenced in December of 2010, and was completed in August of 2011. A sixth excavation in Pit 4 commenced in April of 2011, and was completed in

October 2011. The Accelerated Retrieval Projects have collectively retrieved and packaged more than 5,526 m^3 of targeted waste from a combined area of 1.19 ha (2.96 acres).

In addition to continuing current waste retrieval as directed by regulatory and legal documents, the ROD addresses remaining contamination in the Subsurface Disposal Area through a combination of continued vacuuming solvent vapors from the subsurface (Organic Contamination in the Vadose Zone Project), grouting some mobile contaminants (completed 2010), and constructing a moisture-inhibiting surface barrier over the entire landfill. This project is expected to cost approximately $1.3 billion and will take approximately 20 years to complete. Retrieval of targeted waste will continue until approximately 2017, followed by construction of a surface barrier.

3.2.8 Waste Area Group 8 – Naval Reactors Facility

Naval Reactors Facility environmental program updates are discussed in the Naval Reactors Facility environmental monitoring reports and are not included in this report.

3.2.9 Waste Area Group 9 – Materials and Fuels Complex

All WAG 9 remediation activities have been completed. Three sites will remain under institutional controls until 2097 to allow for natural decay of cesium-137 to background levels.

3.3 Waste Management and Disposition

Waste management and disposition covers a variety of operations and functions, including: (1) storage of waste pending disposition; (2) characterization of waste to allow it to be placed in storage or to be transported, treated, or disposed of; (3) transportation of waste to locations on or off the INL Site for treatment or disposal or both; (4) treatment of waste prior to disposal; and (5) disposal. Safe operations and compliance with applicable federal, state, and local regulations are the highest priorities, along with meeting the commitments made in the Idaho Settlement Agreement (DOE 1995) and the 2011 Idaho National Laboratory Site Treatment Plan, INL-STP (ICP 2011).

3.3.1 Federal Facility Compliance Act

The Federal Facility Compliance Act requires preparation of a site treatment plan for the treatment of mixed wastes at the INL Site. Mixed wastes contain both radioactive and Resource Conservation and Recovery Act (RCRA)-regulated hazardous components.

In accordance with the INL Site Treatment Plan (ICP 2011), the INL Site began receiving mixed waste from offsite locations for treatment in January 1996. Mixed waste has been received from other sites within the DOE complex, including Hanford, Los Alamos, Paducah, Pantex, Sandia, and six locations managed by the Office of Naval Reactors. A backlog of mixed waste is being managed in RCRA-permitted storage units at the INL Site. During 2011, the INL Site treated or processed 2,867 m^3 of legacy mixed waste, of that total, 496 m^3 was mixed low-level waste shipped offsite for treatment/disposal, and 2,369 m^3 was mixed contact-handled transuranic waste that was shipped offsite to the Waste Isolation Pilot Plant for disposition.

Additionally, 2 m^3 of remote-handled transuranic waste was shipped offsite for disposition, the majority of which was specified by the INL Site Treatment Plan.

During 2011, six INL Site Treatment Plan milestones were met and a milestone associated with Remote-handled Sodium Treatment, (P-1) to submit a RCRA Part B permit application, was extended from first quarter 2012 to second quarter 2013. Also extended were two milestones associated with the Sodium Bearing Waste Treatment, (P-4 and P-5) to commence operations and to submit a system backlog schedule, from first quarter 2012 to the second quarter of 2012. The following milestones were completed:

- Identify Funding Requirements for Calcine Disposition (P-1)
- Commercial Backlog Treatment/Disposal – 72 m^3 (94 yd^3)
- Advanced Mixed Waste Treatment Project (AMWTP) Processing – 4,500 m^3 (5,886 yd^3)
- Sodium Components Maintenance Shop Backlog – 2 m^3 (2.6 yd^3)
- Remote Handled Transuranic (TRU) Waste Disposition Project for Repackaging – 0.9 m^3 (1.2 yd^3)
- Sodium Bearing Waste Treatment Facility – P-4 Commence Full-Scale System Testing third Quarter 2011.

3.3.2 Advanced Mixed Waste Treatment Project

Operations at AMWTP require retrieval, characterization, treatment, and packaging of transuranic waste currently stored at the INL Site. The vast majority of the waste the AMWTP processes resulted from the manufacture of nuclear components at Colorado's Rocky Flats Plant. The waste contains industrial debris, such as rags, work clothing, machine parts and tools, as well as soil and sludge. The waste is contaminated with transuranic radioactive elements (primarily plutonium).

After the waste containers have been retrieved from waste storage, they are examined in the AMWTP Characterization Facility. During characterization, each container is examined to determine its contents. Characterized waste containers that need further treatment before they can be shipped offsite for disposal are either sent to the AMWTP Treatment Facility or to the Drum Treatment Tent in WMF-628. The AMWTP Treatment Facility treats the waste by size-reducing, sorting, and repackaging the waste. Waste sent to the Treatment Facility is transported to different areas within the facility by an intricate system of conveyers, and all waste is handled remotely. The Treatment Facility houses a supercompactor and a shredder for major size-reduction of the waste. Any restricted items, such as liquids or compressed gas cylinders, are removed, and the waste is repackaged. The Drum Treatment Tent primarily treats drums that contain sludge waste with excess liquids by adding liquid absorbent. The Drum Treatment Tent may also repackage old drums into new drums.

There are two loading areas at the AMWTP. In both loading facilities, the waste containers go through two major steps: payload assembly and TRUPACT II loading. Payload assembly

includes grouping the waste into four different configurations consisting of 55-gallon drums, 100-gallon pucks drums (i.e., drums of compacted waste), waste over-packed into Standard Waste Boxes, and waste over-packed into Ten Drum Overpacks. Then, the waste is loaded into the TRUPACT II containers for shipping. A TRUPACT II container is a special double-containment vessel that is approved for waste transport. After the payloads are placed in the TRUPACT II containers, the containers are visually and mechanically inspected before they are certified for travel. Once a TRUPACT II container is certified for travel, the waste is sent 2,092 km (1,300 mi) to its final destination at the Waste Isolation Pilot Plant in Carlsbad, New Mexico.

During 2011, the AMWTP shipped 5,517 m^3 (7,210 yd^3) of stored transuranic waste to the Waste Isolation Pilot Plant, for a cumulative total of 37,034 m^3 (48,400 yd^3) of waste shipped off the INL Site. The AMWTP also shipped offsite 333 m^3 (435 yd^3) of mixed low-level waste that historically had been managed as stored transuranic waste, for a cumulative total of 8,248 m^3 (10,779 yd^3) of waste shipped offsite. A combined cumulative total of 45,282 m^3 (59,179 yd^3) of stored transuranic waste has been shipped offsite. In addition, the AMWTP has shipped a cumulative total of 5,215 m^3 (6,815 yd^3) of buried transuranic waste (see 3.2.7, “Waste Area Group 7 – Radioactive Waste Management Complex”) to the Waste Isolation Pilot Plant.

3.3.3 High-Level Waste and Facilities Disposition

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

In October 2002, DOE issued the *Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement* (DOE 2002) that included alternatives other than calcination for treatment of the sodium-bearing waste. DOE-ID issued a ROD for this Final Environmental Impact Statement on December 13, 2005 (DOE 2005). This ROD specified steam reforming to treat the remaining sodium-bearing waste at the INTEC Tank Farm. DOE-ID plans to complete sodium-bearing waste treatment using this technology by December 31, 2012. This technology will treat the remaining approximately 3.4 million L (900,000 gal) of liquid, sodium-bearing waste that has been consolidated into three 1.14 million L (300,000 gal) below grade tanks at the INTEC Tank Farm for interim storage.

The new Sodium-Bearing Waste Treatment Project facility is under construction, with a goal of commencing steam reforming operations in Fiscal Year 2012. Seven other 1.14 million L (300,000 gal) INTEC Tank Farm tanks have been emptied, cleaned, and removed from service in preparation for final closure. With regard to tank closures, DOE issued a final Section 3116

Waste Determination and amended ROD (71 FR 228) in November 2006. Filling the seven cleaned tanks and their surrounding vaults began in November 2006 and was completed in March 2008.

The Final Environmental Impact Statement also included analysis of alternatives for treating the calcined waste. On December 23, 2009, DOE issued an amended ROD (75 FR 1; 75 FR 7) for the treatment of calcine using an industrially mature manufacturing process known as hot isostatic pressing. Issuing the ROD by the end of 2009 met an interim requirement in the 1995 Settlement Agreement. This selected technology presents the flexibility to either:

- Treat calcine in a sealed high-temperature and high-pressure canning process, including using treatment additives necessary to produce a glass-ceramic and volume-reduced monolithic waste form; or
- Treat calcine in a sealed high-temperature and high-pressure canning process without using treatment additives, resulting in an even greater volume reduction.

DOE-ID is now in the process of implementing the ROD by initiating the technology development and design process for applying the hot isostatic pressing technology to treat calcine waste. The design effort includes a system to retrieve the existing high-level waste calcine from the consolidated calcine storage facilities (bin sets) and packaging following treatment.

3.3.4 Low-Level and Mixed Radioactive Waste

In 2011, more than 1,089 m^3 (1,424 yd^3) of mixed low-level waste and 1,855 m^3 (2,426 yd^3) of low-level waste was shipped off the INL Site for treatment or disposal or both. Approximately 39.93 m^3 (52 yd^3) of newly generated, low-level waste was disposed of at the Subsurface Disposal Area in 2011.

3.4 Environmental Management System

An environmental management system provides a framework of elements following a plan, do, check, act cycle; that when established, implemented and maintained; will foster improved environmental performance. An EMS focuses on three core concepts: pollution prevention, environmental compliance, and continuous improvement. The primary system components are (1) environmental policy, (2) planning, (3) implementation and operation, (4) checking and corrective action, and (5) management review.

Executive Order (EO) 13423, “Strengthening Federal Environmental, Energy, and Transportation Management,” mandates that all federal agencies implement environmental management systems at all appropriate organizational levels. DOE Order 436.1, “Departmental Sustainability,” requires compliance with this EO, and further requires that DOE sites use their EMS as a platform for Site Sustainability Plan implementation. Sites must maintain their EMS as being certified to or conforming to the International Organization for Standardization’s (ISO) 14001:2004 in accordance with the accredited registrar provisions or self-declaration instructions.

The three main INL Site contractors have established EMSs for their respective operations. The ICP and INL contractors maintain ISO 14001 systems certified and registered by accredited registrars. Auditors from the registrars conduct periodic surveillances and full audits of the systems to determine improvement or degradation, and eligibility for recertification. The AMWTP contractor's EMS is self-declared conformant to the ISO standard, based upon conformance audits by independent, external, qualified auditors. DOE strongly supports the management system concept and its auditors review contractor processes to ensure they meet DOE's requirements.

3.4.1 Sustainability Program

The Site Sustainability Plan and program implemented sustainable practices in facility design operation, procurement, and program operations that meet the requirements of EO 13514, "Federal Leadership in Environmental, Energy, and Economic Performance," and DOE Order 436.1, "Departmental Sustainability." The goal of EO 13514 is "to establish an integrated strategy towards sustainability in the Federal Government and to make reduction of greenhouse gas emissions a priority for Federal agencies."

The goal of the INL sustainability program is to promote economic, environmental, and social sustainability for the INL, helping to ensure its long-term success and viability as a premier DOE national laboratory. The sustainability program focuses on water, and greenhouse gas reductions, as well as responsible use and disposal of materials and resources; advancing sustainable building designs; exploring the potential use of renewable energy; reducing utility costs across the INL; and supporting cost-effective facilities, services, and program management. The challenge is to minimize the impact of operations of the laboratory. The INL is integrating environmental performance improvement in the areas that matter most to its stakeholders and the laboratory, including minimizing the environmental footprint, taking a progressive approach to climate change, and championing energy conservation.

Energy Reduction – The INL Site goal for energy usage is a 30 percent reduction of energy intensity by FY-2015, as compared to the FY-2003 energy intensity baseline. Energy intensity is defined as energy use divided by the building area measured in Btu/ft^2. On average, an annual energy use reduction goal of 3 percent supports meeting the overall goal and provides a means to measure and trend progress.

The INL Site energy intensity for FY-2011 was 173,194 Btu/ft^2 compared to 183,471 Btu/ft^2 in FY-2003 for a calculated reduction of 5.6 percent. This reduction falls far short of the desired 18 percent cumulative reduction goal for 2011. However, the INL Site normalizes energy intensity each year to provide for a weather-related adjusted comparison with the base year. To make this correction, the portion used for space conditioning (defined as 43 percent of the total according to DOE's Energy Information Administration) is adjusted to the weather conditions of the base year. In FY-2011, there were 8,970 Heating Degree Days as compared to only 7,892 in FY-2003. In this comparison, the energy intensity would decrease had temperatures been as warm in 2011 as they were in 2003. The result is a corrected energy intensity of 164,244 Btu/ft^2, and when compared to the base year energy intensity of 183,471 Btu/ft^2, it calculates to an annual 10.5 percent reduction.

Water Conservation – The INL Site's goal for water usage is a 16 percent reduction of usage intensity by FY-2015, or 2 percent each year, as compared to the FY-2007 Water Usage Intensity Baseline measured in gal/ft^2.

Due to the nature of the various INL Site missions, many of the operations can be cyclical and result in varying usages of water throughout the year and from year to year. In addition, as facilities are removed and processes are shut down, the lower square footage can actually result in an increase in water intensity even as overall water usage is reduced.

The water intensity reduction goal will be very difficult for the INL Site to accomplish. Long payback calculations based on inexpensive water and electric rates make water saving projects unattractive. Completion of Energy Savings Performance Contract projects is anticipated to contribute approximately 7.5 percent towards the 16 percent goal. However, water usage is so dependent upon process usage and unplanned events such as wildfires and American Recovery & Reinvestment Act-funded additional D&D work, that the remaining 8.5 percent may be very difficult to attain.

As per the water reduction goals found in DOE 436.1, the INL Site should be at an 8 percent water intensity reduction at the end of 2011 compared to the 2007 Reportable Water Usage Baseline. The INL Site used a total of 898.7 M gallons of water in 2011, resulting in a water usage intensity of 166.8 gal/ft^2, a decrease of 4 percent over the FY-2007 baseline (173.9 gal/ft^2). However, as demonstrated through the water use and building square footage data, the INL Site total water used has decreased from 1,050.9 MG in 2007 to 898.7 MG in 2011, for a total water used reduction of 14.5 percent.

INL partnered with industrial water system experts from the Pacific Northwest National Laboratory to evaluate the water systems, primarily at the Advanced Test Reactor (ATR) Complex. This evaluation identified several areas of significant water use that may be addressed through system modifications. The final report is due mid-2012.

Other actions to conserve water in 2011 include installation of xeriscaping at one of the University Boulevard buildings in Idaho Falls, implementation of the Materials and Fuels Complex (MFC) Energy Savings Performance contract—which resulted in 2.3 M fewer gallons of consumption—and deactivation D&D of the INTEC Analytical Laboratory facilities which resulted in a 50 MG/yr water savings.

High Performance Sustainable Buildings (HPSB) – The INL Site goal for HPSB is that 15 percent of existing buildings greater than 5,000 gross square feet (gsf) be compliant with the five Guiding Principles (GPs) of HPSBs by FY-2015. There are 27 GPs in five categories, and to achieve compliance with the GPs, all 27 must be met.

The INL Site has 170 buildings that are appropriate to consider for audits and upgrades to implement the GPs. Fifteen percent of these buildings calculates to a minimum of 26 buildings that must meet the GPs by 2015. Twenty-three buildings have been identified as having the highest probability of meeting the GPs. These buildings are either currently metered or have been targeted for metering in 2012. Of these 23 buildings, one is Leadership in Energy and

Environmental Design (LEED™) Certified, one is LEED™ Gold Certified, and one is pending LEED™ Gold Certification. The remaining 20 buildings will be targeted for the GPs compliance path.

The ATR Complex Technical Support Building (TRA-1608) was LEED™ certified in November 2010. The LEED™ design package was also submitted for the new Radiological and Environmental Sciences Laboratory (IF-683) during 2011.

Metering was installed on seven facilities (three in town, three at Central Facilities Area [CFA], and one at ATR Complex) in order to obtain electrical data. Energy and water reduction projects were developed in 2011 for IF-601, IF-602, IF-616, and IF-654 to further enhance implementation of the GPs in these facilities.

The INL Site performed assessments on over 90 percent of the buildings eligible for GP certification, resulting in the DOE HPSB scorecard going from red to green in two of the four measured categories for the DOE Office of Nuclear Energy.

Fleet Operations – The INL Site is developing diversified strategies for increasing alternative fuel consumption and reducing carbon emissions associated with light and heavy-duty vehicles. One of the DOE O 436.1 transportation fuels goals is to increase the use of alternative fuels by 10 percent annually, as compared to the 2005 usage baseline.

In 2011, the INL Site used 236,889 gasoline gallon equivalents of alternative fuels. This represents an increase of 210 percent over the 2005 baseline and a 39 percent increase over 2010. These usages are a compilation of all Site contractors and indicate that the INL Site is exceeding the alternative fuel usage goal and expects to continue this performance through 2015.

The INL Site is exceeding the alternative fuel increase goals through actively pursuing Ethanol (E-85) fuel usage and by using biodiesel blends. These increases are facilitated by increasing the availability of E-85 and mandating its use while researching and implementing the use of biodiesel blends in the INL bus fleet throughout the year and across varied climate conditions.

Additionally, the INL Site is developing diversified strategies for reducing fossil fuel use and carbon emissions associated with light and heavy-duty vehicles. One of the DOE O 436.1 transportation fuel goals is to reduce petroleum fuels by 2 percent annually through 2020 (30 percent total reduction), as compared to the 2005 usage baseline. There are many opportunities to affect the DOE's petroleum fuel usage by implementing fuel reduction and fuel switching activities at INL Site.

In 2011, the INL Site used 862,527 gasoline gallons equivalent, an 8.1 percent reduction from 2005. This usage is a compilation of all INL Site contractors. INL used 623,934 gal of petroleum fuels, a 30 percent decrease over the 2005 baseline and a 23 percent reduction from 2010.

The INL also procures light-duty fleet vehicles almost exclusively through the General Services Administration (GSA) vehicle-leasing program. Maximizing the use of the GSA program

is at the forefront of INL plans to achieve the goal of having 75 percent of light-duty vehicle purchases consisting of alternative fuel vehicles (AFV). A rotation schedule based on vehicle age and mileage determines when the vehicles are returned to GSA. When currently allocated vehicles are due for replacement, the old vehicle is replaced with an AFV or hybrid vehicle from GSA. There are currently very few exceptions for receiving conventional vehicles. Examples include some emergency response vehicles and heavy-duty full size pickups. However, DOE-HQ has directed that hybrid vehicles (which are not AFV vehicles at this time) be procured when available. This greatly impacts the 75 percent AFV target.

The INL Site light-duty fleet is comprised of 396 vehicles of which 71 percent are AFV, 224 are E-85, and 58 are gas/electric hybrids. The INL Site acquired 101 light-duty vehicles in 2011, 47 are flex-fuel (46.5 percent), 46 are hybrid (45.5 percent), and eight are gasoline (8 percent). Of the 101 acquired, 92 percent are either AFVs or hybrid vehicles.

Furthermore, the INL Site met the interim goal of a 15 percent fleet reduction in 2011. In 2011, the INL took the following actions to reduce fleet numbers without losing support capabilities:

- INL modified three heavy-duty dump trucks to carry multiple beds. A heavy-duty truck is typically a single-purpose truck (i.e., a dump truck can only be a dump truck). These trucks now use a J-Hook lift and removable beds to accomplish multiple functions. INL maintains a flat rack bed, water truck bed, dump bed, panel truck bed, garbage container bed, and sander bed that can be used on any of these three trucks.
- INL continued working with GSA on replacing the aging and fuel inefficient bus fleet. The current fleet size is 103 buses. Converting to GSA leasing will reduce the total number of buses by 13, maintaining a core bus fleet of approximately 90 buses. This reduction is possible through greater seating capacity of the new buses, each capable of seating 55 passengers (older coaches seat 44 passengers). A newer fleet will require fewer spare coaches due to mechanical unreliability.
- INL is consolidating equipment and prepositioning a small equipment pool at MFC. There is currently one large equipment pool located at CFA. Historically, when a piece of equipment was needed at another location, a duplicate piece of equipment was often purchased. Consolidating the equipment pool and maintaining a satellite area will allow the overall pool to decrease in size and will result in increased equipment utilization.

Greenhouse Gases – EO 13514 mandates that agencies develop specific greenhouse gas (GHG) reductions targets. DOE has set a reduction target of 28 percent for Scope 1 and 2 GHGs and a 13 percent reduction in Scope 3 GHG emissions. The EO sets 2008 as the baseline year against which reductions are measured.

Scope 1, 2 and 3 are defined as:

- **Scope 1.** Direct or INL Site-owned emissions that are produced onsite, such as stationary combustion (from fuel combustion), mobile combustion (from fleet vehicles), and fugitive

emissions (from refrigerants, onsite landfills, and onsite wastewater treatment). These include emissions that may benefit another entity or contractor, but for which the INL Site controls or owns the associated process.

- **Scope 2.** Indirect or shared emissions produced by INL's electricity, heat, and steam purchases.
- **Scope 3.** Indirect or shared emissions generated by outsourced activities that benefit the INL Site (occur outside the INL Site's organizational boundaries, but are a consequence of the INL Site's activities). This can include a large number of activities, so the INL Site focuses on transmission and distribution losses, employee commuting, employee travel, contracted waste disposal and contracted wastewater treatment since these categories were identified in the Technical Support Document for required reporting. Other activities that could be included in Scope 3 include the embodied emissions of purchased materials.

Many factors influence the INL Site's GHG emissions, including the large land area on which the Laboratory's facilities are located. The area requires long commutes, an extensive fleet to provide transportation for desert Site workers, and contains many antiquated inefficient facilities built before the current appreciation for energy efficiency and high-performance design. These factors tie directly into the following conclusions from the INL Site's baseline GHG inventory:

- Electricity is the largest contributor to the INL Site's GHG inventory, with over 60 percent of the net anthropogenic CO_2 emissions from Scope 1 and Scope 2
- Other sources with high emissions were stationary combustion and fugitive emissions from the onsite landfills
- Among the sources with low emissions within Scope 1 and 2 were fugitive emissions from refrigerants and onsite wastewater treatment.

The INL Site contractors' Environmental Management Systems (EMS) provide the framework and process for evaluating and monitoring Scopes 1, 2, and 3 GHG emissions and related reduction activities. On an annual basis, appropriate sustainability targets are developed and monitored through the EMS to support the overall reduction in GHG emissions.

In 2011, the INL reduced Scope 1 GHG emissions 24.8 percent and Scope 2 GHG emissions by 9.5 percent. The combined Scope 1 and Scope 2 emissions decreased 13.6 percent in 2011 from the 2008 baseline.

As the Environmental Management missions end at various Site locations, overall Scope 3 emissions are expected to decrease. Between 2011 and 2017, employees traveling to and from the Site may be reduced by as many as 2,000 when subcontractors are included. Removing vehicles directly impacts Scope 1 and Scope 3 emissions.

In 2011, the INL reduced Scope 3 GHG emissions 23.3 percent. Transportation fuel was the largest source of GHG emissions for Scope 3. Another source with high emissions was business air travel. Sources with low emissions were contracted waste disposal, contracted wastewater treatment, and business ground travel (rental and personal vehicles).

INL continues to reduce GHGs by transporting employees with a modernized transportation system, taking nearly 2,000 cars per day off the road. By streamlining the INL mass transit system that provides safe, efficient, and sustainable transportation to work for INL employees throughout the eastern Idaho region, INL encourages travel behavior changes to reduce carbon emissions and fossil fuel consumption and increased highway safety. In doing so, INL models future trends in mass transit to local governments across the region. Other actions include instituting a park and ride system, relocating employees to town offices, use of E-85 and biodiesel fuels, and use of modern buses, vans, and light duty vehicles to reduce carbon emissions.

3.4.2 Pollution Prevention

The Pollution Prevention Program incorporates national and DOE requirements to reduce, reuse, and recycle wastes and pollutants by implementing cost-effective techniques, practices, and programs. Such actions are required by various federal statutes, including, but not limited to the Pollution Prevention Act and RCRA. In 2007, EO 13423, “Strengthening Federal Environmental, Energy, and Transportation Management,” was passed. It consolidates and strengthens five EOs and two memoranda of understanding, and establishes new and updated goals, practices and reporting requirements for environmental, energy, and transportation performance and accountability. It also requires more widespread use of EMSs to manage and improve sustainability practices. In 2009, EO 13514, “Federal Leadership in Environmental, Energy, and Economic Performance,” was passed. This EO does not rescind or eliminate the requirements of EO 13423. Instead, it expands on the energy reduction and environmental performance requirements for federal agencies identified in EO13423.

The Pollution Prevention Program is managed by the INL Site contractors under their EMSs. Its scope incorporates waste prevention and elimination, reduction of environmental releases, environmentally preferable purchasing, environmental stewardship in program planning and operational design, and recycling of solid wastes. The program is designed to minimize the environmental impact of the INL Site while enhancing support for the mission. In some instances, the INL Site Pollution Prevention Program has become a nationally recognized leader of environmental stewardship (e.g., electronics stewardship). The INL Site Pollution Prevention Program is also recognized locally and regionally for its leadership in voluntary environmental partnership and community partnership programs. Most opportunities for improvement exist in the area of tracking, monitoring, and documenting the waste prevention and minimization efforts as normal project planning, execution, and evaluation components. The following paragraphs discuss specific projects that addressed these goals during 2011.

The INL Site Pollution Prevention Plan (DOE/ID-10333) describes the pollution prevention practices pursued at the INL Site.

The INL Site continues to utilize a number of processes to reduce the quantity and toxicity of hazardous chemicals. The processes follow the simple reduce, reuse, and recycle steps to help achieve the overall goal. The INL Site utilizes chemical coordinators and environmental personnel to help ensure requested materials are actually needed, are not available through an exchange/sharing program, and the smallest/most appropriate quantity is being ordered. INL

also stipulates the use of the Massachusetts Institute of Technology Green Chemical alternatives list at http://web.mit.edu/environment/academic/alternatives.html to help chemical coordinators identify “greener” alternatives to requested chemicals. INL currently shares chemicals at IRC and town facilities (and at the Site when possible); all chemicals are targeted as an overall reduction. Chemical coordinators actively search for existing inventory to preclude new purchases. In 2011, approximately 16 chemical transfers occurred for usage by another organization or contractor. INL is participating with other national laboratories to establish a chemical reduction guidance that will outline more specific steps and reduction goals for INL. The next steps are to keep working towards minimizing what is procured and increasing sharing of existing inventories because there is limited money for disposal. INL is actively and continually working towards improvement in reduction of inventories through acquisition, use, and disposal.

The AMWTP Hazardous Waste Management Act/Resource Conservation and Recovery Act Permit requires that AMWTP conduct and complete a source reduction evaluation review and written plan, in accordance with the procedures and format provided in the “EPA Waste Minimization Opportunity Assessment Manual” (EPA/625/7-88/003). This review and plan was submitted to the state of Idaho Department of Environmental Quality, March 31, 2011, and includes detailed descriptions of any programs AMWTP may have to assist generators of hazardous and mixed waste in reducing volume (quantity) and toxicity of wastes produced.

AMWTP reduces and minimizes the quantity and toxicity of hazardous chemicals and materials through a procurement process that stresses environmentally preferable purchases. One of the objectives stated in the AMWTP management procedure for the acquisition of material and services is to use recycled-content and bio-based content materials and other environmentally preferable products and services to the maximum practicable extent. Purchase requisitions are screened by an assigned procurement specialist for environmentally preferable materials.

The INL Site diverted 15.3 percent of its non-hazardous solid waste in 2011. INL diverted 25.2 percent of municipal solid waste from the landfill during the same period. ICP diverted 3.5 percent of municipal solid waste from the landfill in 2011.

INL implemented two pilot projects in 2011 to help identify additional waste streams for diversion assessment: cafeteria waste/composting and battery recycling. Both pilot programs were initiated and carried out for several months each; however, neither appears to be economically viable. Further evaluation will be needed depending on funding.

In 2011, INL held a campaign to reduce the use of paper by setting all copiers and printers to default duplex printing. An average of 12 reams of paper per person has been used annually since 2007. A survey was conducted midway through the campaign, which determined that approximately 21 percent of copiers and printers are capable of duplexing were set to default duplex. The campaign encouraged users to save paper by setting their printers to duplex default and instructed them how to do it.

The INL has incremental goals for construction and demolition waste, increasing 10 percent every year from 2011 through 2015. INL exceeded the 2011 goal of 10 percent diversion by diverting 12 percent of its construction and demolition waste.

The majority of AMWTP and ICP construction and demolition waste is prohibited from offsite reuse due to the DOE moratorium. Construction waste and landfill acceptance data is analyzed quarterly to track performance against the goals. INL diverted 39.4 percent of construction and demolition waste during 2011. This includes construction and demolition soil reused as landfill cover and asphalt regeneration. The tracking system for waste material sent to the landfill was enhanced to better categorize conditional waste into the following subcategories: concrete, metal, soils, and furniture. This will allow INL to analyze this waste stream and determine if segregation is viable.

INL intends to perform the following action to enhance the construction and demolition waste diversion process:

- Incorporate metals recycling into one pilot D&D task when allowed under the current recycling moratorium
- Analyze the conditional waste stream to better develop segregation and reuse strategies
- Develop a process to accurately measure the wood waste diverted to the wood chipper
- Engage construction subcontractors to solicit best practice ideas relative to the INL logistics and market potential.

ICP will evaluate D&D and other waste streams for recycle and reuse dependent upon reasonableness of costs compared to onsite disposal as well as the metals moratorium and potential for radioactive or chemical contamination.

Federal Electronics Challenge – The Federal Electronics Challenge is a program that encourages federal facilities and agencies to purchase greener electronic products, reduce impacts of electronic products during use, and manage obsolete electronics in an environmentally responsible way. The INL Site Pollution Prevention Program is one of the leaders in the DOE complex in its electronics stewardship program. In 2011, the INL Site received the 2011 Federal Electronics Challenge Bronze Award for reducing the environmental impacts of electronic equipment. The INL Site has received Silver and Bronze Awards in previous years.

Earth Day – DOE-ID, the INL Site contractors, and the ESER contractor participated in the organizing committee for the 2011 Idaho Falls Earth Day celebration, joining forces with the city of Idaho Falls, state agencies, and private business to celebrate a community-based Earth Day on the last Saturday of April. Idaho Falls Earth Day features displays of green products, extensive recycling opportunities, live music, and education and outreach opportunities for adults and children. Children are encouraged to participate in essay writing, poster designing, and creating sculptures from trash. The event draws approximately 6,000 people.

Recycling – As part of the previous year's ISO 14001 objective and target for recycling, the INL Site continued to minimize waste by recycling or reusing an estimated 45 percent of sanitary waste from all operations by weight; this includes waste from routine operations and cleanup-stabilization operations. Table 3-8 presents a summary of materials reused and recycled during 2011.

Table 3-8. Reused and Recycled Materials (2011).

Material Reused or Recycled	Weight kg (lb)	
Antifreeze	6,028.24	(13,290.0)
Co-Mingled Waste	98,353.9	(216,831.0)
Excess computers and equipment to schools	20,681.3	(45,594.0)
Excess materials to other DOE sites, INL orgs, state, etc.	4,702.8	(10,367.7)
Excess materials to public	9,397.53	(20,718.0)
Batteries	33,893.33	(74,722.0)
Lead scrap	0.86	(1.9)
Mercury	23.18	(51.1)
Paper and cardboard at INL Site	51,791.7	(114,180.0)
Paper and cardboard in Idaho Falls	191,197.80	(421,519.0)
RCRA[a] scrap	12,630.73	(27,846.0)
Silver scrap	0	(0)
Toner cartridges	5,390.49	(11,884.0)
Universal waste lamps	2,578.58	(5,684.8)
Used oil	41,949.58	(92,483.0)
Wood chips	14,437.1	(31,828.0)
Total	**493,128.62**	**(1,087,162.5)**

a. RCRA = Recsource Conservation and Recovery Act

INL's recycling initiative, which includes commingled recycling and paper shredding, continued to expand through the fourth quarter of 2011. The commingled recycling has allowed employees to recycle plastics, metals and assorted paper products in addition to office paper and corrugated cardboard without having to separate them. All office paper from town and site buildings (excluding SMC) can be shredded by a commercial shredding service and recycled.

The first phase of INL's recycling initiative was successfully rolled out to INL's Idaho Falls buildings during FY-2009, followed by SMC in December of 2009. In 2010, the second phase of the initiative was expanded to the remaining Site facilities—ATR Complex, CFA, and MFC. Commingled recycling and paper shredding reduced landfill trash by 30 percent which corresponds to a 38 percent decrease in the funds that would have been allocated to pay for trash collection.

In 2011, INL facilities recycled 216,831 lbs (98,353 kg) of co-mingled materials and 441,760 lbs (200,379 kg) of office paper and cardboard. With the participation of the Site facilities, the recycled numbers increased approximately 84 percent for co-mingled materials and 50 percent for paper. This accounts for approximately 24 percent diversion of municipal solid wastes collected at INL facilities.

In summary, the INL Site Pollution Prevention Program continued to successfully meet the goals of the INL Site Pollution Prevention Plan. The INL Site achieved these goals to protect the environment and enhance mission accomplishment while minimizing life-cycle cost and liability of DOE programs. As required, the INL Site provided certifications to the state of Idaho that it has a pollution prevention and waste minimization program in place to "reduce the volume and toxicity of hazardous waste generated…which minimizes the present and future threat to human health and the environment."

3.5 Other Major Environmental Programs and Activities

3.5.1 Decontamination and Decommissioning Activities

The ICP continued decontamination and decommissioning (D&D) surplus DOE Environmental Management-owned buildings and structures at the INL Site. In 2011, 17 buildings and structures were demolished for a footprint reduction of 313,828 ft^2 (29,156 m^2). This included a reactor building, a hot cell facility, a spent fuel reprocessing facility, a large laboratory building, and numerous warehouses and storage buildings. This effort significantly reduced life-cycle cost and risk by eliminating aging facilities that were no longer necessary for the INL Site mission. Descriptions of specific projects at various facilities follow.

Advanced Test Reactor Complex (ATR Complex) – In 2011, D&D work at the ATR Complex was completed. This included the final demolition of the TRA-603 MTR Reactor Building and the TRA-632 Hot Cells. A total of six facilities were demolished for a footprint reduction of 65,317 ft^2 (6,068 m^2).

Idaho Nuclear Technology and Engineering Center (INTEC) – In 2011, D&D crews completed their work at INTEC by demolishing seven facilities for a footprint reduction of 193,923

ft^2 (18,016 m^2). Most significantly, this included the CPP-601 Fuel Reprocessing Complex and the CPP-602 Laboratory Building.

Radioactive Waste Management Complex (RWMC) – In 2011, D&D crews demolished two facilities at RWMC, the WMF-736 Cold Test Pit, and the WMF-711 Air Support Building-II Foundation for a footprint reduction of 27,500 ft^2 (2,555 m^2).

Materials and Fuels Complex (MFC) – In 2011, two facilities at MFC were demolished. The MFC-750A Experimental Breeder Reactor - No. 2 (EBR-II), and the MFC-793A Alcohol Recovery Tank were demolished for a footprint reduction of 3405 ft^2 (316 m^2). Progress was made on the deactivation of MFC-766 Sodium Boiler Building and the MFC-767 EBR-II Reactor Building.

3.5.2 Spent Nuclear Fuel

Spent nuclear fuel (SNF) is fuel that has been irradiated in a nuclear reactor. SNF contains some unused enriched uranium and radioactive fission products. Because of its radioactivity (primarily from gamma rays), it must be properly shielded. DOE's SNF is from development of nuclear energy technology (including foreign and domestic research reactors), national defense, and other programmatic missions. Several DOE offices manage SNF. Fuel is managed by the ICP contractor at INTEC, the Naval Nuclear Propulsion Program at the Naval Reactors Facility, and the INL contractor at the ATR Complex and MFC. SNF, ranging in size from 0.9 kg (2 lb) to 0.45 metric tons (0.5 tons), are managed at the INL Site.

Between 1952 and 1992, SNF was reprocessed at the Idaho Chemical Processing Plant (now called INTEC) to recover fissile material for reuse. However, the need for fuel-grade uranium and plutonium decreased. A 1992 decision to stop reprocessing left a large quantity of SNF in storage pending the licensing and operation of an SNF and high-level waste repository or interim storage facility. Licensing of a repository at Yucca Mountain is being reconsidered, but the Idaho Settlement Agreement requires all INL Site fuel be removed from the state of Idaho by 2035. The Blue Ribbon Commission on America's Nuclear Future is charged with reviewing spent nuclear fuel management policies. The commission issued a draft of the report in June 2011, and should submit the final to the Secretary of Energy by January 29, 2012.

In 2011, INL Site SNF was stored in both wet and dry conditions. Dry storage is preferred because it reduces concerns about corrosion and is less expensive to monitor. An effort is underway to put all INL Site legacy SNF in dry storage. The Nuclear Materials Disposition team completed all 3,186 fuel handling units of ICP-assigned SNF to dry storage. Descriptions of SNF storage facilities follow.

Fluorinel Dissolution Process and Fuel Storage Facility (CPP-666) – This INTEC facility, also called FAST, is divided into two parts, an SNF storage basin area and the Fluorinel Dissolution Facility, which operated from 1983 to 1992 and is currently being used in remote-handled TRU waste management. The storage area consists of six storage basins currently storing SNF under about 11 million L (3 MG) of water, which provides protective shielding and cooling. All ICP-managed SNF has been removed from the basins and stored in the INTEC dry storage facilities described below. SNF from the ATR, EBR-II reactor and Naval Nuclear

Propulsion Program is stored in the basins. Navy SNF is being transferred to the Naval Reactors Facility for dry storage. In 2011, ICP transferred the first two of 227 shipments of EBR-II SNF to the MFC for processing. Eventually, all SNF will be removed from this underwater storage pool and placed in dry storage in preparation for shipment out of Idaho.

Irradiated Fuel Storage Facility (CPP-603) – This INTEC facility, also called the IFSF, is the dry side of the Wet and Dry Fuel Storage Facility. It has 636 storage positions and has provided dry storage for SNF since 1973. In 2008, D&D of the old fuel storage basin (the wet side) was completed. The Irradiated Fuel Storage Facility received two shipments of spent nuclear fuel from domestic sources, (one on Site and one from Reed College) in 2011 and will continue to receive SNF from foreign and domestic research reactors in 2012.

Cask Pad (CPP-2707) and Rail Casks – This INTEC facility provides safe dry storage of SNF in transport casks staged on an asphalt pad and on a rail siding.

TMI-2 Independent Spent Fuel Storage Installation (CPP-1774) – This INTEC facility, also called the Independent Spent Fuel Storage Installation (ISFSI), is a U.S. Nuclear Regulatory Commission-licensed dry storage area for SNF and debris from the Three Mile Island reactor accident. Fuel and debris were transferred to TAN for examination, study, and storage following the accident. After the examination, the SNF and debris were transferred to the ISFSI. The ISFSI provides safe, environmentally secure, aboveground storage for the SNF and debris, which are kept in metal casks inside concrete vaults.

Peach Bottom Fuel Storage Facility (CPP-749) – This INTEC facility consists of 193 below ground-vaults of various sizes for dry storage of SNF. The vaults generally are constructed of carbon steel tubes, with some of them containing concrete plugs. All of the tubes are completely below grade and are accessed from the top using specially designed equipment.

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

Advanced Test Reactor (TRA-670) – The ATR is located at the ATR Complex. The ATR is a research reactor that performs materials testing for domestic and foreign customers. During routine maintenance outages, spent fuel elements are removed and placed in underwater racks in the ATR canal, also located in Building TRA-670. Fuel elements are allowed to cool before being transferred to the Fluorinel Dissolution Process and Fuel Storage Facility, as described previously. The ATR canal is designated as a working facility rather than a storage facility. The ultimate disposition of ATR or spent fuel may be either recycle or disposition in the repository.

Radioactive Scrap and Waste Facility (MFC-771) – The Radioactive Scrap and Waste Facility has operated since 1964 for the dry storage of SNF and solid radioactive wastes resulting from nuclear energy research and development. This facility is located at MFC. It is a fenced outdoor

compound with over 1,000 steel pipe storage vaults set into the ground. The storage vaults are typically 0.6 m (24 in.) in diameter and just over 3.7 m (12 ft) long. The pipe storage vaults have concrete or steel shield plugs inserted into their tops to protect workers from radiation fields and to prevent water intrusion. The storage vaults also are cathodically protected from corrosion. Currently, 19.6 metric tons (43,120 lb) of SNF, mostly from the deactivated EBR-II, is stored in the steel pipe storage vaults.

Since 1996, 3.84 metric tons (8,360 lb) of the original EBR-II inventory has been removed from the Radioactive Scrap and Waste Facility and processed using a dry electrometallurgical process. This process operates at the MFC Fuel Conditioning Facility and results in extracted, fairly pure, low-enriched, uranium metal and also a ceramic and a stainless steel, solid, high-level waste. The extracted low-enriched uranium metal is stored at the Transient Reactor Test Facility Warehouse at MFC. DOE is seeking to provide this extracted uranium to the commercial nuclear fuel fabrication industry for reuse. The two high-level waste forms are expected to be disposed of at a national geologic repository. The Radioactive Scrap and Waste Facility also stores mixed waste (primarily steel reactor components waste contaminated with sodium metal) and is managed under a RCRA hazardous waste storage permit.

3.5.3 Environmental Oversight and Monitoring Agreement

The 2010 Environmental Oversight and Monitoring Agreement (DOE-ID 2010b) between DOE-ID; DOE Naval Reactors, Idaho Branch Office; and the state of Idaho maintains the state's program of independent oversight and monitoring established under the first agreement in 1990 that created the state of Idaho INL Oversight Program. The main objectives of the current five-year agreement are to:

- Assess the potential impacts of present and future DOE activities in Idaho
- Assure citizens that all present and future DOE activities in Idaho are protective of the health and safety of Idahoans and the environment
- Communicate the findings to citizens in a manner that provides them the opportunity to evaluate these potential impacts.

The INL Oversight Program's main activities include environmental surveillance; emergency coordination, planning, preparedness and response; impact analyses and public information; and education. More information can be found on the INL Oversight Program website at http://www.deq.idaho.gov/.

3.5.4 Citizens Advisory Board

The INL Site Environmental Management Citizens Advisory Board is a federally appointed citizen panel formed in 1994 that provides advice and recommendations on ICP activities to DOE-ID. The Citizens Advisory Board consists of 15 members who represent a wide variety of key perspectives on issues of relevance to Idaho citizens. They come from a wide variety of backgrounds, including environmentalists, natural resource users, INL Site workers, and representatives of local government, health care, higher education, business, and the general

public. One member represents the Shoshone-Bannock Tribes. Members are appointed by DOE and serve voluntarily without compensation. Three additional liaisons (nonvoting) include representatives from DOE-ID, Environmental Protection Agency Region 10, and the Idaho Department of Environmental Quality. The liaisons provide information to the Citizens Advisory Board on their respective agencies' policies and views.

The Citizens Advisory Board is chartered by DOE through the Federal Advisory Committee Act. The Citizens Advisory Board's charter is to provide input and recommendations to DOE on topics such as cleanup standards and environmental restoration, waste management and disposition, stabilization and disposition of nonstockpile nuclear materials, excess facilities, future land use and long-term stewardship, risk assessment and management, and cleanup science and technology activities. The Citizens Advisory Board has provided over 148 recommendations during its tenure. More information about the Board's recommendations, membership and meeting dates and topics can be found at http://www.inlemcab.org/.

Earth Day 2011.

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Chapter 4. Environmental Monitoring Programs (Air)

Chapter 4 Highlights

An estimated total of 3,520 curies of radioactivity, primarily in the form of short-lived noble gas isotopes, were released as airborne effluents from Idaho National Laboratory (INL) Site facilities in 2011. The highest contributors to the total release were the Idaho Nuclear Technology and Engineering Center at 47 percent, the Advanced Test Reactor Complex at 43 percent, and the Radioactive Waste Management Complex at 10 percent of total. The INL Site environmental surveillance programs emphasize measurements of airborne contaminants because air is the most important transport pathway from the INL Site to receptors living outside the INL Site boundary. Because of this, samples of airborne particulates, atmospheric moisture, and precipitation were collected on the INL Site, at INL Site boundary locations, and at distant communities and were analyzed for radioactivity in 2011.

Approximately 2,030 charcoal cartridges, collected weekly using a network of low-volume air samplers maintained by the INL contractor and the Environmental Surveillance, Education, and Research contractor, were analyzed for radioiodine during 2011. Iodine-131 from the Fukushima Daiichi Nuclear Power Plant complex reactor accident in Japan was detected in many samples collected in the second half of March and April.

Particulates were filtered from air using the same network of low-volume air samplers, and the filters were analyzed for gross alpha activity, gross beta activity, and specific radionuclides, primarily strontium-90, cesium-137 (^{137}Cs), plutonium-239/240, and americium-241. (The INL contractor only analyzes samples for gamma-emitting radionuclides.) Gross alpha and gross beta activities were used primarily for trend analyses and indicated that there were no statistically significant differences between onsite, boundary, and distant locations. Seasonal variations were also observable in the concentrations.

The period when eastern Idaho received fallout from the Fukushima accident was during the second half of March and during April and therefore included parts of the first and second quarters. The INL Site contractors measured cesium-134 (^{134}Cs) and ^{137}Cs presumably from Fukushima fallout on many first and second quarter composites. Elevated weekly gross beta activity levels during the period from March 16 to March 30 most likely corresponded with releases from the Fukushima accident. Measurements in 2011 do not indicate any relation between radionuclides released from the INL Site and environmental concentrations measured off the INL Site.

Airborne particulates were also collected biweekly around the perimeters of the Subsurface Disposal Area of the Radioactive Waste Management Complex and the Idaho Comprehensive Environmental Response, Compensation, and Liability Act Disposal Facility at the Idaho Nuclear Technology and Engineering Center. Gross alpha and gross beta activities measured on the filters were comparable with historical results and no new trends were identified in 2011. Cesium-137 was the only gamma-emitting radionuclide detected at any waste management facility in 2011. The detections were made during the first quarter when fallout from the Fukushima accident was measured in other INL Site samples. Plutonium-239/240 detections were comparable to past measurements and are likely due to resuspended soils contaminated from past burial practices at the Subsurface Disposal Area.

Atmospheric moisture and precipitation samples were obtained at the INL Site and off the INL Site and analyzed for tritium. Tritium detected in some samples was most likely present due to natural production in the atmosphere and not INL Site releases. Gamma analysis of precipitation samples collected on March 22 and March 28 showed the presence of radioiodine and ^{137}Cs from the Fukushima accident.

All measured results were below health-based regulatory limits.

4. ENVIRONMENTAL MONITORING PROGRAMS (AIR)

Idaho National Laboratory (INL) Site facilities have the potential to release radioactive and nonradioactive constituents. Pathway vectors, such as air, soil, plants, animals, and groundwater, may transport these constituents to nearby populations (Figure 3-1). Air is the most important radionuclide transport pathway to members of the general public (EG&G 1993). The INL Site air monitoring programs emphasize measurement of airborne radioactive contaminants because air has the potential to transport large amounts of radioactive materials to receptors in a relatively short period and can directly expose human receptors located off the INL Site.

This chapter presents results of radiological analyses of airborne effluents and ambient air samples collected on and off the INL Site. The results include those from the INL contractor, the Idaho Cleanup Project (ICP) contractor, and the Environmental Surveillance, Education, and Research Program (ESER) contractor. Table 4-1 summarizes the air monitoring activities on and off the INL Site. Details may be found in the *Idaho National Laboratory Environmental Monitoring Plan* (DOE-ID 2010).

4.1 Organization of Air Monitoring Programs

The INL contractor monitors airborne effluents at individual INL facilities to comply with the Clean Air Act National Emission Standards for Hazardous Air Pollutants (NESHAPs). Section 4.2 summarizes the results of radiological airborne effluent monitoring.

Table 4-1. Air Monitoring Activities by Organization.

Area/Facility[a]	Airborne Effluent Monitoring Programs	Environmental Surveillance Programs					
	Airborne Effluents[b]	Low-Volume Charcoal Cartridges (iodine-131)	Low-volume Gross Alpha	Low-volume Gross Beta	Specific Radionuclides[c]	Atmospheric Moisture	Precipitation
ICP Contractor: CH2M-WG Idaho, LLC (CWI)[d]							
INTEC	•		•	•	•		
RWMC	•		•	•	•		
INL Contractor: Battelle Energy Alliance (BEA)[e]							
MFC	•						
INL/Regional		•	•	•	•	•	
Environmental Surveillance, Education, and Research Program[f]							
INL/Regional		•	•	•	•	•	•

a. INTEC = Idaho Nuclear Technology and Engineering Center, RWMC = Radioactive Waste Management Complex, MFC = Materials and Fuels Complex, INL = INL Site facilities as shown in Table 4-2, Regional = locations outside of the INL Site as shown in Table 4-3.

b. Facilities that required monitoring during 2011 for compliance with 40 CFR 61, Subpart H, "National Emissions Standards for Hazardous Air Pollutants."

c. Gamma-emitting radionuclides are measured by the ICP contractor monthly, by the ESER contractor quarterly, and by the INL contractor quarterly. Strontium-90, plutonium-238, plutonium-239/240, and americium-241 are measured by the ICP and ESER contractors quarterly and by the INL contractor when anomalous gross alpha or beta results exceed threshold levels.

d. The ICP contractor monitors waste management facilities.

e. The INL contractor monitors airborne effluents at MFC and ambient air outside INL Site facilities.

f. The ESER contractor collects samples on, around, and distant from the INL Site.

Ambient air monitoring is conducted by the INL contractor, the ESER contractor, and the ICP contractor to ensure that the INL Site remains in compliance with the U.S. Department of Energy (DOE) Order 458.1, "Radiation Protection of the Public and the Environment." The INL contractor collected about 2,210 air samples (primarily on the INL Site) for radiological analyses in 2011. The INL contractor also collects air moisture samples at four sites to determine tritium concentrations. Results of ambient air monitoring by the INL contractor and ICP contractor are summarized in Section 4.3.

The ESER contractor collects air samples from an area covering approximately 23,309 km^2 (9,000 mi^2) of southeastern Idaho, Jackson, Wyoming, as well as at locations on, around, and distant from the INL Site. The ESER contractor collected approximately 2,000 air samples, primarily off the INL Site, for radiological analyses in 2011. The ESER contractor also collects air moisture and precipitation samples at selected locations for tritium analysis. Results of ambient air monitoring by the ESER contractor are discussed in Section 4.3.

The ICP contractor monitors waste management activities on the Subsurface Disposal Area (SDA) at the Radioactive Waste Management Complex (RWMC) and at the Idaho Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Disposal Facility (ICDF). Section 4.4 discusses air sampling by the ICP contractor in support of waste management activities.

The INL Oversight Program, conducted by the State of Idaho Department of Environmental Quality, collects air samples from a series of air monitoring stations, many of which are collocated with the INL and ESER contractors' monitoring stations. The INL Oversight Program reports their data independently at http://www.deq.state.id.us/inl_oversight.

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

4.2 Radiological Airborne Effluent Monitoring

Radiological effluent monitoring results are used to estimate doses to members of the public from INL Site airborne releases. Because of this, they are a major component of determining compliance with regulatory dose standards. Each regulated INL Site facility determines its airborne effluent concentrations as required under state and federal regulations. Criteria air pollutants and hazardous air pollutant effluent data for the INL Site are contained in the National Emission Inventory database and can be obtained from the Environmental Protection Agency Clearinghouse for Inventories and Emission Factors website (http://www.epa.gov/ttn/chief/index.html). Information on radiological effluents is contained in *National Emission Standards for Hazardous Air Pollutants—Calendar Year 2011 INL Report for Radionuclides*, referred to hereafter as the NESHAPs Report (DOE-ID 2012).

The NESHAPs Report describes three categories of airborne emissions:

- The first category includes sources that require continuous monitoring under the NESHAPs regulation
- The second category consists of releases from other point sources
- The final category is comprised of nonpoint, or diffuse, sources, which include radioactive waste ponds and contaminated soil areas and decontamination and decommissioning of facilities by ICP.

INL Site emissions include all three of these categories, as represented in Table 4-2. During 2011, an estimated 3,520 Ci of radioactivity were released to the atmosphere from all INL Site sources, which were within the range of releases from previous years, and continued the downward trend observed over the last ten years.

Approximately 75 percent of the radioactive effluent were the noble gases argon, krypton, and xenon. A noble gas is inert, which means that it exists in a gaseous state and does not enter into chemical combination with other elements. Most of the remaining effluent was tritium (Table 4-2 and Figure 4-1). The following facilities were contributors to the total emissions:

- **Idaho Nuclear Technology and Engineering Center (INTEC) Emissions Sources (47 percent of total)** – Radiological air emissions from INTEC sources are primarily associated with spent nuclear fuel management (e.g., fuel shipments, handling, and wet and dry storage) and liquid waste operations (e.g., Tank Farm Facility, Evaporator Tank System, Process Equipment Waste Evaporator, and Liquid Effluent Treatment and Disposal). These radioactive emissions include particulates and gaseous radionuclides (e.g., noble gases and iodines). Additional radioactive emissions are associated with decontamination and debris treatment activities, sample analysis, site remediation, remote-handled transuranic waste management, radiological and hazardous waste storage facilities, equipment maintenance, and miscellaneous emissions from radioactively contaminated buildings. Most of the INTEC emissions contained krypton-85 (^{85}Kr). Krypton-85 is a radionuclide commonly associated with the nuclear fuel cycle and has a 10-yr half-life. The dose potentially received from ^{85}Kr is primarily external exposure from immersion in a contaminated plume.
- **Advanced Test Reactor Complex (ATR Complex) Emissions Sources (43 percent of total)** – Radiological air emissions from ATR Complex are primarily associated with operation of ATR. These emissions include noble gases, iodines, and other mixed fission and activation products, but are primarily relatively short-lived noble gases. Other radiological air emissions are associated with hot cell operations, sample analysis, site remediation, research and development activities, and decontamination and demolition activities. Another emission source is the INL Radioanalytical Chemistry Laboratory, which began operation in the first quarter of 2011. Activities at the lab include wet chemical analysis to determine trace radionuclides, higher level radionuclides, inorganic, and general purpose analytical chemistry. High-Efficiency Particulate Air filtered hoods are located in the laboratory including the radiological control room used for analysis of contaminated samples.
- **Radioactive Waste Management Complex (RWMC) Emissions Sources (10 percent of total)** – Emissions from RWMC result from various activities conducted in the SDA to

Table 4-2. Radionuclide Composition of Idaho National Laboratory Site Airborne Effluents (2011)[a].

		Airborne Effluent (Ci)						
Radionuclide	Half life[b]	ATR Complex[c]	CFA[c]	INTEC[c]	MFC[c]	RWMC[c]	TAN[c]	Total
Ac-227	21.8 y	—[d]	—	—	—	3.78E-15	—	3.78E-15
Ag-108m	130 y	2.66E-09	—	—	—	—	—	2.66E-09
Ag-110	24.6 s	—	—	—	1.60E-15	—	—	1.60E-15
Ag-110m	249.9 d	6.05E-06	—	2.18E-06	1.60E-15	—	—	8.23E-06
Am-241	432.2 y	1.01E-04	1.14E-09	6.95E-06	8.62E-08	4.14E-03	—	4.24E-03
Am-242	16 h	—	—	—	—	2.54E-14	—	2.54E-14
Am-243	7380 y	1.39E-07	4.65E-09	3.24E-13	3.40E-07	6.16E-14	—	4.83E-07
Ar-39	269 y	1.48E-19	—	—	—	—	1.48E-06	1.48E-06
Ar-41	1.827 h	1.13E+03	—	—	—	—	2.11E-06	1.13E+03
Ba-133	10.5 y	1.64E-11	7.45E-12	—	6.03E-10	—	—	6.27E-10
Ba-137m	2.552 m	—	—	—	—	6.38E-04	—	6.38E-04
Ba-139	82.7 m	9.96E-03	—	—	—	—	—	9.96E-03
Ba-140	12.74 d	1.23E-06	—	—	—	—	—	1.23E-06
Ba-141	18.3 m	1.73E-08	—	—	—	—	—	1.73E-08
Be-7	53.3 d	—	—	—	—	7.33E-09	—	7.33E-09
Be-10	1.36E+06 y	2.08E-17	—	—	—	—	—	2.08E-17
Bi-207	33 y	—	7.50E-12	—	—	1.63E-18	—	7.50E-12
Bi-210	120 h	7.68E-22	—	—	—	—	—	7.68E-22
Bi-210m	3E+6 y	5.73E-28	—	—	—	—	—	5.73E-28
Bi-212	60.6 m	—	—	4.34E-10	—	7.55E-06	—	7.55E-06
Bi-214	19.7 m	—	—	—	—	8.50E-18	—	8.50E-18
Br-80	17.68 m	—	—	—	—	—	2.50E-01	2.50E-01
Br-80m	4.4205 h	—	—	—	—	—	2.34E-01	2.34E-01
Br-82	35.282 h	—	—	—	—	—	4.73E-01	4.73E-01
Br-83	2.40 h	1.56E-05	—	—	—	—	1.94E-08	1.56E-05
C-14	5730 y	7.70E-06	3.84E-05	8.83E-06	2.26E-10	1.37E-01	—	1.37E-01
Ca-45	162.61 d	3.27E-14	—	—	—	—	—	3.27E-14
Cd-109	462.6 d	2.08E-12	2.14E-13	—	1.62E-11	—	—	1.85E-11
Ce-139	137.64 d	7.80E-14	1.50E-10	—	—	—	—	1.50E-10
Ce-141	32.5 d	5.87E-06	—	—	—	—	—	5.87E-06
Ce-144	284.3 d	2.44E-04	—	—	8.74E-12	7.69E-06	—	2.52E-04

Table 4-2. Radionuclide Composition of Idaho National Laboratory Site Airborne Effluents (2011) (continued) [a].

		Airborne Effluent (Ci)						
Radionuclide	Half life[b]	ATR Complex[c]	CFA[c]	INTEC[c]	MFC[c]	RWMC[c]	TAN[c]	Total
Cl-36	3.01E+5 y	1.06E-17	—	3.53E-05	—	—	2.26E-10	3.53E-05
Cl-38	37.23 m	—	—	—	—	—	2.89E-12	2.89E-12
Cm-242	162.8 d	1.20E-07	—	1.05E-12	—	2.54E-14	—	1.20E-07
Cm-243	28.5 y	1.30E-14	1.13E-14	—	—	1.05E-12	—	1.07E-12
Cm-244	18.11 y	1.79E-06	1.46E-08	8.97E-12	5.45E-12	1.53E-04	—	1.55E-04
Cm-248	3.48E+05 y	—	—	1.99E-22	5.23E-10	—	—	5.23E-10
Co-57	270.9 d	1.55E-11	6.96E-11	—	1.62E-11	—	—	1.01E-10
Co-58	70.8 d	5.63E-05	—	—	6.41E-11	—	—	5.63E-05
Co-60	5.271 y	6.10E-02	1.36E-10	6.14E-02	2.41E-11	2.84E-05	—	1.22E-01
Co-60m	10.5 m	1.03E-19	—	—	—	—	—	1.03E-19
Cr-51	27.704 d	8.06E-03	—	—	4.71E-11	—	—	8.06E-03
Cs-134	2.062 y	5.15E-05	6.96E-11	2.84E-07	3.00E-07	3.15E-05	—	8.36E-05
Cs-135	2.3E+6 y	—	—	—	1.41E-11	—	—	1.41E-11
Cs-137	30.0 y	2.24E-02	6.92E-11	2.41E-02	2.10E-02	6.41E-04	—	6.78E-02
Cs-138	32.2 m	2.01E-01	—	—	—	—	—	2.01E-01
Eu-150b	36.78 y	—	—	—	—	1.70E-17	—	1.70E-17
Eu-152	13.33 y	1.29E-03	2.40E-14	6.55E-04	—	6.14E-15	—	1.94E-03
Eu-154	8.8 y	1.33E-03	3.13E-11	4.97E-04	6.00E-09	1.51E-13	—	1.83E-03
Eu-155	4.96 y	3.24E-04	—	1.62E-05	—	9.92E-12	—	3.40E-04
Eu-156	15.185 d	5.22E-11	—	—	—	—	—	5.22E-11
Fe-55	2.7 y	2.69E-05	6.98E-11	—	2.62E-10	3.21E-07	—	2.72E-05
Fe-59	44.4529 d	6.15E-06	—	—	1.34E-11	—	—	6.15E-06
Fe-60	1.5E+06 y	1.03E-19	—	—	—	—	—	1.03E-19
Ge-71	11.43 d	3.21E-19	—	—	—	—	—	3.21E-19
H-3	12.35 y	2.77E+02	1.06E+00	2.00E+02	8.58E-02	3.57E+02	1.45E-02	8.35E+02
Hf-175	70 d	7.73E-06	—	—	—	—	—	7.73E-06
Hf-178m	3.94 s	2.35E-20	—	—	—	—	—	2.35E-20
Hf-179m	25.05 d	5.34E-20	—	—	—	—	—	5.34E-20
Hf-181	42.39 d	1.52E-04	—	—	—	—	—	1.52E-04
Hf-182	9E+06 y	2.55E-23	—	—	—	—	—	2.55E-23
Hg-203	46.6 d	3.70E-07	5.48E-08	—	1.62E-11	—	—	4.25E-07
I-125	60.1 d	52.8 m	1.20E-05	—	—	—	—	1.20E-05

Table 4-2. Radionuclide Composition of Idaho National Laboratory Site Airborne Effluents (2011) (c9ntinued)[a].

		Airborne Effluent (Ci)						
Radionuclide	Half life[b]	ATR Complex[c]	CFA[c]	INTEC[c]	MFC[c]	RWMC[c]	TAN[c]	Total
I-128	24.99 m	8.92E-02	—	—	—	—	—	8.92E-02
I-129	1.57 E+07 y	1.61E-07	8.96E-08	3.00E-02	4.16E-11	—	—	3.00E-02
I-131	8.04 d	8.10E-03	—	—	4.20E-07	—	—	8.10E-03
I-132	2.3 h	6.90E-05	—	—	—	—	—	6.90E-05
I-133	20.8 h	9.95E-04	—	—	—	—	—	9.95E-04
I-134	52.8 m	2.97E-04	—	—	—	—	—	2.97E-04
I-135	6.61 h	2.09E-03	—	—	—	—	—	2.09E-03
Ir-192	74.02 d	5.76E-21	—	—	—	—	—	5.76E-21
K-40	1.277E+08 y	5.97E-14	3.13E-15	—	—	9.77E-09	3.80E-09	1.36E-08
K-42	12.4 h	—	—	—	—	—	4.26E-02	4.26E-02
K-43	22.6 h	—	—	—	—	—	1.13E-09	1.13E-09
Kr-79	35.04 h	—	—	—	—	—	9.41E-12	9.41E-12
Kr-83m	1.83 h	—	—	—	—	—	6.53E-08	6.53E-08
Kr-85	10.72 y	—	—	1.45E+03	1.20E-09	1.95E-06	—	1.45E+03
Kr-85m	4.48 h	4.40E+00	—	—	—	—	—	4.40E+00
Kr-87	76.3 m	1.15E+01	—	—	—	—	—	1.15E+01
Kr-88	2.84 m	1.02E+01	—	—	—	—	—	1.02E+01
La-140	40.27 h	2.52E-07	—	—	—	—	—	2.52E-07
La-142	92.5 m	1.80E-12	—	—	—	—	—	1.80E-12
Mn-53	3.7 E+06 y	7.20E-23	—	—	—	—	—	7.20E-23
Mn-54	312.5 d	3.91E-05	6.32E-11	—	5.97E-11	—	—	3.91E-05
Mn-56	2.5785 h	1.71E-11	—	—	—	—	—	1.71E-11
Mo-93	3.5E+03 y	1.01E-09	—	—	—	—	—	1.01E-09
Mo-99	66.0 h	2.11E-05	—	—	—	—	—	2.11E-05
Na-22	2.6 y	—	—	—	9.10E-05	5.84E-17	—	9.10E-05
Na-24	15.0 h	1.19E-03	—	—	—	—	—	1.19E-03
Nb-93m	16.1 y	6.48E-13	—	—	—	—	—	6.48E-13
Nb-94	2.03 E+04 y	4.24E-10	—	—	—	—	—	4.24E-10
Nb-95	35.15 d	4.79E-06	—	—	8.06E-12	—	—	4.79E-06
Ni-59	7.5E+04 y	1.89E-06	3.00E-14	—	—	—	—	1.89E-06
Ni-63	96 y	4.49E-04	9.04E-12	2.79E-02	2.88E-07	1.01E-06	—	2.84E-02
Np-237	2.14E+06 y	1.26E-07	6.51E-10	9.58E-10	6.45E-08	9.74E-14	—	1.93E-07

Table 4-2. Radionuclide Composition of Idaho National Laboratory Site Airborne Effluents (2011) (continued) [a].

		Airborne Effluent (Ci)						
Radionuclide	Half life[b]	ATR Complex[c]	CFA[c]	INTEC[c]	MFC[c]	RWMC[c]	TAN[c]	Total
Np-239	2.355 d	5.75E-06	—	—	—	6.12E-14	—	5.75E-06
Os-185	93.6 d	4.44E-21	—	—	—	—	—	4.44E-21
Os-191	15.4 d	2.74E-06	—	—	—	—	—	2.74E-06
P-32	14.262 d	5.88E-18	—	—	—	—	—	5.88E-18
P-33	25.34 d	3.15E-21	—	—	—	—	1.36E-12	1.36E-12
Pa-233	27.0 d	—	—	2.30E-10	—	—	—	2.30E-10
Pa-234m	1.17 m	—	—	7.74E-11	—	—	—	7.74E-11
Pb-205	1.53E+07 y	1.72E-21	—	—	—	—	—	1.72E-21
Pb-210	22.3 y	1.92E-13	1.69E-16	—	—	2.21E-09	—	2.21E-09
Pb-212	13.6 h	—	—	4.34E-10	—	7.55E-06	—	7.55E-06
Pb-214	26.83 m	—	—	—	—	9.14E-19	—	9.14E-19
Pm-147	2.6234 y	—	—	2.30E-05	—	7.75E-06	—	3.08E-05
Po-210	138.38 d	3.03E-21	—	—	5.00E-27	—	—	3.03E-21
Po-212	0.305 m	—	—	—	—	4.82E-06	—	4.82E-06
Po-216	0.15 s	—	—	—	—	7.55E-06	—	7.55E-06
Pr-144	17.3 m	—	—	—	—	7.72E-06	—	7.72E-06
Pu-236	2.9 y	1.60E-14	4.71E-14	5.85E-13	—	—	—	6.48E-13
Pu-238	87.74 y	5.55E-05	2.25E-12	7.85E-05	4.31E-08	1.12E-03	—	1.25E-03
Pu-239	24065 y	5.55E-05	9.94E-10	3.23E-04	1.97E-06	2.75E-03	—	3.13E-03
Pu-240	6537 y	2.25E-05	7.91E-17	1.62E-04	1.82E-07	5.14E-04	—	6.99E-04
Pu-241	14.4 y	2.94E-04	1.43E-14	6.10E-03	2.33E-06	5.47E-03	—	1.19E-02
Pu-242	3.8E+05 y	1.25E-13	9.43E-11	6.63E-14	9.88E-11	4.80E-08	—	4.82E-08
Ra-224	3.66 d	—	—	4.34E-10	—	7.55E-06	—	7.55E-06
Ra-226	1600 y	3.06E-10	2.89E-14	—	—	5.52E-15	—	3.06E-10
Ra-228	5.74 y	—	2.18E-16	—	—	—	—	2.18E-16
Rb-88	17.8 m	9.69E-02	—	—	—	—	—	9.69E-02
Rb-89	15.2 m	1.21E-01	—	—	—	—	—	1.21E-01
Re-184	38.0 d	3.06E-18	—	—	—	—	—	3.06E-18
Re-184m	165 d	2.35E-18	—	—	—	—	—	2.35E-18
Re-186	3.77 d	8.28E-20	—	—	—	—	—	8.28E-20
Re-186m	2.0E+05 y	8.28E-20	—	—	—	—	—	8.28E-20
Re-187	5E+10 y	3.45E-17	—	—	—	—	—	3.45E-17

Table 4-2. Radionuclide Composition of Idaho National Laboratory Site Airborne Effluents (2011) (continued) [a].

		Airborne Effluent (Ci)						
Radionuclide	Half life[b]	ATR Complex[c]	CFA[c]	INTEC[c]	MFC[c]	RWMC[c]	TAN[c]	Total
Re-188	17.005 h	1.21E-02	—	—	—	—	—	1.21E-02
Rh-106	368.2 d	—	—	—	—	3.16E-15	—	3.16E-15
Ru-103	39.26 d	1.97E-05	—	—	—	—	—	1.97E-05
Ru-106	373.59 d	—	—	—	5.28E-06	3.16E-15	—	5.28E-06
Sb-122	2.7238 d	2.31E-06	—	—	—	—	—	2.31E-06
Sb-124	60.2 d	1.01E-05	—	—	—	—	—	1.01E-05
Sb-125	2.77 y	5.64E-09	—	2.10E-06	1.58E-04	4.68E-07	—	1.61E-04
Sc-46	83.83 d	5.01E-06	—	—	—	—	—	5.01E-06
Se-81	18.45 m	—	—	—	—	—	—	5.42E-14
Se-81m	57.28 m	—	—	—	—	—	3.67E-14	3.67E-14
Si-32	100 y	1.55E-14	—	—	—	—	—	1.55E-14
Sm-151	90 y	—	—	2.40E-04	—	—	—	2.40E-04
Sn-113	115.09 d	8.77E-12	2.18E-16	—	1.62E-11	—	—	2.50E-11
Sr-85	64.84 d	3.00E-10	1.76E-10	—	—	—	—	4.76E-10
Sr-89	50.5 d	2.57E-06	—	—	—	—	—	2.57E-06
Sr-90	29.12 y	3.31E-02	7.57E-10	1.36E-02	1.39E-04	5.73E-04	3.01E-05	4.70E-02
Sr-91	9.5 h	6.85E-10	—	—	—	—	—	6.85E-10
Sr-92	2.7 h	6.71E-10	—	—	—	—	—	6.71E-10
Ta-179	1.8 y	1.34E-14	—	—	—	—	—	1.34E-14
Ta-180m	7.1E+15 y	5.01E-33	—	—	—	—	—	5.01E-33
Ta-182	114.43 d	7.98E-06	—	—	—	—	—	7.98E-06
Ta-183	5.1 d	8.91E-10	—	—	—	—	—	8.91E-10
Tc-99	2.13E+05 y	1.53E-10	8.00E-10	6.43E-07	3.78E-11	—	—	6.44E-07
Tc-99m	6.02 h	5.78E-05	6.00E-10	—	—	—	—	5.78E-05
Te-123m	119.7 d	1.50E-16	—	—	—	—	—	1.50E-16
Te-125m	57.4 d	3.00E-13	—	—	—	—	—	3.00E-13
Th-228	1.9116 y	2.09E-11	—	4.60E-11	—	7.55E-06	—	7.55E-06
Th-229	7340 y	3.60E-16	9.16E-14	1.72E-17	—	1.30E-16	—	9.21E-14
Th-230	7.7E+04 y	2.76E-14	2.39E-14	1.72E-15	—	2.74E-15	—	5.59E-14
Th-231	25.5 h	—	—	6.44E-10	—	—	—	6.44E-10
Th-232	1.4 E+10 y	3.09E-11	1.82E-12	1.01E-22	—	2.07E-06	—	2.07E-06
Th-234	24.1 d	—	—	7.74E-11	—	3.92E-15	—	7.74E-11

Table 4-2. Radionuclide Composition of Idaho National Laboratory Site Airborne Effluents (2011) (continued) [a].

		Airborne Effluent (Ci)						
Radionuclide	Half life[b]	ATR Complex[c]	CFA[c]	INTEC[c]	MFC[c]	RWMC[c]	TAN[c]	Total
Tl-204	3.77 y	3.81E-21	—	—	—	—	—	3.81E-21
U-232	72 y	5.66E-11	6.00E-09	4.38E-10	—	7.38E-06	—	7.39E-06
U-233	1.585E+05 y	1.29E-14	7.54E-08	4.70E-08	6.88E-06	2.89E-04	—	2.96E-04
U-234	2.457E+05 y	1.25E-06	2.92E-12	3.75E-07	2.65E-08	1.64E-06	—	3.32E-06
U-235	7.038E+08 y	4.51E-08	6.46E-11	3.05E-08	1.52E-08	8.48E-15	—	9.21E-08
U-236	4.468 E+09 y	1.08E-15	—	5.47E-09	—	—	—	5.47E-09
U-238	4.5 E+09y	1.13E-07	6.80E-07	8.84E-08	9.82E-08	1.26E-14	—	1.09E-06
V-49	330 d	3.21E-19	—	—	—	—	—	3.21E-19
W-181	121.2 d	4.08E-09	—	—	—	—	—	4.08E-09
W-185	75.1 d	6.87E-08	—	—	—	—	—	6.87E-08
W-187	23.9 h	6.39E-03	—	—	—	—	—	6.39E-03
W-188	69.78 d	2.59E-08	—	—	—	—	—	2.59E-08
Xe-133	5.245 d	1.05E+00	—	—	—	—	—	1.05E+00
Xe-135	9.09 h	1.92E+01	—	—	—	—	—	1.92E+01
Xe-135m	15.29 m	9.35E+00	—	—	—	—	—	9.35E+00
Xe-138	14.17 m	4.21E+01	—	—	—	—	—	4.21E+01
Y-88	106.64 d	1.07E-12	3.02E-14	—	—	—	—	1.10E-12
Y-90	64.0 h	2.29E-03	—	—	1.43E-11	5.73E-04	—	2.86E-03
Y-92	3.54 h	2.34E-12	—	—	—	—	—	2.34E-12
Zn-65	243.9 d	8.83E-05	2.71E-11	—	4.25E-12	—	—	8.83E-05
Zr-95	63.98 d	6.21E-06	—	—	8.43E-12	—	—	6.21E-06
Zr-97	16.9 h	1.14E-11	—	—	—	—	—	1.14E-11
Total		1.51E+03	1.06E+00	1.65E+03	1.07E-01	3.57E+02	1.01E+00	3.52E+03

a. Radionuclide release information provided by the INL contractor.
b. d = days, h = hours, m = minutes, ms = milliseconds, s = seconds, y = years
c. ATR = Advanced Test Reactor, CFA = Central Facilities Area, INTEC = Idaho Nuclear Technology and Engineering Center, MFC = Materials and Fuels Complex, RWMC = Radioactive Waste Management Complex, including Advanced Mixed Waste Treatment Project, TAN = Test Area North.
d. A long dash signifies the radionuclide was not reported to be released to air from the facility in 2011

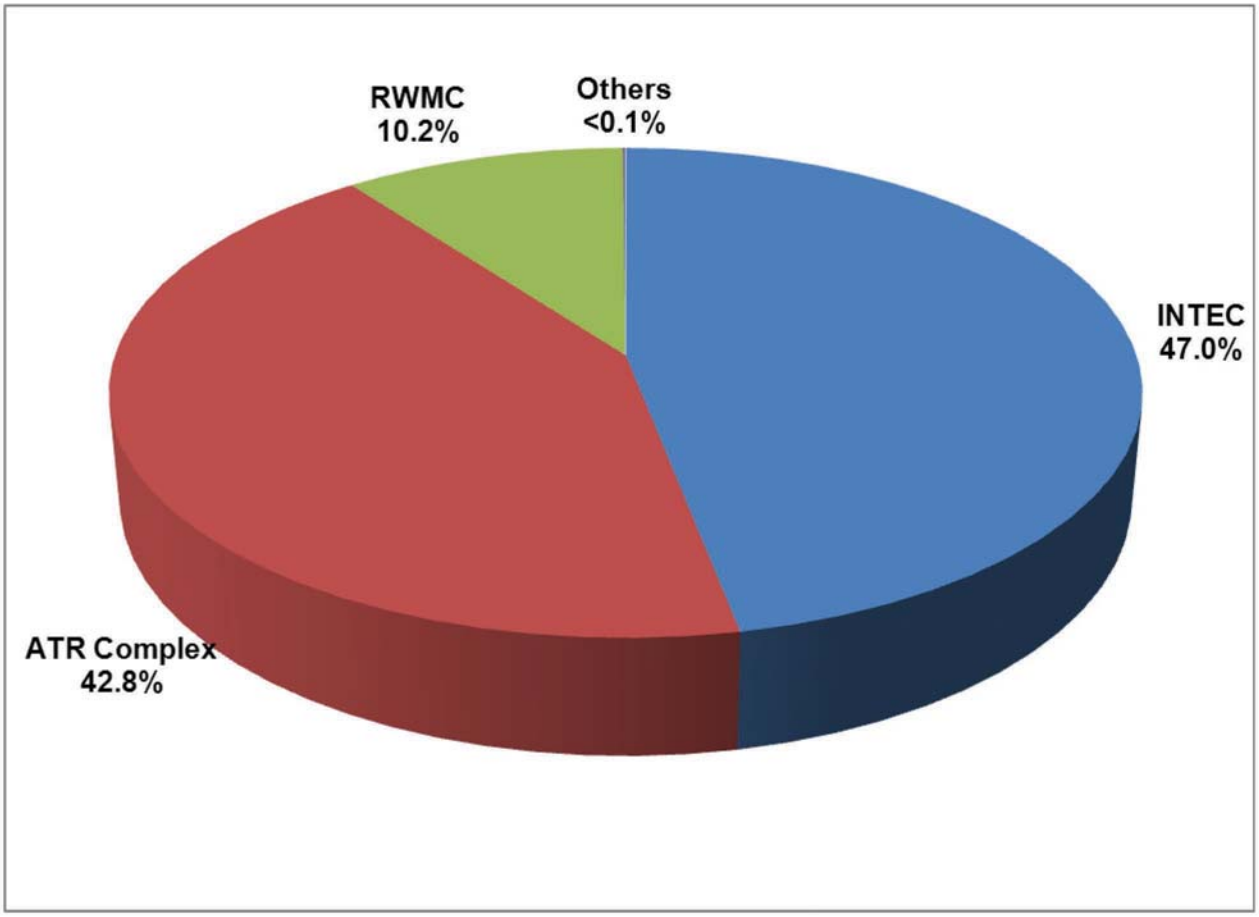


Figure 4-1. Percent Contributions, by Facility, to Total INL Site Airborne Radionuclide Releases (2011).

complete environmental cleanup of the area, including waste retrieval activities and operation of several units that extract volatile organic compounds from the subsurface. Operations at the Advanced Mixed Waste Treatment Project also contribute to these emissions. Radiological air emissions from the Advanced Mixed Waste Treatment Project result from retrieval, characterization, and treatment of transuranic waste, alpha-contaminated low-level mixed waste, and low-level mixed waste. The emissions from RWMC were estimated to be almost exclusively tritium.

- **Central Facilities Area (CFA) Emissions Sources (0.03 percent of total)** - Minor emissions occur from CFA facilities where work with small quantities of radioactive materials is routinely conducted. This includes low-level radiological performance testing samples preparation and verification at the Radiological and Environmental Sciences Laboratory (prior to relocation to Idaho Falls in June, 2011) and radiochemical research and development. Other minor emissions result from research and development laboratory operations and groundwater

usage. In 2011, the ICP contractor completed soil remediation at site CFA-54, a contaminated soil site. There were some minor emissions from that activity.

- **Test Area North (TAN) Emissions Sources (0.03 percent of total)** – The three main emissions sources at TAN are from the Specific Manufacturing Capability (SMC) project, the New Pump and Treat Facility (NPTF), and the Radiological Response Test Range (RRTR). Radiological air emissions from SMC are associated with processing of depleted uranium. Potential emissions are uranium isotopes and associated radioactive progeny. The main purpose of the NPTF is to reduce concentrations of trichloroethylene and other volatile organic compounds in the medial zone portion of the Operable Unit 1-07B contamination groundwater plume at TAN to below drinking water standards. Low levels of strontium-90 and tritium are also present in the treated water and are released to the atmosphere by the treatment process. The RRTR North Training Range (located at TAN) began operation in July, 2011, to support federal agencies responsible for the nuclear forensics mission. The RRTR North Training Range was configured to provide a realistic environment for personnel to develop and demonstrate proficiency and effective use of equipment in response to a radiological incident. Radioactive emissions from the 2011 training exercise were mainly comprised of radioactive isotopes of bromine and potassium-42. There were no activities at the RRTR South Training Range at RWMC that resulted in radioactive emissions.
- **Materials and Fuels Complex (MFC) Emissions Sources (<0.01 percent of total)** - Radiological air emissions are primarily associated with spent fuel treatment at the Fuel Conditioning Facility (FCF), waste characterization at the Hot Fuel Examination Facility (HFEF), and fuel research and development at the Fuel Manufacturing Facility (FMF). These facilities are equipped with continuous emission monitoring (CEM) systems. On a regular basis, the effluent streams from FCF, HFEF, FMF and other non-CEM radiological facilities are sampled and analyzed for particulate radionuclides. Gaseous and particulate radionuclides may also be released from other MFC facilities during laboratory research activities, sample analysis, waste handling and storage, and maintenance operations. In 2011, ICP decontamination and demolition activities involved several MFC facilities, including MFC-766, Sodium Boiler Building, and MFC-767, Experimental Breeder Reactor-II (EBR-II) Reactor Plant Building. These activities also included treatment of elemental sodium and sodium/potassium alloy in the EBR-II Primary Tank by reaction with a citric acid solution. These activities resulted in some radiological emissions.

The INL Site dose was calculated using all sources that emitted radionuclides to the environment (DOE-ID 2012). Radiological dose to the public is discussed further in Chapter 8 of this report.

4.3 Ambient Air Monitoring

The INL, ICP, and ESER contractors' environmental surveillance programs monitor air pathways on and off the INL Site for radionuclides. Figure 4-2 shows the regional ambient air monitoring locations.

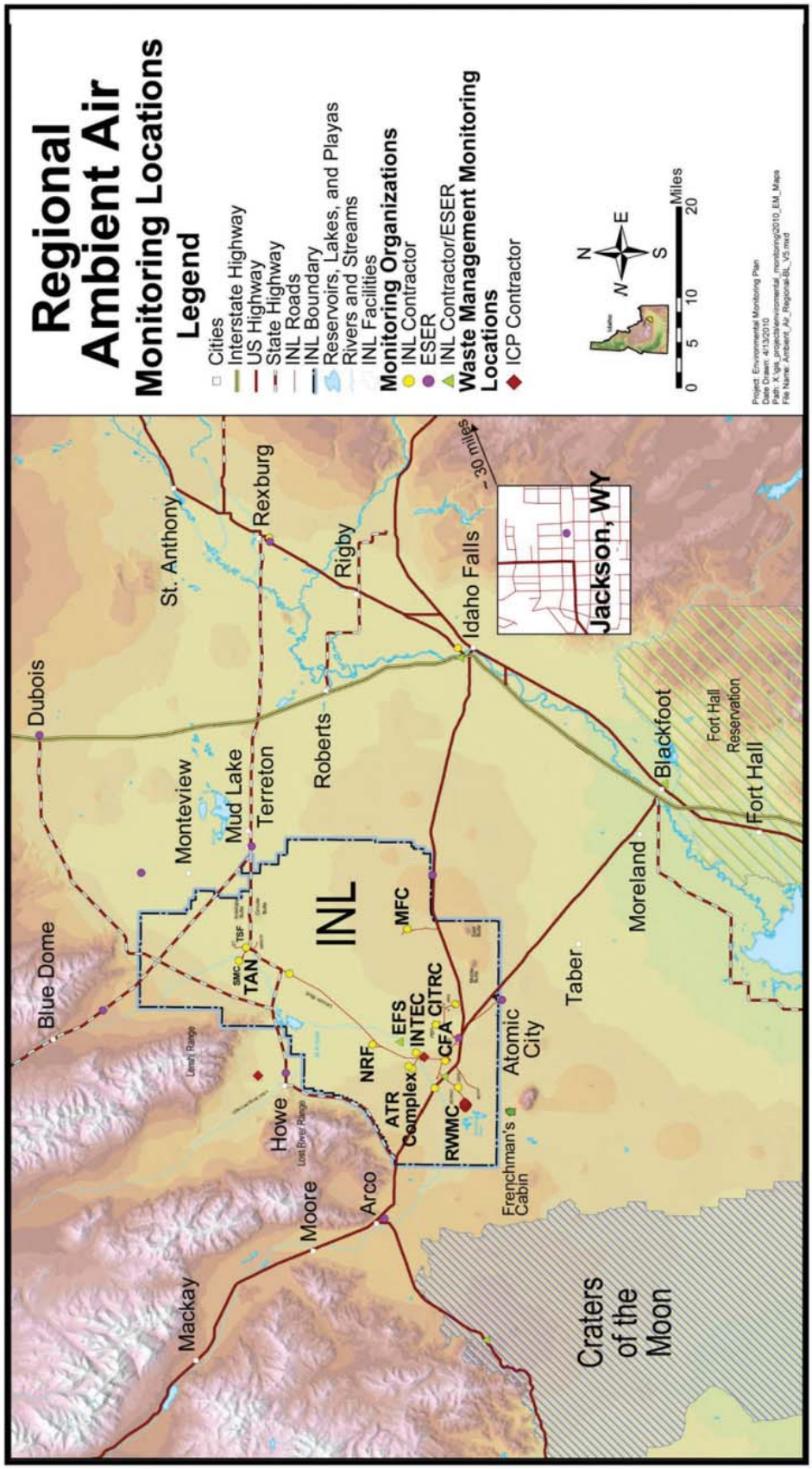


Figure 4-2. Idaho National Laboratory Site Environmental Surveillance Air Sampling Locations.

Air monitoring filters generally are collected weekly from a network of low-volume air monitors. At each monitor, a pump pulls air (about 57 L/minute [2 ft^3/min]) through a 5-cm (2-in.), 1.2-µm membrane filter and a charcoal cartridge. The membrane filters are collected weekly and analyzed in a laboratory for gross alpha and beta activity. Gross alpha and beta results generally are considered screenings because specific radionuclides are not identified. Rather, the results reflect a mix of alpha- and beta-emitting radionuclides. Gross alpha and beta radioactivity in air samples are usually dominated by the presence of naturally occurring radionuclides. Because of this, gross alpha and gross beta radioactivity are almost always detected in each air filter collected. If the results are higher than normal, sources other than background radionuclides may be suspected, and then other laboratory techniques can be used to identify specific radionuclides of concern. Gross alpha and beta activity also are examined over time and between locations to detect trends, which might indicate the need for more specific analyses.

The filters are composited quarterly by the ESER and INL[1] contractors and monthly by the ICP contractor for laboratory analysis of gamma-emitting radionuclides, such as cesium-137 (^{137}Cs). Cesium-137 is a man-made radionuclide and is present in soil on and off the INL Site from historical INL Site activities and global fallout. The contaminated soil particles can become airborne and subsequently filtered by air samplers. Naturally occurring gamma-emitting radionuclides that are typically detected in air filters include beryllium-7 (^{7}Be) and potassium-40 (^{40}K).

The ESER and ICP contractors also use laboratories to radiochemically analyze the quarterly and monthly composited samples for selected alpha- and beta-emitting radionuclides. These radionuclides include americium-241 (^{241}Am), plutonium-238 (^{238}Pu), plutonium-239/240 ($^{239/240}Pu$), and strontium-90 (^{90}Sr). They were selected for analysis because they have been detected historically in air samples and may be present due to resuspension of surface soil particles contaminated by INL Site activities or global fallout. The INL contractor currently screens for certain actinides (uranium-235, uranium-238, and ^{241}Am) using the quarterly gamma spectrometry analysis of the composited air samples.

Charcoal cartridges are collected and analyzed weekly for iodine-131 (^{131}I) by the INL and ESER contractors. Iodine-131 is of particular interest because it is produced in relatively large quantities by nuclear fission, is readily accumulated in human and animal thyroids, and has a half-life of eight days. This means that any elevated level of ^{131}I in the environment could be from a recent release of fission products.

The ESER and INL contractors monitor tritium in atmospheric water vapor in ambient air on the INL Site at the Experimental Field Station (EFS) and Van Buren Boulevard, and off the INL Site at Atomic City, Blackfoot, Craters of the Moon, Idaho Falls, and Rexburg. Air passes through

1 The INL contractor altered the ambient air monitoring program and technical reasons in 2008. This included ceasing routine analysis for ^{90}Sr and alpha-emitting radionuclides and changing the gamma spectrometry analysis frequency from quarterly to semiannual composites. In March 2011, quarterly composites were reinstated. The quarterly composites are analyzed for gamma-emitting radionuclides in accordance with DOE Guide -173T.

a column of molecular sieve, which is an adsorbent material that adsorbs water vapor in the air. Columns are sent to a laboratory for analysis when the material has adsorbed sufficient moisture to obtain a sample. The laboratory extracts water from the material by distillation and determines tritium concentrations by liquid scintillation counting. Tritium typically is present in air moisture due to natural production in the atmosphere, although it also is released by INL Site facilities (Table 4-2).

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

4.3.1 Ambient Air Monitoring Results

Gaseous Radioiodines – The INL contractor collected and analyzed approximately 1,062 charcoal cartridges (excluding field duplicates and blanks) in 2011. Of these 1,062 cartridges, there were 80 statistically positive detections of ^{131}I. These positive detections coincided with the passing of the plume of contamination from the Fukushima reactor accident caused by the tsunami that struck the Fukushima Daiichi nuclear power plant in Japan on March 11, 2011. Positive ^{131}I detections were observed at all INL contractor monitoring locations starting with samples collected the week of March 23, 2011. The last detection was observed in the sample collected on April 20, 2011, at the "TRA" monitoring location. During this time period, concentrations ranged from a minimum of $0.102 \times 10^{-13} \pm 0.035 \times 10^{-13}$ µCi/mL at the TRA monitoring location on April 20, 2011, to a maximum of $4.23 \times 10^{-13} \pm 0.28 \times 10^{-13}$ µCi/mL at the Rexburg location on March 23, 2011.

All other ^{131}I sample concentrations reported were below the measurement method detection limit.

During 2011, the ESER contractor analyzed 936 cartridges, looking specifically for ^{131}I. Of these 936 cartridges, there were 104 statistically positive detections of ^{131}I. Iodine-131 was detected during the period of fallout from the Fukushima accident, beginning the week of March 23. All sampling locations continued to show detectable ^{131}I through the week of April 13, and then it was found at selected locations through the week of May 11. The highest measured concentration was 5.19×10^{-13} µCi/mL at Blue Dome on March 23, 2011.

Gross Activity – All air filters were analyzed for gross alpha activity and gross beta activity. Gross alpha and gross beta measurements were assessed in terms of historical measurements and trends between locations and contractors, as well as over time. All measurements were included in these assessments, even the few that were not considered to be detected, to make the statistical analyses more robust. For more information see the discussion of "less-than-detectable values" in the document entitled *Statistical Methods Used in the Idaho National Laboratory Annual Site Environmental Report*, which is a supplement to this report.

- ***Gross Alpha.*** Gross alpha concentrations measured in individual INL contractor samples ranged from a low of $-4.1 \times 10^{-16} \pm 5.4 \times 10^{-16}$ µCi/mL collected at Craters of the Moon on April 27, 2011, to a high of $7.0 \times 10^{-15} \pm 1.5 \times 10^{-15}$ µCi/mL collected at Test Area North on September 28, 2011. Gross alpha concentrations measured in weekly ESER contractor

samples ranged from a minimum of 0.11 × 10^{-15} µCi/mL at Idaho Falls during the week ending March 9, 2011, to a maximum of 8.3 × 10^{-15} µCi/mL during the week ending February 2, 2011, at EFS. All results were within the range of historical measurements and less than the Derived Concentration Standard (DCS) of 4 × 10^{-14} µCi/mL for ^{241}Am (see Table A-1 of Appendix A).

INL and ESER contractor gross alpha activity data differed little when analyzed by location grouping, as illustrated in Figure 4-3. In this figure, median concentrations measured at INL Site and offsite locations (boundary and distant) are plotted for each week of the year. Each median weekly concentration was computed using all measurements, including negative values and statistically undetected results. Both data sets (INL contractor and ESER contractor) indicate that gross alpha concentrations measured at INL Site and offsite locations follow a similar pattern with respect to time. In addition, the median values were well within historical data except at the end of the year during week 50 (December 14 - 21). The highest values were observed above the historical median by both the INL Site and ESER contractor during this week and can be attributed to strong meteorological inversion conditions present at that time. This is discussed in greater detail in the Gross Beta section which follows.

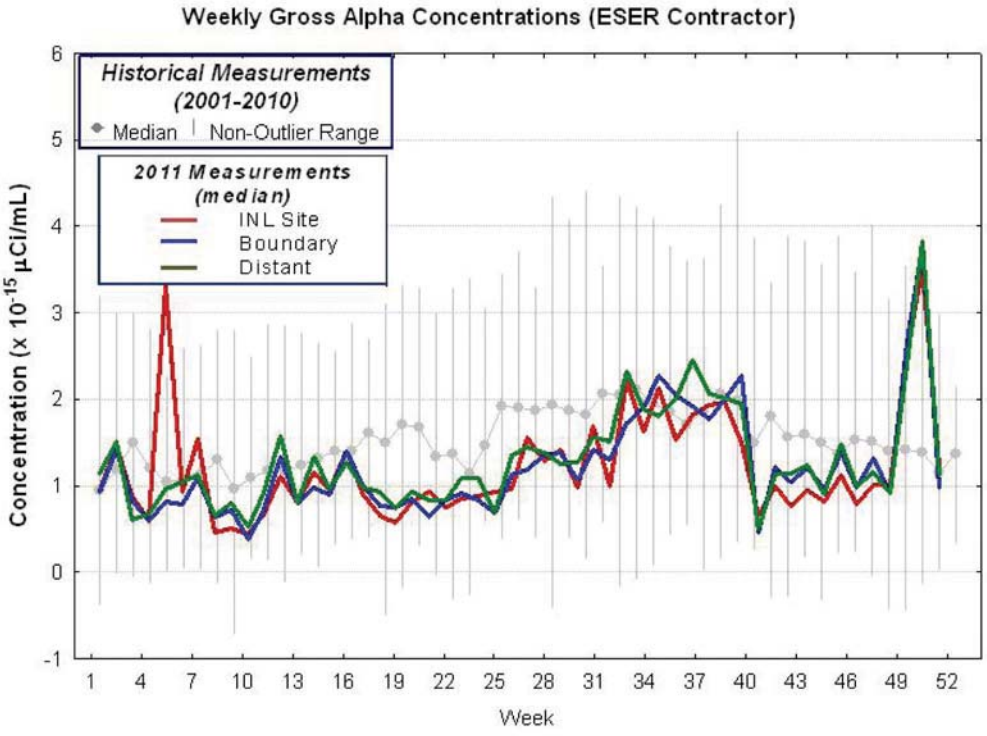
Median annual gross alpha concentrations calculated by the INL contractor ranged from 9.4 × 10^{-16} µCi/mL at Blackfoot to 1.42 × 10^{-15} µCi/mL at Gate 4. Median annual gross alpha concentrations calculated by the ESER contractor for each location ranged from 0.91 × 10^{-15} µCi/mL at the Federal Aviation Administration Tower to 1.3 × 10^{-15} µCi/mL at Idaho Falls (Table 4-3). The median annual gross alpha concentrations were typical of those detected previously and well within those measured historically.

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.

- ***Gross Beta.*** Gross beta concentrations in ESER contractor samples were fairly consistent with those of INL contractor samples. Weekly gross beta concentrations in INL contractor samples ranged from a low of 7.9 × 10^{-15} ± 2.0 × 10^{-15} µCi/mL at the Rest Area monitoring location on May 4, 2011, to a high of 1.01 × 10^{-13} ± 9.3 × 10^{-15} µCi/mL at EFS on December 21, 2011. Weekly gross beta concentrations detected in individual ESER contractor samples ranged from a low of 6.8 × 10^{-15} µCi/mL on November 2, 2011, at Dubois to a high of 1.05 × 10^{-13} µCi/mL on December 21, 2011, at Blackfoot. These results are within the range of past measurements.

  Figure 4-4 displays the median weekly gross beta concentrations for the ESER and INL contractors at INL Site, boundary, and distant sampling groups in 2011, as well as historical median and range of data



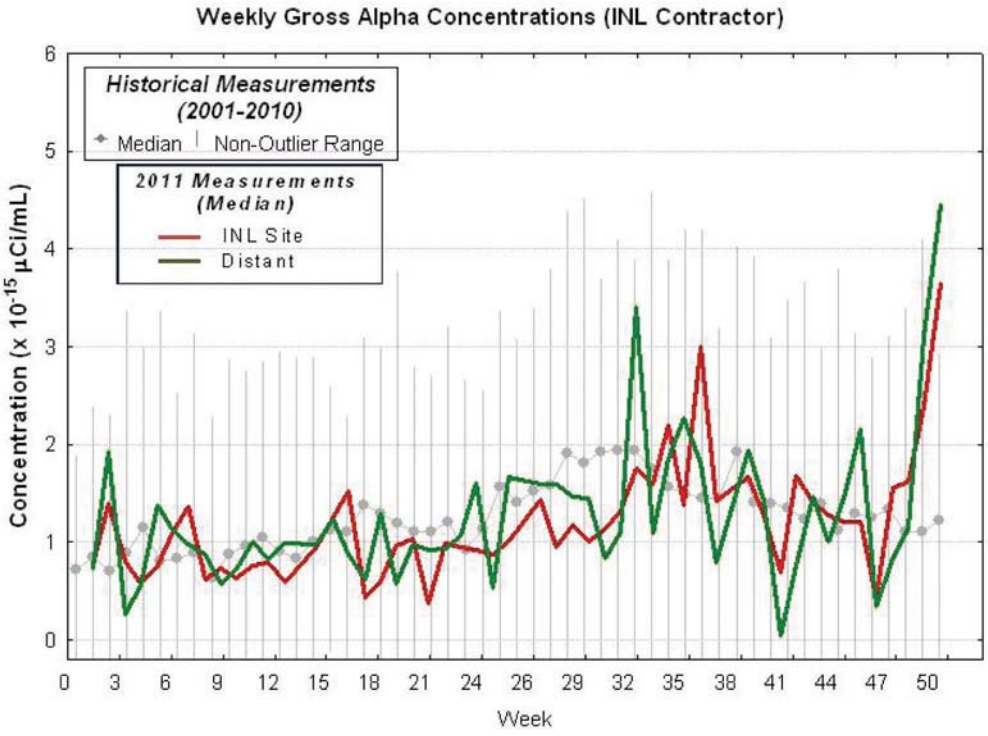


Figure 4-3. Median Weekly Gross Alpha Concentrations in Air (2011).

Table 4-3. Median Annual Gross Alpha Concentrations in Air (2011).

Group	Location[a]	No. of Samples[b]	Range of Concentrations[c] ($\times 10^{-15}$ µCi/mL)	Annual Median[c] ($\times 10^{-15}$ µCi/mL)
		ESER Contractor		
Distant	Blackfoot CMS	52	0.37 – 4.1	1.2
	Craters of the Moon	51	0.25 – 4.4	0.95
	Dubois	52	0.31 – 3.8	1.0
	Idaho Falls	51	0.11 – 2.9	1.3
	Jackson	52	0.21 – 4.4	1.1
	Rexburg CMS	52	0.54 – 3.9	1.1
			Distant Median:	1.1
Boundary	Arco	52	0.28 – 4.5	1.1
	Atomic City	52	0.17 – 4.0	0.99
	Blue Dome	50	0.27 – 4.0	0.95
	Federal Aviation Administration Tower	52	0.26 – 2.4	0.91
	Howe	51	0.21 – 4.8	1.1
	Monteview	51	0.23 – 5.1	1.2
	Mud Lake	52	0.45 – 4.1	1.2
			Boundary Median:	1.1
INL Site	EFS	51	0.20 – 8.3	0.99
	Main Gate	50	0.32 – 4.4	1.0
	Van Buren	51	0.46 – 3.5	1.0
			INL Site Median:	1.0
		INL Contractor		
Distant	Blackfoot	50	0.04– 3.2	0.9
	Craters of the Moon	49	-0.41 – 4.6	1.2
	Idaho Falls	51	-0.02 – 4.5	1.3
	Rexburg	51	-0.05 – 3.9	1.2
			Distant Median:	1.2
INL Site	ARA	47	-0.27 – 3.6	0.94
	ATR Complex (south side)	51	-0.34 – 4.3	1.4
	ATR Complex (NE corner)	51	-0.34 – 4.1	1.1
	CFA	51	-0.32 – 3.6	1.3
	CITRC	51	-0.02 – 3.9	1.1
	INTEC (west side)	51	-0.32 – 4.8	1.1
	EBR-I	50	-0.27 – 3.7	0.96
	EFS	50	0.01 – 3.7	1.2
	Gate 4	51	0.06 – 4.3	1.4
	INTEC (NE corner)	51	-0.32 – 4.5	1.1
	MFC	51	-0.35 – 4.3	1.2
	NRF	51	-0.04 – 6.1	1.2

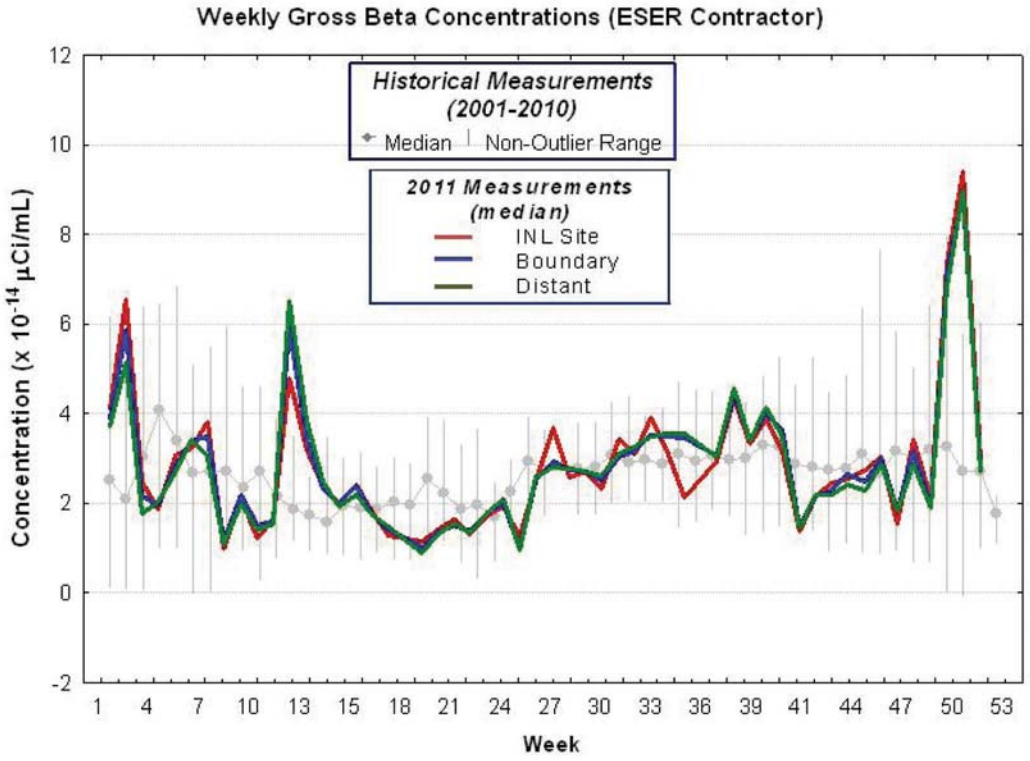
Table 4-3. Median Annual Gross Alpha Concentrations in Air (2011) (continued).

Group	Location[a]	No. of Samples[b]	Range of Concentrations[c] ($\times 10^{-15}$ µCi/mL)	Annual Median[c] ($\times 10^{-15}$ µCi/mL)
	Rest Area	51	-0.08 – 4.4	1.4
	RWMC	51	-0.33 – 5.6	1.1
	SMC	51	-0.24 – 4.5	1.1
	TAN	51	-0.34 – 7.0	1.1
	Van Buren	51	-0.32 – 4.0	1.1
			INL Site Median:	1.1

a. ARA = Auxiliary Reactor Area, ATR = Advanced Test Reactor, CFA = Central Facilities Area, CITRC = Critical Infrastructure Test Range Complex, CMS = Community Monitoring Station, CPP = Chemical Processing Plant, EBR-I = Experimental Breeder Reactor No. 1, EFS = Experimental Field Station, INTEC = Idaho Nuclear Technology and Engineering Center, MFC = Materials and Fuels Complex, NRF = Naval Reactors Facility, RWMC = Radioactive Waste Management Complex, SMC = Specific Manufacturing Capability, TAN = Test Area North. See Figure 3-2 for locations on INL Site.
b. Includes valid (i.e., sufficient volume) samples only. Does not include duplicate measurements.
c. All measurements, including those <3s, are included in this table and in computation of median annual values. A negative result indicates that the measurement was less than the laboratory background measurement.

measured by the ESER contractor during the 10-year period from 2001 through 2010. In general, median airborne radioactivity levels for the three groups (on INL Site, boundary, and distant locations) tracked each other closely throughout the year. These data are typical of the annual fluctuation pattern for natural gross beta concentrations in air, with higher values generally occurring at the beginning and end of the calendar year during winter inversion conditions (see sidebar). An inversion can lead to natural radionuclides being trapped close to the ground. The highest median weekly concentrations of gross beta activity were detected during two weeks in December by the ESER contractor. Analysis of meteorological data for these two weeks indicated that particularly strong and persistent inversion conditions were present in the Snake River Plain. The maximum median weekly gross beta concentration was 9.2×10^{-14} µCi/mL, which is significantly below the DCS of 240×10^{-14} µCi/mL (see Table A-1 of Appendix A) for the most restrictive beta-emitting radionuclide in air (radium-228 [^{228}Ra]).

ESER contractor median annual gross beta concentrations ranged from 2.3×10^{-14} µCi/mL at Craters of the Moon to 2.7×10^{-14} µCi/mL at Monteview and Mud Lake (Table 4-4). INL contractor data ranged from a median annual concentration of 2.1×10^{-14} µCi/mL at Craters of the Moon, to 2.7×10^{-14} µCi/ mL at Gate 4. All results detected by the ESER and INL contractors were well within valid measurements taken within the last 13 years (Figure 4-4). This indicates that the fluctuation patterns over the entire sampling network



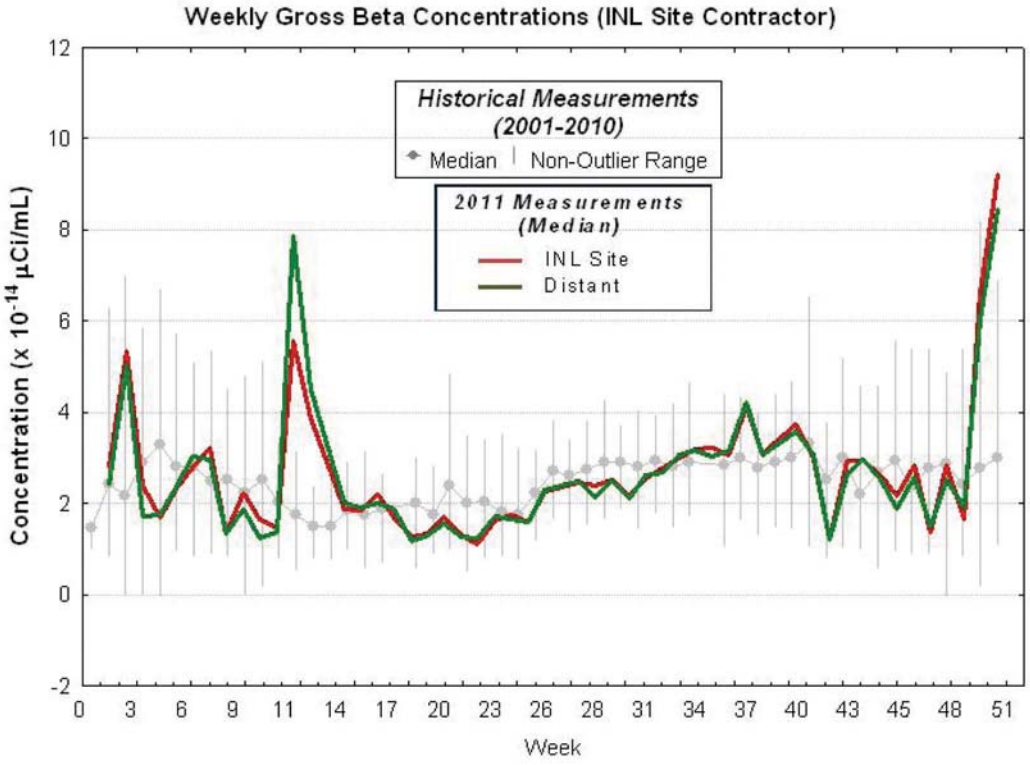


Figure 4-4. Median Weekly Gross Beta Concentrations in Air (2011).
The elevated concentration during week 12 (March 16-23, 2011) corresponds with the Fukushima accident fallout event.

Table 4-4. Median Annual Gross Beta Concentrations in Air (2011).

Group	Location[a]	No. of Samples[b]	Range of Concentrations[c] ($\times 10^{-14}$ µCi/mL)	Annual Median[c] ($\times 10^{-14}$ µCi/mL)
		ESER Contractor		
Distant	Blackfoot CMS	52	0.94 – 10.5	2.6
	Craters of the Moon	51	0.89– 9.2	2.3
	Dubois	52	0.68 – 8.1	2.5
	Idaho Falls	51	0.84– 7.3	2.6
	Jackson	52	0.72 – 9.2	2.6
	Rexburg CMS	52	0.91 – 9.7	2.6
			Distant Median:	2.5
Boundary	Arco	52	0.96 – 9.2	2.6
	Atomic City	52	0.86 – 10.3	2.6
	Blue Dome	50	0.90 – 7.7	2.6
	Federal Aviation Administration Tower	52	0.79 – 6.5	2.4
	Howe	51	0.88 – 10.3	2.6
	Monteview	51	0.93 – 9.4	2.7
	Mud Lake	52	0.90 – 10.0	2.7
			Boundary Median:	2.6
INL Site	EFS	51	0.90 – 10.1	2.6
	Main Gate	50	0.95 – 9.2	2.6
	Van Buren	51	0.90 – 8.9	2.5
			INL Site Median:	2.6
		INL Contractor		
Distant	Blackfoot	50	0.97 – 7.9	2.2
	Craters of the Moon	49	1.0 – 8.9	2.1
	Idaho Falls	51	1.2 – 9.7	2.4
	Rexburg	51	0.82 – 8.4	2.4
			Distant Median	2.3
INL Site	ARA	47	0.1.1 – 8.6	2.2
	ATR Complex (south side)	51	1.1 – 9.4	2.5
	ATR Complex (NE corner)	51	1.0 – 9.3	2.5
	CFA	51	0.84 – 9.3	2.7
	CITRC	51	0.92 – 9.3	2.6
	INTEC (west side)	51	1.0 – 8.8	2.5
	EBR-I	50	0.9 – 9.4	2.4
	EFS	50	1.1 – 10.1	2.5
	Gate 4	51	0.83 – 9.2	2.7
	INTEC (NE corner)	51	1.2 – 9.4	2.4

Table 4-4. Median Annual Gross Beta Concentrations in Air (2011) (continued).

Group	Location[a]	No. of Samples[b]	Range of Concentrations[c] ($\times 10^{-14}$ µCi/mL)	Annual Median[c] ($\times 10^{-14}$ µCi/mL)
	MFC	51	0.81 – 8.1	2.3
	NRF	51	0.92 – 8.9	2.5
	Rest Area	51	0.79 – 9.0	2.4
	RWMC	51	0.83 – 8.8	2.3
	SMC	51	0.95 – 9.2	2.4
	TAN	51	0.87 – 9.0	2.4
	Van Buren	51	1.2 – 8.1	2.4
			INL Site Median:	2.4

a. ARA = Auxiliary Reactor Area, ATR = Advanced Test Reactor, CFA = Central Facilities Area, CITRC = Critical Infrastructure Test Range Complex, CMS = Community Monitoring Station, CPP = Chemical Processing Plant, EBR-I = Experimental Breeder Reactor No. 1, EFS = Experimental Field Station, INTEC = Idaho Nuclear Technology and Engineering Center, MFC = Materials and Fuels Complex, NRF = Naval Reactors Facility, RWMC = Radioactive Waste Management Complex, SMC = Specific Manufacturing Capability, TAN = Test Area North.
b. Includes valid samples only. Does not include duplicate measurements.
c. All measurements, including those <3s, are included in this table and in computation of median annual values.

are representative of natural conditions and are not caused by a localized source, such as a facility or activity at the INL Site.

- ***Gross Activity Statistical Comparisons.*** Statistical comparisons were made using the gross alpha and gross beta radioactivity data collected from the INL Site, boundary, and distant locations (see the supplemental report, *Statistical Methods Used in the Idaho National Laboratory Annual Site Environmental Report*, for a description of methods used). If the INL Site were a significant source of offsite contamination, contaminant concentrations would be statistically greater at boundary locations than at distant locations. There were no statistical differences among annual concentrations collected from the INL Site, boundary, and distant locations in 2011. There were a few statistical differences between weekly boundary and distant data sets collected by the ESER contractor during the 52 weeks of 2011 that can be attributed to expected statistical variation in the data and not to INL Site releases. Quarterly reports detailing these analyses are provided at http://www.gsseser.com/Publications.htm. INL contractor data sets from samples collected on the INL Site and distant locations were compared, and there were no statistical differences.

Specific Radionuclides – The period when eastern Idaho received fallout from the Fukushima accident was during the second half of March and during April and therefore included parts of the first and second quarters. The ESER contractor measured cesium-134 (^{134}Cs) and

^{137}Cs on first quarter composites and ^{137}Cs on some second quarter composites. The maximum concentration in the first quarter was 1.31 x 10^{-15} µCi/mL for ^{134}Cs (in Idaho Falls) and 1.40 x 10^{-15} µCi/mL for ^{137}Cs (at the Van Buren Gate duplicate sampler). The maximum ^{137}Cs concentration in the second quarter was 5.62 x 10^{-16} µCi/mL at Rexburg. Further information on Fukushima results can be found in Appendix B.

The ESER contractor also found numerous detections of ^{90}Sr during the second through fourth quarters. Detectable concentrations ranged from 3.2 x 10^{-17} µCi/mL at Idaho Falls in the fourth quarter to 3.3 x 10^{-16} µCi/mL at the Van Buren Gate duplicate sampler in the third quarter. Similar concentrations were found at distant, boundary, and INL Site locations. An origin for the ^{90}Sr is unclear. The ESER contractor began using a new laboratory for this analysis starting in the second quarter; a more sensitive analytical method is being used by this laboratory.

Cesium-134 and ^{137}Cs were detected in multiple quarterly composite samples collected by the INL contractor in the first and second quarters of calendar year 2011. During the first quarter of 2011, ^{134}Cs concentrations ranged from 4.9 × 10^{-16} ± 4.4 × 10^{-17} µCi/mL at the ATR Complex location to 1.0 × 10^{-15} ± 7.2 × 10^{-17} µCi/mL at Blackfoot, with a median value of 6.6 × 10^{-16} µCi/mL, and ^{137}Cs concentrations ranged from 5.1 × 10^{-16} ± 5.6 × 10^{-17} µCi/mL at the ATR Complex location to 1.2 × 10^{-15} ± 9.0 × 10^{-17} µCi/mL, with a median value of 6.9 × 10^{-15} µCi/mL. These detections were widespread across the monitoring network, and are attributed to the release of radioactivity from the accident at Fukushima. Similar concentrations of the cesium isotopes were also detected by the ESER and ICP contractors, as well as by the State of Idaho INL Oversight Program.

Additionally, zinc-65 was detected at Naval Reactors Facility in the third quarterly composite at a concentration of 3.0 × 10^{-16} ± 9.3 × 10^{-17} µCi/mL, which is just above the method detection limit of 2.7 × 10^{-16} µCi/mL. No other samples in the third quarterly composite, or the fourth quarterly composite contained anthropogenic radionuclides above the method detection limits.

Natural ^{7}Be was detected in numerous ESER and INL contractor composite samples at concentrations consistent with past concentrations. Atmospheric ^{7}Be results from reactions of galactic cosmic rays and solar energetic particles with nitrogen and oxygen nuclei in earth's atmosphere. No other radionuclides were detected in the samples.

4.3.2 Atmospheric Moisture Monitoring Results

The INL contractor collected atmospheric moisture samples at the EFS and Van Buren Boulevard on the INL Site and at Idaho Falls and Craters of the Moon off the INL Site. During 2011, 33 samples were collected. One statistically positive detection occurred. Tritium was detected at EFS at a concentration of 6.5 × 10^{-12} ± 1.9 × 10^{-12} µCi/mL on July 20, 2011. The result most likely represents tritium from natural production in the atmosphere by cosmic ray bombardment, residual weapons testing fallout, and possible analytical variations, rather than tritium from INL Site operations.

During 2011, the ESER contractor collected 61 atmospheric moisture samples at Atomic City, Blackfoot, Idaho Falls, and Rexburg. Table 4-5 presents the range of values detected

Table 4-5. Ranges of Tritium Concentrations Detected in ESER Contractor Atmospheric Moisture Samples (2011).[a]

Location	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
		(× 10^{-13} µCi/mL)		
Atomic City	4.0[b]	5.1 – 8.2	11.1 – 14.1	ND[c]
Blackfoot	3.5 – 8.7	3.7 – 10.1	10.4	ND
Idaho Falls	4.3 – 5.5	5.3 – 9.3	10.3	ND
Rexburg	8.2 – 8.4	6.0 – 11.8	11.8	ND

a. Results shown are ≥ 3s.
b. When a single value is reported, tritium was detected in only one sample.
c. ND = not detected.

at each station by quarter. Tritium was detected in 28 samples, ranging from a low of 3.5 × 10^{-13} µCi/mL at Blackfoot to a high of 14 × 10^{-13} µCi/mL at Atomic City. The detections are consistent with historical measurements. The highest concentration of tritium detected in an atmospheric moisture sample since 1998 was 38 × 10^{-13} µCi/mL at Atomic City. The results are within historical measurements and are probably natural in origin. The highest observed tritium concentration is far below the DCS for tritium in air (as hydrogen tritium oxygen) of 1.4 × 10^{-8} µCi/mL (see Table A-1 of Appendix A).

4.3.3 Precipitation Monitoring Results

The ESER contractor collects precipitation samples weekly at EFS, when available, and monthly at CFA and off the INL Site in Idaho Falls. A total of 46 precipitation samples were collected during 2011 from the three sites. Tritium concentrations were detected in 30 samples, and detectable results ranged from 64 pCi/L at Idaho Falls to 206 pCi/L at EFS. Table 4-6 shows the concentration ranges by quarter for each location. The highest concentration is well below the DCS level for tritium in water of 1.9 × 10^{6} pCi/L. The concentrations are well within the historical normal range at the INL Site. The maximum concentration measured since 1998 was 553 pCi/L at EFS in 2000. The results are well within measurements made by the Environmental Protection Agency in Region 10 (Alaska, Idaho, Oregon, and Washington) for the past ten years (http://www.epa.gov/enviro/html/erams/).

To monitor fallout from the Fukushima accident in Japan, portions of the Idaho Falls sample were analyzed for gamma-emitting radionuclides. Samples were collected on March 22 and March 28 following rain events. Iodine-131 was detected in the March 22 sample at 74 pCi/L and the March 28 sample at 275 pCi/L. Cesium-137 was also found at concentrations of 17 and 72 pCi/L in the respective samples. These values are similar to others reported around the western United States by the Environmental Protection Agency's RadNet program during that time period. Further information about Fukushima monitoring results can be found in Appendix B.

Table 4-6. Ranges of Tritium Concentrations Detected in ESER Contractor Precipitation Samples (2011).[a]

Location[b]	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
		(pCi/L)		
CFA	ND[c]	90 - 175	101 - 145	105[d]
EFS	115 - 179	114 - 206	101 - 146	111
Idaho Falls	106	64 - 132	64 - 177	115

a. Results shown are ≥ 3s.
b. CFA = Central Facilities Area, EFS = Experimental Field Station.
c. ND = not detected.
d. When a single value is reported, tritium was detected in only one sample.

4.3.4 Suspended Particulates Monitoring Results

In 2011, the ESER contractor measured concentrations of suspended particulates using filters collected from the low-volume air samplers. The filters are 99 percent efficient for collection of particles greater than 0.3 µm in diameter. That is, they collect the total particulate load greater than 0.3 µm in diameter.

Mean annual particulate concentrations ranged from 7 µg/m^3 at Blue Dome to 23 µg/m^3 at Dubois. In general, particulate concentrations were higher at offsite locations than at the INL Site stations. This is most likely influenced by agricultural activities off the INL Site.

4.4 Waste Management Surveillance Monitoring

4.4.1 Gross Activity

The ICP contractor conducts environmental surveillance in and around waste management facilities to comply with DOE Order 435.1, “Radioactive Waste Management.” Currently, ICP waste management operations occur at the SDA at RWMC and the Idaho CERCLA Disposal Facility at INTEC and have the potential to emit radioactive airborne particulates. The ICP contractor collected samples of airborne particulate material from the perimeters of these waste management areas in 2011 (Figure 4-5). The ICP contractor also collected samples from a control location north of Howe, Idaho (Figure 4-2), to compare with the results of the SDA and Idaho CERCLA Disposal Facility. Samples were obtained using suspended particle monitors similar to those used by the INL and ESER contractors. Gross alpha and gross beta activity were determined on all suspended particle samples.

Table 4-7 shows the gross alpha and gross beta monitoring results. The results that were received for the SDA and Idaho CERCLA Disposal Facility are comparable to historical results, and no new trends were identified.

Figure 4-5. Locations of Low-volume Air Samplers at Waste Management Areas. (Radioactive Waste Management Complex [top] and Idaho CERCLA Disposal Facility [bottom]).

Table 4-7. Gross Activity Concentrations Measured in ICP Contractor Air Samples (2011).[a,b]

Activity	Low (µCi/mL)	High (µCi/mL)	Annual Mean (µCi/mL)
Subsurface Disposal Area (SDA)			
Gross Alpha	$(1.52 \pm 2.23) \times 10^{-16}$ 2nd half of January at SDA 6.3	$(4.89 \pm 0.45) \times 10^{-14}$ 1st half of December at SDA 1.3	3.14×10^{-15}
Gross Beta	$(1.01 \pm 0.13) \times 10^{-14}$ 2nd half of April at SDA 4.2	$(1.31 \pm 0.11) \times 10^{-13}$ 1st half of December at SDA 1.3	2.79×10^{-14}
Idaho CERCLA Disposal Facility (INT)			
Gross Alpha	$(3.82 \pm 2.67) \times 10^{-16}$ 1st half of March at INT 100.3	$(3.68 \pm 0.37) \times 10^{-14}$ 1st half of December at INT 100.3	3.22×10^{-15}
Gross Beta	$(1.10 \pm 0.13) \times 10^{-14}$ 2nd half of May at INT 100.3	$(9.77 \pm 0.84) \times 10^{-14}$ 1st half of December at INT 100.3	2.72×10^{-14}

a. Result ± 1s.
b. SDA 4.2 results from October 3, 2011, to November 1, 2011, are missing due to no power, no meter reading, and power inverter not working.

4.4.2 Specific Radionuclides

In 2011, ^{137}Cs was the only gamma-emitting radionuclide that was detected at the SDA. There were only three detections, all in the first quarter at levels consistent with those seen in the past. The detections are shown on Table 4-8. There were no gamma-emitting radionuclides detected at the Idaho CERCLA Disposal Facility at INTEC.

Also, Table 4-8 shows alpha- and beta-emitting radionuclides detected in air samples analyzed using radiochemistry in 2011. These detections are consistent with levels measured in air at RWMC in previous years, and are attributed to resuspension of soils in and adjacent to RWMC. The values and locations for plutonium and americium detections remained consistent from 2010 to 2011; however, the number of ^{241}Am detections decreased. The higher number of detections in 2010 is likely due to ^{241}Am being identified in an ^{243}Am tracer at the laboratory. All of the affected packages have been corrected and resubmitted. All of the detections shown in Table 4-8 are likely due to resuspension of contaminated soils inside or northeast of the SDA and fugitive emissions from the Accelerated Retrieval Project. The soils outside RWMC

Table 4-8. Human-made Radionuclides Detected in ICP Contractor Air Samples (2011).[a]

Radionuclide	Result (µCi/mL)	Location	Quarter Detected[b]
Am-241	$(2.93 \pm 0.44) \times 10^{-17}$	SDA[c] 2.3	2nd
	$(5.86 \pm 1.91) \times 10^{-18}$	SDA 4.2	2nd
	$(7.03 \pm 2.13) \times 10^{-18}$	SDA 6.3	2nd
	$(1.51 \pm 0.29) \times 10^{-17}$	SDA 4.2	3rd
	$(1.94 \pm 0.33) \times 10^{-17}$	SDA 4.3	3rd
	$(1.43 \pm 0.31) \times 10^{-17}$	SDA 6.3	3rd
	$(4.15 \pm 0.55 \times 10^{-17}$	SDA 11.3	3rd
	$(3.99 \pm 1.16) \times 10^{-18}$	SDA 1.3	4th
	$(1.81 \pm 0.30) \times 10^{-18}$	SDA 4.2	4th
	$(9.40 \pm 1.80) \times 10^{-18}$	SDA 4.3	4th
	$(4.23 \pm 1.19) \times 10^{-18}$	SDA 9.3	4th
Cs-137	$(2.38 \pm 0.63) \times 10^{-15}$	SDA 2.3	1st
	$(2.67 \pm 0.73) \times 10^{-15}$	SDA 4.3	1st
	$(2.41 \pm 0.70) \times 10^{-15}$	SDA 6.3	1st
Pu-238	$(6.96 \pm 1.87) \times 10^{-18}$	SDA 11.3	3rd
Pu-239/240	$(4.48 \pm 1.49) \times 10^{-18}$	SDA 4.3	2nd
	$(8.65 \pm 2.18) \times 10^{-18}$	SDA 6.3	2nd
	$(2.75 \pm 0.46) \times 10^{-17}$	SDA 4.2	3rd
	$(8.66 \pm 2.17) \times 10^{-18}$	SDA 4.3	3rd
	$(1.33 \pm 0.30) \times 10^{-17}$	SDA 6.3	3rd
	$(3.52 \pm 0.32) \times 10^{-16}$	SDA 11.3	3rd
	$(8.18 \pm 2.55) \times 10^{-18}$	SDA 4.2	4th
	$(5.52 \pm 1.66) \times 10^{-18}$	SDA 4.3	4th
Sr-90	$(4.39 \pm 1.42) \times 10^{-17}$	Howe[c] 400.3	2nd
	$(5.35 \pm 1.50) \times 10^{-17}$	INT[d] 100.3	2nd
	$(6.21 \pm 1.86) \times 10^{-17}$	INT 100.3	3rd

a. Result ± 1s. Results shown are ≥ 3s.
b. SDA = Subsurface Disposal Area.
c. Howe = Control.
d. INT = Idaho CERCLA Disposal Facility.

are contaminated as a result of early burial practices (Markham et al. 1978). Recent studies of radionuclide concentrations in soils (VanHorn et al. 2012) confirm that $^{239/240}$Pu and ^{241}Am still are present in measurable amounts in surface soils surrounding RWMC, with maximum concentrations northeast of the SDA. Measurable amounts of ^{238}Pu also have been reported in subsurface soils north of the SDA and in surface soils at several locations immediately outside the INTEC fence line, including locations near the Idaho CERCLA Disposal Facility and the Integrated Waste Treatment Unit. The ICP contractor will continue to closely monitor these radionuclides to identify trends.

REFERENCES

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VanHorn R. L., L. S. Cahn, V. M. Kimbro, K. J. Holdren, 2012, *Operable Unit 10-04 Long-Term Ecological Monitoring Report for Fiscal Years 2003 to 2008*, DOE/ID 11390, Rev. 1, U.S. Department of Energy Idaho Operations Office.

Chapter 5. Compliance Monitoring for Liquid Effluents, Drinking Water, and Surface Water

Chapter 5 Highlights

Liquid effluents, drinking water, and surface water runoff were monitored in 2011 by the Idaho National Laboratory (INL) contractor and the Idaho Cleanup Project contractor for compliance with applicable regulatory standards established to protect human health and the environment.

Wastewater discharged to land surfaces and evaporation ponds at the INL Site is regulated by the state of Idaho groundwater quality and wastewater rules and requires a wastewater reuse permit. During 2011, permitted facilities were:

- Central Facilities Area (CFA) Sewage Treatment Plant
- Idaho Nuclear Technology and Engineering Center (INTEC) New Percolation Ponds
- Advanced Test Reactor (ATR) Complex Cold Waste Pond
- Material and Fuels Complex (MFC) Industrial Waste Ditch and Industrial Waste Pond.

These facilities were sampled for parameters required by their facility-specific permits. No permit limits were exceeded in 2011.

Additional liquid effluent and groundwater monitoring was performed in 2011 at ATR Complex, CFA, INTEC, and MFC to comply with environmental protection objectives of the Department of Energy (DOE). All parameters were below applicable health-based standards, with the exception of some groundwater samples from INTEC that had elevated aluminum, iron, and manganese results. It appears these were due to sediment in unfiltered samples.

Eleven drinking water systems were monitored in 2011 for parameters required by “Idaho Rules for Public Drinking Water Systems.” Water samples collected from drinking water systems were well below drinking water limits for all relevant regulatory parameters. Because workers are potentially impacted from radionuclides in the CFA distribution system, the dose from ingesting tritium to a CFA worker was calculated. The dose was 0.22 mrem for 2011. This is below the Environmental Protection Agency standard of 4 mrem/yr for public drinking water.

Surface water runoff from the Subsurface Disposal Area of the Radioactive Waste Management Complex was sampled in 2011 for radionuclides in compliance with DOE limits. Results were within historical measurements, with americium-241 and plutonium-239/240 about the same as the previous year’s results.

5. COMPLIANCE MONITORING FOR LIQUID EFFLUENTS, GROUNDWATER, DRINKING WATER, AND SURFACE WATER

This chapter presents analytical results of water samples collected by the Idaho National Laboratory (INL) contractor (Battelle Energy Alliance, LLC) and Idaho Cleanup Project (ICP) contractor (CH2M-WG Idaho, LLC) at the INL Site and the Research and Education Campus (Idaho Falls facilities). Included in this chapter are descriptions and results of liquid effluent and related groundwater monitoring, drinking water monitoring, and surface water runoff monitoring conducted for compliance with regulatory limits and permits.

To improve the readability of this chapter, data tables are only included that compare monitoring results to specified discharge limits, permit limits, or maximum contaminant levels. Data tables for other monitoring results are provided in Appendix C.

5.1 Summary of Monitoring Programs

The INL contractor and ICP contractor monitor drinking water, liquid effluent, surface water runoff, and groundwater that could be impacted by INL Site operations and activities. This monitoring is conducted to comply with applicable laws and regulations, Department of Energy (DOE) orders, and other requirements (e.g., wastewater reuse permit requirements).

Table 5-1 presents compliance monitoring performed at the INL Site. A comprehensive discussion and maps of environmental monitoring performed by various organizations within and around the INL Site may be found in the *Idaho National Laboratory Environmental Monitoring Plan* (DOE-ID 2010).

5.2 Liquid Effluent and Related Groundwater Compliance Monitoring

The INL contractor and ICP contractor monitor constituents of concern in liquid waste influent, effluent, and groundwater in the vicinity of and downgradient of the liquid releases. Wastewater is discharged to the ground surface at the following areas:

- Percolation ponds southwest of the Idaho Nuclear Technology and Engineering Center (INTEC), Materials and Fuels Complex (MFC) Industrial Waste Pond, and the Advanced Test Reactor (ATR) Complex Cold Waste Pond
- A sprinkler irrigation system at the Central Facilities Area (CFA) used during the summer months to apply industrial and treated sanitary wastewater.

Discharge of wastewater to the land surface is regulated by wastewater rules (Idaho Administrative Procedures Act [IDAPA] 58.01.16 and .17). A wastewater reuse permit normally requires monitoring of nonradioactive parameters in the influent waste, effluent waste, and groundwater, as applicable. However, some facilities may have specified radiological parameters monitored for surveillance purposes (not required by regulations). The liquid effluent and groundwater monitoring programs implement wastewater and groundwater quality rules at INL

Table 5-1. Water Monitoring at the Idaho National Laboratory Site for Regulatory Compliance.

Area/Facility	Media				
	Liquid Effluent (Permitted)[a]	Liquid Effluent (Surveillance)	Groundwater (Permitted)	Drinking Water	Surface Runoff
Idaho Cleanup Project: CH2M-WG Idaho, LLC (CWI)					
Idaho Nuclear Technology and Engineering Center	•	•	•	•	
Radioactive Waste Management Complex				•	•
INL Contractor: Battelle Energy Alliance, LLC (BEA)					
Advanced Test Reactor Complex	•	•	•	•	
Central Facilities Area[b]	•	•		•	
Materials and Fuels Complex	•	•	•	•	
Critical Infrastructure Test Range Complex				•	
Test Area North/Technical Support Facility				•	
TAN/CTF (SMC)				•	

a. In 2009, the City of Idaho Falls assumed responsibility for the semiannual liquid effluent monitoring conducted at the Research and Education Campus.

b. Includes Weapons Range, Experimental Breeder Reactor I, and Main Gate.

Site facilities that have wastewater reuse permits. Table 5-2 lists the status of each wastewater reuse-permitted facility as of December 2011.

The permits generally require that data from groundwater monitoring wells at the INL Site comply with the Idaho groundwater quality primary constituent standards and secondary

Table 5-2. Status of Wastewater Reuse Permits.

Facility	Permit Status at End of 2011	Explanation
Advanced Test Reactor Complex Cold Waste Pond	Permit issued	DEQ[a] issued Permit #LA-000161-01 on February 26, 2008, modified on August 20, 2008, and expires on February 25, 2013.
Central Facilities Area Sewage Treatment Facility	Permit issued	DEQ issued Permit #LA-000141-03 on March 17, 2010. The permit will expire on March 16, 2015.
Idaho Nuclear Technology and Engineering Center New Percolation Ponds	Renewal permit application submitted	DEQ issued Permit LA-000130-04 on November 19, 2004, modified on October 25, 2005, and March 16, 2007, and expired on November 18, 2009. A renewal permit application (ICP 2009) was submitted to DEQ in May 2009. DEQ notified ICP on November 10, 2009, that the current permit will remain in effect until the renewed permit is issued.
Materials and Fuels Complex Industrial Waste Pond and Industrial Waste Ditch	Permit issued	In 2010 DEQ issued permit LA-000160-01, effective May 1, 2010 to April 30, 2015.

a. DEQ = Idaho Department of Environmental Quality

constituent standards (IDAPA 58.01.11). The permits specify annual discharge volumes, application rates and effluent quality limits. Annual reports (ICP 2012a, 2012b; INL 2012a, 2012b, 2012c) were prepared and submitted to the Idaho Department of Environmental Quality (DEQ) as required for permitted facilities.

During 2011, the INL contractor and ICP contractor monitored, as required by the permits, the following facilities (Table 5-2):

- CFA Sewage Treatment Plant
- INTEC New Percolation Ponds
- ATR Complex Cold Waste Pond
- MFC Industrial Waste Ditch and Industrial Waste Pond.

The following subsections present results of wastewater and groundwater monitored to comply with facility-specific permits.

Additional effluent parameters are monitored to comply with environmental protection objectives of DOE Order 458.1 Administrative Change 2. Section 5.3 discusses the results of liquid effluent surveillance monitoring.

5.2.1 Research and Education Campus

Description – The City of Idaho Falls is authorized by the Clean Water Act, National Pollutant Discharge Elimination System to set pretreatment standards for nondomestic wastewater discharges to publicly owned treatment works. The INL contractor facilities in Idaho Falls are required to comply with the applicable regulations in Chapter 1, Section 8 of the Municipal Code of the City of Idaho Falls.

The Industrial Wastewater Acceptance Permits for the Research and Education Campus (Idaho Falls facilities) specify special conditions and compliance schedules, prohibited discharge standards, reporting requirements, monitoring requirements, and effluent concentration limits for specific parameters.

Wastewater Monitoring Results – In 2009 the City of Idaho Falls assumed responsibility for the semiannual monitoring conducted at the Research and Education Campus. The 2011 monitoring results complied with all applicable regulations established in the municipal code. Analytical results are available upon request from the City of Idaho Falls.

5.2.2 Central Facilities Area Sewage Treatment Facility

Description – The CFA Sewage Treatment Facility serves all major buildings at CFA. The treatment facility is southeast of CFA, approximately 671 m (2,200 ft) downgradient of the nearest drinking water well.

A 1,500-L/min (400-gal/min) pump applies wastewater from a 0.2-HA (0.5-acre) lined, polishing pond to approximately 30 HA (74 acres) of sagebrush steppe grassland through a computerized center pivot irrigation system.

Wastewater Monitoring Results for the Wastewater Reuse Permit – DEQ issued a permit for the CFA Sewage Treatment Plant on March 17, 2010. The permit requires effluent monitoring and soil sampling in the wastewater land application area (soil samples are only required in 2010 and 2013). Effluent samples were collected from the pump pit (prior to the pivot irrigation system) during land application in August. All samples were collected as 24-hour flow proportional composites, except pH and coliform samples, which were collected as grab samples. Table C-1 summarizes the results.

Wastewater was intermittently applied via the center pivot irrigation system in August 2011. On the days it operated, discharge to the pivot irrigation system averaged 506,235 L/day (133,733 gal/day).

A total of 1.22 MG of wastewater was applied to the land in 2011, which is equivalent to a loading rate of 0.61 acre-in./acre/yr. This is significantly less than the permit limit of 37 MG (18.5 acre-in./acre/yr). The nitrogen loading rate (0.28 lb/acre/yr) was significantly lower than the projected maximum loading rate of 32 lb/acre/yr. Nitrogen loading should not exceed the amount necessary for crop utilization plus 50 percent. However, wastewater is applied to grassland without nitrogen removal via crop harvest. To estimate nitrogen buildup in the soil under this condition, a nitrogen balance was prepared by Cascade Earth Science, Ltd., which estimated it would take 20 to 30 years to reach normal nitrogen agricultural levels in the soil (based on a loading rate of 32 lb/acre/yr) (CES 1993). The low nitrogen loading rate had a negligible effect on nitrogen accumulation.

The annual total chemical oxygen demand loading rate at the CFA Sewage Treatment Facility (7.98 lb/acre/yr) was less than state guidelines of 50 lb/acre/day (which is equivalent to 18,250 lb/acre/yr), and the annual total phosphorus loading rate (0.05 lb/acre/yr) was below the projected maximum loading rate of 4.5 lb/acre/yr. The amount of phosphorus applied was probably removed by sorption reactions in the soil and utilized by vegetation rather than lost to groundwater.

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

5.2.3 Advanced Test Reactor Complex Cold Waste Pond

Description – The Cold Waste Pond (CWP) is located approximately 137 m (450 ft) from the southeast corner of the ATR Complex compound and approximately 1.2 km (¾ of a mile) southwest of the Big Lost River channel (Figure 5-1). The existing CWP was excavated in 1982. It consists of two cells, each with dimensions of 55 × 131 m (180 × 430 ft) across the top of the berms, and a depth of 3 m (10 ft). Total surface area for the two cells at the top of the berms is approximately 1.44 hectares (3.55 acres). Maximum capacity is approximately 10.22 MG.

Wastewater discharged to the CWP consists primarily of noncontact cooling tower blowdown, once through cooling water for air conditioning units, coolant water from air compressors, secondary system drains, and other nonradioactive drains throughout the ATR Complex. Chemicals used in the cooling tower and other effluent streams discharged to the CWP include commercial biocides and corrosion inhibitors. DEQ issued a wastewater reuse permit for the pond in February 2008.

Wastewater Monitoring Results for the Wastewater Reuse Permit – The industrial wastewater reuse permit requires monthly sampling of the effluent to the Cold Waste Pond. The permit sets monthly concentration limits for total suspended solids (100 mg/L) and total nitrogen (20 mg/L), and the results (minimum, maximum, and median) of those permit-limited parameters are shown in Table 5-3. During 2011, neither total suspended solids nor total nitrogen exceeded the permit limit. The minimum, maximum, and median results of all parameters monitored are presented in Table C-2.

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

Table 5-3. Total Nitrogen and Total Suspended Solids Effluent Monitoring Results at Advanced Test Reactor Complex Cold Waste Pond (2011).

Parameter	Minimum	Maximum	Median	Permit Limit
Total nitrogen[a] (mg/L)	1.031	3.277	1.49	20
Total suspended solids (mg/L)	4 U[b]	4 U	4 U	100

a. Total nitrogen is calculated as the sum of total Kjeldahl nitrogen and nitrate + nitrite, as nitrogen.

b. U flag indicates the result was below the detection limit.

Concentrations of sulfate and total dissolved solids are higher during reactor operation because of evaporative concentration of the corrosion inhibitors and biocides added to the reactor cooling water.

Groundwater Monitoring Results for the Wastewater Reuse Permit – To measure potential impacts from the Cold Waste Pond, the permit requires groundwater monitoring in April and October at five wells (Figure 5-1; Table C-3).

Aluminum, iron, and manganese were elevated in some of the unfiltered samples because of suspended rock fragments or rust particles in the well water. The metals concentrations in the filtered samples were below the applicable standards.

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

Description – The INTEC New Percolation Ponds are comprised of two unlined ponds excavated into the surficial alluvium and surrounded by bermed alluvial material. Each pond is 93 m × 93 m (305 ft × 305 ft) at the top of the berm and is approximately 3 m (10 ft) deep. Each pond is designed to accommodate a continuous wastewater discharge rate of 3 MG per day.

The INTEC New Percolation Ponds receive discharge of only nonhazardous industrial and municipal wastewater. Industrial wastewater (i.e., service waste) from INTEC operations consists of steam condensates, noncontact cooling water, reverse osmosis/water softener/demineralizer regenerate, boiler blowdown wastewater, and storm water. Municipal wastewater (i.e., sanitary waste) is treated at the INTEC Sewage Treatment Plant prior to discharge to the New Percolation Ponds.

The Sewage Treatment Plant is located east of INTEC, outside the INTEC security fence, and treats and disposes of sanitary and other related wastes at INTEC. The Sewage Treatment Plant depends on natural biological and physical processes (digestion, oxidation, photosynthesis, respiration, aeration, and evaporation) to treat the sanitary waste in four lagoons. After treatment in the lagoons, the effluent is combined with the service waste and discharged to the INTEC New Percolation Ponds.

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

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

As required by the permit, all samples are collected as 24-hour flow proportional composites, except pH and total coliform, which are collected as grab samples. The permit specifies the parameters that must be monitored for each location, but the permit does not set limits for any of the parameters monitored at CPP-769 or CPP-773. The monitoring results (minimum, maximum, and average) for CPP-769 and CPP-773 are presented in Tables C-4 and C-5, respectively.

The permit sets monthly concentration limits for total suspended solids (100 mg/L) and total nitrogen (20 mg/L) at the combined effluent (CPP-797), and the results of those permit-limited parameters are shown in Table 5-4. During 2011, neither total suspended solids nor total nitrogen exceeded the permit limit in the combined effluent. The minimum, maximum, and average results of all parameters monitored at the combined effluent are presented in Table C-6.

The permit specifies maximum daily and yearly hydraulic loading rates for the INTEC New Percolation Ponds. Table 5-5 shows the maximum daily flow and the yearly total flow to the INTEC New Percolation Ponds. As the table shows, the maximum daily flow and the yearly total flow to the INTEC New Percolation Ponds were below the permit limits during 2011.

Table 5-4. Total Nitrogen and Total Suspended Solids Effluent Monitoring Results at CPP-797 (2011).[a]

Parameter	Minimum	Maximum	Average[b]	Permit Limit
Total nitrogen[c] (mg/L)	1.61	6.94	3.24	20
Total suspended solids (mg/L)	2.0[d]	9.3	2.8	100

a. Duplicate samples were collected in May for nitrogen and June for total suspended solids. Duplicate results are included in the summaries.

b. Annual average is determined from the average of the monthly values. Half the reported detection limit was used in the yearly average calculation for those data reported as below the detection limit.

c. Total nitrogen is calculated as the sum of total Kjeldahl nitrogen and nitrate + nitrite, as nitrogen.

d. Sample result was less than the detection limit; value shown is half the detection limit.

Table 5-5. Hydraulic Loading Rates for Idaho Nuclear Technology and Engineering Center New Percolation Ponds (2011).

	2011 Flow	Permit Limit
Maximum daily (MG)	0.963	3
Yearly total (MG)	183.372	1,095

Groundwater Monitoring Results for the Wastewater Reuse Permit – To measure potential impacts to groundwater from the INTEC New Percolation Ponds, the permit requires that groundwater samples be collected from six monitoring wells (Figure 5-2):

- One background aquifer well (ICPP-MON-A-167) upgradient of the INTEC New Percolation Ponds.
- One background perched water well (ICPP-MON-V-191) north of the INTEC New Percolation Ponds and just south of the Big Lost River.
- Two aquifer wells (ICPP-MON-A-165 and ICPP-MON-A-166) downgradient of the INTEC New Percolation Ponds.
- Two perched water wells (ICPP-MON-V-200 and ICPP-MON-V-212) adjacent to the INTEC New Percolation Ponds. Well ICPP-MON-V-200 is north of the INTEC New Percolation Ponds, and Well ICPP-MON-V-212 is between the two ponds.

Aquifer Wells ICPP-MON-A-165 and ICPP-MON-A-166 and perched water Wells ICPP-MON-V-200 and ICPP-MON-V-212 are the permit compliance points. Aquifer Well ICPP-MON-A-167 and perched water Well ICPP-MON-V-191 are upgradient, noncompliance points.

The permit requires that groundwater samples be collected semiannually during April and October and lists which parameters must be analyzed. Contaminant concentrations in the compliance wells are limited by primary constituent standards and secondary constituent standards specified in IDAPA 58.01.11, “Ground Water Quality Rule.” All permit-required samples are collected as unfiltered samples.

Table C-7 shows the 2011 water table elevations and depth to water table, determined prior to purging and sampling, and the analytical results for all parameters specified by the permit for aquifer wells. Table C-8 presents similar information for the perched water wells. As the tables show, the majority of the permit-required parameters remained below their respective primary constituent standards or secondary constituent standards during the 2011 reporting year for all wells associated with the INTEC New Percolation Ponds. Additional information concerning groundwater concentrations for aluminum, iron, and manganese is provided in the following paragraphs.

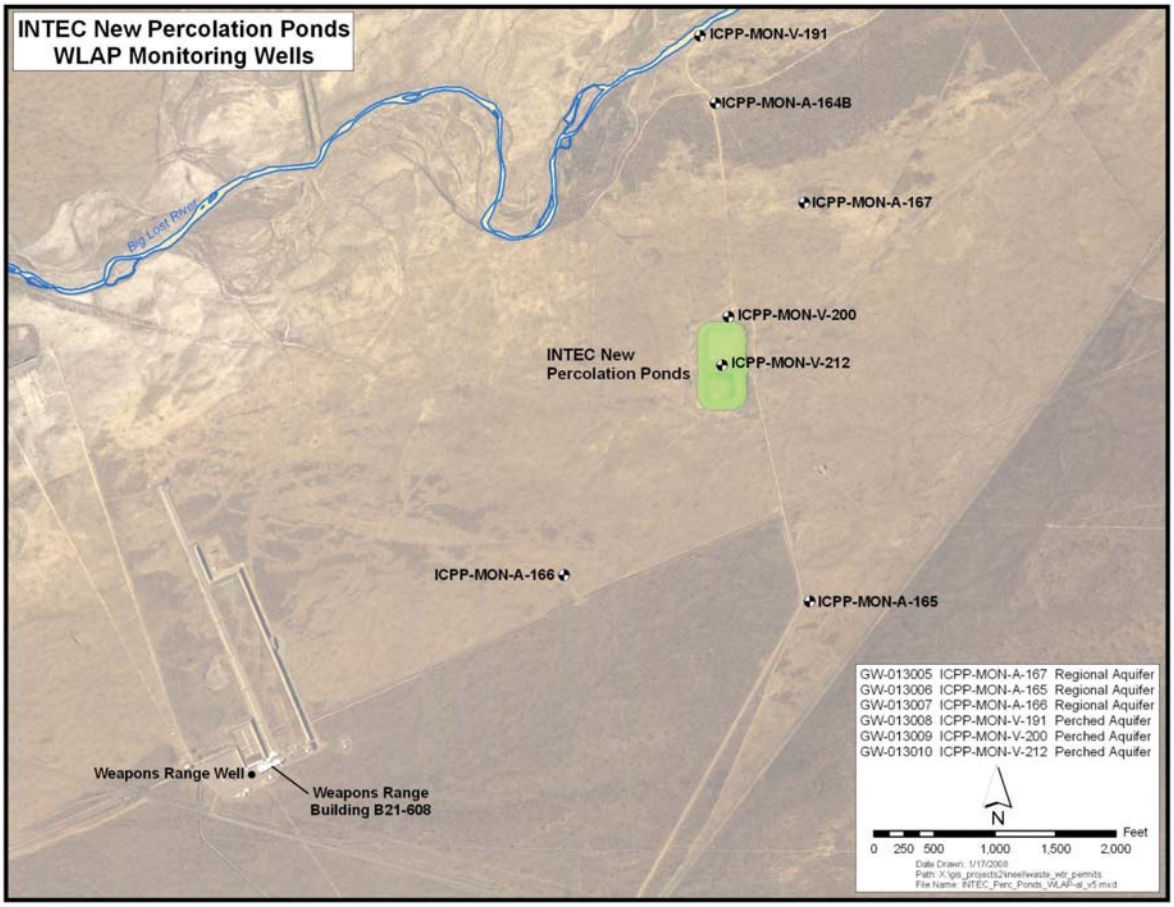

Figure 5-2. Permitted Monitoring Locations Southwest of the Idaho Nuclear Technology and Engineering Center (*Well ICPP-MON-A-164B and the Weapons Range Well are not permitted wells and are shown for location reference only*).

Exceedances of aluminum, iron, and manganese in Well ICPP-MON-A-167 occurred in April and October 2011 (see Table C-7). Aquifer Well ICPP-MON-A-167 is an upgradient, noncompliance point and, therefore, these exceedances are not considered permit noncompliances. The logbook indicated that Well ICPP-MON-A-167 had only 1.83 ft of water and was described as very muddy in April 2011, and that it had only 1.45 ft of water and described as very dirty in October 2011. Because of the low volume of water in the well, both samples were collected using a bailer. Based on this information, the elevated total aluminum, iron, and manganese concentrations in the samples collected from Well ICPP-MON-A-167 are most likely the result of metals from the collected sediment within the well and are not representative of the groundwater upgradient of the New Percolation Ponds.

The permit renewal application proposed replacing Well ICPP-MON-A-167 with Well ICPP-MON-A-164B (ICP 2009). Results of samples collected from Well ICPP-MON-A-164B in April 2011 and October 2011 are provided in Table C-7.

For the perched water wells, all groundwater results were below associated groundwater quality standards, except for exceedances of aluminum and iron, in Well ICPP-MON-V-212 in April and October 2011, and exceedances of aluminum, iron, and manganese in Well ICPP-MON-V-191 in July 2011 (see Table C-8). As required by the permit, DEQ was notified of the exceedances in Well ICPP-MON-V-212 (Hutchison 2011a, 2011b). The aluminum, iron, and manganese exceedances in Well ICPP-MON-V-191 are not permit noncompliances because this well is an upgradient noncompliance point and outside the zone of influence of the New Percolation Ponds.

Perched water Well ICPP-MON-V-191 was dry during the April and October 2011 sampling events. The water level in this well is influenced by the presence or absence of flow in the Big Lost River. From June 25, 2011, until July 13, 2011, the Big Lost River flowed in the vicinity of the Vadose Zone Research Park. Groundwater Monitoring Program personnel identified an increase in the water level in Well ICPP-MON-V-191, and samples were collected on July 6, 2011. This was only the fourth time this well has been sampled since the New Percolation Ponds began operating in August 2002. The groundwater monitoring logbook from the July 2011 sampling event indicated that 9.01 ft of water was in Well ICPP-MON-V-191 at the time of sampling. The condition of the water in this well was described as clear when purging began, but became cloudier as the purge continued over the next 19 min. The water was described as very murky and dirty by the time the samples were collected. Monitoring personnel had to use two filters to obtain the filtered (dissolved) metal sample. Based on this information, the elevated aluminum, iron, and manganese concentrations in the samples collected from Well ICPP-MON-V-191 are most likely the result of metals from the collected sediment within the well.

In 2011, concentrations of aluminum, iron, and manganese in some of the filtered samples slightly exceeded the associated secondary constituent standards. However, concentrations in the filtered samples were significantly less than those in the unfiltered samples (see Tables C-7 and C-8), indicating that the elevated metals are not in solution in the groundwater, but are associated with the sediment in the unfiltered samples being dissolved during the analytical process (e.g., acidification). In the permit renewal application, the ICP contractor proposed to base compliance with the groundwater quality standards on filtered sample results (ICP 2009).

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

Description – The wastewater reuse permit issued by DEQ for the MFC Industrial Waste Ditch and Pond became effective May 1, 2010. The MFC Industrial Waste Pond was first excavated in 1959 and has a design capacity of 285 MG at a maximum water depth of 13 ft (Figure 5-3).

Industrial wastewater discharged to the pond via the Industrial Waste Pipeline consists primarily of noncontact cooling water, boiler blowdown, cooling tower overflow, air wash flows, and steam condensate.

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

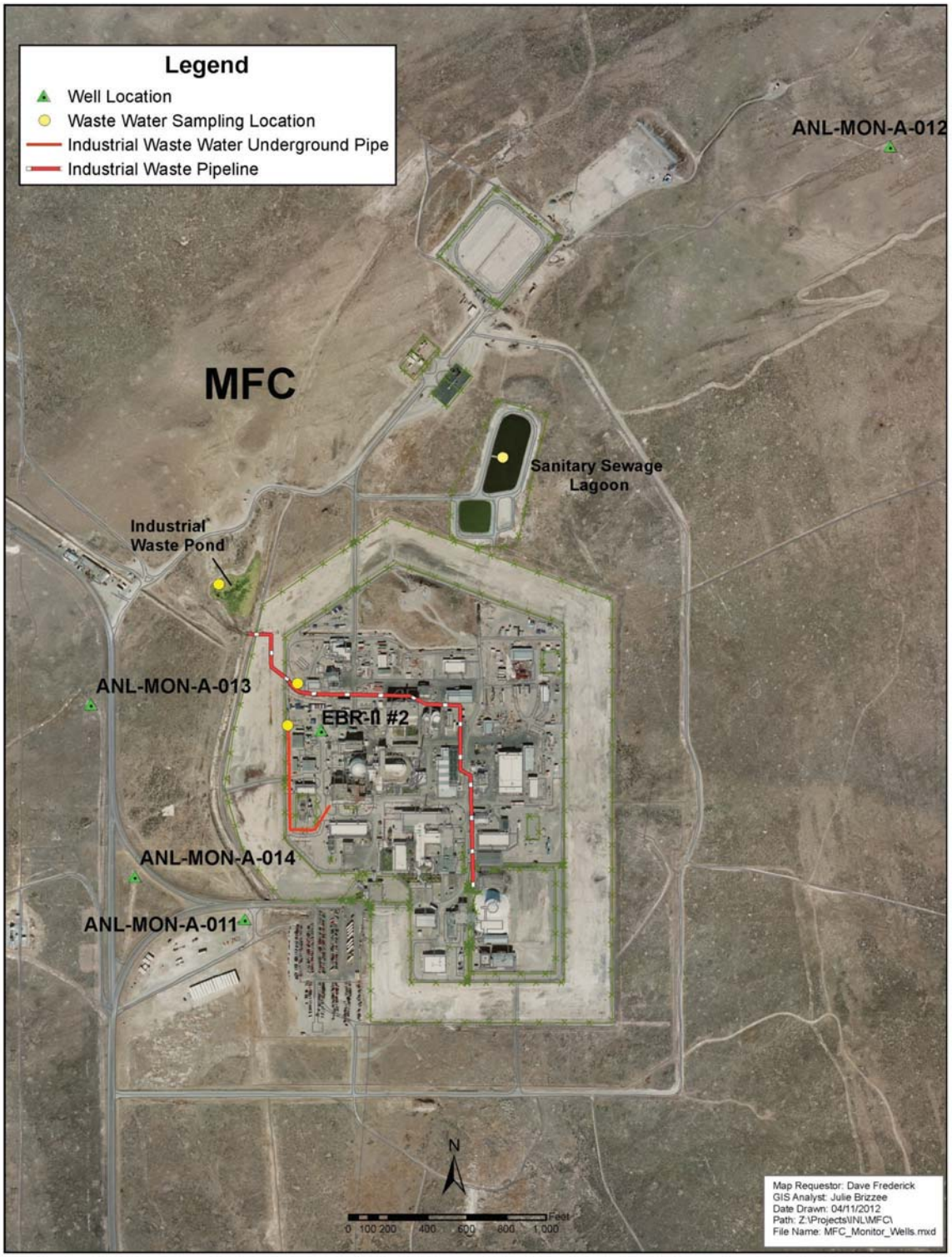

Figure 5-3. Wastewater and Groundwater Sampling Locations at the Materials and Fuels Complex.

Wastewater Monitoring Results for the Wastewater Reuse Permit – The industrial wastewater reuse permit requires monthly sampling of the effluent to the pond discharged to the Industrial Waste Pipeline. The permit requires quarterly samples of the discharge to Ditch C from the Industrial Waste Water Underground Pipe. The permit sets monthly concentration limits for total suspended solids (100 mg/L) and total nitrogen (20 mg/L), and the results of those permit-limited parameters are summarized in Tables 5-6 and 5-7. During 2011, neither total suspended solids nor total nitrogen exceeded the permit limit. The minimum, maximum, and median results of all parameters monitored for the permit are presented in Tables C-9 and C-10.

Groundwater Monitoring Results for the Wastewater Reuse Permit – To measure potential impacts from the Industrial Waste Pond, the permit requires groundwater monitoring in April/May and September/October at one upgradient and two downgradient wells (Figure 5-3).

Table 5-6. Total Nitrogen and Total Suspended Solids Effluent Monitoring Results at MFC Industrial Waste Pipeline (2011).

Parameter	Minimum	Maximum	Median	Permit Limit
Total nitrogen[a] (mg/L)	2.156	3.32	2.772	20
Total suspended solids (mg/L)	4 U[b]	8	4 U	100

a. Total nitrogen is calculated as the sum of total Kjeldahl nitrogen and nitrate + nitrite, as nitrogen.

b. U flag indicates the result was below the detection limit.

Table 5-7. Total Nitrogen and Total Suspended Solids Effluent Monitoring Results at MFC Industrial Waste Water Underground Pipe (2011).

Parameter	Minimum	Maximum	Median	Permit Limit
Total nitrogen[a] (mg/L)	4.533	5.747	4.633	20
Total suspended solids (mg/L)	4 U[b]	4 U	4 U	100

a. Total nitrogen is calculated as the sum of total Kjeldahl nitrogen and nitrate + nitrite, as nitrogen.

b. U flag indicates the result was below the detection limit.

The analytical results are summarized in Table C-11. Analyte concentrations in the downgradient wells were essentially indistinguishable from background levels in the upgradient well.

5.3 Liquid Effluent Surveillance Monitoring

The following sections discuss results of additional liquid effluent monitoring performed at each facility. As stated in Section 5.2, additional constituents of concern specified in the Idaho groundwater quality standards also are monitored. This additional monitoring is performed to comply with environmental protection objectives of DOE Orders 450.1A and 458.1.

5.3.1 Advanced Test Reactor Complex

The effluent to the Cold Waste Pond receives a combination of process water from various ATR Complex facilities. Table C-12 lists wastewater surveillance monitoring results for those parameters with at least one detected result. Radionuclides detected in groundwater samples are summarized in Table C-13. The tritium concentrations are below the Idaho groundwater primary constituent standard for tritium (20,000 pCi/L), which is the same as the Environmental Protection Agency health-based maximum contaminant level (MCL) for tritium in drinking water.

5.3.2 Central Facilities Area

The effluent from the CFA Sewage Treatment Facility is monitored according to the wastewater reuse permit. Table C-14 lists surveillance monitoring results for 2011 at the CFA Sewage Treatment Facility and shows parameters with at least one detected result during the year. The reported concentrations were consistent with historical data.

5.3.3 Idaho Nuclear Technology and Engineering Center

Table C-15 summarizes the additional monitoring conducted during 2011 at the INTEC Sewage Treatment Plant and INTEC New Percolation Ponds and shows the analytical results for parameters that were detected in at least one sample during the year. During 2011, most of the additional parameters were within their expected historical concentration levels, except for conductivity at CPP-769, and CPP-773, which were above their historical averages.

In addition, groundwater samples for radiological parameters were collected from five wells (aquifer Wells ICPP-MON-A-164B, ICPP-MON-A-165, and ICPP-MON-A-166, and perched water Wells ICPP-MON-V-200 and ICPP-MON-V-212) near the INTEC New Percolation Ponds in April and October 2011. These samples were collected to satisfy the surveillance objectives of DOE Order 450.1A. Table C-15 shows the results. The gross alpha activity was below the 15-pCi/L action level, and the gross beta activity was below the 40-pCi/L action level in all five monitoring wells.

5.3.4 Materials and Fuels Complex

The Secondary Sanitary Lagoon and Industrial Waste Pond are sampled quarterly for gross alpha, gross beta, gamma spectroscopy, and tritium. Annual samples are collected for selected isotopes of americium, cerium, iron, strontium, plutonium, and uranium (Figure 5-3). In addition, the Secondary Sanitary Lagoon is sampled annually for selected metals, nutrients, and other

parameters. Tables C-16 and C-17 summarize the results for analytes detected in at least one sample.

5.4 Drinking Water Monitoring

The INL and ICP contractors monitor drinking water to ensure it is safe for consumption and to demonstrate that it meets federal and state regulations. Drinking water parameters are regulated by the state of Idaho under authority of the Safe Drinking Water Act. Parameters with primary MCLs must be monitored at least once every 3 years. Parameters with secondary MCLs are monitored every 3 years based on a recommendation by the Environmental Protection Agency. Many parameters require more frequent sampling during an initial period to establish a baseline, and subsequent monitoring frequency is determined from the baseline results.

Currently, the INL Site has 11 drinking water systems. The INL contractor and ICP contractor monitor these systems to ensure a safe working environment. The INL contractor monitors nine of these drinking water systems, and the ICP contractor monitors two. According to the "Idaho Rules for Public Drinking Water Systems" (IDAPA 58.01.08), INL Site drinking water systems are classified as either nontransient or transient, noncommunity water systems. The five INL contractor transient, noncommunity water systems are at the Experimental Breeder Reactor I, Gun Range (Live Fire Test Range), Critical Infrastructure Test Range Complex (CITRC), Test Area North/Technical Support Facility (TAN/TSF), and the Main Gate. The four remaining INL contractor water systems are classified as nontransient, noncommunity water systems. These systems are located at CFA, MFC, ATR Complex, and TAN/Contained Test Facility (CTF). The two ICP contractor nontransient, noncommunity water systems are INTEC and the Radioactive Waste Management Complex (RWMC).

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

Because of historic or problematic contaminants in the drinking water systems, the INL contractor and the ICP contractor monitor certain parameters more frequently than required by regulation. For example, bacterial analyses are conducted monthly rather than quarterly at all nine INL contractor drinking water systems and at one ICP contractor drinking water system during months of operation. No compliance samples were positive (present) for bacteria in 2011. Because of known groundwater plumes near two INL contractor drinking water wells and one ICP contractor drinking water well, additional sampling is conducted for tritium at CFA, for trichloroethylene at TAN/TSF, and for carbon tetrachloride at RWMC.

5.4.1 INL Site Drinking Water Monitoring Results

During 2011, the INL contractor collected 293 routine samples and 16 quality control samples from the nine INL Site drinking water systems. In addition to routine samples, the INL contractor

also collected 23 nonroutine samples after a water main was repaired, a building put into service, or maintenance repairs. Drinking water systems at Experimental Breeder Reactor I, CITRC, Gun Range, MFC, ATR Complex, and TAN/CTF were well below drinking water limits for all regulatory parameters; therefore, they are not discussed further in this report. In addition, all water systems were sampled for nitrates. All water systems results were less than the reporting limit of 1.0 mg/L, except for CFA and MFC. Their results were 2.49 mg/L and 1.90 mg/L, respectively, which is less than the MCL of 10.00 mg/L.

Also, lead and copper sampling was conducted at ATR-Complex, CFA, MFC, and TAN/CTF water systems as is required once every 3 years. All results were less than the MCL of 15 ppb for lead and 1300 ppb for copper.

5.4.2 Central Facilities Area

The CFA water system serves approximately 600 people daily. Since the early 1950s, wastewater containing tritium was disposed of to the Eastern Snake River Plain Aquifer through injection wells and infiltration ponds at INTEC and the ATR Complex. This wastewater migrated south-southwest and is the suspected source of tritium contamination in the CFA water supply wells. Disposing of wastewater through injection wells was discontinued in the mid-1980s. In general, tritium concentrations in groundwater have been decreasing (Figure 5-4) because of changes in disposal techniques, diffusion, dispersion, recharge conditions, and radioactive decay.

Prior to 2007, compliance samples for the CFA water distribution system were collected semiannually from Well CFA #1 at CFA-651 and Well CFA #2 at CFA-642, and quarterly from the distribution manifold at CFA-1603. Because the results were consistently below the MCL for tritium, the INL contractor decreased the tritium sampling frequency to semiannually at CFA-1603 [manifold]) and annually at the wells.

CFA Worker Dose – Because of the potential impacts to workers at CFA from an upgradient plume of radionuclides in the Eastern Snake River Plain Aquifer, the potential effective dose equivalent from radioactivity in water was calculated. The 2011 calculation was based on the mean tritium concentration for the CFA distribution system in 2011. For the 2011 dose calculation, it was assumed that each worker's total daily water intake would come from the CFA drinking water distribution system. This assumption overestimates the actual dose because workers typically consume only about half their total intake during working hours and typically work only 240 days rather than 365 days per year. The estimated annual effective dose equivalent to a worker from consuming all their drinking water at CFA during 2011 was 0.22 mrem (2.2 μSv), below the Environmental Protection Agency standard of 4 mrem/yr for public drinking water systems.

5.4.3 Idaho Nuclear Technology and Engineering Center

Drinking water for INTEC is supplied by two wells, CPP-04 and ICPP-POT-A-012, located north of the facility. A disinfectant residual (chlorine) is maintained throughout the distribution system. Samples were collected from the point of entry to the distribution system (CPP-614) and from various buildings throughout the distribution system. During 2011, the following drinking water samples were collected at INTEC:

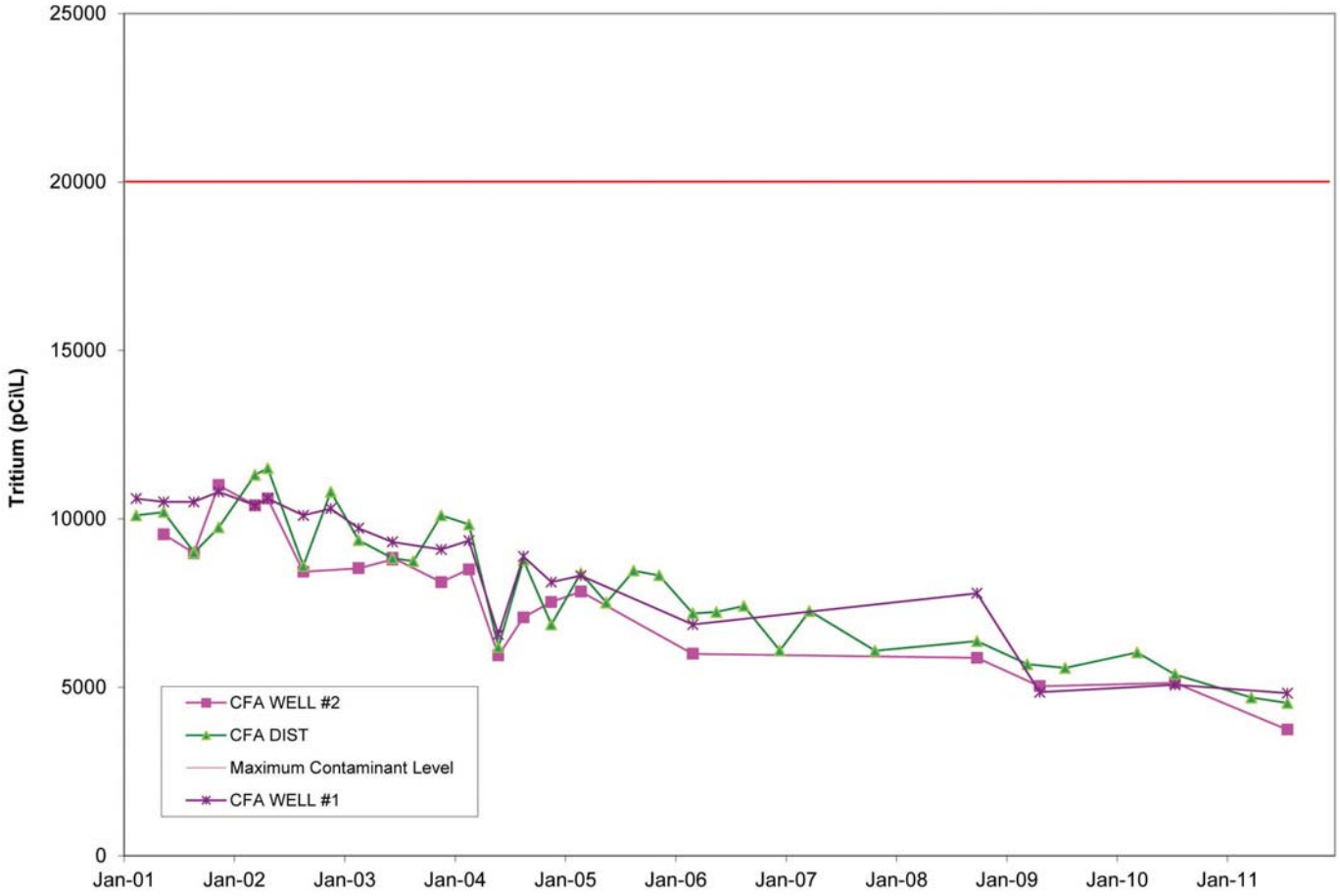

Figure 5-4. Tritium Concentrations in Two Central Facilities Area Wells and Distribution System (2001 – 2011).

- 43 routine (compliance) samples
- 13 quality control samples (eight field duplicates, two trip blanks, and three performance evaluation samples)
- 52 nonroutine samples (52 bacterial construction/special samples).

All parameters monitored at INTEC were below their respective drinking water limits in 2011.

5.4.4 Radioactive Waste Management Complex

The RWMC production well is located in Building WMF-603 and is the source of drinking water for RWMC and the Advanced Mixed Waste Treatment Project. A disinfectant residual (chlorine) is maintained throughout the distribution system. Samples were collected from the source (WMF-603), from the point of entry to the distribution system (WMF-604), and from various buildings throughout the distribution system.

During 2011, the following drinking water samples were collected at RWMC:

- 27 routine (compliance) samples
- 17 quality control samples (eight field duplicates, four trip blanks, and five performance evaluation samples)
- 44 nonroutine samples (37 bacterial construction/special samples; and seven samples for 524.2 volatile organics).

Historically, carbon tetrachloride had been detected in samples collected at the WMF-603 Production Well (Figure 5-5). In July 2007, a packed tower air stripping treatment system was placed into operation to treat the water. During 2011, carbon tetrachloride was not detected (<0.5 µg/L) in any of the samples collected at the WMF-604 point of entry to the distribution system.

All other RWMC-monitored parameters were below their respective drinking water limits in 2011.

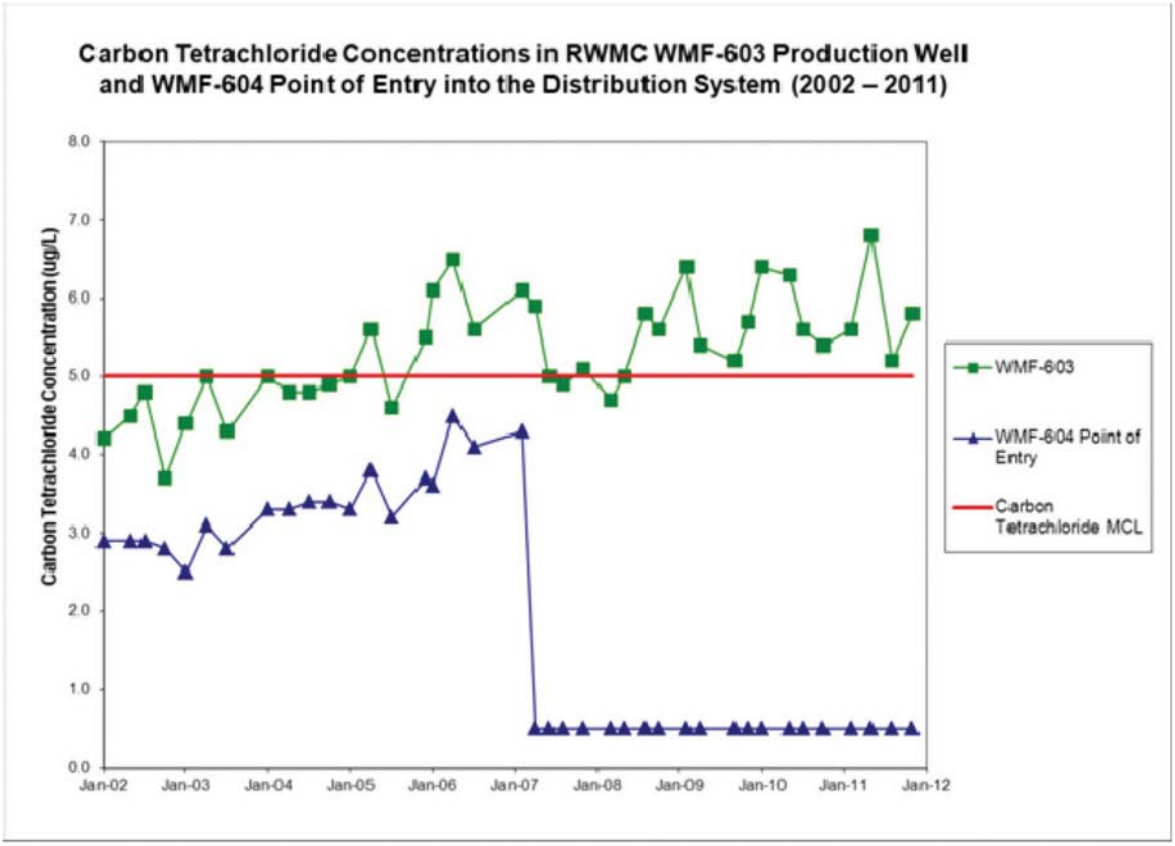

Figure 5-5. Carbon Tetrachloride Concentrations in RWMC WMF-603 Production Well and WMF-604 Point of Entry into the Distribution System (2002 – 2011).

5.4.5 Test Area North/Technical Support Facility

Well TSF #2 supplies drinking water to less than 25 employees at TSF. The facility is served by a chlorination system. TSF #2 is sampled for surveillance purposes only (not required by regulations), and the distribution system is the point of compliance (required by regulations).

In the past, trichloroethylene contamination has been a concern at TSF. The principal source of this contamination was an inactive injection well (TSF-05). Although regulations do not require sampling Well TSF #2, samples are collected to monitor trichloroethylene concentrations due to the historical contamination. Since mid-2006, concentrations appear to be declining, but this will have to be confirmed with the collection of additional data.

Figure 5-6 illustrates the trichloroethylene concentrations in both Well TSF #2 and the distribution system from 2001 through 2011. Table 5-8 summarizes the trichloroethylene concentrations at TSF #2 and the distribution system. The mean concentration at the distribution system for 2011 was less than the reporting limit of 0.5 µg/L.

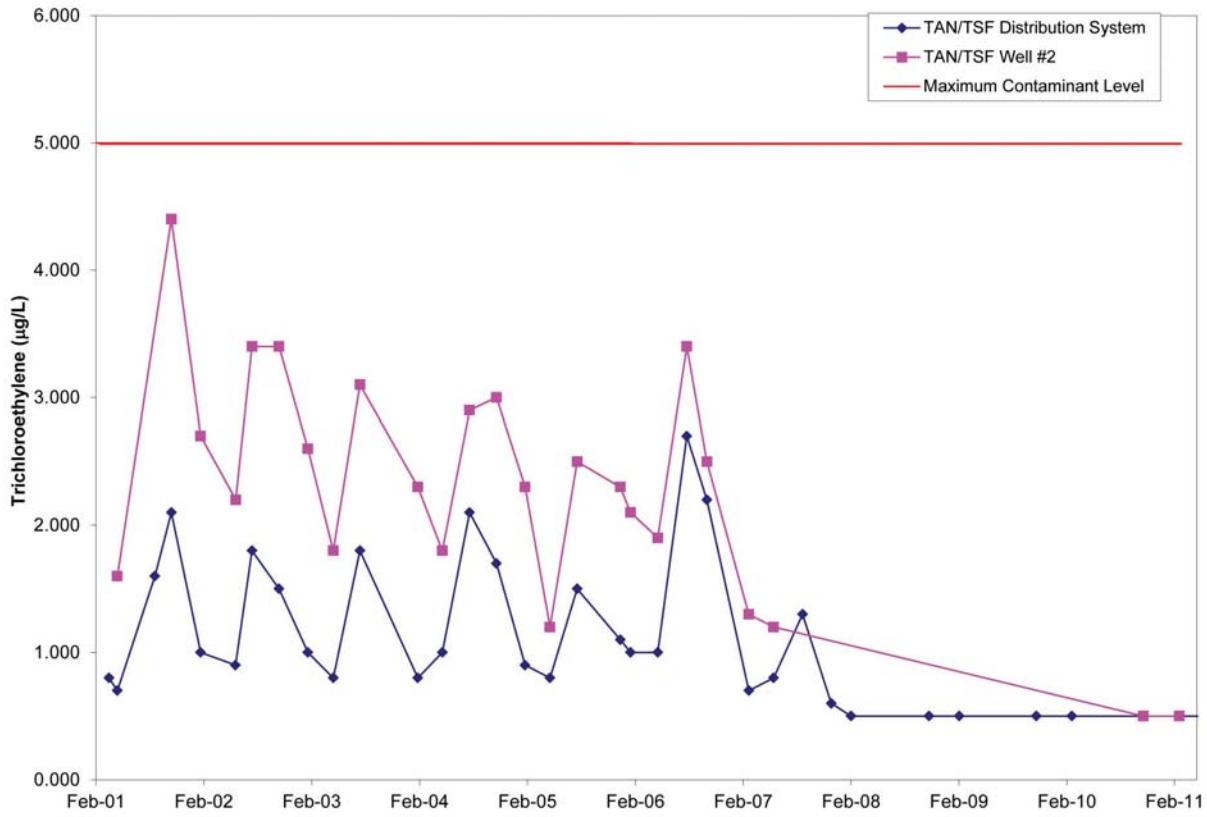

Figure 5-6. Trichloroethylene Concentrations in Technical Support Facility Drinking Water Well and Distribution System (2001 – 2011).

Table 5-8. Trichloroethylene Concentrations at Test Area North/Technical Support Facility Well #2 and Distribution System (2011).

Location	Number of samples	Trichloroethylene Concentration (µg/L)			
		Minimum	Maximum	Mean	MCL[b]
TAN/TSF #2 (612)[a]	1	<0.5	<0.5	<0.5	NA[c]
TAN/TSF Distribution (610)	2	<0.5	<0.5	<0.5	5.0

a. Since regulations do not require sampling at this well and there was no detection at TAN-610, TAN #2 well was not sampled in 2009.

b. MCL = Maximum contaminant level (see Table A-3).

c. NA = Not applicable. Maximum contaminant level applies to the distribution system only.

5.5 Waste Management Surveillance Surface Water Sampling

In compliance with DOE Order 435.1, the ICP contractor collects surface water runoff samples at the RWMC Subsurface Disposal Area (SDA) from the location shown in Figure 5-7. Near the end of 2009, a lift station was installed, and the sampling point is now at the lift station. Surface water is collected to determine if radionuclide concentrations exceed administrative control levels or if concentrations have increased significantly compared to historical data. A field blank is also collected for comparison. Because of changes in the area and the change to the lift station as the sampling point, samples were collected monthly the first quarter during 2011 and then quarterly during the remaining 2011 to more closely monitor these changes.

Radionuclides could be transported outside the RWMC boundaries via surface water runoff. Surface water runs off the SDA only during periods of rapid snowmelt or heavy precipitation. At these times, water may be pumped out of the SDA retention basin into a drainage canal, which directs the flow outside RWMC. The canal also carries runoff from outside RWMC that has been diverted around the SDA.

Samples collected were sent to ALS Laboratory Group, Fort Collins, Colorado, for analysis. Table 5-9 summarizes the specific alpha and beta results of human-made radionuclides. No human-made gamma-emitting radionuclides were detected. The americium-241 and plutonium-239/240 concentrations are approximately the same as those detected in 2010 and are well below the applicable DOE derived concentration standards and MCLs. There were no positive detections of plutonium-238 during 2011. The ICP contractor will closely monitor quarterly during 2012, when water is available, and evaluate the results to identify any abnormal trends or the need to change sampling frequency.

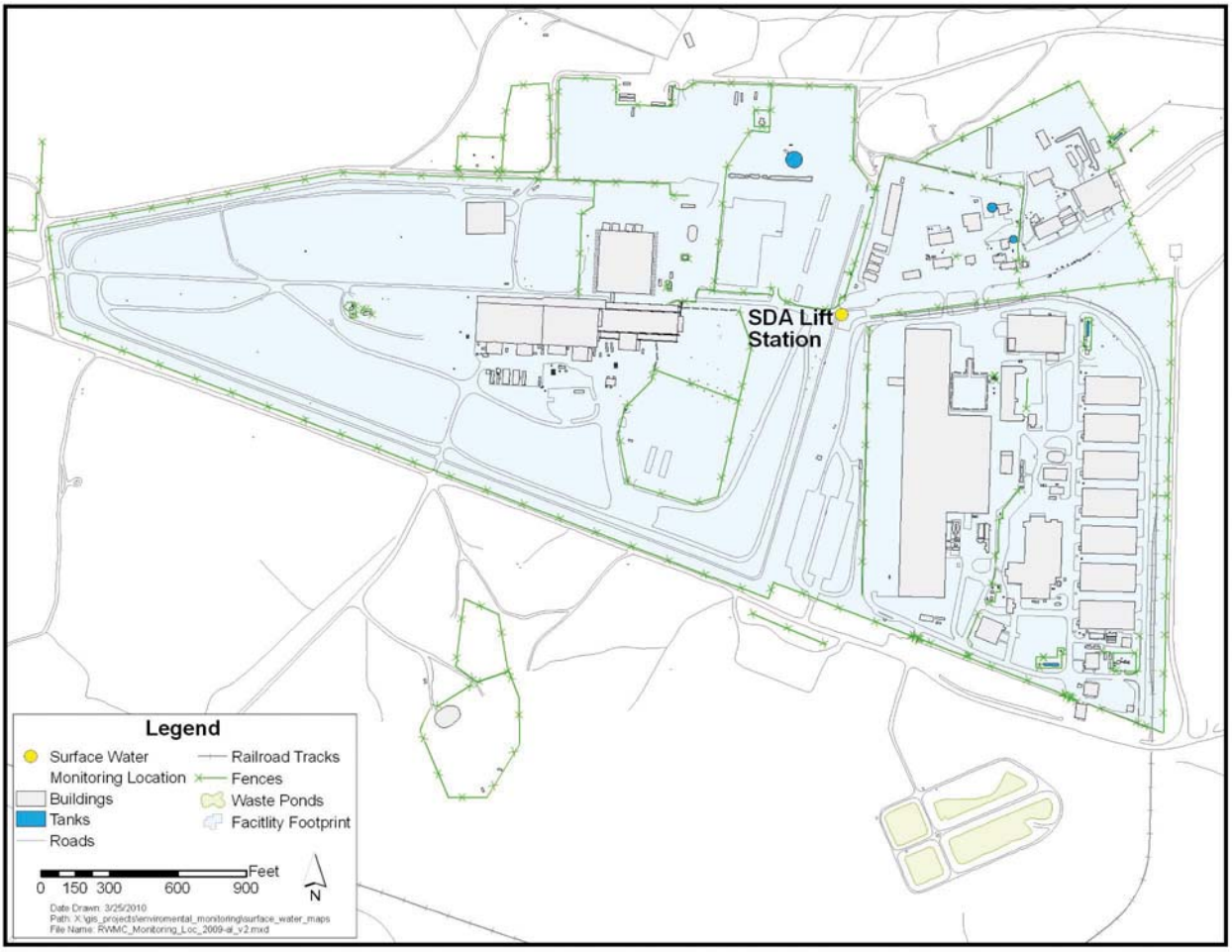

Figure 5-7. Surface Water Sampling Location at RWMC Subsurface Disposal Area.

Table 5-9. Radionuclides Detected in Surface Water Runoff at the RWMC Subsurface Disposal Area (2011).

Parameter	Maximum Concentration[a] (pCi/L)	% Derived Concentration Standard[b]
Americium-241	2.25 ± 0.18	1.32
Plutonium-239/240	1.73 ± 0.26	1.24
Strontium-90	1.08 ± 0.15	0.01

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

b. See Table A-2.

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IDAPA 58.01.11, 2011, "Ground Water Quality Rule," Idaho Administrative Procedures Act, Idaho Department of Environmental Quality.

IDAPA 58.01.16, 2011, "Wastewater Rules," Idaho Administrative Procedures Act, Idaho Department of Environmental Quality.

IDAPA 58.01.17, 2011, "Rules for the Reclamation and Reuse of Municipal and Industrial Wastewater," Idaho Administrative Procedures Act, Idaho Department of Environmental Quality.

INL, 2012a, *2011 Annual Wastewater Reuse Report for the Idaho National Laboratory Site's Central Facilities Area Sewage Treatment Plant*, INL/EXT-11-24269, Idaho National Laboratory.

INL, 2012b, *2011 Annual Industrial Wastewater Reuse Report for the Idaho National Laboratory Site's Advanced Test Reactor Complex Cold Waste Pond*, INL/EXT-12-24337, Idaho National Laboratory.

INL, 2012c, *2011 Annual Industrial Wastewater Reuse Report for the Idaho National Laboratory Site's Materials and Fuels Complex Industrial Waste Ditch and Industrial Waste Pond*, INL/EXT-12-24452, Idaho National Laboratory.

2011

Chapter 6. Environmental Monitoring Program - Eastern Snake River Plain Aquifer

Chapter 6 Highlights

One potential pathway for exposure from contaminants released at the Idaho National Laboratory (INL) Site is through the groundwater pathway. Historic waste disposal practices have produced localized areas of chemical and radiochemical contamination beneath the INL Site. These areas are regularly monitored by the U.S. Geological Survey (USGS) and reports are published showing the extent of contamination plumes. Results for some monitoring wells within the plumes show decreasing concentrations of tritium and strontium-90 over the past 20 years. The decrease is probably the result of radioactive decay, discontinued disposal, dispersion, and dilution within the aquifer.

Several purgeable organic compounds continue to be found by the USGS in monitoring wells, including drinking water wells, at the INL Site. The concentration of tetrachloromethane (carbon tetrachloride) was above the U.S. Environmental Protection Agency maximum contaminant level during 11 of 12 months of 2011 in one well monitored by the USGS, and concentrations have increased with time in that well. Concentrations of five other purgeable organic compounds that were detected were below maximum contaminant levels and state of Idaho groundwater primary constituent standards for these constituents. Concentrations of chloride, nitrate, sodium, and sulfate are above background concentrations in many wells, but are below the applicable standards. The chromium result in one well that had concentrations above the maximum contaminant level in the past was below the maximum contaminant level in 2011.

Groundwater surveillance monitoring required in area-specific Records of Decision under the Comprehensive Environmental Response, Compensation, and Liability Act was performed in 2011.

At Test Area North (TAN), in situ bioremediation is used to reduce the concentration of volatile organic compounds in the aquifer. The strategy is to promote the growth of naturally occurring bacteria that are able to break down organic compounds. Monitoring data for 2011 indicate the remedy is reducing the concentration of these compounds in most of the wells in the groundwater plume at TAN.

Data collected from seven groundwater wells in the vicinity of the Advanced Test Reactor Complex show declining concentrations of chromium, strontium-90, and tritium. Chromium and tritium levels have declined faster than modeling predicted.

Groundwater collected from 14 monitoring wells at the Idaho Nuclear Technology and Engineering Center indicated strontium-90 concentrations exceeded the maximum contaminant level at nine well locations sampled. Technitium-99 and nitrate also exceeded the maximum contaminant level in at least one well. Other constituents measured were all below maximum contaminant levels.

Monitoring of groundwater for the Central Facilities Area landfills consists of sampling seven wells for metals, volatile organic compounds, and anions and two wells for volatile organic compounds. Iron and aluminum were detected above the secondary maximum contaminant level in two landfill wells. Five organic compounds were detected in groundwater downgradient of the Central Facilities Area (CFA) landfills, but all were below established maximum contaminant levels. Four wells were also sampled downgradient of the CFA for nitrate to monitor a nitrate plume. The nitrate concentration in one well exceeded its maximum contaminant level in 2011, but the concentration was within historic levels.

At the Radioactive Waste Management Complex (RWMC), nearly 3,800 analyses were performed in 2011 for radionuclides, inorganic constituents, volatile organic compounds, and 1,4-dioxane. Carbon tetrachloride slightly exceeded the maximum contaminant level in one well north of the RWMC during one month, but the average concentration was below the maximum contaminant level for the first time since 1998.

Drinking water and springs were sampled by the Environmental Surveillance, Education, and Research contractor in the vicinity of the INL Site and analyzed for gross alpha and gross beta activity, and tritium. Results were consistent with historical measurements and do not indicate any impact from historical INL Site releases. The Big Lost River was also sampled twice in 2011 and results do not implicate any contamination from the INL Site.

6. ENVIRONMENTAL MONITORING PROGRAM – EASTERN SNAKE RIVER PLAIN AQUIFER AND OFFSITE SURFACE WATER

This chapter discusses the hydrogeology of the Idaho National Laboratory (INL) Site and presents results from eastern Snake River Plain aquifer studies conducted by the Idaho National Laboratory (INL) contractor, Idaho Cleanup Project (ICP) contractor, and the U.S. Geological Survey (USGS). Results are compared for informational design to the following:

- State of Idaho groundwater primary constituent standards (Idaho Administrative Procedures Act [IDAPA] 58.01.11)
- State of Idaho secondary constituent standards (IDAPA 58.01.11)
- U.S. Environmental Protection Agency (EPA) health-based maximum contaminant levels (MCLs) for drinking water (40 CFR 141)

- U.S. Department of Energy (DOE) Derived Concentration Standards for ingestion of water (DOE Order 458.1).

Results also are reviewed to determine compliance with all the applicable regulatory guidelines, and if exceedances are reported, all stakeholders and regulatory agencies are notified so appropriate actions can be addressed.

Finally, this chapter presents the Environmental Surveillance, Education, and Research (ESER) contractor's surface water and offsite drinking water monitoring results.

6.1 Summary of Monitoring Programs

The USGS INL Project Office performs groundwater monitoring, analyses, and studies of the eastern Snake River Plain aquifer under and adjacent to the INL Site. USGS utilizes an extensive network of strategically placed monitoring wells on the INL Site (Figures 6-1 and 6-2) and at locations throughout the Eastern Snake River Plain. Chapter 3, Section 3.1, summarizes the USGS routine groundwater surveillance program. In 2011, USGS personnel collected and analyzed about 1,300 samples for radionuclides and inorganic constituents, including trace elements and approximately 40 samples for purgeable organic compounds. USGS uses the National Water Quality Laboratory and the Radiological and Environmental Sciences Laboratory for analyses of samples.

As detailed in Chapter 3, Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) activities at the INL Site are divided into 10 Waste Area Groups (WAGs) (Figure 6-3). Each WAG addresses specific groundwater contaminants. WAG 10 has been designated as the INL Site-wide WAG and addresses the combined impact of the individual contaminant plumes. As individual records of decision are approved for each WAG, many of the groundwater monitoring activities are turned over to the Long-Term Stewardship Program to consolidate monitoring activities.

The Environmental Surveillance, Education, and Research (ESER) contractor collects drinking water samples off the INL Site, as well as samples from natural surface waters. This includes the Big Lost River, which occasionally flows through the INL Site, and springs downgradient of the INL Site.

Table 6-1 presents the various groundwater, drinking water, and surface water monitoring activities performed on and around the INL Site. Details may be found in the *Idaho National Laboratory Environmental Monitoring Plan* (DOE-ID 2010a).

6.2 Hydrogeology of the Idaho National Laboratory Site

The INL Site occupies approximately 2,300 km^2 (890 mi^2) at the northwestern edge of the eastern Snake River Plain, with the INL Site boundaries coinciding with the Mud Lake sub-basin and the Big Lost Trough. The eastern Snake River Plain aquifer was formed by a unique sequence of tectonic, volcanic, and sedimentologic processes associated with the migration of

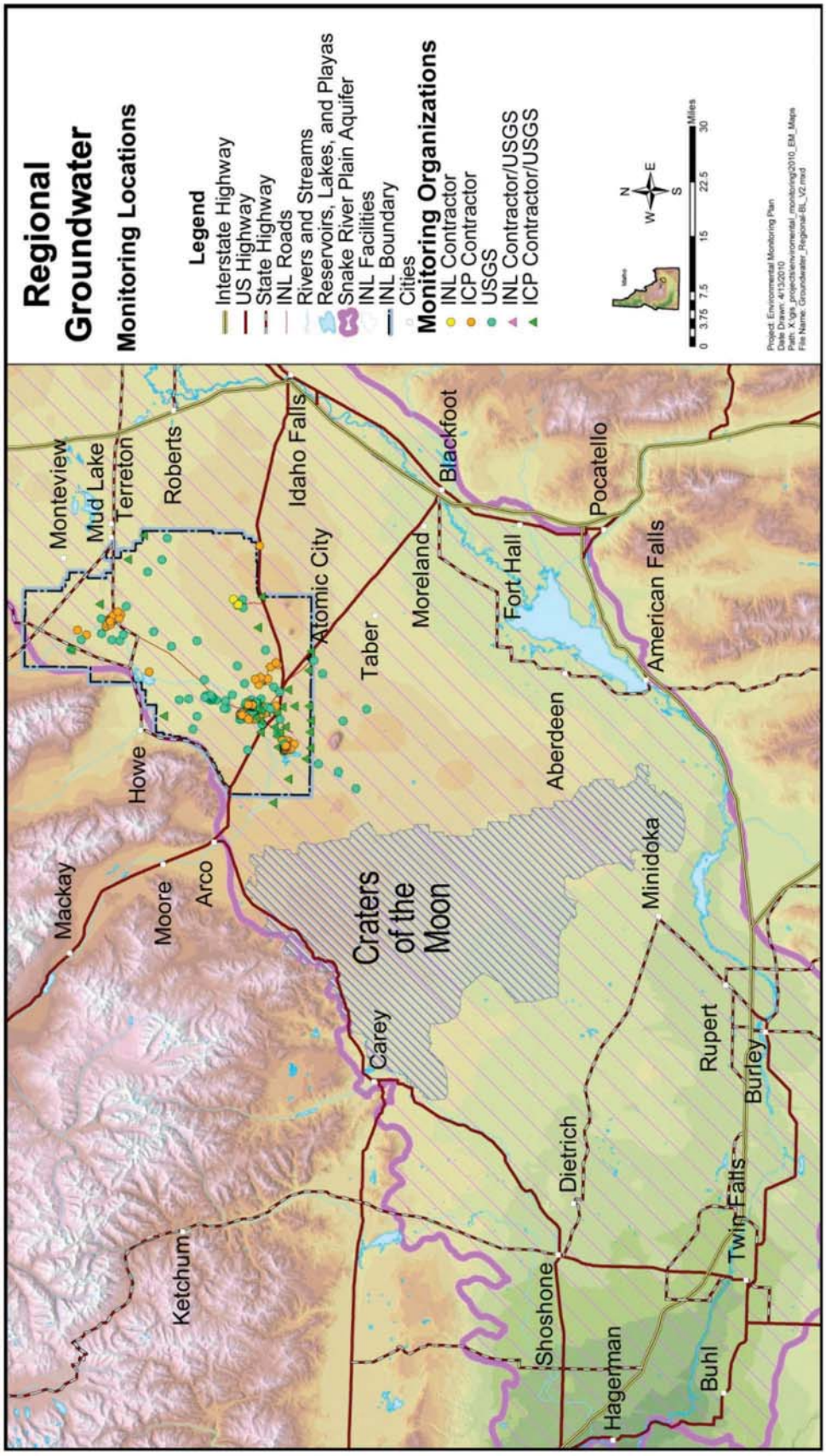

Figure 6-1. Regional Groundwater Monitoring Locations.

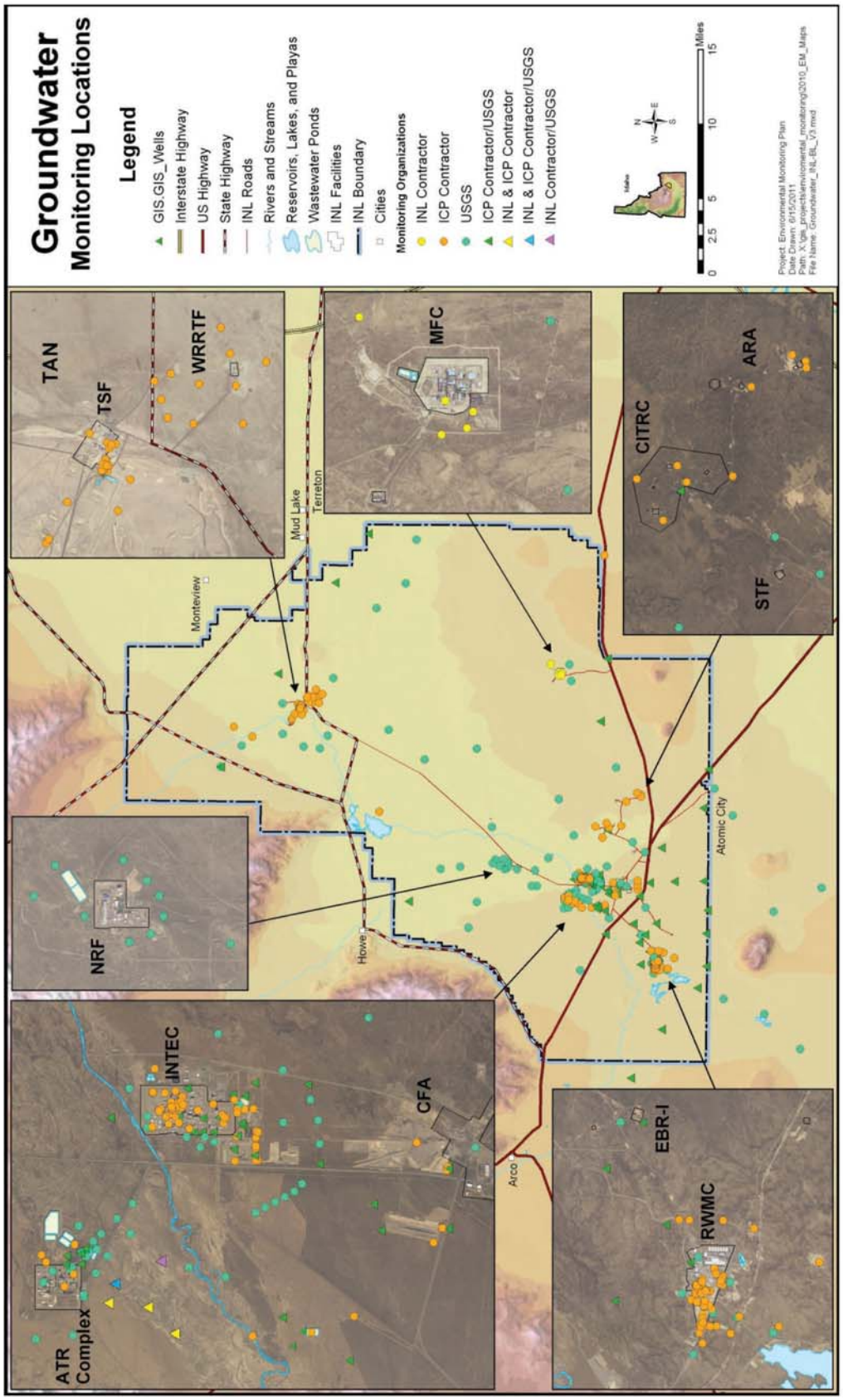

Figure 6-2. Idaho National Laboratory Site Groundwater Monitoring Locations.

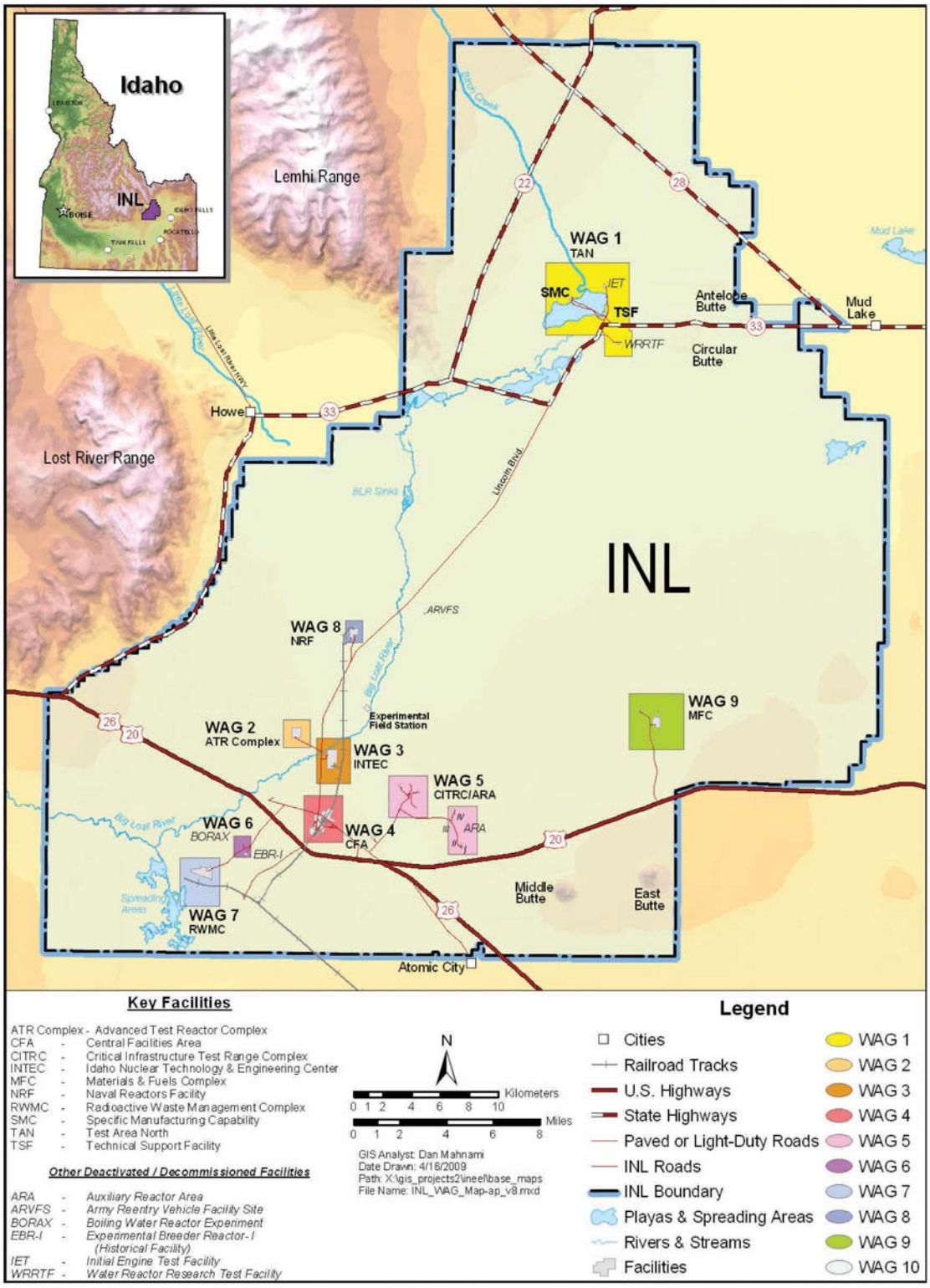

Figure 6-3. Map of the Idaho National Laboratory Site Showing Locations of Facilities and Corresponding Waste Area Groups.

Table 6-1. Monitoring of the Eastern Snake River Plain Aquifer and Surface Water on and Around the INL Site.

Area/Facility	Monitoring Activity				
	Groundwater Quality (Radiological)	Groundwater Quality (Nonradiological)	CERCLA Groundwater Monitoring	Offsite Drinking Water[a]	Surface Water[b]
ICP Contractor					
Advanced Test Reactor Complex			•		
Central Facilities Area			•		
Idaho Nuclear Technology and Engineering Center			•		
Power Burst Facility/Critical Infrastructure Test Range Complex			•		
Test Area North			•		
Radioactive Waste Management Complex			•		
INL Contractor					
Materials and Fuels Complex			•		
Environmental Surveillance, Education, and Research Program					
				•	•
U.S. Geological Survey					
INL Site/Distant	•	•			

a. Compliance monitoring of INL Site drinking water is discussed in Chapter 5. Results of surveillance of drinking water samples collected off the INL Site are reported in this chapter.

b. Liquid effluent, waste pond, and surface water runoff monitoring is addressed in Chapter 5. Surveillance of natural surface waters (rivers and springs) by the Environmental Surveillance, Education, and Research Program is presented in this chapter. Surface water samples are also collected by the regional office of the U.S. Geological Survey (see http://id.water.usgs.gov/projects/INL/monitor.html) but are not discussed in this report.

the North American tectonic plate southwestward across the Yellowstone hot spot, or mantle plume (Geslin et al. 1999). Most of the basalt lava flows that host the aquifer and comprise the overlying vadose zone are very porous and permeable due to emplacement processes and fracturing during cooling. Rubble zones between lava flows and cooling fractures allow very rapid flow of water in the saturated zone, rapid infiltration of water and contaminants, and deep penetration of air into the vadose zone. Alluvial, eolian, and lacustrine sediments interbedded within the basalt sequence are generally fine-grained, commonly serving as aquitards below the water table, and affecting infiltration and contaminant transport in the vadose zone (Smith 2004).

The subsiding Eastern Snake River Plain and the high elevations of the surrounding recharge areas comprise a large drainage basin that receives enormous amounts of precipitation and feeds high quality groundwater into the aquifer. A northeast–southwest-directed extension of the Eastern Snake River Plain produces significant anisotropy to the hydraulic conductivity of the rocks (Smith 2004).

The Big Lost Trough receives sediment primarily from Basin and Range fluvial systems of the Big Lost River, Little Lost River, and Birch Creek. The Big Lost Trough contains a more-than-200-m (650-ft) -thick succession of lacustrine, fluvial, eolian, and playa sediments, recording high-frequency Quaternary climatic fluctuations interbedded with basalt flows. Alternating deposition of clay-rich lacustrine sediments and sandy fluvial and eolian sediments in the central part of the basin was in response to the interaction of fluvial and eolian systems with Pleistocene Lake Terreton, which also, in part, is responsible for the modern day Mud Lake.

Numerous studies suggest the hydraulic gradient of the eastern Snake River Plain aquifer is to the south/southwest (Figure 6-4), with velocities ranging from 0.5 to 6.1 m/day (2 to 20 ft/day). This velocity is much faster than most studied aquifers and is attributed to the Eastern Snake River Plain architecture and porous media.

6.3 Hydrogeologic Data Management

Over time, hydrogeologic data at the INL Site have been collected by a number of organizations, including USGS, current and past contractors, and other groups. The INL Site Hydrogeologic Data Repository maintains and makes the data generated by these groups available to users and researchers.

The ICP Site Sample and Analysis Management Program was established to provide consolidated environmental sampling activities and analytical data management. The Sample and Analysis Management Program provides a single point of contact for obtaining analytical laboratory services and managing cradle-to-grave analytical data records.

The USGS data management program involves putting all data in the National Water Information System, which is available on the internet at: http://waterdata.usgs.gov/id/nwis/qw.

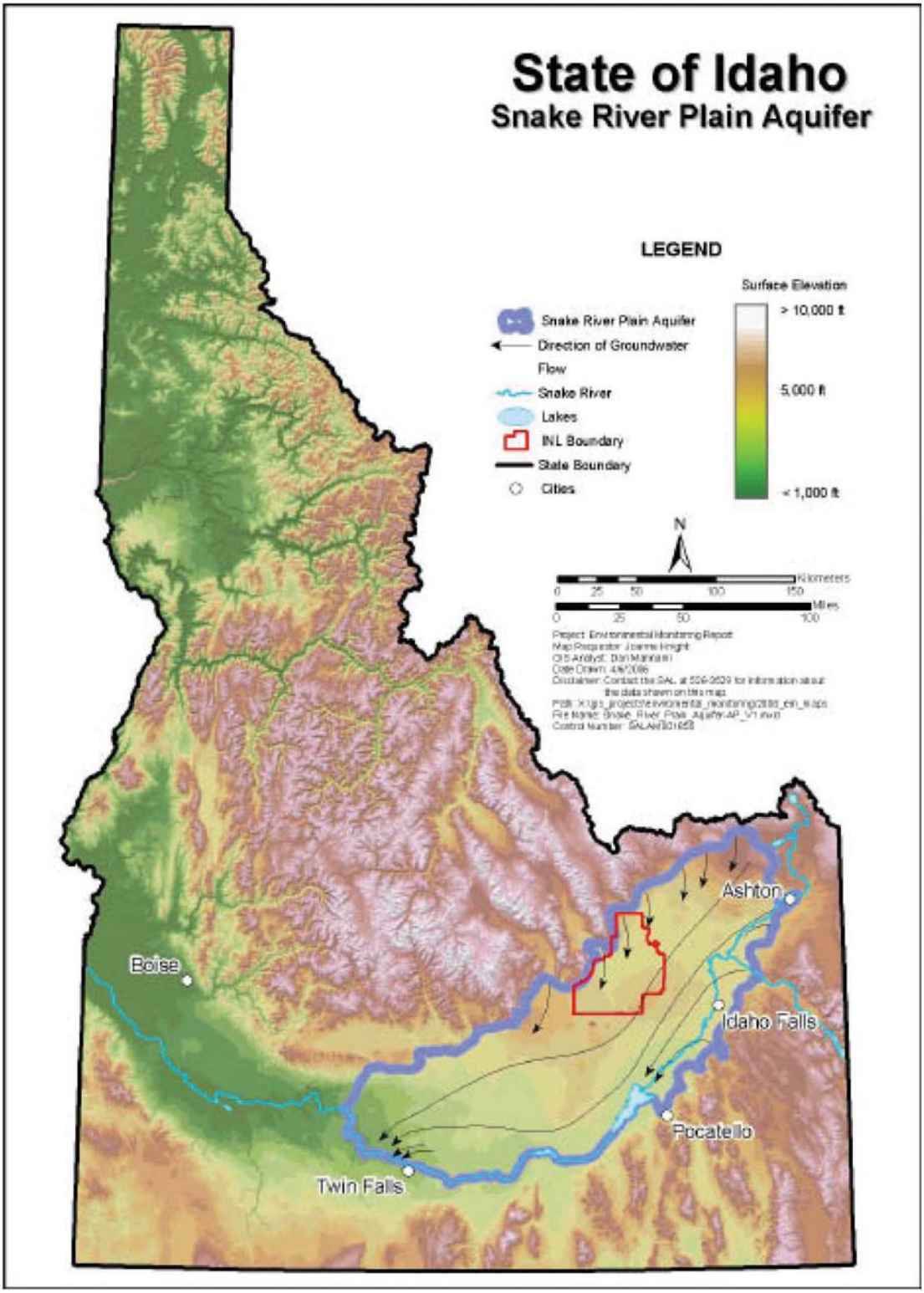

Figure 6-4. Location of the Idaho National Laboratory Site in Relation to the Eastern Snake River Plain Aquifer.

6.4 Aquifer Studies of the Idaho National Laboratory Site and the Eastern Snake River Plain Aquifer

The eastern Snake River Plain aquifer serves as the primary source for drinking water and crop irrigation in the Upper Snake River Basin. A description of the hydrogeology of the INL Site and water movement in the aquifer is given in Section 6.2. Further information may be found in numerous USGS publications. Some of these publications can be accessed at http://id.water.usgs.gov/projects/INL/pubs.html or requested from the USGS INL Project Office by calling (208) 526-2438. During 2011, USGS INL Project Office personnel published four documents covering hydrogeologic conditions at the INL Site, on the eastern Snake River Plain aquifer, and in other areas of interest around the world. The abstracts to these reports are presented in Chapter 9.

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

Historic waste disposal practices have produced localized areas of radiochemical contamination in the eastern Snake River Plain aquifer beneath the INL Site. The Idaho Nuclear Technology and Engineering Center (INTEC) used direct injection as a disposal method up to 1984. This wastewater contained elevated concentrations of tritium, strontium-90 (^{90}Sr), and iodine-129 (^{129}I). Injection at INTEC was discontinued in 1984 and the injection well was sealed in 1989. When direct injection ceased, INTEC wastewater was directed to shallow percolation ponds, where the water infiltrated into the subsurface. Disposal of low- and intermediate-level radioactive waste solutions to the percolation ponds ceased in 1993 with the installation of the Liquid Effluent Treatment and Disposal Facility. The old percolation ponds were taken out of service to be closed, and the new INTEC percolation ponds went into operation in August 2002.

The Advanced Test Reactor (ATR) Complex, formerly known as the Test Reactor Area and the Reactor Technology Complex, also had a disposal well but primarily discharged contaminated wastewater to a shallow percolation pond. The ATR Complex pond was replaced in 1993 by a flexible, plastic (Hypalon®)-lined evaporative pond, designed to prevent radioactive wastewater from reaching groundwater.

The average combined rate of tritium wastewater disposed of at ATR Complex and INTEC was highest from 1952 to 1983 (910 Ci/yr), decreased during 1984 to 1991 (280 Ci/yr), and continued to decrease during 1992 to 1995 (107 Ci/yr). From 1952 to 1998, the INL Site disposed of about 93 Ci of ^{90}Sr at ATR Complex and about 57 Ci at INTEC. Wastewater containing ^{90}Sr was never directly discharged to the aquifer at ATR Complex; however, at INTEC, a portion of the ^{90}Sr was injected directly to the aquifer. From 1996 to 1998, the INL Site disposed of about 0.03 Ci of ^{90}Sr to the INTEC infiltration ponds (Bartholomay et al. 2000). An additional 18,100 Ci of ^{90}Sr was reported to have leaked at the INTEC Tank Farm (Cahn et al. 2006).

Presently, ^{90}Sr is the only radionuclide that continues to be detected by the ICP contractor and USGS above the primary constituent standard in some surveillance wells between INTEC and Central Facilities Area (CFA). Other radionuclides (e.g., gross alpha) have been detected above their primary constituent standard in wells monitored by individual WAGs.

Tritium – Because tritium is equivalent in chemical behavior to hydrogen, a key component of water, it has formed the largest plume of any of the radiochemical pollutants at the INL Site. The configuration and extent of the tritium contamination area, based on the most recent published USGS data (2008), are shown in Figure 6-5 (Davis 2010). The area of contamination within the 0.5-pCi/L contour line decreased from about 103 km^2 (40 mi^2) in 1991 to about 52 km^2 (20 mi^2) in 1998 (Bartholomay et al. 2000).

The area of elevated tritium concentrations near CFA likely represents water originating at INTEC some years earlier when larger amounts of tritium were disposed. This source is further supported by the fact that there are no known sources of tritium contamination to groundwater at CFA.

Two monitoring wells downgradient of ATR Complex (USGS-065) and INTEC (USGS-077) have continually shown the highest tritium concentrations in the aquifer over time (Figure 6-6). For this reason, these two wells are considered representative of maximum concentration trends in the rest of the aquifer. The average tritium concentration in USGS-065 near ATR Complex decreased from 5,190 pCi/L in 2010 to 4,400 pCi/L in 2011; the tritium concentration in USGS-077 south of INTEC decreased from 4,290 pCi/L in 2010 to 3,490 pCi/L in 2011.

The Idaho primary constituent standard for tritium (20,000 pCi/L) in groundwater is the same as the EPA MCL for tritium in drinking water. The values in both Wells USGS-065 and USGS-077 dropped below this limit in 1997 as a result of radioactive decay (tritium has a half-life of 12.3 years), ceased tritium disposal, advective dispersion, and dilution within the aquifer.

Strontium-90 – The configuration and extent of ^{90}Sr in groundwater, based on the latest published USGS data, are shown in Figure 6-7 (Davis 2010). The contamination originates from INTEC from historic injection of wastewater. No ^{90}Sr was detected by USGS in the eastern Snake River Plain aquifer near ATR Complex during 2011. All ^{90}Sr at ATR Complex was disposed of to infiltration ponds in contrast to the direct injection that occurred at INTEC. At ATR Complex, ^{90}Sr is retained in surficial sedimentary deposits, interbeds, and perched groundwater zones. The area of ^{90}Sr contamination from INTEC is approximately the same as it was in 1991.

The ^{90}Sr trend over the past 20 years (1991 – 2011) in Wells USGS-047, USGS-057 and USGS-113 is shown in Figure 6-8. Concentrations in Well USGS-047 have varied through time but indicate a general decrease. Concentrations in Wells USGS-057 and USGS-113 also have generally decreased through this period. The general decrease is probably the result of radioactive decay (^{90}Sr has a half-life of 29.1 years), discontinued ^{90}Sr disposal, advective dispersion, and dilution within the aquifer. The variability of concentrations in some wells was thought to be due, in part, to a lack of recharge from the Big Lost River that would dilute the ^{90}Sr. Other reasons also may include increased disposal of other chemicals into the INTEC percolation ponds that may have changed the affinity of ^{90}Sr on soil and rock surfaces, causing it to become more mobile (Bartholomay et al. 2000).

Summary of other USGS Radiological Groundwater Monitoring – USGS collects samples annually from select wells at the INL Site for gross alpha, gross beta, gamma

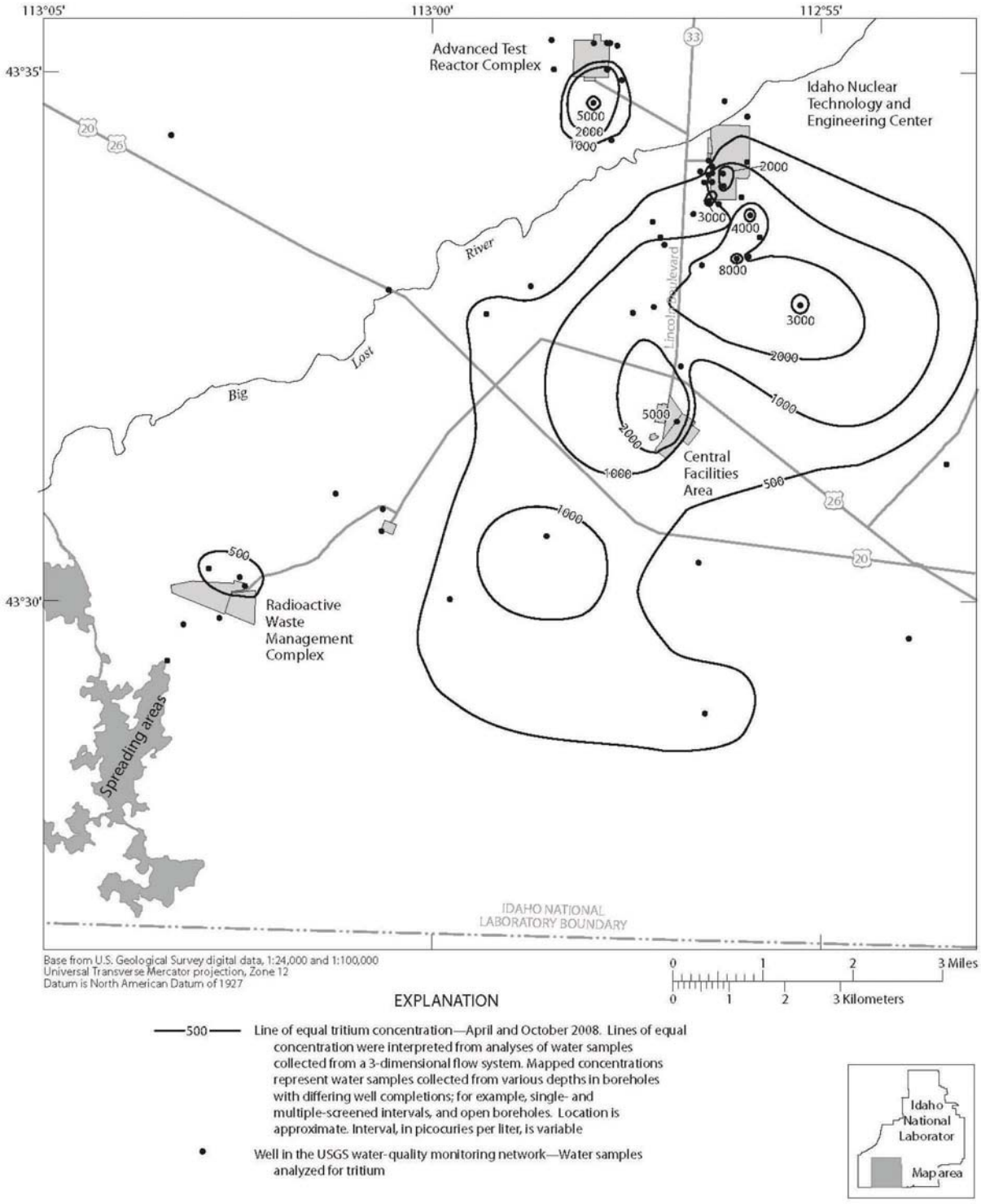

Figure 6-5. Distribution of Tritium in the eastern Snake River Plain Aquifer on the Idaho National Laboratory Site in 2008 (from Davis 2010).

spectroscopy analyses, and plutonium and americium isotopes (Table 3-6). Results for wells sampled in 2011 are available at http://waterdata.usgs.gov/id/nwis/. Monitoring results for 2006 – 2008 are summarized in Davis (2010). During 2006 – 2008, concentrations of cesium-137 (^{137}Cs), plutonium-238, plutonium-239/240, and americium-241 in all samples analyzed were less than the reporting level. During 2006-07, concentrations of gross-alpha particle radioactivity in 58 wells sampled were less than the reporting level. In 2008, reportable concentrations of gross alpha radioactivity were observed in 24 of the 58 wells and ranged from 2.3 +/-0.7 to 6.6 +/-1.3 pCi/L. The change in the amount of reportable concentrations was attributed to increasing the sensitivity of the analyses and changing the radionuclide reported for gross alpha radioactivity (Davis, 2010). Beta particle radioactivity exceeded the reporting level in 37 of 58 wells sampled, and concentrations ranged from 2.8 +/-0.9 to 21.6+/-1.8 pCi/L (Davis 2010).

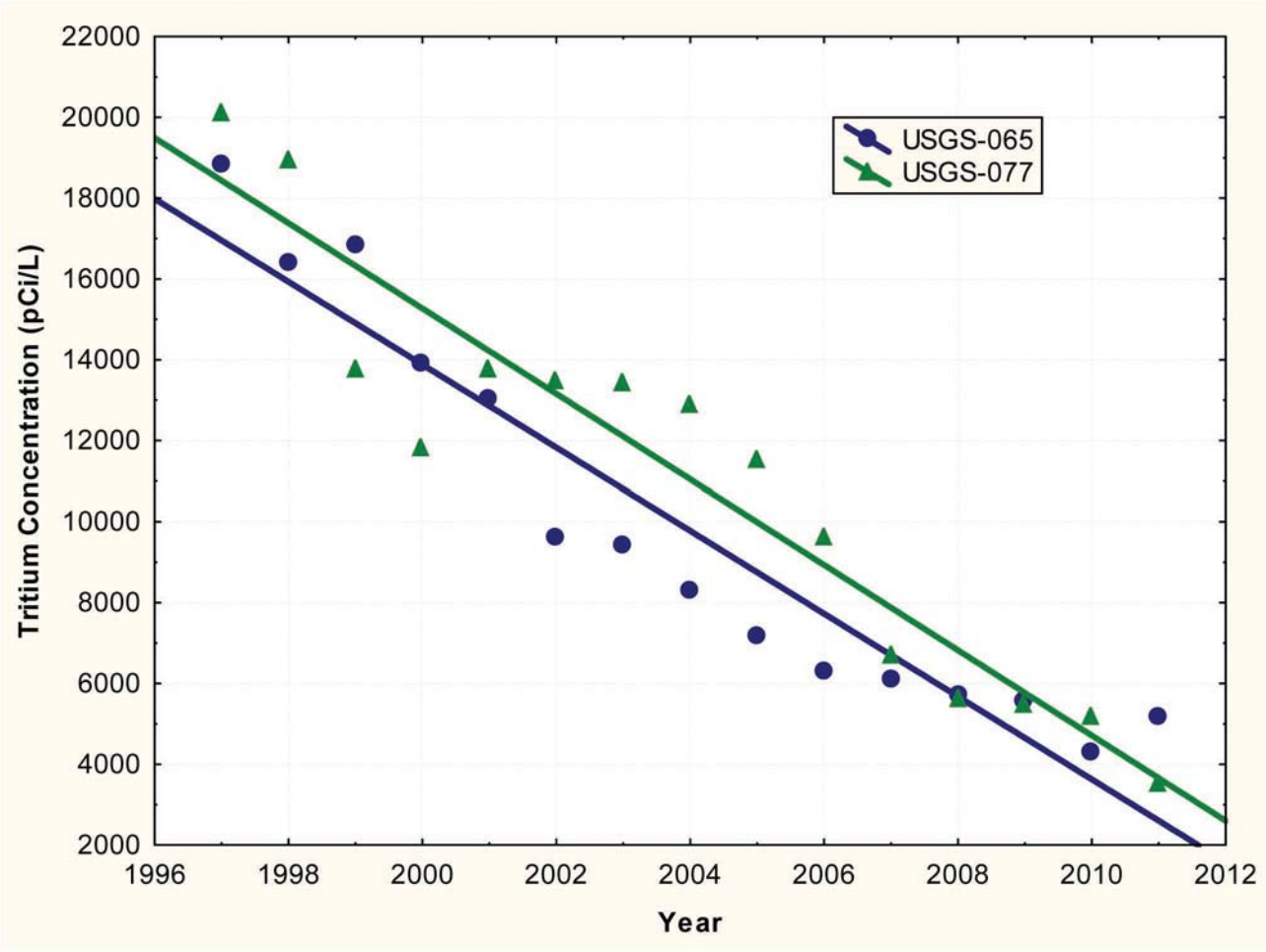

Figure 6-6. Long-Term Trend of Tritium in Wells USGS -065 and -077 (1997 – 2011).

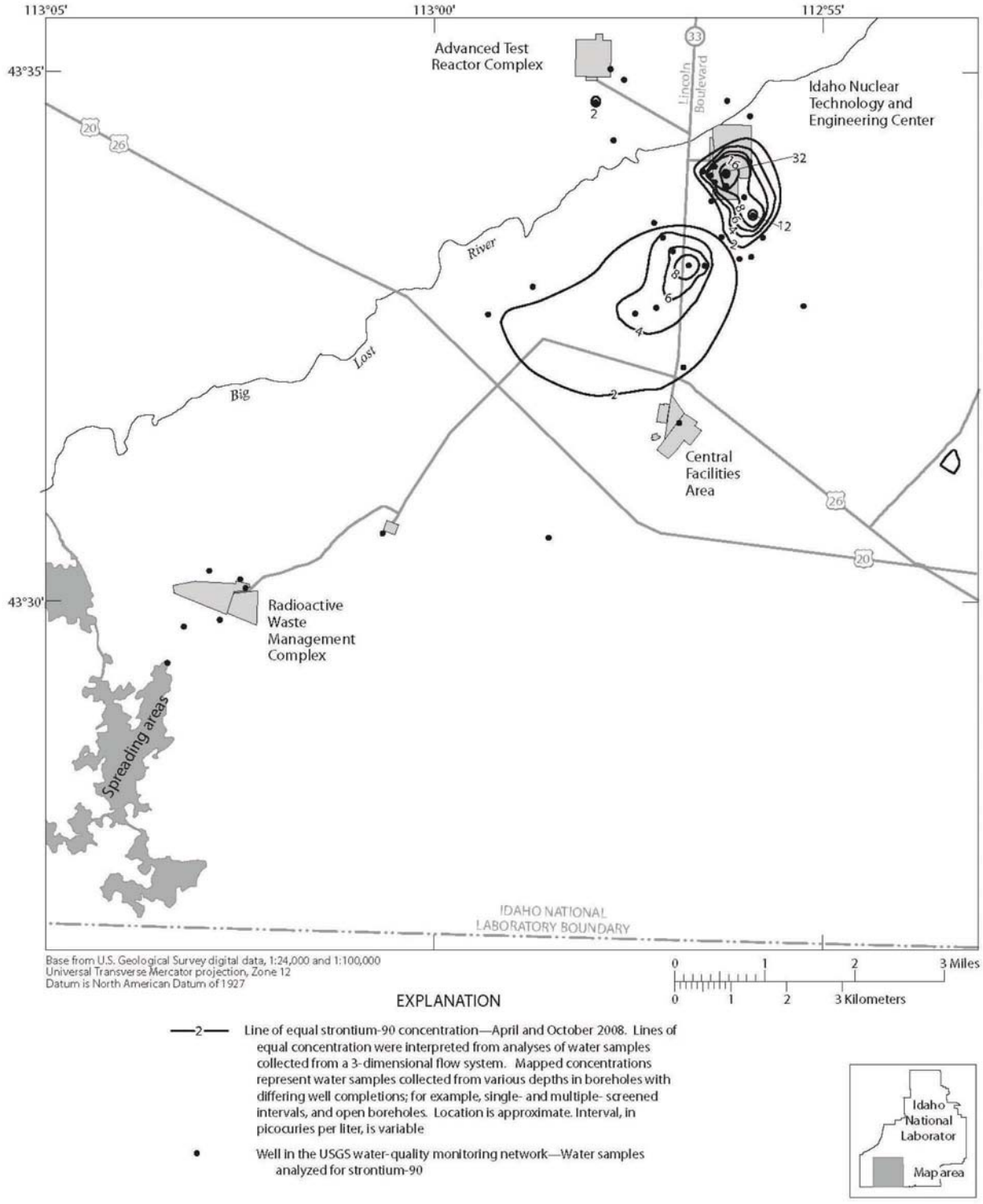

Figure 6-7. Distribution of Strontium-90 in the Eastern Snake River Plain Aquifer on the Idaho National Laboratory Site in 2008 (from Davis 2010).

USGS periodically has sampled for ^{129}I in the Snake River Plain aquifer, and monitoring programs from 1977, 1981, 1986 and 1990 – 1991 were summarized in Mann et al. (1988) and Mann and Beasley (1994). USGS evaluated results from samples collected in 2003 and 2007, and Bartholomay (2009) discusses the results. The USGS sampled for ^{129}I in wells at the INL in the fall of 2011 and results will be published in a future USGS report. Average concentrations of 19 wells sampled in 1990 – 1991, 2003, and 2007 decreased from 0.975 pCi/L in 1990 – 1991 to 0.25 pCi/L in 2007. The maximum concentration in 2007 was 1.16 ± 0.04 pCi/L, which exceeded the drinking water MCL (1 pCi/L). The average concentrations of the 19 wells sampled in 2003 and 2007 did not differ; however, slight increases and decreases of concentrations in several areas around INTEC were evident in the aquifer. The decreases are attributed to the discontinued disposal and to dilution and dispersion in the aquifer. The increases may be due to movement of remnant perched water below INTEC. The configuration and extent of ^{129}I in groundwater, based on the 2007 USGS data (most current to date), are shown in Figure 6-9 (Bartholomay 2009).

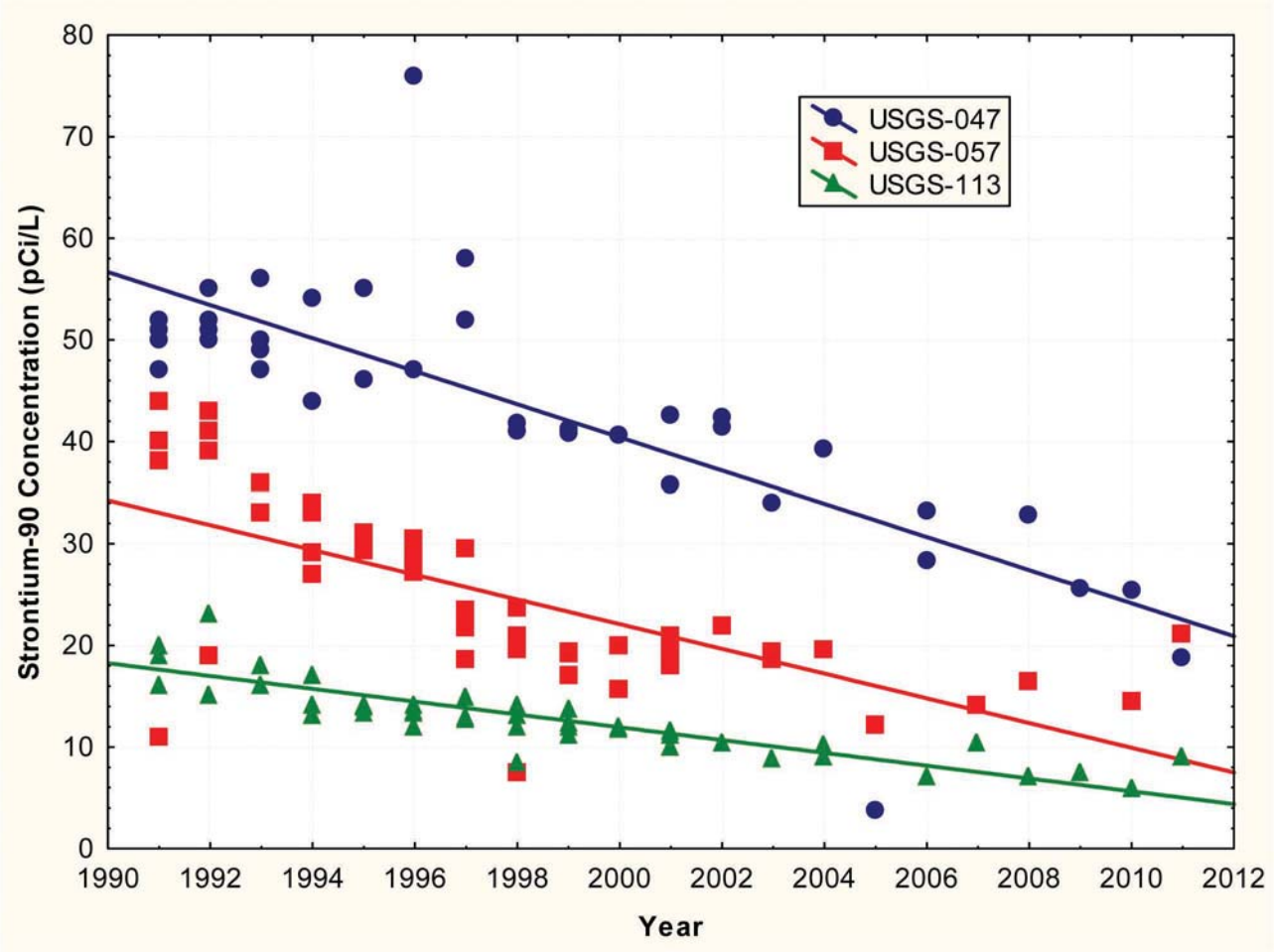

Figure 6-8. Long-Term Trend of Strontium-90 in Wells USGS-047,-057 and -113 (1991 – 2011).

6.6 U.S. Geological Survey Nonradiological Groundwater Monitoring at the Idaho National Laboratory Site

USGS collects samples annually from select wells at the INL Site for chloride, sulfate, sodium, fluoride, nitrate, chromium and selected other trace elements, total organic carbon, and purgeable organic compounds (Table 3-6). Davis (2010) provides a detailed discussion of results for samples collected during 2006 – 2008. Chromium had a concentration at the MCL of 100

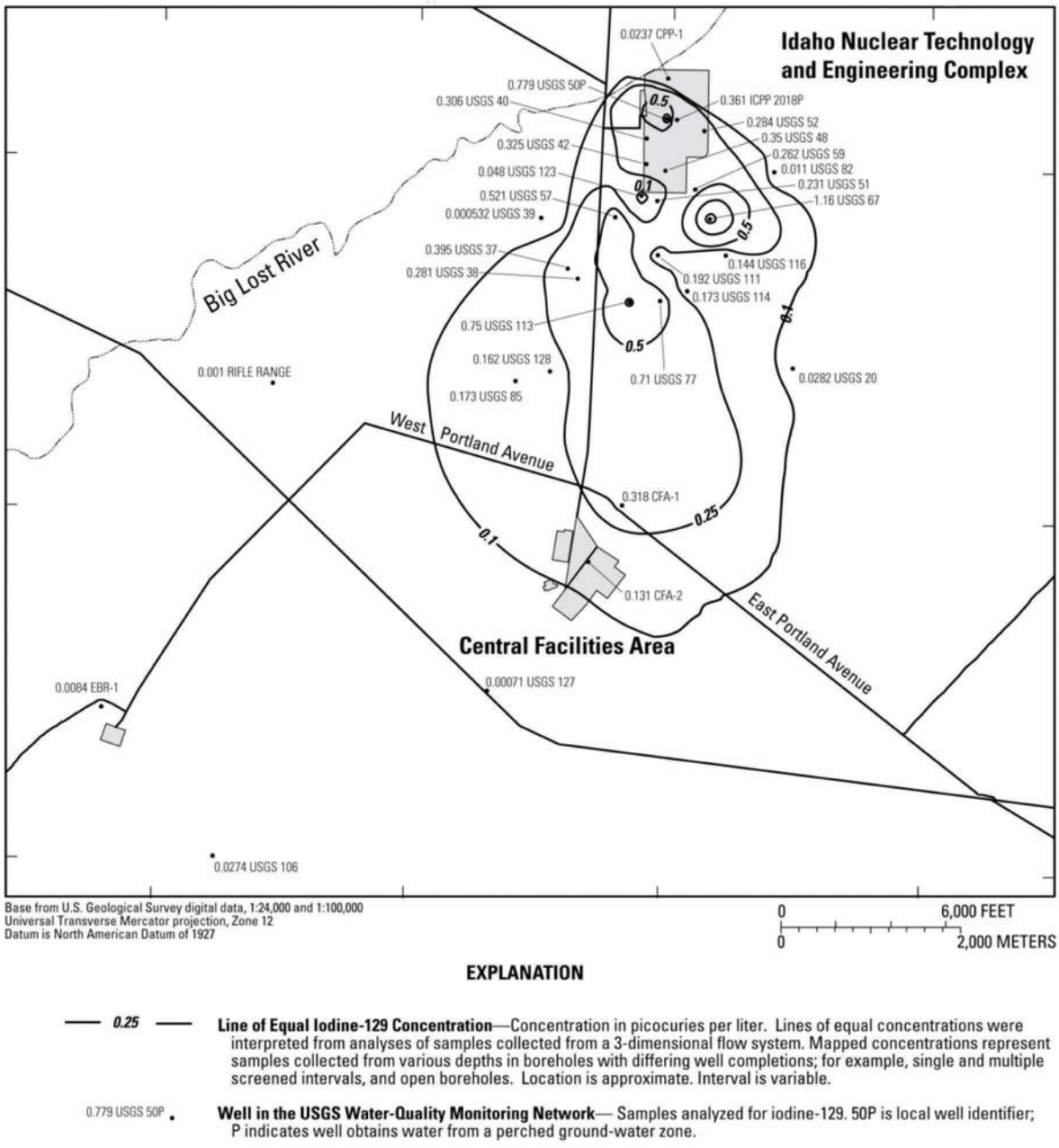

Figure 6-9. Distribution of Iodine-129 in the Snake River Plain Aquifer on the Idaho National Laboratory Site in 2007 (from Bartholomay 2009).

µg/L in Well 65 in 2005 (Davis 2008) and 2009, but its concentration dropped below the MCL in 2011 to 97 µg/L. Concentrations of chloride, nitrate, sodium, and sulfate historically have been above background concentrations in many wells at the INL Site, but concentrations were below established MCLs or secondary maximum contaminant levels in all wells during 2008 (Davis 2010).

USGS sampled for purgeable (volatile) organic compounds (VOC) in groundwater at the INL Site during 2011. Samples from 30 groundwater monitoring wells were collected and submitted to the USGS National Water Quality Laboratory in Lakewood, Colorado, for analysis of 61 purgeable organic compounds. USGS reports describe the methods used to collect the water samples and ensure sampling and analytical quality (Mann 1996; Bartholomay et al. 2003; Knobel et al. 2008). Six purgeable organic compounds were detected above the laboratory reporting level of 0.2 or 0.1 µg/L in at least one well on the INL Site (Table 6-2). The production well at the Radioactive Waste Management Complex (RWMC) is monitored monthly, and concentrations of tetrachloromethane (also known as carbon tetrachloride) exceeded the EPA MCL of 5 µg/L 11 of the 12 months in 2011 (Table 6-3). Tetrachloromethane also exceeded the MCL in well USGS 87 (Table 6-2). None of the other measured constituents were above their respective primary constituent standard. Annual average concentrations of tetrachloromethane in the production well at RWMC generally have increased through time (Davis 2010).

Table 6-2. Purgeable Organic Compounds in Annual U.S. Geological Survey Well Samples (2011).

Constituent	USGS-065	USGS-087	USGS-088	USGS-120
Tetrachloromethane (µg/L) (MCL=5)[a]	ND[b]	5.07	0.579	0.653
Trichloromethane (µg/L)	ND	0.306	0.392	ND
1,1,1-Trichloroethane (µg/L) (PCS=200)[c]	0.106	0.216	ND	ND
Tetrachloroethene (µg/L) (MCL=5)	ND	0.154	ND	ND
Toluene (µg/L) (MCL=1000)	ND	ND	0.162	ND
Trichloroethene (µg/L) (PCS=5)	ND	1.03	0.434	ND

a. MCL = maximum contaminant level from Environmental Protection Agency in micrograms per liter (40 CFR 141).
b. ND = not detected.
c. PCS = primary constituent standard values from IDAPA 58.01.11.

Table 6-3. Purgeable Organic Compounds in Monthly Production Well Samples at the Radioactive Waste Management Complex (2011).

Constituent	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Tetrachloromethane (μg/L) (MCL=5)[a]	6.56	8.10	6.77	6.42	7.45	9.93	8.62	8.11	4.95	5.67	6.35	7.27
Trichloromethane (μg/L) (MCL=100)[b]	1.88	2.09	1.73	2.75	2.46	2.46	1.86	1.41	2.02	2.48	2.25	2.10
Tetrachloroethene (μg/L) (PCS=5)[c]	0.301	0.328	0.322	0.404	0.385	0.407	0.368	0.283	0.299	0.378	0.400	0.401
1,1,1-Trichloroethane (μg/L) (PCS=200)	0.415	0.519	0.436	0.615	0.527	0.501	0.426	0.338	0.536	0.491	0.424	0.496
Trichloroethene (μg/L) (PCS=5)	3.40	3.99	3.44	4.77	4.75	4.49	3.86	2.88	3.91	4.57	4.18	3.91

a. MCL = maximum contaminant level values from the Environmental Protection Agency (40 CFR 141).

b. The MCL for total trihalomethanes is 100 μg/L This MCL is based on concentrations of bromodichloromethane, dibromochloromethane, tribromomethane and trichloromethane.

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

6.7 Comprehensive Environmental Response, Compensation, and Liability Act Groundwater Monitoring During 2011

CERCLA activities at the INL Site are divided into WAGs that roughly correspond to the major facilities, with the addition of the INL Site-wide WAG 10. Locations of the various WAGs are shown on Figure 6-3. The following subsections provide an overview of groundwater sampling results. More detailed discussions of the CERCLA groundwater sampling can be found in the WAG-specific monitoring reports within the CERCLA Administrative Record at http://ar.inel.gov. WAG 8 is managed by the Naval Reactors Facility and is not discussed in this report.

6.7.1 Summary of Waste Area Group 1 Groundwater Monitoring Results

Groundwater is monitored at WAG 1 to measure the progress of the remedial action at Test Area North (TAN). The groundwater plume at TAN has been divided into three zones for the three different remedy components. In 2011, the groundwater monitoring plans for the three remedy components were consolidated into one plan (DOE-ID 2011). The monitoring program and the results are summarized by zone in the following paragraphs.

Hot Spot Zone (trichloroethene [TCE] concentrations exceeding 20,000 µg/L) — In situ bioremediation (ISB) is used in the hot spot (TSF-05) to promote bacterial growth by supplying essential nutrients to bacteria that occur naturally in the aquifer and are able to break down contaminants. The hot spot concentration was defined using data from 1997 and is not reflective of current concentrations (Figure 6-10).

The 2011 ISB operations consisted of injections of sodium lactate solution and whey powder to produce anaerobic conditions for efficient biologically mediated breakdown of TCE. The ISB injection strategy is maintaining effective anaerobic reductive dechlorination conditions, as evidenced by complete degradation of TCE to ethene in the vicinity of the injection wells. Usually by the month after an injection, TCE concentrations are below MCLs. The amount of contactable residual source in the aquifer appears to be declining in all wells within the residual source area in the aquifer.

To evaluate the impact of ISB operations on the flux of contaminants downgradient from the treatment area, medial zone contaminant concentration data from wells located downgradient just outside the hot spot (TAN-28, TAN-30A, TAN-1860, and TAN-1861) are used. Trends in TCE concentrations at wells TAN-30A and TAN-1861 generally indicate that flux from the hot spot has been reduced at these wells, but the flux has not been reduced sufficiently at Wells TAN-28 and TAN-1860.

Overall, the 2011 groundwater monitoring data indicate that the ISB hot spot remedy is reducing the concentration of VOCs in the hot spot zone, and progress toward the remedial action objectives is being made (DOE-ID 2012a).

Medial Zone (TCE concentrations between 1,000 and 20,000 µg/L) — A pump and treat process has been used in the medial zone. In the medial zone, the New Pump and Treat Facility was generally operated Monday through Thursday and all compliance samples were

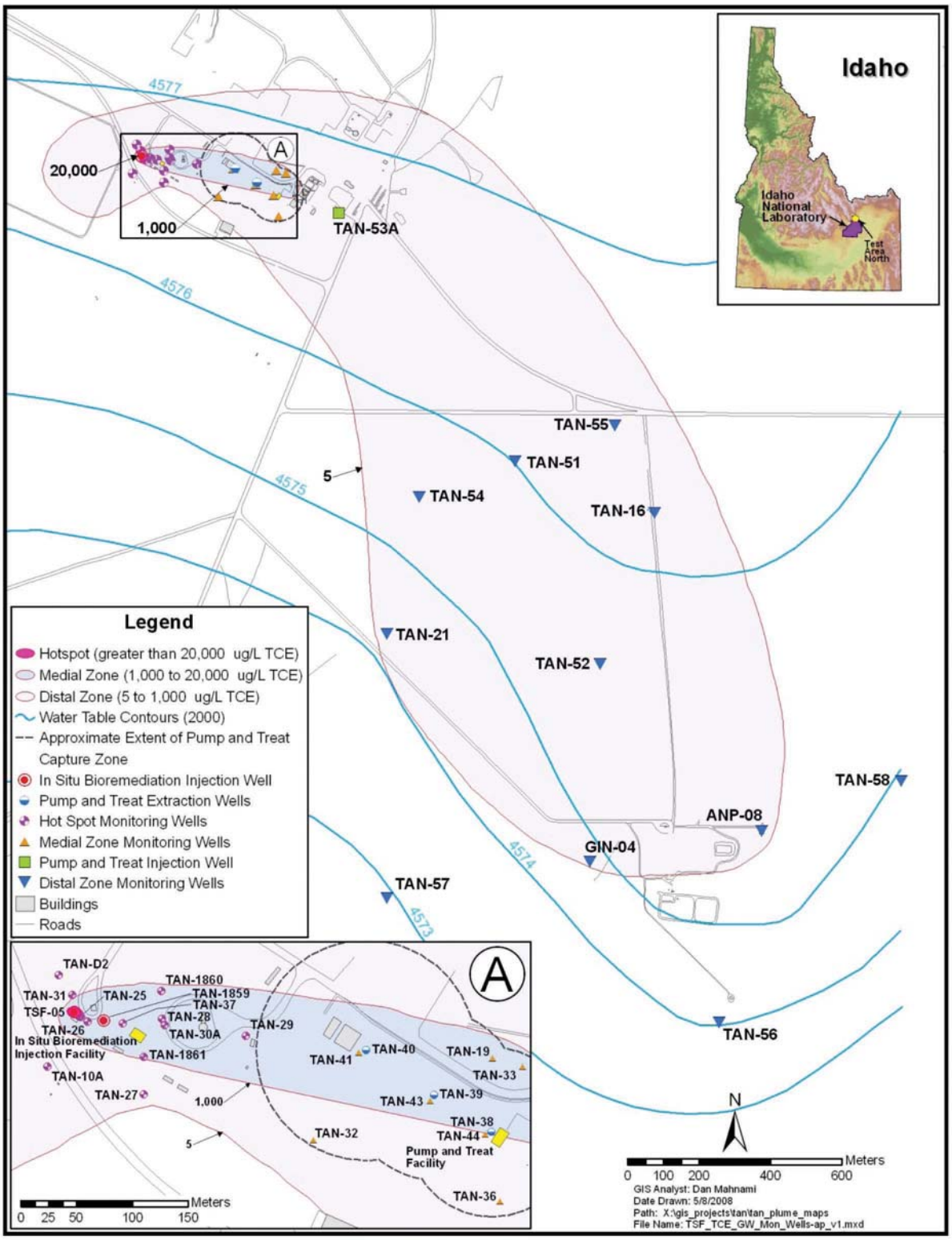

Figure 6-10. Trichloroethene Plume at Test Area North in 1997.

below the discharge limits. The pump and treat process involves extracting contaminated groundwater, treating through air strippers, and reinjecting treated groundwater into the aquifer. TCE concentrations used to define the medial zone are based on data collected in 1997 before remedial actions started and do not reflect current concentrations. Trichloroethene concentrations in the medial zone wells are significantly lower than the historically defined concentration range of 1,000 to 20,000 µg/L. The TCE concentrations have declined to less than 75 µg/L in TAN-33 and to 50 µg/L or less in TAN-36 and TAN-44.

In addition to the New Pump and Treat Facility, the Air Stripper Treatment Unit was operated from January 31 until July 28, 2011, and treated approximately 10.5 million gallons of water. After shutting down, the Air Stripper Treatment Unit was placed into standby.

Distal Zone (TCE concentrations between 5 and 1,000 µg/L) — Monitored natural attenuation is the treatment for the distal zone of the plume as defined by 1997 TCE concentrations (Figure 6-10). Monitored natural attenuation is the sum of physical, chemical, and biological processes that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in groundwater. Engineering and administrative controls are in place to protect current and future users from health risks associated with groundwater contamination.

Trichloroethene data collected in 2011 from the distal zone wells indicate that additional data are needed to confirm that the monitored natural attenuation part of the remedy is on track with the model predictions for all wells in the distal portion of the plume. The TCE data from the plume expansion wells suggest that plume expansion has occurred but is within the limits allowed in the Record of Decision Amendment (DOE-ID 2001).

Radionuclide Monitoring — Radionuclide data for wells in the source area show increasing trends, probably due to ISB activities. Radionuclide trends will need to be evaluated during the upcoming ISB rebound test to determine if radionuclides will meet the remedial action objective of declining to below MCLs by 2095.

6.7.2 Summary of Waste Area Group 2 Groundwater Monitoring Results

Groundwater samples were collected from seven aquifer wells for WAG 2, ATR Complex, during 2011. The locations of the wells sampled for WAG 2 are shown on Figure 6-11. Aquifer samples were analyzed for ^{90}Sr, gamma-emitting radionuclides, tritium, and chromium (unfiltered and filtered). Unfiltered samples were used to obtain the total chromium concentration in the sample, including chromium adsorbed onto suspended particulates; filtered samples are used to obtain the dissolved chromium concentration. The data for the October 2011 sampling event are included in the Fiscal Year 2012 Annual Report for WAG 2 (DOE-ID 2012b). The October 2011 sampling data are summarized in Table 6-4.

The only analyte to occur above its MCL was unfiltered chromium in one aquifer well. The highest unfiltered chromium concentration occurred in Well TRA-07, but the filtered chromium concentration was 99 µg/L and was just below the MCL of 100 µg/L in this well. The filtered

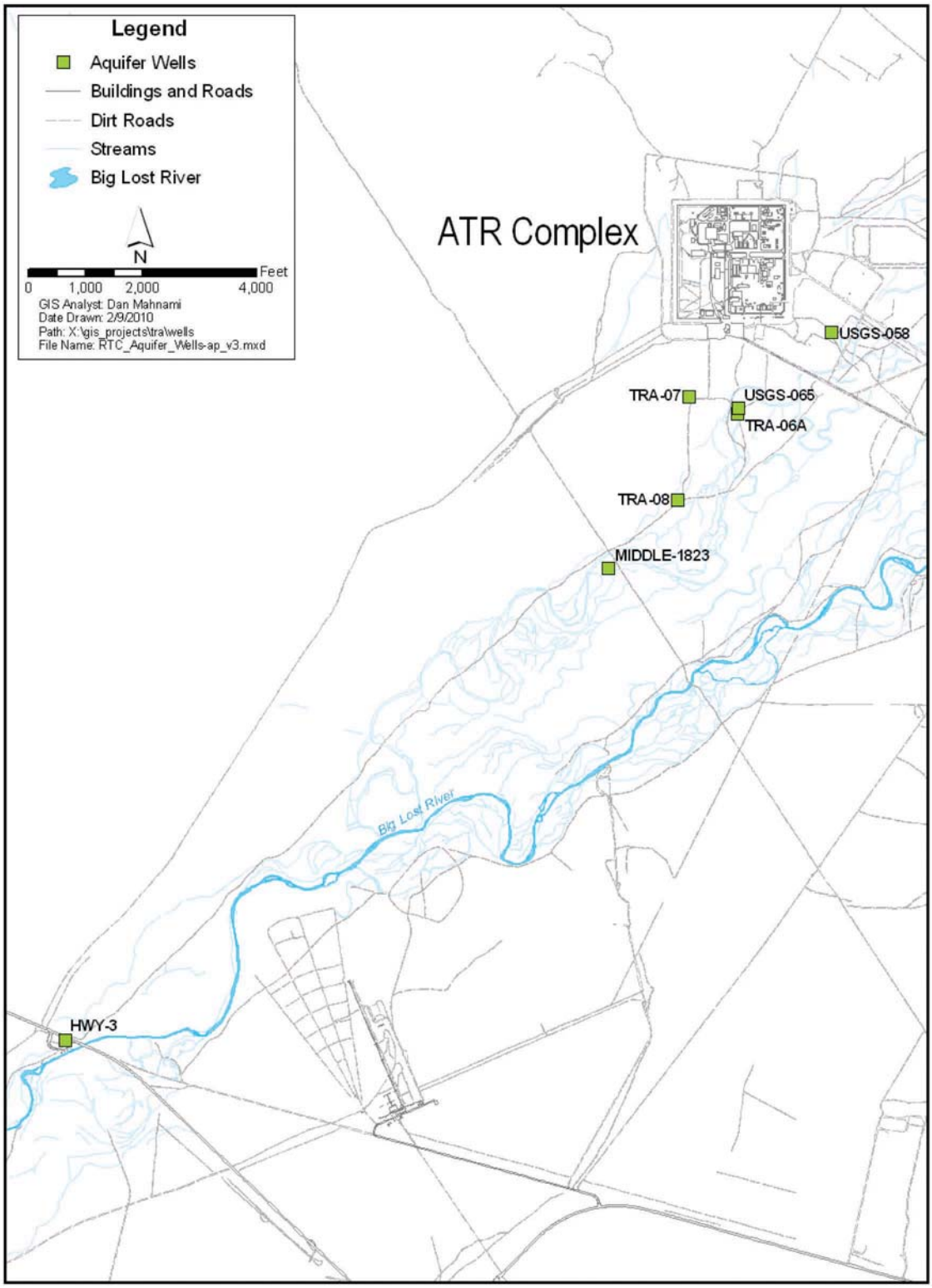

Figure 6-11. Locations of Waste Area Group 2 Aquifer Monitoring .

Table 6-4. Waste Area Group 2 Aquifer Groundwater Quality Summary for 2011.

Analyte	MCL	Background[a]	Maximum	Minimum	Number of Wells above MCL
Chromium (filtered) (µg/L)	100	2–3	99	1.1	0
Chromium (unfiltered) (µg/L)	100	NA	**140**[b]	1.8	1
Sr-90 (pCi/L)	8	0	ND	ND	0
Tritium (pCi/L)	20,000	75–150	8,730	ND	0

a. Background concentrations are from Knobel et al. (1992), except tritium, which is from Orr et al. (1991).
b. **Bold** value exceeds MCL.

MCL maximum contaminant level
NA not applicable
ND not detected

chromium concentration in Well USGS-065 was also close to the MCL at 83 µg/L. Although the chromium concentration in both TRA-07 and USGS-065 are close to the MCL, both of these wells show long-term downward trends in chromium concentration.

Well TRA-08 is the only aquifer well that has had consistent ^{90}Sr concentrations in the past, but ^{90}Sr was below detection limits in the October 2011 sample. The ^{90}Sr concentrations in TRA-08 had been decreasing since the first occurrence of ^{90}Sr in 2005 and dropped below detection limits in October 2010.

Although tritium concentrations were above background concentrations in all aquifer wells sampled except for the Highway 3 well, tritium concentrations were below the MCL of 20,000 pCi/L in all wells sampled.

Chromium and tritium concentrations in the aquifer have declined faster than predicted by the WAG 2 models used for the Operable Unit 2-12 Record of Decision and the revised modeling performed after the first five-year review (DOE-NE-ID 2005).

The October 2011 Snake River Plain aquifer water table map prepared for the vicinity of ATR Complex was consistent with previous maps showing similar groundwater flow directions (DOE-ID 2012b). Water levels in the vicinity of ATR Complex fell less than a foot on average from October 2010 to October 2011.

6.7.3 Summary of Waste Area Group 3 Groundwater Monitoring Results

At Idaho Nuclear Technology and Engineering Center (INTEC), groundwater samples were collected from 14 Snake River Plain aquifer monitoring wells during 2011 (Figure 6-12). Groundwater samples were analyzed for a suite of radionuclides and inorganic constituents, and the data are summarized in the 2011 annual report (DOE-ID 2012c). Table 6-5 summarizes the maximum concentrations observed, along with the number of MCL exceedances reported for each constituent.

Strontium-90, technetium-99 (^{99}Tc), and nitrate exceeded their respective drinking water MCLs in one or more of the Snake River Plain aquifer monitoring wells at or near INTEC, with ^{90}Sr exceeding its MCL by the greatest margin. Strontium-90 concentrations remained above the MCL (8 pCi/L) at nine of the well locations sampled. All well locations showed similar or slightly lower ^{90}Sr levels compared to those reported during the previous sampling events.

As in the past, ^{99}Tc was detected above the MCL (900 pCi/L) in two monitoring wells within the INTEC facility, but concentrations were below the MCL at all other locations. During 2011, the highest ^{99}Tc level in Snake River Plain aquifer groundwater was at monitoring well ICPP-2021 (1,250 pCi/L) located southeast of the INTEC Tank Farm. All of the wells sampled showed stable or declining trends from the previous reporting period.

Nitrate was detected in all wells sampled during this reporting period. The highest concentration was reported at Well ICPP-2021 (14.7 mg/L as N). This was the only location where nitrate concentration exceeded the MCL (10 mg/L as N). This well is located relatively close to the Tank Farm, and shows groundwater quality impacts attributed to past releases of Tank Farm liquid waste. Nitrate concentrations are similar or slightly lower than observed in previous years.

Iodine-129 concentrations were less than the MCL (1 pCi/L) at all Snake River Plain aquifer monitoring wells, and below detection limits at most locations. The highest ^{129}I concentration was reported at Well USGS-67 (0.537 pCi/L) located southeast of INTEC. Iodine-129 concentrations in groundwater have declined significantly from concentrations observed during the 1980s and 1990s. None of the wells showed a significant increase in ^{129}I levels since the previous reporting period.

Tritium was detected in all of the wells sampled, but none of the groundwater samples exceeded the tritium MCL (20,000 pCi/L). The highest tritium concentrations in groundwater were reported at Well ICPP-2021 (4,920 pCi/L) and Well MW-18-4 (4,770 pCi/L), both located near the INTEC Tank Farm. Tritium concentrations have declined at nearly all locations over the past few years.

During the reporting period, no plutonium isotopes were detected in any of the Snake River Plain aquifer groundwater samples. Uranium-238 was detected at all SRPA well locations, with the highest concentration at Well LF3-08 (2.38 pCi/L) located several miles downgradient of INTEC, near the CFA landfills. The ^{238}U results are consistent with background concentrations reported for Snake River Plain aquifer groundwater. Similarly, ^{234}U also was detected in all groundwater samples, with concentrations ranging as high as 4.54 pCi/L at Well LF3-08.

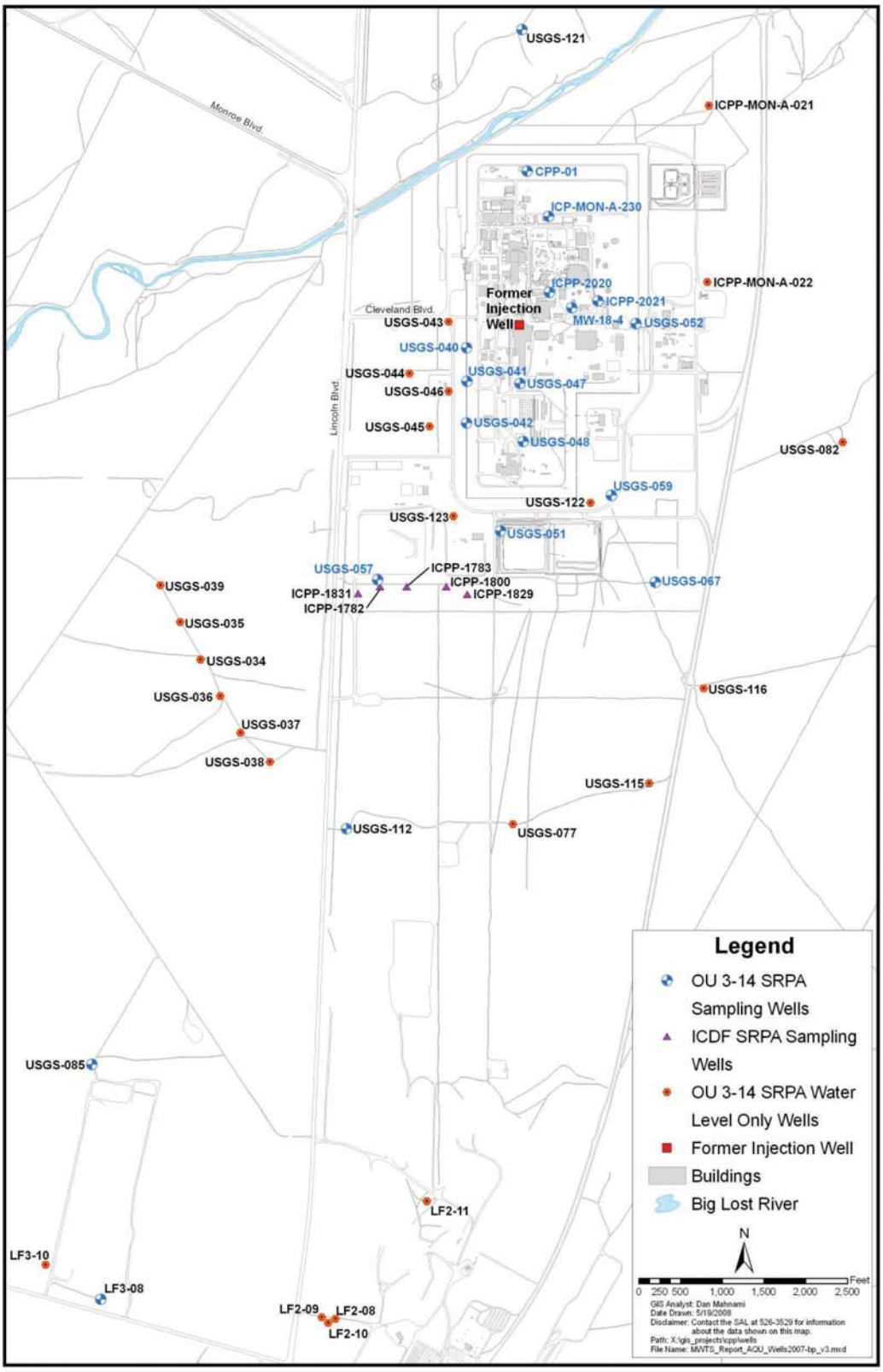

Figure 6-12. Locations of Waste Area Group 3 Monitoring Wells.

Table 6-5. Summary of Constituents Detected in WAG 3 Aquifer Monitoring Wells (FY 2011).

			Snake River Plain Aquifer Groundwater – April 2011		
Constituent	**EPA MCL[a]**	**Units**	**Maximum Reported Value**	**Number of Results[b]**	**Results > MCL[b]**
Gross alpha	15	pCi/L	7.24	20	0
Gross beta	NA[c]	pCi/L	509	20	NA
Cesium-137	200	pCi/L	ND[d]	20	0
Strontium-90	8	pCi/L	**21.3**[e]	20	11
Technetium-99	900	pCi/L	**1,250**	20	2
Iodine-129	1	pCi/L	0.537	20	0
Tritium	20,000	pCi/L	4,920	20	0
Plutonium-239	15	pCi/L	ND	20	0
Plutonium-239/240	15	pCi/L	ND	20	0
Uranium-233/234	15	pCi/L	4.54	20	0
Uranium-235	15	pCi/L	0.15J[f]	20	0
Uranium-238	15	pCi/L	2.38	20	0
Alkalinity	NA	mg/L	163	20	NA
Calcium	NA	mg/L	67.4	20	NA
Chloride	250	mg/L	122	20	0
Magnesium	NA	mg/L	22	20	NA
Nitrate (as N)	10	mg/L	**14.7**	20	1
Potassium	NA	mg/L	4.83	20	NA
Sodium	NA	mg/L	37.4	20	NA
Sulfate	250	mg/L	52.9	20	0
Total dissolved solids	500	mg/L	432	20	0

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

Uranium-234 is the daughter product of alpha decay of the long-lived, naturally occurring ^{238}U. Ratios of $^{234}U/^{238}U$ were similar to background $^{234}U/^{238}U$ activity ratios of 1.5 to 3.1 reported for the eastern Snake River Plain aquifer.

Uranium-235 was reported in groundwater samples from two monitoring wells at concentrations ranging from non-detect (<0.0993 pCi/L, estimated detection limit) to 0.15 pCi/L (estimated value). An evaluation of uranium in groundwater near the RWMC indicates that Snake Rriver Plain aquifer background ^{235}U activities are generally less than 0.15 pCi/L (95 percent upper tolerance limit). Reported ^{235}U concentrations in groundwater at INTEC have historically been slightly above the background level, which is consistent with limited uranium impacts to groundwater from past operations at INTEC.

The 2011 groundwater contour map is similar in shape to the maps prepared for previous years, although water elevations vary slightly from year to year in response to wet-dry climate cycles. Groundwater levels declined during 2000–2005 as a result of the drought during this period. However, as a result of near normal precipitation during 2005–2011 and corresponding periods of flow of the Big Lost River, groundwater levels have remained relatively constant during this period.

6.7.4 Summary of Waste Area Group 4 Groundwater Monitoring Results

The WAG 4 groundwater monitoring consists of two different components: 1) CFA landfill monitoring and 2) monitoring of a nitrate plume south of CFA. Groundwater monitoring for the CFA landfills consisted of sampling seven wells for metals (filtered), VOCs, and anions (nitrate, chloride, fluoride, and sulfate) and two wells for VOCs only in accordance with the long-term monitoring plan (DOE-ID 2009). Four wells downgradient of CFA were sampled for nitrate and other anions to monitor a nitrate plume south of CFA. The CFA monitoring well locations are shown on Figure 6-13. Analytes detected in groundwater are compared to regulatory levels in Table 6-6. A complete list of the groundwater sampling results is contained in the 2011 Monitoring Report (DOE-ID 2012d).

In the four wells sampled to monitor the CFA nitrate plume, the nitrate concentration at 16.1 mg/L-N in Well CFA-MON-A-002 continued to exceed the groundwater MCL for nitrate of 10 mg/L N. The historical range of nitrate concentrations in CFA-MON-A-002 is 15 to 21 mg/L-N. The nitrate concentration in Well CFA-MON-A-003 at 8.52 mg/L-N is below the MCL and within its historic range of 8 to 11 mg/L-N. Except for the 2005 spike in nitrate concentration in Well CFA-MON-A-003, nitrate concentrations in Wells CFA-MON-A-002 and 003 have been within the above ranges since monitoring started in 1995.

Iron and aluminum were the only analytes detected above their MCL or secondary maximum contaminant level (SMCL) at the CFA landfills. Iron occurred above its SMCL of 300 µg/L in wells LF3-08 and LF3-09 (Figure 6-13). The highest iron concentration was in LF3-08 at 1,000 µg/L. The high iron concentration is inconsistent with the high dissolved oxygen level in LF3-09 and slightly alkaline pH. Aluminum was above its SMCL of 200 µg/L in the above two wells also. The high aluminum concentrations are inconsistent with a pH of 8.5. The inconsistencies suggest that particles less than 0.45 microns may have gone through the filter or some filter breakthrough may have occurred.

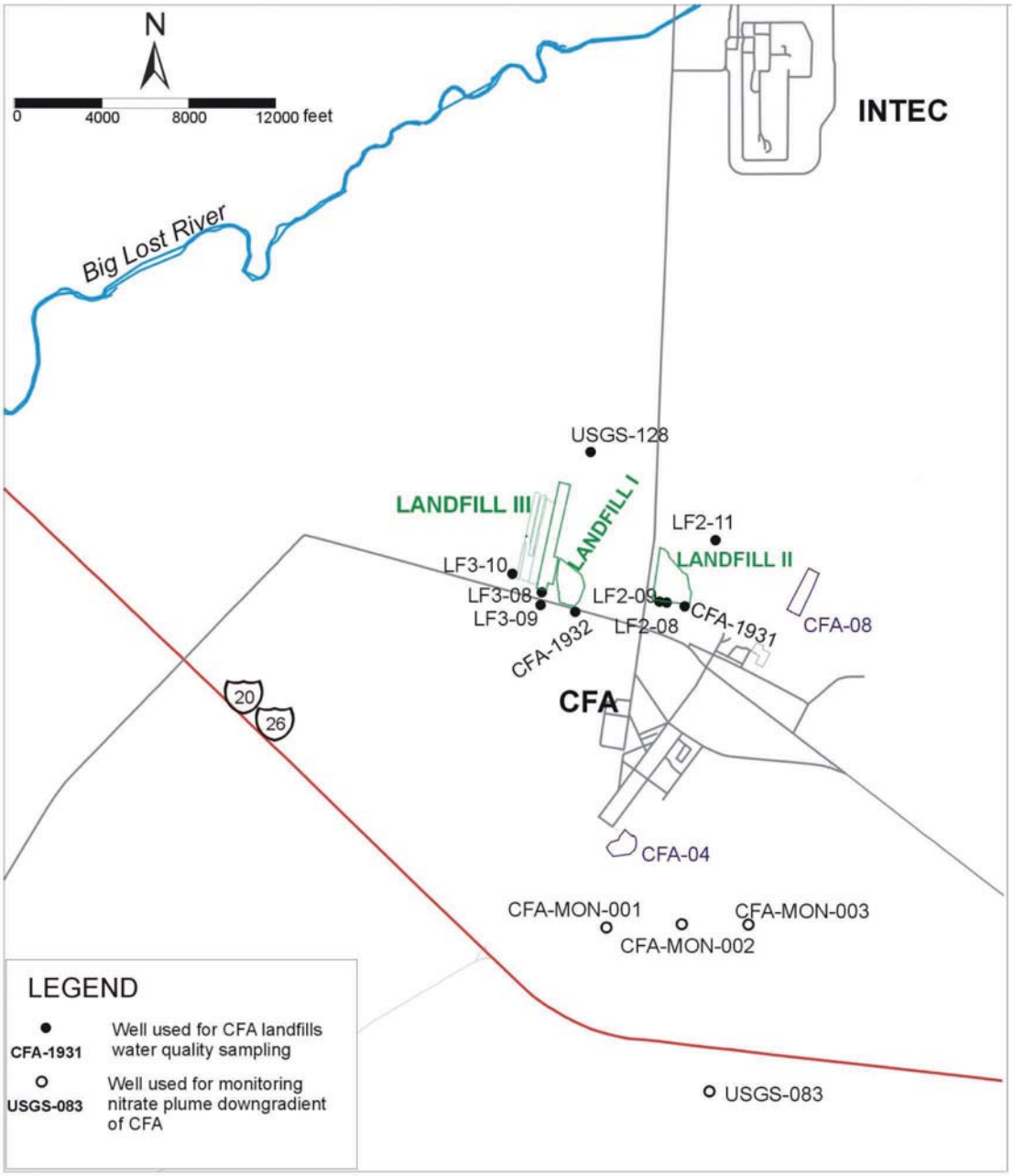

Figure 6-13. Locations of Waste Area Group 4/Central Facilities Area Monitoring Wells Sampled in 2011.

Chloroform, 1,1,1-trichloroethane, 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, and toluene were the VOCs detected in groundwater downgradient from the CFA landfills in the 2011 sampling event. The detected VOCs were well below their respective MCLs. Although 1,2-dichlorobenzene, toluene, and chloroform were detected in groundwater, their concentrations in soil gas samples were low, with maximum concentrations of only 46, 5.4, and 69 parts per billion by volume, respectively. The compound 1,2,4 trichlorobenzene was not detected in any soil gas samples. The source of the chloroform, 1,2,4 trichlorobenzene, 1,2-dichlorobenzene, and

Table 6-6. Comparison of Waste Area Group 4 Groundwater Sampling Results to Regulatory Levels (2011).

Compound	MCL or SMCL[a]	Maximum Detected Value	Number of Wells above MCL or SMCL
Downgradient Central Facilities Area Wells			
Chloride (mg/L)	*250*	59.5	0
Fluoride (mg/L)	*2*	0.265	0
Sulfate (mg/L)	*250*	27.0	0
Nitrate/nitrite (mg-N/L)	10	**16.1**[b]	1
Central Facilities Area Landfill Wells			
Anions			
Chloride (mg/L)	*250*	77.7	0
Fluoride (mg/L)	*2*	0.284	0
Sulfate (mg/L)	*250*	37.9	0
Nitrate/nitrite (mg-N/L)	10	2.76	0
Common Cations			
Calcium (µg/L)	None	56,300	NA
Magnesium (µg/L)	None	16,900	NA
Potassium (µg/L)	None	4,870	NA
Sodium (µg/L)	None	35,300	NA
Inorganic Analytes			
Antimony (µg/L)	6	1.9	0
Aluminum (µg/L)	*50–200*	**554**	2
Arsenic (µg/L)	10	2.3	0
Barium (µg/L)	2,000	109	0
Beryllium (µg/L)	4	0.61	0
Cadmium (µg/L)	5	ND	0
Chromium (µg/L)	100	70.1	0
Copper (µg/L)	1,300/*1,000*	2.9	0
Iron (µg/L)	*300*	**1,000**	2
Lead (µg/L)	15[c]	2	0
Manganese (µg/L)	50	20.9	0
Mercury (µg/L)	2	ND	0
Nickel (µg/L)	None	51	NA
Selenium (µg/L)	50	2.7	0
Silver (µg/L)	*100*	ND	0
Thallium (µg/L)	2	1.4	0
Vanadium (µg/L)	None	3.8	NA
Zinc (µg/L)	*5,000*	340	0
Detected Volatile Organic Compounds			
1,1,1-Trichloroethane (µg/L)	200	0.102	0
Chloroform (µg/L)	100	0.971	0
1,2,4-trichlorobenzene (µg/L)	70	0.135	0
Toluene (µg/L)	1,000	5.2	0
1,2-dichlorobenzene (µg/L)	600	0.0655	0

a. Numbers in *italics* are for the secondary MCL.
b. **Bold** values exceed an MCL or a secondary SMCL.
c. The action level for lead is 15 µg/L.
MCL = maximum contaminant level
NA = not applicable
ND = not detected
SMCL = secondary maximum contaminant level

toluene in the groundwater is uncertain because no source in the landfills appears capable of causing the groundwater contamination.

The compound 1,1,1-trichloroethane was detected in groundwater samples from Wells CFA-1931 and CFA-1932 at concentrations near the detection limit of about 0.1 µg/L. These detections may be the result of vapor migration from the landfills. However, the concentrations in groundwater are more than two orders of magnitude below the MCL of 200 µg/L.

Water-level measurements taken in the CFA area in 2011 suggest that after the sharp drop in water levels from 2000 to 2005, water levels appear to be stabilizing because they have changed little since 2005. A water table map produced from water levels collected in August 2011 was consistent with previous maps in terms of gradients and groundwater flow directions (DOE-ID 2012d).

6.7.5 Summary of Waste Area Group 5 Groundwater Monitoring Results

Groundwater was not monitored for WAG 5 in 2011. Groundwater monitoring for WAG 5 was concluded in November 2006 in accordance with the recommendations from the first five-year review (DOE-NE-ID 2007).

6.7.6 Summary of Waste Area Group 7 Groundwater Monitoring Results

Aquifer samples collected in the vicinity of RWMC in Calendar Year (CY)-2011 were analyzed for radionuclides, inorganic constituents, VOCs, and 1,4-dioxane. Of nearly 3,800 analyses, only 22 results exceeded background reporting thresholds or quantitation limits. Table 6-7 lists WAG seven contaminants of concern that were detected above reporting thresholds or quantitation limits.

Carbon tetrachloride was detected at concentrations above the reporting (quantitation) limit of 1 µg/L at six monitoring locations in CY-2011 and slightly exceeded the MCL of 5 µg/L one time at Well M7S north of RWMC in May 2011 (see Figure 6-14). The average carbon tetrachloride concentration at well M7S in CY-2011 decreased from the CY-2010 average and is below the MCL (see Figure 6-15). The average concentration at this well has not been below the MCL since 1998.

In general, trends of contaminants of concern in the aquifer, namely carbon tetrachloride and TCE, are relatively stable or trending slightly downward.

6.7.7 Summary of Waste Area Group 9 Groundwater Monitoring Results

Five wells (four monitoring and one production) at the Materials and Fuels Complex (formerly Argonne National Laboratory-West) are sampled twice a year for selected radionuclides, metals, total organic carbon, total organic halogens, and other water quality parameters as required under the WAG 9 Record of Decision (Figure 6-16; ANL-W 1998). The reported concentrations of analytes that were detected in at least one sample are summarized in Table 6-8. The elevated iron in ANL-MON-A-013 is attributed to rust or mineral material in the sample; all other results were below their respective water quality limits. Overall, the data show no discernable impacts from activities at the Materials and Fuels Complex.

Table 6-7. Summary of Waste Area Group 7 Aquifer Sampling and Analyses (FY 2011).

Analyte	Number of Wells Sampled	Number of Analyses[a]	Number of Reportable Detections[b]	Maximum Concentration (µg/L)	Number of Detections Greater Than MCL	MCL[c] (µg/L)
Carbon tetrachloride	14	29	14	**5.04**[d]	1	5
Trichloroethylene	14	29	8	2.61	0	5

a. The number of analyses includes duplicate samples collected for quality control purposes.

b. Reported results are Operable Unit 7-13/14 contaminants of concern at concentrations greater than background reporting thresholds or quantitation limits, along with other analytes detected above maximum contaminant levels (MCLs). Background reporting thresholds do not apply to carbon tetrachloride and trichloroethylene because background concentrations in the Snake River Plain Aquifer are essentially zero; therefore, laboratory quantitation limits are used as reporting limits for volatile organic compounds.

c. MCL = maximum contaminant level. MCLs are from "National Primary Drinking Water Regulations" (40 CFR 141).

d. **Bold** values exceed an MCL or a SMCL.

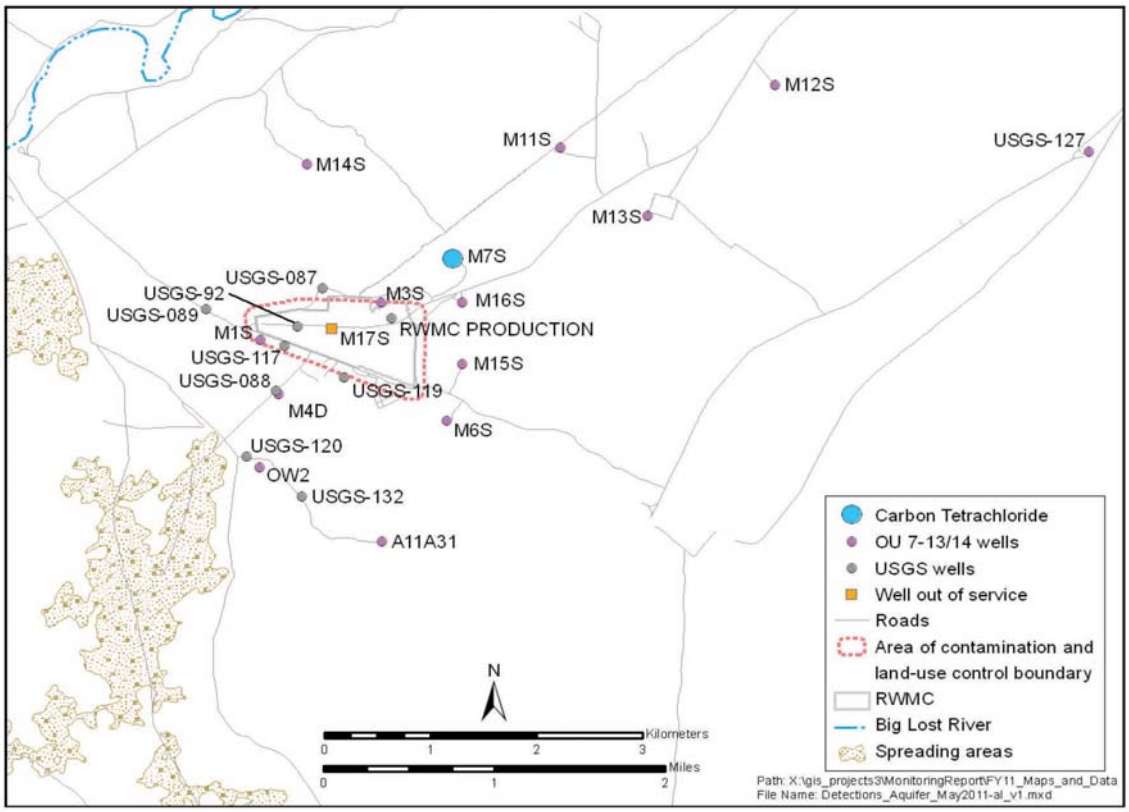

Figure 6-14. Location of Aquifer Monitoring Well M7S Where Carbon Tetrachloride Exceeded the Maximum Contaminant Level in May 2011.

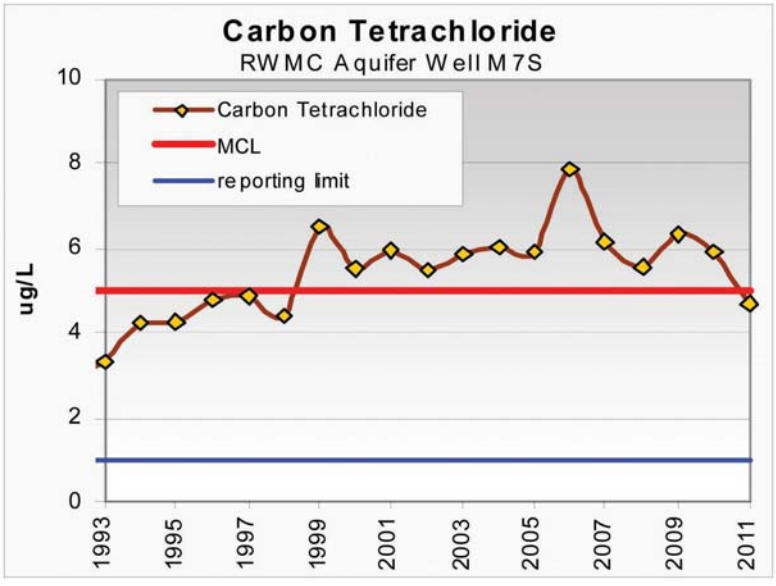

Figure 6-15. Annual Average Carbon Tetrachloride Concentrations by Calendar Year in Aquifer Monitoring Well M7S North of the Radioactive Waste Management Complex.

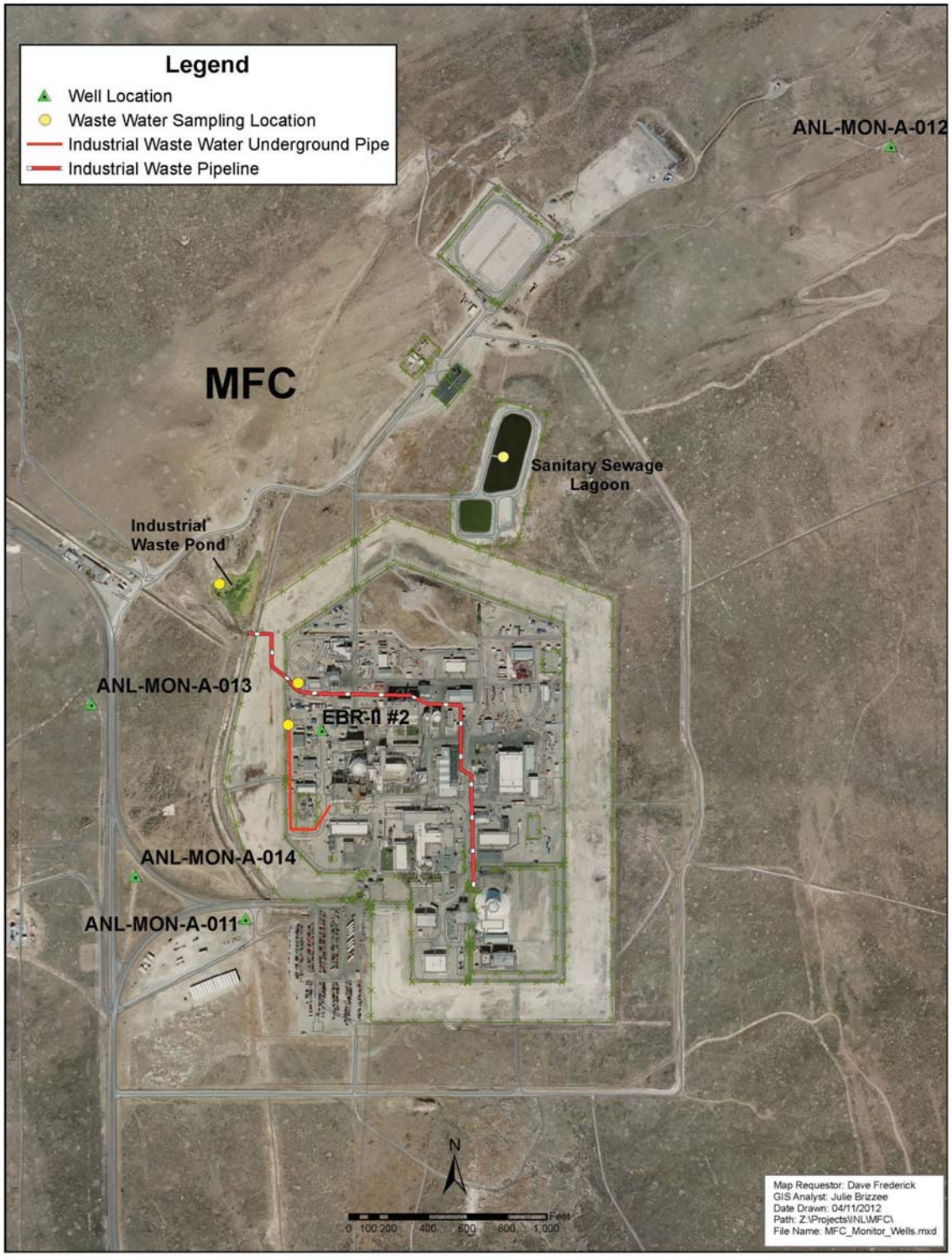

Figure 6-16. Locations of Waste Area Group 9 Wells Sampled in 2011.

Table 6-8. Comparisons of Detected Analytes to Drinking Water Standards at Waste Area Group 9 Monitoring Wells (2011).

Well:	ANL-MON-A-011		ANL-MON-A-012		ANL-MON-A-013		ANL-MON-A-014		EBR-II[a] No. 2		PCS/ SCS[b]
Sample Date:	**4/28/11**	**9/29/11**	**4/27/11**	**9/28/11**	**4/27/11**	**9/28/11**	**4/27/11**	**9/28/11**	**4/28/11**	**9/29/11**	
Radionuclides[c]											
Gross alpha (pCi/L)	1.88 ± 0.802	ND[d] (ND)[f]	ND	ND	ND	ND	2.6 ± 1.01	2.14 ± 0.735	1.91 ± 0.507	ND	15 pCi/L
Gross beta (pCi/L)	ND	3.49 ± 1.1 (ND)	5.16 ± 1.14	4.64 ± 0.993	ND	6.45±1.3	4.46 ± 1.1	3.87 ± 0.942	3.94 ± 0.694	ND	4 mrem/yr
Potassium-40 (pCi/L)	ND	ND (ND)	ND	ND	ND	ND	34.3 ± 9.2	ND	ND	ND	
Uranium-233/234 (pCi/L)	1.07 ± 0.177 U	1.2 ± 0.158 (1.22 ± 0.15)	1.2 ± 0.182	1.63 ± 0.222	1.38 ± 0.209	1.3 ± 0.179	1.52 ± 0.227	1.74 ± 0.225	1.45 ± 0.211	1.15 ± 0.147	186,000
Uranium-238 (pCi/L)	0.516 ± 0.112	0.652 ± 0.105 (0.606 ± 0.0931)	0.631 ± 0.121	0.714 ± 0.127	0.512 ± 0.113	0.598 ± 0.108	0.603 ± 0.126	0.534 ± 0.102	0.528 ± 0.112	0.684 ± 0.103	9.9
Metals											
Aluminum (µg/L)	5.1	5.3 (4.5)	7.1	6	29.8	15.4	3.6	5.2	4.3	3.9	200
Arsenic (µg/L)	1.9	1.6 (1.7)	2	1.5	2.2	1.7	2	1.5	2	1.6	50
Barium (µg/L)	35.5	34.5 (34.3)	39.6	37.5	37.5	35.7	36.8	35.6	36.3	35.2	2,000
Calcium (mg/L)	38.6	34.7 (34.7)	39.6	35.7	39.8	35.6	39	35.6	39.6	35.4	NE[e]
Chromium (µg/L)	2.6	2.5 U (2.5 U)	2.5 U	2.5	8	2.5 U	4.6	3.8	2.5 U	2.5 U	100
Copper (µg/L)	8.3	2.5 U (2.5 U)	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	4.3	1,300
Iron (µg/L)	96 [50 U]	50.1 (50 U) [50 U (50 U)]	73.5 [50 U]	50 U [50 U]	**459**[g] [52]	122 [50 U]	119 [50 U]	65.3 [50 U]	50 U [50 U]	50 U [50 U]	300
Lead (µg/L)	0.53	0.5 U (0.5 U)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.52	0.54	15
Magnesium (mg/L)	12.6	11.1 (11.3)	12.2	10.9	12.9	11.4	12.7	11.4	12.8	11.3	NE
Nickel (µg/L)	3	2.5 U (2.5 U)	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	4.1	NE
Potassium (mg/L)	3.3	2.98 (2.95)	3.6	3.23	3.38	3.02	3.33	3.02	3.36	3.02	NE
Selenium (µg/L)	0.5 U	0.52 (0.55)	0.56	0.59	0.54	0.5 U	0.73	0.53	0.62	0.63	50
Sodium (mg/L)	17.8	16.2 (16.2)	18	16.7	19.4	17.5	18.1	16.6	18.3	16.6	NE

Table 6-8. Comparisons of Detected Analytes to Drinking Water Standards at Waste Area Group 9 Monitoring Wells (2011) (continued).

Well:	ANL-MON-A-011		ANL-MON-A-012		ANL-MON-A-013		ANL-MON-A-014		EBR-II[a] No. 2		PCS/ SCS[b]
Vanadium (µg/L)	5.2	4.6 (4.8)	5	5.1	6.2	5.4	5.6	4.9	5.2	4.7	NE
Zinc (µg/L)	6.4	2.5 U (2.5 U)	2.8	2.5 U	3.3	2.5 U	2.5 U	2.5 U	9.4	10.6	5,000
Anions											
Chloride (mg/L)	17.9	18.4 (18.4)	17	17.8	18.7	18.2	18.4	18.5	19.3	18.9	250
Nitrate-as nitrogen (mg/L)	2.05	1.9 (1.91)	1.95	1.84	2.05	1.91	2.04	1.88	2.08	1.89	10
Phosphorus (mg/L)	0.0126	0.014 (0.0134)	0.0121	0.0143	0.0235	0.0157	0.0115	0.0185	0.0131	0.0134	NE
Sulfate (mg/L)	16.9	16.8 (16.8)	16.3	16.3	19.4	18.4	18.1	17.2	18.1	17.2	250
Water Quality Parameters											
Alkalinity (mg/L)	149	142 (143)	143	138	142	142	140	141	142	144	NE
Bicarbonate alkalinity (mg/L)	149	142 (143)	143	138	142	142	140	141	142	144	NE
Total dissolved solids (mg/L)	259	243 (236)	253	239	265	232	262	232	244	247	500
Total organic carbon (mg/L)	1 U	1 U (1 U)	1 U	1 U	1.29	1 U	1 U	1 U	1 U	1 U	NE

a. EBR-II = Experimental Breeder Reactor II.
b. PCS = primary constituent standard; SCS = secondary constituent standard.
c. Result ± 1s.
d. ND = not detected. U = not detected at the concentration shown.
e. NE = not established. A primary or secondary constituent standard has not been established for this constituent.
f. Results in parentheses are field duplicate. Results in brackets are filtered (i.e., dissolved) concentrations.
g. Concentrations shown in bold are above the Ground Water Quality Rule SCS. Filtered sample results, shown in brackets, are below the SCS.

6.7.8 Summary of Waste Area Group 10 Groundwater Monitoring Results

In accordance with the monitoring plan (DOE-ID 2010b), groundwater samples are collected for WAG 10 every 2 years at the locations shown on Figure 6-17. In 2011, eight wells were sampled, and seven intervals from four Westbay wells were sampled (DOE-ID 2012e). Groundwater samples were analyzed for VOCs, metals (filtered), anions, and radionuclides (i.e., ^{129}I, tritium, ^{99}Tc, gross alpha, and ^{90}Sr).

No contaminant exceeded EPA MCLs (Table 6-9). Iron occurred above its SMCL of 300 µg/L in two wells. The cause of the elevated iron concentration is uncertain because the elevated iron concentrations are inconsistent with measured dissolved-oxygen concentrations and pH. Lead was detected just below its action level in two wells. However, the zinc concentration was also elevated in these wells, and the source of the lead and zinc is probably galvanized riser pipe in the wells. The galvanized pipe in both wells was replaced in the fall of 2011. Both lead and zinc concentrations should decline in these two wells, as has been observed at other Waste Area Group 10 wells after the galvanized pipe was replaced.

6.8 Offsite Drinking Water Sampling

As part of the offsite monitoring program performed by the ESER contractor, drinking water samples were collected off the INL Site for radiological analyses in 2011. Two locations, Shoshone and Minidoka, which are downgradient of the INL Site, were co-sampled with the State of Idaho Department of Environmental Quality (DEQ) INL Oversight Program (IOP) in May and November. The DEQ IOP results for May are available at http://www.deq.idaho.gov/media/795384-inl-oversight-monitoring-q2-data-report-2011-report.pdf. ESER also collected samples at Mud Lake, Atomic City, Craters of the Moon, Howe, Idaho Falls, Minidoka, and the public rest area at Highway 20/26. A control sample (bottled water) was obtained from a local grocery. The samples were analyzed for gross alpha and beta activities and for tritium. The results are shown in Table 6-10.

Gross alpha activity was detected in samples collected from Atomic City in the spring of 2011. The Atomic City sample collected by the DEQ IOP in the second quarter of 2011 had gross alpha activity at a similar result. Gross alpha activity was not detected in any other ESER or DEQ IOP offsite drinking water sample. The measurements made at Atomic City are within the range of offsite drinking water results detected historically and are below the MCL of 15 pCi/L for gross alpha activity in drinking water.

Gross beta activity was also detected in all valid drinking water samples collected by ESER, except for the control sample. Gross beta activity has been measured at these levels historically in offsite drinking water samples. In addition, it was detected at a similar level in the DEQ IOP Shoshone and Minidoka samples. The results are below the screening MCL of 8 pCi/L for ^{90}Sr. This MCL is extremely conservative because the radionuclides contributing to the gross beta activity are most likely naturally-occurring decay products of thorium and uranium, which are present in the aquifer, and not ^{90}Sr, which is a man-made radionuclide.

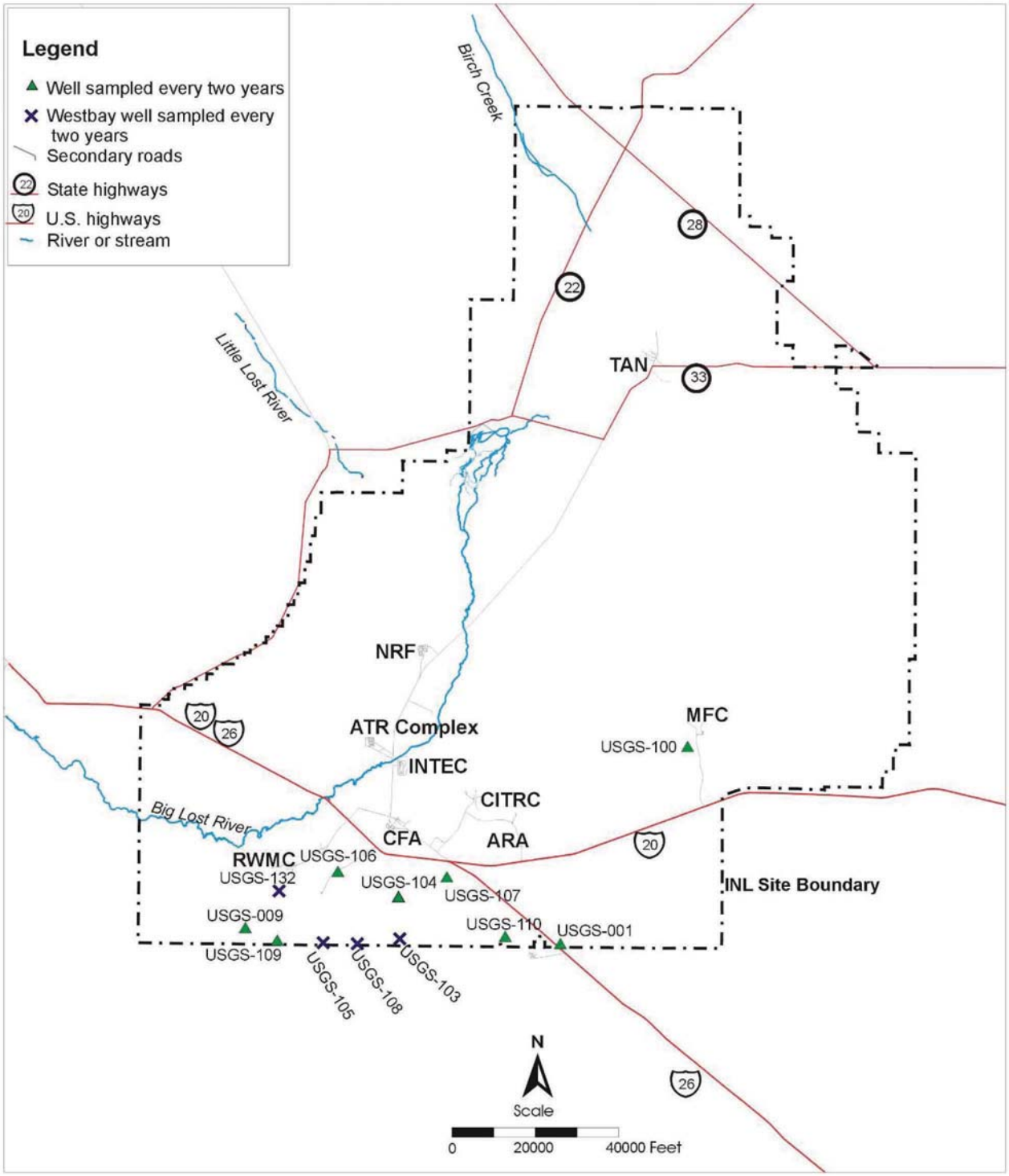

Figure 6-17. Locations and Sampling Frequency for Wells to be Sampled for Operable Unit 10-08 (*Note that wells were not sampled in 2010, but were sampled in 2011*).

Table 6-9. Comparison of Waste Area Group 10 Analytes with Regulatory Levels for 2011.

Analyte	MCL/SMCL[a]	Maximum Concentration	Detections above MCL/SMCL
Radionuclides			
Gross alpha (pCi/L)	15	2.7	0
Iodine-129 (pCi/L)	1	ND	0
Technetium-99 (pCi/L)	900	ND	0
Strontium-90 (pCi/L)	8	ND	0
Tritium (pCi/L)	20,000	523	0
Volatile Organic Compounds[b]			
Carbon tetrachloride (µg/L)	5	0.34	0
Anions			
Chloride (mg/L)	*250*	20.6	0
Fluoride (mg/L)	*2*	0.75	0
Nitrate/nitrite as N (mg/L)	10	1.96	0
Sulfate (mg/L)	*250*	34.1	0
Common Cations			
Calcium (µg/L)	None	47,400	NA
Magnesium (µg/L)	None	18,700	NA
Potassium (µg/L)	None	3,700	NA
Sodium (µg/L)	None	25,200	NA
Metals			
Aluminum (µg/L)	*50 to 200*	ND	0
Antimony (µg/L)	6	ND	0
Arsenic (µg/L)	10	3.0	0
Barium (µg/L)	2,000	53.7	0
Beryllium (µg/L)	4	ND	0
Cadmium (µg/L)	5	0.558	0
Chromium (µg/L)	100	7.38	0
Cobalt (µg/L)	None	0.158	NA
Copper (µg/L)	1,300/*1,000*	1.15	0
Iron (µg/L)	*300*	**395**[c]	2
Lead (µg/L)	15[d]	12	0
Manganese (µg/L)	*50*	46.5	0
Mercury (µg/L)	2	ND	0
Nickel (µg/L)	None	2.51	NA
Selenium (µg/L)	50	ND	0
Silver (µg/L)	None	ND	NA
Thallium (µg/L)	2	ND	0
Uranium (µg/L)	30	2.93	0
Vanadium (µg/L)	None	8.16	NA
Zinc (µg/L)	*5,000*	224	0

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

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

Table 6-10. Gross Alpha, Gross Beta, and Tritium Concentrations in Offsite Drinking Water Samples Collected by the ESER Contractor in 2011.

Location	Sample Results (pCi/L)[a]		
Gross Alpha			
	Spring 2011	Fall 2011	EPA MCL[b]
Atomic City	2.34 ± 0.53	ND[c]	15 pCi/L
Control (bottled water)	ND	ND	15 pCi/L
Craters of the Moon	I[d]	ND	15 pCi/L
Howe	I[d]	ND	15 pCi/L
Idaho Falls	I[d]	ND	15 pCi/L
Minidoka	ND	ND	15 pCi/L
Mud Lake (Well #2)	I[d]	ND	15 pCi/L
Rest Area (Highway 20/26)	ND	ND	15 pCi/L
Shoshone	I[d]	ND	15 pCi/L
Gross Beta			
	Spring 2011	Fall 2011	EPA MCL
Atomic City	7.83 ± 0.61	2.69 ± 0.50	4 mrem/yr (8 pCi/L ^{90}Sr)[e]
Control (bottled water)	ND	ND	4 mrem/yr (8 pCi/L ^{90}Sr)
Craters of the Moon	I[d]	2.61 ± 0.50	4 mrem/yr (8 pCi/L ^{90}Sr)
Howe	I[d]	1.53 ± 0.48	4 mrem/yr (8 pCi/L ^{90}Sr)
Idaho Falls	I[d]	3.77 ± 0.56	4 mrem/yr (8 pCi/L ^{90}Sr)
Minidoka	4.58 ± 0.59	3.53 ± 0.55	4 mrem/yr (8 pCi/L ^{90}Sr)
Mud Lake (Well #2)	I[d]	3.30 ± 0.50	4 mrem/yr (8 pCi/L ^{90}Sr)
Rest Area (Highway 20/26)	2.23 ± 0.52	4.85 ± 0.51	4 mrem/yr (8 pCi/L ^{90}Sr)
Shoshone	I[d]	4.33 ± 0.53	4 mrem/yr (8 pCi/L ^{90}Sr)
Tritium			
	Spring 2011	Fall 2011	EPA MCL
Atomic City	ND	ND	20,000 pCi/L
Control (bottled water)	93 ± 21	ND	20,000 pCi/L
Craters of the Moon	ND	ND	20,000 pCi/L
Howe	ND	ND	20,000 pCi/L
Idaho Falls	106 ± 21	ND	20,000 pCi/L
Minidoka	73 ± 20	ND	20,000 pCi/L
Mud Lake (Well #2)	65 ± 20	ND	20,000 pCi/L
Rest Area (Highway 20/26)	107 ± 21	ND	20,000 pCi/L
Shoshone	70 ± 21	ND	20,000 pCi/L

a. Result ± 1s

b. EPA = Environmental Protection Agency; MCL = Maximum Contaminant Level.

c. ND = not detected (results < 3s)

d. I = Invalid sample. A chemical reaction occurred in the sample when acidified producing a thick, green viscous substance which could not be analyzed. The cause was not identified.

e. The MCL for gross beta activity is not established. However, the EPA drinking water standard of 4 mrem/y for public drinking water systems is applied a conservative screening level of 8 pCi/L (the MCL for strontium-90) is used.

Tritium was detected in most of the drinking water samples (including the control) collected in the spring, but not the fall, of 2011. The results were within historical measurements and well below the EPA MCL of 20,000 pCi/mL The DEQ IOP detected no tritium in the Shoshone and Minidoka water supplies. The discrepancy could be due to differing analytical techniques.

6.9 Surface Water Sampling

Surface water was co-sampled with DEQ IOP in May and November 2011 at three springs located downgradient of the INL Site: Alpheus Springs near Twin Falls; Clear Springs near Buhl; and a trout farm near Hagerman (see Figure 6-18). ESER contractor results are shown in Table 6-11. Gross alpha activity was detected in almost all samples at levels below the MCL. It was also detected at similar levels in samples collected by DEQ IOP at the same locations (see http://www.deq.idaho.gov/media/557033-2010_env_surv_q4.pdf). Gross beta activity was detected in all three surface water samples, as was the case for DEQ IOP samples. However, the ESER contractor samples appear to be biased slightly higher than the DEQ IOP samples by a factor of about 1.5, possibly reflecting differences in analytical methods. In both programs, the highest result was measured at Alpheus Springs and the lowest at Hagerman. Alpheus Springs has historically shown higher results, occasionally above 8 pCi/L, and is most likely due to natural decay products of thorium and uranium that dissolve into water as it passes through the surrounding basalts of the eastern Snake River Plain aquifer.

Tritium was detected in almost all of the surface water samples collected by the ESER contractor. However, it was only detected by DEQ IOP in the Alpheus Springs samples collected in May.

The ESER contractor also collected surface water samples from the Big Lost River on the INL Site. The Big Lost River is an intermittent, ephemeral body of water that flows only during periods of high spring runoff and releases from the Mackay dam, which impounds the river upstream of the INL Site. The river flows through the INL Site and enters a depression, where the water flows into the ground, called Big Lost River Sinks (see Figure 6-18). The river then mixes with other water in the eastern Snake River Plain aquifer. Water in the aquifer then emerges about 100 miles (160 km) away at Thousand Springs near Hagerman and other springs downstream of Twin Falls.

In 2011, the Big Lost River had sufficient water flowing through it to collect samples at the following locations on June 30 and July 15: the public rest stop on State Highway 20/26; along Lincoln Boulevard near INTEC (June 30 only); along Lincoln Boulevard near the Naval Reactors Facility; at the Experimental Field Station; and at the Big Lost River Sinks. Gross alpha activity was detected in many of the samples, at similar, low levels and below the MCL. Gross beta results were detected in most samples at levels below the results for spring water samples collected downgradient of the INL Site and below the screening MCL for ^{90}Sr. Tritium was detected in most Big Lost River samples, however, at levels well below the MCL and below levels measured last year. The source of the tritium is most likely from remnants in the atmosphere from earlier bomb testing, as well as natural production in the atmosphere which then enters surface water through precipitation.

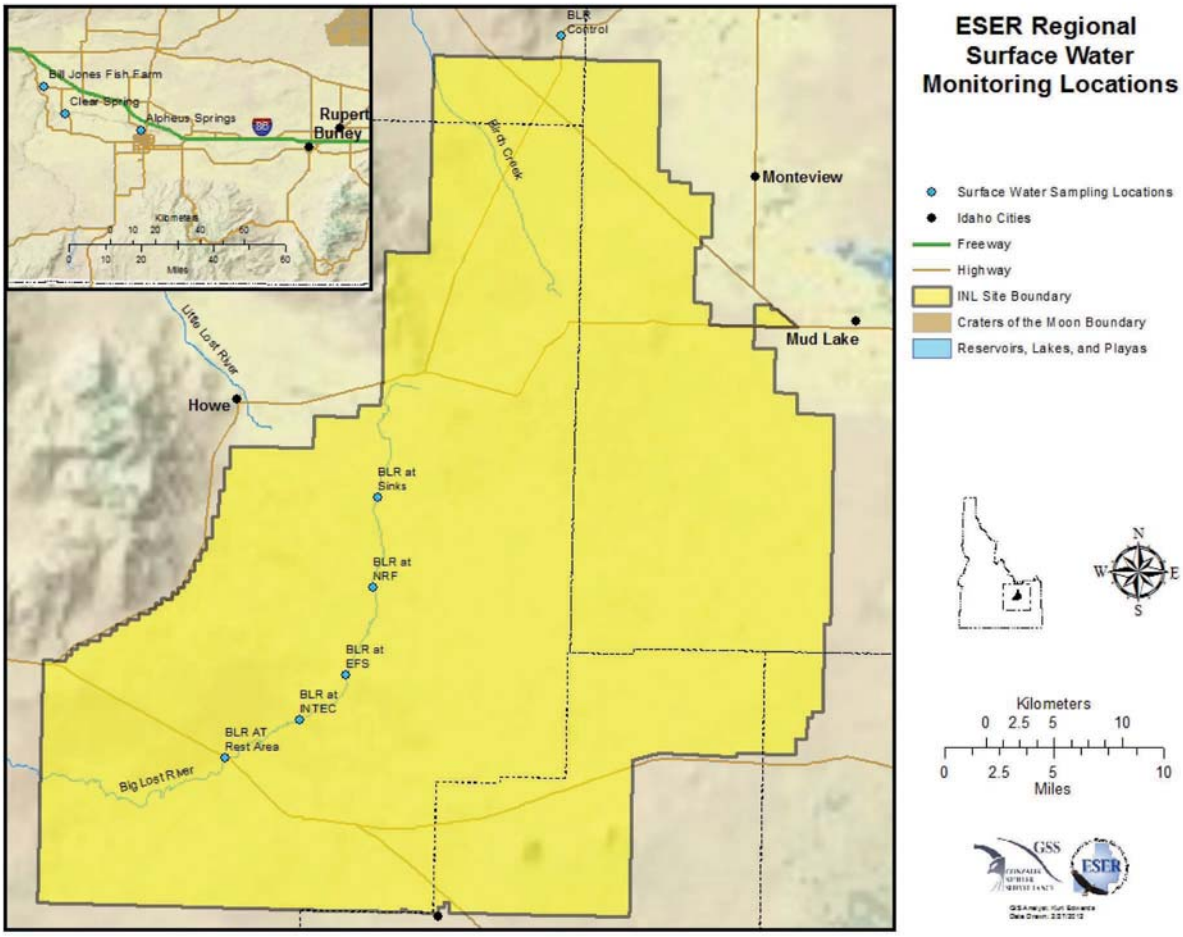

Figure 6-18. Detailed Map of ESER Program Surface Water Monitoring Locations.

Table 6-11. Gross Alpha, Gross Beta, and Tritium Concentrations in Surface Water Samples Collected by the ESER Contractor in 2011.

Location	Sample Results (pCi/L)[a]		
Gross Alpha			
	Spring/Summer[b]	Fall[b]	EPA MCL[c]
Alpheus Springs (Twin Falls)	ND[d]	ND	15
Clear Springs (Buhl)	I[e]	ND	15
Bill Jones Hatchery (Hagerman)	I	ND	15
BLR[f] at Highway 20/26 rest area	1.18 ± 0.39/4.55 ± 0.53	No water	15
BLR at EFS	2.07 ± 0.43/6.15 ± 0.63	No water	15
BLR near INTEC	5.61 ± 0.59/No water	No water	15
BLR near NRF	1.90 ± 0.42/1.79 ± 0.41	No water	15
BLR at BLR Sinks	2.94 ± 0.50/2.82 ± 0.51	No water	15
Birch Creek (control)	1.39 ± 0.38/2.94 ± 0.49	No water	15
Gross Beta			
	Spring/Summer	Fall	EPA MCL
Alpheus Springs (Twin Falls)	7.93 ± 0.67	5.21 ± 0.54	4 mrem/yr (8 pCi/L ^{90}Sr)[g]
Clear Springs (Buhl)	I	4.89 ± 0.60	4 mrem/yr (8 pCi/L ^{90}Sr)
Bill Jones Hatchery (Hagerman)	I	ND	4 mrem/yr (8 pCi/L ^{90}Sr)
BLR at Highway 20/26 rest area	3.00 ± 0.51/2.37 ± 0.49	No water	4 mrem/yr (8 pCi/L ^{90}Sr)
BLR at EFS	3.84 ± 0.53/3.50 ± 0.54	No water	4 mrem/yr (8 pCi/L ^{90}Sr)
BLR near INTEC	3.79 ± 0.54/No water	No water	4 mrem/yr (8 pCi/L ^{90}Sr)
BLR near NRF	2.77 ± 0.50/3.38 ± 0.51	No water	4 mrem/yr (8 pCi/L ^{90}Sr)
BLR at BLR Sinks	5.02 ± 0.56/7.68 ± 0.63	No water	4 mrem/yr (8 pCi/L ^{90}Sr)
Birch Creek (control)	3.51 ± 0.51/5.40 ± 0.56	No water	4 mrem/yr (8 pCi/L ^{90}Sr)
Tritium			
	Spring/Summer	Fall	EPA MCL
Alpheus Springs (Twin Falls)	81 ± 21	119 ± 30	20,000
Clear Springs (Buhl)	110 ± 21	ND	20,000
Bill Jones Hatchery (Hagerman)	ND	ND	20,000
BLR at Highway 20/26 rest area	138 ± 21.9	No water	20,000
BLR at EFS	132 ± 22.1	No water	20,000
BLR near INTEC	72 ± 21.3	No water	20,000
BLR near NRF	95.3 ± 21.4	No water	20,000
Birch Creek (control)	83.8 ± 21.2	No water	20,000

a. Result ± 1s
b. The springs and hatchery were sample on May 23 and November 14, 2011. The Big Lost River (BLR) was sampled on June 30 and July 15, 2011 when water was available in the river.
c. EPA = Environmental Protection Agency; MCL = Maximum Contaminant Level.
d. ND = not detected (results < 3s).
e. I = Invalid sample. A chemical reaction occurred in the sample when acidified producing a thick, green viscous substance which could not be analyzed. The cause could not be identified.
f. BLR = Big Lost River.
g. The MCL for gross beta activity is not established. However, the EPA drinking water standard of 4 mrem/y for public drinking water systems is applied and a conservative screening level of 8 pCi/L (the MCL for strontium-90) is used. It is conservative because it is highly unlikely that the gross beta activity is due to strontium-90 and more likely due to naturally occurring radionuclides in the sample.

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ESER Sample Manager, Katie Moore, collecting surface water sample.

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

Chapter 7 Highlights

Idaho National Laboratory (INL) Site-released radionuclides may be assimilated by agricultural products and game animals which humans may then consume. These media are thus sampled because of the potential transfer of radionuclides to people through food chains.

Radionuclides may also be deposited on soils and can be measured on the surface with detectors or in the laboratory through radioanalysis of samples. Direct radiation measurements detect ionizing radiation in the environment.

Some human-made radionuclides were detected in agricultural products (milk, lettuce, alfalfa, and elk forage) collected in 2011. However, the results could not be directly linked to operations at the INL Site. Iodine-131 from the Fukushima nuclear accident in Japan was detected in one weekly and two monthly milk samples. The highest reported value was 0.3 percent of the Food and Drug Administration's Limit for Public Health. Concentrations of strontium-90 detected in agricultural products were consistent with historic measurements and suggest that the source is fallout from past atmospheric weapons testing. Tritium was also detected in three milk samples at levels that indicate natural sources in the environment. The maximum levels for these radionuclides were all well below regulatory health-based limits for protection of human health and the environment.

Cesium-137 was detected in the meat of one of the five road-killed, large game animals sampled in 2011. The concentration was within the range of background samples collected across the western United States in previous years and is most likely due to atmospheric fallout from past nuclear weapons testing.

Human-made radionuclides were also detected in some samples of waterfowl collected on ponds at the INL Site. Concentrations of several of the man-made radionuclides were higher in waterfowl taken from ponds in the vicinity of the Advanced Test Reactor Complex than in control and other pond samples. The ducks most likely received the contamination while accessing the Advanced Test Reactor Complex ponds area. Results were similar to those found in the previous two years and significantly lower than in previous research studies.

Cesium-137 was measured in INL Site surface soils using an in-situ gamma detector. These measurements are performed annually at and around specific INL Site facilities. Areas of known contamination, from historic activities on the INL Site, had higher scan results. Other areas showed results consistent with background levels from global fallout. Some in situ

measurements around facilities also indicate the presence of other radionuclides associated with past INL Site operations.

Direct radiation measurements made at boundary and distant locations were consistent with background levels. The average annual dose equivalent from external exposure was 122 mrem at boundary locations and 124 mrem at distant locations. 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 were greater than background levels but lower than measurements taken prior to 2010. This is due to the fact that the active pit was covered in 2009.

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

This chapter summarizes results of environmental monitoring of agricultural products, wildlife, soil, and direct radiation on and around the Idaho National Laboratory (INL) Site during 2011. Details of these programs may be found in the Idaho National Laboratory Environmental Monitoring Plan (DOE-ID 2010). The INL, Idaho Cleanup Project (ICP), and Environmental Surveillance, Education, and Research Program (ESER) contractors monitor soil, vegetation, biota, and direct radiation on and off the INL Site to comply with applicable U.S. Department of Energy (DOE) orders and other requirements. The focus of INL and ICP contractor monitoring is on the INL Site, particularly on and around facilities (Table 7-1). The ESER contractor's primary responsibility is to monitor the presence of contaminants in media off the INL Site which may originate from INL Site releases (Table 7-1).

7.1 Agricultural Products and Biota Sampling

Agricultural products and game animals are sampled by the ESER contractor because of the potential transfer of radionuclides to people through food chains (Figure 3-1).

7.1.1 Milk

Milk is sampled to monitor the pathway from potentially contaminated, regionally grown feed to cows to milk, which is then ingested by humans. During 2011, the ESER contractor collected 136 milk samples at various locations off the INL Site (Figure 7-1) and from commercially-available milk from outside the state of Idaho. The number and location of the dairies can vary from year to year as farmers enter and leave the business. Milk samples were collected weekly in Idaho Falls and monthly at other locations around the INL Site. All samples were analyzed for gamma-emitting radionuclides, including iodine-131 (^{131}I) and cesium-137 (^{137}Cs). During the second and fourth quarters, samples were analyzed for strontium-90 (^{90}Sr) and tritium.

Iodine is an essential nutrient element and is readily assimilated by cows eating plants containing the element. Iodine-131 is of particular interest because it is produced by nuclear

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

	Media							
Area/Facility[a]	Agricultural Products (milk, wheat, and potatoes)	Biota (waterfowl, large game animals)	Biota (vegetation)	CERCLA Ecological (Soil, sediment, water, Vegetation, and animals)	Soil	In-Situ Gamma Spectrometry (^{137}Cs in soil)	Direct Radiation (global positioning radiometric scanner)	Direct Radiation (TLDs)
Environmental Surveillance, Education, and Research Program Contractor								
INL Site/Regional	•	•	•	•	•			•
Idaho National Laboratory Contractor								
CFA (WRP)				•				
INL Site						•		•
Regional								•
Idaho Cleanup Project Contractor								
RWMC			•		•		•	
INL Site				•				

a. CFA (WRP) = Wastewater Reuse Permit soil sampling at Central Facilities Area
INL Site = Idaho National Laboratory Site facility areas and areas between facilities
RWMC = Radioactive Waste Management Complex.

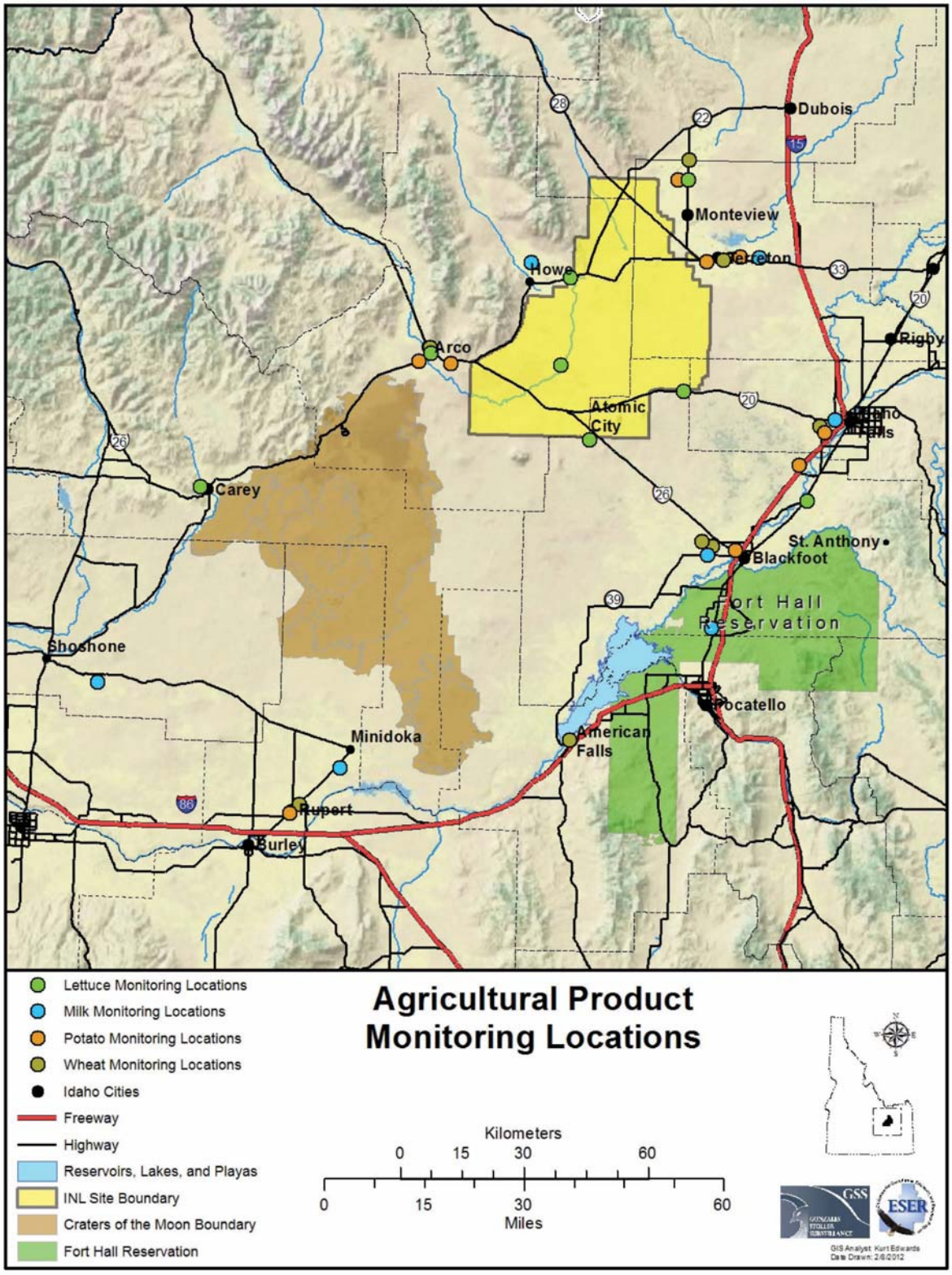

Figure 7-1. Locations of Agricultural Product Samples Collected (2011).

reactors or weapons, is readily detected and, along with cesium-134 (^{134}Cs) and ^{137}Cs, can dominate the ingestion dose regionally after a severe nuclear event such as the Chernobyl accident (Kirchner 1994) or the 2011 accident at Fukushima in Japan. Iodine-131 has a short half-life (8 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. A small amount of ^{131}I (approximately 8.1 mCi in 2011) is still released by the Advanced Test Reactor (ATR) at the INL Site but is not detected in air samples collected at the INL Site boundary (Chapter 4). Iodine-131 from the Fukushima accident was detected in three milk samples. A weekly sample from Idaho Falls collected on March 22 had a concentration just above the detection limit at 5.1 pCi/L. The April and May samples from Fort Hall showed concentrations of 14.3 and 7.4 pCi/L, respectively. The Fort Hall dairy is a small dairy and during the period when fallout from Fukushima was detected in eastern Idaho, the cows were on pasture and drinking from an open water source. For comparison, the Food and Drug Administration's Limit for Public Health for ^{131}I in milk is 3,700 pCi/L. More information on results following the Fukushima accident can be found in Appendix B.

Cesium-137 is chemically analogous to potassium in the environment and behaves similarly. It has a half-life of about 30 years and tends to persist in soil, and if in soluble form can readily enter the food chain through plants. It is widely distributed throughout the world from historic nuclear weapons detonations, which occurred between 1945 and 1980, and has been detected in all environmental media at the INL Site. Regional sources include releases from INL facilities and resuspension of previously contaminated soil particles. Cesium-137 was not detected in any milk samples collected in 2011.

Strontium-90 is an important radionuclide because it behaves like calcium and can deposit in bones. Strontium-90, like ^{137}Cs, is produced in high yields from nuclear reactors or detonations of nuclear weapons. It has a half-life of 28 years and can persist in the environment. Strontium tends to form compounds that are soluble, compared to ^{137}Cs, and therefore comparatively mobile in ecosystems. Strontium-90 was detected in seven of 15 milk samples analyzed, including one of the two control samples from outside the state. Concentrations ranged from 0.09 pCi/L at Howe to 0.65 pCi/L at Fort Hall and Idaho Falls (Figure 7-2). These levels were consistent with levels reported by the U.S. Environmental Protection Agency (EPA) as resulting from worldwide fallout deposited on soil and taken up by cows through ingestion of grass. Results from EPA Region 10 (which includes Idaho) of 10 samples collected over a 10-year period (2002-2011) ranged from 0 to 1.2 pCi/L (EPA 2012).

DOE has established Derived Concentration Standards (DCSs) for radionuclides in air and water. A DCS is the concentration of a radionuclide in air or water that would result in a dose of 100 mrem from ingestion, inhalation, or immersion in a gaseous cloud for one year. There is no established DCS for foodstuffs such as milk. For reference purposes, the DCS for ^{90}Sr in water is 1,100 pCi/L. The maximum observed value in milk samples (0.65 pCi/L) is, therefore, approximately 0.06 percent of this DCS for drinking water.

Tritium, with a half-life of about 12 years, is an important radionuclide because it is a radioactive form of hydrogen, which combines with oxygen to form tritiated water. The

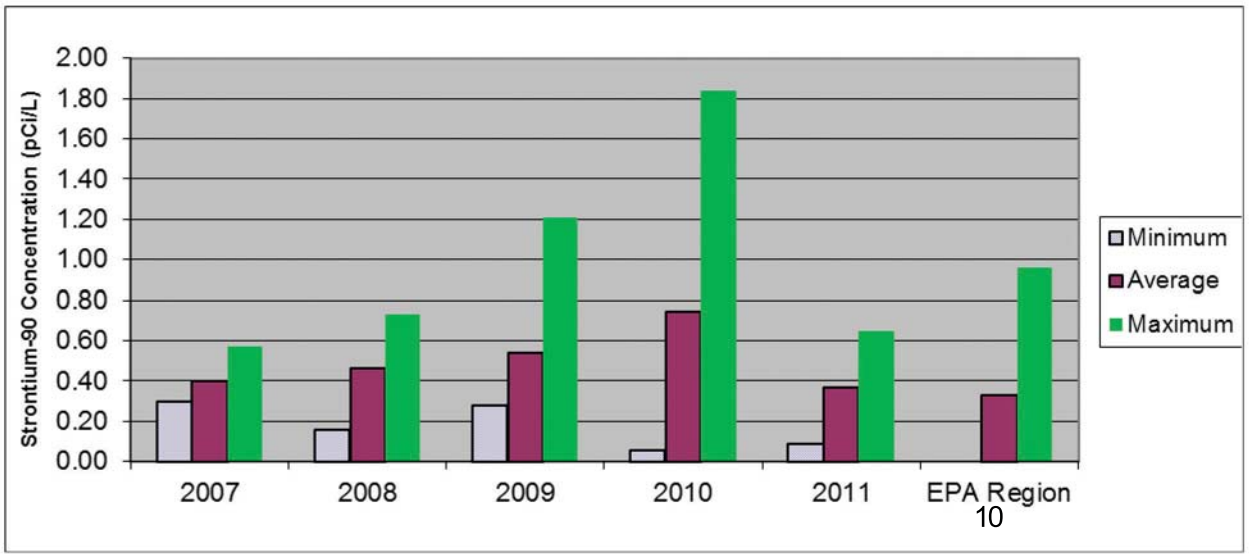

Figure 7-2. Strontium-90 Concentrations in Milk (2007 – 2011).

environmental behavior of tritiated water is like that of water, and it can be present in surface water, precipitation, and atmospheric moisture. Tritium is formed by natural processes, as well as by reactor operation and nuclear weapons testing. Tritium enters the food chain through surface water that animals drink, as well as from plants that contain water. Tritium was detected in three of 15 milk samples analyzed at concentrations of 81 pCi/L in Blackfoot, 120 pCi/L in Rupert, and 285 pCi/L in Terreton. These concentrations are similar to those of previous years and are consistent with those found in atmospheric moisture and precipitation samples. The DCS for tritium in water is 19,000 pCi/L. The maximum observed value in milk samples is about 1.5 percent of the DCS.

7.1.2 Lettuce

Lettuce was sampled in 2011 because radionuclides in air can be deposited on soil and plants, which can then be ingested by people (Figure 3-1). Uptake of radionuclides by plants may occur by root uptake from soil or absorption of deposited material on leaves. For most radionuclides uptake by foliage is the dominant process for contamination of plants (Amaral et al. 1994). For this reason, green leafy vegetables like lettuce have higher concentration ratios of radionuclides to soil than other kinds of plants. The ESER contractor collects lettuce samples every year from areas on and adjacent to the INL Site. The number and locations of gardens have changed from year to year depending on whether or not vegetables were available. Some home gardens were replaced with portable lettuce planters (Figure 7-3) because the availability of lettuce from home gardens was unreliable at some key locations. Also, the planters can be

Figure 7-3. Portable Lettuce Planter.

placed and lettuce collected at areas previously unavailable to the public, such as on the INL Site and near air samplers. The planters can allow radionuclides deposited from air to accumulate on the soil and plant surfaces throughout the growth cycle. The planters are placed in the spring, filled with soil, sown with lettuce seed, and self-watered through a reservoir.

Five lettuce samples were collected from portable planters at Arco, Atomic City, the Experimental Field Station, the Federal Aviation Administration Tower, and Monteview. In addition, samples were obtained from home gardens at Blackfoot, Carey, and Howe. A control sample from an out-of-state location was obtained and a duplicate sample was collected at Atomic City. The samples were analyzed for ^{90}Sr and gamma-emitting radionuclides.

Strontium-90 was detected in five of the 10 lettuce samples collected. The maximum ^{90}Sr concentration of 112 pCi/kg, measured in the lettuce sample from the onsite Experimental Field Station, was above the range of concentrations detected in the past 5 years (0-96 pCi/kg) but

only slightly so and similar to those seen in some previous years. This result was most likely fallout from past weapons testing and not INL Site operations. Strontium-90 is present in the environment as a residual of fallout from aboveground nuclear weapons testing, which occurred between 1945 and 1980. Figure 7-4 shows the average of all measurements (including those below detection levels) from 2007 through 2011. Although the 2011 mean was the highest in this 5-year period, it was consistent with the means from many earlier years.

No other human-made radionuclides were detected in any of the lettuce samples. Although ^{137}Cs from nuclear weapons testing fallout is measureable in soils, the ability of vegetation such as lettuce to incorporate cesium from soil in plant tissue is much lower than for strontium (Fuhrmann et al. 2003; Ng et al. 1982; Schulz 1965). In addition, the availability of ^{137}Cs to plants depends highly on soil properties, such as clay content or alkalinity, which can act to bind the radionuclide (Schulz 1965). Soils in southeast Idaho tend to be moderately to highly alkaline. For more detail see http://www.or.nrcs.usda.gov/pnw_soil/id_reports.html. Strontium, on the other hand, has a tendency to form compounds that are comparatively soluble. These factors could help explain why ^{90}Sr was detected in lettuce and ^{137}Cs was not.

7.1.3 Grain

Grain (including wheat and barley) is sampled because it is a staple crop in the region. The ESER contractor collected nine grain samples from areas surrounding the INL Site in 2011 and obtained one commercially-available sample from outside the state of Idaho. The locations were selected because they are typically farmed for grain and are encompassed by the air surveillance network. Exact locations may change as growers rotate their crops. No human-made gamma-

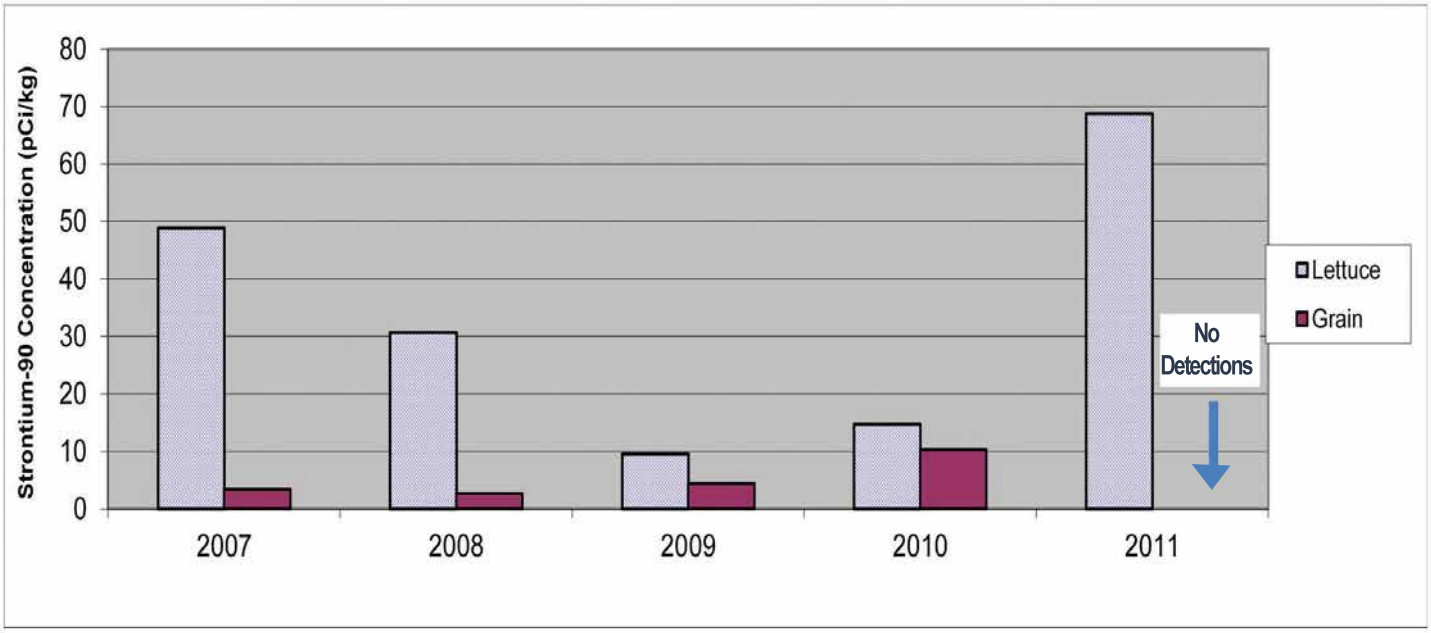

Figure 7-4. Average Strontium-90 Concentrations in Lettuce and Grain (2007 – 2011).

emitting radionuclides were found in any samples. None of the 10 grain samples collected in 2011 contained detectable concentrations of ^{90}Sr either. Average current and historical results are presented in Figure 7-4.

The concentrations of ^{90}Sr measured in grain are generally less than those measured in lettuce. Agricultural products such as fruits and grains are naturally lower in radionuclides than green, leafy vegetables (Pinder et al. 1990). No other human-made radionuclides were detected in any of the samples. As discussed in Section 7.1.2, strontium in soil from fallout is more bioavailable to plants than cesium.

7.1.4 Potatoes

Potatoes are collected because they are one of the main crops grown in the region and are of special interest to the public. Because they are not exposed to airborne contaminants, they are not typically considered a key part of the ingestion pathway. Potatoes were collected by the ESER contractor at eight locations in the vicinity of the INL Site and obtained from one location outside eastern Idaho. None of the nine potato samples collected during 2011 contained a detectable concentration of any human-made, gamma-emitting radionuclides or ^{90}Sr.

7.1.5 Alfalfa

In addition to analyzing milk, the ESER contractor began collecting data in 2010 on alfalfa consumed by milk cows. This was in response to the DOE Headquarters Independent Oversight Assessment of the Environmental Monitoring program at the Idaho National Laboratory Site conducted during that year. The assessment team commented, with reference to the milk sampling program, that the ESER contractor should consider sampling locally grown alfalfa offsite, along with collection of alfalfa usage data. Questionnaires were sent to each milk provider concerning what they feed their cows. All of the dairies feed their cows locally-grown alfalfa. A sample of alfalfa was collected in June from a farm in Terreton, which is located where the highest potential offsite air concentration was calculated by the National Oceanic and Atmospheric Administration Air Resources Laboratory – Field Research Division (see Figure 8-3). The sample was divided into three subsamples and analyzed for gamma-emitting radionuclides and ^{90}Sr. Cesium-137 was detected in one of the three sample splits on the initial count; however, a recount of the sample did not confirm the detection. One of the three subsamples showed detectable ^{90}Sr at 100 pCi/kg, which is just above the detection limit; the other two subsamples were just below the detection limit.

7.1.6 Elk Forage

As another response to the DOE Headquarters Independent Oversight Assessment of the Environmental Monitoring program at the Idaho National Laboratory Site, the ESER program in 2011 sampled elk forage (grasses and forbs) at locations known to be occupied by elk. Samples were collected at a location north of the Materials and Fuels Complex, on the north side of the Radioactive Waste Management Complex (RWMC), and at a background location near the Craters of the Moon National Monument. Three sample splits were prepared from each location. All samples were analyzed for gamma-emitting radionuclides; additionally, RWMC samples were analyzed for ^{90}Sr and transuranic radionuclides. No human-made gamma-emitting radionuclides

or transuranics were found in any samples. One of the three sample splits from RWMC had a detectable ^{90}Sr result. The value of 124 pCi/kg is similar to values found in both lettuce and alfalfa samples during 2011.

7.1.7 Large Game Animals

Muscle samples were collected by the ESER contractor from five game animals (two elk, two mule deer, and one pronghorn) accidentally killed on INL Site roads. Thyroid samples were obtained for four of the animals, and liver samples were collected from three of the animals. The samples were all analyzed for ^{137}Cs because it is an analogue of potassium and is readily incorporated into muscle and organ tissues. Thyroids were analyzed for iodine-131 because when assimilated by higher animals, it selectively concentrates in the thyroid gland and is, thus, an excellent bioindicator of atmospheric releases.

In 1998 and 1999, four pronghorn, five elk, and eight mule deer muscle samples were collected as background samples from hunters across the western United States, including three from central Idaho, three from Wyoming, three from Montana, four from Utah and one each from New Mexico, Colorado, Nevada, and Oregon (DOE-ID 1999). Each background sample had small, but detectable, ^{137}Cs concentrations in its muscle. These concentrations likely can be attributed to the ingestion of plants containing radionuclides from fallout associated with aboveground nuclear weapons testing. Allowing for radioactive decay since the time of the study, background measurements would be expected to range from about 4 to 11 pCi/kg in 2011.

Of the muscle and liver samples collected in 2011, ^{137}Cs was detected at a concentration of 4 pCi/kg from only one muscle sample collected in March from an elk. This value was at the lower end of the 4 to 11 pCi/kg background range from the above-cited study. It was also well within the range of detectable values from the previous several years. With the exception of an immature deer sampled in 2008 that had elevated ^{137}Cs concentrations, all values have been between about 4 and 11 pCi/kg.

No ^{131}I was detected in any of the thyroid samples.

7.1.8 Waterfowl

Waterfowl are collected each year by the ESER contractor at ponds on the INL Site and at a location off the INL Site. Twelve ducks were collected during 2011: six from the ATR Complex wastewater ponds, and three each from the MFC wastewater ponds, and a control location near American Falls Reservoir. Each sample was divided into the following three subsamples: (1) edible tissue (muscle, gizzard, heart, and liver), (2) external portion (feathers, feet, and head), and (3) all remaining tissue. All samples were analyzed for gamma-emitting radionuclides, ^{90}Sr, plutonium-238 (^{238}Pu), plutonium-239/240 ($^{239/240}$Pu), and americium-241 (^{241}Am). These radionuclides were selected because they are often measured in liquid effluents from some INL Site facilities (Chapter 5).

Several man-made radionuclides were detected in the samples from the ATR Complex ponds, including ^{137}Cs, cobalt-60 (^{60}Co), ^{90}Sr, and zinc-65 (^{65}Zn). Except for ^{90}Sr, each of these

radionuclides also was found in at least one edible tissue sample. Cesium-137 was found in the external portion of one duck from the MFC ponds. No human-made radionuclides were detected in birds from the American Falls control location. Radionuclide concentrations measured in the edible tissues of waterfowl from ATR Complex in 2011 are shown in Figure 7-5.

Because most of the detected human-made radionuclides were found in ducks from ATR Complex and not at other locations, it is assumed that this facility is the source of these radionuclides. The ducks were not taken directly from the two-celled hypalon-lined radioactive wastewater evaporation pond, but rather from an adjacent sewage lagoon. However, the ducks probably used the evaporation pond. Concentrations of ^{137}Cs in 2011 were much lower than those in 2010; ^{60}Co and ^{65}Zn concentrations were similar. In addition, concentrations were lower in 2011 than those of a 1994 – 1998 study (Warren et al. 2001). Further information on potential doses from consuming waterfowl is presented in Chapter 8.

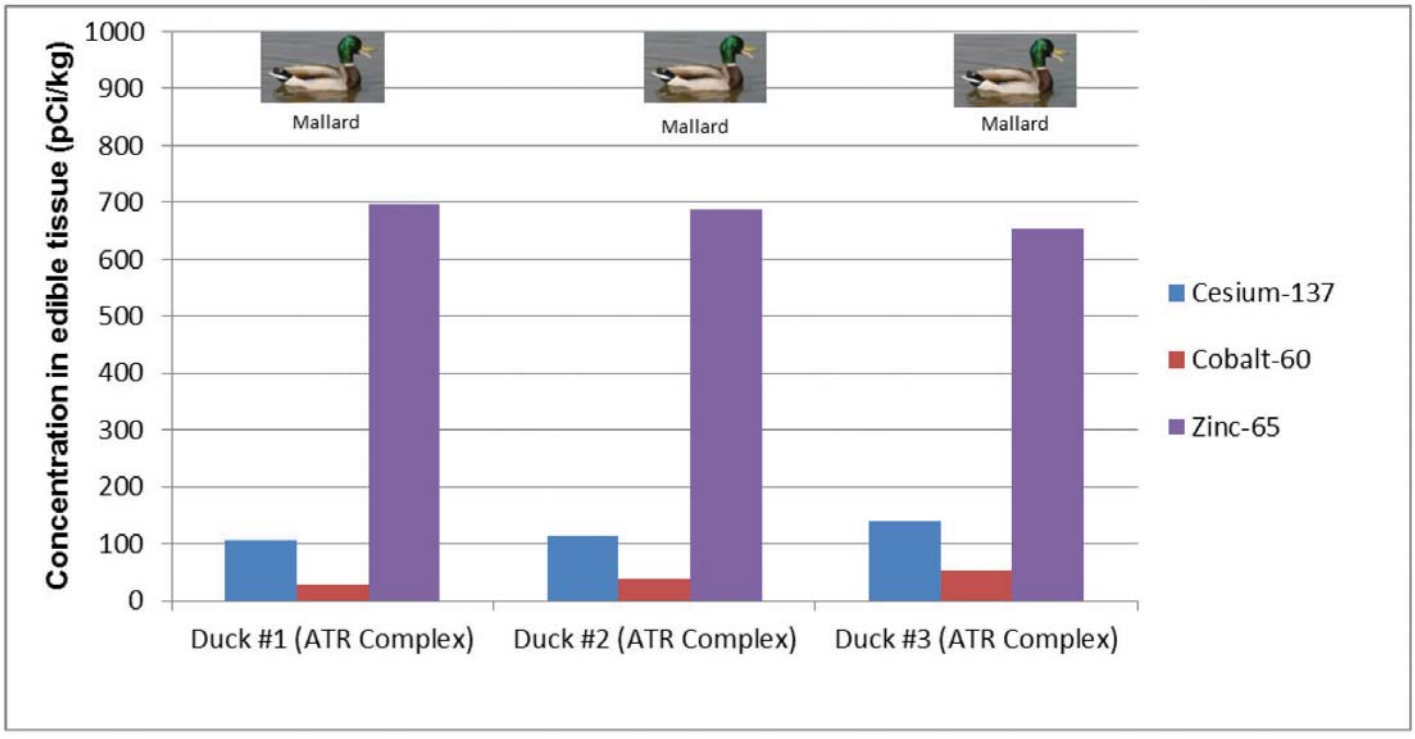

Figure 7-5. Radionuclide Concentrations Detected in Edible Tissues of Waterfowl (2011).

7.2 Soil Sampling and In Situ Gamma Spectrometry

7.2.1 Soil Sampling off the INL Site

Aboveground nuclear weapons testing has resulted in many radionuclides being distributed throughout the world via atmospheric deposition. Cesium-137, ^{90}Sr, ^{238}Pu, $^{239/240}$Pu, and ^{241}Am are radionuclides that may be detected in soil because of global fallout but could also be present from INL Site operations. These radionuclides are of particular interest because of their abundance resulting from nuclear fission events (e.g., ^{137}Cs and ^{90}Sr or from their persistence in the environment due to long half-lives (e.g., $^{239/240}$Pu, with a half-life of 24,110 years). Soil samples are collected by the ESER contractor every 2 years (in even-numbered years). Soil sampling locations are shown in Figure 7-6. A new location was added in 2010 at Frenchman's Cabin located at the southern boundary of the INL Site. This location has been the site of the maximally exposed individual for EPA dose calculations performed to comply with EPA requirements during recent years (see Chapter 8). Soil samples are analyzed for gamma-emitting radionuclides, ^{90}Sr, ^{241}Am, and plutonium radionuclides.

Soil was last sampled by the ESER contractor in 2010. Results for ^{137}Cs and ^{90}Sr from the beginning of sampling in 1975 to 2010 are presented in Figure 7-7. Aboveground nuclear weapons testing has been extremely limited since 1975 and no tests have occurred since 1980, so no ^{137}Cs and ^{90}Sr has been deposited on soil from sources outside the INL Site in that time. It would be expected that the concentrations of these two radionuclides would decrease over time from the levels measured in 1975 at a rate consistent with their approximate 30-year half-lives unless the INL Site was having an impact. Figure 7-7 shows that ^{137}Cs follows the expected decay line fairly closely. Strontium-90 has been tracking below the expected line during the past several sampling cycles. This may be because the samples represent the top 12.5 cm (5 in.) of soil and some of the ^{90}Sr may have migrated to deeper levels and some of the ^{90}Sr may have been taken up by vegetation. No accumulation of either radionuclide on soil by operations at the INL Site is indicated.

No ^{241}Am or plutonium isotopes were detected in 2010 or in the previous sampling cycle in 2008. A limited number of detections occurred in 2006.

7.2.2 Wastewater Reuse Permit Soil Sampling at Central Facilities Area

The Wastewater Reuse Permit for the Central Facilities Area Sewage Treatment Facility allows nonradioactive wastewater to be pumped from the treatment lagoons to the ground surface by sprinkler irrigation. The permit requires collection of soil samples at 10 locations within the land application area in 2010 and 2013. No soil samples were collected in 2011.

7.2.3 In Situ Gamma Spectrometry

In-situ gamma spectrometry using portable high purity germanium (HPGe) detectors is a technique that measures the gamma-ray fluence rate from a gamma-emitting source for the purpose of obtaining the activity or concentration of radioactive materials (Shebell et al. 2003). The most common application of in-situ gamma-ray spectrometry has been the measurement of gamma-emitting radionuclides, such as ^{137}Cs, in surface soils. The technique is a rapid and

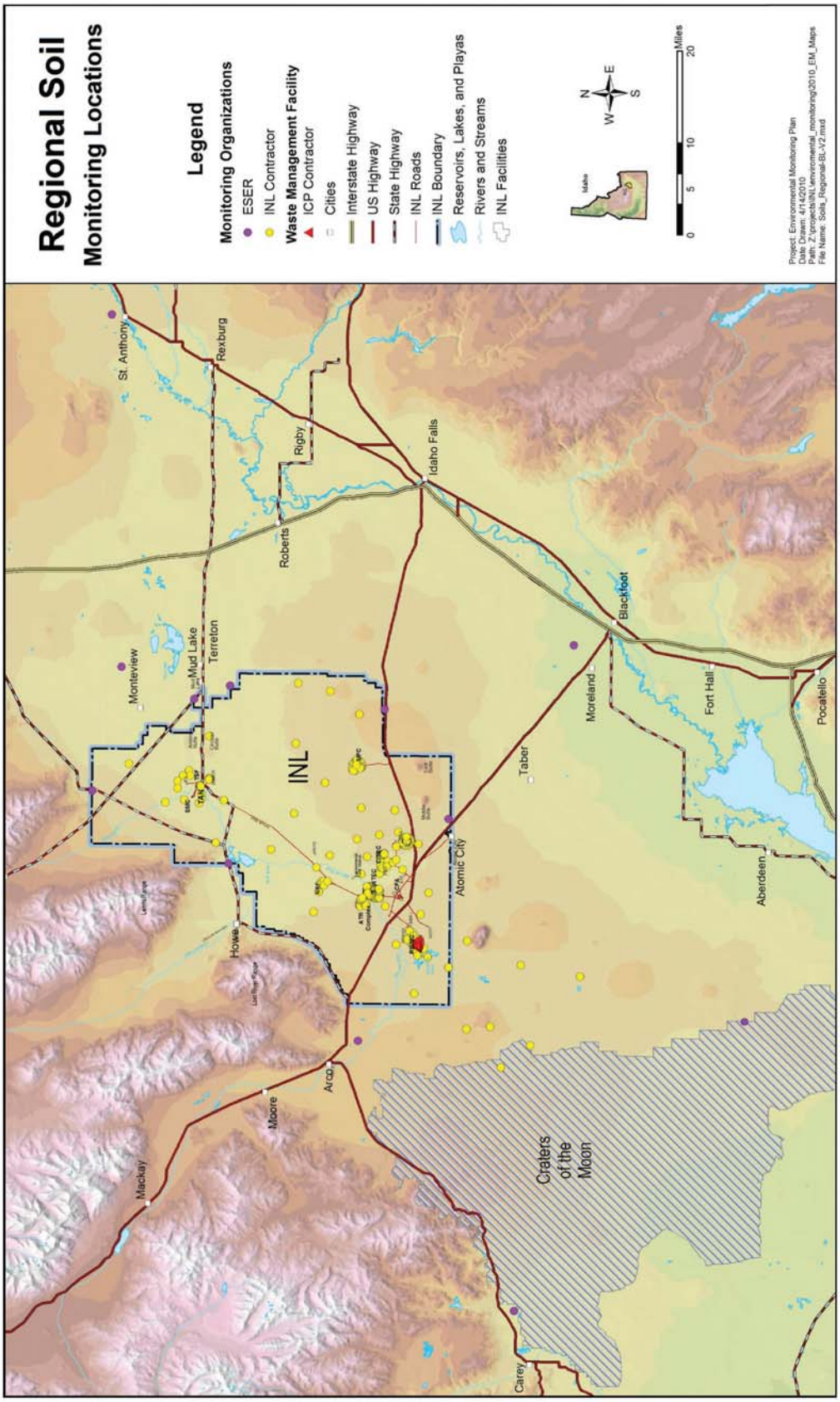

Figure 7-6. Soil Sampling Locations.

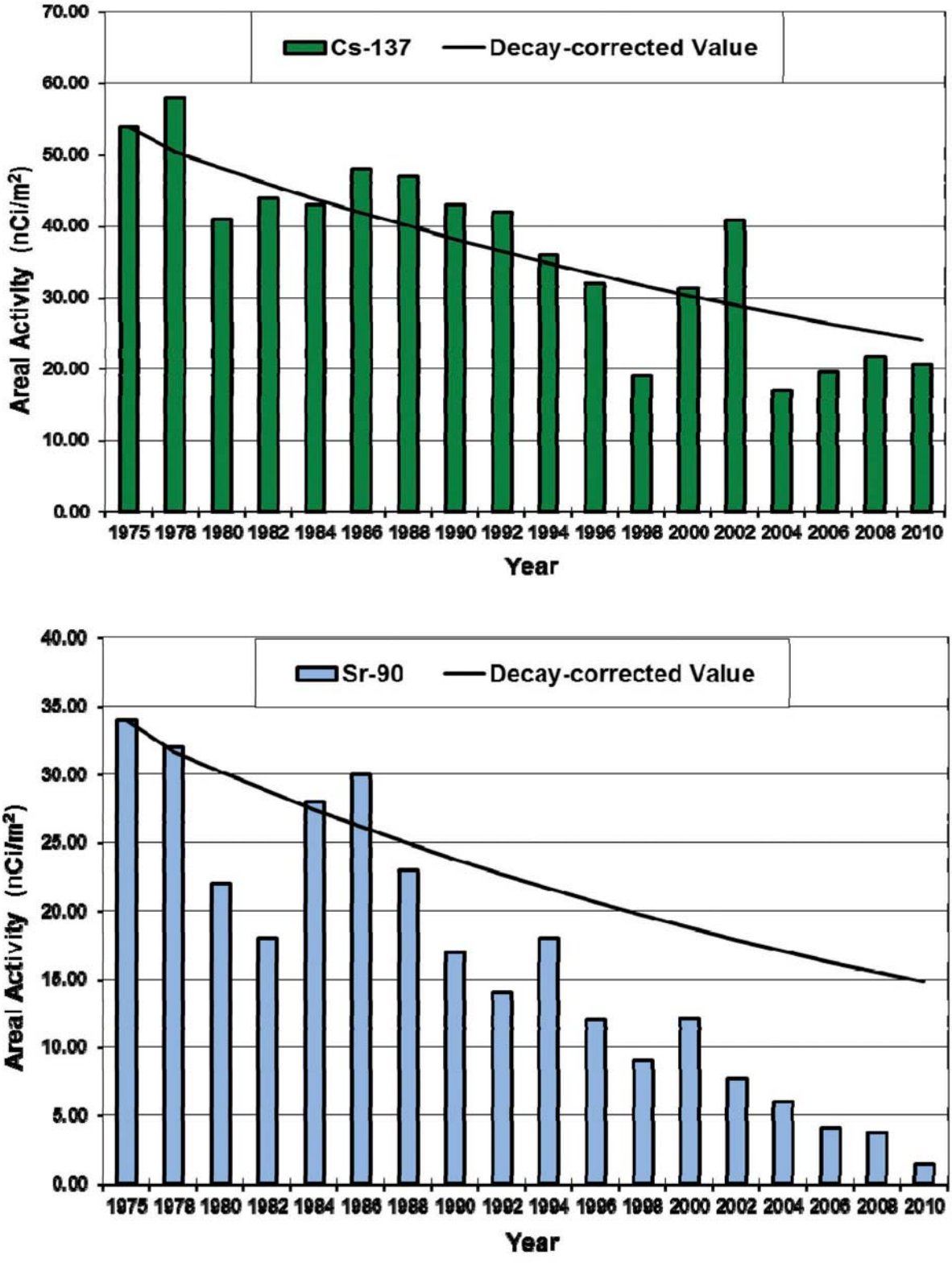

Figure 7-7. Mean Activities in Surface (0 – 12 cm [0 – 5 in.]) Soils off the INL Site (1975 – 2010).

cost effective way to assay surface soil for gamma-emitting radionuclides, especially as part of site characterization. In 2011, several other naturally occurring radioactive material (NORM) and anthropogenic radionuclides were measured for this work. These included the following NORM isotopes: bismuth-214, actinium-228, lead-214, radium-226, thallium-208, uranium-234, and uranium-238 (^{238}U). Anthropogenic isotopes measured in 2011 (in addition to ^{137}Cs) included the following: uranium-235, europium-152 (^{152}Eu), ^{60}Co, and ^{241}Am. Results in this report are those that were true positive detects. This means that the reported isotopic concentration was greater than three times the reported uncertainty for that isotope.

The concentration levels of the isotopes with measured positive detect values at these locations do not rise to cleanup levels.

The detected anthropogenic radionuclides detected in INL soils in 2011 included ^{137}Cs, ^{60}Co, ^{152}Eu, ^{241}Am, and ^{238}U. Cesium-137 has a half-life of 30.2 years and originates as a fallout fission product from nuclear weapons testing or from past effluent or stack releases. Cesium-137 is strongly retained on clay soils which limits plant uptake and it is not readily soluble in fresh water. Cesium-137 human metabolism resembles that of potassium so it can be uniformly distributed in the body. The mean background concentration of ^{137}Cs at the INL is documented to be 0.44 pCi/g and the upper threshold limit is 1.61 pCi/g based on results from historical grab sampling of soils. Cobalt-60 is also an activation product produced in reactors and has a half-life of 5.3 years. Europium-152 is also an activation product produced in reactors and has a half-life of 13.5 years. It is produced as both fission and activation products in nuclear reactors. Trace amounts of ^{152}Eu are present in soil around the globe from radioactive fallout. It can also be present at certain nuclear facilities, such as reactors and spent fuel reprocessing plants. Europium is generally one of the more immobile radioactive metals in the environment. It preferentially adheres to soil, and the concentration associated with soil particles is estimated to be about 240 times higher than in interstitial water (the water in the pore space between soil particles). Americium-241 is a decay product of plutonium-241 and has a half-life of 432 years. Americium-241 does not occur in nature; however, some americium may be found in the environment as the result of atmospheric testing of nuclear weapons and disposal of wastes.

The INL contractor performed 243 field-based gamma spectrometry measurements in 2011 using several HPGe detector measurement systems based on the methodology described in the Environmental Measurements Laboratory Procedures Manual (DOE 1997). A summary of 2011 measured results, historical mean background values, and 99 percent upper threshold values based on grab sampling is presented in Table 7-2. Measured ^{137}Cs concentrations are reported for all measurement locations. Appendix D shows facility maps with the positive detect values. At RWMC, positive detect values for ^{241}Am were noted at five locations along the east and north boundary areas. These values are likely due to the shine from aboveground waste storage and disposal operations sites. Three elevated ^{238}U values were also noted. At Auxiliary Reactor Area Complex, ten locations showed very low concentrations (positive detects) of ^{60}Co and one location showed a positive detect for ^{60}Co, ^{137}Cs and ^{241}Am. INTEC results showed one positive detect each for ^{60}Co and ^{152}Eu. Uranium-238 was detected at six locations. At ARA, two positive detects for ^{238}U were noted. For the large grid five positive detects for ^{238}U were noted. At MFC,

Table 7-2. In-Situ Gamma Scan Results for INL Site Locations (2011)(all values in pCi/g).

Location	Radionuclide detected	Number of Observations	Minimum	Maximum	Mean	INL Site Mean Background Value[a]	95%/99% UCL[b]
ARA	Cs-137	25	0.23	9.58	1.72	0.44	1.61
ARA	U-238	2	3.23	4.21	3.72	1.04	2.15
CITRC	Cs-137	15	0.09	0.46	0.34	0.44	1.61
INTEC	Cs-137	64	0.18	12.68	3.47	0.44	1.61
INTEC	Eu-152	1	----	0.09	----	NA	NA
INTEC	Co-60	1	----	0.03	----	NA	NA
INTEC	U-238	6	2.66	5.80	3.67	1.04	2.15
Large Grid	Cs-137	62	0.08	0.64	0.39	0.44	1.61
Large Grid	U-238	5	1.40	4.57	3.42	1.04	2.15
MFC	Cs-137	16	0.14	0.97	0.47	0.44	1.61
MFC	Co-60	1	----	0.17	----	NA	NA
MFC	U-238	1	----	3.82	----	1.04	2.15
NRF	Cs-137	5	0.26	0.93	0.51	0.44	1.61
RTC	Cs-137	19	0.37	1.75	0.87	0.44	1.61
RTC	Co-60	10	0.03	0.09	0.05	NA	NA
RTC	Eu-152	1	----	0.62	----	NA	NA
RTC	Cs-134	1	----	0.05	----	NA	NA
RTC	Am-241	1	----	0.49	----	0.005	0.025
RWMC	Am-241	5	0.30	3.69	1.33	0.005	0.025
RWMC	Cs-137	20	0.13	0.76	0.41	0.44	1.61
RWMC	U-238	3	2.66	4.46	3.49	1.04	2.15
TAN-SMC	Cs-137	17	0.21	2.57	0.57	0.44	1.61
TAN-SMC	U-238	2	2.36	3.02	2.69	1.04	2.15

a. INL Site mean background and upper tolerance limit values are from INEL-94/0250, Rev 1 August 1996, "Background Dose Equivalent Rates and Surficial Soil Metal and Radionuclide Concentrations at the Idaho National Engineering Laboratory," S.M. Rood, et al.

b. 95%/99% upper confidence limit (UCL) values give 95% confidence of encompassing the smallest 99% of the background concentrations.

single positive detects were noted for ^{60}Co and ^{238}U. At Test Area North-Specific Manufacturing Capability, there were two ^{238}U positive detects, and three ^{134}Cs positive detects.

7.3 Direct Radiation

Thermoluminescent dosimeters (TLDs) measure cumulative exposures to ambient ionizing radiation. TLDs detect changes in ambient exposures attributed to handling, processing, transporting, or disposing of radioactive materials. TLDs are sensitive to beta energies greater than 200 kilo-electron volts (keV) and to gamma energies greater than 10 keV. The TLD packets contain four lithium fluoride chips and are placed about 1 m (about 3 ft) above the ground at specified locations (Figure 7-8). The four chips provide replicate measurements at each location. Beginning with the May 2010 distribution of dosimeters, the INL contractor began using optically stimulated luminescent dosimeters (OSLDs) collocated with the traditional TLDs. The ESER contractor deployed OSLDs in November 2011 and will run a side-by-side comparison with TLDs for the next year. Results will be reported in the 2012 annual report. Similar to TLDs, OSLDs also measure cumulative exposures (or dose) to ionizing radiation. Each OSLD contains four aluminum oxide detectors that are sensitive to ionizing radiation ranging in energy from 5 keV to 20 MeV, with a minimum dose equivalent reporting of 5 mrem. The primary advantage of the OSLD technology to the traditional TLD is that the nondestructive reading of the OSLD allows for dose verification (i.e. the dosimeter can be read multiple times without destruction of the accumulated signal inside the aluminum oxide chips). The dosimetry packets are replaced in May and November of each year. The sampling periods for 2011 were from November 2010 through April 2011 (spring collection) and from May through October 2011 (fall collection). The results for both types of dosimeters are provided in Appendix D. The results presented below include both TLD and OSLD data. The ESER contractor also deployed OSLDs with their TLDs beginning in November 2011 and will replace TLDs with OSLDs after one year of side-by-side measurements in November 2012. The results of the INL and ESER paired TLD/OSLD measurements, as well as an independent study by an Idaho State University graduate student of the performance of OSLDs under controlled laboratory conditions, will be presented in the 2012 annual report.

The measured cumulative environmental radiation exposure for locations off the INL Site from November 2010 through October 2011 is shown in Table 7-3 for two adjacent sets of TLDs maintained by the ESER and INL contractor. For purposes of comparison, annual exposures from 2007 to 2010 also are included for each location.

The mean annual exposures from distant locations in 2011 were 119 milliroentgens (mR) measured by the ESER contractor dosimeters and 121 mR (TLD) and 126 mR (OSLD) measured by the INL contractor dosimeters. For boundary locations, the mean annual exposures were 116 mR measured by the ESER contractor dosimeters and 121 mR (TLD) and 128 mR (OSLD) measured by the INL contractor dosimeters. Using both ESER and INL contractors' TLD data, the average dose equivalent of the distant group was 124 mrem when a dose equivalent conversion factor of 1.03 mrem/mR (for 662 keV gamma rays from ^{137}Cs) was used to convert from mR to mrem in tissue (ANSI/HPS 2009). The average dose equivalent for the boundary group was 122 mrem.

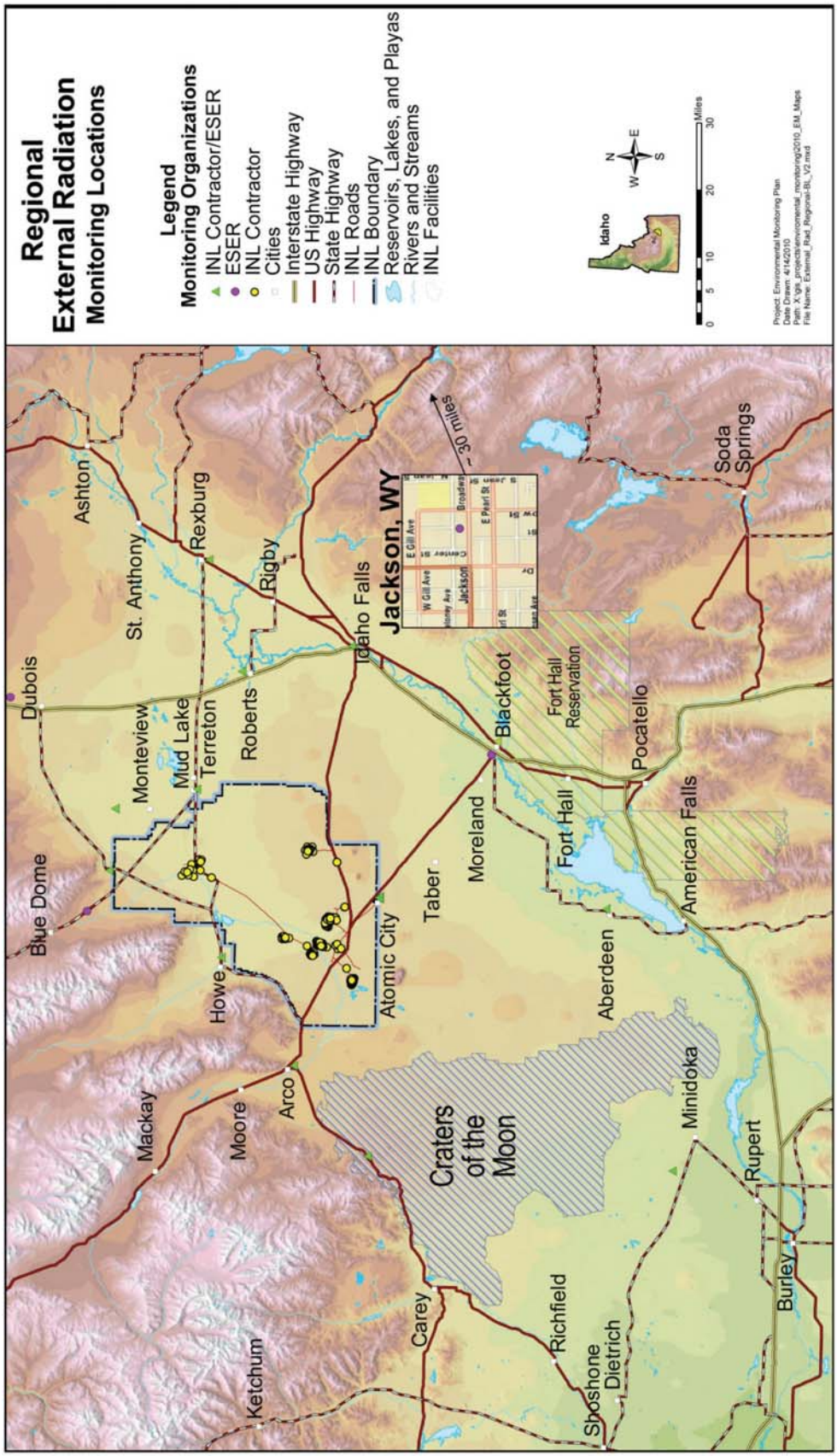

Figure 7-8. Regional Direct Radiation Monitoring Locations.

Table 7-3. Annual Environmental Radiation Exposures (2007 – 2011).

Location	2007		2008		2009		2010		2011	
	ESER[a]	INL[b] Contractor	ESER	INL Contractor	ESER	INL Contractor	ESER	INL Contractor	ESER	INL Contractor
	(mR)									
Distant Group										
Aberdeen	128 ± 9	132 ± 9	130 ± 6	128 ± 9	130 ± 6	128 ± 9	130 ± 6	133 ± 9	126 ± 6	128 ± 9
Blackfoot	118 ± 8	111 ± 8	122 ± 6	113 ± 8	122 ± 6	113 ± 8	120 ± 6	114 ± 8	121 ± 6	114 ± 8
Blackfoot (CMS)[c,d]	110 ± 8	N/A	110 ± 6	NA	110 ± 6	NA	113 ± 6	NA	112 ± 6	NA
Craters of the Moon	116 ± 8	117 ± 8	120 ± 5	125 ± 9	120 ± 5	125 ± 9	121 ± 5	135 ± 9	119 ± 6	118 ± 8
Dubois[d]	100 ± 7	N/A	103 ± 5	NA	103 ± 5	NA	104 ± 5	NA	100 ± 5	NA
Idaho Falls	121 ± 8	117 ± 8	120 ± 6	121 ± 8	120 ± 6	121 ± 8	124 ± 6	121 ± 8	124 ± 6	118 ± 8
Jackson[d]	102 ± 7	N/A	102 ± 5	NA	102 ± 5	NA	102 ± 5	NA	101 ± 5	NA
Minidoka	109 ± 8	112 ± 8	111 ± 5	111 ± 8	111 ± 5	111 ± 8	114 ± 6	119 ± 8	116 ± 4	115 ± 8
Rexburg	135 ± 9	116 ± 8	138 ± 7	118 ± 8	138 ± 7	118 ± 8	152 ± 7	128 ± 9	138 ± 7	124 ± 9
Roberts	129 ± 9	132 ± 9	130 ± 6	130 ± 9	130 ± 6	130 ± 9	--[e]	143 ± 10	134 ± 7	133 ± 9
Mean	117 ± 8	120 ± 8	119 ± 6	121 ± 8	119 ± 6	121 ± 8	120 ± 6	126 ± 9	119 ± 6	121 ± 8
Boundary Group										
Arco	127 ± 6	125 ± 6	119 ± 8	121 ± 8	121 ± 6	124 ± 9	128 ± 6	129 ± 9	130 ± 6	130 ± 9
Atomic City	129 ± 6	124 ± 6	126 ± 9	120 ± 8	122 ± 6	120 ± 8	127 ± 6	122 ± 8	121 ± 6	123 ± 8
Blue Dome[d]	104 ± 5	N/A	106 ± 7	N/A	107 ± 5	NA	105 ± 5	NA	105 ± 5	NA
Howe	118 ± 6	120 ± 6	117 ± 8	116 ± 8	116 ± 6	117 ± 8	117 ± 6	119 ± 8	111 ± 5	114 ± 8
Monteview	115 ± 6	119 ± 6	115 ± 8	120 ± 8	116 ± 5	119 ± 8	119 ± 6	128 ± 9	112 ± 6	116± 8
Mud Lake	128 ± 6	132 ± 6	128 ± 9	129 ± 9	130 ± 6	135 ± 9	134 ± 7	138 ± 10	134 ± 7	132 ± 9
Birch Creek Hydro	111 ± 5	109 ± 5	110 ± 8	114 ± 8	112 ± 6	113 ± 8	--[f]	NA	109 ± 5	112 ± 8
Mean	119 ± 6	121 ± 6	117 ± 8	120 ± 8	118 ± 6	121 ± 8	122 ± 6	127 ± 9	116 ± 6	121 ± 8

a. ESER = Environmental, Surveillance, Education and Research
b. INL = Idaho National Laboratory
c. CMS = Community Monitoring Station
d. The INL contractor does not sample at this location.
e. Dosimeter was missing at one of the collection times.
f. Reader malfunctioned during measurement of dosimeter.

Dosimeters maintained on the INL Site by the INL contractor representing the same exposure period as the dosimeters off the INL Site are shown in Appendix D, Figures D-10 through D-19. The dose equivalents for these locations are tabulated in Table D-1. Dosimeters on the INL Site are placed at facility perimeters, concentrated in areas likely to show the highest gamma radiation readings. Other dosimeters on the INL Site are located near radioactive materials storage areas and along roads. For decades the number and locations of INL Site area dosimeters have been relatively constant; however, factors affecting potential exposures have changed. These changes include a reduced number of operating nuclear reactors, personnel, and waste shipments; numerous buildings and facilities have undergone decontamination and demolition; and radionuclide-contaminated ponds and soil areas have been remediated. Because of these changes and because years of TLD exposures at many established locations were equivalent to natural background, in November 2008, the INL contractor reduced the number of INL Site TLD locations while ensuring area exposures are still being measured. Additionally, in May, 2011, additional monitoring locations were added near select Research and Education Campus facilities in Idaho Falls. These locations include IF-627 which is near the new DOE-ID Radiological and Environmental Sciences Laboratory (RESL), and IF-675 which is the Portable Isotopic Neutron Spectroscopy (PINS) facility. For the purposes of environmental monitoring, the Idaho Falls Facilities are collectively referred to as the "INL REC Group."

The maximum exposure (dose equivalent) recorded by a TLD on the INL Site during 2011 was 488 mR (503 mrem) at ATR Complex. The corresponding dose equivalent measured with the OSLD was 159 mrem. This location, TRA 13, is near controlled radioactive material areas where movement and storage of materials affect the exposure rate. This exposure is comparable to that of 488 mR observed in 2010.

A statistical analysis comparing the results of the OSLD and TLD (converted to mrem) was completed to evaluate whether or not there was a statistically significant difference in the results from the two technologies. The OSLD and TLD data sets including onsite, boundary, and distant locations were considered individually and separately by group location. The boundary and distant groups were normally distributed, and the results of a paired t-test indicated that there was not a statistically significant difference between the TLD and OSLD results in these two groups. The onsite data were not normally distributed. As such a Mann-Whitney rank sum test was performed. The result of this test indicated that the difference between the median values is statistically significant at the 95 percent confidence level. In general, the OSLD values were higher than the TLD values by 7 percent, with the largest difference of 20 percent occurring at location ICPP O-15. The OSLD and TLD study will be evaluated in more detail in 2012 ASER and will include data from the ESER study as well as the laboratory study conducted by Idaho State University.

Table 7-4 summarizes the calculated effective dose equivalent a hypothetical individual would receive on the Snake River Plain from various natural background radiation sources. This table has been updated using the latest recommendations of the National Council on Radiation Protection and Measurements (NCRP) in *Ionizing Radiation Exposure of the Population of the United States* (NCRP 2009).

Table 7-4. Calculated Effective Dose Equivalent from Natural Background Sources (2011).

Source of Radiation Dose Equivalent		Total Average Annual Dose	
		Calculated (mrem)	Measured (mrem)
External irradiation			
	Terrestrial	67[a]	NA[b]
	Cosmic	57[c]	NA
	Subtotal	124	124
Internal irradiation (primarily ingestion)[d]			
	Potassium-40	15	
	Thorium-232 and uranium-238	13	
	Others (carbon-14 and rubidium-87	1	
Internal irradiation (primarily inhalation)[d]			
	Radon-222 (radon) and its short-lived decay products	212	
	Radon-220 (thoron) and its short-lived decay products	16	
Total		381	

a. Estimated using concentrations of naturally-occurring radionuclide concentrations in soils in the Snake River Plain.
b. NA indicates terrestrial and cosmic radiation parameters were not measured individually but were measured collectively using thermoluminescent devices.
c. Estimated from Figure 3-4 of NCRP Report No. 160.
d. Values reported for average American adult in Table 3.14 of NCRP Report No. 160.

The terrestrial natural background radiation exposure estimate is based on concentrations of naturally occurring radionuclides found in soil samples collected from 1976 through 1993, as summarized by Jessmore et al. (1994). Concentrations of naturally occurring radionuclides in soil do not change significantly over this relatively short period. Data indicated the average concentrations of ^{238}U, thorium-232 (^{232}Th), and potassium-40 (^{40}K) were 1.5, 1.3, and 19 pCi/g, respectively. The calculated external dose equivalent received by a member of the public from ^{238}U plus decay products, ^{232}Th plus decay products, and ^{40}K based on the above-average area soil concentrations were 21, 28, and 27 mrem/yr, respectively, for a total of 76 mrem/yr (Mitchell et al, 1997). Because snow cover can reduce the effective dose equivalent Idaho residents receive from soil, a correction factor must be made each year to the estimated 76 mrem/yr. For

2011, this resulted in a corrected dose of 67 mrem/yr because of snow cover, which ranged from 2.54 to 33.0 cm (1 to 16 in.) deep over 114 days with recorded snow cover.

The cosmic component varies primarily with increasing altitude. Using Figure 3.4 in NCRP Report No. 160 (NCRP 2009), it was estimated that the annual cosmic radiation dose near the INL Site is about 57 mrem. Cosmic radiation may vary slightly because of solar cycle fluctuations and other factors.

The estimated sum of the terrestrial and cosmic components of external radiation dose to a person residing on the Snake River Plain in 2011 was calculated to be 124 mrem/yr (Table 7-4). This is the same as the 124 mrem/yr measured at distant locations by the ESER and INL contractor TLDs after conversion from mR to mrem in tissue. Measured values are very close, and within normal variability, of the calculated background doses. Therefore, it is unlikely that INL Site operations contribute to background radiation levels at distant locations.

The component of background dose that varies the most is inhaled radionuclides. According to the NCRP, the major contributor of dose equivalent 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 of the area. The amount of radon also varies among buildings of a given geographic area depending upon the materials each contains, the amount of ventilation and air movement, and other factors. The United States average of 212 mrem/yr was used in Table 7-4 for this component of the total background dose because no specific estimate for southeastern Idaho has been made and few specific measurements have been made of radon in homes in this area. 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 NCRP Report No. 160 to be 29 mrem/yr (NCRP 2009).

The total background dose to an average individual living in southeast Idaho was estimated to be approximately 381 mrem/yr (Table 7-4). The total effective dose equivalent from natural background radiation for residents in the INL Site vicinity actually may be higher or lower and will vary from one location to another.

7.4 Waste Management Surveillance Sampling

Vegetation and soil are sampled, and direct radiation is measured at RWMC to comply with DOE Order 435.1, “Radioactive Waste Management” (2001).

7.4.1 Vegetation Sampling at the Radioactive Waste Management Complex

At RWMC, vegetation is collected from four major areas (see Figure 7-9) (due to construction, vegetation was not available in RWMC Area 4) and a control location approximately 7 miles south of the Subsurface Disposal Area (SDA) at the base of Big Southern Butte. Crested wheatgrass and perennials (invasive species) are collected in odd-numbered years if available. Therefore, crested

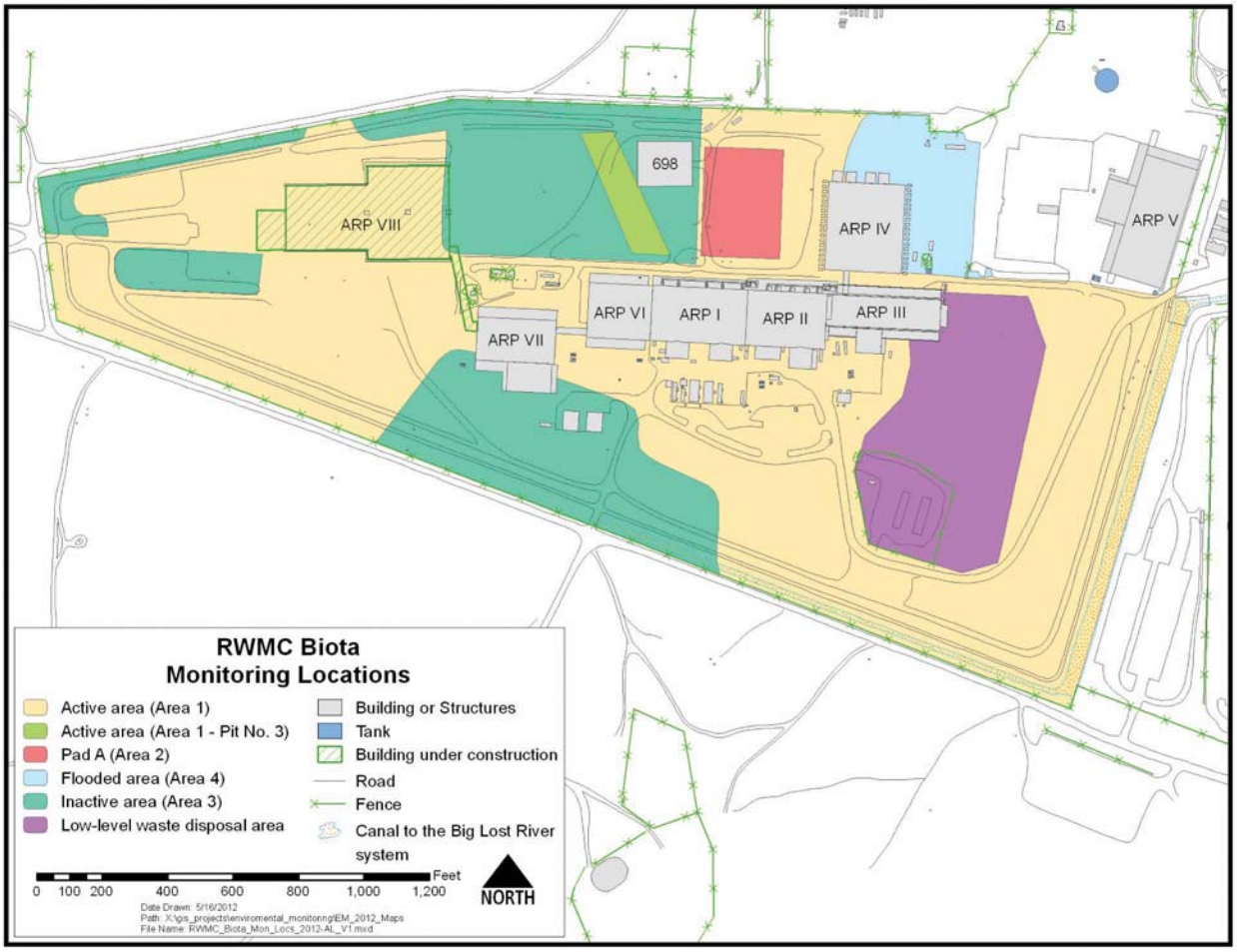

Figure 7-9. Four Vegetation Sampling Areas at the Radioactive Waste Management Complex.

wheatgrass and perennials (rabbit brush) were collected in 2011. No human-made gamma-emitting radionuclides were identified in either samples collected of the crested wheatgrass or the rabbit brush. Table 7-5 shows the radiochemistry results. Due to high results on the control sample and false positives in the double blind spikes that were submitted with the samples, these results may be questionable and could be biased, with the exception of the ^{241}Am. The ^{241}Am detections are likely due to increased activity within the SDA and at the Accelerated Retrieval Projects.

7.4.2 Soil Sampling at the Radioactive Waste Management Complex

The ICP contractor samples soil every 3 years. Samples were collected during 2009, and the next scheduled collection is in 2012.

7.4.3 Direct Radiation at the Radioactive Waste Management Complex

A vehicle-mounted global positioning radiometric scanner was used to conduct soil surface radiation (gross gamma) surveys at the SDA to complement soil sampling. The system utilizes a

Table 7-5. Radiochemistry Results of Vegetation Samples at the Radioactive Waste Management Complex.

	Am-241 (pCi/g)	Pu-238 (pCi/g)	Pu-239/240 (pCi/g)	Sr-90 (pCi/g)
Rabbit Brush				
RWMC Area 1 Collected 9/29/11	Undetected (sample value <3 sigma)	Undetected (sample value <3 sigma)	$(7.06 \pm 1.60) \times 10^{-4}$	$(3.32 \pm 0.50) \times 10^{-2}$
RWMC Area 2 Collected 9/29/11	$(5.51 \pm 0.55) \times 10^{-3}$	Undetected (sample value <3 sigma)	$(1.93 \pm 0.25) \times 10^{-3}$	$(2.55 \pm 0.38) \times 10^{-2}$
RWMC Area 3 Collected 9/29/11	$(7.61 \pm 1.92) \times 10^{-4}$	$(2.68 \pm 0.87) \times 10^{-4}$	$(6.42 \pm 1.40) \times 10^{-4}$	$(8.48 \pm 1.00) \times 10^{-0}$
Frenchman's Cabin (control) Collected 9/28/11	Undetected (sample value <3 sigma)	$(6.48 \pm 1.55) \times 10^{-4}$	$(3.37 \pm 1.01) \times 10^{-4}$	$(2.29 \pm 0.35) \times 10^{-2}$
Crested Wheat Grass				
RWMC Area 1 Collected 7/13/11	Undetected (sample value <3 sigma)	Undetected (sample value <3 sigma)	Undetected (sample value <3 sigma)	Undetected (sample value <3 sigma)
RWMC Area 2 Collected 7/13/11	$(1.07 \pm 0.18) \times 10^{-3}$	Undetected (sample value <3 sigma)	$(1.04 \pm 0.17) \times 10^{-3}$	Undetected (sample value <3 sigma)
RWMC Area 3 Collected 7/13/11	$(3.32 \pm 0.35) \times 10^{-3}$	Undetected (sample value <3 sigma)	$(4.31 \pm 0.52) \times 10^{-3}$	$(1.59 \pm 0.72) \times 10^{-2}$
Frenchman's Cabin (control) Collected 8/8/11	Undetected (sample value <3 sigma)	Undetected (sample value <3 sigma)	Undetected (sample value <3 sigma)	$(1.61 \pm 0.28) \times 10^{-2}$

Trimble Global Positioning System and two plastic scintillation detectors connected to a personal computer on board the vehicle. The global positioning radiometric scanner system data are differentially corrected and transmitted via satellites, and geographic coordinates (latitude and longitude) are recorded at least every 2 seconds. The vehicle was driven less than or equal to 5 miles per hour, with the detector height at 36 in. above the ground.

Figure 7-10 shows the radiation readings from the 2011 annual survey. Although readings vary slightly from year to year, the 2011 results for most areas are comparable to previous years' measurements. The active low-level waste pit was covered during 2009, and as a result of the reduced shine, elevated measurements from the buried waste in pits and trenches are more visible. In 2011, the maximum gross gamma radiation measurement on the SDA was 19,753 cps, compared to the 2010 measurement of 18,710 cps. Both the 2010 and 2011 maximum readings were measured at the western end of the SVR-7 soil vault row. The elevated readings next to WMF-698 are from waste stored inside.

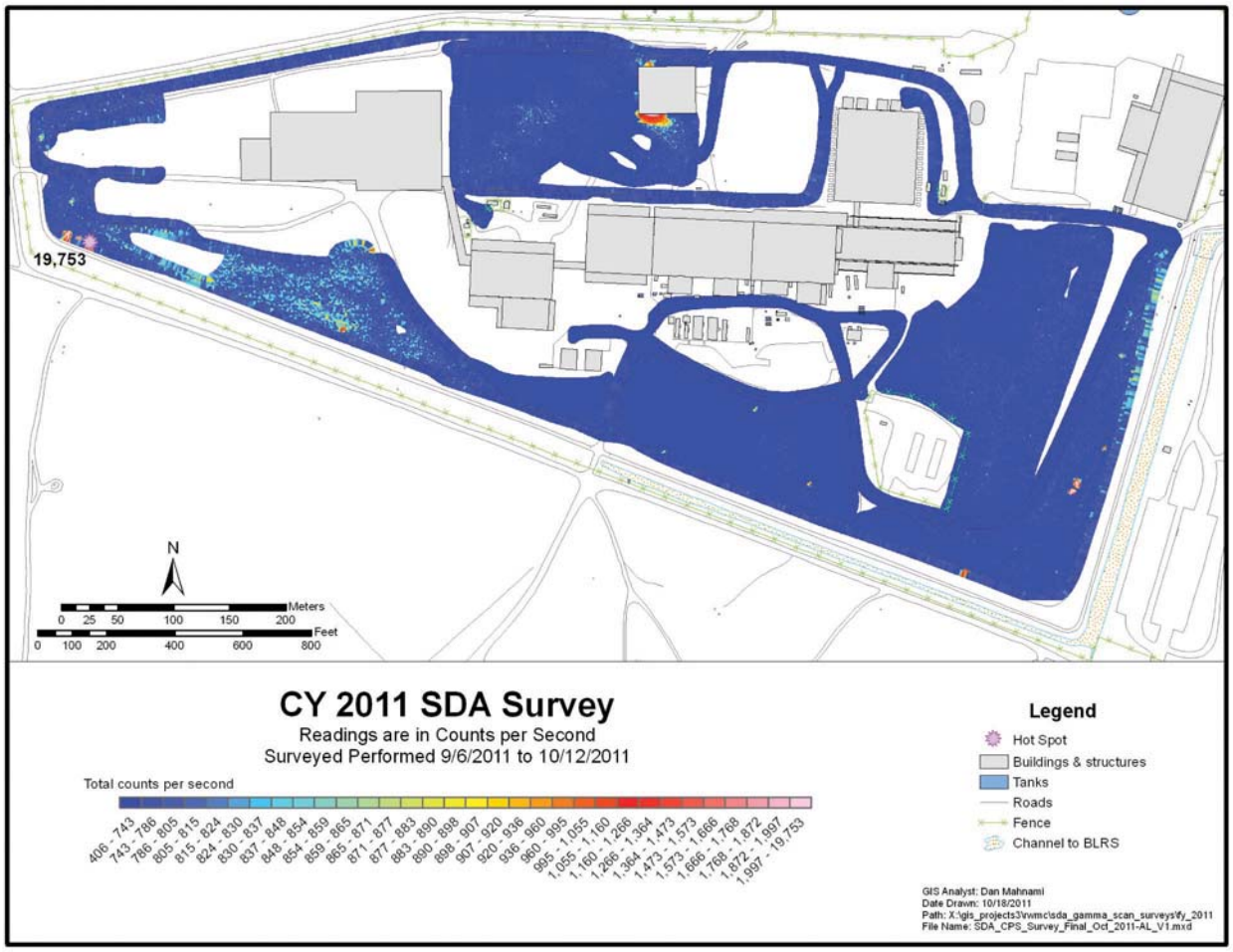

Figure 7-10. Radioactive Waste Management Complex Surface Radiation Survey (2011).

7.5 CERCLA Ecological Monitoring

Ecological monitoring at the INL Site was conducted in accordance with the Record of Decision for Operable Unit 10-04 (DOE-ID 2002) developed under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 USC § 9601 et seq., 1980). The selected remedy was no action with long-term ecological monitoring to reduce uncertainties in the INL Site-wide ecological risk assessment.

Yearly sampling and surveys occurred from 2003 through 2008 to characterize contaminant levels, evaluate possible effects, and collect population-level data (VanHorn and Haney 2007). In general, samples for contaminant analysis and effects were collocated to minimize sources of variability. Terrestrial samples were collected from surface soil, subsurface soil, *Peromyscus maniculatus* (deer mice), *Artemisia tridentata* (sagebrush), and *Agropyron cristatum* (crested wheatgrass) in areas near INL Site facilities and from background areas. Aquatic samples were collected from sediments, surface water, and plants in facility ponds and an aquatic background area. Effects data for deer mice included kidney-to-body-weight and liver-to-body-weight ratios, and histopathology of kidney and liver. Toxicity testing included deer mice, earthworms, and seedlings. Populations of birds, reptiles, plants, small mammals, and soil fauna were surveyed for presence, absence, abundance, and diversity. Data were compiled in a summary report (VanHorn et al. 2012).

Six years of data and observations detected minimal effects. Differences between areas near facilities and background areas were slight, and may be attributable wholly or partly to natural variability. Because monitoring substantially reduced uncertainties in the INL Site-wide ecological risk assessment and increased confidence that the no action decision is protective, further ecological monitoring under CERCLA is not required.

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Chapter 8. Dose to the Public and Biota

Chapter 8 Highlights

The potential radiological dose to the public from Idaho National Laboratory (INL) Site operations was evaluated to determine compliance with pertinent regulations and limits. The Clean Air Act Assessment Package 88-PC computer program is required by the U.S. Environmental Protection Agency to demonstrate compliance with the Clean Air Act. The dose to the hypothetical, maximally exposed individual in 2011, as determined by this program, was 0.046 mrem, well below the applicable standard of 10 mrem per year.

The maximum potential population dose to the approximately 305,509 people residing within an 80-km (50-mi) radius of any INL Site facility was also evaluated. The population dose was calculated using reported releases, an air dispersion model developed by the National Oceanic and Atmospheric Administration Air Resources Laboratory-Field Research Division, and methodology recommended by the Nuclear Regulatory Commission. For 2011, the estimated potential dose was 0.61 person-rem. This dose is about 0.0005 percent of that expected from exposure to natural background radiation (116,399 person-rem).

Using the maximum radionuclide concentrations in collected waterfowl and large game animals, a maximum potential dose from ingestion was calculated. The maximum potential dose to an individual was calculated to be 0.004 mrem for ingestion of waterfowl and 0.017 mrem for ingestion of game animals.

The potential doses to aquatic and terrestrial biota from contaminated soil and water were evaluated using a graded approach. Initially, the potential doses were screened using maximum concentrations of radionuclides detected in soil and effluents at the INL Site. Results of the screening calculations indicate that contaminants released from INL Site activities do not have an adverse impact on plants or animal populations. In addition, maximum concentrations of radionuclides measured in waterfowl accessing INL Site ponds were used to estimate internal doses to the waterfowl. These calculations indicate that the potential doses to waterfowl do not exceed the Department of Energy limits for biota.

No unplanned releases occurred from the INL Site in 2011, and, therefore, no doses were associated with unplanned releases.

8. DOSE TO THE PUBLIC AND BIOTA

It is the policy of the U.S. Department of Energy (DOE), "To implement sound stewardship practices that are protective of the air, water, land, and other natural and cultural resources impacted by DOE operations and by which DOE cost-effectively meets or exceeds compliance with applicable environmental, public health, and resource protection laws, regulations, and DOE requirements" (DOE Order 436.1). DOE Order 458.1 further states, "It is also a DOE objective that potential exposures to members of the public be as far below the limits as is reasonably achievable..." This chapter describes the potential dose to members of the public and biota from operations at the Idaho National Laboratory (INL) Site, based on 2011 environmental monitoring measurements.

8.1 Possible Exposure Pathways to the Public

Air, soil, groundwater, agricultural products, and biota are routinely sampled to document the amount of radioactivity in these media and to determine if radioactive materials have been transported off the INL Site. The air pathway is the primary way people living beyond the INL Site boundary could be exposed to releases from INL Site operations (Figure 8-1). Airborne radioactive materials are rapidly carried from the source and dispersed by winds. The concentrations from routine releases are too small to measure at locations around the INL Site,

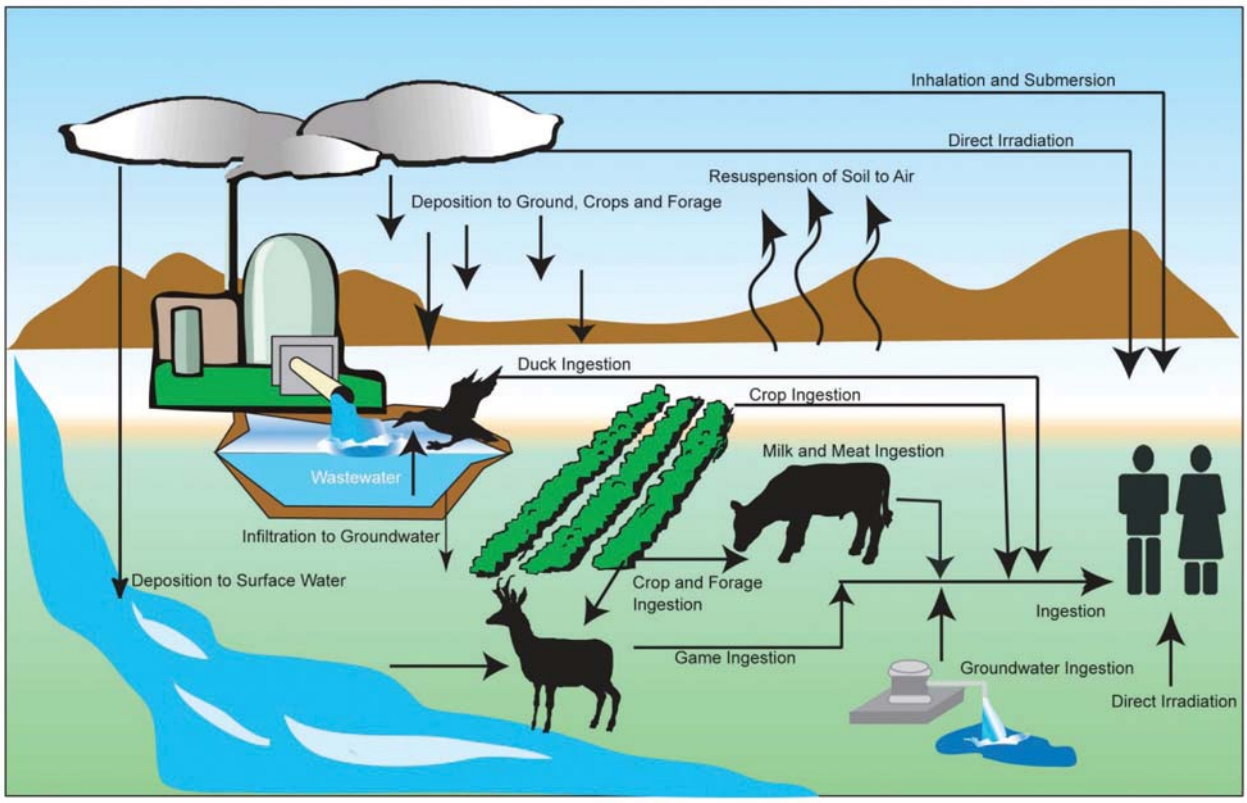

Figure 8-1. Potential Exposure Pathways to Humans from the INL Site.

so atmospheric dispersion models were used to estimate the downwind concentration of air pollutants and the potential doses from these projected offsite concentrations. Conservative doses were also calculated from ingestion of meat from wild game animals and waterfowl that access the INL Site. The ingestion doses were calculated from concentrations of radionuclides measured in game animals killed by vehicles on roads at the INL Site and in waterfowl harvested from ponds on the INL Site. External doses from exposure to radiation in the environment (primarily from naturally-occurring radionuclides) were measured directly using thermoluminescent dosimeters (TLDs) and optically stimulated luminescent dosimeters (OSLDs).

Water pathways were not considered major contributors to dose because no surface water flows off the INL Site and no radionuclides associated with INL Site releases have been measured in public drinking water wells.

8.2 Dose to the Public from INL Site Air Emissions

The potential doses from INL Site air emissions were estimated using the amounts reported to be released by the facilities. During 2011, doses were calculated for the radionuclides and data presented in Table 4-2 and summarized in Table 8-1. Although noble gases were the radionuclides released in the largest quantities, they contributed very little to the cumulative dose (affecting immersion only) largely because of their short half-lives and the fact that they are not incorporated into the food supply. The radionuclides which contributed the most to the overall dose (strontium-90 [^{90}Sr], iodine-129, cesium-137 [^{137}Cs], americium-241, and plutonium isotopes) are typically associated with airborne particulates and were a very small fraction of the total amount of radionuclides reported.

Two kinds of dose estimates were made using the release data:

- **The effective dose equivalent to the hypothetical maximally exposed individual, as defined by the National Emission Standards for Hazardous Air Pollutants (NESHAPs) regulations.** The Clean Air Act Assessment Package (CAP) 88-PC computer code (EPA 2007) was used to predict the maximum downwind concentration at the nearest offsite receptor location and estimate the dose to the maximally exposed individual.
- **The collective effective dose equivalent (population dose) for the population within 80 km (50 mi) of any INL Site facility.** For this calculation the mesoscale diffusion (MDIFF) model (Sagendorf et al. 2001) was used to model air transport and dispersion. The population dose was estimated using dispersion values from the model projections to comply with DOE Order 458.1.

The dose estimates considered immersion dose from direct exposure to airborne radionuclides, internal dose from inhalation of airborne radionuclides, internal dose from ingestion of radionuclides in plants and animals, and external dose from direct exposure to radionuclides deposited on soil (Figure 8-1.) The CAP88-PC computer code uses dose and risk tables developed by the U.S. Environmental Protection Agency (EPA). Population dose calculations were made using the MDIFF air dispersion model in combination with Nuclear

Table 8-1. Summary of Radionuclide Composition of Idaho National Laboratory Site Airborne Effluents (2011).

	Curies Released										
Facility[a]	Tritium	^{85}Kr	Noble Gases[b] ($T_{1/2}$ < 40 days)	Short-lived Fission and Activation Products[c] ($T_{1/2}$ < 3 hours)	Fission and Activation Products[d] ($T_{1/2}$ > 3 hours)	Total Radioiodine[e]	Total Radiostrontium[f]	Total Uranium[g]	Plutonium[h]	Other Actinides[i]	Other[j]
ATR Complex	277		1150	0.429	1.18E-01	0.101	0.0331	1.41E-06	4.28E-04	1.09E-04	7.70E-06
CFA	1.06			6.00E-10	5.63E-08	1.21E-05	9.33E-10	7.61E-07	1.09E-09	2.10E-08	3.84E-05
INTEC	200	1450		5.11E-10	1.15E-01	0.03	0.0132	5.48E-07	6.66E-03	6.96E-06	8.84E-06
MFC	0.0858	1.20E-09	1.00		2.13E-02	4.20E-07	1.39E-04	7.02E-06	4.53E-06	4.91E-07	2.26E-10
RWMC	357	1.95E-06		6.66E-04	1.30E-03		5.73E-04	2.98E-04	9.86E-03	4.23E-03	1.37E-01
TAN	0.0145		2.18E-06	0.25	7.50E-01		3.01E-05				
Total	**835**	**1452**	**1150**	**0.680**	**1.00**	**0.131**	**0.047**	**3.08E-04**	**1.70E-02**	**4.43E-03**	**0.137**

a. CFA = Central Facilities Area; INTEC = Idaho Nuclear Technology and Engineering Center; MFC = Materials and Fuels Complex; RTC = Reactor Technology Complex (including ATR = Advanced Test Reactor (Operation: 1967 to Present) and MTR = Materials Test Reactor (Operation 1952-1970) are located at the RTC); RWMC = Radioactive Waste Management Complex (including AMWTP = Advanced Mixed Waste Treatment Project); TAN = Test Area North (including SMC = Specific Manufacturing Capability).

b. Noble gases with half-lives less than 40 days released from the INL Site are: ^{39}Ar, ^{41}Ar, ^{85m}Kr, ^{87}Kr, ^{88}Kr, ^{127}Xe, ^{129m}Xe, ^{131m}Xe, ^{133}Xe, ^{133m}Xe, ^{135}Xe, ^{135m}Xe, and ^{138}Xe. (Ar = argon, Kr = krypton, and Xe = xenon.)

c. Fission products and activation products ($T_{1/2}$<3 hours) = ^{136m}Ba, ^{137m}Ba, ^{139}Ba, ^{141}Ba, ^{212}Bi, ^{83}Br, ^{138}Cs, ^{60m}Co, ^{138}Cs, ^{67}Cu, ^{179m}Hf, ^{114}In, ^{142}La, ^{56}Mn, ^{93}Mo, ^{99}Mo, ^{97}Nb, ^{212}Po, ^{216}Po, ^{144}Pr, ^{144m}Pr, ^{88}Rb, ^{89}Rb, ^{103m}Rh, ^{106m}Rh, ^{219}Rn, ^{126m}Sb, ^{129}Te, ^{208}Tl, ^{187}W, ^{90}Y, ^{91m}Y, ^{92}Y, etc. (Ba = barium, Bi = bismuth, Br = bromine, Co = copper, Cs = cesium, Cu = curium, Hf = Hafnium, In = Indium, La = lanthanum, Mn = manganese, Mo = molybdenum, Nb = Niobium, Po = polonium, Pr = Praeseodymium, Rb = rubidium, Rh = rhodium, Rn = radon, Sb = anitmony, Te = tellurium, Tl = thallium, W = tungsten, and Y =yttrium.)

d. Fission products and activation products ($T_{1/2}$>3 hours) = ^{144}Ce, ^{58}Co, ^{51}Cr, ^{134}Cs, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{155}Eu, ^{55}Fe, ^{175}Hf, ^{181}Hf, ^{203}Hg, ^{22}Na, ^{24}Na, ^{95}Nb, ^{63}Ni, ^{147}Pm, ^{224}Ra, ^{188}Re, ^{103}Ru, ^{106}Ru, ^{124}Sb, ^{125}Sb, ^{127}Sb, ^{46}Sc, ^{151}Sm, ^{182}Ta, ^{99}Tc, ^{99m}Tc, ^{65}Zn, ^{95}Zr, etc. (Ce = cerium, Co = cobalt, Cr = chromium, Cs = cesium, Eu = europium, Fe = iron, Hf = hafnium, Hg = mercury, Na = sodium, Nb = Niobium, Ni = nickel, Pm = promethium, Ra = radium, Re = rhenium, Ru = ruthenium, Sb = antimony, Sc = scandium, Sm = samarium, Ta = tantalum, Tc = technetium, Zn = zinc, and Zr = zirconium)

e. Total radioiodine = ^{125}I, ^{128}I, ^{129}I, ^{131}I, ^{132}I, ^{133}I, ^{134}I, and ^{135}I.

f. Total radiostrontium = ^{85}Sr, ^{89}Sr, ^{90}Sr, ^{91}Sr, and ^{92}Sr.

g. Total uranium = ^{232}U, ^{233}U, ^{234}U, ^{235}U, ^{236}U, ^{237}U, and ^{238}U.

h. Total plutonium = ^{236}Pu, ^{237}Pu, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, and ^{242}Pu.

i. Other actinides = ^{227}Ac, ^{241}Am, ^{243}Am, ^{249}Cf, ^{242}Cm, ^{243}Cm, ^{244}Cm, ^{245}Cm, ^{246}Cm, ^{247}Cm, ^{248}Cm, ^{237}Np, ^{239}Np, ^{231}Pa, ^{234}Pa, ^{227}Th, ^{228}Th, ^{229}Th, ^{230}Th, ^{231}Th, ^{232}Th, and ^{234}Th. (Ac = actinium, Am = americium, Cf = californium, Cm = curium, Np = neptunium, Pa = protactinium, and Th = thorium.)

j. Other = radioisotopes of other elements that are not noble gases, activation or fission products or actinides.

Regulatory Commission (NRC) dose calculation methods (NRC 1977), EPA dose conversion factors for internally deposited radionuclides (Eckerman et al. 1988), and EPA dose conversion factors for external exposure to radionuclides in the air and deposited on the ground surface (Eckerman and Ryman 1993).

8.2.1 Maximally Exposed Individual Dose

The EPA NESHAPs regulation requires demonstrating that radionuclides other than radon released to air from any DOE nuclear facility do not result in a dose to the public of greater than 10 mrem/yr (40 Code of Federal Regulations [CFR] 61, Subpart H). This includes releases from stacks and diffuse sources such as resuspension of contaminated soil particles. EPA requires the use of an approved computer code such as CAP88-PC to demonstrate compliance with 40 CFR 61. CAP88-PC uses a modified Gaussian plume model to estimate the average dispersion of radionuclides released from up to six sources. It uses an average annual wind file, based on multiple-year meteorological data collected at the INL Site by National Oceanic and Atmospheric Administration (NOAA). Assessments are done for a circular grid of distances and directions from each source with a radius of 80 km (50 mi) around the facility. The program computes radionuclide concentrations in air, rates of deposition on ground surfaces, concentrations in food and intake rates to people from ingestion of food produced in the assessment area. Estimates of the radionuclide concentrations in produce, leafy vegetables, milk ,and meat consumed by humans are made by coupling the output of the atmospheric transport models with the U.S. Nuclear Regulatory Commission Regulatory Guide 1.109 terrestrial food chain models.

Who is the maximally exposed individual?

The maximally exposed individual is a hypothetical individual who, because of proximity, activities, or living habits, could potentially receive the maximum dose of radiation from a given event or process. This individual lives outside the INL Site at the location where the highest concentration of radionuclides in air have been modeled using reported effluent releases and the CAP88-PC model. In 2011, this hypothetical person lived at Frenchman's Cabin, just south of the INL Site boundary (Figure 4-2).

The dose from INL Site airborne releases of radionuclides was calculated to the maximally exposed individual to demonstrate compliance with NESHAPs and is published in the *National Emissions Standards for Hazardous Air Pollutants – Calendar Year 2011 INL Report for Radionuclides* (DOE-ID 2012). In order to identify the maximally exposed individual, the doses at 63 locations were calculated and then screened for the maximum potential dose to an individual who might live at one of these locations. The highest potential dose was screened to be to a hypothetical person living at Frenchman's Cabin, located at the southern boundary of the INL Site (see Figure 4-2). This location is inhabited only during portions of the year, but it must be considered as a potential maximally exposed individual location according to NESHAPs. An effective dose equivalent of 0.046 mrem (0.46 µSv) was calculated for a hypothetical person living at Frenchman's Cabin during 2011.

Although noble gases were the radionuclides released in the largest quantities, they contributed relatively little to the cumulative dose from all pathways (affecting immersion only) largely because of their short half-lives and the fact that they are not incorporated into the food supply. Many of the radionuclides that contributed the most to the overall dose (americium-241,

^{137}Cs, ^{90}Sr, plutonium-238 and -239, and iodine-129) are typically associated with airborne particulates and were a very small fraction of the total amount of radionuclides reported. Particulates are mostly released from clean-up and waste management activities at the INL Site. Tritium and argon-41, which are not associated with particulates, contributed about 35 percent of the calculated dose in 2011.

Figure 8-2 compares the maximum individual doses calculated for 2002 through 2011. All of the doses are well below the whole body dose limit of 10 mrem (100 µSv) for airborne releases of radionuclides established by 40 CFR 61. The highest dose was estimated in 2008 and was attributable primarily to plutonium-241 which was reported to be released during the dismantling of facilities at Test Area North.

8.2.2 Eighty Kilometer (50 Mile) Population Dose

The National Oceanic and Atmospheric Administration Air Resources Laboratory – Field Research Division (NOAA ARL-FRD) developed an air transport and dispersion model called MDIFF around 1970 (Sagendorf et al. 2001). The MDIFF model was developed by the NOAA ARL-FRD from field experiments in arid environments (e.g., the INL Site and the Hanford

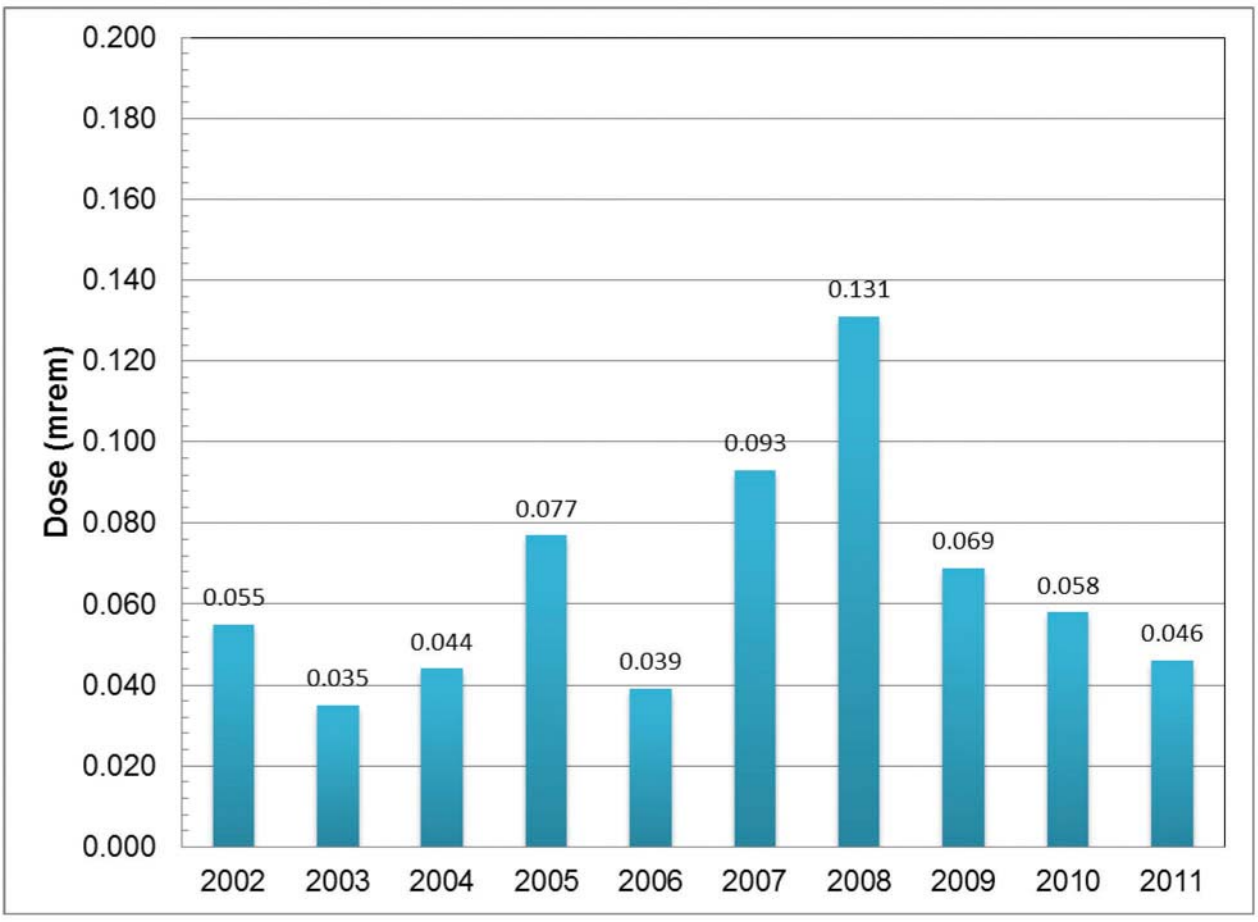

Figure 8-2. Maximum Individual Doses from INL Site Airborne Releases Estimated for 2002 – 2011.

Site in eastern Washington). The model was used in the population dose calculations. A detailed description of the model and its capabilities may be found at http://www.noaa.inel.gov/capabilities/modeling/T&D.htm.

The NOAA ARL-FRD gathered meteorological data continuously at 35 meteorological stations during 2011 on and around the INL Site (see Meteorological Monitoring, a supplement to this Annual Site Environmentaql Report). The transport and dispersion of contaminants by winds was projected by the MDIFF model. MDIFF utilized wind speeds and directions from the 1-hr Mesonet database for 2011. The model predicted average annual air concentrations, resulting from INL Site airborne effluent releases, at each of over 10,000 grid points on and around the INL site (Figure 8-3).

The results were used to prepare a contour map showing calculated annual air concentrations called time integrated concentrations (Figure 8-4). The higher numbers on the map represent higher annual average concentrations. So, for example, the annual air concentration resulting from INL Site releases were estimated to be about four times higher at Terreton than at Dubois. This map was used to identify where an individual might be exposed to the highest air concentration during the year, and what that annual air concentration was. This concentration

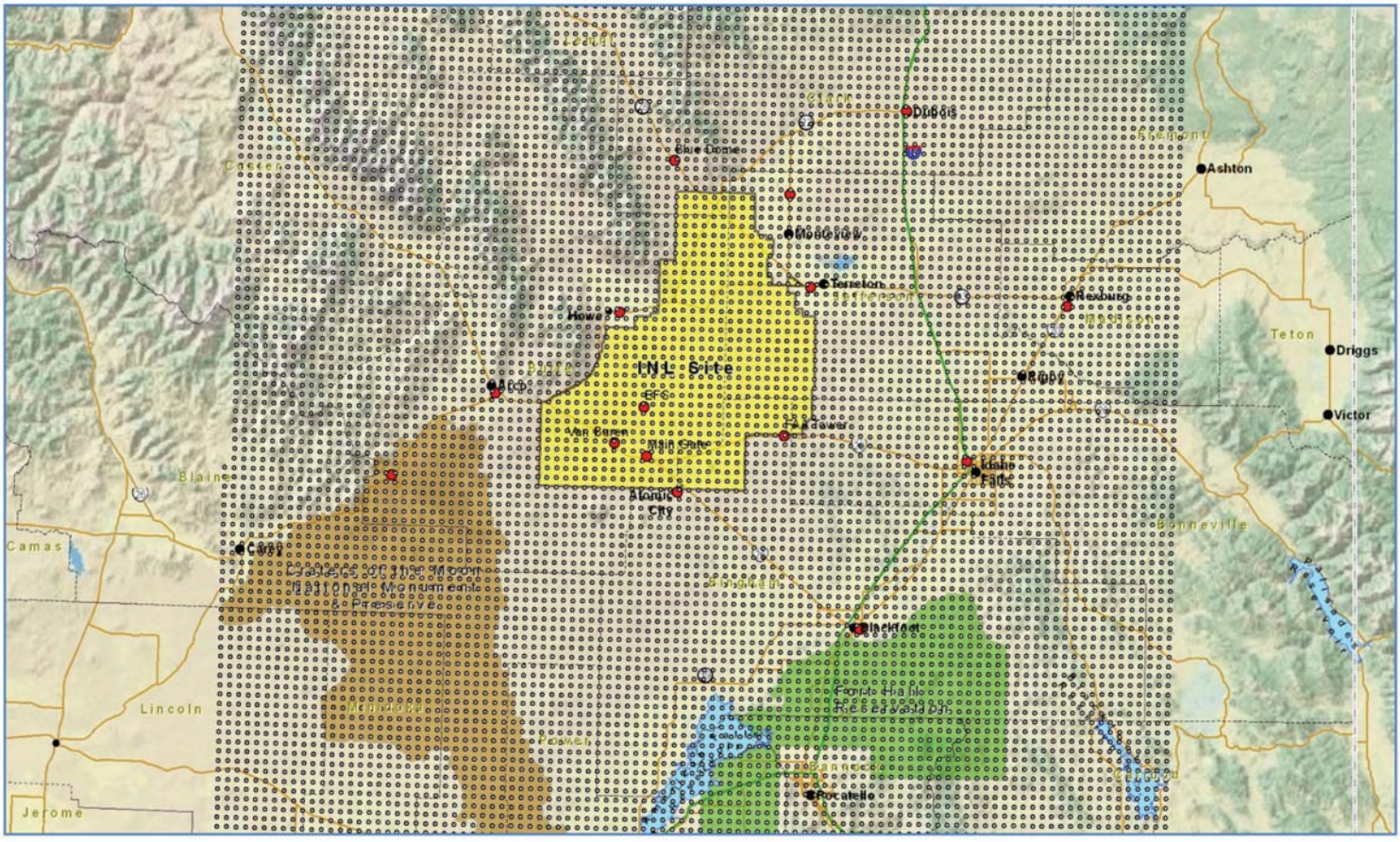

Figure 8-3. INL Site Mesoscale Grid Currently Used in MDIFF Simulations of INL Site Air Dispersion Annual TICs. Red Circles Represent Current ESER Air Monitoring Locations.

was then used to calculate the 80-km population dose. In 2011 this individual was projected by MDIFF to live northwest of Mud Lake. This location is different from the location of the maximally exposed individual used by CAP88-PC because it relies on a more refined grid and meteorological data.

The average modeled air concentration from each INL Site facility at the Mud Lake location was then input into a spreadsheet used to estimate doses with Nuclear Regulatory Commission methods and EPA dose conversion factors.

The population of each census division was updated with data from the 2010 census. The doses received by people living in each census division were calculated by multiplying the following four variables together:

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

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

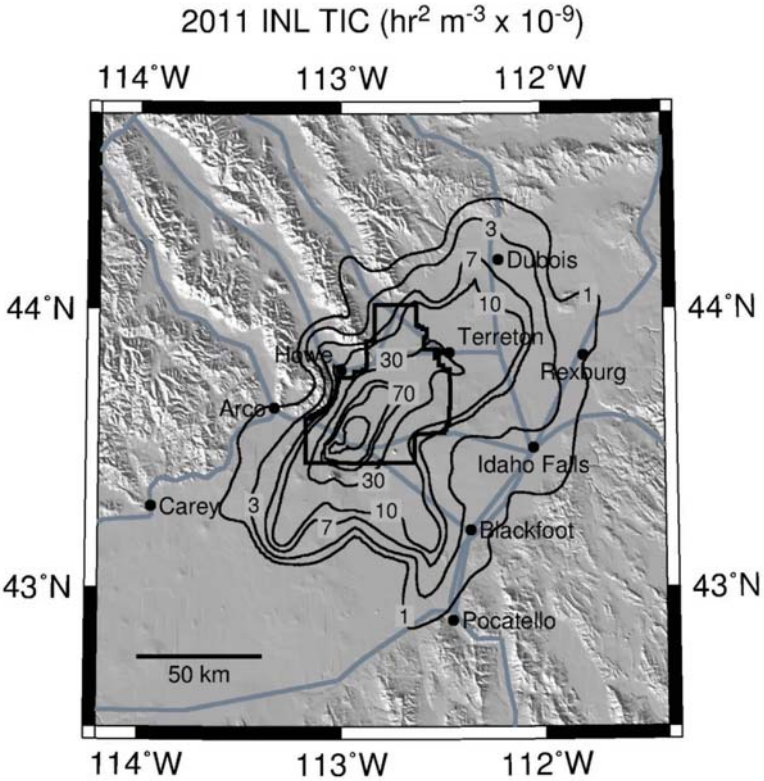

Figure 8-4. INL Site Time Integrated Concentrations (2011).

Table 8-2. Dose to Population within 80 Kilometers (50 miles) of INL Site Facilities (2011).

	Curies Released										
Facility[a]	Tritium	^{85}Kr	Noble Gases[b] ($T_{1/2}$ < 40 days)	Short-lived Fission and Activation Products[c] ($T_{1/2}$ < 3 hours)	Fission and Activation Products[d] ($T_{1/2}$ > 3 hours)	Total Radioiodine[e]	Total Radiostrontium[f]	Total Uranium[g]	Plutonium[h]	Other Actinides[i]	Other[j]
ATR Complex	2.77E+02		1150	.429	1.18E-01	0.101	0.0331	1.41E-06	4.28E-04	1.09E-04	7.70E-06
CFA	1.06	N/A	0.00E+00	6.00E-10	5.63E-08	1.21E-05	9.33E-10	7.61E-07	1.091E-09	2.1E-08	3.84E-05
INTEC	200	1453	0.00E+00	5.11E-10	1.15E-01	0.03	0.0136	5.475E-07	6.66E-03	6.96E-06	8.84E-06
MFC	0.0858	1.15E-07	1.00	0.00	2.13E-02	4.20E-07	1.39E-04	7.02E-06	4. 69E-06	4.91E-07	2.26E-10
RWMC	357	1.95E-06	0.00E+00	6.66E-04	1.30E-03		5.73E-04	2.98E-04	9.86E-03	4.23E-03	1.37E-01
SMC											
TAN	0.0145	0	2.18E-06	.25	7.50E-01		3.01E-05		0.00E+00	0.00E+00	0.00E+00
Total	**835**	**1453**	**1150**	**0.680**	**1.00**	**0.131**	**0.047**	**3.08E-04**	**1.70E-02**	**4.426E-03**	**0.137**

a. CFA = Central Facilities Area; INTEC = Idaho Nuclear Technology and Engineering Center; MFC = Materials and Fuels Complex; RTC = Reactor Technology Complex (including ATR = Advanced Test Reactor (Operation: 1967 to Present) and MTR = Materials Test Reactor (Operation 1952-1970) are located at the RTC); RWMC = Radioactive Waste Management Complex (including AMWTP = Advanced Mixed Waste Treatment Project); TAN = Test Area North (including SMC = Specific Manufacturing Capability).

b. Noble gases with half-lives less than 40 days released from the INL Site are: ^{41}Ar, ^{79}Kr, ^{883m}Kr, ^{85m}Kr, ^{133}Xe, ^{135m}Xe. (Ar = argon, Kr = krypton, and Xe = xenon.)

c. Fission products and activation products ($T_{1/2}$<3 hours) = ^{110}Ag, ^{137m}Ba, ^{139}Ba, ^{141}Ba, ^{212}Bi, ^{214} Bi, ^{80}Br, ^{38} Cl, ^{60m}Co,^{1} ^{138}Cs, ^{178m}Hf, ^{142}La, ^{56}Mn, , ^{212}Po, ^{216}Po, ^{144}Pr, ^{144m}Pr, ^{88}Rb, ^{89}Rb, , ^{81} Se,^{81m}Se, ^{92}Y, etc. (Ba = barium, Bi = bismuth, Br = bromine, Cl=Chlorine,, Cs = cesium, , Hf = Hafnium, La = lanthanum, Mn = manganese, , Po = polonium, Pr = Praeseodymium, Rb = rubidium, , and Y =yttrium.)

d. Fission products and activation products ($T_{1/2}$>3 hours) = ^{144}Ce, ^{58}Co, ^{51}Cr, ^{134}Cs, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{155}Eu, ^{55}Fe, ^{175}Hf, ^{181}Hf, ^{203}Hg, ^{22}Na, ^{24}Na, ^{95}Nb, ^{63}Ni, ^{147}Pm, ^{224}Ra, ^{188}Re, ^{103}Ru, ^{106}Ru, ^{124}Sb, ^{125}Sb, ^{127}Sb, ^{46}Sc, ^{151}Sm, ^{182}Ta, ^{99}Tc, ^{99m}Tc, ^{65}Zn, ^{95}Zr, etc. (Ce = cerium, Co = cobalt, Cr = chromium, Cs = cesium, Eu = europium, Fe = iron, Hf = hafnium, Hg = mercury, Na = sodium, Nb = Niobium, Ni = nickel, Pm = promethium, Ra = radium, Re = rhenium, Ru = ruthenium, Sb = antimony, Sc = scandium, Sm = samarium, Ta = tantalum, Tc = technetium, Zn = zinc, and Zr = zirconium)

e. Total radioiodine = ^{125}I, ^{128}I, ^{129}I, ^{131}I, ^{132}I, ^{133}I, ^{134}I, and ^{135}I.

f. Total radiostrontium = ^{85}Sr, ^{89}Sr, ^{90}Sr, ^{91}Sr, and ^{92}Sr.

g. Total uranium = ^{232}U, ^{233}U, ^{234}U, ^{235}U, ^{236}U, ^{237}U, and ^{238}U.

h. Total plutonium = ^{236}Pu, ^{237}Pu, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, and ^{242}Pu.

i. Other actinides = ^{227}Ac, ^{241}Am, ^{242} Am,^{243}Am, ^{252}Cf, ^{242}Cm, ^{243}Cm, ^{244}Cm, , ^{248}Cm, ^{237}Np, ^{239}Np, ^{233}Pa, ^{228}Th, ^{229}Th, ^{230}Th, ^{231}Th, ^{232}Th, and ^{234}Th. (Ac = actinium, Am = americium, Cf = californium, Cm = curium, Np = neptunium, Pa = protactinium, and Th = thorium.)

j. Other = radioisotopes of other elements that are not noble gases, activation or fission products or actinides.

The estimated potential population dose was 0.61 person-rem (6.1 x 10^{-3} person-Sv) to a population of approximately 305,509. When compared with the approximate population dose of 116,399 person-rem (1,164 person-Sv) estimated to be received from natural background radiation, this represents an increase of only about 0.0005 percent. The largest collective doses are in the Idaho Falls and Pocatello census divisions due to their greater populations.

The largest contributors to the population dose were plutonium-241, contributing about 29 percent of the total population dose, and americium-241 contributing about 20 percent (Figure 8-5).These were followed by plutonium-239 (14 percent), iodine-129 and ^{90}Sr (each 10 percent), plutonium-238 (5 percent), argon-41 and plutonium-240 (3 percent each) and ^{137}Cs (2 percent). All other isotopes contributed less than 1 percent each.

For 2011, the Radioactive Waste Management Complex contributed nearly 67 percent of the total dose followed by Advanced Test Reactor (ATR) Complex at 22 percent. The Idaho Nuclear Technology and Engineering Center contributed 9 percent; all other facilities were less than one percent.

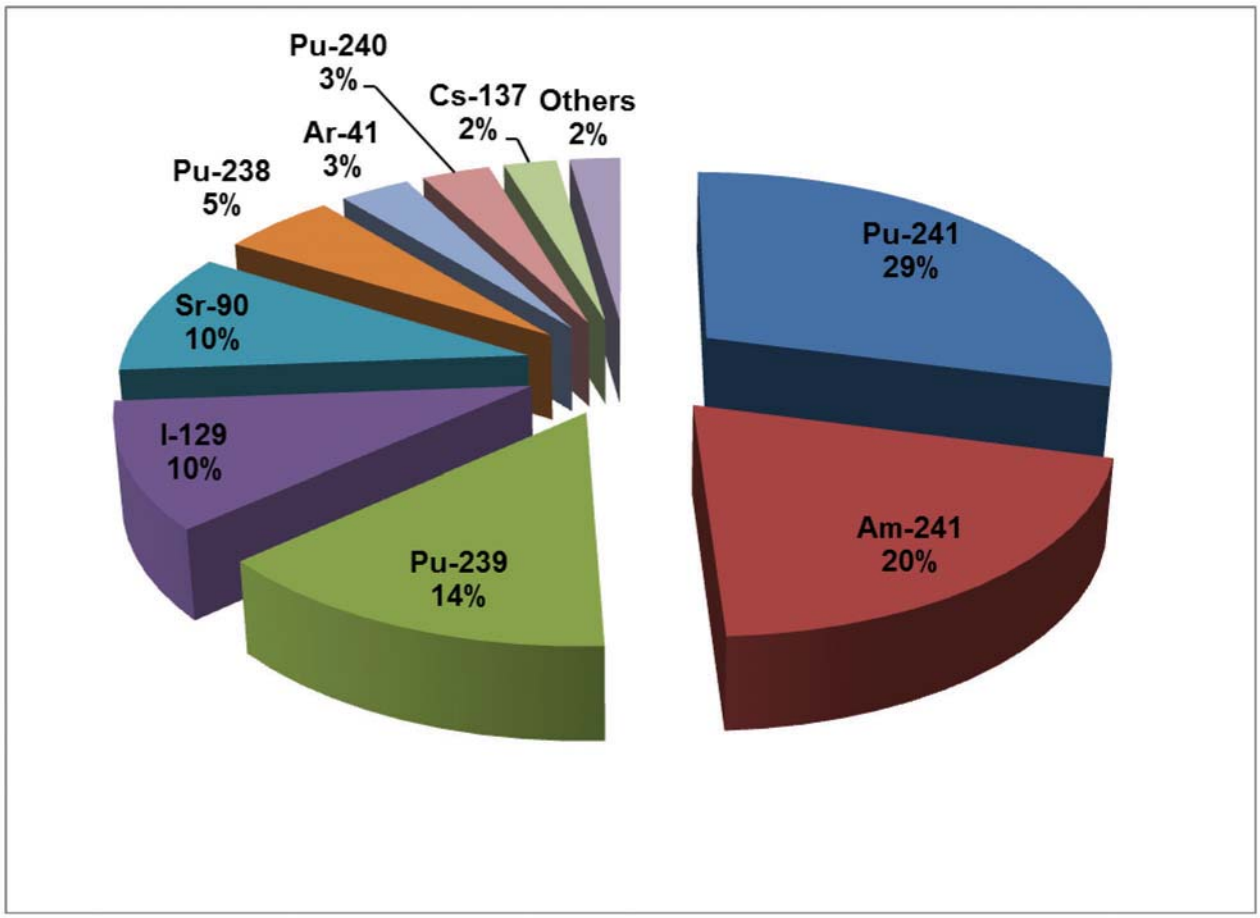

Figure 8-5. Radionuclides Contributing to Dose to Population Dose from INL Site Airborne Effluents as Calculated Using the MDIFF Air Dispersion Model (2011).

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

The potential dose an individual may receive from occasionally ingesting meat from game animals continues to be studied at the INL Site. These studies estimate the potential dose to individuals who may eat waterfowl that briefly reside at wastewater disposal ponds at the ATR Complex and Materials and Fuels Complex and game animals that may reside on or migrate across the INL Site.

8.3.1 Waterfowl

In 2011, six ducks were collected from disposal ponds at the ATR Complex and three from Materials and Fuels Complex wastewater ponds. Three ducks were collected off the INL Site (near American Falls Reservoir) as control samples. The maximum potential dose from eating 225 g (8 oz) of duck meat collected in 2011 is presented in Table 8-3. Radionuclide concentrations used to determine these doses are reported in Figure 7-5. Doses from consuming waterfowl are conservatively based on the assumption that ducks are eaten immediately after leaving the pond.

The maximum potential dose of 0.004 mrem (0.04 μSv) from these waterfowl samples is substantially below the 0.89 mrem (8.9 μSv) committed effective dose equivalent estimated from the most contaminated ducks taken from the evaporation ponds between 1993 and 1998 (Warren et al. 2001). These evaporation ponds have been remediated and are no longer available to waterfowl. The ducks were not collected directly from the wastewater disposal ponds at the ATR Complex but from sewage lagoons adjacent to them. However, they probably resided at all the ponds while they were in the area.

Table 8-3. Maximum Annual Potential Dose from Ingestion of Edible Waterfowl Tissue Using INL Site Wastewater Disposal Ponds in 2011.[a]

Radionuclide	ATR Complex Maximum Dose[b] (mrem/yr)	MFC Maximum Dose[b] (mrem/yr)	Control Sample Maximum Dose[b] (mrem/yr)
Cobalt-60	1.54×10^{-4}	0	0
Cesium-137	1.58×10^{-3}	0	0
Zinc-65	2.29×10^{-3}	0	0
Total Dose	**4.02×10^{-3}**	**0**	**0**

a. Committed (50-yr) effective dose equivalent from consuming 225 g (8 oz) of edible (muscle) waterfowl tissue. Dose conversion factors are from Federal Guidance Report No. 13 (EPA 2002).

b. Doses are calculated on maximum radionuclide concentrations in different waterfowl collected at the Advanced Test Reactor Complex wastewater disposal ponds, and are, therefore, worst-case doses.

8.3.2 Big Game Animals

A study on the INL Site from 1976 to 1986 conservatively estimated the potential whole-body dose that could be received from an individual eating the entire muscle (27,000 g [952 oz]) and liver mass (500 g [17.6 oz]) of an antelope with the highest levels of radioactivity found in these animals was 2.7 mrem (Markham et al. 1982). Game animals collected at the INL Site during the past few years have generally shown much lower concentrations of radionuclides. The only game animal that had a detectable concentration of ^{137}Cs was an elk, which would have a much larger muscle mass than a pronghorn. The potential dose from consuming the meat was estimated to be approximately 0.017 mrem (0.04 μSv).

The contribution of game animal consumption to the population dose has not been calculated because only a limited percentage of the population hunts game, few of the animals killed have spent time on the INL Site, and most of the animals that do migrate from the INL Site would have reduced concentrations of radionuclides in their tissues by the time they were harvested (Halford et al. 1983). The total population dose contribution from these pathways would, realistically, be less than the sum of the population doses from inhalation of air, submersion in air, ingestion of vegetables, and deposition on soil.

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

Tritium has previously been detected in two U.S. Geological Survey monitoring wells located along the southern boundary of the INL Site. These wells, located in an uninhabited area, have shown a historical downward trend in tritium detections. The maximum concentration (<1,150 pCi/L) is considerably less than the maximum contaminant level established by EPA for drinking water (20,000 pCi/L). The maximum contaminant level corresponds to a dose from the drinking water ingestion pathway of 4 mrem per year. An individual drinking water from these wells would hypothetically receive a dose of less than 0.2 mrem in one year. Because no one uses these wells for drinking water, this is an unrealistic scenario and the groundwater ingestion pathway is not included in the total dose estimate to a maximally exposed individual.

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 TLDs and OSLDs (Figure 7-8). In 2011, the external radiation measured along the INL Site boundary was statistically equivalent to that of background radiation and, therefore, does not represent a dose resulting from INL Site operations.

8.6 Dose to the Public from All Pathways

DOE Order 458.1 establishes a radiation dose limit to a member of the general public from all possible pathways as a result of DOE facility operations. This limit is 100 mrem/yr (1 mSv/yr) above the dose from background radiation and includes the air transport, ingestion, and direct exposure pathways. For 2011, the only probable pathways from INL Site activities to a realistic maximally exposed individual include the air transport pathway and ingestion of game animals.

The hypothetical individual, assumed to live on the southern INL Site boundary at Frenchman's Cabin (Figure 4-2), would receive the highest calculated dose from INL Site airborne releases reported for 2011 (Section 8.2.1). For this analysis, we also assumed that the same hypothetical individual would kill and eat a duck with the maximum radionuclide concentrations detected in 2011 (Figure 7-5). The same hypothetical individual was assumed to kill and eat a large game animal that has resided on the INL Site and has the maximum concentration of ^{137}Cs measured in 2011 (Section 7.5.1). For this scenario, the duck would be killed at the nearby Mud Lake Wildlife Management Area. Also for this scenario, the maximally exposed individual would kill a game animal during the INL Site elk depredation controlled hunt (along the northwestern tip). In both cases, the animals would be killed soon after they leave the INL Site.

The dose estimate for an offsite maximally exposed individual from the air and game animal pathways is presented in Table 8-4. The total dose was conservatively estimated to be 0.07 mrem for 2011. For comparison, the total dose received by the maximally exposed individual in 2010 was calculated to be 0.12 mrem, mostly via the air pathway.

The total dose calculated to be received by the hypothetical maximally exposed individual for 2011 (0.07 mrem) represents about 0.02 percent of the dose expected to be received from background radiation (Table 7.4) and is well below the 100 mrem/yr limit above background established by DOE. As discussed in the Helpful Information section of this report, the 100 mrem limit is far below the exposure levels that cause acute health effects.

Table 8-4. Contribution to Dose by Pathway (2011).

Pathway	Dose to Maximally Exposed Individual (mrem)	Dose to Maximally Exposed Individual (mSv)	Percent of DOE 100-mrem/yr Limit	Estimated Population Dose (person-rem)	Estimated Population Dose (person-Sv)	Population within 80 km	Estimated Background Radiation Population Dose (person-rem)[a]
Air	0.046	0.00046	0.046	0.61	0.006	305,509	116,399
Waterfowl ingestion	0.004	0.00004	0.004	NA[b]	NA	NA	NA
Big game animals	0.017	0.00017	0.017	NA	NA	NA	NA
Total pathways	**0.067**	**0.0007**	**0.067**	**NA**	**NA**	**NA**	**NA**

a. The individual dose from background was estimated to be 381 mrem in 2011 (Table 7-4).
b. NA = Not applicable

The dose received by the entire population within 50 mi of INL Site facilities was calculated to be 0.61 person-rem. This is approximately 0.0005 percent of the dose (116,399 person-rem) expected from exposure to natural background radiation in the region.

8.7 Dose to Biota

8.7.1 Introduction

The impact of environmental radioactivity at the INL Site on nonhuman biota was assessed using *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE 2002) and the associated software, RESRAD-Biota (DOE 2004). The graded approach includes a screening method and three more detailed levels of analysis for demonstrating compliance with standards for protection of biota. The threshold of protection is assumed at the following doses: 1 rad/d (10 mGy/d) for aquatic animals, 0.1 rad/d (1 mGy/d) for terrestrial animals, and 1 rad/d (10 mGy/d) for terrestrial plants.

The graded approach begins the evaluation using conservative default assumptions and maximum values for all currently available data. This general screening level (Level 1 in RESRAD-Biota) provides generic limiting concentrations of radionuclides in environmental media termed “Biota Concentration Guides.” Each Biota Concentration Guide is the environmental concentration of a given radionuclide in soil or water that, under the assumptions of the model, would result in a dose rate less than 1 rad/d (10 mGy/d) to aquatic animals or terrestrial plants or 0.1 rad/d (1 mGy/d) to terrestrial animals. If the sum of the measured maximum environmental concentrations divided by the biota concentration guides (the combined sum of fractions) is less than one, no negative impact to plant or animal populations is expected. No doses are calculated unless the screening process indicates a more detailed analysis is necessary. Failure at this initial screening step does not necessarily imply harm to organisms. Instead, it is an indication that more realistic model assumptions may be necessary.

If the screening process indicates the need for a more site-specific analysis, an analysis is performed using site-representative parameters (e.g., distribution coefficients, bioconcentration factors) instead of the more conservative default parameters. This is Level 2 in RESRAD-Biota.

The next step in the graded approach methodology involves a site-specific analysis employing a kinetic modeling tool provided in RESRAD-Biota (Level 3). Multiple parameters which represent contributions to the organism internal dose (e.g., body mass, consumption rate of food/soil, inhalation rate, lifespan, biological elimination rates) can be modified to represent site- and organism-specific characteristics. The kinetic model employs equations relating body mass to internal dose parameters. At Level 3, bioaccumulation (the process by which biota concentrate contaminants from the surrounding environment) can be modeled to estimate the dose to a plant or animal. Alternatively, concentrations of radionuclides measured in the tissue of an organism can be input into RESRAD-Biota to estimate the dose to the organism.

The final step in the graded approach involves an actual site-specific biota dose assessment, which would involve a problem formulation, analysis, and risk characterization protocol similar to that recommended by EPA (1998). RESRAD-Biota cannot perform these calculations.

8.7.2 Terrestrial Evaluation

Of particular importance for the terrestrial evaluation portion of the 2011 biota dose assessment is the division of the INL Site into evaluation areas based on potential soil contamination and habitat types. For the INL Site, it is appropriate to consider specific areas that have been historically contaminated above background levels. Most of these areas have been monitored for radionuclides in soil since the early 1970s (Jessmore et al. 1994). In some of these areas, structures have been removed and areas cleaned to a prescribed, safe contamination level, but the soil may still have residual, measurable concentrations of radionuclides. These areas are associated with facilities shown in Figure 1-3 and include:

- Auxiliary Reactor Area
- Advanced Test Reactor Complex
- Critical Infrastructure Test Range Complex
- Large Grid, a 24-mile radius around the Idaho Nuclear Technology and Engineering Center
- Materials and Fuels Complex
- Naval Reactors Facility
- Radioactive Waste Management Complex
- Test Area North.

For the initial terrestrial evaluation, the most recently measured maximum concentrations of radionuclides in soil were used (Table 8-5.) The table includes laboratory analyses of soil samples collected in 2005, 2006, and 2009 by the INL and ICP contractors. The INL contractor currently uses in situ gamma spectroscopy to determine levels of ^{137}Cs and other gamma-emitting radionuclides in surface soils. The results of these surveys (Table 7-2) are also included in Table 8-5.

Using the maximum radionuclide concentrations for all locations in Table 8-6, a screening level analysis was made of the potential terrestrial biota dose. The analysis also assumed that animals have access to water in facility effluents and ponds. The maximum radionuclide concentrations reported in Appendix C were used to represent surface water concentrations. The combined sum of fractions was less than one for both terrestrial animals (0.65) and plants (0.0066) and passed the general screening test (Table 8-6).

Based on the results of the graded approach, there is no evidence that INL Site-related radioactivity in soil is harming terrestrial plant or animal populations.

8.7.3 Aquatic Evaluation

For the aquatic evaluation, maximum effluent or pond radionuclide concentrations are typically used. The maximum concentration for each radionuclide reported in any pond or effluent in Appendix C was used. When the constituent was reported as “total strontium” it

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

Location[a]	Radionuclide	Detected Concentration (pCi/g)[b] Minimum	Maximum
ARA	Cesium-137	0.23	9.58
	Uranium-238	3.23	4.21
	Strontium-90	0.21	0.37
	Plutonium-238	3.90×10^{-3}	3.90×10^{-3}
	Plutonium-239/240	1.30×10^{-2}	1.80×10^{-2}
	Americium-241	5.50×10^{-3}	8.50×10^{-3}
ATR	Cobalt-60	2.50×10^{-2}	9.10×10^{-2}
	Cesium-134	5.30×10^{-2}	5.30×10^{-2}
	Cesium-137	0.37	1.75
	Europium-152	0.62	0.62
	Americium-241	0.49	0.49
	Strontium-90	5.82×10^{-2}	5.82×10^{-2}
	Plutonium-238	5.90×10^{-3}	4.30×10^{-2}
	Plutonium-239/240	1.70×10^{-2}	2.18×10^{-2}
CITRC	Cesium-137	9.20×10^{-2}	0.46
MFC	Cobalt-60	0.17	0.17
	Cesium-137	0.14	0.97
	Uranium-238	3.82	3.82
	Plutonium-239/240	1.50×10^{-2}	2.90×10^{-2}
	Americium-241	4.30×10^{-3}	1.20×10^{-2}
INTEC	Cobalt-60	3.30×10^{-2}	3.30×10^{-2}
	Cesium-137	0.18	12.68
	Europium-152	9.20×10^{-2}	9.20×10^{-2}
	Uranium-238	2.66	5.80
	Strontium-90	0.49	0.71
	Plutonium-238	2.50×10^{-2}	4.30×10^{-2}
	Plutonium-239/240	1.10×10^{-2}	2.90×10^{-2}
	Americium-241	6.10×10^{-3}	8.10×10^{-3}
Large Grid	Cesium-137	8.14×10^{-2}	0.64
	Uranium-238	1.40	4.57
	Strontium-90	0.11	0.11
	Plutonium-238	3.30×10^{-3}	4.00×10^{-3}
	Plutonium-239/240	1.00×10^{-2}	2.50×10^{-2}
	Americium-241	5.50×10^{-3}	8.50×10^{-3}
NRF	Cesium-137	0.26	0.93
	Plutonium-239/240	5.70×10^{-3}	1.60×10^{-2}
	Americium-241	4.30×10^{-3}	9.70×10^{-3}
RWMC	Cesium-137	0.13	0.76
	Uranium-238	2.66	4.46

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

Location[a]	Radionuclide	Detected Concentration (pCi/g)[b] Minimum	Maximum
	Americium-241[c]	0.49	3.69
	Plutonium-239/240[d]	6.20×10^{-2}	9.20×10^{-2}
TAN/SMC	Cesium-137	0.21	2.57
	Uranium-238	2.36	3.02
	Plutonium-239/240	1.25×10^{-2}	1.74×10^{-2}
	Americium-241	3.20×10^{-3}	5.70×10^{-3}
ALL	Cobalt-60	2.50×10^{-2}	0.17
	Cesium-134	3.20×10^{-2}	5.30×10^{-2}
	Cesium-137	5.30×10^{-2}	12.7
	Europium-152	9.20×10^{-2}	0.62
	Strontium-90	5.82×10^{-2}	0.71
	Uranium-238	1.41	5.80
	Plutonium-238	3.30×10^{-3}	4.30×10^{-2}
	Plutonium-239/240	5.70×10^{-3}	9.20×10^{-2}
	Americium-241[c]	3.20×10^{-3}	3.69

a. ARA = Auxiliary Reactor Area; ATR = Advance Test Reactor Complex; CITRC = Critical Infrastructure Test Range Complex; Large Grid = A 24-mile radius around INTEC; MFC = Materials and Fuels Complex; INTEC = Idaho Nuclear Technology and Engineering Center NRF = Naval Reactors Facility; RWMC = Radioactive Waste Management Complex; TAN/SMC = Test Area North/Specific Manufacturing Capability.

b. Legend:
- Results measured in 2011 using in situ gamma spectroscopy (see Table 7-3.)
- Results measured by laboratory analyses of soil samples collected in 2005
- Results measured by laboratory analyses of soil samples collected in 2006
- Results measured by laboratory analyses of soil samples collected in 2009.

c. The results shown are from in situ surveillance of soils around the RWMC. The maximum results, measured near the RWMC, is most likely from shine from material containing americium-241, which is stored near where the surface activity was measured. The result in the table does not represent a true measurement of activity in soil and is therefore conservative.

d. Soil samples collected within RWMC by the ICP contractor.

Table 8-6. RESRAD Biota 1.5 Biota Dose Assessment (Screening Level) of Terrestrial Ecosystems on the INL Site (2011).

Terrestrial Animal						
	Water			Soil		
Nuclide	Concentration (pCi/L)	BCG[a](pCi/L)	Ratio	Concentration (pCi/g)	BCG (pCi/g)	Ratio
Am-241	0	2.02E+05	0.00E+00	3.69	3.89E+03	9.47E-04
Co-60	0	1.19E+06	0.00E+00	0.171	6.92E+02	2.47E-04
Cs-134	0	3.26E+05	0.00E+00	0.053	1.13E+01	4.69E-03
Cs-137	0	5.99E+05	0.00E+00	12.7	2.08E+01	6.12E-01
Eu-152	0	2.55E+06	0.00E+00	0.627	1.52E+03	4.12E-04
H-3	1950	2.31E+08	8.44E-06	0	1.74E+05	0.00E+00
I-129	0.193	5.70E+06	3.38E-08	0	5.67E+03	0.00E+00
Pu-238	0	1.89E+05	0.00E+00	0.043	5.27E+03	8.16E-06
Pu-239	0	2.00E+05	0.00E+00	0.092	6.11E+03	1.50E-05
Sr-90	0	5.45E+04	0.00E+00	0.71	2.25E+01	3.16E-02
U-233	1.41	4.01E+05	3.52E-06	0	4.83E+03	0.00E+00
U-234	1.41	4.04E+05	3.49E-06	0	5.13E+03	0.00E+00
U-238	0.739	4.06E+05	1.82E-06	5.8	1.58E+03	3.68E-03
Summed	-	-	**1.73E-05**	-	-	**6.53E-01**
Terrestrial Plant						
	Water			Soil		
Nuclide	Concentration (pCi/L)	BCG (pCi/L)	Ratio	Concentration (pCi/g)	BCG (pCi/g)	Ratio
Am-241	0	7.04E+08	0.00E+00	3.69	2.15E+04	1.71E-04
Co-60	0	1.49E+07	0.00E+00	0.171	6.13E+03	2.79E-05
Cs-134	0	2.28E+07	0.00E+00	0.053	1.09E+03	4.88E-05
Cs-137	0	4.93E+07	0.00E+00	12.7	2.21E+03	5.76E-03
Eu-152	0	3.06E+07	0.00E+00	0.627	1.47E+04	4.26E-05
H-3	1950	7.04E+09	2.77E-07	0	1.68E+06	0.00E+00
I-129	0.193	4.93E+08	3.92E-10	0	1.69E+05	0.00E+00
Pu-238	0	3.95E+09	0.00E+00	0.043	1.75E+04	2.46E-06
Pu-239	0	7.04E+09	0.00E+00	0.092	1.27E+04	7.25E-06
Sr-90	0	3.52E+07	0.00E+00	0.71	3.58E+03	1.98E-04
U-233	1.41	1.06E+10	1.33E-10	0	5.23E+04	0.00E+00
U-234	1.41	3.08E+09	4.58E-10	0	5.16E+04	0.00E+00
U-238	0.739	4.28E+07	1.72E-08	5.8	1.57E+04	3.69E-04
Summed	-	-	**2.95E-07**	-	-	**6.62E-03**

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

was conservatively assumed that it was ^{90}Sr. When "uranium-233/234" was reported, it was conservatively assumed that each radionuclide was present in equal concentrations.

The results shown in Table 8-7 indicate that INL Site-related radioactivity in ponds and liquid effluents is not harming aquatic biota.

Tissue data from waterfowl collected on the ATR Complex ponds in 2011 were also available (Figure 7-5). Concentrations of radionuclides in tissue can be input into the RESRAD-Biota code at the Level 3 step to calculate the internal dose to biota. To confirm that doses to waterfowl from exposure to radionuclides in the vicinity of the ATR Complex are not harmful, a Level 3 analysis was performed using the maximum tissue concentrations shown in Figure 7-5. The waterfowl were assumed in the model to be riparian animals, accessing both aquatic and terrestrial environments in the area. External dose was calculated using the maximum radionuclide concentrations measured in soils around the ATR Complex.

Table 8-7. RESRAD Biota 1.5 Assessment (Screening Level) of Aquatic Ecosystems on the INL Site (2011).

Aquatic Animal

	Water			Sediment		
Nuclide	Concentration (pCi/L)	BCG[a] (pCi/L)	Ratio	Concentration (pCi/g)	BCG (pCi/g)	Ratio
H-3	1950	4.99E+09	3.90E-07	0.00195	7.04E+06	2.77E-10
I-129	0.193	1.00E+06	1.93E-07	0.00193	4.93E+05	3.92E-09
U-233	1.41	2.00E+02	7.06E-03	0.0705	1.06E+07	6.65E-09
U-234	1.41	2.02E+02	6.99E-03	0.0705	3.08E+06	2.29E-08
U-238	0.739	2.23E+02	3.31E-03	0.03695	4.28E+04	8.62E-07
Summed	-	-	**1.74E-02**	-	-	8.96E-07

Riparian Animal

	Water			Sediment		
Nuclide	Concentration (pCi/L)	BCG (pCi/L)	Ratio	Concentration (pCi/g)	BCG (pCi/g)	Ratio
H-3	1950	2.65E+08	7.36E-06	0.00195	3.74E+05	5.21E-09
I-129	0.193	3.84E+04	5.02E-06	0.00193	2.86E+04	6.75E-08
U-233	1.41	6.76E+02	2.09E-03	0.0705	5.28E+03	1.34E-05
U-234	1.41	6.83E+02	2.06E-03	0.0705	5.27E+03	1.34E-05
U-238	0.739	7.56E+02	9.78E-04	0.03695	2.49E+03	1.49E-05
Summed	-	-	**5.14E-03**	-	-	**4.17E-05**

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

Results of the dose evaluation to waterfowl using radionuclide concentrations measured in tissue are shown in Table 8-8. The estimated dose to waterfowl was calculated by RESRAD-Biota 1.5 to be 2.93 x 10^{-5} rad/d (2.93 x 10^{-4} mGy/d) (DOE 2004). This dose is less than the standard of 1 rad/d (10 mGy/d). Based on these results, there is no evidence that impounded water at the INL Site is harming aquatic biota.

8.8 Doses from Unplanned Releases

No unplanned radioactive releases from the INL site were reported in 2011. As such, there are no doses associated with unplanned releases during 2011.

Table 8-8. RESRAD Biota 1.5 Assessment (Level 3 Analysis) of Aquatic Ecosystems on the INL Site Using Measured Waterfowl Tissue Data (2011).

	Waterfowl Dose (rad/d)				
Nuclide	**Water[a]**	**Soil[b]**	**Sediment**	**Tissue[c]**	**Summed**
Am-241	0.00E+00	8.62E-08	0.00E+00	0.00E+00	8.62E-08
Co-60	0.00E+00	2.26E-06	0.00E+00	1.82E-06	4.08E-06
Cs-134	0.00E+00	7.91E-07	0.00E+00	0.00E+00	7.91E-07
Cs-137	0.00E+00	9.47E-06	0.00E+00	2.77E-06	1.22E-05
Eu-152	0.00E+00	7.04E-06	0.00E+00	0.00E+00	7.04E-06
Pu-238	0.00E+00	4.41E-11	0.00E+00	0.00E+00	4.41E-11
Pu-239	0.00E+00	1.12E-11	0.00E+00	0.00E+00	1.12E-11
Sr-90	0.00E+00	1.05E-08	0.00E+00	0.00E+00	1.05E-08
Zn-65	0.00E+00	0.00E+00	0.00E+00	5.05E-06	5.05E-06
Total	**0.00E+00**	**1.97E-05**	**0.00E+00**	**9.64E-06**	**2.93E-05**

a. None of these radionuclides were measured in the ATR Complex Cold Waste Pond. Hence, there were no doses calculated for water and sediment.
b. External doses to waterfowl were calculated using soil concentrations. Maximum concentrations ofradionuclides measured in soil at the ATR Complex were used (Table 8-5).
c. Internal doses to waterfowl were calculated using maximum concentrations in edible tissue shown in Figure 7-5.

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Chapter 9. Environmental Research at the Idaho National Laboratory Site

Chapter 9 Highlights

The Idaho National Laboratory (INL) was designated as a National Environmental Research Park (NERP) in 1975. The NERP program was established in response to recommendations from citizens, scientists, and members of Congress to set aside land for ecosystem preservation and study. In many cases, these protected lands became the last remaining refuges of what were once extensive natural ecosystems. The NERPs provide rich environments for training researchers and introducing the public to ecological sciences. NERPs have been used to educate grade school and high school students and the general public about ecosystem interactions at U.S. Department of Energy (DOE) sites; train graduate and undergraduate students in research related to site-specific, regional, national, and global issues; and promote collaboration and coordination among local, regional, and national public organizations, schools, universities, and federal and state agencies.

During 2011, seven ecological monitoring and research projects were conducted on the Idaho NERP:

- Surveying, Monitoring and Predicting the Occurrence and Spread of Native and Non-Native Plant Species at the Idaho National Laboratory Site
- Post-wildfire Wind Erosion In and Around the Idaho National Laboratory Site
- Long-term Vegetation Transects
- Distribution, Movements, and Space Use by Elk on the Idaho National Laboratory Site
- The Influence of Precipitation, Vegetation and Soil Properties on the Ecohydrology of Sagebrush Steppe Rangelands on the INL
- Remote Sensing of Sagebrush Canopy Nitrogen
- Shrub Cover and Volume Estimates Using Ground and Airborne Laser Scans and Hyperspectral Imagery.

The United States Geological Survey (USGS) has been studying the hydrology and geology of the eastern Snake River Plain and eastern Snake River Plain aquifer since 1949. The USGS INL Project Office collects data from research and monitoring wells to create and refine hydrologic and geologic models of the aquifer, to track contaminant plumes in the aquifer and improve understanding of the complex relationships between the rocks, sediments and water

that compose the aquifer. Four reports were published in 2011 by the INL Project Office:

- Multilevel groundwater monitoring of hydraulic head and temperature in the eastern Snake River Plain aquifer, Idaho National Laboratory, Idaho 2007-08
- Paleomagnetic correlation of surface and subsurface basaltic lava flows and flow groups in the southern part of the Idaho National Laboratory, Idaho, with paleomagnetic data tables for drill cores
- Geophysical logs and water-quality data collected for boreholes Kimama-1A and -1B and Kimama Water Supply well near Kimama, southern Idaho
- Assessing controls on perched saturated zones beneath the Idaho Nuclear Technology and Engineering Center, Idaho.

9. ENVIRONMENTAL RESEARCH AT THE IDAHO NATIONAL LABORATORY SITE

This chapter summarizes ecological research performed at the Idaho National Environmental Research Park (Section 9.1) and research conducted on the Snake River Plain aquifer by the United States Geological Survey (Section 9.2) during 2011.

9.1 Ecological Research and Monitoring at the Idaho National Environmental Research Park

The Idaho National Laboratory (INL) Site was designated as a National Environmental Research Park in 1975. The National Environmental Research Park Program was established in response to recommendations from citizens, scientists, and members of Congress to set aside land for ecosystem preservation and study. This has been one of the few formal efforts to reserve land on a national scale for ecological research and education. In many cases, these protected lands became the last remnants of what were once extensive natural ecosystems.

Five basic objectives guide activities on National Environmental Research Parks:

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

National Environmental Research Parks provide rich environments for training researchers and introducing the public to the ecological sciences. They have been used to educate grade school and high school students and the general public about ecosystem interactions at Department of Energy (DOE) sites; train graduate and undergraduate students in research related to site-specific, regional, national, and global issues; and promote collaboration and coordination among local, regional, and national public organizations, schools, universities and federal and state agencies. Ecological research on National Environmental Research Parks is leading to better land-use planning, identifying sensitive areas on DOE sites so that restoration and other activities are compatible with ecosystem protection and management, and increased contributions to ecological science in general.

Ecological research was conducted at federal laboratories long before National Environmental Research Parks were established. For example, at the INL Site, ecological research began in 1950 with the establishment of the long-term vegetation transect study. This is perhaps DOE's oldest ecological data set and one of the most intensive data sets for sagebrush steppe. In addition, in 1989, a long-term reptile monitoring study was initiated, which is the longest continuous study of its kind in the world. Also, in 1993, a protective cap biobarrier experiment was initiated, which evaluated the long-term performance of evapotranspiration caps and biological intrusion barriers. Those long-term plots are now being used to test hypotheses on the potential effects of climate change.

The Idaho National Environmental Research Park provides coordination of ecological research and information exchange at the INL Site. It facilitates ecological research on the INL Site by attracting new researchers to use the area, providing background data for new research projects, and assisting researchers to obtain access to the INL Site. The Idaho National Environmental Research Park provides infrastructure support to ecological researchers through the Experimental Field Station and reference specimen collections. The Idaho National Environmental Research Park tries to foster cooperation and research integration by encouraging researchers to collaborate, developing interdisciplinary teams to address more complex problems, encouraging data sharing, and leveraging funding across projects to provide more efficient use of resources. It also integrates research results from many projects and disciplines and provides analysis of ecosystem-level responses. The Idaho National Environmental Research Park has developed a centralized ecological database to provide an archive for ecological data and to facilitate data retrieval for new research projects and land management decisions. It also provides interpretation of research results to land and facility managers to support the National Environmental Policy Act process, natural resources management, radionuclide pathway analysis, and ecological risk assessment.

A total of 39 graduate students, post-doctoral students, faculty, and agency and contractor scientists participated in seven research projects on the Idaho National Environmental Research Park in 2011. Several undergraduate students and technicians also gained valuable experience through participation in these research activities. The seven projects include five graduate student research projects, with students and faculty from Idaho State University, Boise State University, Montana State University, and Washington State University. Other researchers represented the Environmental Surveillance, Education, and Research Program,

U.S. Department of Agriculture – Agricultural Research Service, U.S. Department of Agriculture – Forest Service Rocky Mountain Research Station, and the Idaho National Laboratory.

Two of the graduate students received at least part of their research funding from the Department of Energy, Idaho Operations Office (DOE-ID) through the Environmental Surveillance, Education, and Research Program. Three of the seven projects received funding in whole or part from DOE-ID through the Environmental Surveillance, Education, and Research Program. Other funding sources included the Bureau of Land Management, Idaho State University, U.S. Environmental Protection Agency, U.S. Department of Agriculture – Forest Service Rocky Mountain Research Station, Idaho Space Grant Consortium, National Oceanic and Atmospheric Administration Office of Oceanic and Atmospheric Research Earth Systems Research Laboratory, U.S. Department of Defense, INL Laboratory Directed Research and Development Program, and National Science Foundation.

Most of the DOE-ID-funded research and monitoring and much of the research and monitoring funded by other agencies address conservation planning issues applicable to the INL Site. These issues include preparing for potential Endangered Species Act listings, understanding wildland fire effects, minimizing invasive species impacts, and understanding long-term trends in plant community composition, sagebrush health, and potential effects of climate change. The results of these projects will be used to support the preparation of a Conservation Management Plan. The Conservation Management Plan will address Greater Sage-Grouse (*Centrocercus urophasianus*) conservation strategies across the entire INL Site because they were under consideration for protection under the Endangered Species Act. Conservation planning for other species of concern, including sensitive mammals and plants and all sagebrush-obligate species, will be limited to a 125-square-mile area in the center of the INL Site referred to as the Development Zone (Figure 9-1).

9.1.1 Survey, Monitoring and Predicting the Occurrence and Spread of Native and Non-Native Plant Species at Idaho National Laboratories.

Investigators and Affiliations

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Tyler Brummer, Department of Land Resources and Environmental Sciences, Montana State University, Bozeman, Montana

Kimberley Taylor, Department of Land Resources and Environmental Sciences, Montana State University, Bozeman, Montana

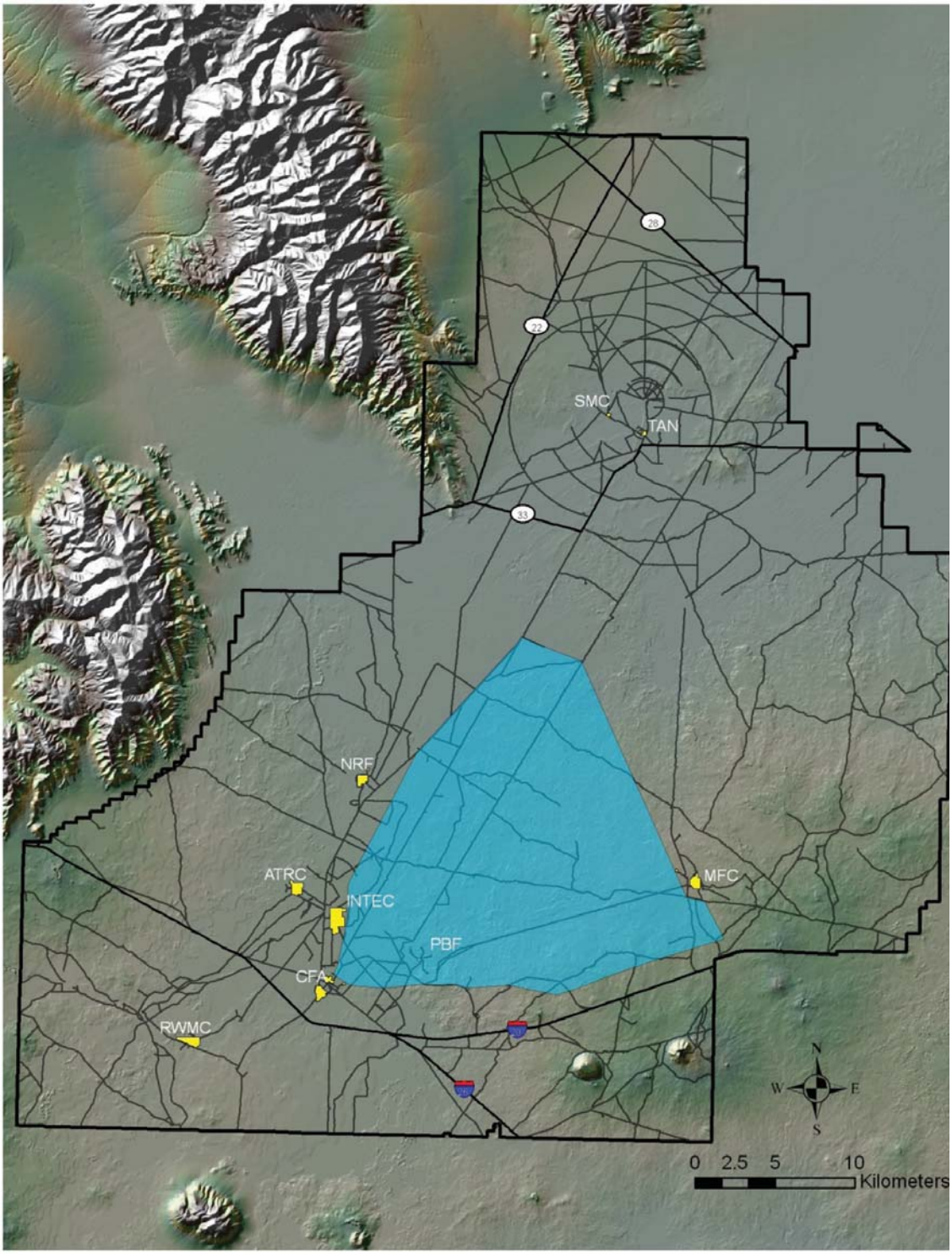

Figure 9-1. The Idaho National Laboratory Site with the Conservation Management Plan Development Zone Highlighted in Blue.

Funding Source

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

Background

Management of both non-indigenous plant species (NIS) and rare plants species (RPS) is a high priority in many managed forests, wildlands and rangeland areas. However, rarely do either public or private agencies have sufficient resources to manage all NIS or conserve all RPS. Neither do agencies have sufficient information on the potential impacts of future anthropogenic development. Therefore, a better understanding of the temporal and spatial processes which drive both NIS and RPS population distributions and dynamics is required to improve management effectiveness and efficiency. The difficulty in increasing our knowledge of NIS and RPS population dynamics in the sagebrush-steppe plant community is that they occur with low frequency on the landscape and can be difficult to detect because they are similar in morphology to the co-occurring species. By using knowledge of probable routes of introduction for the NIS, and particular habitat requirements for the RPS, appropriate survey methods can be developed. Repeated sampling can then help to elucidate the spatiotemporal dynamics of select populations. From such data, predictive occurrence maps can be generated for the current landscape, but also for a range of future scenarios including anthropogenic development. Incorporating the information into a decision support management prioritization framework can help resource managers prioritize populations to manage and help evaluate the potential impacts of different disturbance scenarios to minimize the negative (RPS) or positive (NIS) impacts on plant population dynamics.

Objectives

The goal of this study was to determine the current distribution of NIS and RPS on the INL Site and predict the potential spatial and temporal metapopulation dynamics of these species to help inform management and future development decisions.

Accomplishments through 2011

Survey detection error and metapopulation dynamics: A total of 45 10-m wide belt transects that originated on roads or facility margins and traveled 2-km away from the road or facility were completed in 2011. Transects were repeats from previous years and were selected according to stratification on fire chronology and proximity to facilities. Presence and absence of eight targeted NIS were recorded along these transects. In addition to repeating the whole transects, two 200-m sections of each transect were repeated again, to evaluate within season detection error. The 200-m sections were randomly located, one within 0 - 1000-m and the other 1001 - 2000-m from the road.

The repeat NIS data were used to evaluate detection error, and also to assess metapopulation dynamics. All analysis was performed in R using the ‘unmarked’ package. To evaluate detection error and effect on predictions we evaluated five Models: Model 1 used just the first visit in a logistic regression, Model 2 used the second visit only in a logistic regression,

Model 3 used the maximum of the detection history in a logistic regression, Model 4 used both visits in a hierarchical occupancy model, with the detection process as intercept only, and Model 5 was the same as Model 4 but allowed detection to vary as a function of covariates. Depending on the objectives of each analysis, covariates were either excluded or included for the occupancy process in these five different groups of models.

To assess metapopulation dynamics covariates were carefully constructed based on hypothesized drivers that were determined *a priori*, which included habitat suitability (HS) (determined via logistic regression on the species P/A data using only environmental predictors), occupied neighborhood density (OND, calculated as the number of neighboring occupied cells divided by the total number of neighboring cells within a given radius) and disturbance variables of paved (continuous variable) and two-track (binary variable) roads, wildfire (binary variable), time since fire for areas that had burned (categorical variable), and *Agropyron cristatum* "Green Strips" (binary variable).

Biodiversity analysis: Using a subset of the entire 2009-2010 transects, the frequency of all plant species was recorded along 76 transects in two 1000 m sections (0-1000 m and 1001-2000 m from the road), as well as along a 1000 m transect that followed the road and that was bisected at the mid distance (500 m) by the transect running perpendicular to the road.

The biodiversity data was analyzed to determine the influence of NIS and other ecological parameters (e.g., disturbance and fire) on the abundance and diversity of native plant species including any RPS found during the course of field work. Data were analyzed in R.

***Bromus tectorum* response to fire:** The percent cover of Bromus tectorum, the four most dominant plant species, litter and bareground were recorded in 10-m * 10-m plots. The plots were randomly placed along transects that were stratified by time since fire. Three transects were assessed in areas burned 15 years ago, two transects in areas that burned 11 years ago, two transects in areas that burned three to four years ago, 10 transects in areas that burned one year ago (Jefferson Fire), and seven transects in areas that had not burned recently.

A logistic regression of the binomial family was used to model *B. tectorum* cover as a function of presence or absence of fire, time since fire, percent litter, percent native vegetation cover, percent NIS vegetation (excluding *B. tectorum*) cover, and dominant species in the plot. Data were analyzed in R.

Results

Survey detection error and metapopulation dynamics: Empirical detection rates for the eight targeted NIS – *Agropyron cristatum, Alyssum desertorum, Bromus tectorum, Carduus nutans, Descurainia sophia, Halogeton glomeratus, Lepidium perfoliatum*, and *Sisymbrium altissimum* - ranged from 0.24 to 0.94 although the majority of detection rates were greater than 0.75. There was a significant trend that as a species occupancy on the landscape increased, so too did our detection rate (Figure 9-2), albeit that there was a lot of variability at low occupancy rates. Overall detection error did not change species rank occurrence substantially suggesting that if species are managed according to their relative frequency on the landscape detection error is unlikely to change the species order much.

Of the eight species evaluated only three of them showed a seasonal change in detection of 10 percent and this did not sufficiently bias regression coefficients to make practical changes to predicted probability of occurrence, nor did observer differences. Evaluation of hierarchical models (McKenzie's) showed that uncertainty was greater when the hierarchical model was used for three of eight species but was unchanged for four of eight species. Complementarily, predictions of probability of occupancy using general linear regression were robust to choice of model method for four of eight species while predictions changed substantially for three of eight species. Predictions for species with detection higher than 87 percent were robust to each modeling method. In conclusion, we generally found detection rates to be high and logistic regression to be more reliable and interpretable for the development of predictive maps.

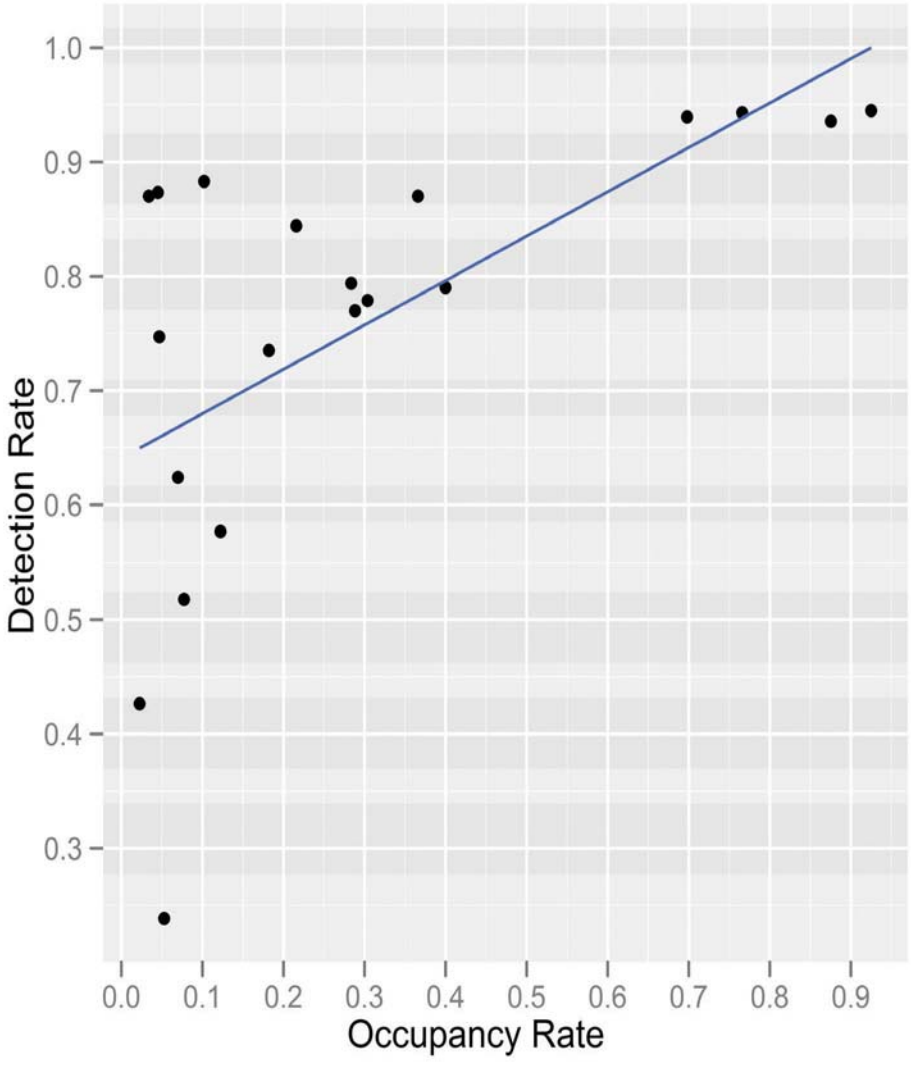

Figure 9-2. Plot of Estimated Detection Rate as a Function of Occupancy Rate.
Detection rate increased as occupancy rate increased (p = 0.01) with no evident effect of year (p = 0.11). The fitted line from a simple linear regression of detection rate as a function of occupancy rate is shown.

Models of spatial variation in colonization and extinction ranged from very simple (six species) to very complex (*A. desertorum* and *S. altissimum*). The effect of occupied neighborhood density was the only consistent predictor with greater colonization associated with greater occupied neighborhood density, coupled with lower extinction. Seven of the eight species responded to fire with the four annual Brassicaceae (*A. desertorum, D. sophia, L. perfoliatum,* and *S. altissimum*) having higher colonization and lower extinction in the fire, and colonization decreased and extinction increased as time since fire increased.

Temporal information (2009-2010, 2010-2011) was only available for three species but suggested strong temporal dynamics for *S. altissimum* and *C. nutans* that corresponded with yearly climate differences, while *A. cristatum* followed the same general (increasing metapopulation size) trajectory for both years.

Biodiversity analysis: The ecological factors that have the greatest influence on vascular plant biodiversity are first and foremost the degree of disturbance, followed by the degree of seasonality - whether measured in terms of precipitation, temperature, or water deficit. The least explanatory variables included the abundance and diversity of NIS, as well as the historical legacy of fire. In all fire categories (Figure 9-3), introduced species (red vertical lines) are distributed evenly along the rank abundance of native species (black open circles), according to a Kolmogorov-Smirnov test, suggesting they add to, rather than replace, native plant diversity. A general trend along this fire chronology was that total plant diversity and the proportion of native plant species to NIS remained approximately the same. At the least, fire by itself did not decrease plant diversity or increase the proportion of NIS.

Principle coordinates (PCO) analysis arrayed the 76 INL Site transects in two dimensions (Figure 9-4) using community phylogenetic distances (roughly a composite measure of how different each transect is with respect to shared species, genera, families, etc.; results using traditional community metrics such as Bray-Curtis or Euclidean distances rendered the same results as described below but with lower measure of fit). In the left panel (Figure 9-4), the contour lines represent Simpson's diversity index of native plant species whereas the color of the transect represents the disturbance category. The diversity of native species and disturbance category were determined to be the most explanatory variables of phylogenetic community composition using General Additive Model, Canonical Correspondence Analysis, and distance modeling and model ranking approaches (e.g., AIC). In the right panel, the contour lines represent Simpson's diversity index of introduced plant species whereas the color of the transect represents the fire category. These last two variables were determined to be some of the least explanatory using the same modeling approaches. The results here suggest that the diversity and abundance of native species is a good indicator of the degree of disturbance that has occurred at a site, whereas the diversity and abundance of NIS is about the same everywhere regardless of ecological variation within the INL sagebrush steppe.

The conclusion is that plant biodiversity within the INL Site boundaries is in good condition because disturbance is minimal in this "accidental wilderness area." Fire also doesn't constitute much of a disturbance at least from the perspective of plant biodiversity at this scale (1000 m * 10 m). A logical extension of this would be that the most effective means of reestablishing

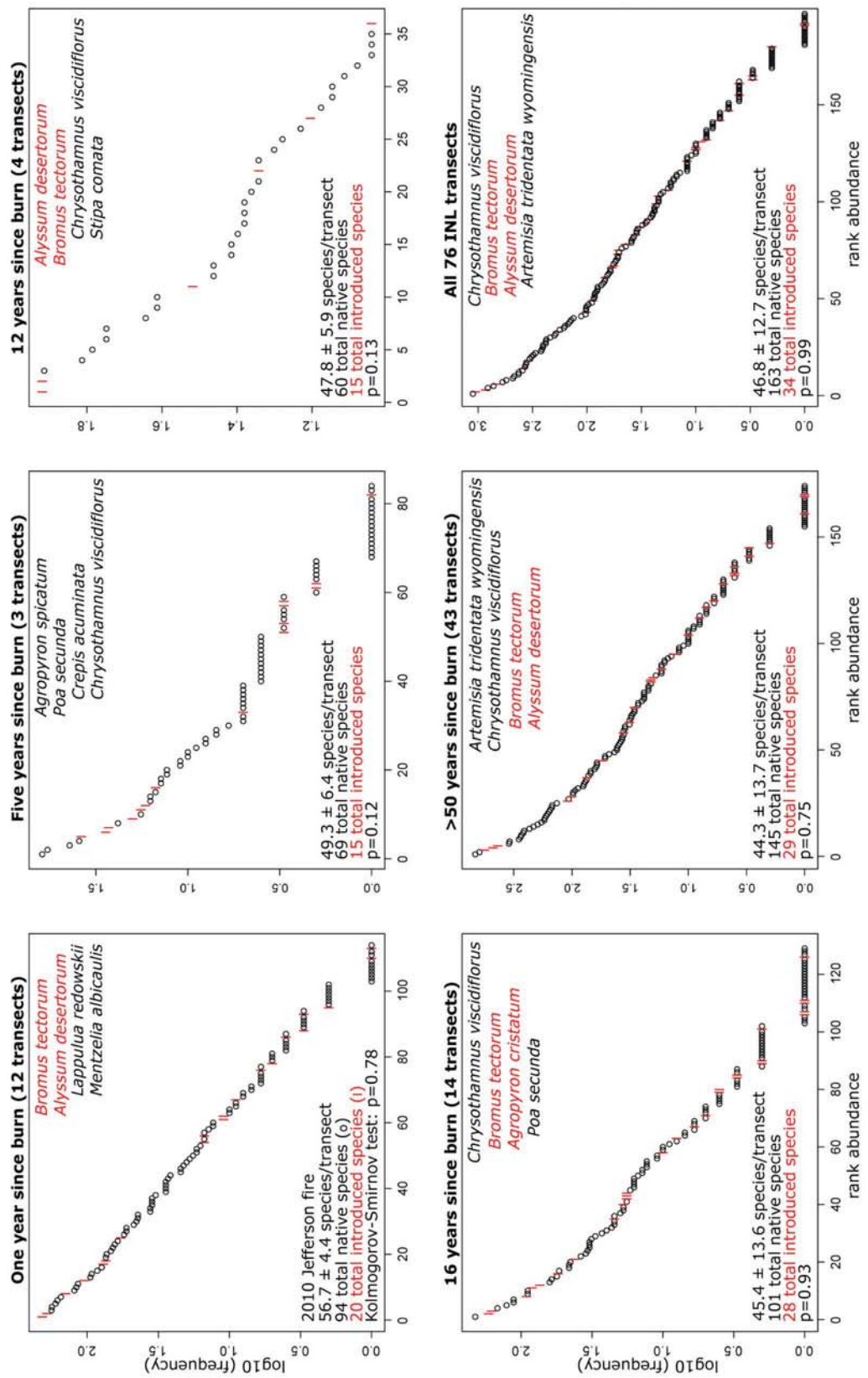

Figure 9-3. Rank Abundance (log10 frequency) for the Vascular Plant Species Sampled Along the 76 Transects and Stratified by Fire Interval, Within the INL Development Area.

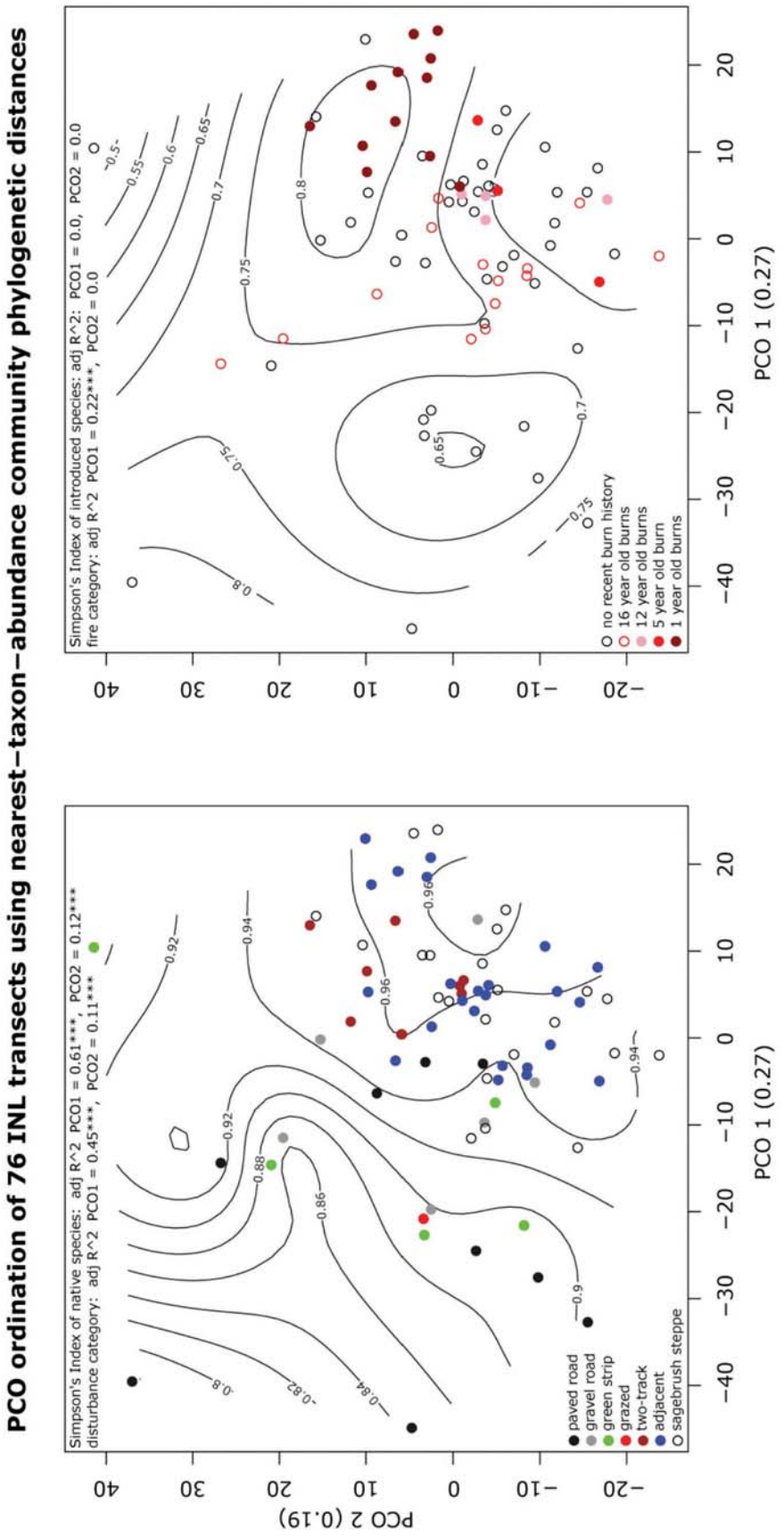

Figure 9-4. Principal Coordinates Analysis of the 76 Transects, Using the Three 1000 m Sections (adjacent to the road, 0-1000 m and 1001-2000 m).

sagebrush steppe after fire within an infrequently disturbed setting such as the INL Site would be to minimize physical disturbances such as those caused by the creation of fire lines, the establishment of green strips, or by reseeding or revegetation efforts.

With respect to RPS, no federally or state listed rare plants were found during three summers of intensive searching.

Bromus tectorum response to fire: *B. tectorum cover* was best explained by the presence or absence of fire in the past 15 years, percent native vegetation cover, percent NIS vegetation cover (excluding *B. tectorum*), and presence or absence of *Elymus lanceolatus*, as determined by logistic regression. Presence of fire, presence of *E. lanceolatus* and percent native vegetation cover all had a negative effect on *B. tectorum* cover, while percent NIS cover had a positive effect. The odds of finding *B. tectorum* cover in a burned area were only 48.37 percent of the odds of finding it in an unburned area. The fire chronology results suggested that *B. tectorum* did not always increase in cover after fire. While other studies have concluded that *B. tectorum* populations increase after fire, it is possible that in highly undisturbed sites such as the INL, fire may not cause *B. tectorum* cover to consistently increase. This hypothesis is supported by the fact that higher *B. tectorum* cover was positively correlated with percent NIS cover, which was higher in more disturbed sites.

The odds of finding *B. tectorum* cover in a plot with *Elymus lanceolatus* were only 34.55 percent of the odds of finding *B. tectorum* in a plot without *E. lanceolatus*. These results suggest that areas with higher *B. tectorum* cover occur where *E. lanceolatus* is not present. This result could be due to differences in habitat preferences between the two species. It could also be a result of either high *B. tectorum* cover causing reduced *E. lanceolatus* cover or vice versa. More research is necessary to determine if *E. lanceolatus* could be used to restore highly disturbed areas infested with *B. tectorum* if a restoration approach was considered desirable, although the biodiversity results suggest this may not be necessary.

Plans for Continuation

Data analysis, interpretation and finalization of manuscripts are on going but should be completed shortly. Tyler Brummer will be presenting his findings and defending his Master of Science candidacy April 3, 2012.

Publications, Theses, Reports

Brummer TB, Maxwell BD, Higgs M, and Rew LJ. Surveying non-native species occurrence and modeling realized distributions at local and landscape scales. Submitted to Biological Invasions March 2012.

Brummer TB, Maxwell BD, Lele S, and Rew LJ. Detection error in plant surveys: to correct or not to correct. In Preparation.

Brummer TB, Maxwell BD, Lavin M, and Rew LJ. Regional population dynamics of non-native plant species. In Preparation.

Lavin M, Brummer T, Seipel T, Maxwell B, and Rew L (in press) The intermountain flora sets the stage for a community phylogenetic analysis of plant biodiversity in the sagebrushsteppe of western North America. Brittonia. (Accepted Dec. 2012).

9.1.2 Post-wildfire Wind Erosion In and Around the Idaho National Laboratory Site

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Funding Sources

- U.S. Department of Defense
- Bureau of Land Management
- US Geological Survey
- USDA Forest Service Rocky Mountain Research Station

Background

Wind erosion following large wildfires on and around the INL Site is a recurrent threat to human health and safety, DOE operations and trafficability, and ecological and hydrological condition of the INL Site and down-wind landscapes. Causes and consequences of wind erosion

are mainly known from warm deserts (e.g. Southwest US), dunefields, and croplands, and some but not all findings are transferable to the cold desert environments such as where the INL Site lies.

Objectives

This is a large and multifaceted research program with the overall goal being to determine and describe wildland fire effects on wind erosion in rangelands on and around the INL Site. The specific objectives include the following:

- To quantify the role of wind erosion and dust emissions in post-fire environments as well as the associated potential impacts on site fertility, invasibility by exotic grasses, micro-scale geomorphology, and regional air quality
- To determine if the aerodynamic parameters friction velocity, roughness length, and displacement height change through time following wildland fire, and to identify how these parameters relate to vegetation recovery after fire
- To determine the effects of repeat burning on levels of wind erosion, for sites that reburn a few years following prior fires
- To determine how surface-soil moisture variations relate to (i.e., control) erodibility over the months when vegetation has yet to recover on the site
- To link monitoring of near-soil saltation activity to dust emission and model regional dust plumes culminating from INL fires, using a combination of ground-level, air quality, and remotely sensed approaches.

Accomplishments through 2011

In 2011, we used a combination of ground-based and remotely sensed approaches towards our objects on the 2010 Jefferson Fire and 2010 Middle Butte Fire. The Jefferson Fire burned ~100,000 acres, and we ended a year-long instrumentation campaign located on the U.S. Bureau of Land Management lands due east of INL Site in August, and in 2011 we began in intensive remote sensing assessment of surficial and vegetation changes across the entire burn site, including field validation. The Middle Butte Fire burned over portions of the 2007 Twin Buttes fire that we had previously evaluated. Our original saltation bridges were still in place, enabling an estimate of repeat burning effects on soil loss.

Results

Jefferson Fire, Preliminary Results: Dust plumes in satellite imagery combined with our measurements of airborne particulate matter and dispersion modeling and show that the 2010 Jefferson Fire caused substantial impacts to air quality in the Greater Yellowstone Ecosystem. Erosion led to losses of several centimeters of soil, resulting in a less-fertile landscape dominated by hard surface crust that is less capable of absorbing summer precipitation. Fluxes of PM_{10} and saltation near ground level in September 2010 are about as large, or are larger than other values reported for eroding rangeland or even croplands.

We have adapted energy balance models to create estimates of surface soil moisture (top mm or so of soil) and are relating this to erodibility in the >10 months that the Jefferson Fire site was without vegetation following fire. Surface soil moisture appears highly uncoupled from the conventional surrogate measures of water content commonly used as proxies, such as relative humidity or bulk soil water. On the Jefferson Fire site, areas dominated by native perennials (particularly sagebrush) have since had a large increase in exotic herbs, such as halogeton. We made detailed measurements of microsite elevation variations relative to residual shrub stumps and have evaluated the variation to the extent that we will propose a method of reconstructing historic soil loss from burn sites.

Middle Butte Fire, Preliminary Results: Horizontal fluxes determined over 12 months from sediment traps were many times greater on the portions of this fire that had not burned previously (at least for many decades) compared to the portions that had burned several years prior in the Twin Buttes Fire. Similarly, soil surface deflation determined from saltation bridges was 1-2 cm greater on the landscape that had not burned previously compared to that reburned (for the latter, we detected no net change in soil surface elevation). These findings will be important for predicting impacts of recurrent burning and for predictive modeling of future erosion.

Twin Buttes and Associated Fires: In 2011, we continued to analyze data and submit manuscripts for publication on our previous year's efforts, and the following findings are published now: Using a portable wind-tunnel, we demonstrated the direct effect of burning on erodibility and dust supply, and found that sagebrush microsites have a relatively high capacity to produce erodible soils after fires (Sankey et al. 2011, 2012). While this effect would seem to erode the heterogeneity of soils (between islands of fertility under native perennials and barren plant interspaces), we instead found that sites that appeared to be in good ecological condition prior burning (Twin Butte, Moonshiner, and Hwy 20 fires) retained much of their heterogeneity and associated plant diversity (Hoover and Germino 2012, Sankey et al. in press). We documented appreciable transfer of carbon and nitrogen in INL Site fires occurring prior to 2010 (Twin Butte Fire), with large fractions of organic matter being transported with soil in wind (Hasselquist et al. 2011, Sankey et al. in press B).

Plans for Continuation

In 2012, we do not plan to collect more field data unless new fire and erosion conditions arise. Our efforts are focused on using existing data for modeling, analysis, and publication efforts in 2012.

Publications, Theses, Reports

Publications:

Sankey J, Germino MJ, Sankey T, Hoover A (In Press, available online) Fire effects on the spatial patterning of soil properties in sagebrush steppe, USA: Meta-analysis. *International Journal of Wildland Fire*.

Sankey J, Germino MJ, Glenn N, Benner S (In Press B, available online) Bioavailable nutrients transported by wind in an eroding cold desert. *Aeolian Research*.

Hasselquist N, Germino MJ, Sankey J, Glenn N, Ingram J. 2011. High potential for nutrient redistribution in aeolian sediment fluxes following wildfire in sagebrush steppe. *Biogeosciences* 8: 3649-3659.

Sankey J, Germino MJ, Glenn NJ. 2012. Dust supply varies with sagebrush microsites and time since burning in experimental erosion events. *Journal of Geophysical Research-Biogeosciences* doi:10.1029/2011JG001724.

Sankey J, Eitel J, Glenn N, Germino MJ, Vierling L. 2011. Quantifying relationships of burning, roughness, and potential dust emission with laser altimetry of soil surfaces at submeter scales. *Geomorphology* doi:10.1016/j.geomorph.2011.08.016.

Hoover A, Germino MJ. 2012. Post-fire, Resource-Island Effects on Bromus tectorum and Pseudoroegneria spicata: Evidence From a Common-Garden Study. *Rangeland Ecology and Management* doi: 10.2111/REM-D-11-00026.1.

Presentations:

Germino MJ, Sankey JB, Glenn NF. Post-fire wind erosion: causes, consequences, and implications. Great Basin Consortium First Annual Meeting, Nov 2011, Reno, NV.

Germino MJ, Sankey JB, Glenn NF. Surface conditions affecting post-fire wind erosion in cold desert. Association for Fire Ecology Annual Meeting, Nov 2011, Snowbird, UT.

Sankey JB, Germino MJ, Glenn NF, Ravi S. Quantifying biogeomorphic response to fire at micro-biome scales. Association for Fire Ecology Annual Meeting, Nov 2011, Snowbird, UT

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9.1.3 Long-Term Vegetation Transects

Investigators and Affiliations

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Funding Sources

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

Background

The Long-Term Vegetation (LTV) Transects and associated permanent plots were established on what is now the Idaho National Laboratory (INL) Site in 1950 for the purposes of assessing impacts of nuclear energy research and production on surrounding ecosystems (Singlevich 1951). Initial sampling efforts focused on potential fallout from nuclear reactors and the effects of radionuclides on the flora and fauna of the Upper Snake River Plain. After several years of sampling, however, the concentrations and any related effects of radionuclides on the sagebrush steppe ecosystem of the INL Site were determined to be negligible (Harniss 1968).

Because the LTV plots were widely distributed across two transects which bisect the INL Site (Figure 9-5) and vegetation abundance data had been collected periodically since their establishment, their utility as a basis for monitoring vegetation trends in terms of species composition, abundance, and distribution was eventually recognized. Accordingly, vegetation abundance data collection has continued on the LTV plots on a semi-regular basis; about once every 5 years. Eight-nine LTV plots are still accessible and many have now been sampled on 12 occasions between 1950 and 2011, making the resulting dataset one of the oldest, largest, and most comprehensive for sagebrush steppe ecosystems in North America.

In many ways the LTV plots are still used to assess the impacts of energy research and development on the INL Site. The mission of the INL Site has moved beyond a strict focus on the development of nuclear energy to activities which pertain to securing energy-related infrastructure, further development of non-nuclear based energy technologies, and the cleanup of legacy waste. As the mission has grown and changed, so too have the potential impacts of mission-related activities on the vegetation of the INL Site. Potential ecological impacts of energy development at regional, national, and global scales are also of greater concern than they were when the LTV plots were established more than 60 years ago. Accordingly, issues currently addressed by the LTV dataset include; habitat quality for sensitive species, effects of exotic species invasions, increased rates of disturbance, habitat fragmentation, climate change, and the resilience of sagebrush steppe plant communities to various stressors.

The most recent sampling effort was conducted during the 2011 growing season. In addition to collecting and analyzing abundance data on the permanent plots, we will also include analysis on an ancillary vegetation data set in the report associated with the 2011 sampling effort. Prompted by sustained declines in big sagebrush (*Artemisia tridentata*) cover across the LTV plots since the late 1970s, a demography study was initiated to better understand population-level mechanisms which may be causing the declines. Data for this study were collected on 14 plots located in the central portion of the INL Site (Figure 9-5) in 2006 and sample processing continued through 2011. Results from this ancillary study and their implications on the biology of

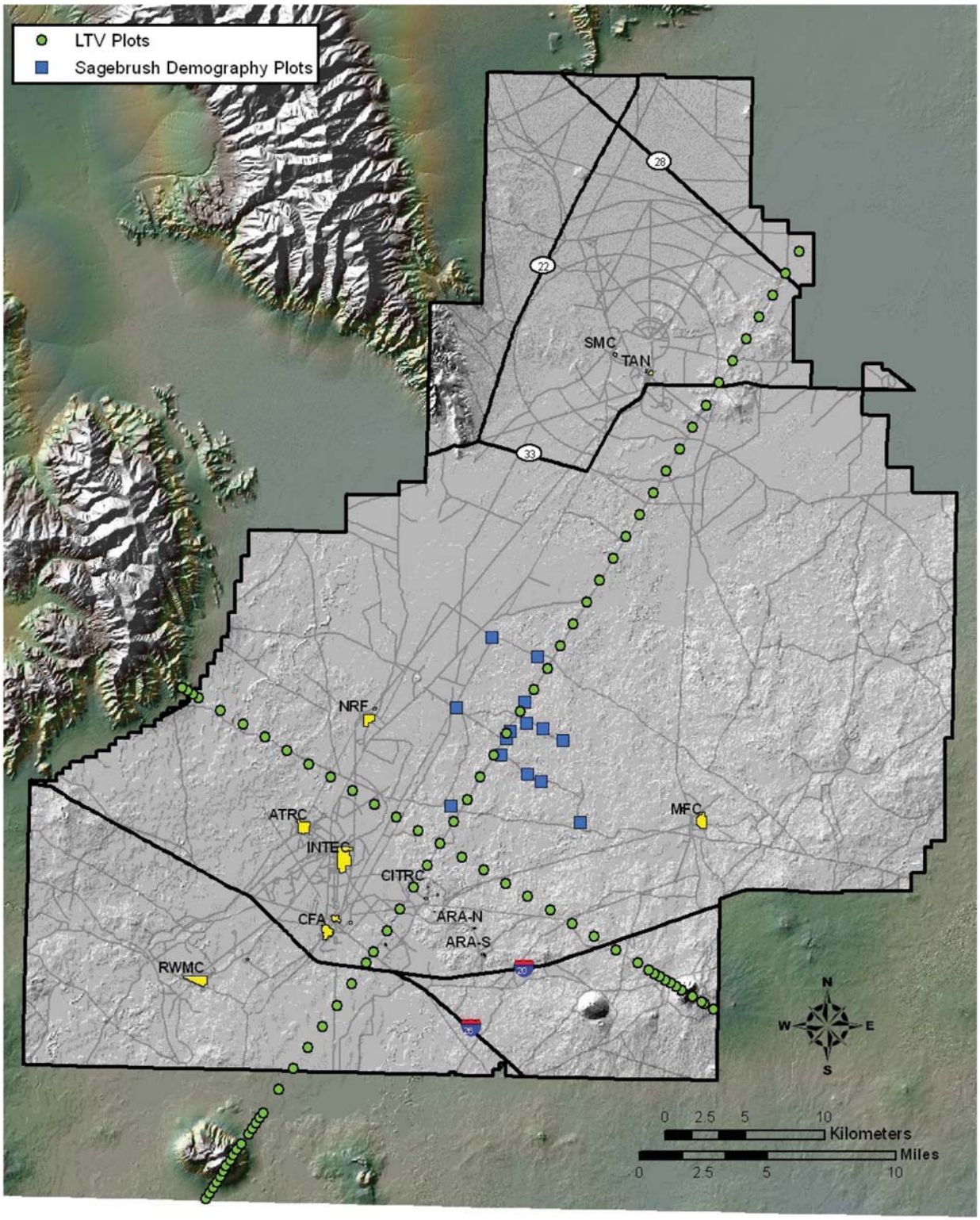

Figure 9-5. Map of the INL Site with Plot Locations for the LTV Permanent Plots and the Ancillary Sagebrush Demography Study Plots.

big sagebrush will be interpreted within the context of long-term trends in sagebrush-dominated communities represented by the LTV dataset.

Objectives

We will approach data analysis and organize the technical report associated with the 2011 data collection effort according to five primary objectives. These objectives reflect a continuation of the vegetation trend analyses on which the LTV has been historically based, and the use of some new datasets and novel analyses of older datasets to identify specific mechanisms influencing overall vegetation trends. Results from the current analysis and reporting effort will allow us to make specific recommendations about conservation management goals and the likely effects of potential habitat management actions.

The first two objectives include updating trend analyses previously performed on the LTV dataset using the current 2011 dataset. **Objective 1** is focused on native, primarily perennial species, and addresses long-term abundance trends in functional groups and individual species of interest, as well as the stability of total community vegetative cover and species composition through time. **Objective 2** emphasizes trends in the abundance and distribution of non-native species and will include updating several analyses presented in the report associated with the 2006 sample period (Forman et al. 2010), such as tracking cheatgrass (*Bromus tectorum*) abundance and distribution on the LTV plots through time.

The purpose of **Objective 3** is to characterize the rate of community change, in terms of species composition, at the local scale. Results from previous analyses of the LTV data suggest that although good-condition native plant communities at the INL Site change relatively slowly when abundance data are analyzed by functional group and are averaged across many plots, changes in individual species' abundance at the plot scale can be quite dynamic over relatively short time periods. By addressing this objective, we hope to gain a better understanding of the natural range of variability in these semi-arid communities both spatially and temporally.

Objective 4 includes analysis and interpretation of the Sagebrush Demography data. We will use these data to identify the mechanisms which have potentially caused the long-term, persistent declines in big sagebrush cover at the INL Site, as well as the effects of stochastic events on population structure and big sagebrush abundance.

Objective 5 is a synthesis of many of the analyses conducted during this sample period and the results presented in previous LTV reports. We will present a paradigm for sagebrush population and community dynamics at the INL Site which can be used to inform interpretations of vegetation monitoring data and to evaluate the efficacy of proposed management actions for improving sagebrush habitat.

Accomplishments through 2011

The primary LTV Database was updated prior to data collection in 2011. We revised the species metadata table to reflect changes in taxonomy between the 2006 and 2011 sample periods using the Plants National Database (USDA, NRCS 2011). A 2011 LTV Project Database was created to mirror the primary LTV Database. We used the 2011 LTV Project Database for

daily data processing and associated Quality Assurance/Quality Control procedures. Once all of the data in the 2011 LTV Project Database are verified and validated to insure the integrity and completeness of the 2011 dataset, the 2011 LTV Project Database will be integrated back into the primary LTV Database. All of the 89 active LTV plots were sampled during the 2011 growing season according to the standardized protocols outlined in previous reports (e.g. Forman et al. 2010). We incorporated all of the resulting data into the 2011 LTV Project Database and completed all Quality Assurance/Quality Control procedures and data verification and validation processes on those data.

Shrub abundance data and big sagebrush cross sections for ring counts were collected for the Sagebrush Demography study in 2006. The sagebrush cross sections were processed and ring counts were completed throughout 2010 and early 2011. A formalized database was designed and populated with all data collected to support this project.

Results

We had not yet initiated data analysis on either the LTV or Sagebrush Demography datasets in 2011; results are forthcoming.

Plans for Continuation

The primary LTV Database will be updated with the data in the 2011 LTV Project Database and the Sagebrush Demography database will be finalized prior to data analysis. The databases will be complementary to one another through corresponding metadata table structures. Analysis and reporting to address the five objectives discussed above will be completed in 2012.

Deliverables

Final databases for both datasets and a technical report detailing data analyses, results, and management implications will be provided.

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9.1.4 Distribution, Movements, and Space Use by Elk on the Idaho National Laboratory Site

Investigators and Affiliations

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Funding Sources

- U.S. Department of Energy-Idaho Operations Office
- U.S. Environmental Protection Agency
- Idaho State University.

Background

Large mammals play important functional roles in many ecosystems, including sagebrush-steppe. Indeed, large herbivores often act as keystone species, and thus understanding the causes and consequences of their patterns of behavior can provide important insights into a variety of ecosystem processes. In addition, detailed data on movements of large mammals can provide land managers with critical information on ecological interactions between those animals and their environment. Such information is necessary for understanding past effects of anthropogenic disturbance on mammals and for predicting effects of future development, as well as for minimizing the negative effects of development on mammals. Such data may also provide important clues about the potential transport of nutrients and environmental contaminants by large mammals across landscapes. Nevertheless, the detailed data necessary to understand large-scale patterns of movement and resource selection by large mammals on the INL Site have never been obtained.

The overall goal of our project is to document landscape-scale patterns of movement and resource selection by elk (*Cervus elaphus*) at the INL Site. Results of our study will be integrated into the Conservation Management Plan for the INL Site, and will provide the Department of Energy with important information for environmental planning purposes. In addition, our results will provide information useful for managers desiring to minimize depredation of crops

surrounding the INL Site by large herbivores, and will provide insights into the potential role of large mammals in distributing environmental contaminants both on and off of the study site.

Objectives

- Capture 20 elk per year during 2010-2012 on the INL Site in order to collect data on body condition, morphology, disease, and pregnancy status, and to fit each of those animals with a GPS collar programmed to collect hourly locations between March and December
- Determine the extent to which critical habitat (e.g., calving grounds) for elk occurs within the Development Zone
- Determine when, where, and to what extent elk move between the INL Site and surrounding agricultural lands to aid in quantifying potential depredation problems and potential transport of contaminants off of the INL Site by elk.

Accomplishments through 2011

- 20 female elk were captured and fit with global positioning system (GPS) collars in March, 2010, by net-gun from a helicopter. During the capture, data on body condition, morphology, and blood parameters were collected.
- An additional 20 female elk were captured and fit with GPS collars in March, 2011, by drive-netting. Morphological and physiological data obtained during 2010 were also obtained from animals captured in 2011.
- A total of roughly 100,000 hourly GPS locations have now been obtained from elk collared on the INL Site during 2010 and 2011.

Results

We collected roughly 17,000 hourly GPS locations from female elk collared on the INL Site during 2010, and roughly 85,000 hourly GPS locations from female elk collared on the INL Site during 2011 (Figure 9-6). Those data are currently being analyzed to determine important habitat associations, movement patterns, calving areas, and other aspects of the ecology of elk in this desert environment. Preliminary results, however, indicate heavy use of the central and southwestern portions of the INL Site by elk, particularly during autumn and winter. In addition, GPS data have indicated that elk wintering on the INL Site may travel 50 miles or more from the Site during the summer months. Our results also demonstrate some use of areas located near INL facilities and major highways in the western portion of the INL Site (Figure 9-7). Finally, Figure 9-8 illustrates how daily movement distances obtained from hourly GPS locations can be used to infer timing of parturition and periods of maximum movement and associated energy expenditure.

Plans for Continuation

Roughly 20 more female elk will be captured on the INL Site in February 2012, and fit with real-time GPS collars programmed to collect hourly location data through 1 December. 2012 is the last year of data collection planned for this project.

Publications, Reports, and Theses

This project is ongoing (i.e., field data are still being collected), and thus no publications have been completed at this time. Several peer-reviewed publications and a Ph.D. dissertation will be forthcoming when the project is completed in 2013.

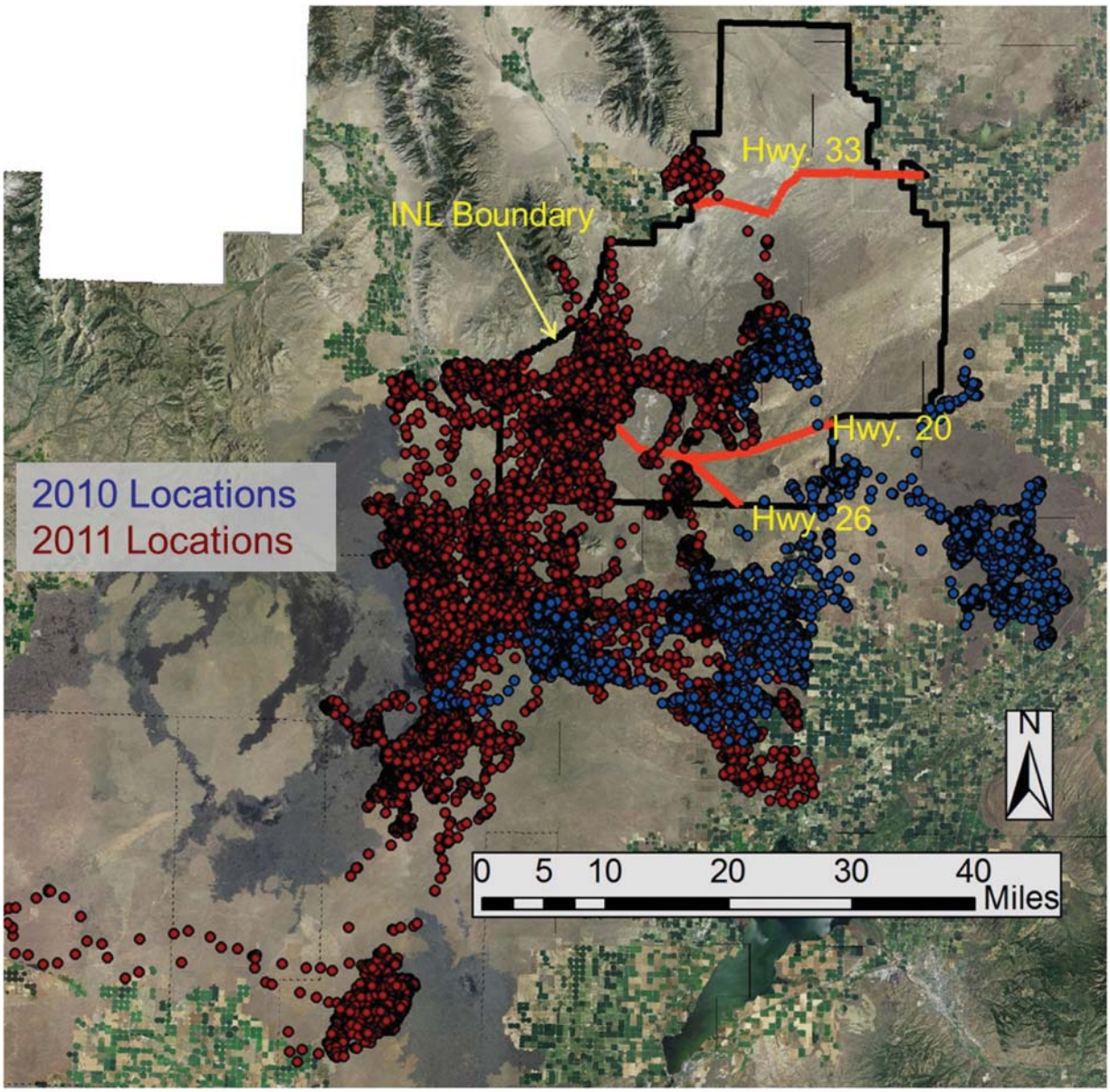

Figure 9-6. Roughly 100,000 Hourly GPS Locations Obtained from Collared Female Elk (*Cervus elaphus*) on the INL Site from March-December, 2010-2011.

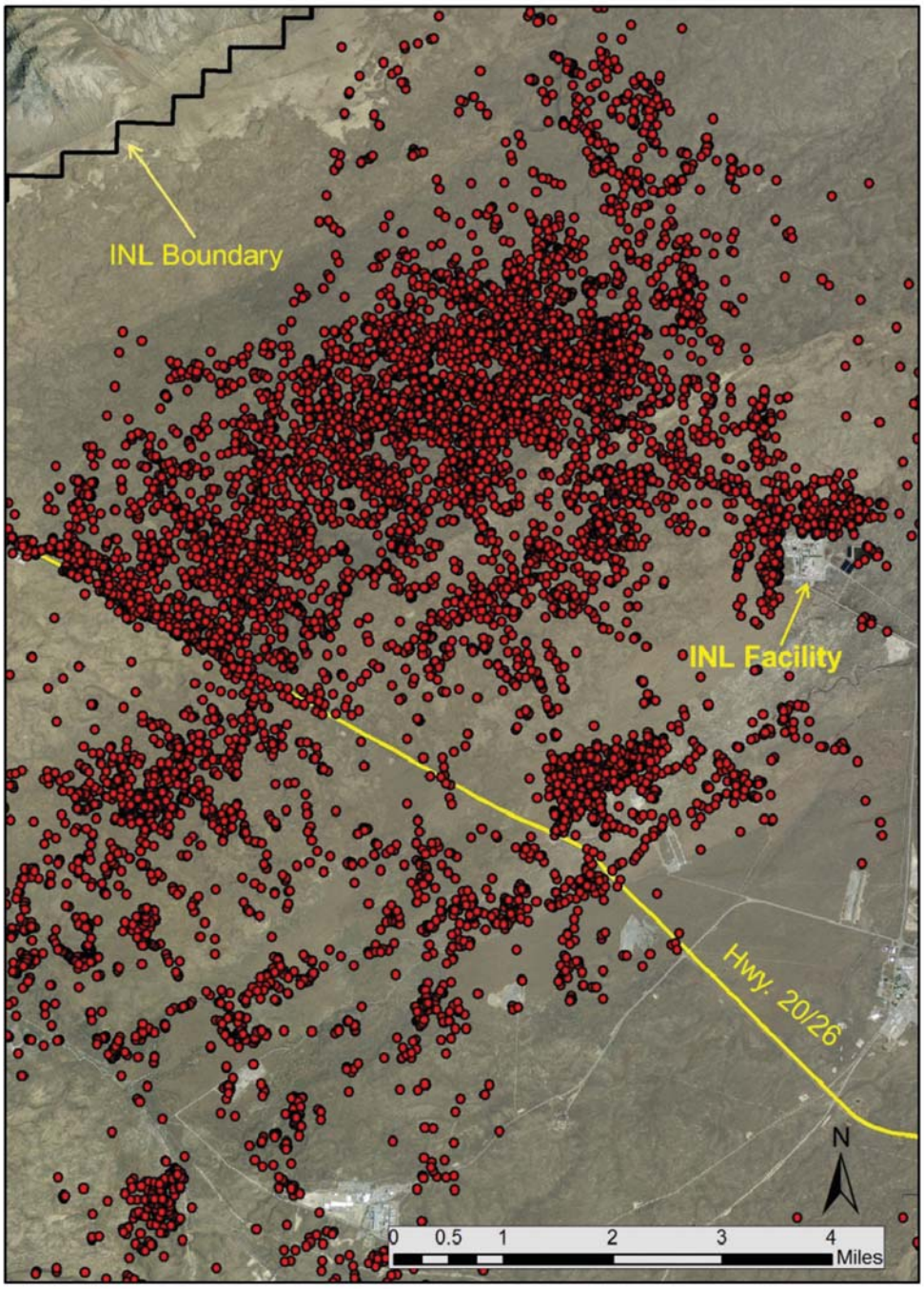

Figure 9-7. Hourly GPS Locations Obtained from Collared Female Elk (*Cervus elaphus*) During 2011 Showing Some Use by Elk of Areas Near Major Highways and INL Site Facilities.

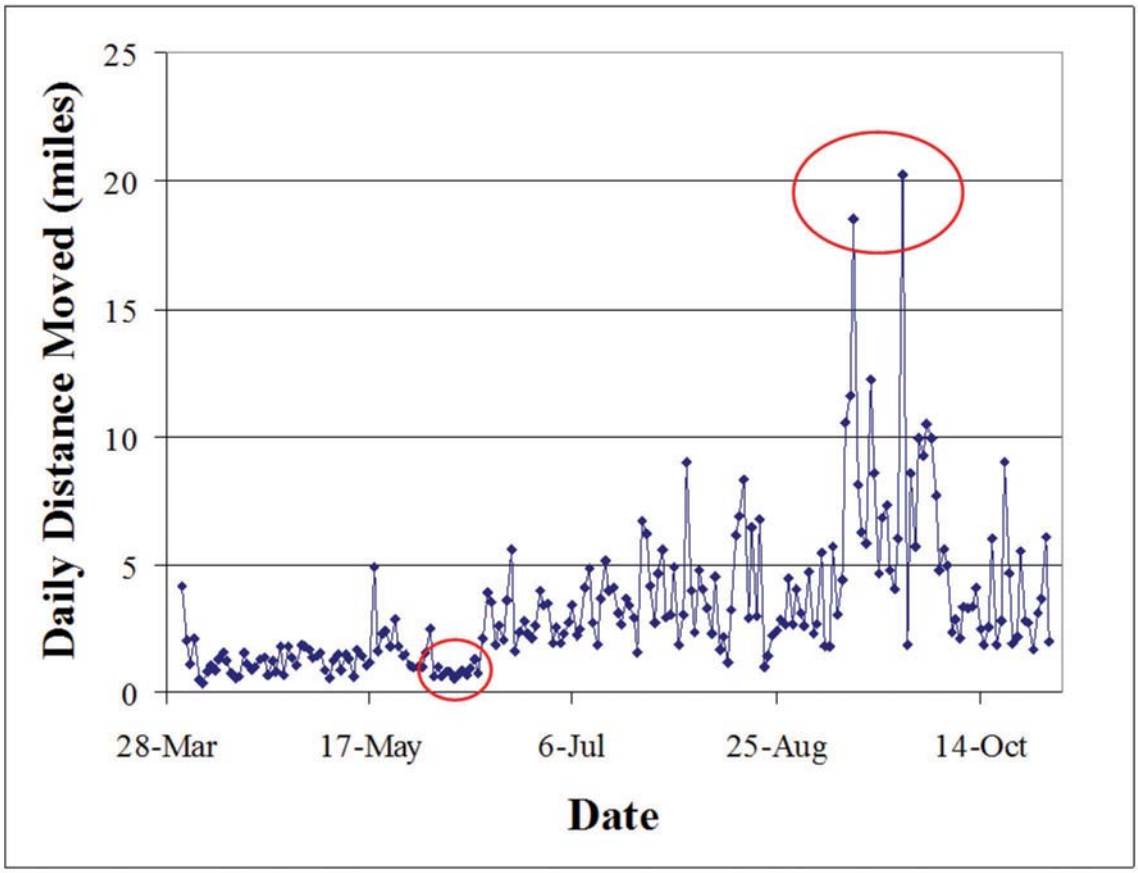

Figure 9-8. Daily Distance Moved by Collared Female Elk (*Cervus elaphus*) #50082 During 2010.

Circled days indicate periods of minimal and maximal movement, with the period of minimal movement in early June likely representing the time of parturition.

9.1.5 The Influence of Precipitation, Vegetation and Soil Properties on the Ecohydrology of Sagebrush Steppe Rangelands on the INL

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Funding Sources

- Idaho Experimental Program to Stimulate Competitive Research (EPSCoR), National Science Foundation
- U.S. Geological Survey
- In-kind facilities and infrastructure support from DOE INL, logistics support through ESER Program and Gonzales-Stoller Surveillance, LLC.

Background

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

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

Objectives

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

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

Accomplishments through 2011

In 2011 we inserted new Time Domain Reflectometry (TDR) water content sensors in an effort to reduce our reliance on manual neutron-probe measurements, an effort that will continue. We made detailed measurements of vegetation cover, using the standard methods of the previous principal investigators in combination with some adjusted techniques that we will seek to rely on in the future. We performed a substantial amount of soil sampling and evaluated biogeochemical and soil physical measurements.

Results

Preliminary results suggest that irrigation, particularly when added in winter on deep soils, increases sagebrush but also cheatgrass. Soil microbial activity, particularly chitinases, is enhanced by irrigation, and increased microbial activity may explain observations of reduced soil carbon in irrigated plots. Increased aggregation of soils has also been observed in response to irrigation, particularly under sagebrush plants. Additionally, the heterogeneity between perennial plant patches (“islands of fertility”) in nitrogen cycling and other biogeochemical properties is strongly affected by the precipitation treatments. The results will be useful in understanding how use of crested wheatgrass plantings compared to native perennial vegetation affects the resistance of restoration sites to cheatgrass invasion.

Plans for Continuation

We will continue making the same types of measurements as in the past year, generating multiple-years of data to substantiate our findings. New additions will include 1) assessments of soil solution biogeochemistry done through installation of lysimeters via cores from the surface, 2) measurements of net primary productivity, 3) assessment of litter inputs and decomposition processes.

Publications, Theses, Reports

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9.1.6 Remote Sensing of Sagebrush Canopy Nitrogen

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Funding Sources

- Idaho Space Grant Consortium
- NOAAOAR ESRL/ Physical Sciences Division Grant # NA06OAR4600124

Background

Remotely sensing foliar nitrogen (N) in semiarid shrublands would significantly improve our limited understanding of vegetation functionality in dryland ecosystems. Whereas vegetation indices such as Modified Soil-Adjusted Vegetation Index (MSAVI) attempt to quantify vegetation abundance, estimates of foliar N across arid and semi-arid environments could help answer process-driven questions related to topics such as controls on canopy photosynthesis and the influence of N on carbon cycling behavior. Also, in systems where soil water is the primary limiting resource and influenced by changes in available N, there is opportunity for remote sensing of foliar N to augment studies related to nutrient pulse dynamics and post-fire recovery. Remote sensing of sagebrush (*Artemisia* spp.) N, in particular, can yield assessments of forage nutritional status across large areas.

In 2010, investigators obtained encouraging results from applying spectroscopic methods to estimate sagebrush N concentrations in the laboratory using dry leaf material and in the field using individual live shrub canopies. The project was extended to the canopy scale using hyperspectral imagery we had the opportunity to acquire on 13 August 2010 using an airborne HyMap sensor (operated byHyVista, Inc., Sydney, Australia). This imagery augmented the hyperspectral imagery that was acquired in 2009 from an unmanned aerial vehicle (UAV) platform owned and operated by the INL (Matt Anderson and Ryan Hruska). The HyMap sensor collected two overlapping flightlines (≈ 11 km^2 total) approximately 2,496 m above ground level with a nominal pixel resolution of 2.1 m. Plot level sagebrush N estimations collected in the field from 09 to 10 August 2010 were then related to corresponding reflectance data in the HyMap imagery by extracting pixels located within the plot boundaries. Several different transformation procedures were applied to the reflectance spectra and partial least square (PLS) regressions were used to identify wavelengths having a strong predictive relationship with N concentration.

Objectives

- Determine if sagebrush canopy signals are strong enough to support detection of canopy N from an airborne hyperspectral platform.
- Compare how two different methods for estimating whole canopy-level N affect agreement between wavelength predictors and N concentrations in sparse desert shrubland. The first method estimates phytomass by expressing cover on a mass basis using mass per unit area (LMA) measurements while the second method uses a shrub volume surrogate that combines absolute cover and height.
- Compare the relative performance of two different spectral transformation techniques: standard derivative analysis and continuum removal.

Accomplishments Through 2011

Final results from the 2010 investigation of leaf and whole canopy sagebrush N using a field spectroradiometer were published in Remote Sensing Letters. Preliminary results for estimating sagebrush canopy N concentrations from remotely sensed data were presented in oral format and published as an extended abstract for the 34th International Symposium on Remote Sensing of Environment in Sydney, Australia. Final results were submitted to Remote Sensing of Environment for publication.

Results

Our study determined that further exploration into estimating sagebrush canopy N concentrations from an airborne platform is warranted, despite remote sensing challenges inherent to open canopy systems (Table 9-1). Hyperspectral data transformed using standard derivative analysis were capable of quantifying sagebrush canopy N concentrations using PLS regression with an R^2 value of 0.72 and an R^2 predicted value of 0.42 (n = 35). Subsetting the dataset to minimize the influence of bare ground (n = 19) increased R^2 to 0.95 (R^2 predicted = 0.56). Ground-based estimates of canopy N using leaf mass per unit area measurements (LMA) yielded consistently better model fits than ground-based estimates of canopy N using cover and height measurements. The LMA approach is likely a method that could be extended to other semiarid shrublands. Overall, the results of this study are encouraging for future landscape scale N estimates and represent an important step in addressing the confounding influence of bare ground, which we found to be a major influence on predictions of sagebrush canopy N from an airborne platform.

Plans for Continuation

A final paper is expected to be published in Remote Sensing of Environment and the project is complete. Additional sagebrush nitrogen data that was collected by Matt Germino in August 2010 for experimental plots at the long-term ecological monitoring site will also be related to the HyMap imagery acquired on 13 August 2010. If feasible, the additional data will be used to further test the relationship between HyMap spectra and sagebrush canopy N concentrations.

Publications, Theses and Reports

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Mitchell, J., Glenn, N., Sankey, T., Derryberry, D., Anderson, M. and Hruska, R. 2012. Spectroscopic detection of Nitrogen concentrations in sagebrush: implications for hyperspectral remote sensing, Remote Sensing Letters, 3 (4), 285-294.

Mitchell, J., Glenn, N., Sankey, T., Derryberry, D. Hyperspectral remote sensing of sagebrush canopy nitrogen, Remote Sensing of Environment, in review.

Table 9-1. PLS Regression Results for Relating Foliar N Concentrations to HyMap Spectra Extracted from Field Plots (7 m X 7 m; n = 35).
Prediction error sum of squares (PRESS) and R2 predicted values are reported.

Dataset	No. of PLS components	R^2	R^2 Predicted	PRESS	Wavelength Selection
Spectral Transformation: Continuum Removed Reflectance					
Canopy N estimated using proportional leaf area and leaf mass per unit area measurements (*n*=35)	2	0.65	0.19	1.02	1046, 1076, 2360*, 591, 2343*, 2117*
Canopy N estimated using proportional leaf area and leaf mass per unit area measurements (*n*=19) Bare Ground < 40%	1	0.65	0.18	0.47	1016*,2117*, 2043*, 2062*, 2293*, 679
Bulk Canopy N (height and absolute cover) (*n*=35)	1	0.37	0	1363.32	1046, 2343*, 546, 2024, 2376, 2360*
Bulk Canopy N (height and absolute cover) (*n*=19) Bare Ground < 40%	1	0.56	0	430.28	2117*, 2043*, 2062*, 2293*,1076, 1046
Spectral Transformation: First Derivative Reflectance of [$\log_{10}$ (1/Reflectance)]					
Canopy N estimated using proportional leaf area and leaf mass per unit area measurements (*n*=35)	2	0.72	0.42	0.74	1676*, 2024, 1990*, 1076, 513,1151
Canopy N estimated using proportional leaf area and leaf mass per unit area measurements (*n*=19) Bare Ground < 40%	4	0.95	0.56	0.25	808, 1663, 2024, 1675*, 503, 1163
Bulk Canopy N (height and absolute cover) (*n*=35)	1	0.55	0.26	909.38	1163, 1749, 1919, 1424, 1078, 2425
Bulk Canopy N (height and absolute cover) (*n*=19) Bare Ground < 40%	5	0.97	0.55	151.60	1154, 1661, 508, 827, 891, 1091

*Within 20 nm of a known N absorption feature.

9.1.7 Shrub Cover and Volume Estimates Using Ground and Airborne Laser Scans and Hyperspectral Imagery

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Matt Anderson, Idaho National Laboratory, Idaho Falls, Idaho

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Trent Armstrong, Idaho National Laboratory, Idaho Falls, Idaho

Funding Sources

- NOAAOAR ESRL/ Physical Sciences Division Grants # NA06OAR4600124 and #NA10OAR4680240
- National Science Foundation, Idaho EPSCoR Program and National Science Foundation, award number EPS-0814387
- Idaho National Laboratory - Laboratory Directed Research and Development Grants (Battelle, FY12) and the Idaho National Laboratory and Idaho State University Collaborative Remote Sensing Program.

Background

Sagebrush vegetation communities cover 1.1 x 106 km^2 of North American rangelands and provide food or cover for over 350 wildlife species. Like most vegetation, sagebrush cover and height varies across the landscape. Accurately mapping this variation is important for certain species, such as the greater sage-grouse, where sagebrush percent cover, visual cover and height are important characteristics for habitat selection. Cover, height and volume are important factors when trying to estimate rangeland biomass, which is an indicator of hydrologic function, forage potential, and species dominance. The low stature and spectrally indeterminate vegetation communities in semiarid environments are challenging to quantify with traditional remotely sensed data. Recent research has demonstrated the ability of LiDAR data to extract

sagebrush height characteristics and the ability of hyperspectral analysis to quantify foliar nitrogen concentrations from individual sagebrush. We expand upon this body of research by investigating approaches to shrub cover and volume estimation using a combination of field reference data, ground-based terrestrial laser scanning (TLS) plot data and airborne laser (LiDAR) and hyperspectral acquisitions.

Objectives

- Use object based image analysis techniques to delineate individual shrubs in the TLS plot data
- Apply volumetric rendering techniques to the TLS plot data to generate bulks estimates of canopy volume
- Relate ground-based volume estimates to airborne estimates derived from airborne lidar and hyperspectral data fusion products.

Accomplishments Through 2011

Terrestrial laser scanning data were collected in September 2011 with a Leica ScanStation C10. The TLS dataset were collected at the highest resolution (0.02-m spacing at 100-m) using a defined field of view. A Topcon HiPer lite real time kinematic global positioning system (Topcon Positioning Systems Inc., California, USA) was used to record horizontal and vertical position of the control points.

Twenty 7-m x 7-m plots (n=20) were randomly located in the study area. The north and south boundaries of each plot were established and a tape was used to sample at 1-m intervals, for a total of eight, 7-m transects per plot. Vegetation information was recorded at each plot using both the line intercept and point intercept methods. Shrub metrics (i.e., height and intercepted length) were recorded for each transect for the line intercept method. Presence and vegetation type including ground type were recorded every 1-m along each transect for the point intercept method. Percent shrub cover was determined for the line intercept method by summing the total length of intercepted shrubs per plot and dividing by total plot length (n = 56-m). Likewise, shrub percent cover was determined for the point intercept method by dividing the total number of shrub hits per plot by total number of sampling locations (n = 64).

Preliminary results for estimating vegetation cover and volume using TLS and LiDAR data and hyperspectral imagery were presented in poster format at the 2011 American Geophysical Union (AGU) Fall Meeting in San Francisco, California. Exploratory results for fusing LiDAR data and hyperspectral imagery were also presented in poster format at the 2011 AGU Fall Meeting in San Francisco, California.

Results

Preliminary results show a potential relationship between field measured sagebrush vegetation cover and LiDAR and field measured sagebrush vegetation cover and hyperspectral indices. This relationship also appears to be strengthened when the two are combined; however, work is still needed to integrate object based image analysis and TLS data. It is apparent that TLS data have high potential in aiding volumetric estimations across landscapes (Figure 9-9).

Plans for Continuation

Final shrub volume estimation results using TLS data will be submitted to Photogrammetric Engineering and Remote Sensing or other journal for publication. Final LiDAR and hyperspectral data fusion techniques for shrub canopy volume estimation will be submitted to Advances in Ecological Research or other journal for publication.

Publications, Theses and Reports

Spaete, L., Mitchell, J., Glenn, N., Shrestha, R., Sankey, T., Murgoitio, J., Gould, S., Leedy, T., and Hardegree, S. *Vegetation Cover and Volume Estimates in Semi-arid Rangelands using LiDAR and Hyperspectral Data.* 2011 AGU Fall Meeting, 5-9 December, San Francisco, CA.

Moore, C., Olsoy, P., Gertman, V., Mitchell, J., Glenn, N., Joshi, A., Shrestha, R., Spaete, L., Norpchen, D., Pernice, M., Whiting, E., Grover, S., Lee, R., Anderson, J., and Busche, C. *3D Immersive Environments: Discovering New Methods for Data Fusion, Visualization, and Analysis of Hyperspectral and Laser Altimetry Data.* 2011 AGU Fall Meeting, 5-9 December, San Francisco, CA.

Mitchell, J., Glenn N., Spaete, L., Shrestha, R., Lee, R. and Armstrong, T. Shrub canopy delineation and volume estimation using Terrestrial Laser Scanning (TLS) data, in preparation. Target journal: *Photogrammetric Engineering and Remote Sensing.*

Mitchell, J., Glenn N., Spaete, L., Murgoitio, J., Anderson, M., and Hruska, R. Explorations in LiDAR and hyperspectral fusion for shrub canopy volume estimation, in preparation. Target journal: *Advances in Ecological Research.*

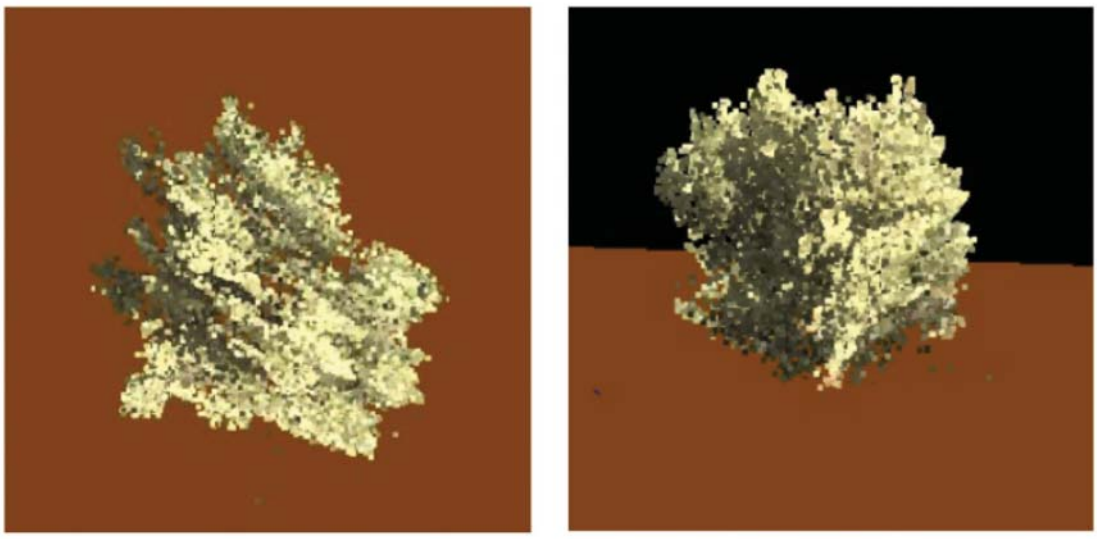


Figure 9-9. Terrestrial Laser Scanning (TLS) Offers the Ability to Make Very Accurate Volume Estimates.

Top view of individual sagebrush (left) and side view of individual sagebrush (right) were used to derive height (0.67 m), major axis (0.69 m), minor axis (0.53 m), and volume (0.128 m^3).

9.2 U.S. Geological Survey 2011 Publication Abstracts

In 1949, the United States Geological Survey (USGS) was asked to characterize water resources prior to the building of nuclear-reactor testing facilities at the INL site. Since that time, USGS hydrologists and geologists have been studying the hydrology and geology of the eastern Snake River Plain and the Eastern Snake River Plain Aquifer.

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

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

Data gathered from these activities is used to create and refine hydrologic and geologic models of the aquifer, to track contaminant plumes in the aquifer and improve understanding of the complex relationships between the rocks, sediments and water that compose the aquifer. The USGS INL Project Office publishes reports about their studies, available through the USGS Publications Warehouse (http://pubs.er.usgs.gov/.)

Four reports were published by the USGS INL Project Office in 2011. The abstracts of these studies and the publication information associated with each study are presented below.

9.2.1 Multilevel Groundwater Monitoring of Hydraulic Head and Temperature in the Eastern Snake River Plain Aquifer, Idaho National Laboratory, Idaho 2007-08 (Jason C. Fisher and Brian V. Twining)

During 2007 and 2008, the U.S. Geological Survey, in cooperation with the U.S. Department of Energy, collected quarterly depth-discrete measurements of fluid pressure and temperature in six boreholes located in the eastern Snake River Plain aquifer of Idaho. Each borehole was instrumented with a multilevel monitoring system consisting of a series of valved measurement ports, packer bladders, casing segments, and couplers. Hydraulic heads (head) and water temperatures in boreholes were monitored at 86 hydraulically-isolated depth intervals located 448.0 to 1,377.6 feet below land surface. The calculation of head is most sensitive to fluid pressure and the altitude of the pressure transducer at each port coupling; it is least sensitive to barometric pressure and water temperature. An analysis of errors associated with the head calculation determined the accuracy of an individual head measurement at ±2.3 feet. Many of the sources of measurement error are diminished when considering the differences between two closely-spaced readings of head; therefore, a ±0.1 foot measurement accuracy was assumed for vertical head differences (and gradients) calculated between adjacent monitoring zones.

Vertical head and temperature profiles were unique to each borehole, and were characteristic of the heterogeneity and anisotropy of the eastern Snake River Plain aquifer. The vertical hydraulic gradients in each borehole remained relatively constant over time with minimum

Pearson correlation coefficients between head profiles ranging from 0.72 at borehole USGS 103 to 1.00 at boreholes USGS 133 and MIDDLE 2051. Major inflections in the head profiles almost always coincided with low permeability sediment layers. The presence of a sediment layer, however, was insufficient for identifying the location of a major head change in a borehole. The vertical hydraulic gradients were defined for the major inflections in the head profiles and were as much as 2.2 feet per foot. Head gradients generally were downward in boreholes USGS 133, 134, and MIDDLE 2050A, zero in boreholes USGS 103 and 132, and exhibited a reversal in direction in borehole MIDDLE 2051. Water temperatures in all boreholes ranged from 10.2 to 16.3 degrees Celsius. Boreholes USGS 103 and 132 are in an area of concentrated volcanic vents and fissures, and measurements show water temperature decreasing with depth. All other measurements in boreholes show water temperature increasing with depth. A comparison among boreholes of the normalized mean head over time indicates a moderately positive correlation.

9.2.2 Paleomagnetic Correlation of Surface and Subsurface Basaltic Lava Flows and Flow Groups in the Southern Part of the Idaho National Laboratory, Idaho, with Paleomagnetic Data Tables for Drill Cores (Duane E. Champion, Mary K.V. Hodges, Linda C. Davis, and Marvin A. Lanphere)

Paleomagnetic inclination and polarity studies have been conducted on thousands of subcore samples from 51 coreholes located at and near the Idaho National Laboratory (INL). These studies are used to paleomagnetically characterize and correlate successive stratigraphic intervals in each corehole to similar depth intervals in adjacent coreholes. Paleomagnetic results from 83 surface paleomagnetic sites, within and near the INL, are used to correlate these buried lava flow groups to basaltic shield volcanoes still exposed on the surface of the eastern Snake River Plain. Sample handling and demagnetization protocols are described as well as the paleomagnetic data averaging process. Paleomagnetic inclination comparisons between coreholes located only kilometers apart show comparable stratigraphic successions of mean inclination values over tens of meters of depth. At greater distance between coreholes, comparable correlation of mean inclination values is less consistent because flow groups may be missing or additional flow groups may be present and found at different depth intervals. Two shallow intersecting cross-sections, A–A' and B–B' (oriented southwest-northeast and northwest-southeast, respectively), drawn through southwest Idaho National Laboratory coreholes show the corehole to corehole or surface to corehole correlations derived from the paleomagnetic inclination data.

From stratigraphic top to bottom, key results included the (1) Quaking Aspen Butte flow group, which erupted from Quaking Aspen Butte southwest of the INL, flowed northeast, and has been found in the subsurface in corehole USGS 132; (2) Vent 5206 flow group, which erupted near the southwestern border of the Idaho National Laboratory, flowed north and east, and has been found in the subsurface in coreholes USGS 132, USGS 129, USGS 131, USGS 127, USGS 130, USGS 128, and STF-AQ-01; and (3) Mid Butte flow group, which erupted north of U.S. Highway 20, flowed northwest, and has been found in the subsurface at coreholes ARA-COR-005 and STF-AQ-01. The high K_20 flow group erupted from a vent that may now be buried south of U.S. Highway 20 near Middle Butte, flowed north, and is found in the subsurface in coreholes USGS

131, USGS 127, USGS 130, USGS 128, USGS 123, STF-AQ-01, and ARA-COR-005 ending near the Idaho Nuclear Technology and Engineering Center. The vent 5252 flow group erupted just south of U.S. Highway 20 near Middle and East Buttes, flowed northwest, and is found in the subsurface in coreholes ARA-COR-005, STF-AQ-01, USGS 130, USGS 128, ICPP 214, USGS 123, ICPP 023, USGS 121, USGS 127, and USGS 131. The Big Lost flow group erupted from a now-buried vent near the Radioactive Waste Management Complex, flowed southwest to corehole USGS 135, and northeast to coreholes USGS 132, USGS 129, USGS 131, USGS 127, USGS 130, STF-AQ-01, and ARA-COR-005. The AEC Butte flow group erupted from AEC Butte near the Advanced Test Reactor Complex and flowed south to corehole Middle 1823, northwest to corehole USGS 134, northeast to coreholes USGS 133 and NRF 7P, and south to coreholes USGS 121, ICPP 023, USGS 123, and USGS 128.

Evidence of progressive subsidence of the axial zone of the ESRP is shown in these cross-sections, distorting the original attitudes of the lava flow groups and interbedded sediments. A deeper cross-section, C–C' (oriented west to east), spanning the entire southern Idaho National Laboratory shows correlations of the lava flow groups in the saturated part of the ESRP aquifer.

Areally extensive flow groups in the deep subsurface (from about 100–800 meters below land surface) can be traced over long distances. In cross-section C–C', the flow group labeled "Matuyama" can be correlated from corehole USGS 135 to corehole NPR Test/W-02, a distance of about 28 kilometers (17 miles). The flow group labeled "Matuyama 1.21 Ma" can be correlated from corehole Middle 1823 to corehole ANL-OBS-A-001, a distance of 26 kilometers (16 miles). Other flow groups correlate over distances of up to about 18 kilometers (11 miles).

9.2.3 Geophysical Logs and Water-quality Data Collected for Boreholes Kimama-1A and -1B and Kimama Water Supply Well Near Kimama, Southern Idaho (Brian V. Twining and Roy C. Bartholomay)

In September 2010, a research consortium led by scientists from Utah State University began drilling the first of three continuously cored boreholes on the Snake River Plain in southern Idaho. The goals of this effort, the Snake River Scientific Drilling Project, are to study the interaction between the Earth's crust and mantle, to identify potential geothermal energy sources, and to track the evolution of the Yellowstone hotspot on the Snake River Plain.

The first borehole, located near Kimama, Idaho, is about 50 miles southwest of the U.S. Department of Energy's Idaho National Laboratory. Because geohydrologic data are scarce for that area of the central Snake River Plain, the Kimama borehole, completed in January 2011, provided a unique opportunity to collect geophysical and water-chemistry data from the eastern Snake River Plain aquifer system, downgradient of the laboratory. Therefore, in conjunction with the Snake River Scientific Drilling Project, scientists from the U.S. Geological Survey's Idaho National Laboratory Project Office conducted geophysical logging and collected water samples at the Kimama site. Wireline geophysical logs were collected for the diverging borehole, Kimama-1A and -1B, from land surface to 976 and 2,498 feet below land surface (BLS), respectively. Water samples were collected from Kimama-1A at depths near 460 and 830 feet BLS, and from the Kimama Water Supply (KWS) well located about 75 feet away.

Geophysical log data included a composite of natural gamma, neutron, gamma-gamma dual density, and gyroscopic analysis for boreholes Kimama-1A and -1B. Geophysical logs depicted eight sediment layers (excluding surficial sediment) ranging from 4 to 60 feet in thickness. About 155 individual basalt flows were identified, ranging from less than 3 feet to more than 175 feet in thickness (averaging 15 feet) for borehole Kimama-1B (0 to 2,498 feet BLS). Sediment and basalt contacts were selected based on geophysical traces and were confirmed with visual inspection of core photographs. Temperature logs from the water table surface (about 260 feet BLS) to the bottom of borehole Kimama-1B (2,498 feet BLS) were nearly isothermal, ranging from about 62 to 64 degrees Fahrenheit. Gyroscopic data revealed that borehole Kimama-1B begins to separate from borehole Kimama-1A near a depth of 676 feet BLS. Drillhole azimuth and horizontal deviation at total logged depth for boreholes Kimama-1A and -1B were 172.6 and 188.3 degrees and 25.9 and 82.0 feet, respectively.

Water samples were collected and analyzed for common ions; selected trace elements; nutrients; isotopes of hydrogen, oxygen, and carbon; and selected radionuclides. One set of water samples was collected from the KWS well and the two other sample sets were collected from borehole Kimama-1A near 460 and 830 feet BLS. With one exception, data for all three zones sampled near Kimama generally indicated that the water chemistry was similar. The exception was found in the deepest zone in borehole Kimama-1A (830 feet BLS) where concentrations probably were affected by the drilling mud. A comparison of the inorganic, organic, and stable chemistry data between the KWS well and the 460-foot zone in borehole Kimama-1A indicated similar chemistry of the aquifer water, except for some variability with nitrate plus nitrite, orthophosphate, iron, zinc, and carbon-14. Radionuclide concentrations were either less than reporting levels or at background levels for the eastern Snake River Plain aquifer.

9.2.4 Assessing Controls on Perched Saturated Zones Beneath the Idaho Nuclear Technology and Engineering Center, Idaho (Benjamin B. Mirus, Kim S. Perkins, and John R. Nimmo)

Waste byproducts associated with operations at the Idaho Nuclear Technology and Engineering Center (INTEC) have the potential to contaminate the eastern Snake River Plain aquifer. Recharge to the Eastern Snake River Plain aquifer is controlled largely by the alternating stratigraphy of fractured volcanic rocks and sedimentary interbeds within the overlying vadose zone and by the availability of water at the surface. Beneath the INTEC facilities, localized zones of saturation perched on the sedimentary interbeds are of particular concern because they may facilitate accelerated transport of contaminants. The sources and timing of natural and anthropogenic recharge to the perched zones are poorly understood. Simple approaches for quantitative characterization of this complex, variably saturated flow system are needed to assess potential scenarios for contaminant transport under alternative remediation strategies. During 2009–2011, the U.S. Geological Survey (USGS), in cooperation with the U.S. Department of Energy, employed data analysis and numerical simulations with a recently developed model of preferential flow to evaluate the sources and quantity of recharge to the perched zones. Piezometer, tensiometer, temperature, precipitation, and stream-discharge data were analyzed, with particular focus on the possibility of contributions to the perched zones from snowmelt and flow in the neighboring Big Lost River (BLR). Analysis of the timing and magnitude of subsurface

dynamics indicate that streamflow provides local recharge to the shallow, intermediate, and deep perched saturated zones within 150 m of the BLR; at greater distances from the BLR the influence of streamflow on recharge is unclear. Perched water-level dynamics in most wells analyzed are consistent with findings from previous geochemical analyses, which suggest that a combination of annual snowmelt and anthropogenic sources (for example, leaky pipes and drainage ditches) contribute to recharge of shallow and intermediate perched zones throughout much of INTEC. The source-responsive fluxes model was parameterized to simulate recharge via preferential flow associated with intermittent episodes of streamflow in the BLR. The simulations correspond reasonably well to the observed hydrologic response within the shallow perched zone. Good model performance indicates that source-responsive flow through a limited number of connected fractures contributes substantially to the perched-zone dynamics. The agreement between simulated and observed perched-zone dynamics suggest that the source-responsive fluxes model can provide a valuable tool for quantifying rapid preferential flow processes that may result from different land management scenarios.

References for Section 9.2

Champion, D.E., Hodges, M.K.V., Davis, L.C., and Lanphere, M.A., 2011, *Paleomagnetic correlation of surface and subsurface basaltic lava flows and flow groups in the southern part of the Idaho National Laboratory, Idaho*, with paleomagnetic data tables for drill cores, U.S. Geological Survey Scientific Investigations Report 2011-5049, 34 p., 1 pl. (DOE/ID 22214).

Fisher, J.C., and Twining, B.V., 2011, *Multilevel groundwater monitoring of hydraulic head and temperature in the eastern Snake River Plain aquifer, Idaho National Laboratory, Idaho, 2007–08*, U.S. Geological Survey Scientific Investigations Report 2010-5253, 62 p.

Mirus, B.B., Perkins, K.S., and Nimmo, J.R., 2011, *Assessing controls on perched saturated zones beneath the Idaho Nuclear Technology and Engineering Center, Idaho*, U.S. Geological Survey Scientific Investigations Report 2011–5222 (DOE/ID-22216), 20 p., available at http://pubs.usgs.gov/sir/2011/5222/.

Twining, B.V., and Bartholomay, R.C., 2011, *Geophysical logs and water-quality data collected for boreholes Kimama-1A and -1B, and a Kimama water supply well near Kimama, southern Idaho*, U.S. Geological Survey Data Series 622 (DOE/ID 22215), 18 p., plus appendix.

ISU Teacher Workshop at the INL Site.

Chapter 10. Quality Assurance

10. QUALITY ASSURANCE

Quality assurance (QA) consists of the planned and systematic activities necessary to provide adequate confidence that the product or service will meet requirements. An effective QA program is essential to collect quality data. QA procedures are designed to ensure sample integrity, precision, and accuracy in the analytical results and to ensure that the environmental data are representative and complete. This chapter presents information on specific measures taken by the effluent monitoring and environmental monitoring programs in 2011 to ensure the quality of data collected and presented in this annual report.

10.1 Quality Assurance Policy and Requirements

The primary policy, requirements, and responsibilities for establishing and maintaining plans and actions that ensure QA in U.S. Department of Energy (DOE) activities are provided in DOE Order 414.1D, "Quality Assurance," 10 CFR 830, Subpart A, "Quality Assurance Requirements," and American Society of Mechanical Engineers (ASME) NQA-1-2008, "Quality Assurance Requirement for Nuclear Facility Applications." The ASME NQA-1-2008 is the preferred standard for activities at nuclear facilities. Additional QA program requirements in 40 Code of Federal Regulations (CFR) 61, Appendix B must be met for all radiological air emission sources continuously monitored for compliance with 40 CFR 61, Subpart H.

The ten criteria established in 10 CFR 830, Subpart A and DOE Order 414.1D that are required as part of a quality program are shown in the box on the right. Each Idaho National Laboratory (INL) Site environmental monitoring organization incorporates the requirements into its QA program documentation for environmental monitoring.

Quality Assurance Criteria Established by the U.S. Department of Energy

- **Quality assurance program**
- **Personnel training and qualification**
- **Quality improvement process**
- **Documents and records**
- **Established work processes**
- **Established standards for design and verification**
- **Established procurement requirements**
- **Inspection and acceptance testing**
- **Management assessment**
- **Independent assessment**

10.2 Environmental Monitoring Program Documentation

Strict adherence to program procedures is an implicit foundation of QA. In 2011, samples were collected and analyzed according to documented

program procedures. Samples were collected by personnel trained to conduct sampling and properly process samples. Sample integrity was maintained through a system of sample custody records. Analytical data quality was verified by a continuing program of quality control (QC) detailed in program QA documents. Results were evaluated and input into databases using data management, validation, and reporting procedures. An overview of the Idaho Cleanup Project (ICP) contractor, INL contractor, and Environmental Surveillance, Education, and Research (ESER) contractor environmental monitoring program documentation is presented in Table 10-1, Figure 10-1 and Figure 10-2, respectively.

10.3 Environmental Monitoring Program Quality Assurance Program Documentation

Implementation of QA elements for sample collection and data assessment activities were documented using the approach recommended by the Environmental Protection Agency (EPA). The EPA policy on QA plans is based on the national consensus standard ANSI/ASQC E4-1994, "Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs." The EPA approach to data quality centers on the data quality objective process. Data quality objectives are project dependent and are determined on the basis of the data users' needs and the purpose for which data are generated. Quality elements applicable to environmental monitoring and decision-making are specifically addressed in *EPA Requirements for Quality Assurance Project Plans (EPA QA/R-5)* (EPA 2001). These elements are categorized as follows:

- Project management
- Data generation and acquisition
- Assessment and oversight
- Data validation and usability.

A Quality Assurance Project Plan documents the planning, implementation, and assessment procedures for a particular project, as well as any specific QA and QC activities. It integrates all the technical and quality aspects of the project in order to provide a "blueprint" for obtaining the type and quality of environmental data and information needed for a specific decision or use.

The following sections summarize how each monitoring organization at the INL Site implements QA requirements.

10.3.1 Idaho National Laboratory Contractor

The INL contractor integrates applicable requirements from *Manual 13A—Quality Assurance Laboratory Requirements Documents* (INL 2012) into the implementing monitoring program plans and procedures for non-CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act) monitoring activities. The program plans address the QA elements as stated in "EPA Requirements for Quality Assurance Project Plans (EPA QA/R-5)" (EPA 2001) to ensure that the required standards of data quality are met.

Table 10-1. Idaho Cleanup Project Environmental Program Procedures.

Document/Media Type	Document No.[a] and Title
Requirements Documents	PRD-5030, Environmental Requirements for Facilities, Processes, Materials, and Equipment MCP-3480, Environmental Instructions for Facilities, Processes, Materials, and Equipment
Data and Validation Documents	PLN-491, Laboratory Performance Evaluation Program Plan PLN-1401, Transferring Integrated Environmental Data Management System Data to the Environmental Data Warehouse MCP-9236, Analytical Data Verification GDE-201, Inorganic Analyses Data Validation for INL Sample and Analysis Management GDE-204, Guide to Assessment of Radionuclide Analysis of Performance Evaluation Samples GDE-205, Radioanalytical Data Validation GDE-206, Obtaining Laboratory Services for Sample Analyses GDE-234, Generating Sampling and Analysis Plan Tables for Environmental Sampling Activities GDE-239, Validation of Volatile Organic Compounds Data Analyzed Using Gas Chromatography/Mass Spectrometry GDE-240, Validation of Gas and Liquid Chromatographic Organic Data GDE-241, Validation of Semivolatile Organic Compounds Data Analyzed Using Gas Chromatography/Mass Spectrometry GDE-7003, Levels of Analytical Method Data Validation MCP-1298, Sample and Analytical Data Management Process for the Sample and Analysis Management Program MCP-9229, Validating, Verifying and Controlling Environmental Monitoring Data
Sampling Documents	MCP-9439, Environmental Sampling Activities at the INL
Groundwater Documents	PLN-1305, Groundwater Monitoring Program Plan SPR-162, Measuring Groundwater Levels and Sampling Groundwater TPR-6539, Calibrating and Using the Hydrolab Quanta Water Quality Multiprobe TPR-7582, Well Inspection/Logging Using Down-Hole Cameras
Liquid Effluent Documents	PLN-729, Idaho Cleanup Project Liquid Effluent Monitoring Program Plan GDE-142, Quality Control Sample Submission SPR-101, Liquid Effluent Sampling TPR-6539, Calibrating and Using the Hydrolab Quanta Water Quality Multiprobe
Drinking Water Documents	PLN-730, Idaho Cleanup Project Drinking Water Program Plan SPR-188, Collecting Water Samples for Radiological Analysis SPR-189, Routine Collection of Samples for Coliform Bacteriological Analysis SPR-190, Sampling of Public Water Systems TPR-6555, Cross Connection Inspections and Backflow Prevention Assembly Testing
Surveillance Documents	PLN-720, Environmental Surveillance Program Plan
Biota Documents	SPR-106, Biotic Monitoring
Air Documents	SPR-107, Waste Management Low-Volume Suspended Particulate Air Monitoring SPR-193, Ambient Air Monitoring for NESHAP Compliance at Accelerated Retrieval Project MCP-1264, Ambient Air Surveillance Instrumentation Calibration
Soil Documents	SPR-110, Surface Soil Sampling
Surface Water Documents	SPR-213, Surface Water Sampling at Radioactive Waste Management Complex
Surface Radiation Documents	TPR-6525, Surface Radiation Surveys Using the Global Positioning Radiometric Scanner

Table 10-1. Idaho Cleanup Project Environmental Program Procedures (continued).

Document/Media Type	Document No.[a] and Title
In Situ Documents	TPR-6526, In Situ Soil Radiation Measurements TPR-6863, In Situ Gamma Radiation Measurement of Radionuclides in Containers TPR-7485, Filling Gamma Detector with Liquid Nitrogen TPR-7859, Shipping Screen Gamma Scan TPR-7860, Germanium Detector Calibration and Performance Testing Using Gamma Vision-32
Documentation Documents	MCP-9227, Environmental and Regulatory Services Logkeeping Practices MCP-9235, Reporting Requirements of the Liquid Effluent Monitoring and Wastewater Land Application Permit Groundwater Monitoring Programs
Sample Management Documents	MCP-9228, Managing Nonhazardous Samples MCP-1394, Managing Hazardous Samples

a. GDE = Guide
MCP = Management Control Procedure
PLN = Plan
PRD = Program Requirements Document
SPR = Sampling Procedure
TPR = Technical Procedure.

In addition, the INL contractor uses a documented approach for collecting, assessing, and reporting environmental data. Environmental and effluent monitoring are conducted in accordance with PLN-8510, "Planning and Management of Environmental Support and Services Monitoring Services Activities," PLN-8515, "Data Management Plan for the INL Environmental Support and Services Monitoring Services Program," and PLN-8550, "Environmental Support and Services Monitoring Services Surveillance Plan" in order to ensure that analytical work for environmental and effluent monitoring supports data quality objectives.

10.3.2 Idaho Cleanup Project Contractor

All CERCLA monitoring activities at the INL Site are conducted in accordance with the *Quality Assurance Project Plan (QAPjP) for Waste Area Groups 1, 2, 3, 4, 5, 6, 7, 10 and Removal Actions* (DOE-ID 2009). The Quality Assurance Project Plan was written in accordance with "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Office of Emergency and Remedial Response" (EPA 1988). In addition, the ICP contractor uses:

- PLN-720, "Environmental Surveillance Program Plan"
- PLN-729, "Idaho Cleanup Project Liquid Effluent Monitoring Program Plan"
- PLN-730, "Idaho Cleanup Project Drinking Water Program Plan"
- PLN-1305, "Groundwater Monitoring Program Plan."

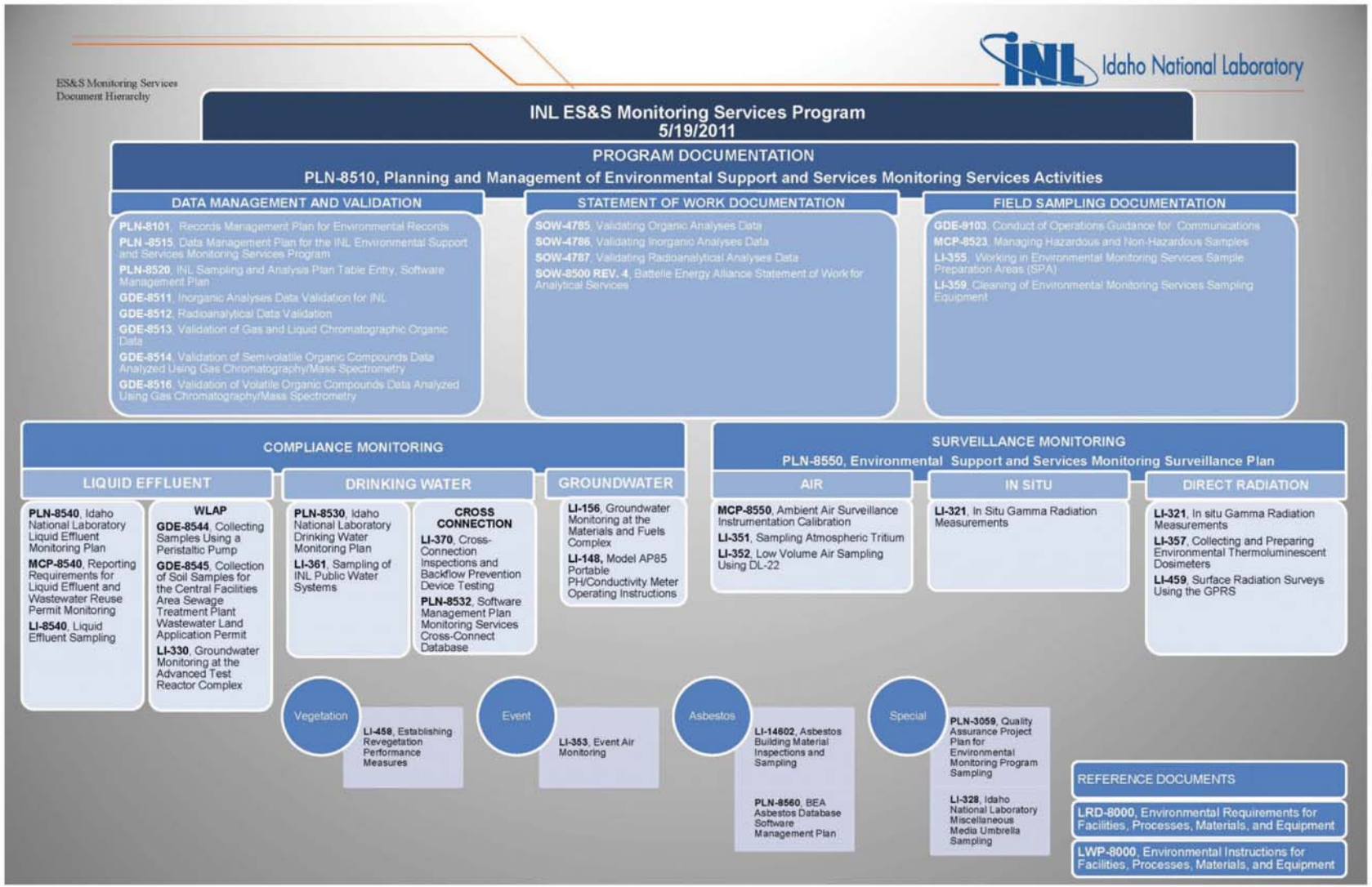


Figure 10-1. Idaho National Laboratory Environmental Support and Services Program Documentation.

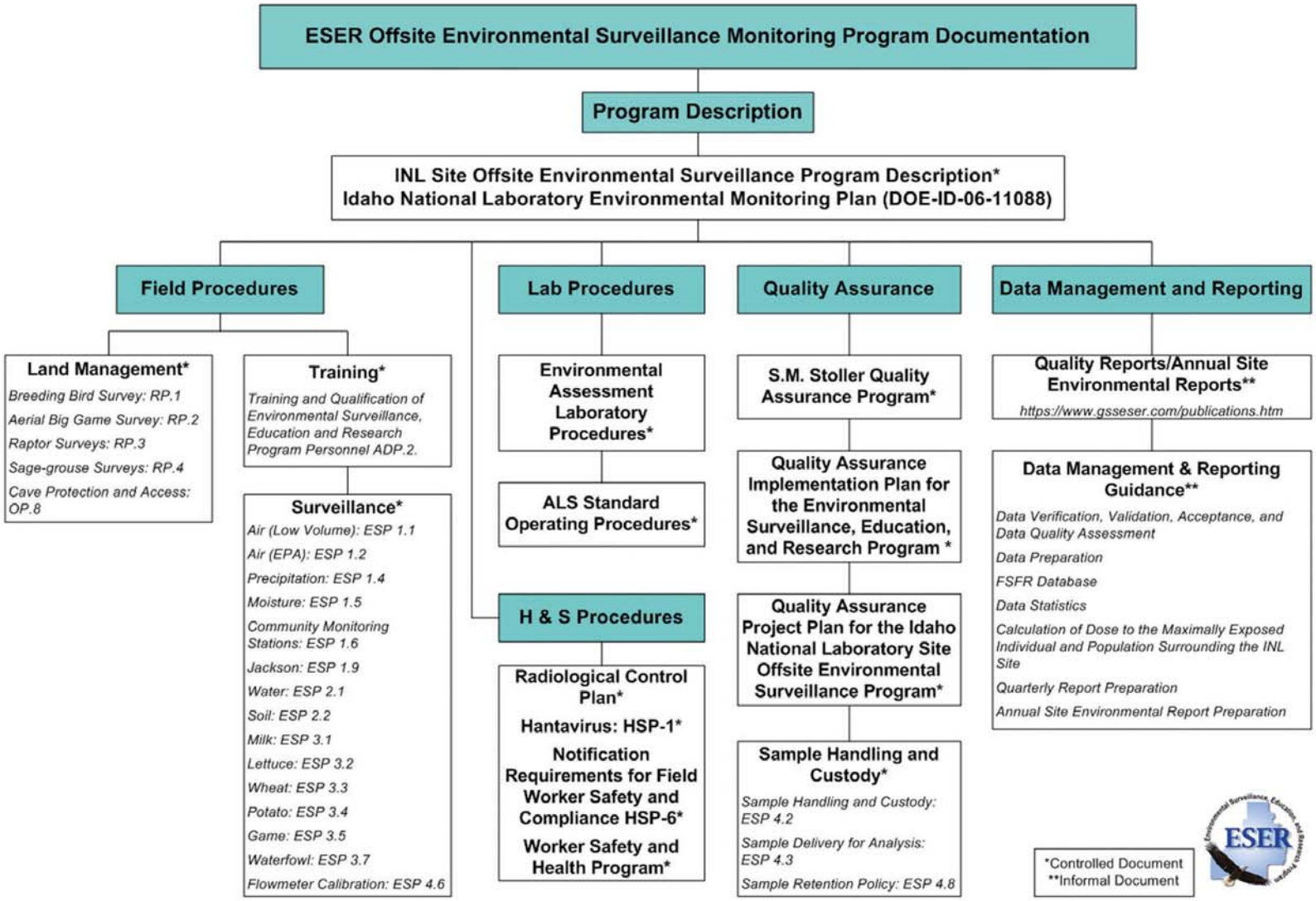


Figure 10-2. Environmental Surveillance, Education and Research Program Offsite Environmental Surveillance Documentation.

10.3.3 Advanced Mixed Waste Treatment Project

The Advanced Mixed Waste Treatment Project (AMWTP) maintains a QA program in accordance with 40 CFR 61, Appendix B, as required of all radiological air emission sources continuously monitored for compliance with 40 CFR 61, Subpart H. The QA requirements are documented in AMWTP-PD-EC&P-02, *Quality Assurance Project Plan for the WMF 676 NESHAPs Stack Monitoring System*.

10.3.4 Environmental Surveillance, Education, and Research Program

The ESER Program maintains a QA program consistent with the requirements of 10 CFR 830 and DOE Order 414.1C that is implemented through the ESER *Quality Management Plan for the Environmental Surveillance, Education and Research Program*. Additional QA requirements for monitoring activities are provided in the ESER *Quality Assurance Project Plan for the INL Offsite Environmental Surveillance Program*. Analytical laboratories used by the ESER Program maintain their own QA programs consistent with DOE requirements.

10.3.5 U.S. Geological Survey

Field Methods and Quality-Assurance Plan for Quality-of-Water Activities, U.S. Geological Survey, Idaho National Laboratory, Idaho (Knobel et al. 2008) defines procedures and tasks performed by project-office personnel that ensure the reliability of water quality data. The plan addresses all elements needed to ensure reliability:

- Reliability of the water-quality data
- Compatibility of the data with data collected by other organizations at the INL Site
- That data meet the programmatic needs of DOE and its contractors and the scientific and regulatory communities.

The U.S. Geological Survey (USGS) conducts performance audits on field personnel collecting samples and of the analytical laboratories that analyze their environmental monitoring samples.

10.3.6 National Oceanic and Atmospheric Administration

The National Oceanic and Atmospheric Administration *Quality Program Plan, NOAA Air Resources Laboratory Field Research Division* (NOAA-ARLFRD 1993) addresses the requirements of DOE Order 414.1C, and is consistent with ASME. Implementing procedures include regular independent system and performance audits, written procedures and checklists, follow-up actions, and continuous automated and visual data checks to ensure representativeness and accuracy. The plan and implementing procedures provide the framework to ensure that the INL Meteorological Monitoring Network meets the elements of “Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance” (DOE/EH-0173T).

All the meteorological sensors in the Air Resources Laboratory Field Research Division tower network are inspected, serviced, and calibrated semiannually as recommended by American

Nuclear Society guidelines of ANSI/ANS 3.11 2005. Unscheduled service also is performed promptly whenever a sensor malfunctions.

10.4 Analytical Laboratories

Analytical laboratories used to analyze environmental samples collected on and off the INL Site are presented in Table 10-2.

Radiological analytical laboratories used for routine analyses of radionuclides in environmental media were selected by each environmental monitoring program based on each laboratory's capabilities and past results in performance evaluation programs, such as the Mixed Analyte Performance Evaluation Program (MAPEP) described in Section 10.6.1. Continued acceptable performance in programs such as MAPEP is required to remain as the contracted laboratory.

Each laboratory's adherence to laboratory and QA procedures is checked through audits by representatives of the contracting environmental monitoring program. Subcontract laboratories used by the INL and ICP contractors also are audited by the DOE Consolidated Audit Program. This program uses trained and certified personnel to perform in-depth audits of subcontract laboratories to review:

- Personnel training and qualification
- Detailed analytical procedures
- Calibration of instrumentation
- Participation in an inter-comparison program
- Use of blind controls
- Analysis of calibration standards.

Audit results are maintained by the DOE Consolidated Audit Program. Laboratories are required to provide corrective action plans for audit findings.

Laboratory data quality is verified by a continuing program of internal laboratory QC, participation in inter-laboratory crosschecks, replicate sampling and analysis, submittal of blind standard samples and blanks, and splitting samples with other laboratories. These quality checks are described in the following sections.

10.5 Quality Assurance/Quality Control Results for 2011

QA measurements include completeness, data verification and validation, and results of QC checks. Quality control consists of the steps taken to determine the validity of specific sampling and analytical procedures. As a measure of the quality of data collected, the ESER contractor, INL contractor, and ICP contractor use a variety of QC samples of different media. Quality

Blind Spike — Used to assess the accuracy of the analytical laboratories. Contractors obtain samples spiked with known amounts of radionuclides or nonradioactive substances from suppliers whose spiking materials are traceable to National Institute of Standards and Technology (NIST). These samples are then submitted to the laboratories with regular field samples using the same labeling and sample numbering system. The analytical results are expected to compare to the known value within a set of performance limits. Generally used to establish intra-laboratory or analyst-specific precision and accuracy or to assess the performance of all or a portion of the measurement system. A **double blind spike** is a sample submitted to evaluate performance with concentration and identity unknown to both the submitter and the analyst.

Performance Evaluation Sample — A type of blind sample. The composition of performance evaluation samples is unknown to the analyst. Performance evaluation samples are provided to evaluate the ability of the analyst or laboratory to produce analytical results within specified limits. Performance evaluation samples (submitted as double blind spikes) are required to assess analytical data accuracy.

Field Replicates (duplicates or collocated samples) — Two samples collected from a single location at the same time. Two separate samples are taken from the same source, stored in separate containers, and analyzed independently. In the case of air sampling, two air samplers are placed side by side and each filter is analyzed separately. Duplicates are useful in documenting the precision of the sampling process. Field duplicates provide information on analytical variability caused by sample heterogeneity, collection methods and laboratory procedures.

Split Sample — A sample collected and later divided into two portions that are analyzed separately. The samples are taken from the same container and analyzed independently. Split samples are used to assess analytical variability and comparability.

Trip Blank — A sample of analyte-free media taken from the sample preparation area to the sampling site and returned to the analytical laboratory unopened. A trip blank is used to document contamination attributable to shipping and field handling procedures. This type of blank is useful in documenting contamination of volatile organics samples.

Field Blank — A clean analyte-free sample which is carried to the sampling site and then exposed to sampling conditions, returned to the laboratory, and treated as an environmental sample. Collected to assess the potential introduction of contaminants during sampling. This blank is used to provide information about contaminants that may be introduced during sample collection, storage, and transport.

Table 10-2. Analytical Laboratories Used by INL Site Contractors and U.S. Geological Survey Environmental Monitoring Programs.

Contractor and Program	Laboratory	Type of Analysis
ICP Drinking Water Program	GEL Laboratories, LLC	Radiological
	Intermountain Analytical Service – EnviroChem	Microbiological
	Underwriters Laboratories, Inc.	Inorganic and organic
ICP Environmental Program	ALS Laboratory Group – Fort Collins	Radiological
ICP Effluent Monitoring Program	ICP Wastewater Laboratory	Microbiological
	GEL Laboratories, LLC	Radiological
	Southwest Research Institute	Inorganic
ICP Groundwater Monitoring Program	GEL Laboratories, LLC	Microbiological
	Southwest Research Institute	Inorganic and radiological
INL Drinking Water Program	General Engineering Laboratories	Radiological
	Intermountain Analytical Service – EnviroChem	Inorganic
	Teton Microbiology Laboratory of Idaho Falls	Bacterial

Table 10-2. Analytical Laboratories Used by INL Site Contractors and U.S. Geological Survey Environmental Monitoring Programs (continued).

Contractor and Program	Laboratory	Type of Analysis
INL Liquid Effluent and Groundwater Programs	General Engineering Laboratories	Radiological
	Southwest Research Institute	Inorganic, nonradiological
INL Environmental Surveillance Program	ALS Laboratory Group (formerly Paragon Analytics)	Radiological
Environmental Surveillance, Education and Research Program	Environmental Assessments Laboratory at Idaho State University	Gross radionuclide analyses (e.g., gross alpha and gross beta) and gamma spectrometry
	ALS Laboratory Group – Fort Collins	Specific radionuclide (e.g., strontium-90, americium-241, plutonium-238 and plutonium-239/240)
U.S. Geological Survey	DOE's Radiological and Environmental Sciences Laboratory	Radiological
	USGS National Water Quality Laboratory	Nonradiological and low-level tritium and stable isotopes
	Purdue Rare Isotope Measurement Laboratory	Low-level iodine-129
	TestAmerica Laboratories	Radiological and nonradiological for the USGS Naval Reactors Facility sample program
	Brigham Young University Laboratory of Isotope Geochemistry	Low-level tritium for the USGS Naval Reactors Facility sample program

control samples measure precision and accuracy of sampling and analysis activities. **Precision** is a measure of agreement among repeated measurements of the same property under identical, or substantially similar, conditions and is expressed generally in terms of the standard deviation. **Accuracy** is a measure of the overall agreement of a measurement to a known value. Accuracy includes a combination of random error (precision) and systematic error (bias) components that are due to sampling and analytical operations. QC samples include blind spike samples, field replicate samples, split samples, performance evaluation samples, trip blanks, and field blanks. These terms are defined on the following page. Definitions used specifically by USGS for their QA/QC program may be found on page 12 of Knobel et al. (2008).

Results of the QA measurements for 2011 are summarized in the following sections.

10.5.1 Liquid Effluent Program Quality Assurance/Quality Control

Idaho National Laboratory Contractor – The INL contractor Liquid Effluent Monitoring and Groundwater Monitoring Programs have specific QA/QC objectives for analytical data. Goals are established for accuracy, precision, and completeness. The program submits field duplicates to provide information on variability caused by sample heterogeneity and collection methods. In 2011, field duplicates were collected at the ATR Complex Cold Waste Pond, USGS-076, Materials and Fuels Complex Industrial Waste Pipeline and the Industrial Waste Water Underground Pipe, and well ANL-MON-A-011 at MFC.

For nonradiological analytes, if the reported concentration in the first sample and the duplicate exceeded the detection limit by a factor of five or more, the laboratory precision was evaluated by calculating the relative percent difference (RPD) using Equation 1:

$$RPD = \frac{|R_1 - R_2|}{(R_1 + R_2)/2} \times 100 \qquad (1)$$

Where

R_1 = concentration of analyte in the first sample

R_2 = concentration of analyte in the duplicate sample.

The INL contractor Liquid Effluent Monitoring and Groundwater Program requires that the RPD from field duplicates be less than or equal to 35 for 90 percent of the analyses. Over 90 percent of the results for the duplicate samples were comparable to the original samples.

The goal for completeness is to collect 100 percent of all required compliance samples. This goal was met in 2011.

Accuracy was assessed using the results of the laboratory's continuing calibration and matrix spikes.

Idaho Cleanup Project Contractor – The ICP contractor Liquid Effluent Monitoring Program has specific QA/QC objectives for analytical data. All effluent sample results were usable in 2011 except some sample results that were rejected during data validation because of QC issues.

Goals are established for accuracy, precision, and completeness, and all analytical results are validated following standard EPA protocols. The ICP contractor Liquid Effluent Monitoring Program submits three types of QC samples:

- At a minimum, performance evaluation samples are required quarterly. During 2011, performance evaluation samples were submitted to the laboratory with routine monitoring samples on February 16, 2011, April 20, 2011, May 8, 2011, and November 9, 2011. Most results were within performance acceptance limits, indicating acceptable accuracy. The laboratory was notified of the results outside the performance acceptance limits, and the laboratory implemented corrective action, as necessary.
- Field duplicate samples were collected at CPP-769, CPP-773, and CPP-797 on May 18, 2011, and at CPP-797 on June 22, 2011. The RPD between the duplicate samples is used to assess data precision. For 2011, 91 percent of duplicate sample results were within the program goal of less than or equal to 35 percent.
- Rinsate samples were collected at CPP-773 on January 19, 2011. A rinsate sample is a sample of analyte-free medium (such as HPLC-grade water for organics or reagent-grade deionized or distilled water for inorganics) that has been used to rinse the sampling equipment. It is collected after completion of decontamination and prior to sampling. Rinsate samples are collected to evaluate the effectiveness of equipment decontamination. The analytical results for the rinsate samples indicate that decontamination procedures are adequate.

The goal for completeness is to collect 100 percent of all required compliance samples. During 2011, this goal was met.

10.5.2 Idaho Cleanup Project Contractor Wastewater Reuse Permit Groundwater Monitoring Quality Assurance/Quality Control

Groundwater sampling for Wastewater Reuse Permit compliance follows established procedures and analytical methodologies.

During 2011, groundwater samples were collected from all of the Idaho Nuclear Technology and Engineering Center wells that had sufficient water. Samples were not collected from perched water Well ICPP-MON-V-191 in April and October 2011 because the well was dry; however, the water level increased in July 2011, and samples were collected from that well on July 6, 2011. All other permit-required samples were collected.

All groundwater sample results were usable.

Field QC samples were collected or prepared during sampling in addition to regular

groundwater samples. Laboratories qualified by the ICP Sample and Analysis Management organization performed all ICP groundwater analyses during 2011.

Duplicate samples are collected to assess natural variability and precision of analyses. One duplicate groundwater sample was collected for every 20 samples collected or, at a minimum, 5 percent of the total number of samples collected. Duplicate samples were collected using the same sampling techniques and preservation as regular groundwater samples. Duplicate samples have precision goals within 35 percent as determined by the RPD measured between the paired samples.

Field blanks are collected to assess the potential introduction of contaminants during sampling activities. They were collected at the same frequency as the duplicate samples. Results from the field blanks did not indicate field contamination.

Equipment blanks (rinsates) were collected to assess the potential introduction of contaminants from incomplete decontamination activities. They were collected by pouring analyte-free water through the sample port manifold after decontamination and before subsequent use. Results from the equipment blanks indicate proper decontamination procedures.

Results from the duplicate, field blank, and equipment blank (rinsate) samples indicate that laboratory procedures, field sampling procedures, and decontamination procedures effectively produced high quality data.

During the April 2011 groundwater sampling events, performance evaluation samples were analyzed for fecal and total coliforms, inorganics, and metals. The April 2011 performance evaluation sample results for aluminum, iron, and mercury were outside the performance acceptance limits, and the laboratory was notified so they could evaluate whether corrective action was necessary.

During the October 2011 groundwater sampling event, performance evaluation samples were analyzed for fecal and total coliforms, inorganics, and metals. The laboratories were notified of the fecal and total coliforms, mercury, and silver results being outside the performance acceptance limits so they could evaluate whether corrective action was necessary.

10.5.3 Drinking Water Program Quality Assurance/Quality Control

Idaho National Laboratory Contractor – The INL contractor Drinking Water Program has specific QA/QC objectives for analytical data. Drinking Water Program goals are established for precision of less than or equal to 35 percent for 90 percent of the analyses and 100 percent completeness. All Drinking Water Program analytical results, except bacteria, are validated following standard EPA protocols. The Drinking Water Program submits field duplicates to provide information on analytical variability caused by sample heterogeneity, collection methods, and laboratory procedures.

For nonradiological analytes, if the reported concentration in the first sample and the duplicate exceeded the detection limit by a factor of five or more, the laboratory precision was evaluated by calculating the RPD.

The INL contractor Drinking Water Program requires that the RPD from field duplicates be less than or equal to 35 percent for 90 percent of the analyses. For nonradiological duplicate sample sets in which one or both of the results reported for a particular analyte were less than one set five times the detection limit, the level of precision was considered acceptable if the two results differed by an amount equal to or less than the detection limit. The RPD was not calculated if either the sample or its duplicate was reported as nondetect. For 2011, the INL contractor had no set of organic data with detectable quantities. Using the above criteria, 100 percent of the inorganic and organic results for the duplicate samples were comparable to the original samples.

Precision of the radiological results was considered acceptable if the RPD was less than or equal to 35 percent or if the condition of Equation (2) was met:

$$|R_1 - R_2| \leq 3(\sigma_1^2 + \sigma_2^2)^{1/2} \quad (2)$$

Where

R_1 = concentration of analyte in the first sample

R_2 = concentration of analyte in the duplicate sample

σ_1 = sample standard deviation of the first sample

σ_2 = sample standard deviation of the duplicate sample.

RPD was not calculated if either the sample or its duplicate was reported as nondetect. For 2011, the Drinking Water Program had six sets of radiological data with detectable quantities. Using the above criteria, 100 percent of the radiological data is comparable, meeting the RPD goal of less than or equal to 35 percent for 90 percent of the analyses.

Blind spike samples are used to determine the accuracy of laboratory analyses for concentrations of parameters in drinking water. Within each calendar year, 10 percent of the samples collected (excluding bacteria samples) are QA/QC samples, which include blind spikes. All blind spike percent recoveries must fall within the standards range.

Representativeness is ensured through use of established sampling locations, schedules, and procedures for field sample collections, preservation, and handling.

The data quality objectives address completeness for laboratory and field operations. The criterion for completeness by laboratories is that at least 90 percent of the surveillance and 100 percent of the compliance samples submitted annually must be successfully analyzed and

reported according to specified procedures. Similarly, the criterion for field data collection under the INL Environmental Support and Services Monitoring Services is that at least 90 percent of the surveillance and 100 percent of the compliance samples must be successfully collected on an annual basis and reported according to the specified procedures. If a completeness criterion is not met, the problem will be evaluated, and it will be determined whether the quality of the remaining data is suspect and whether a corrective action is needed either in the field collection or laboratory analysis.

Comparability is ensured through the use of (1) LIs for sample collection, preparation, and handling, (2) approved analytical methods for laboratory analyses, and (3) consistency in reporting procedures.

Idaho Cleanup Project Contractor – The ICP contractor Drinking Water Program completeness goal is to collect, analyze, and verify 100 percent of all compliance samples. This goal was met during 2011.

The ICP contractor Drinking Water Program requires that 10 percent of the samples (excluding microbiological) collected be QA/QC samples to include duplicates, trip blanks, and blind spikes. This goal was met in 2011 for all parameters.

The RPD between the duplicate samples is used to assess data precision. The ICP contractor Drinking Water Program met the precision goals in 2011.

Most performance evaluation samples were within the QC performance acceptance limits, indicating acceptable accuracy. The laboratory was notified of the results outside the performance acceptance limits, and the laboratory implemented corrective action, as necessary.

10.5.4 Environmental Surveillance, Education, and Research Program Quality Assurance/ Quality Control

Goals are established for completeness, accuracy, and precision, and all analytical results are validated by the laboratories. The ESER Program submitted four types of QC samples to the laboratories in 2011 – blank samples, field duplicate samples, laboratory split samples, and performance evaluation samples (i.e., blind spike samples).

The ESER contractor met its completeness goals of greater than 98 percent in 2011. Eleven air samples were considered invalid because insufficient volumes were collected due to power interruptions. A few milk samples were not collected in 2011 because they were not available for collection. All other samples were collected as planned.

Two significant events in the ESER Program occurred during 2011. First, the program went through the process of qualifying a new laboratory for radiochemical analysis. The new laboratory is ALS Environmental of Fort Collins, Colorado. ALS began analyzing samples in the second quarter of 2011. The second issue dealt with the installation of a new digital flow meter system for the air sampling network. These units replaced the older analog flow meters and contain readable chips that can provide a constant readout of air flow measurements.

Field blank samples were submitted with each set of samples to test for the introduction of contamination during the process of field collection, laboratory preparation, and laboratory analysis. Ideally, blank results should be within two standard deviations of zero and preferably within one standard deviation. In 2011, the majority of blanks were within one to two standard deviations of zero.

Field duplicate samples were collected for air and for milk, lettuce, potatoes, and grain to help assess data precision and sampling bias. Most duplicate data were associated with the air sampling program. Duplicate air samplers were operated at two locations (Van Buren and Dubois) adjacent to regular air samples. The objective was to have data close enough to conclude that there was minor sampling bias between the samplers and acceptable laboratory precision. The ESER QA program establishes that sample results should agree within three standard deviations (Equation 2). Any variation outside the predetermined criterion could be due to one of the samplers not operating correctly (e.g., a leak in one sampling system) or not operating within the same operating parameters (e.g., flow rate, sampling time). In addition, any variation outside the predetermined criterion could be attributed to inhomogeneous distribution of a contaminant in the sample medium so that true replication is not possible. The sample and duplicate results agreed with each in approximately 95 percent of all environmental samples collected during 2011 indicating acceptable precision.

The analytical laboratories split and analyzed a number of agriculture product, precipitation, and atmospheric moisture samples to assess agreement within the 20 percent or the 3σ criterion. The latter criterion was applied in nearly all cases. All split sample analyses met acceptance criteria in 2011 indicating acceptable precision.

The Idaho State University Environmental Assessment Laboratory recounts a number of samples of each media type as another measure of precision. The lab tests each recount using both the 20 percent criterion and the 3σ criterion. All recounts were within acceptable limits, with the exception of one result for potassium-40 in milk. The laboratory attributed the discrepancy to fluctuations in laboratory background during the counting period.

Accuracy is measured through the successful analysis of samples spiked with a known standard traceable to the National Institute for Standards and Technology (NIST). Each analytical laboratory conducted an internal spike sample program using NIST standards to confirm analytical results. Each laboratory also participated in the MAPEP by analyzing performance evaluation samples provided by that program. Due to a unit reporting error, one set of results for a soil sample analyzed by Idaho State University received a “Not Acceptable” rating. If the correct units had been reported, the values would have been in the Acceptable Range. The laboratory has instituted a number of measures to prevent a recurrence.

As an additional check on accuracy, the ESER contractor provided blind spiked samples (prepared by MAPEP personnel at the Radiological and Environmental Sciences Laboratory as described in Section 10.6.2) for wheat, air, and water samples. All results for wheat and composite spikes were “Acceptable,” except for cesium-134 in wheat, which was “Acceptable with Warning.” Analysis could not be completed on the water sample due to an extremely high

particulate concentration on the counting planchet, which interfered with the counting of the sample.

10.5.5 INL Environmental Surveillance Program Quality Assurance/Quality Control

The INL contractor analytical laboratories analyzed all Surveillance Monitoring Program samples as specified in the statements of work. These laboratories participate in a variety of intercomparison QA programs, which verify all the methods used to analyze environmental samples. The programs include the DOE MAPEP and the EPA National Center for Environmental Research Quality Assurance Program. The Surveillance Monitoring Program met its completeness and precision goals. Samples were collected and analyzed as planned from all available media. The Environmental Surveillance Program submitted duplicate, blank, and QC samples with routine samples for analyses as required. Results concluded the laboratories met the performance objectives specified by MAPEP and the National Center for Environmental Research.

10.5.6 ICP Waste Management Surveillance Quality Assurance/Quality Control

On July 1, 2010, the analytical laboratory that analyzed surveillance samples (Centauri Labs, Montgomery, Alabama) closed without notifying the ICP contractor. Consequently, samples that were collected from May 3, 2010, to June 15, 2010, were not analyzed or reported. Subsequently, a new laboratory (ALS Laboratory Group, Fort Collins, Colorado) was contracted to analyze and report ICP surveillance samples.

Both of the laboratories participated in a variety of intercomparison QA programs, which verify all the methods used to analyze environmental samples. The programs include the DOE MAPEP and the EPA National Center for Environmental Research Quality Assurance Program. Both laboratories met the performance objectives specified by MAPEP and the National Center for Environmental Research.

All blind performance evaluation samples submitted to the contract laboratory for analysis in 2011 for the Waste Management Surveillance Program showed satisfactory agreement except the following: vegetation samples showed false positives for plutonium-239/240 ($^{239/240}$Pu) and strontium-90 (^{90}Sr) and were reported as positive detections on control samples for $^{239/240}$Pu and ^{90}Sr. The laboratory was contacted and suggestions were made to insure complete dissolution of the sample. The laboratory made improvements and changed their procedure accordingly. The laboratory subsequently passed the performance evaluation in 2012.

The ICP Waste Management Surveillance Program met its completeness and precision goals. The ICP Waste Management Surveillance Program submitted duplicate and blank samples to the contract laboratory with routine samples for analyses per PLN-720. For 2011, the results for the analyzed samples, with the exception of the vegetation samples discussed in the previous paragraph, were within the acceptable range.

10.5.7 U.S. Geological Survey Water Sampling Quality Control/Quality Assurance

Water samples are collected in accordance with a QA plan for quality-of-water activities by personnel assigned to the USGS INL project office; the plan was revised in 2008 (Knobel et al.

2008). Additional QA is assessed with QA/QC duplicates, blind replicates, replicates, blanks, equipment blanks, splits, trip blanks, and spikes (Knobel et al. 2008). Evaluations of QA/QC data collected by USGS can be found in Wegner (1989), Williams (1996), Williams (1997), Williams et al. (1998); and Bartholomay and Twining (2010). During 2011, the USGS collected 20 replicate samples, four equipment blank samples, three blank samples, and one trip blank sample. Evaluation of results will be summarized in a future USGS report.

10.5.8 In Situ Gamma Spectroscopy Quality Control

High purity Germanium detectors used for in situ gamma spectroscopy measurements are calibrated yearly using NIST traceable radioactive sources in a laboratory setting. These calibrations are performed using a fixed geometry, long count time procedure. Collected calibration spectra are stored and then analyzed using a standard peak search peak fit algorithm. Energy calibration is performed to establish a linear relationship between peak positions and spectrum channels. The same calibration spectrum is then used to establish a relationship between the peak widths and peak energies. Finally, the detector efficiency is established and a mathematical fit of efficiency versus gamma ray energy is established. The peak energy, peak width, and efficiency parameters for each detector are stored and used for all subsequent daily quality control checks.

Prior to daily field use, each detector undergoes a quality control check. This is performed using the same NIST traceable source as above. The overall activity of the measured source is compared to the certified (NIST) value.

During field measurements, the position of the naturally occurring potassium-40 gamma ray peak is checked to make certain that energy drift has not occurred during field spectrum acquisition. In addition, approximately 10 percent of field measurements are repeated with a different detector so that the two measurements can be compared. Finally, very long time acquisitions are performed at selected field locations in order to assure stability in the measurements. Results from these measurements are also compared to regular count time results at those locations. Software analysis of field spectra is addressed in several publications, including HASL-300 (www.orau.org/ptp/PTP%20library/library/DOE/EML/hasl300/HASL300/TOC.htm) and ICRU Report No. 53 (ICRU 1994).

10.6 Performance Evaluation Programs

10.6.1 Mixed Analyte Performance Evaluation Program

The MAPEP is administered by DOE's Radiological and Environmental Sciences Laboratory. DOE has mandated since 1994 that all laboratories performing analyses in support of the Office of Environmental Management shall participate in MAPEP. MAPEP distributes samples of air, water, vegetation, and soil for analysis during the first and third quarters. Series 24 was distributed in March 2011, and Series 25 was distributed in September 2011.

Both radiological and nonradiological constituents are included in MAPEP. Results can be found at http://www.inl.gov/resl/mapep/reports.html (DOE 2011).

Laboratories that participate in MAPEP sometimes have results with a flag. MAPEP laboratory results may include the following flags:

A = Result acceptable, bias ≤20 percent

W = Result acceptable with warning, 20 percent < bias <30 percent

N = Result not acceptable, bias >30 percent

L = Uncertainty potentially too low (for information purposes only)

H = Uncertainty potentially too high (for information purposes only)

QL = Quantitation limit

RW = Report warning

NR = Not reported.

MAPEP issues a letter of concern to a participating laboratory for sequential unresolved failures. This is to help participants identify, investigate, and resolve potential quality issues. A more detailed explanation on MAPEP's quality concerns criteria can be found at http://www.inl.gov/resl/mapep/mapep_loc_final_2_.pdf.

10.6.2 National Institute of Standards and Technology

The DOE Radiological and Environmental Sciences Laboratory participates in a traceability program administered through NIST. The Radiological and Environmental Sciences Laboratory prepares requested samples for analysis by NIST to confirm their ability to adequately prepare sample material to be classified as NIST traceable. NIST also prepares several alpha-, beta-, and gamma-emitting standards in all matrix types for analysis by the Radiological and Environmental Sciences Laboratory to confirm their analytical capabilities. The Radiological and Environmental Sciences Laboratory maintained NIST certifications in both preparation and analysis in 2011.

10.6.3 Dosimetry

To verify the quality of the environmental dosimetry program conducted by the INL contractor and the ESER contractor, the Operational Dosimetry Unit participates in International Environmental Dosimeter Intercomparison Studies. The Operational Dosimetry Unit's past results have been within ±30 percent of the test exposure values on all intercomparisons. This is an acceptable value that is consistent with other analyses that range from ±20 to ±35 percent.

The INL contractor Operational Dosimetry Unit also QA-tests environmental thermoluminescent dosimeters during monthly and quarterly processing periods. The QA test dosimeters were prepared by a program administrator. The delivered irradiation levels were blind to the processing technician. The results for each of the QA tests have remained within the 20-percent acceptance criteria during each testing period.

10.6.4 Other Programs

INL Site contractors participate in additional performance evaluation programs, including those administered by the International Atomic Energy Agency, EPA, and the American Society for Testing and Materials. Contractors are required by law to use laboratories certified by the state of Idaho or certified by another state whose certification is recognized by the state of Idaho for drinking water analyses. The Idaho Department of Environmental Quality oversees the certification program and maintains a list of approved laboratories. Where possible (i.e., the laboratory can perform the requested analysis), the contractors use state-approved laboratories for all environmental monitoring analyses.

10.7 Independent Assessment of INL Site Environmental Monitoring Programs

In 2010, the DOE Headquarters Office of Independent Oversight within the Office of Health, Safety, and Security reviewed QA in conjunction with an independent assessment of the INL Site environmental monitoring programs (see Section 3.1.2). The full Assessment Report entitled "Independent Oversight Assessment of Environmental Monitoring at the Idaho National Laboratory," is available at http://www.hss.doe.gov/indepoversight/reports/eshevals.html. The report stated that "Quality Assurance laboratory analyses and data reporting is adequate but could be improved further with enhanced laboratory oversight and accountability." The independent assessment found that all laboratories used by INL Site contractors participate in the MAPEP proficiency testing (PT) program. Their conclusions are documented in the following statements:

> *However, because PT is only conducted semiannually for certain analytes within particulate matrices (i.e., soil, water, vegetation, and air filters), it cannot be completely relied upon to ensure the validity and reliability of environmental data… While some contractors are using double blind samples to provide for continuing quality assurance of laboratory data, the approach is inconsistent and is not implemented by all contractors.*

To correct this, the independent assessment team recommended that minimum standards be established in the technical basis document development that include double blind sampling by all contractors to complement the MAPEP process in the overall QA program for environmental monitoring. This will be addressed in the technical basis development that is being conducted by the INL, ICP, and ESER contractors (see Section 3.1.2).

10.8 Duplicate Sampling between Organizations

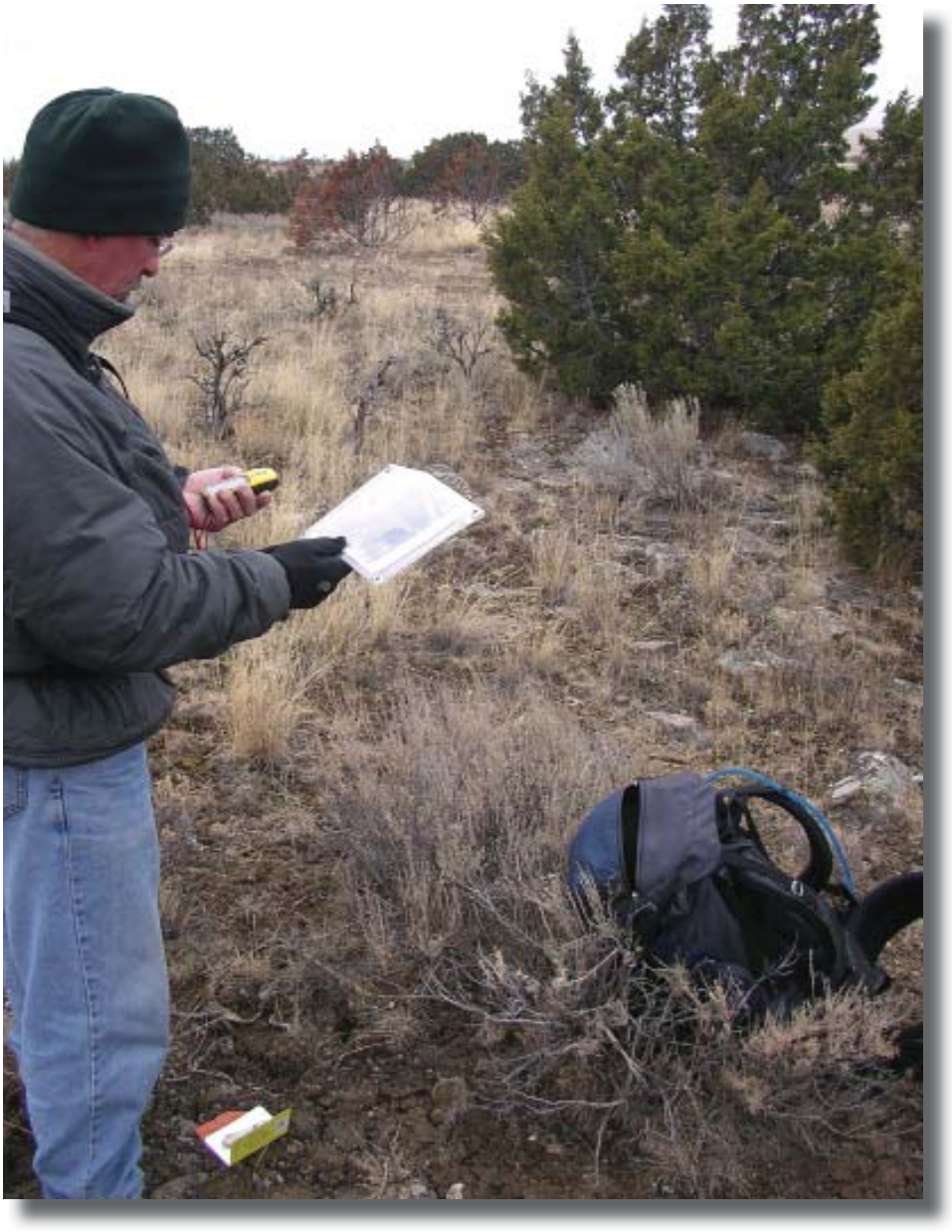
The ESER contractor, the INL contractor, and the state of Idaho's Department of Environmental Quality (DEQ) INL Oversight Program (OP) collected air monitoring data throughout 2011 at four common sampling locations: the distant locations of Craters of the Moon National Monument and Idaho Falls, and on the INL Site at the Experimental Field Station and Van Buren Boulevard Gate. While some differences exist in precise values due to variances in sampling methods, collection dates, and analytical methods, data from these sampling locations show similar patterns over the year. The INL Oversight Program Annual Report for 2011 is not

yet available; however, according to the INL Oversight Program Annual Report 2010 (available at http://www.deq.idaho.gov/media/781813-inl-oversight-annual-report-2010.pdf):

> *Gross alpha and beta particle results for suspended particulate matter samples from monitoring stations used by DEQ-INL OP are compared with results from co-located stations operated by the Environmental Surveillance, Education and Research Program (ESER) and by Battelle Energy Alliance (BEA). As a convention, agreement of paired samples is taken as the two sample results being within 20 percent of each other or within 3 standard deviations. Agreement between 80% of the paired samples is considered to indicate overall statistical agreement of the programs being compared. Another test of agreement is to determine if the conclusions relevant to public health drawn from the results of one program differ from those drawn from the results of another program.*
>
> *For 2010, gross alpha particle results agreed for more than 90% of the paired samples. Gross beta particle results for DEQ-INL OP, were not in overall statistical agreement with those of ESER, or BEA. Variations in sampling schedule, equipment configuration and random uncertainty may contribute to observed differences. It is important to recognize that gross alpha and beta particle measurements are a screening method and do not represent quantitative measurement of specific radionuclides.*
>
> *The results do agree in the important sense that all measurements from the three monitoring organizations are several orders of magnitude below the most restrictive regulatory limit for radionuclides of concern from the INL. The results from all three monitoring agencies indicate that there is no public health risk.*
>
> *Comparing tritium sample results among DEQ-INL OP, ESER, and BEA is problematic because although sampling sites are co-located, samples are not paired or split samples. Each monitoring agency collects its tritium sample when the desiccant material becomes saturated with moisture; therefore the sampling frequency is dependent on the volume of desiccant used and the sampler flow rate resulting in differences and overlaps in sampling schedules throughout the year. Also, most of the results are near or below the MDC, where statistical uncertainties are relatively high. These factors make a direct one-to-one comparison of results not possible. However, all the results agree in that they are several orders of magnitude below minimum regulatory limits. Results from all three monitoring agencies indicate no public health risk.*
>
> *DEQ-INL OP has placed several EICs at locations monitored by DOE contractors, using thermoluminescent dosimetry (TLD). Ambient penetrating radiation measurements during 2010 showed 100% of BEA's TLD measurements and 100% of ESER Gonzales-Stoller Surveillance, LLC (GSS)'s TLD measurements satisfied the "3 sigma" test when compared with co-located DEQ-INL OP EIC measurements. The INL Oversight Program, through the Idaho Department*

of Environmental Quality and Shoshone-Bannock Tribes, routinely collects groundwater samples simultaneously with USGS. Some comparison of results from this sampling is regularly documented in reports prepared by the INL Oversight Program.

The DEQ-INL OP also collects surface water and drinking water samples at select downgradient locations in conjunction with the ESER Contractor. Samples are collected at the same place and time, using similar methods. The results are discussed in Sections 6.8 and 6.9.



Bob Starck mapping sage-grouse lek location.

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Appendix A. Environmental Statutes and Regulations

The following environmental statutes and regulations apply, in whole or in part, to the Idaho National Laboratory (INL) or at the INL Site boundary:

- 36 CFR 79, 2002, "Curation of Federally-Owned and Administered Archeological Collections," U.S. Department of the Interior, National Park Service, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 50, 2010, "National Primary and Secondary Ambient Air Quality Standards," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 61, 2010, "National Emission Standards for Hazardous Air Pollutants," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 112, 2010, "Oil Pollution Prevention," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 122, 2008, "EPA Administered Permit Programs: the National Pollutant Discharge Elimination System," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 141, 2010, "National Primary Drinking Water Regulations," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 260, 2010, "Hazardous Waste Management System: General," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 261, 2010, "Identification and Listing of Hazardous Waste," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 262, 2010, "Standards Applicable to Generators of Hazardous Waste," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 263, 2010, "Standards Applicable to Transporters of Hazardous Waste," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 264, 2010, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 265, 2010, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register
- 40 CFR 267, 2006, "Standards for Owners and Operators of Hazardous Waste Facilities Operating under a Standardized Permit," U.S. Environmental Protection Agency, *Code of*

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- 43 CFR 7, 2002, "Protection of Archeological Resources," U.S. Department of the Interior, National Park Service, *Code of Federal Regulations*, Office of the Federal Register
- 50 CFR 17, 2010, "Endangered and Threatened Wildlife and Plants," U.S. Department of the Interior, Fish and Wildlife Service, *Code of Federal Regulations*, Office of the Federal Register
- 50 CFR 226, 2009, "Designated Critical Habitat," U.S. Department of Commerce, National Marine Fisheries Service, *Code of Federal Regulations*, Office of the Federal Register
- 50 CFR 402, 2009, "Interagency Cooperation – Endangered Species Act of 1973, as Amended," U.S. Department of the Interior, Fish and Wildlife Service, *Code of Federal Regulations*, Office of the Federal Register
- 50 CFR 424, 2002, "Listing Endangered and Threatened Species and Designating Critical Habitat," U.S. Department of the Interior, Fish and Wildlife Service, *Code of Federal Regulations*, Office of the Federal Register
- 50 CFR 450–453, 2002, "Endangered Species Exemption Process," U.S. Department of the Interior, Fish and Wildlife Service, *Code of Federal Regulations*, Office of the Federal Register
- DOE Order 231.1A, 2004, "Environment, Safety, and Health Reporting," Change 1, U.S. Department of Energy
- DOE Order 435.1, 2001, "Radioactive Waste Management," Change 1, U.S. Department of Energy
- DOE Order 436.1, 2011, "Departmental Sustainability," U.S. Department of Energy
- DOE Order 458.1, 2011, "Radiation Protection of the Public and the Environment," U.S. Department of Energy
- DOE Standard 1196-2011, 2011, "Derived Concentration Technical standard," U.S. Department of Energy
- Executive Order 11514, 1970, "Protection and Enhancement of Environmental Quality"
- Executive Order 11988, 1977, "Floodplain Management"
- Executive Order 11990, 1977, "Protection of Wetlands"
- Executive Order 12580, 1987, "Superfund Implementation"
- Executive Order 12856, 1993, "Federal Compliance With Right-to-Know Laws and Pollution Prevention Requirements"
- Executive Order 12873, 1993, "Federal Acquisition, Recycling, and Waste Prevention"
- Executive Order 13101, 1998, "Greening the Government Through Waste Prevention, Recycling, and Federal Acquisition"

- IDAPA 58.01.01, 2010, “Rules for the Control of Air Pollution in Idaho,” Idaho Administrative Procedures Act, Idaho Department of Environmental Quality
- IDAPA 58.01.02, 2010, “Water Quality Standards,” Idaho Administrative Procedures Act, Idaho Department of Environmental Quality
- IDAPA 58.01.03, 2010, “Individual/Subsurface Sewage Disposal Rules,” Idaho Administrative Procedures Act, Idaho Department of Environmental Quality
- IDAPA 58.01.05, 2010, “Rules and Standards for Hazardous Waste,” Idaho Administrative Procedures Act, Idaho Department of Environmental Quality
- IDAPA 58.01.06, 2010, “Solid Waste Management Rules,” Idaho Administrative Procedures Act, Idaho Department of Environmental Quality
- IDAPA 58.01.08, 2010, “Idaho Rules for Public Drinking Water Systems,” Idaho Administrative Procedures Act, Idaho Department of Environmental Quality
- IDAPA 58.01.11, 2010, “Ground Water Quality Rule,” Idaho Administrative Procedures Act, Idaho Department of Environmental Quality
- IDAPA 58.01.15, 2010, “Rules Governing the Cleaning of Septic Tanks,” Idaho Administrative Procedures Act, Idaho Department of Environmental Quality
- IDAPA 58.01.17, 2010, “Rules for the Reclamation and Reuse of Municipal and Industrial Wastewater,” Idaho Administrative Procedures Act, Idaho Department of Environmental Quality
- Memorandum of Understanding to Foster Ecosystems Approach 1995, signed by 14 Federal Agencies dated December 15, 1995.

DOE Order 458.1 provides the principal requirements for protection of the public and environment at the INL Site. The DOE public dose limit is shown in Table A-1, along with the Environmental Protection Agency statute for protection of the public, for the airborne pathway only.

Derived Concentration Standards are established to support DOE Order 458.1 in DOE Standard 1196-2011 (DOESTD-1196-2011), “Derived Concentration Technical Standard”. These quantities represent the concentration of a given radionuclide in either water or air that results in a member of the public receiving 100 mrem (1 mSv) effective dose following continuous exposure for one year for each of the following pathways: ingestion of water, submersion in air, and inhalation. The Derived Concentration Standards used the environmental surveillance programs at the INL Site are shown in Table A-2. The most restrictive Derived Concentration Standard is listed when the soluble and insoluble chemical forms differ. The Derived Concentration Standards consider only inhalation of air, ingestion of water, and submersion in air.

Ambient air quality standards are shown in Table A-3.

Water quality standards are dependent on the type of drinking water system sampled. Tables A-4 through A-7 list maximum contaminant levels set by the Environmental Protection Agency for public drinking water systems in 40 CFR 141 (2010) and the Idaho groundwater quality values from IDAPA 58.01.11 (2010).

REFERENCES

40 CFR 141, 2010, "National Primary Drinking Water Regulations," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register.

DOE Order 458.1, 2011, "Radiation Protection of the Public and the Environment," U.S. Department of Energy.

DOE Standard, 2011, "DOE Standard Derived Concentration Technical Standard," DOE-STD-1196-2011.

DOE, 1988a, *Internal Dose Conversion Factors for Calculation of Dose to the Public*, DOE/EH-0071, U.S. Department of Energy.

DOE, 1988b, *External Dose-Rate Conversion Factors for Calculation of Dose to the Public*, DOE/EH-0070, U.S. Department of Energy.

IDAPA 58.01.11,2010, "Ground Water Quality Rule," Idaho Administrative Procedures Act, Idaho Department of Environmental Quality.

Table A-1. Radiation Standards for Protection of the Public in the Vicinity of Department of Energy Facilities.

Radiation Standard	Effective Dose Equivalent (mrem/yr)	Effective Dose Equivalent (mSv/yr)
DOE standard for routine DOE activities (all pathways)	100[a]	1
EPA standard for site operations (airborne pathway only)	10	0.1

a. The effective dose equivalent for any member of the public from all routine DOE operations, including remedial activities, and release of naturally occurring radionuclides shall not exceed this value. Routine operations refer to normal, planned operations and do not include accidental or unplanned releases.

Table A-2. Derived Concentration Standards for Radiation Protection.

Derived Concentration Standard[a]			Derived Concentration Standard		
Radionuclide	In Air (µCi/ml)	In Water (µCi/ml)	Radionuclide	In Air (µCi/ml)	In Water (µCi/ml)
Gross Alpha[b]	4×10^{-14}	1.7×10^{-7}	Antimony-125	3.1×10^{-10}	2.7×10^{-5}
Gross Beta[c]	2.4×10^{-13}	2.5×10^{-8}	Iodine-129	7×10^{-11}	3.3×10^{-7}
Tritium (tritiated water)	1.4×10^{-8}	1.9×10^{-3}	Iodine-131	4.1×10^{-10}	1.3×10^{-6}
Carbon-14	6.6×10^{-10}	6.2×10^{-5}	Iodine-132	3.0×10^{-8}	9.8×10^{-5}
Sodium-24	4.1×10^{-9}	7.0×10^{-9}	Iodine-133	2.0×10^{-9}	6.0×10^{-6}
Argon-41[d]	1.4×10^{-8}	—	Iodine-135	9.7×10^{-9}	3.0×10^{-5}
Chromium-51	9.4×10^{-8}	7.9×10^{-4}	Xenon-131m[d]	2.4×10^{-6}	—
Manganese-54	1.1×10^{-9}	4.4×10^{-5}	Xenon-133[d]	6.3×10^{-7}	—
Cobalt-58	1.7×10^{-9}	3.9×10^{-5}	Xenon-133m[d]	6.6×10^{-7}	—
Cobalt-60	1.2×10^{-10}	7.2×10^{-6}	Xenon-135[d]	7.8×10^{-8}	—
Zinc-65	1.6×10^{-9}	8.3×10^{-6}	Xenon-135m[d]	4.5×10^{-8}	—
Krypton-85[d]	3.6×10^{-6}	—	Xenon-138[d]	1.6×10^{-8}	—
Krypton-85m[d,e]	1.3×10^{-7}	—	Cesium-134	1.8×10^{-10}	2.1×10^{-6}
Krypton-87[d]	2.2×10^{-8}	—	Cesium-137	3.9×10^{-10}	3.0×10^{-6}
Krypton-88[d]	8.8×10^{-9}	—	Cesium-138	7.5×10^{-8}	3.1×10^{-4}
Rubidium-88[d]	2.5×10^{-8}	8×10^{-4}	Barium-139	5.8×10^{-8}	2.4×10^{-4}
Rubidium-89[d]	7.9×10^{-9}	2×10^{-3}	Barium-140	6.2×10^{-10}	1.1×10^{-5}
Strontium-89	4.6×10^{-10}	1.1×10^{-5}	Cerium-141	9.9×10^{-10}	4×10^{-5}
Strontium-90	2.5×10^{-11}	1.1×10^{-6}	Cerium-144	7.1×10^{-11}	5.5×10^{-6}
Yttrium-91m	3.1×10^{-7}	2.7×10^{-3}	Plutonium-238	3.7×10^{-14}	1.5×10^{-7}
Zirconium-95	6.3×10^{-10}	3.1×10^{-5}	Plutonium-239	3.4×10^{-14}	1.4×10^{-7}
Technetium-99m	1.7×10^{-7}	1.4×10^{-3}	Plutonium-240	3.4×10^{-14}	1.4×10^{-7}
Ruthenium-103	1.3×10^{-9}	4.2×10^{-5}	Plutonium-241	1.8×10^{-12}	7.6×10^{-6}
Ruthenium-106	5.6×10^{-11}	4.1×10^{-6}	Americium-241	4.1×10^{-14}	1.7×10^{-7}

a. Derived concentration standards are from DOE-STD-1196-2011 (*Derived Concentration Technical Standard)* and support the implementation of DOE Order 458.1. They are based on a committed effective dose equivalent of 100 mrem/yr (1 mSv) for ingestion or inhalation of a radionuclide during one year. Inhalation values shown represent the most restrictive lung retention class.

b. Based on the most restrictive alpha emitter (^{241}Am).

c. Based on the most restrictive beta emitter (^{228}Ra).

d. The DCS for air immersion is used because or there is no inhaled air DCG established for the radionuclide.

e. An "m" after the number refers to a metastable form of the radionuclide.

Table A-3. Environmental Protection Agency Ambient Air Quality Standards.

Pollutant	Type of Standard[a]	Sampling Period	EPA[b] (mg/m^3)
Sulfur dioxide	Secondary	3-hour average	1,300
	Primary	24-hour average	365
	Primary	Annual average	80
Nitrogen dioxide	Primary and secondary	Annual average	100
	Secondary	24-hour average	150
Total particulates[c]	Primary and secondary	Annual average	50

a. National primary ambient air quality standards define levels of air quality to protect the public health. Secondary ambient air quality standards define levels of air quality to protect the public welfare from any known or anticipated adverse effects of a pollutant.

b. The state of Idaho has adopted these ambient air quality standards.

c. The primary and secondary standard to the annual average applies only to "particulates with aerodynamic diameter less than or equal to a nominal 10 micrometers."

Table A-4. Environmental Protection Agency Maximum Contaminant Levels for Public Drinking Water Systems and State of Idaho Groundwater Quality Standards for Radionuclides and Inorganic Contaminants.

Constituent	Maximum Contaminant Levels	Groundwater Quality Standards
Gross alpha (pCi/L)	15	15
Gross beta (mrem/yr)	4	4
Beta/gamma emitters	Concentrations resulting in 4 mrem total body or organ dose equivalent	4 mrem/yr effective dose equivalent
Radium-226 plus -228 (pCi/L)	5	5
Strontium-90 (pCi/L)	8	8
Tritium (pCi/L)	20,000	20,000
Uranium (µg/L)	30	30
Arsenic (mg/L)	0.01	0.05
Antimony (mg/L)	0.006	0.006
Asbestos (fibers/L)	7 million	7 million
Barium (mg/L)	2	2
Beryllium (mg/L)	0.004	0.004
Cadmium (mg/L)	0.005	0.005
Chromium (mg/L)	0.1	0.1
Copper[a] (mg/L)	1.3	1.3
Cyanide (mg/L)	0.2	0.2
Fluoride (mg/L)	4	4
Lead (mg/L)	0.015	0.015
Mercury (mg/L)	0.002	0.002
Nitrate (as N) (mg/L)	10	10
Nitrite (as N) (mg/L)	1	1
Nitrate and Nitrite (both as N) (mg/L)	--[b]	10
Selenium (mg/L)	0.05	0.05
Thallium (mg/L)	0.002	0.002

a. Treatment technique action level, the concentration of a contaminant which, if exceeded, triggers treatment or other requirements that a water system must follow.

b. No maximum contaminant level for this constituent.

Table A-5. Environmental Protection Agency Maximum Contaminant Levels for Public Drinking Water Systems and State of Idaho Groundwater Quality Standards for Organic Contaminants.

Constituent	Maximum Contaminant Levels (mg/L)	Groundwater Quality Standards (mg/L)
Benzene	0.005	0.005
Carbon tetrachloride	0.005	0.005
m-Dichlorobenzene	—	0.6
o-Dichlorobenzene	0.6	0.6
p-Dichlorobenzene	0.075	0.075
1,2-Dichloroethane	0.005	0.005
1,1-Dichloroethylene	0.007	0.007
cis-1,2-Dichloroethylene	0.07	0.07
trans-1,2-Dichloroethylene	0.1	0.1
Dichloromethane	0.005	0.005
1,2-Dichloropropane	0.005	0.005
Ethylbenzene	0.7	0.7
Monochlorobenzene	0.1	0.1
Styrene	0.1	0.1
Tetrachloroethylene	0.005	0.005
Toluene	1.0	1.0
1,2,4-Trichlorobenzene	0.07	0.07
1,1,1-Trichloroethane	0.2	0.2
1,1,2-Trichloroethane	0.005	0.005
Trichloroethylene	0.005	0.005
Vinyl chloride	0.002	0.002
Xylenes (total)	10.0	10.0
Bromate	0.01	—
Bromodichloromethane	—	0.1
Bromoform	—	0.1
Chlorodibromomethane	—	0.1
Chloroform	—	0.002
Chlorite	1.0	—
Haloacetic acids (HAA5)	0.06	—
Total Trihalomethanes (TTHMs)	0.08	0.1

Table A-6. Environmental Protection Agency Maximum Contaminant Levels for Public Drinking Water Systems and State of Idaho Groundwater Quality Standards for Synthetic Organic Contaminants.

Constituent	Maximum Contaminant Levels (mg/L)	Groundwater Quality Standards (mg/L)
Alachlor	0.002	0.002
Atrazine	0.003	0.003
Carbofuran	0.04	0.04
Chlordane	0.002	0.002
Dibromochloropropane	0.0002	0.0002
2,4-D	0.07	0.07
Ethylene dibromide	0.00005	0.00005
Heptachlor	0.0004	0.0004
Heptachlor epoxide	0.0002	0.0002
Lindane	0.0002	0.0002
Methoxychlor	0.04	0.04
Polychlorinated biphenyls	0.0005	0.0005
Pentachlorophenol	0.001	0.001
Toxaphene	0.003	0.003
2,4,5-TP (silvex)	0.05	0.05
Benzo(a)pyrene	0.0002	0.0002
Dalapon	0.2	0.2
Di(2-ethylhexyl) adipate	0.4	0.4
Di(2-ethylhexyl) phthalate	0.006	0.006
Dinoseb	0.007	0.007
Diquat	0.02	0.02
Endothall	0.1	0.1
Endrin	0.002	0.002
Glyphosate	0.7	0.7
Hexachlorobenzene	0.001	0.001
Hexachlorocyclopentadiene	0.05	0.05
Oxamyl (vydate)	0.2	0.2
Picloram	0.5	0.5
Simazine	0.004	0.004
2,3,7,8-TCDD (dioxin)	3×10^{-8}	3×10^{-8}

Table A-7. Environmental Protection Agency National Secondary Drinking Water Regulations and State of Idaho Groundwater Quality Standards for Secondary Contaminants.

Constituent	Secondary Standards[a]	Groundwater Quality Standards
Aluminum (mg/L)	0.05 to 0.2	0.2
Chloride (mg/L)	250	250
Color (color units)	15	15
Foaming agents (mg/L)	0.5	0.5
Iron (mg/L)	0.3	0.3
Manganese (mg/L)	0.05	0.05
Odor (threshold odor number)	3 threshold odor number	3
pH	6.5 to 8.5	6.5 to 8.5
Silver (mg/L)	0.1	0.1
Sulfate (mg/L)	250	250
Total dissolved solids (mg/L)	500	500
Zinc (mg/L)	5	5

a. The Environmental Protection Agency (EPA) has not established National Primary Drinking Water Regulations that set mandatory water quality standards (maximum contaminant levels) for these constituents because these contaminants are not considered a risk to human health. EPA has established National Secondary Drinking Water Regulations that set secondary maximal contaminant levels as guidelines to assist public water systems in managing their drinking water for aesthetic considerations, such as taste, color, and odor.

Appendix B. Regional Environmental Monitoring Following the Fukushima Accident

On March 11, 2011, at 2:46 p.m. Japan Standard Time, a 9.0 magnitude earthquake occurred off the northeast coast of Japan, causing an automatic shutdown of the reactors at all four nuclear-power generating stations on the east coast of Japan. Extensive flooding from a subsequent tsunami knocked out all power to the Fukushima Dai-ichi station and damaged the reactor core cooling systems. In the following days, three of the reactor cores overheated and melted, releasing hydrogen gas and fission products into their reactor containment structures. Because of concerns about hydrogen deflagration, the reactor operators vented the containment structures, causing the release of radioactive material into the atmosphere. The venting was insufficient, and multiple hydrogen deflagrations occurred that damaged the containment structures and allowed more radioactive material to be released. It is possible that the large hydrogen explosion in Unit 3 may have damaged stored spent fuel and caused the release of additional radioactive material.

B.1 Initial detection of radionuclides released by Fukushima

The Fukushima reactor accident in Japan resulted in the release and global dispersal of radioactive contaminants. These contaminants were transported in air across the Pacific Ocean to the United States. Between March 16 and 17, a sensitive detector at the Department of Energy's (DOE's) Pacific Northwest National Laboratory in Washington State detected trace amounts of xenon-133 (^{133}Xe), which is a radioactive noble gas produced during nuclear fission. Soon after, other monitoring stations located in the northwestern United States began detecting low concentrations of radioactive iodine, cesium, and tellurium consistent with the Japanese nuclear incident. These included monitoring stations operated at or near the Idaho National Laboratory (INL) Site by the INL contractor (Battelle Energy Alliance), the Environmental Surveillance, Research, and Education (ESER) contractor (Gonzales-Stoller Surveillance, LLC [GSS]), the Environmental Protection Agency (EPA), and the state of Idaho Department of Environmental Quality (DEQ) INL Oversight Program (IOP).

EPA's nationwide radiation monitoring system, RadNet, measures radiation 24 hours a day, 7 days a week. The RadNet air network uses two different types of monitors: fixed (stationary) and deployable (mobile).

1. **Fixed Air Monitors:** Permanently mounted and continuously operating, each fixed monitor contains a high-volume air sampler, gamma and beta radiation detectors, and a computer that controls the air monitor and sends data to a central database at least once an hour. The individual detectors within each air monitor can discriminate between different types of radiation, including those that are naturally occurring.

2. **Deployable Air Monitors:** Deployable monitors are portable and available for rapid response to real events, or during exercises. The monitors have high- and low-volume air samplers, a gamma radiation level monitor, a data logger, and telecommunication systems that send data to the central database. Although deployable monitors do not discriminate the energy of gamma radiation, they do provide real-time gamma exposure rate data, and a record of the exposure rates.

The ESER contractor maintains an EPA RadNet fixed air monitor in Idaho at Idaho Falls, which is 45 miles east of the INL Site. In addition to monitoring the air filters for gross beta and gamma activity on a near real-time basis, the filters are collected twice a week and sent to EPA for detailed laboratory analysis. There is no charcoal cartridge on the fixed air monitoring unit. Along with air monitoring, the EPA also routinely monitors precipitation and drinking water at two Idaho locations: Idaho Falls and Boise.

In addition to the EPA RadNet air monitors, particulate air filters and charcoal cartridges are routinely collected on a weekly basis (every Wednesday) by the ESER and INL contractors at 16 offsite and 23 onsite locations, respectively. In addition, the DEQ IOP collects air filters and charcoal cartridges at many of the same locations (a total of 23 sites) every Thursday of the week. The INL Site monitoring programs and DEQ IOP also routinely sample other media which could be affected by global fallout. These include precipitation, drinking water, and milk samples. Evidence that radionuclides released from the Fukushima accident had reached southeast Idaho was first observed by the DEQ IOP in air samples collected Thursday, March 17, 2011, when iodine-131 (^{131}I) was detected in all 11 charcoal canisters collected at onsite, boundary, and distant locations. This was confirmed in all air samples collected by the INL and ESER contractors the following week on Wednesday, March 23, 2011. This suggests that most of the ^{131}I entered our region after mid-day of March 16. All levels were well below DOE's health protection standards.

B.2 Response

B.2.1 EPA

In response to the Japanese nuclear incident, EPA accelerated and increased sampling frequency and analysis in the RadNet program to confirm that there were no harmful levels of radiation reaching the U.S. from Japan and to inform the public about the levels of radiation detected. During this period EPA focused on ensuring data quality, presenting RadNet data to the public and decision-makers (http://www.epa.gov/japan2011/) in a user-friendly format, coordinating domestic response issues with other state and federal agencies, and providing health physics support to answer the technical questions generated by the presence of detectable activity in the United States (Tupin et al, 2012). A deployable high-volume air monitor was activated in Boise, Idaho on March 21, 2011. The air filters and cartridges were sent to an EPA laboratory for sensitive laboratory analysis to detect radioactive material in the samples. The laboratory results were posted on the web at http://www.epa.gov/japan2011/rert/radnet-sampling-data.html#air. The results from Boise are available through April 10, 2011, when radioactivity from Japan was no longer detectable.

Gross beta and gamma levels at the fixed Idaho Falls monitor continued to be remotely monitored 24 hours a day by EPA in Montgomery, Alabama, as part of its routine monitoring program. Air filters were collected twice weekly, per the usual routine, and sent to the EPA laboratory. However, in order to speed up the process of analyzing samples and getting data out to the public, EPA directed the ESER contractor to use overnight delivery for air samples. The laboratory results for Idaho Falls may be accessed at http://iaspub.epa.gov/enviro/erams_query_v2.simple_query.

During normal operations, EPA analyzes precipitation samples collected at Idaho Falls and Boise every month. During the Fukushima incident in 2011, composited samples collected at Idaho Falls by the ESER contractor were routinely analyzed on the 1st of March and April. Samples were also collected at Boise on the 1st, 22nd, and 27th of March.

Drinking water samples are routinely collected at Idaho Falls and Boise every three months by the ESER contractor for EPA analysis. Routine samples were collected at Idaho Falls on March 10. Additional special sampling occurred at Idaho Falls on March 28 and April 15 and at Boise on March 28 and April 14.

After a thorough data review showing declining radiation levels, on May 3, 2011, the EPA returned to the routine RadNet sampling and analysis schedule for precipitation, drinking water, and milk.

B.2.2 State of Idaho

During the Fukushima nuclear incident, DEQ IOP collected samples on and around the INL Site in conjunction with its routine environmental monitoring program, and the DEQ also tested water from 18 Idaho municipal water systems that use surface water for public drinking. The state of Idaho DEQ began posting information regarding radiation from Japan and the state's monitoring effort after detecting trace amounts of radioiodine on charcoal cartridges on March 17th. The link for information posted by the state is: http://healthandwelfare.idaho.gov/Health/SituationinJapanIdahoUpdate/tabid/1610/Default.aspx. This website also details EPA's additional monitoring and other information to help the public understand what happened and the potential health consequences. The state and federal press releases are particularly useful in discerning the timeline of the Fukushima situation and monitoring response.

The DEQ IOP shared monitoring information and data with the INL Site monitoring programs as it was received by the state. The final results obtained during the period encompassing the Fukushima incident may be found in the first and second quarterly reports at http://www.deq.idaho.gov/media/724220-2011-q1-env-surv-rpt.pdf and http://www.deq.idaho.gov/media/795384-inl-oversight-monitoring-q2-data-report-2011-report.pdf, respectively.

B.2.3 INL Site Monitoring Programs

The INL Site environmental monitoring programs became aware of the Fukushima incident on March 11, 2011, and, after consulting with the U.S. Department of Energy, Idaho Operations Office (DOE-ID), began to monitor the EPA RadNet real-time surveillance, rather than to increase routine sampling frequency of the INL Site monitoring programs. This decision was made for the following reasons:

- The primary purpose of the INL site monitoring system is to monitor for INL operations and that purpose is best served by remaining on the routine schedule.
- The monitoring data are more meaningful if compared over a time period consistent with historical measurements (weekly).

- The minimum detectable concentration is more sensitive if collected over a longer period (e.g., weekly) than a shorter period (e.g., daily) because of the increased sample volume.
- The RadNet system is a nationwide system that continuously monitors ambient environmental radiation levels and those resulting from major nuclear accidents, such as the Fukushima nuclear reactor incident in Japan. RadNet data are specifically used to inform the public, providing assurance if contamination levels are very low or helping to make science-based decisions about taking protective actions if contamination levels are high enough to warrant them.
- The RadNet air monitors include high volume systems with lower detection limits during short time periods (i.e., days) as contrasted with the INL Site low-volume air monitoring systems used for continuous monitoring.

Both INL Site routine monitoring programs (managed by the ESER and the INL Site contractors) detected ^{131}I on charcoal cartridges collected on March 23, 2011. The information was transmitted immediately to DOE-ID, who informed DOE Headquarters. In addition, the analytical laboratories were asked to expedite all analyses so that results could be quickly evaluated and shared. The ESER contractor also requested that air filters be analyzed on a weekly basis, rather than quarterly, to determine what gamma-emitting radionuclides, other than ^{131}I, were present in air.

DOE-ID began to coordinate a weekly information-sharing meeting which included representatives from each regional monitoring program affected (the ESER contractor, INL, the Idaho Cleanup Project, and the DEQ IOP). This group met until radionuclides associated with Fukushima were no longer routinely detectable. Information related to the INL Site and Fukushima was then placed on the INL website at https://inlportal.inl.gov/portal/server.pt/community/home/255/radiation_monitoring_info.

The data from routine monitoring were also shared and discussed with other INL Site scientists from USGS, NOAA, and the Shoshone-Bannock Tribes.

The effect of the airborne radioactive materials on human health was communicated to the public by DOE-ID and ESER contractor scientists via the local newspaper (Berg 2011). In addition, to better inform the public about the Fukushima incident and results of the INL site environmental monitoring programs, environmental monitoring staff from INL Site contractors and DOE-ID participated in two public INL Community Forum workshops conducted in Boise, Idaho, and Jackson, Wyoming, in May 2011.

B.3 Results

Results of environmental monitoring by EPA, the state of Idaho, and INL Site contractors during the period from mid-March through April 2011 are presented below.

B.3.1 Air

Radiodine (charcoal cartridges). Iodine-131 was the first radionuclide associated with the Fukushima accident that was detected by the RadNet system and by the DEQ IOP, ESER, and INL monitoring programs. Figure B-1 shows the ^{131}I concentrations detected in samples collected on and around the INL Site, as well at Boise, between March 16th and April 28th. Iodine-131 results for March 16 have a value of zero on the graph, indicating they were statistically "undetected." As shown in the graph, the ^{131}I results peaked around March 22-24, when detections were reported at all locations, and then trended downward. The maximum concentration, 0.77 pCi/m^3, was reported for a sample collected in Boise by an EPA RadNet deployable monitor on March 24. EPA declared this concentration to be "below a level of public health concern" (Tupin et al., 2012). The concentration was also below the DOE Derived Concentration Standard for ^{131}I (see Appendix A). The EPA ceased analyzing charcoal cartridges after April 8. The DEQ IOP and INL Site programs continued their weekly analyses of charcoal cartridges as part of their routine monitoring.

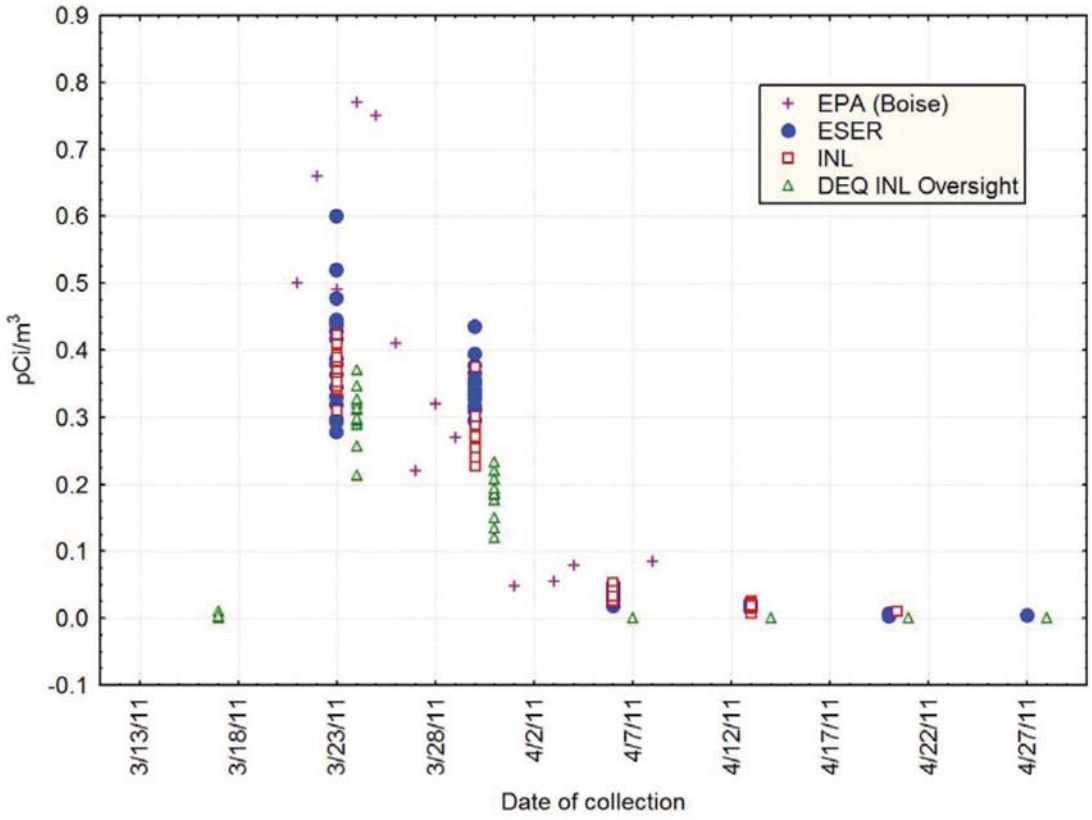

Figure B-1. Concentrations of ^{131}I Detected in Charcoal Cartridges Collected by INL Site Monitoring Contractors, the DEQ INL Oversight Program, and EPA in Boise. The INL Site and DEQ samples were collected weekly and the EPA samples collected more frequently (usually daily).

By the end of April radioiodine was detected at extremely low levels in only a few samples collected by the INL Site monitoring programs and DEQ IOP. By early May, radioiodine concentrations returned to values observed prior to the Fukushima event – that is, ^{131}I was statistically undetectable.

Gamma-emitting radionuclides (air filters). According to Shanks et al. (2012), nine key radionuclides, in terms of projected dose, were released during the Fukushima accident: barium-140, cerium-144, cesium-134 (^{134}Cs), cesium-137 (^{137}Cs), ^{131}I, strontium-89, strontium-90, and tellurium-129m (^{129m}Te). Of these, ^{134}Cs, ^{137}Cs, and ^{131}I were routinely detected by the EPA on air filters collected daily at Boise, and the air monitoring programs around the INL Site during the Fukushima fallout event. Tellurium-132, ^{132}I (a decay product of ^{132}Te), and ^{133}Xe were occasionally detected on a few filters. The detections occurred primarily during the last two weeks of March. Figure B-2 provides a weekly summary of the radionuclides detected by at least one of the air filters collected by INL Site environmental monitoring programs. All concentrations were well below DOE Derived Concentration Standards for those radionuclides (Appendix A).

Gross beta activity (air filters). Gross beta activity is routinely detected in air filters as naturally-occurring radionuclides are present in the environment. However, during the week

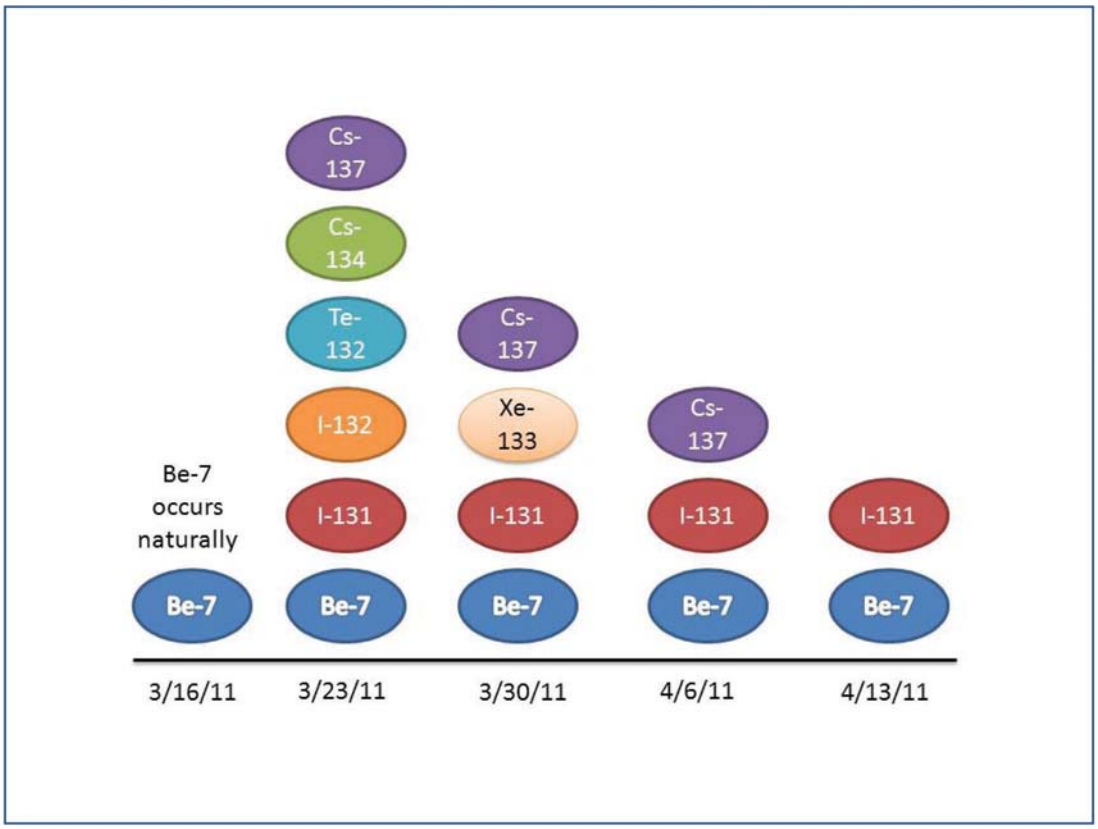

Figure B-2. Gamma-emitting Radionuclides Detected in INL Site Environmental Monitoring Program Air Filters.

ending on March 23, the concentrations were clearly elevated (see Figure B-3) when compared to previous weeks. The concentrations also appear to be elevated to a lesser extent during the week ending March 30. Iodine-131 decays with a half-life of eight days with beta, as well as gamma, emissions which could account for the elevated gross beta activity observed.

B.3.2 Precipitation

With EPA precipitation monitoring samples of rain from 15 states, including Idaho, detected trace concentrations of radioactive material. Elevated levels of radioactive material in rainwater were expected as a result of the Japanese nuclear incident because of contaminant transport in the atmosphere. Precipitation data collected in several states showed detectable levels of radionuclides, but these results remained well-below levels that could harm human health. Boise's levels (a maximum of 390 pCi/L of ^{131}I was observed in a sample collected on March 27) were higher than any other U.S. city and contained ^{134}Cs and ^{137}Cs. While short-term elevations

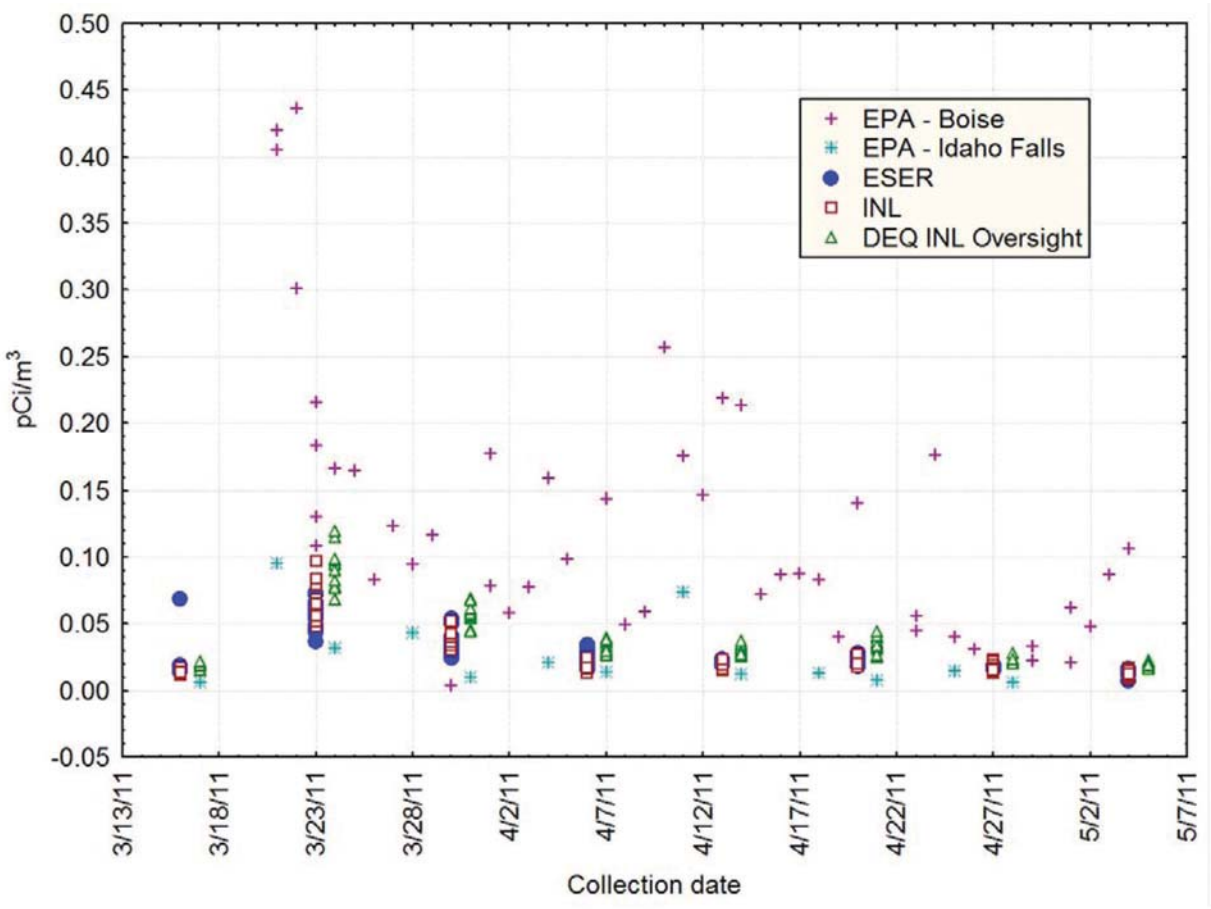

Figure B-3. Concentrations of Gross Beta Activity Detected in Airborne Particulate Material Collected by INL Site Monitoring Contractors, the DEQ INL Oversight Program, and EPA in Boise and Idaho Falls. The INL Site and DEQ samples were collected weekly and the EPA samples collected more frequently (usually daily in Boise and about every 3 days in Idaho Falls).

such as these did not raise public health concerns and the levels seen in rainwater were expected to be relatively short in duration - EPA took steps to increase the level of monitoring of precipitation, drinking water, and other potential exposure routes. After a thorough data review showing declining radiation levels in these samples, EPA returned to the routine RadNet sampling and analysis schedule for precipitation, drinking water, and milk in mid-April.

Portions of the rainwater collected at Idaho Falls on March 22 and 28 by the ESER contractor were analyzed for gamma-emitting radionuclides. Normally these samples are only analyzed for tritium. Radiodine was detected in both samples, with the highest concentration (275 pCi/L) in the second sample. Cesium-137 was also detected in both samples. The concentrations were below the DOE Derived Concentration Standards for Radiation Protection (see Appendix A).

B.3.3 Drinking Water

Drinking water samples from more than a dozen states, including Idaho, tested by the EPA also revealed trace amounts of radioactivity. Drinking water samples collected in Boise on March 28 showed results of 0.2 picocuries per liter while a sample collected from Idaho Falls showed no contamination. The drinking water collected in Boise came from a surface water source, while that in Idaho Falls came from a well. The EPA estimated a person would have to drink over 1,800 gallons of the Boise water to receive the equivalent radiation exposure we experience on a daily basis from natural sources in our environment. A follow-up sample collected on April 14 at Boise showed no detectable radionuclides.

The Idaho DEQ also tested water from 18 Idaho municipal water systems that use surface water for public drinking. The samples, which were collected the week of April 11, showed no detection of radionuclides.

B.3.4 Milk

The ESER contractor routinely monitors milk at locations around the INL Site. Radiodine from the Fukushima accident was detected in three milk samples during the period from March through May. One was a weekly sample collected on March 22 and the other two were monthly samples collected at the beginning of April and May. The results ranged from 5.1 to 14.3 pCi/L and were well below the Food and Drug Administration (FDA) derived intervention level of 4,700 pCi/L for milk. The highest concentration (14.3 pCi/L) was measured in milk co-sampled with the DEQ IOP at Fort Hall. DEQ IOP measured 13.4 pCi/L in their sample (see below).

The DEQ IOP collects milk samples at five locations (Howe, Fort Hall, Mud Lake, Gooding, and Riverside) on a monthly basis. Iodine-131 was detected in three samples, ranging from 3.1 to 13.4 pCi/L, collected during early April and May. The highest concentration was in a sample collected at the same location and time as the maximum ESER contractor sample. The two samples were produced at a family farm which owns two pasture-fed cows. Their water and feed were directly exposed to fallout from the Fukushima accident (i.e., their main source of nutrition was not stored).

B.4 Conclusions

The fallout from the Fukushima accident was detected in the vicinity of the INL Site beginning on March 22, 2011, and was observed in various media (air, precipitation, drinking water, and milk) through April and early May 2011. The evidence for Fukushima being the source of the radionuclides detected include:

- The radionuclides were identified at the source (the Fukushima Dai-ichi Nuclear Power Plant complex)
- The short-lived radionuclides, particularly ^{131}I, which has an 8-day half-life, are typically detected after a nuclear accident, but are not normally detected in southeast Idaho
- Other agencies (the state of Idaho DEQ and U.S. EPA) also detected these radionuclides in southeast Idaho, Boise, and across the United States contemporaneously
- The concentrations detected were consistent among agencies with relatively even distribution throughout the eastern Idaho sampling network.

The consistency of measurements was evaluated statistically using the INL and ESER contractor data collected on and around the INL Site. Both organizations collect air filters and cartridges on the same day of each week. Six of the locations are sampled in common. They are Blackfoot, Craters of the Moon, Rexburg, Idaho Falls, and the Experimental Field Station and Van Buren Gate at the INL Site. The weekly mean radioiodine concentrations measured in cartridges were compared graphically (Figure B-4) and using a paired t-test. The figure shows that the results are very close. The paired t-tests conclude that the mean radioiodine concentrations measured each week by the INL and ESER contractors were statistically the same. If the radioactivity had been released from an INL facility, the distribution would not have been uniform across the networks.

The concentrations of radionuclides detected were below all levels of concern established by DOE, EPA, and the FDA for protection of human health. Figures B-5 and B-6 illustrate this conclusion.

In conclusion, the Fukushima fallout event was of short duration. Radioiodine has a short half-life and decayed away within a month. Some of the ^{134}Cs and ^{137}Cs was probably deposited in the soil, but should not be distinguishable from what is already measured due to global fallout from past nuclear weapons testing. The radionuclides added to the environment and the food supply in southeast will not measurably increase individual cancer risks.

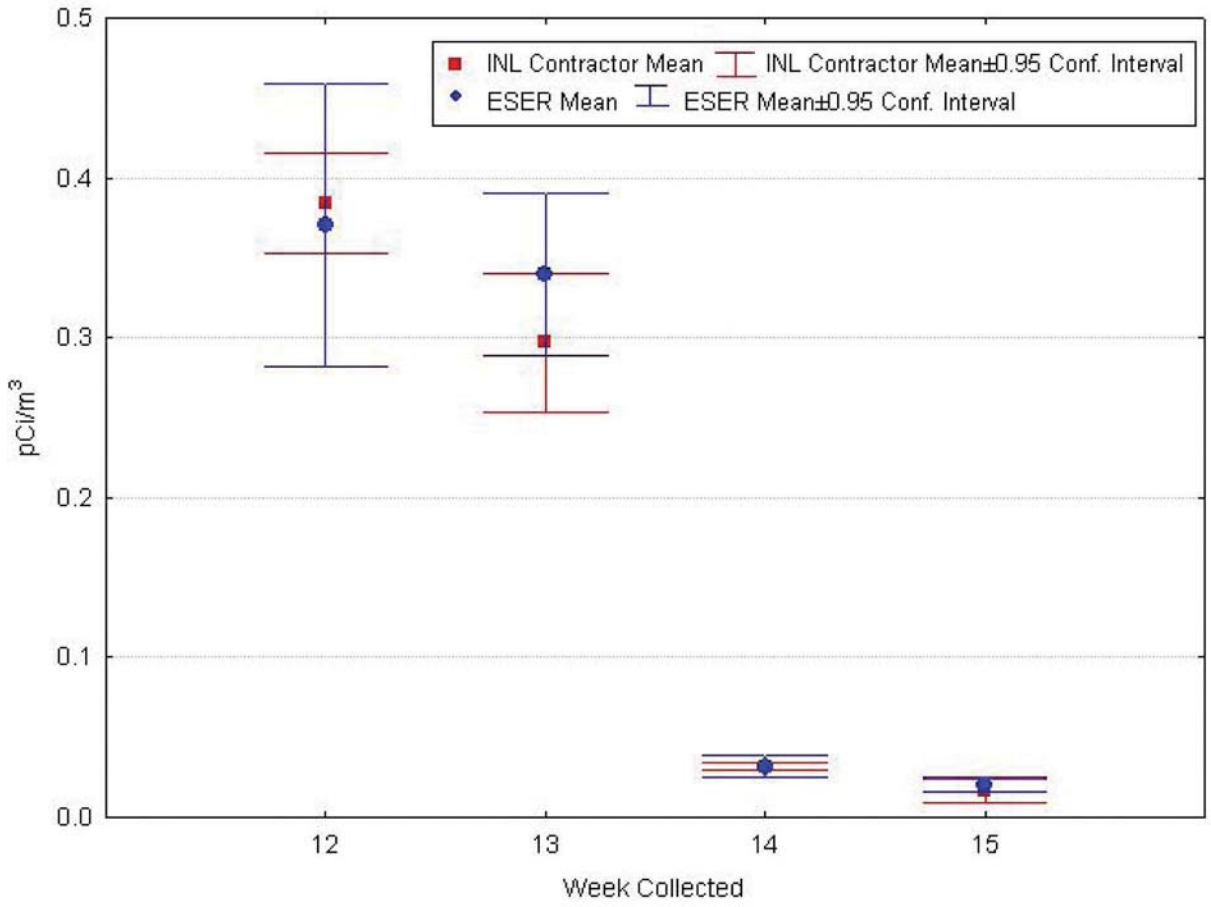

Figure B-4. Comparison of Mean ^{131}I Concentrations in Charcoal Cartridges Collected Weekly by the INL Monitoring Program Contractor and the ESER Contractor at the Same Locations During the Fukushima Incident. The locations are Blackfoot, Craters of the Moon, Rexburg, Idaho Falls, and the Experimental Field Station and Van Buren Gate at the INL Site. Week 12 corresponds to the sampling period from March 16th through March 23rd.

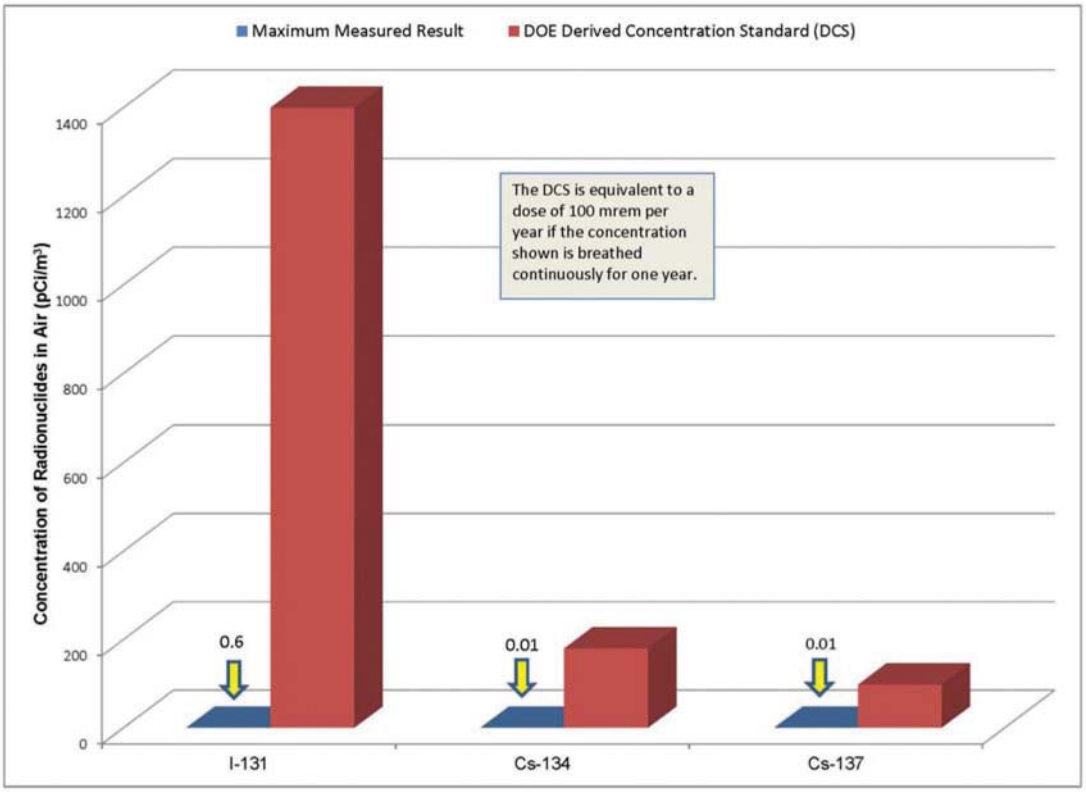

Figure B-5. Maximum Concentrations of Cesium-134, Cesium-137, and Radioiodine in Air Cartridges and Filters Collected Weekly by the ESER Contractor During the Period from March 16 through April 6, 2011. The DOE Derived Concentration Standards are shown for perspective (Appendix A).

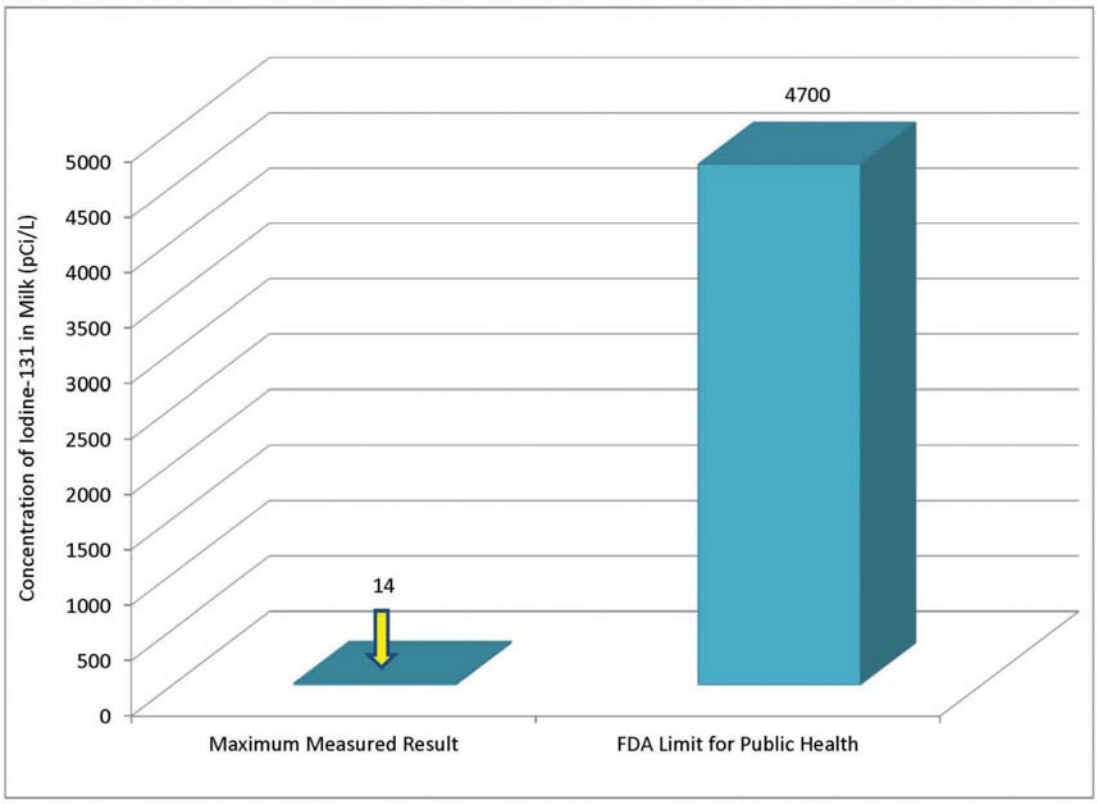

Figure B-6. Maximum Concentration of Radioiodine in Milk Samples Collected by the ESER Contractor. The FDA Derived Intervention Level for Milk is shown for perspective (http://www.fda.gov/downloads/NewsEvents/PublicHealthFocus/UCM251056.pdf)

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U.S. Department of Energy, 2011, DOE Standard Derived Concentration Technical Standard, DOE-STD-1196-2011, April 2011.

Appendix C. Chapter 5 Addendum

Table C-1. Central Facilities Area Sewage Treatment Facility Effluent Monitoring Results (2011).[a]

Parameter	Result of Sample Collected 8/9/11
Chemical oxygen demand (mg/L)	59.8
Coliform, total[b] (/100 mL)	16
Nitrogen, nitrate + nitrite (mg/L)	0.25 U[c]
pH[b]	9.59
Nitrogen, total Kjeldahl (mg/L)	1.99
Total dissolved solids (mg/L)	1,460
Total phosphorus (mg/L)	0.374

a. There are no permit limits for these parameters.
b. Grab sample.
c. U flag indicates the result was below the detection limit.

Table C-2. Advanced Test Reactor Complex Cold Waste Pond Effluent Monitoring Results (2011).

Parameter	Minimum	Maximum	Median
Arsenic (mg/L)	0.005 U[a]	0.0066	0.005 U
Barium (mg/L)	0.0466	0.150	0.0598
Cadmium	0.001 U	0.001 U	0.001 U
Chloride (mg/L)	10.2	35.5	19
Chromium (mg/L)	0.0028	0.0101	0.0044
Conductivity (µS/cm)	437	1,341	579
Cobalt	0.0025 U	0.0025 U	0.0025 U
Copper (mg/L)	0.001 U	0.0108	0.003
Fluoride (mg/L)	0.179	0.456	0.259
Iron (mg/L)	0.025 U	0.201	0.0896
Manganese (mg/L)	0.0025 U	0.0134	0.0025 U
Mercury	0.0002 U	0.0002 U	0.0002 U
Nitrogen, nitrate + nitrite (mg-N/L)	0.848	2.82	1.24
Nitrogen, total Kjeldahl (mg/L)	0.136	0.614	0.239
Selenium (mg/L)	0.001	0.0048	0.0019
Silver	0.005 U	0.005 U	0.005 U
Sulfate (mg/L)	21.2	477	128
Total dissolved solids (mg/L)	241	970	411
Total suspended solids (mg/L)	4 U	4 U	4 U

a. U flag indicates the result was below the detection limit.

Table C-3. Advanced Test Reactor Complex Cold Waste Pond Industrial Wastewater Reuse Permit Monitoring Well Results (2011).

WELL NAME	USGS-065		TRA-07		USGS-076		TRA-08		Middle-1823		PCS/SCS[a]
Sample Date	04/06/11	10/11/11	04/06/11	10/12/11	04/05/11	10/12/11	04/06/11	10/11/11	04/05/11	10/12/11	
pH	8.1	8.13	8.18	7.97	8.05	7.94	8.03	8.1	8.08	8.02	6.5 to 8.5
Total Kjeldahl nitrogen (mg/L)	0.129	0.1 U[b]	0.141	0.253	0.147 [0.1 U][c]	0.117	0.114	0.235	0.142	0.191	NA[d]
Nitrite nitrogen (mg/L)	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U [0.05 U]	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	1
Nitrate nitrogen (mg/L)	1.48	1.39	1.12	1.12	1.05 [1.05]	1.06	1.02	0.975	0.985	0.935	10
Total dissolved solids (mg/L)	439	423	444	432	274 [292]	266	289	284	272	263	500
Aluminum (mg/L)	0.0037 (0.0032)[e]	0.0082 (0.0037)	**0.527**[f] (0.0054)	**5.620** (0.0106)	0.0035 [0.0035] (0.0039) ([0.0033])	0.0044 (0.0046)	**1.910** (0.0178)	**4.270** (0.0183)	0.117 (0.0023)	0.102 (0.0027)	0.2
Antimony (mg/L)	0.0004 U	0.0004 U	0.0004 U	0.0004 U	0.0004 U [0.0004 U]	0.0004 U	0.0004 U	0.0004 U	0.0004 U	0.0004 U	0.006
Arsenic (mg/L)	0.00061	0.0005 U	0.0006	0.0015	0.0017 [0.0013]	0.0014	0.0014	0.0013	0.0019	0.0014	0.05
Barium (mg/L)	0.0437	0.0438	0.0713	0.125	0.0693 [0.0692]	0.0676	0.0807	0.105	0.0614	0.0596	2
Cadmium (mg/L)	0.00025 U	0.00025 U	0.00025 U	0.00025 U	0.00025 U [0.00025 U]	0.00025 U	0.00025 U	0.00025 U	0.00025 U	0.00025 U	0.005
Chloride (mg/L)	19.4	18.7	20.1	21.5	13.7 [13.7]	14.8	11.7	12.3	11.6	12.1	250
Cobalt (mg/L)	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.0025 U [0.0025 U]	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.0025 U	NA
Copper (mg/L)	0.0025 U	0.0025 U	0.0302	0.0240	0.0092 [0.0146]	0.0025 U	0.0205	0.0092	0.104	0.0025 U	1.3
Fluoride (mg/L)	0.242	0.217	0.236	0.210	0.16 [0.164]	0.179	0.219	0.200	0.162	0.173	4
Iron (mg/L)	0.050 U (0.050 U)	0.119 (0.0554)	**0.654** (0.0536)	**3.360** (0.050 U)	0.105 [0.134] (0.050 U) ([0.050 U])	0.050 U (0.050 U)	**1.110** (0.050 U)	**1.540** (0.050 U)	0.0946 (0.050 U)	0.050 U (0.050 U)	0.3
Manganese (mg/L)	0.0025 U (0.0025 U)	0.0025 U (0.0025 U)	0.0091 (0.006)	**0.0508** (0.0025 U)	0.0025 U [0.0025 U] (0.0025 U) ([0.0025 U])	0.0025 U (0.0025 U)	0.020 (0.0025 U)	0.0309 (0.0025 U)	0.0032 (0.0075)	0.0032 (0.0025 U)	0.05

Table C-3. Advanced Test Reactor Complex Cold Waste Pond Industrial Wastewater Reuse Permit Monitoring Well Results (2011) (continued).

WELL NAME	USGS-065		TRA-07		USGS-076		TRA-08		Middle-1823		PCS/SCS[a]
Sample Date	04/06/11	10/11/11	04/06/11	10/12/11	04/05/11	10/12/11	04/06/11	10/11/11	04/05/11	10/12/11	
Mercury (mg/L)	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U [0.0002 U]	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.002
Selenium (mg/L)	0.0016	0.0020	0.0011	0.0019	0.0012 [0.0012]	0.0014	0.00086	0.0013	0.0011	0.0014	0.05
Silver (mg/L)	0.005 U (0.005 U)	0.005 U (0.005 U)	0.005 U (0.005 U)	0.005 U (0.005 U)	0.005 U [0.005 U] (0.005 U) ([0.005 U])	0.005 U (0.005 U)	0.005 U (0.005 U)	0.005 U (0.005 U)	0.005 U (0.005 U)	0.005 U (0.005 U)	0.1
Sulfate (mg/L)	160	162	154	158	32.3 [32.7]	32.8	49.9	49.7	34.4	34.6	250

a. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in the Ground Water Quality Rule, IDAPA 58.01.11.200.01.a and b.

b. U flag indicates that the result was reported as below the instrument detection limit by the analytical laboratory.

c. Values shown in brackets are the results from field duplicate samples.

d. NA- Not applicable.

e. Results shown in parentheses are from filtered samples used for comparison with the SCS.

f. Concentrations shown in bold are above the Ground Water Quality Rule SCS. Filtered sample results, shown in parentheses, are used for permit compliance determinations for these constituents and the results are below the SCS.

Table C-4. Idaho Nuclear Technology and Engineering Center Sewage Treatment Plant Influent Monitoring Results at CPP-769 (2011).[a]

Parameter	Minimum	Maximum	Average[b]
Biochemical oxygen demand (5-day) (mg/L)	183	592	315
Nitrate + nitrite, as nitrogen (mg/L)	0.025[c]	0.694	0.192
Total Kjeldahl nitrogen (mg/L)	61.6	149	103
Total phosphorus (mg/L)	5.64	10.50	8.64
Total suspended solids (mg/L)	100	995	262

a. Duplicate samples were collected in May for all parameters. Duplicate results are included in the summaries.
b. Annual average is determined from the average of the monthly values.
c. Sample result was less than the detection limit; value shown is half the detection limit.

Table C-5. Idaho Nuclear Technology and Engineering Center Sewage Treatment Plant Effluent Monitoring Results at CPP-773 (2011).[a]

Parameter	Minimum	Maximum	Average[b]
Biochemical oxygen demand (5-day) (mg/L)	7.82	48.7	24.7
Chloride (mg/L)	197	483	356
Conductivity (µS/cm) (composite)	1,444	2,430	1,875
Nitrate + nitrite, as nitrogen (mg/L)	1.29	14.5	7.00
pH (standard units) (grab)	7.59	8.91	8.04
Sodium (mg/L)	134	299	227
Total coliform (colonies/100 mL)	270	6,600	2,941
Total dissolved solids (mg/L)	735	1,100	956
Total Kjeldahl nitrogen (mg/L)	8.34	72.2	37.0
Total phosphorus (mg/L)	3.82	11.3	7.48
Total suspended solids (mg/L)	2[c]	55.1	21.3

a. Duplicate samples were collected in May for all parameters (excluding conductivity, pH, and total coliform), and the duplicate results are included in the summaries.
b. Annual average is determined from the average of the monthly values. Half the reported detection limit was used in any calculation for those data reported as below the detection limit.
c. Sample result was less than the detection limit; value shown is half the detection limit.

Table C-6. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Effluent Monitoring Results at CPP-797 (2011)[a]

Parameter	Minimum	Maximum	Average[b]
Aluminum (mg/L)	0.0125[c]	0.0269	0.0146
Arsenic (mg/L)	0.00125[c]	0.0034	0.0017
Biochemical oxygen demand (5-day) (mg/L)	1.0[c]	9.43	4.24
Cadmium (mg/L)	0.0005[c]	0.0005[c]	0.0005[d]
Chloride (mg/L)	21.4	51.0	30.5
Chromium	0.0032	0.0084	0.0052
Conductivity (µS/cm) (composite)	415	599	460
Copper (mg/L)	0.0033	0.0080	0.0054
Fluoride (mg/L)	0.193	0.268	0.242
Iron (mg/L)	0.0125[c]	0.132	0.0648
Manganese (mg/L)	0.00125[c]	0.0055	0.0024
Mercury (mg/L)	0.0001[c]	0.0001[c]	0.0001[d]
Nitrate + nitrite, as nitrogen (mg/L)	1.10	3.06	2.02
pH (grab)	6.76	8.32	7.90
Selenium (mg/L)	0.0010	0.0015	0.0013
Silver (mg/L)	0.0025[c]	0.0025[c]	0.0025[d]
Sodium (mg/L)	14.2	34.7	22.5
Total coliform (colonies/100 mL)	6	46	20
Total dissolved solids (mg/L)	254	348	286
Total Kjeldahl nitrogen (mg/L)	0.294	3.88	1.23
Total nitrogen[e] (mg/L)	1.61	6.94	3.24
Total phosphorus (mg/L)	0.376	1.25	0.887
Total suspended solids (mg/L)	2.0[c]	9.3	2.8

a. Duplicate samples were collected in May for all parameters ,except for biochemical oxygen demand (5-day) and total suspended solids, which were collected in June (excluding conductivity, pH, and total coliform), and the duplicate results are included in the summaries.
b. Annual average is determined from the average of the monthly values. Half the reported detection limit was used in the yearly average calculation for those data reported as below the detection limit.
c. Sample result was less than the detection limit; value shown is half the detection limit.
d. All the results were less than the detection limit. Therefore, the average is based on half the reported detection limit from each of the monthly values.
e. Total nitrogen is calculated as the sum of total Kjeldahl nitrogen and nitrate + nitrite, as nitrogen.

Table C-7. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Aquifer Monitoring Well Groundwater Results (2011).

	ICPP-MON-A-167 (GW-013005)		ICPP-MON-A-165 (GW-013006)			ICPP-MON-A-166 (GW-013007)		ICPP-MON-A-164B[a]		PCS/SCS[b]
Sample date	4/20/2011	10/5/2011	4/19/2011	10/3/2011	10/3/2011[c]	4/18/2011	10/3/2011	4/20/2011	10/4/2011	
Water table depth (below ground surface in ft)	500.17	500.2	503.04	503.32	503.32	509.39	510.52	502.02	503.97	NA[d]
Water table elevation (above mean sea level in ft)[e]	4,450.04	4,450.01	4,449.96	4449.68	4449.68	4,450.10	4,448.97	4,450.20	4,448.25	NA
Aluminum (mg/L)	101[f] (0.247)[f, g]	121[f] (2.5)[f]	0.0250 U[h] (0.0250 U)	0.0250 U (0.0250 U)	0.0250 U (0.0250 U)	0.0718 (0.0250 U)	0.113 (0.0250 U)	0.0250 U (0.0250 U)	0.0461 (0.0250 U)	0.2
Arsenic (mg/L)	0.0050 U (0.0025 U)	0.0029 (0.0012)	0.0025 U (0.0025 U)	0.0010 (0.00095)	0.0011 (0.00094)	0.0025 U (0.0025 U)	0.0016 (0.0017)	0.0025 U (0.0025 U)	0.0011 (0.0014)	0.05
Biochemical oxygen demand (mg/L)	2.0 U	6.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.08	2.0 U	NA
Cadmium (mg/L)	0.0025 U (0.0025 U)	0.0025 U (0.0025 U)	0.0025 U (0.0025 U)	0.0025 U (0.0025 U)	0.0025 U (0.0025 U)	0.0025 U (0.0025 U)	0.0025 U (0.0025 U)	0.0025 U (0.0025 U)	0.0025 U (0.0025 U)	0.005
Chloride (mg/L)	10.7	10.1	45.3	43.0	43.1	8.28	8.44	9.43	10.4	250
Chromium (mg/L)	0.0839 (0.0025 U)	0.0779 (0.0028)	0.0135 (0.0077)	0.0122 (0.0085)	0.0120 (0.0082)	0.0058 (0.0051)	0.0057 (0.0049)	0.0097 (0.0095)	0.0106 (0.0096)	0.1
Coliform, fecal (colonies/100 mL)	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	NA
Coliform, total (colonies/100 mL)	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	1 col/100 mL
Copper (mg/L)	0.254 (0.0050 U)	0.282 (0.0078)	0.0050 U (0.0050 U)	0.0050 U (0.0050 U)	0.0050 U 0.0050 U)	0.0050 U (0.0050 U)	0.0050 U (0.0050 U)	0.0050 U (0.0050 U)	0.0050 U (0.0050 U)	1.3
Fluoride (mg/L)	0.271	0.241	0.240	0.215	0.212	0.301	0.278	0.229	0.201	4
Iron (mg/L)	88.6[f] (0.180)	85.2[f] (1.49)[f]	0.0668 (0.0627)	0.0500 U (0.0500 U)	0.0500 U (0.0500 U)	0.0950 (0.0500 U)	0.110 (0.0500 U)	0.0500 U (0.0500 U)	0.0500 U (0.0500 U)	0.3
Manganese (mg/L)	1.370[f] (0.0261)	1.29[f] (0.0468)	0.0025 U (0.0025 U)	0.0025 U (0.0025 U)	0.0025 U (0.0025 U)	0.0246 (0.0209)	0.0257 (0.0252)	0.0025 U (0.0025 U)	0.0025 U (0.0025 U)	0.05
Mercury (mg/L)	0.00020 U (0.00020 U)	0.00020 U (0.00020 U)	0.00020 U (0.00020 U)	0.00020 U (0.00020 U)	0.00020 U (0.00020 U)	0.00020 U (0.00020 U)	0.00020 U (0.00020 U)	0.00020 U (0.00020 U)	0.00020 U (0.00020 U)	0.002
Nitrate, as nitrogen (mg/L)	0.388	0.331	0.964	0.948	0.941	0.263	0.246	0.754	0.771	10
Nitrite, as nitrogen (mg/L)	0.0500 U	0.0500 U	0.0500 U	0.0500 U	0.0500 U	0.0500 U	0.0500 U	0.0500 U	0.0500 U	1
pH	8.19	8.04	7.85	7.60	7.60	7.59	7.63	7.92	7.65	6.5–8.5
Selenium (mg/L)	0.0023 (0.00061)	0.0025 (0.00084)	0.00082 (0.00081)	0.0012 (0.0012)	0.0012 (0.0011)	0.00053 (0.00052)	0.00069 (0.00066)	0.00075 (0.00074)	0.0010 (0.0011)	0.05
Silver (mg/L)	0.0050 U (0.0050 U)	0.0050 U (0.0050 U)	0.0050 U (0.0050 U)	0.0050 U (0.0050 U)	0.0050 U (0.0050 U)	0.0050 U (0.0050 U)	0.0050 U (0.0050 U)	0.0050 U (0.0050 U)	0.0050 U (0.0050 U)	0.1
Sodium (mg/L)	41.6 (24.2)	37.6 (18.7)	16.2 (16.3)	15.4 (15.5)	15.5 (15.8)	8.9 (10.7)	8.76 (9.0)	8.76 (8.66)	8.66 (8.78)	NA
Total dissolved solids (mg/L)	237	243	313	315	325	203	203	222	259	500
Total Kjeldahl nitrogen (mg/L)	1.01	0.846	0.209	0.100 U	0.198	0.100 U	0.133	0.174	0.114	NA
Total phosphorus (mg/L)	8.21	6.19	0.0207	0.0217	0.0225	0.0259	0.0271	0.0212	0.149	NA

a. Well ICPP-MON-A-164B is an additional upgradient aquifer monitoring well. The permit renewal application proposed replacing Well ICPP-MON-A-167 with Well ICPP-MON-A-164B.
b. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in Idaho Administrative Procedures Act 58.01.11.200.01.a and b.
c. Duplicate sample.
d. NA—Not applicable.
e. Water level elevations referenced to North American Vertical Datum of 1988 (NAVD 88).
f. Exceedance of groundwater quality standard. ICPP-MON-A-167 is an upgradient, noncompliance point, and is outside the zone of influence of the New Percolation Ponds. Therefore, exceedances in this well are not considered permit noncompliances.
g. Sample results in parentheses are from filtered metals sample.
h. U flag indicates the result was reported as below the detection/reporting limit.

Table C-8. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Perched Water Monitoring Well Groundwater Results (2011).

	ICPP-MON-V-191 (GW-013008)			ICPP-MON-V-200 (GW-013009)		ICPP-MON-V-212 (GW-013010)			PCS/SCS[a]
Sample date	April 2011	7/6/2011	October 2011	4/18/2011	10/4/2011	4/19/2011	4/19/2011[b]	10/5/2011	
Water table depth (below ground surface in ft)	Dry[c]	109.49	Dry	113.75	113.19	236.34	236.34	236.07	NA[d]
Water table elevation (above mean sea level in ft)[e]	—	4,838.47	—	4,838.27	4,839.83	4,722.04	4,722.04	4,722.31	NA
Aluminum (mg/L)	—	1.270[f] (0.505)[f g]	—,	0.0318 (0.0250 U[h])	0.105 (0.0250 U)	**0.250** (0.0250 U)	**0.270** (0.0250 U)	**0.354** (0.0250 U)	0.2
Arsenic (mg/L)	—	0.0011 (0.00060)	—	0.0058 (0.0063)	0.0058 (0.0060)	0.0025 U (0.0025 U)	0.0025 U (0.0025 U)	0.0016 (0.0014)	0.05
Biochemical oxygen demand (mg/L)	—	2.87	—	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	NA
Cadmium (mg/L)	—	0.0025 U (0.0025 U)	—	0.0025 U (0.0025 U)	0.0025 U (0.0025 U)	0.0025 U (0.0025 U)	0.0025 U (0.0025 U)	0.0025 U (0.0025 U)	0.005
Chloride (mg/L)	—	3.59	—	55.4	36.2	112	113	82.4	250
Chromium (mg/L)	—	0.0042 (0.0025 U)	—	0.0050 (0.0043)	0.0079 (0.0058)	0.0054 (0.0046)	0.0053 (0.0043)	0.0057 (0.0042)	0.1
Coliform, fecal (colonies/100 mL)	—	Absent	—	Absent	Absent	Absent	Absent	Absent	NA
Coliform, total (colonies/100 mL)	—	Absent	—	Absent	Absent	Absent	Absent	Absent	1 col/100 mL
Copper (mg/L)	—	0.0078 (0.0050 U)	—	0.0050 U (0.0050 U)	0.0050 U (0.0050 U)	0.0050 U (0.0050 U)	0.0050 U (0.0050 U)	0.0050 U (0.0050 U)	1.3
Fluoride (mg/L)	—	0.250	—	0.266	0.245	0.268	0.274	0.260	4
Iron (mg/L)	—	1.230[f] (0.454)[f]	—	0.0658 (0.0500 U)	0.174 (0.0500 U)	**0.459** (0.0500 U)	**0.509** (0.0500 U)	**0.849** (0.0500 U)	0.3
Manganese (mg/L)	—	0.114[f] (0.0397)	—	0.0025 U (0.0025 U)	0.0077 (0.0025 U)	0.0042 (0.0025 U)	0.0047 (0.0025 U)	0.0081 (0.0025 U)	0.05
Mercury (mg/L)	—	0.00020 U (0.00020 U)	—	0.00020 U (0.00020 U)	0.00020 U (0.00020 U)	0.00020 U (0.00020 U)	0.00020 U (0.00020 U)	0.00020 U (0.00020 U)	0.002
Nitrate, as nitrogen (mg/L)	—	0.464	—	3.39	2.33	3.26	3.26	2.41	10
Nitrite, as nitrogen (mg/L)	—	0.0500 U	—	0.0500 U	0.0500 U	0.0500 U	0.0500 U	0.0500 U	1
pH	—	7.36	—	7.68	7.46	7.77	7.77	7.55	6.5–8.5
Selenium (mg/L)	—	0.0012 (0.0013)	—	0.00081 (0.00085)	0.0014 (0.0014)	0.00081 (0.00083)	0.00082 (0.00081)	0.0013 (0.0013)	0.05
Silver (mg/L)	—	0.0050 U (0.0050 U)	—	0.0050 U (0.0050 U)	0.0050 U (0.0050 U)	0.0050 U (0.0050 U)	0.0050 U (0.0050 U)	0.0050 U (0.0050 U)	0.1
Sodium (mg/L)	—	9.36 (9.84)	—	54.6 (55.6)	40.0 (40.8)	63.4 (64.2)	64.2 (62.8)	53.2 (55.2)	NA
Total dissolved solids (mg/L)	—	284	—	344	296	437	454	384	500
Total Kjeldahl nitrogen (mg/L)	—	1.53	—	0.321	0.207	0.404	0.492	0.187	NA
Total phosphorus (mg/L)	—	0.164	—	0.0998	0.118	0.0509	0.0389	0.0536	NA

a. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in Idaho Administrative Procedures Act 58.01.11.200.01.a and b.
b. Duplicate sample.
c. ICPP-MON-V-191 was dry in April 2011 and October 2011.
d. NA—Not applicable.
e. Water level elevations referenced to North American Vertical Datum of 1988 (NAVD 88).
f. **Bold** = Exceedance of groundwater quality standard. Well ICPP-MON-V-191 is an upgradient, noncompliance point, and is outside the zone of influence of the New Percolation Ponds. Therefore, exceedances in this well are not considered permit noncompliances.
g. Sample results in parentheses are from filtered metals sample.
h. U flag indicates the result was below the detection limit.

Table C-9. Materials and Fuels Complex Industrial Waste Pipeline Monitoring Results (2011).

Parameter	Minimum	Maximum	Median
Arsenic (mg/L)	0.0025 U[a]	0.0036	0.0025 U
Barium (mg/L)	0.033	0.040	0.0356
Cadmium (mg/L)	0.001 U	0.001 U	0.001 U
Chloride (mg/L)	21	88.1	58.6
Chromium (mg/L)	0.0025 U	0.0031	0.0025 U
Fluoride (mg/L)	0.585	0.676	0.629
Lead (mg/L)	0.00025 U	0.0012	0.00029
Mercury (mg/L)	0.0002 U	0.0002 U	0.0002 U
Nitrogen, nitrate + nitrite (mg-N/L)	1.8	2.38	2.04
Nitrogen, total Kjeldahl (mg/L)	0.206	1.49	0.553
pH	8.3	8.64	8.44
Phosphorus, total	0.0995	0.435	0.247
Selenium (mg/L)	0.0005 U	0.0039	0.00062
Silver (mg/L)	0.005 U	0.005 U	0.005 U
Sulfate (mg/L)	16.6	21.7	17.8
Total dissolved solids (mg/L)	247	376	317
Zinc (mg/L)	0.0073	0.0212	0.0106

a. U flag indicates the result was below the detection limit.

Table C-10. Materials and Fuels Complex Industrial Waste Water Underground Pipe Monitoring Results (2011).

Parameter	Minimum	Maximum	Median
Arsenic (mg/L)	0.0036	0.0052	0.004
Barium (mg/L)	0.058	0.135	0.0746
Cadmium (mg/L)	0.001 U[a]	0.001 U	0.001 U
Chloride (mg/L)	40.3	49.6	41.6
Chromium (mg/L)	0.003	0.0094	0.0033
Fluoride (mg/L)	1.2	1.78	1.28
Lead (mg/L)	0.00039	0.0034	0.00068
Mercury (mg/L)	0.0002 U	0.0002 U	0.0002 U
Nitrogen, nitrate + nitrite (mg-N/L)	3.75	4.99	4.01
Nitrogen, total Kjeldahl (mg/L)	0.623	0.94	0.783
pH	8.19	8.7	8.3
Phosphorus, total	0.658	1.13	1.03
Selenium (mg/L)	0.0011	0.0015	0.0012
Silver (mg/L)	0.005 U	0.005 U	0.005 U
Sulfate (mg/L)	34.7	43.1	35.3
Total dissolved solids (mg/L)	437	625	504
Zinc (mg/L)	0.0268	0.0582	0.0508

a. U flag indicates the result was below the detection limit.

Table C-11. Summary of Groundwater Quality Data Collected for the Wastewater Reuse Permit for the MFC Industrial Waste Ditch and Pond.

WELL NAME	ANL-MON-A-012 (GW-016001)		ANL-MON-A-013 (GW-016002)		ANL-MON-A-014 (GW-016003)		PCS/SCS[a]
Sample Date	04/27/2011	09/28/2011	04/27/2011	09/28/2011	04/27/2011	09/28/2011	
pH	8.34	8.32	8.26	8.14	8.29	8.09	6.5 to 8.5 (SCS)
Temperature	13.7	13.2	13.0	13.2	12.5	13.8	None
Conductivity (µS/cm)	366	369	378	380	373	374	None
Nitrate nitrogen (mg/L)	1.95	1.84	2.05	1.91	2.04	1.88	10 (PCS)
Phosphorus (mg/L)	0.0121	0.0143	0.0235	0.0157	0.0115	0.0185	None
Total dissolved solids (mg/L)	253	239	265	232	262	232	500 (SCS)
Sulfate (mg/L)	16.3	16.3	19.4	18.4	18.1	17.2	250 (SCS)
Arsenic (µg/L)	2.0	1.5	2.2	1.7	2.0	1.5	50 (PCS)
Barium (µg/L)	39.6	37.5	37.5	35.7	36.8	35.6	2000 (PCS)
Cadmium (µg/L)	0.25 U[b]	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	5 (PCS)
Chloride (mg/L)	17.0	17.8	18.7	18.2	18.4	18.5	250 (SCS)
Chromium (µg/L)	2.5 U	2.5	8	2.5 U	4.6	3.8	100 (PCS)
Iron (µg/L)	73.5 (50 U)	50 U (50 U)	**459**[c] (52)	122 (50 U)	119 (50 U)	65.3 (50 U)	300 (SCS)
Lead (µg/L)	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	15 (PCS)
Manganese (µg/L)	2.5 U (2.5 U)	2.5 U (2.5 U)	7.7 (2.5 U)	3.5 (2.5 U)	2.5 U (2.5 U)	2.5 U 2.5 U	50 (SCS)
Mercury (µg/L)	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	2 (PCS)
Selenium (µg/L)	0.56	0.59	0.54	0.50 U	0.73	0.53	50 (PCS)
Silver (µg/L)	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	100 (SCS)
Sodium (µg/L)	18000	16700	19400	17500	18100	16600	None
Zinc (µg/L)	2.8	2.5 U	3.3	2.5 U	2.5 U	2.5 U	5000 (SCS)

a. Primary Constituent Standard (PCS) or Secondary Constituent Standard (SCS) from IDAPA 58.01.11 (Ground Water Quality Rule).
b. U flag indicates the result was reported as below the instrument detection limit by the analytical laboratory.
c. Concentrations shown in bold are above the Ground Water Quality Rule SCS. Filtered sample results, shown in parentheses, are below the SCS.

Table C-12. Advanced Test Reactor Complex Cold Waste Pond Results (2011).[a]

Parameter	Minimum	Maximum	Median
Antimony (mg/L)	0.00025 U[b]	0.0013	0.00037
Gross alpha (pCi/L ± 1s)	0.336 ± 0.501 U	2.98 ± 0.798	Not calculated
Gross beta (pCi/L ± 1s)	0.0677 ± 1.08 U	21.6 ± 2.12	Not calculated
pH (standard units)	7.96	8.53	8.17
Potassium-40 (pCi/L ± 1s)	-17.3 ± 10.4 U	39.7 ± 9.14	Not calculated
Sodium (mg/L)	8.06	32.8	13.7
Zinc	0.0025 U	0.0027	0.0025 U

a. Only parameters with at least one detected result are shown.
b. U flag indicates the result was below the detection limit.

Table C-13. Radioactivity detected in groundwater samples collected at the Advanced Test Reactor Complex (2011).

Monitoring Well	Sample Date	Parameter	Sample Result (pCi/L)
USGS-065	04/06/11	Gross Alpha	2.83 (± 1.09)[a]
		Gross Beta	7.54 (± 1.52)
		Tritium	4,280 (± 450)
	10/11/11	Gross Alpha	4.28 (± 1.15)
		Gross Beta	4.71 (± 1.23)
		Tritium	4,230 (± 455)
TRA-07	04/06/11	Gross Alpha	2.43 (± 0.939)
		Gross beta	13.7 (± 1.88)
		Tritium	8,750 (± 888)
	10/12/11	Gross Alpha	7.52 (± 1.7)
		Gross Beta	9.08 (± 1.51)
		Cobalt-60	4.74 (± 1.05)
		Tritium	8,810 (± 902)
TRA-08	04/06/11	Gross Alpha	4.33 (± 1.36)
		Gross Beta	4.09 (± 1.33)
		Tritium	1,500 (± 185)
	10/11/11	Gross Alpha	4.38 (± 1.18)
		Gross Beta	4.36 (± 1.16)
		Tritium	1,420 (± 191)
USGS-076	04/05/11	Gross Alpha	ND[b] 5.7[c] (± 1.12)
		Gross Beta	ND 6.11[c] (± 0.992)
		Tritium	519 (± 100) 548[c] (± 105)
	10/12/11	Gross Alpha	2.44 (± 0.935)
		Gross Beta	3.27 (± 1)
		Tritium	751 (± 138)
Middle-1823	04/05/11	Gross Alpha	1.56 (± 0.575)
		Tritium	976 (± 139)
	10/12/11	Gross Alpha	2.92 (± 1.04)
		Tritium	1,070 (± 162)

a. One sigma uncertainty shown in parentheses.
b. ND – Not detected.
c. Analytical result from field duplicate sample collected on April 5, 2011.

Table C-14. Surveillance Monitoring Results for Effluent from CFA Sewage Treatment Plant to Pivot Irrigation System (August 2011).[a]

Parameter	Result
Chloride (mg/L)	599
Fluoride (mg/L)	0.395
Sulfate (mg/L)	87.4
Barium (mg/L)	0.0664
Copper (mg/L)	0.0011
Iron (mg/L)	0.0706
Manganese (mg/L)	0.0031
Selenium (mg/L)	0.0012
Sodium (mg/L)	254
Gross beta (pCi/L ± 1s)	13.1 ± 2.07
Iodine-129 (pCi/L ± 1s)	0.193 ± 0.07
Tritium (pCi/L ± 1s)	1,950 ± 275

Table C-15. Liquid Influent and Effluent and Groundwater Surveillance Monitoring Results for Idaho Nuclear Technology and Engineering Center (2011).

Parameter[a]	Minimum	Maximum	Average[b]
Influent to INTEC Sewage Treatment Plant (CPP-769)			
Conductivity (µS/cm) (grab)	854	8,620	1,728
pH (standard units) (grab)	7.84	8.91	8.47
Effluent from INTEC Sewage Treatment Plant (CPP-773)			
Conductivity (µS/cm) (grab)	1,389	2,390	1,864
Gross beta (pCi/L ± 2s uncertainty)	21.3 ± 4.98	37.7 ± 6.90	29.3 ± 3.44
pH (standard units) (composite)	7.85	8.73	8.20
Effluent to INTEC New Percolation Ponds (CPP-797)			
Conductivity (µS/cm) (grab)	396	509	427
Gross alpha (pCi/L ± 2s uncertainty)	-0.15 ± 1.38[c]	4.62 ± 2.36	1.70 ± 0.60
Gross beta (pCi/L ± 2s uncertainty)	4.55 ± 2.46	10.5 ± 3.28	5.96 ± 0.84
pH (standard units) (composite)	6.91	8.11	7.81
Groundwater at INTEC New Percolation Ponds			
Gross alpha (pCi/L ± 2s uncertainty)	0.10 ± 0.39[c]	4.48 ± 0.95	1.76 ± 0.19
Gross beta (pCi/L ± 2s uncertainty)	1.30 ± 0.61	24.1 ± 3.06	2.39 ± 0.24

a. Only parameters with at least one detected result are shown.
b. For nonradiological parameters, half the reported detection limit is used in the average calculation for those data reported as below detection. Radiological average calculations are weighted by uncertainty.
c. Result was a statistical nondetect.

Table C-16. Monitoring Results for Material and Fuels Complex Industrial Waste Pond (2011).[a]

Parameter	Minimum	Maximum	Median
Potassium-40 (pCi/L ± 1s)	-10.1 ± 8.68 U[c]	41.8 ± 12.2	Not calculated
Gross alpha (pCi/L ± 1s)	0.937 ± 0.536 U	1.78 ± 0.456	Not calculated
Gross beta (pCi/L ± 1s)	4.64 ± 0.686	15.3 ± 1.6	Not calculated
Uranium-233/234[b] (pCi/L ± 1s)	1.41 ± 0.189	1.41 ± 0.189	Not calculated
Uranium-238[b] (pCi/L ± 1s)	0.739 ± 0.121	0.739 ± 0.121	Not calculated

a. Only parameters with at least one detected result are shown.
b. Parameter was analyzed in September only; therefore, the minimum and maximum are the same.
c. U flag indicates the result was below the detection limit.

Table C-17. Surveillance Monitoring Results for Materials and Fuels Complex Secondary Sanitary Lagoon (2011).[a]

Parameter	Minimum	Maximum	Median
Barium[b] (mg/L)	0.0606	0.0606	Not calculated
Chemical Oxygen Demand[b] (mg/L)	238	238	Not calculated
Chloride (mg/L)[b]	173	173	Not calculated
Fluoride (mg/L)[b]	0.29	0.29	Not calculated
Iron (mg/L)[b]	0.282	0.282	Not calculated
Lead[b] (mg/L)[b]	0.00033	0.00033	Not calculated
Manganese[b] (mg/L)	0.0753	0.0753	Not calculated
Nitrogen, nitrate + nitrite[b] (mg-N/L)	3.24	3.24	Not calculated
Nitrogen, total Kjeldahl[b] (mg/L)	17.1	17.1	Not calculated
Selenium[b] (mg/L)	0.0022	0.0022	Not calculated
Sodium[b] (mg/L)	122	122	Not calculated
Sulfate[b] (mg/L)	58.1	58.1	Not calculated
Total dissolved solids[b] (mg/L)	958	958	Not calculated
Total phosphorus[b] (mg/L)	8.26	8.26	Not calculated
Total suspended solids[b] (mg/L)	27.5	27.5	Not calculated
Zinc[b] (mg/L)	0.0098	0.0098	Not calculated
Gross beta (pCi/L ± 1s)	44.6 ± 3.74	248 ± 17.4[d]	Not calculated
Potassium-40 (pCi/L ± 1s)	-4.63 ± 12.1 U[c]	54.3 ± 11.6	Not calculated
Uranium-233/234[b] (pCi/L ± 1s)	0.344 ± 0.0856	0.344 ± 0.0856	Not calculated
Uranium-238[b] (pCi/L ± 1s)	0.0876 ± 0.04	0.0876 ± 0.04	Not calculated

a. Only parameters with at least one detected result are shown.
b. Parameter was only analyzed in the samples collected in September.
c. U flag indicates the result was below the detection limit.
d. Because of the anomalously high value the sample was recounted. The gross beta activity in the recount was 64.9 ± 4.79 pCi/L.

Appendix D. In Situ Soil and Onsite Dosimeter Measurements and Locations

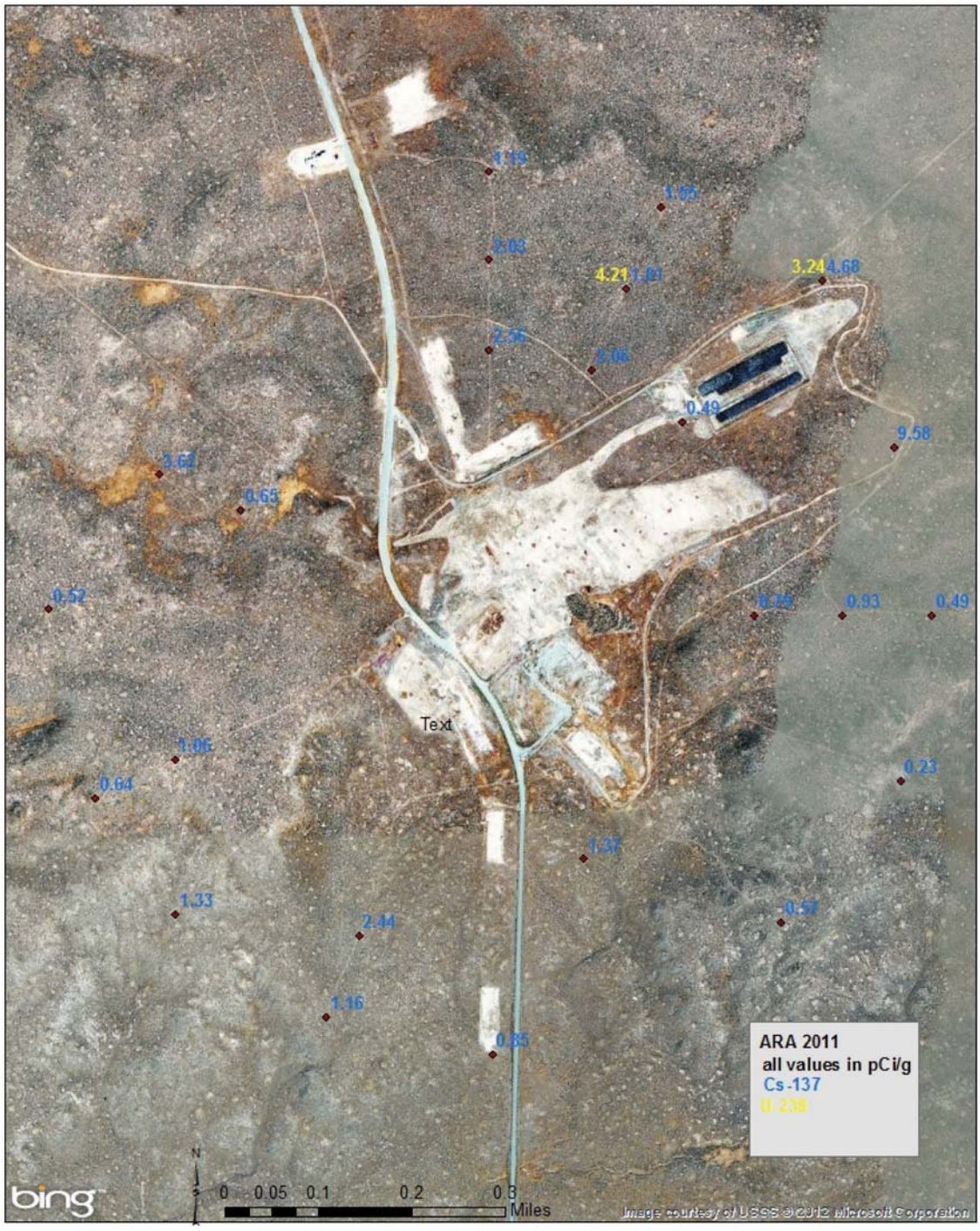


Figure D-1. In Situ Soil Measurements at Auxiliary Reactor Area (2011).

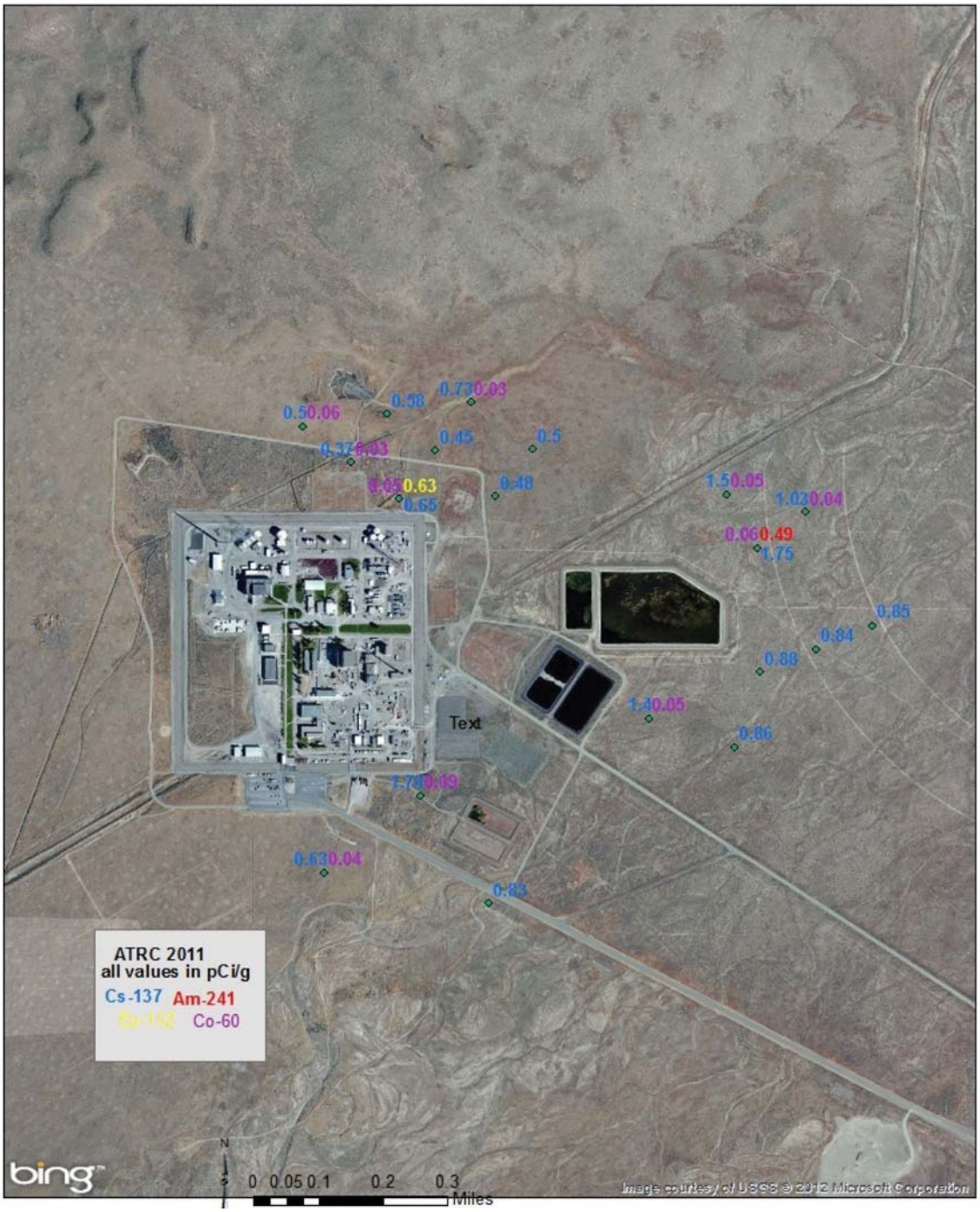


Figure D-2. In Situ Soil Measurements at Advanced Test Reactor Complex (2011).

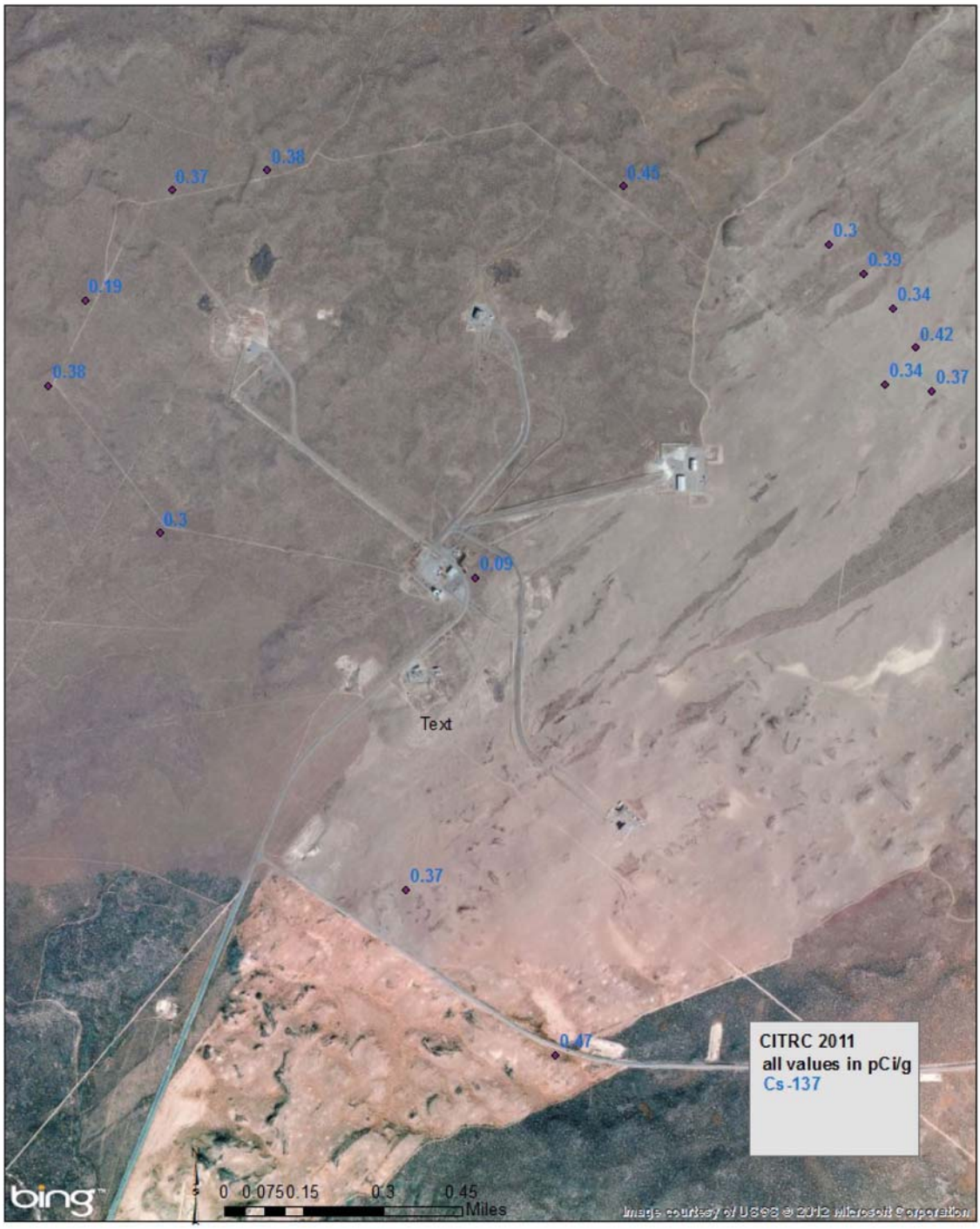


Figure D-3. In Situ Soil Measurements at Critical Infrastructure Test Range Complex (2011).

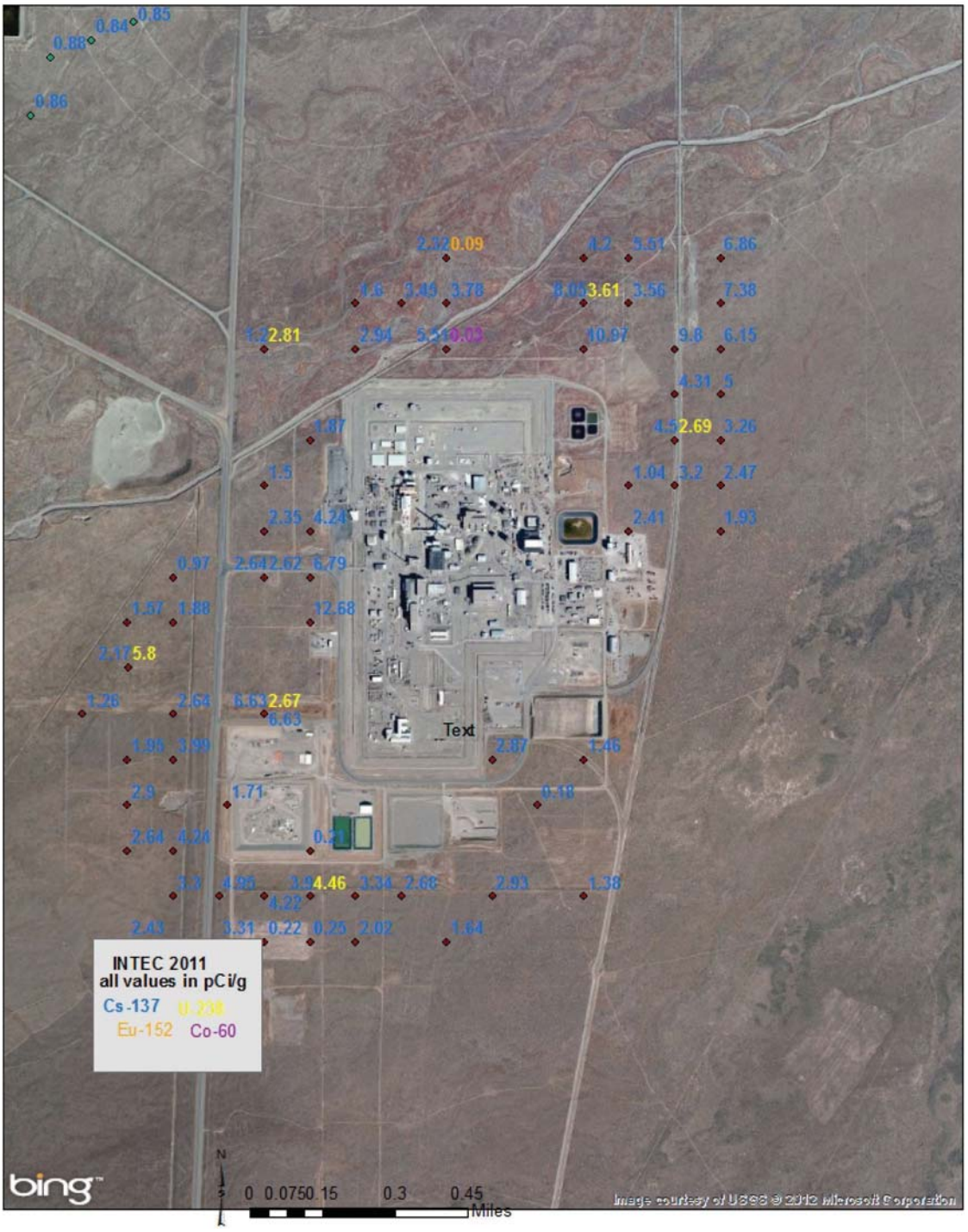


Figure D-4. In Situ Soil Measurements at Idaho Nuclear Technology and Engineering Center (2011).

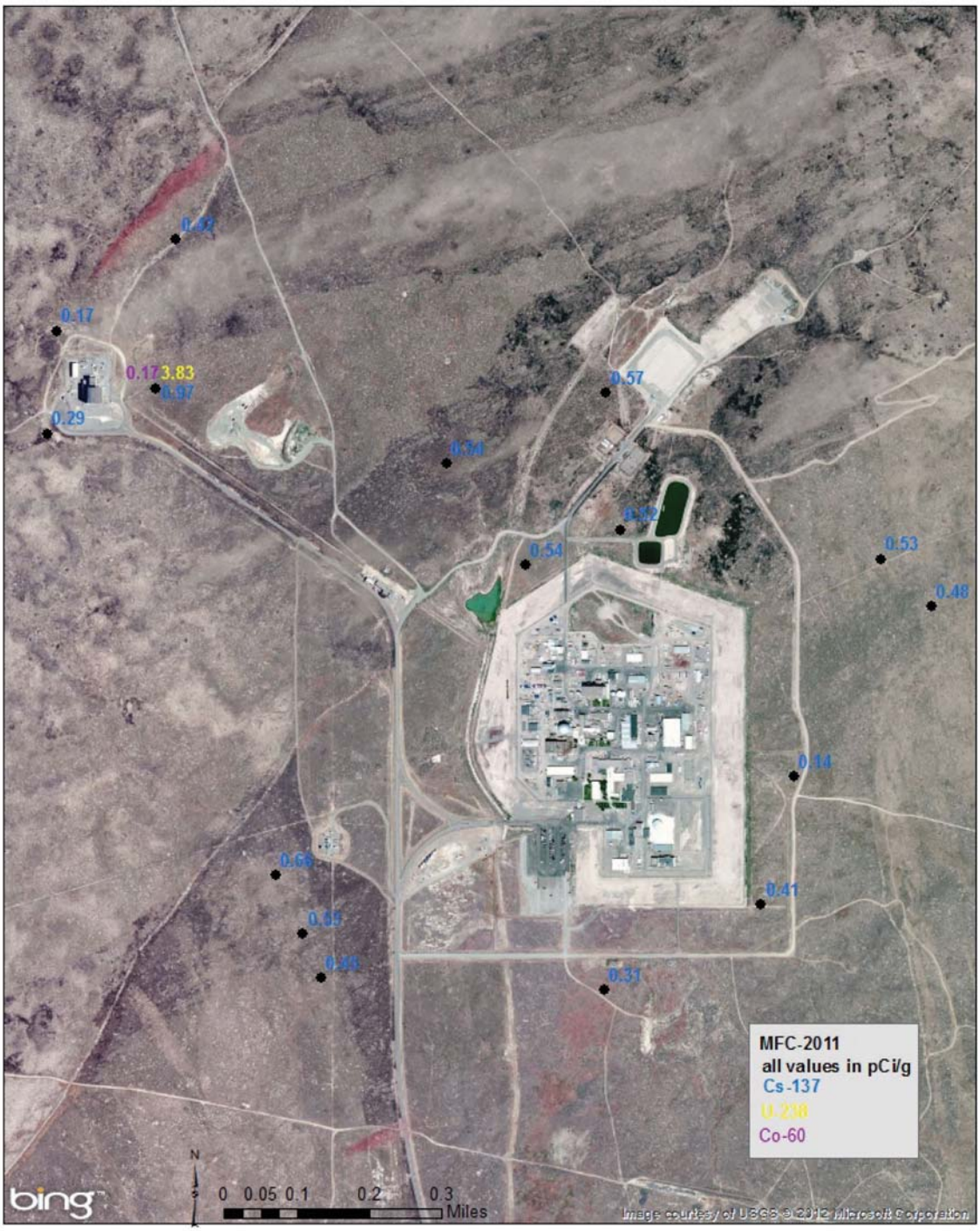


Figure D-5. In Situ Soil Measurements at Materials and Fuels Complex (2011).

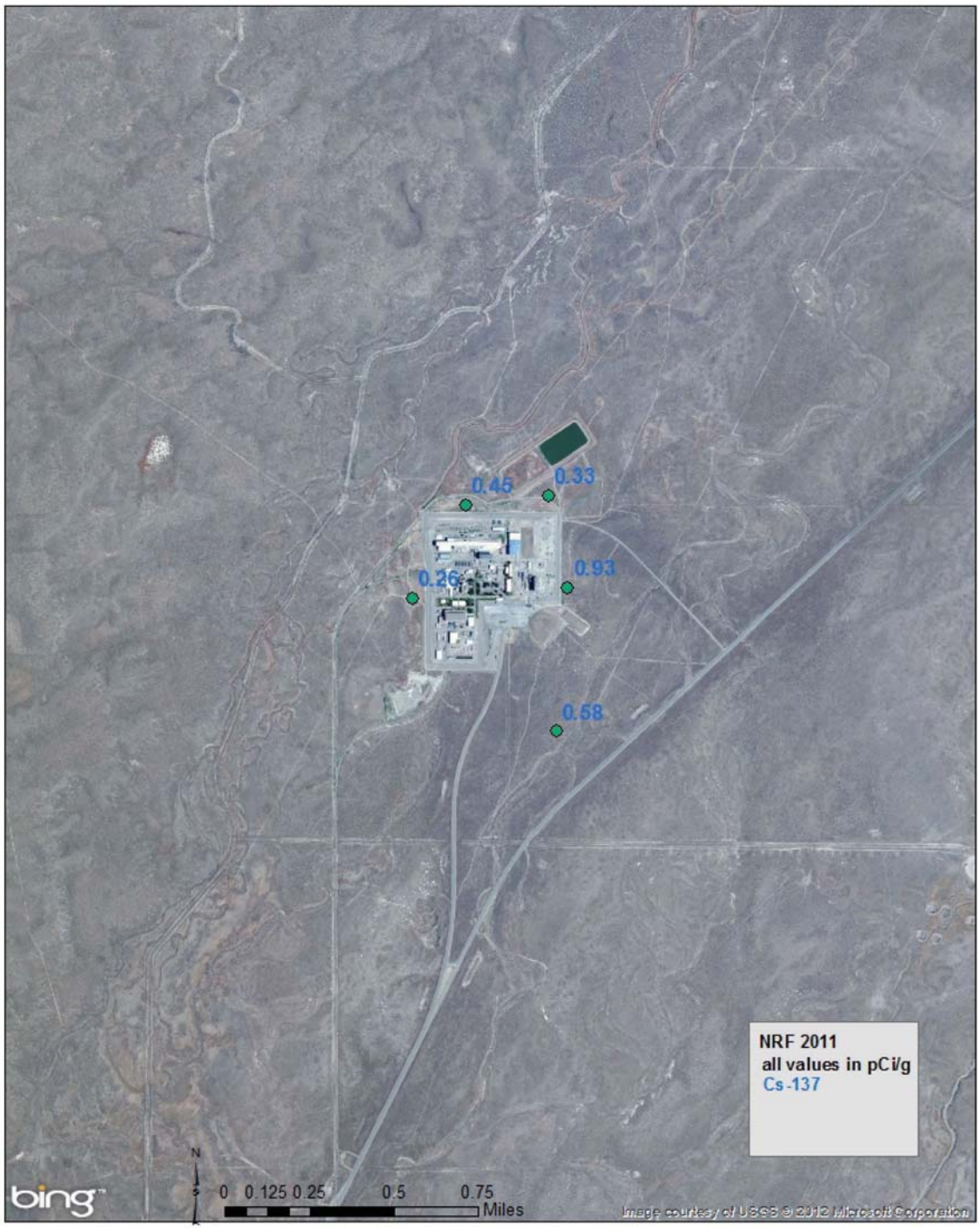


Figure D-6. In Situ Soil Measurements at Naval Reactors Facility (2011).

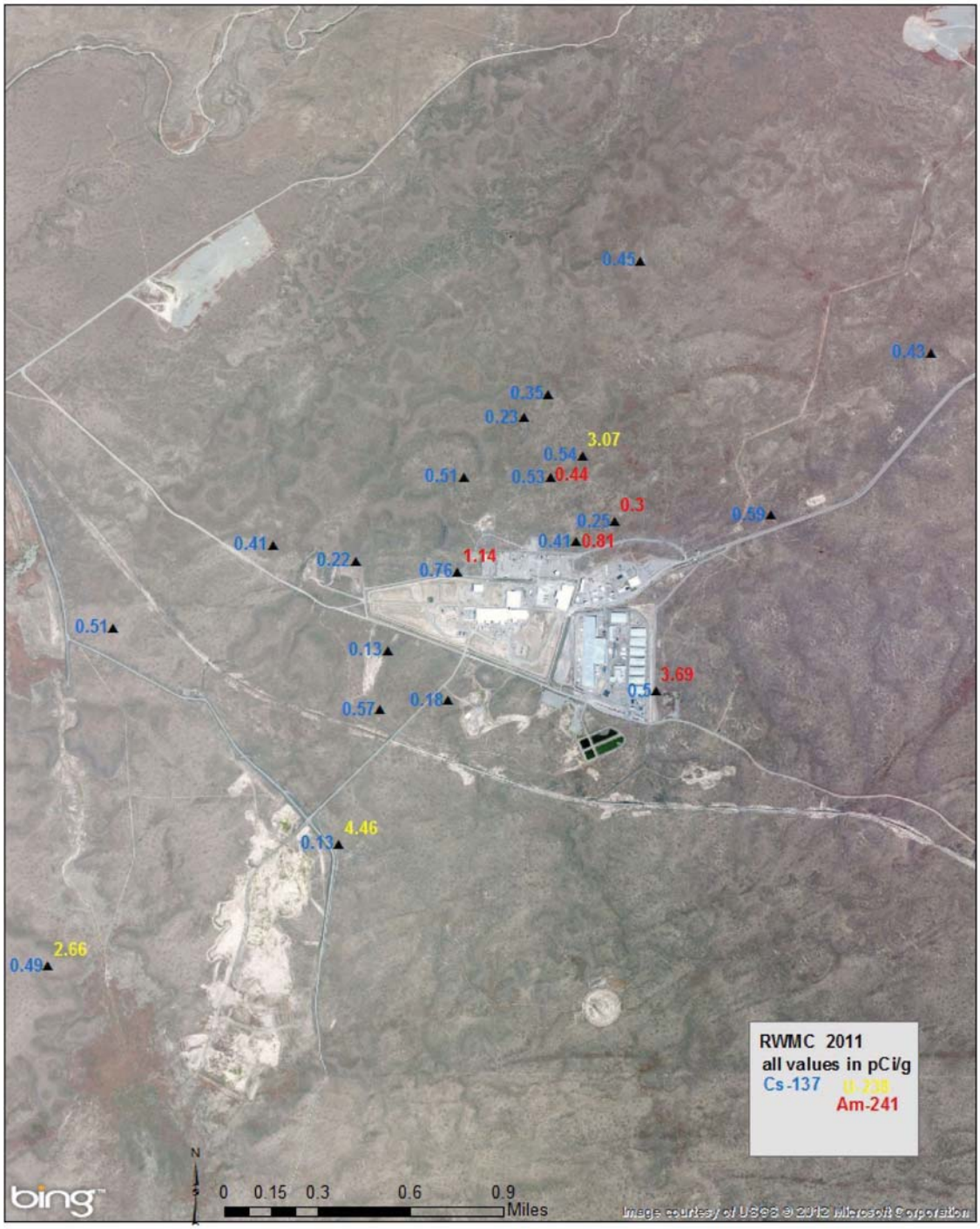


Figure D-7. In Situ Soil Measurements at Radioactive Waste Management Complex (2011).

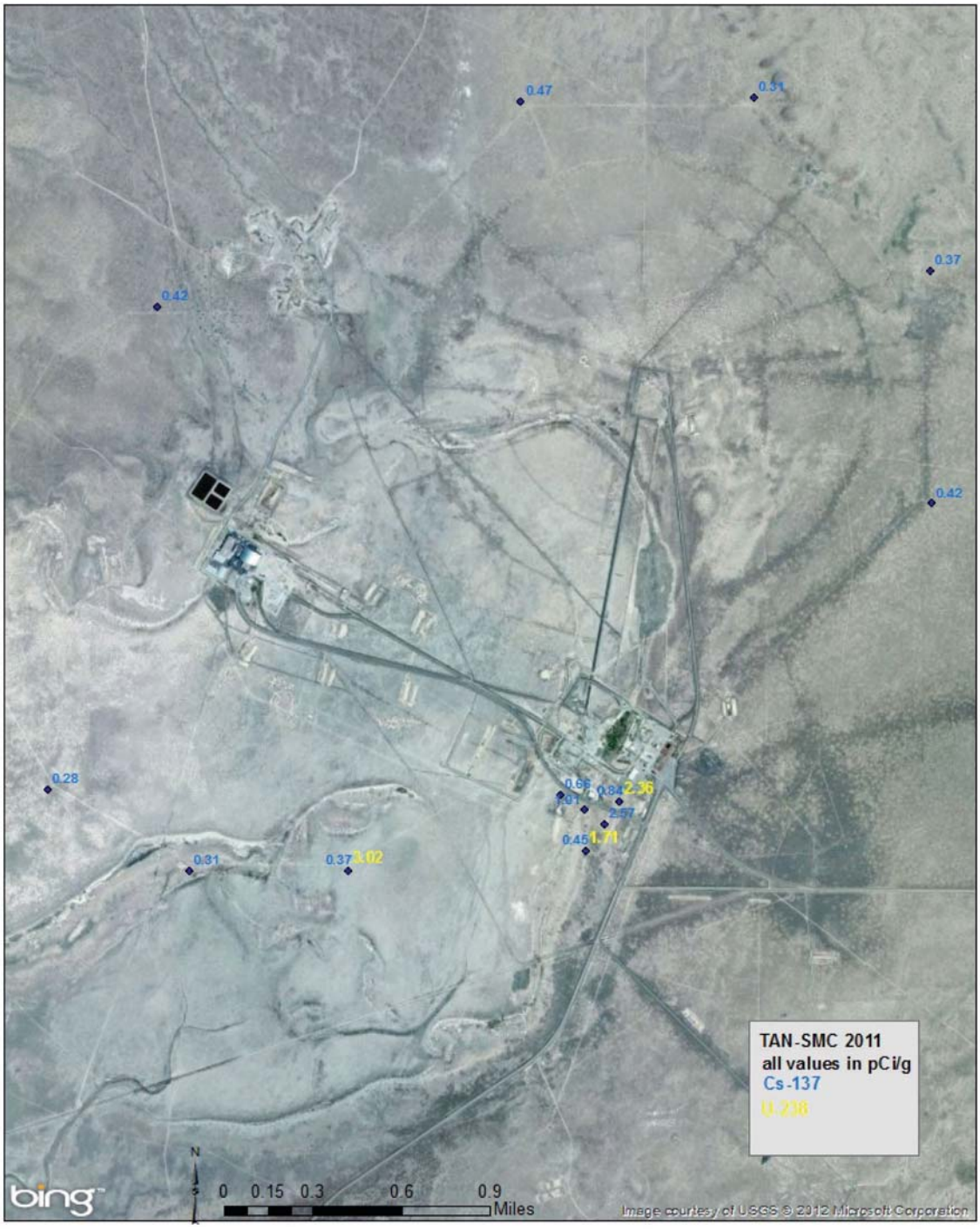


Figure D-8. In Situ Soil Measurements at Test Area North (2011).

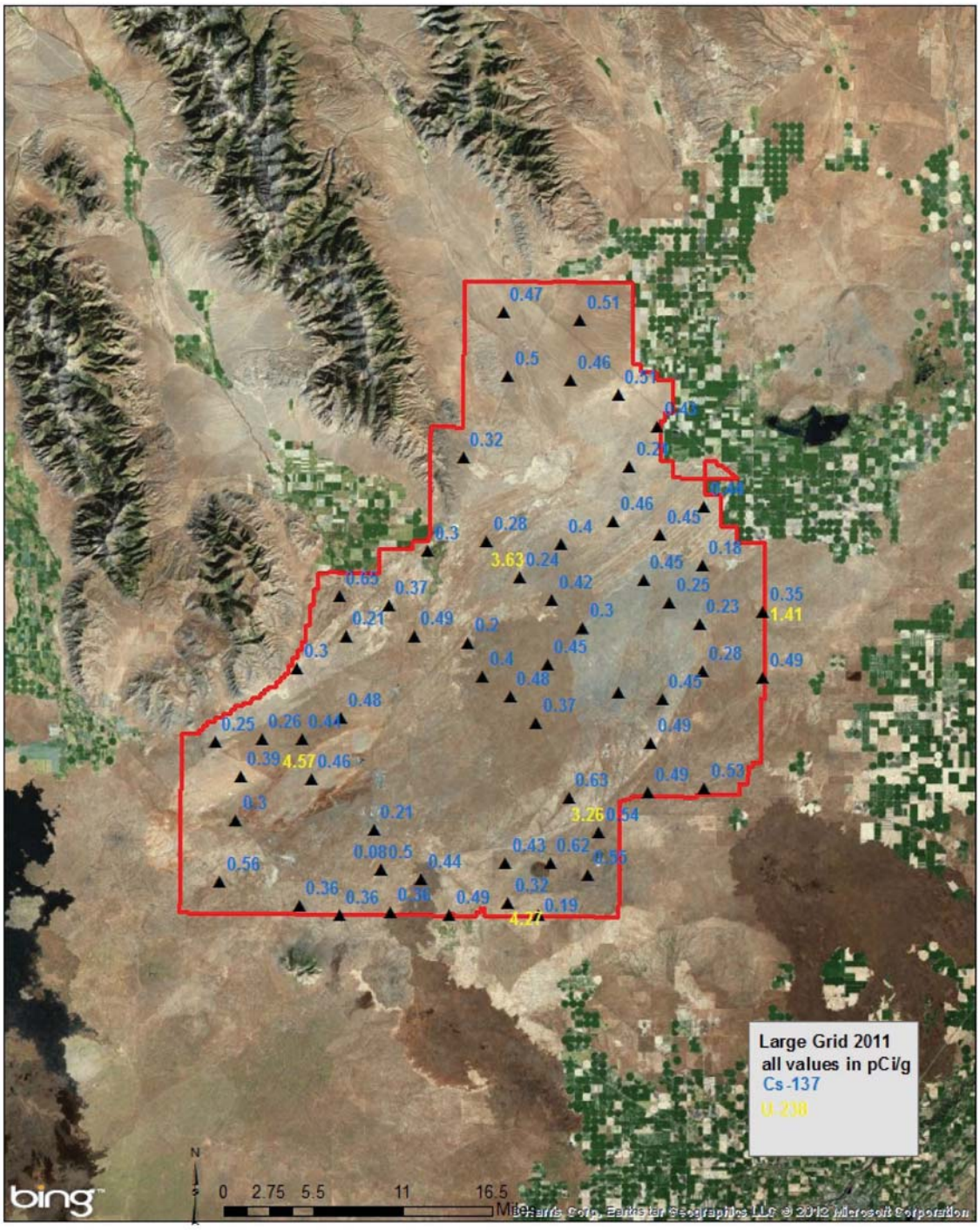


Figure D-9. In Situ Soil Measurements at Large Grid Locations (2011).

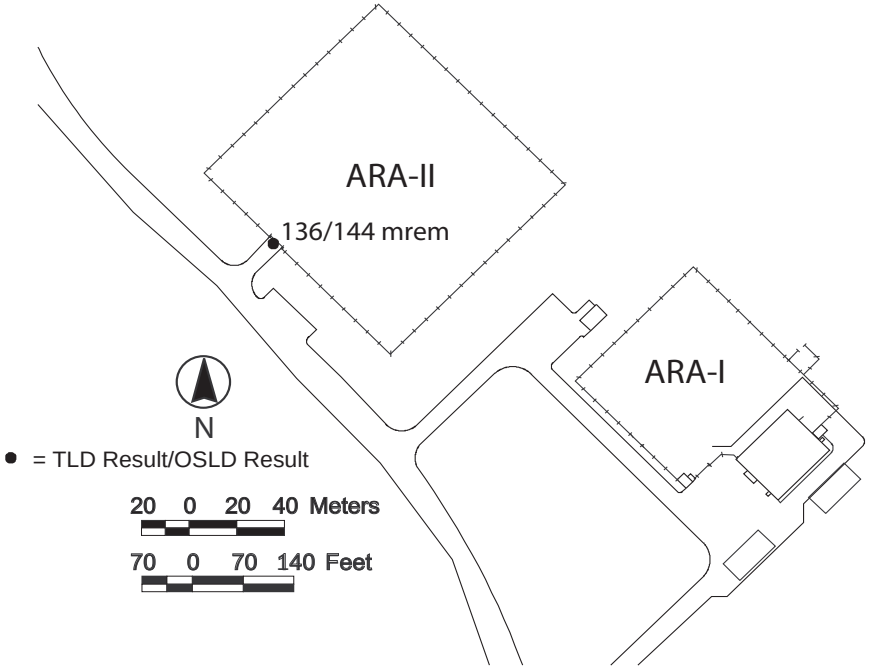


Figure D-10. Environmental Radiation Measurements at Auxiliary Reactor Area (2011).

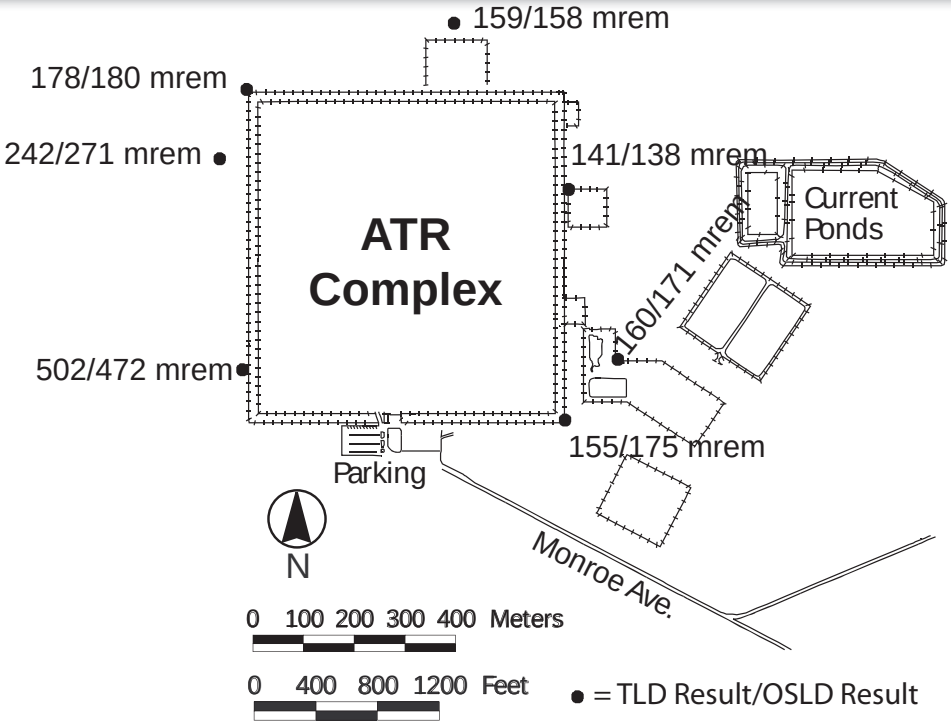


Figure D-11. Environmental Radiation Measurements at Advanced Test Reactor Complex (2011).

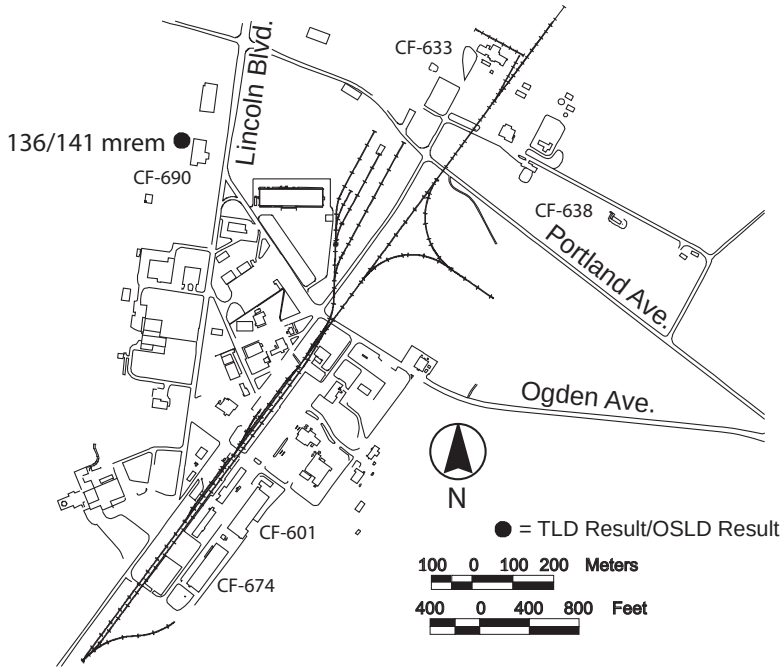


Figure D-12. Environmental Radiation Measurements at Central Facilities Area (2011).

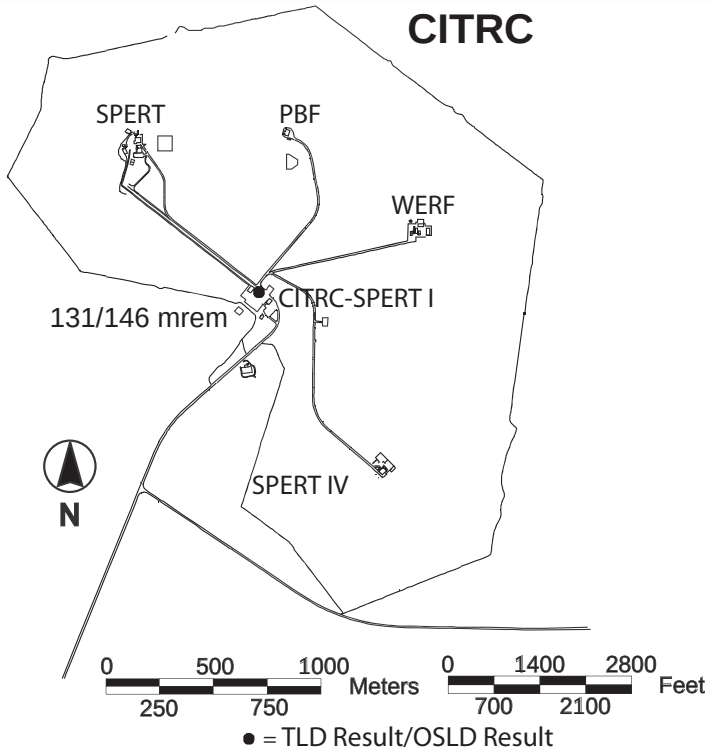


Figure D-13. Environmental Radiation Measurements at Critical Infrastructure Test Range Complex (2011).

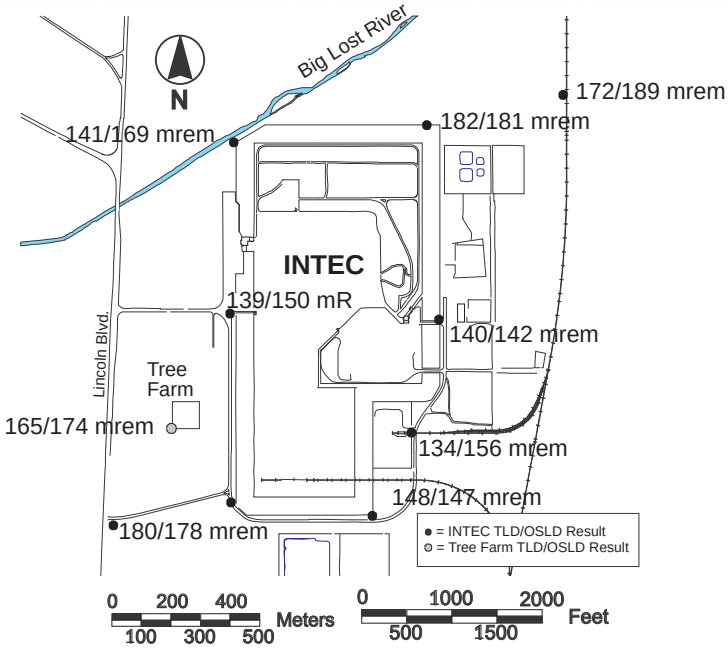


Figure D-14. Environmental Radiation Measurements at Idaho Nuclear Technology and Engineering Center (2011).

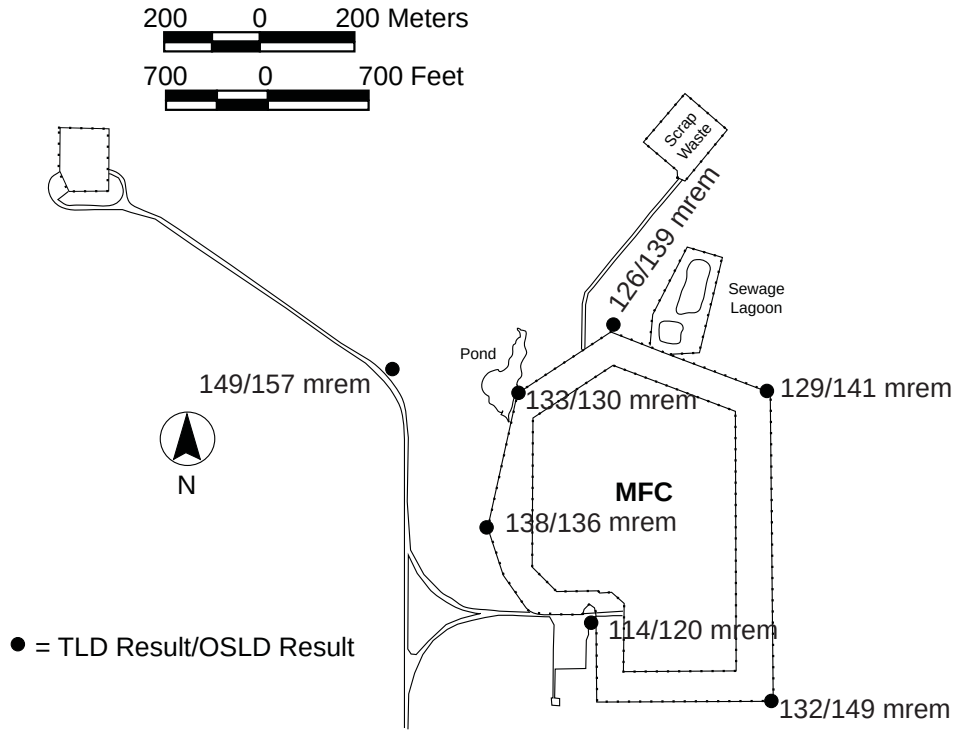


Figure D-15. Environmental Radiation Measurements at Materials and Fuels Complex (2011).

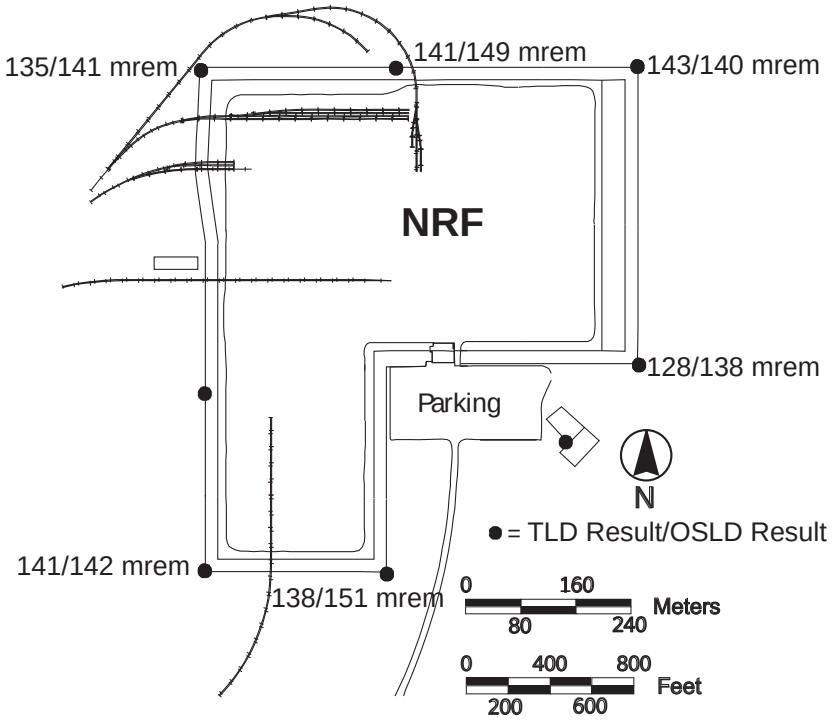


Figure D-16. Environmental Radiation Measurements at Naval Reactors Facility (2011).

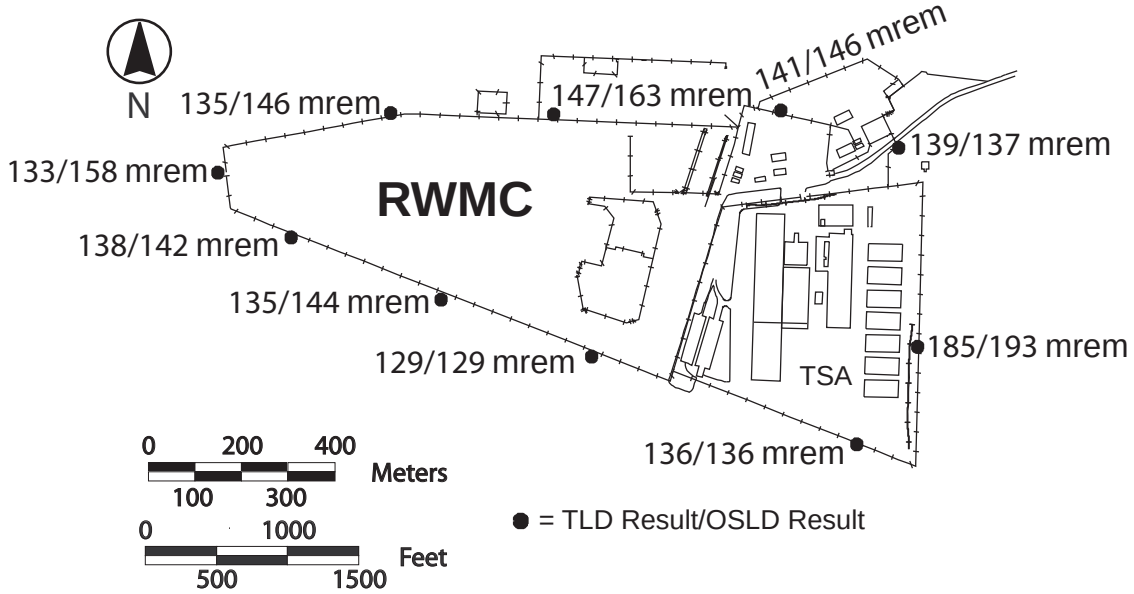


Figure D-17. Environmental Radiation Measurements at Radioactive Waste Management Complex (2011).

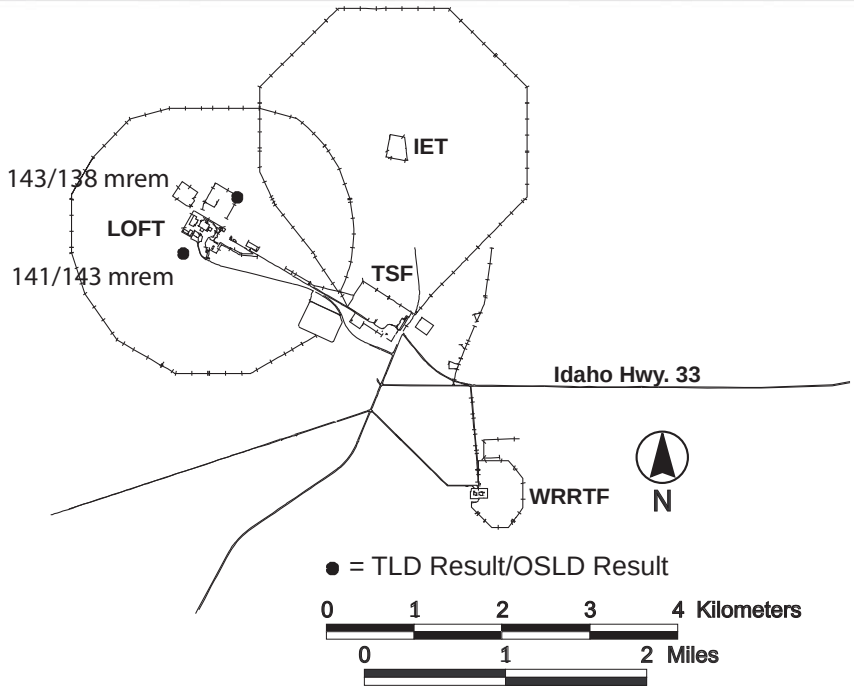


Figure D-18. Environmental Radiation Measurements at Test Area North (2011).

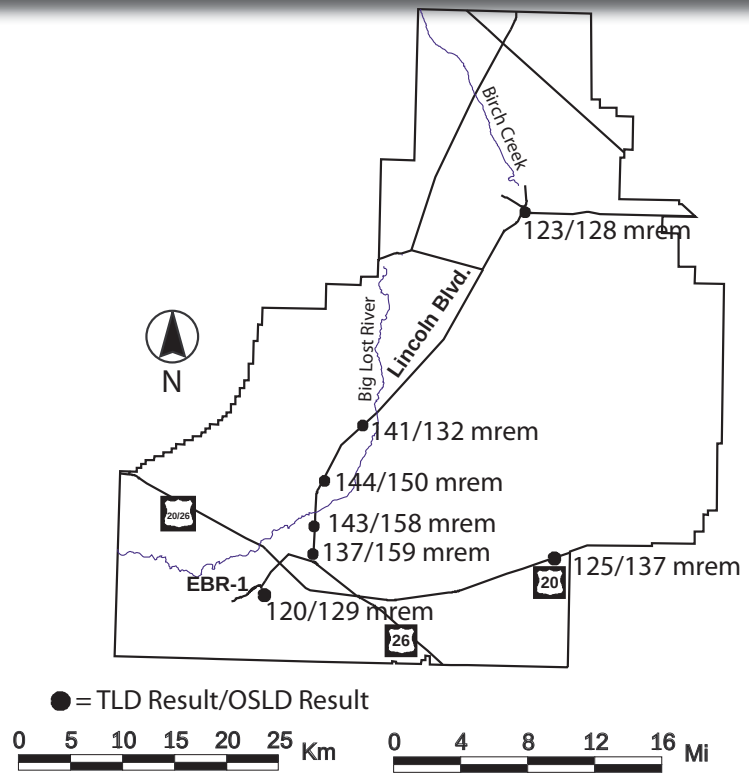


Figure D-19. Environmental Radiation Measurements at Sitewide Locations (2011).

Table D-1. INL Contractor Environmental Radiation Measurements (November 2010 through November 2011).

Location	November 2010-April 2011 (TLD), mrem ± 2σ	May 2011-November 2011 (TLD), mrem ± 2σ	November 2010-April 2011 (OSLD), mrem ± 2σ	May 2011-November 2011 (OSLD), mrem ± 2σ
INL Onsite Group				
ANL W EBR II, O-7	64.7 ± 12.7	73.2 ± 14.3	54.0 ± 5.4	81.9 ± 8.2
ANL W EBR II, O-12	54.5 ± 10.7	59.1 ± 11.5	46.0 ± 4.6	73.6 ± 7.4
ANL W EBR II, O-13	62.3 ± 12.3	70.0 ± 13.7	68.0 ± 6.8	80.7 ± 8.1
ANL W EBR II, O-15	59.6 ± 11.6	69.3 ± 13.6	65.0 ± 6.5	75.9 ± 7.6
ANL W EBR II, O-17	57.5 ± 11.2	68.8 ± 13.5	69.0 ± 6.9	70.3 ± 7.0
ANL W EBR II, O-18	63.2 ± 12.4	70.0 ± 13.7	53.0 ± 5.3	76.9 ± 7.7
ANL W TREAT, O-9	70.5 ± 13.8	78.7 ± 15.5	71.0 ± 7.1	85.6 ± 8.6
ARA-I II, O-1	64.0 ± 12.6	71.7 ± 14.0	59.0 ± 5.9	85.4 ± 8.5
CFA, O-1	63.8 ± 12.5	72.5 ± 14.2	62.0 ± 6.2	78.6 ± 7.9
EBR-I, O-1	59.0 ± 11.5	61.1 ± 11.9	62.0 ± 6.2	66.9 ± 6.7
Hwy 20, Mile 276, O-276	58.4 ± 11.4	66.6 ± 13.1	61.0 ± 6.1	76.4 ± 7.6
ICPP, O-9	77.7 ± 15.2	94.2 ± 18.4	86.0 ± 8.6	102.6 ± 10.3
ICPP, O-15	83.7 ± 16.4	98.8 ± 19.4	76.0 ± 7.6	105.3 ± 10.5
ICPP, O-17	66.6 ± 13.1	74.2 ± 14.5	82.0 ± 8.2	87.3 ± 8.7
ICPP, O-19	67.9 ± 13.3	75.0 ± 14.7	74.0 ± 7.4	76.0 ± 7.6
ICPP, O-21	84.3 ± 16.5	95.5 ± 18.7	75.0 ± 7.5	103.3 ± 10.3
ICPP, O-23	69.5 ± 13.6	78.7 ± 15.5	62.0 ± 6.2	84.8 ± 8.5
ICPP, O-25	61.4 ± 12.1	72.8 ± 14.3	72.0 ± 7.2	84.0 ± 8.4
ICPP, O-26	72.4 ± 14.2	67.6 ± 13.3	63.0 ± 6.3	78.5 ± 7.9
ICPP Tree Farm, O-3	75.3 ± 14.7	90.1 ± 17.7	75.0 ± 7.5	98.8 ± 9.9
Lincoln Blvd, O-1	65.7 ± 12.9	71.1 ± 13.9	76.0 ± 7.6	82.7 ± 8.3
Lincoln Blvd, O-3	65.9 ± 12.9	77.4 ± 15.1	73.0 ± 7.3	84.9 ± 8.5
Lincoln Blvd, O-5	65.4 ± 12.8	78.9 ± 15.5	68.0 ± 6.8	81.8 ± 8.2
Lincoln Blvd, O-9	65.6 ± 12.9	75.7 ± 14.8	56.0 ± 5.6	75.8 ± 7.6
Lincoln Blvd, O-25	64.0 ± 12.6	68.8 ± 13.5	52.0 ± 5.2	76.0 ± 7.6
NRF, O-4	69.0 ± 13.5	73.7 ± 14.4	59.0 ± 5.9	81.2 ± 8.1
NRF, O-5	68.8 ± 13.5	72.4 ± 14.2	72.0 ± 7.2	77.0 ± 7.7
NRF, O-12	59.6 ± 11.6	68.6 ± 13.5	67.0 ± 6.7	70.7 ± 7.1
NRF, O-16	63.6 ± 12.5	71.7 ± 14.0	69.0 ± 6.9	71.9 ± 7.2
NRF, O-19	66.6 ± 13.1	74.3 ± 14.5	54.0 ± 5.4	87.6 ± 8.8
NRF, O-20	64.1 ± 12.6	74.4 ± 14.6	67.0 ± 6.7	83.6 ± 8.4
PBF SPERT, O-1	61.9 ± 12.2	69.1 ± 13.6	67.0 ± 6.7	79.0 ± 7.9
RWMC, O-39	65.2 ± 12.8	73.7 ± 14.4	67.0 ± 6.7	69.7 ± 7.0
RWMC, O-41	88.2 ± 17.3	97.1 ± 19.1	75.0 ± 7.5	118.0 ± 11.8
RWMC, O-43	64.2 ± 12.6	71.4 ± 14.0	50.0 ± 5.0	85.7 ± 8.6
RWMC, O-46	68.1 ± 13.4	72.7 ± 14.2	69.0 ± 6.9	77.5 ± 7.8
RWMC, O-9A	68.1 ± 13.4	78.8 ± 15.5	78.0 ± 7.8	85.0 ± 8.5
RWMC, O-13A	63.3 ± 12.5	72.1 ± 14.1	70.0 ± 7	75.9 ± 7.6
RWMC, O-17A	61.5 ± 12.1	71.4 ± 14.0	75.0 ± 7.5	82.5 ± 8.3
RWMC, O-21A	63.9 ± 12.5	74.5 ± 14.6	70.0 ± 7.0	72.5 ± 7.3
RWMC, O-25A	61.9 ± 12.2	72.8 ± 14.3	63.0 ± 6.3	81.2 ± 8.1
RWMC, O-29A	59.2 ± 11.6	70.1 ± 13.8	59.0 ± 5.9	69.8 ± 7.0
TAN-LOFT, O-6	70.0 ± 13.7	71.2 ± 14.0	69.0 ± 6.9	73.8 ± 7.4
TAN-LOFT, O-7	69.4 ± 13.6	73.1 ± 14.3	58.0 ± 5.8	79.9 ± 8.0

Table D-1. INL Contractor Environmental Radiation Measurements (November 2010 through November 2011) (continued).

Location	November 2010-April 2011 (TLD), mrem ± 2σ	May 2011-November 2011 (TLD), mrem ± 2σ	November 2010-April 2011 (OSLD), mrem ± 2σ	May 2011-November 2011 (OSLD), mrem ± 2σ
INL Onsite Group				
TRA, O-2	70.8 ± 13.9	84.0 ± 16.5	82.0 ± 8.2	93.3 ± 9.3
TRA, O-4	73.6 ± 14.4	86.2 ± 16.9	78.0 ± 7.8	93.3 ± 9.3
TRA, O-6	67.2 ± 13.2	74.1 ± 14.5	62.0 ± 6.2	76.0 ± 7.6
TRA, O-8	73.1 ± 14.3	85.6 ± 16.8	62.0 ± 6.2	96.4 ± 9.6
TRA, O-10	86.9 ± 17.0	91.2 ± 17.8	82.0 ± 8.2	98.3 ± 9.8
TRA, O-11	127.2 ± 24.9	115.3 ± 22.6	137.0 ± 13.7	134.4 ± 13.4
TRA, O-13	278.5 ± 54.6	224.0 ± 43.9	226.0 ± 22.6	246.0 ± 24.6
INL REC Group				
Idaho Falls IF-627, O-30	--[a]	58.1 ± 11.4	--	--
Idaho Falls IF-675E, O-31	--	55.5 ± 10.9	--	--
INL Boundary Group				
Arco	67.1 ± 13.2	67.1 ± 13.2	64.0 ± 6.4	73.0 ± 7.3
Atomic City	61.6 ± 12.1	64.7 ± 12.7	55.0 ± 5.5	65.3 ± 6.5
Howe	58.2 ± 11.4	58.7 ± 11.5	70.0 ± 7.0	64.6 ± 6.5
Monteview	56.7 ± 11.1	63.1 ± 12.4	50.0 ± 5.0	70.2 ± 7.0
Mud Lake	64.5 ± 12.7	71.2 ± 13.9	72.0 ± 7.2	75.2 ± 7.5
INL Distant Group				
Aberdeen	64.0 ± 12.6	68.4 ± 13.4	61.0 ± 6.1	78.8 ± 7.9
Blackfoot	58.9 ± 11.5	58.9 ± 11.5	54.0 ± 5.4	62.7 ± 6.3
Craters of the Moon	53.8 ± 10.5	68.0 ± 13.3	54.0 ± 5.4	76.8 ± 7.7
Idaho Falls	58.9 ± 11.5	62.7 ± 12.3	44.0 ± 4.4	68.6 ± 6.9
Minidoka	57.5 ± 11.2	61.1 ± 11.9	69.0 ± 6.9	61.8 ± 6.2
Reno Ranch	57.4 ± 11.2	57.5 ± 11.2	63.0 ± 6.3	61.8 ± 6.2
Rexburg	63.0 ± 12.4	64.2 ± 12.6	58.0 ± 5.8	67.6 ± 6.8
Roberts	65.2 ± 12.8	71.5 ± 14.0	75.0 ± 7.5	82.0 ± 8.2

a. No measurement taken.

Appendix E. Glossary

A

accuracy: A measure of the degree to which a measured value or the average of a number of measured values agrees with the "true" value for a given parameter; accuracy includes elements of both bias and precision.

actinides: The elements of the periodic table from actinium on. Includes the naturally occurring radionuclides thorium and uranium, as well as the human-made radionuclides plutonium and americium.

alpha radiation: The emission of alpha particles during radioactive decay. Alpha particles are identical in makeup to the nucleus of a helium atom and have a positive charge. Alpha radiation is easily stopped by materials as thin as a sheet of paper and has a range in air of approximately an inch. Despite its low penetration ability, alpha radiation is densely ionizing and, therefore, very damaging when ingested or inhaled.

anthropogenic radionuclide: Radionuclides produced as a result of human activity (human-made).

aquifer: A geologic formation, group of formations or part of a formation capable of yielding a significant amount of groundwater to wells or springs.

aquifer well: A well that obtains its water from below the water table.

B

background radiation: Radiation present in the environment as a result of naturally occurring radioactive materials, cosmic radiation or human-made radiation sources, including fallout, from offsite sources.

basalt: The most common type of solidified lava; a dense, dark grey, fine-grained, igneous rock that is composed chiefly of plagioclase, pyroxene, and olivine; often displaying a columnar structure.

becquerel (Bq): A quantitative measure of radioactivity. This is an alternate measure of activity used internationally. One becquerel of activity is equal to one nuclear decay per second. There are 3.7×10^{10} Bq in 1 Ci.

beta radiation: Radiation comprised of charged particles emitted from a nucleus during radioactive decay. A negatively charged beta particle is identical to an electron. A positively charged beta particle is called a positron. Beta radiation is slightly more penetrating than alpha, and it may be stopped by materials such as aluminum or Lucite panels. Naturally occurring radioactive elements, such as potassium-40, emit beta radiation.

bias: The tendency for an estimate to deviate from an actual or real event. Bias may be the tendency for a model to over- or under-predict.

bioremediation: The process of using various natural or introduced microbes or both to degrade, destroy or otherwise permanently bond contaminants contained in soil or water or both.

biota concentration guide: The limiting concentration of a radionuclide in soil, sediment, or water that would not cause dose limits for protection of populations of aquatic and terrestrial biota to be exceeded.

blank: Used to demonstrate that cross contamination has not occurred. See field, laboratory, equipment, and reagent blank.

blind sample: Contains a known quantity of some of the analytes of interest added to a sample media being collected. A blind sample is used to test for the presence of compounds in the sample media that interfere with the analysis of certain analytes.

butte: A steep-sided and flat-topped hill.

C

calibration: The adjustment of a system and the determination of system accuracy using known sources and instrument measurements of higher accuracy.

chain of custody: A method for documenting the history and possession of a sample from the time of collection, through analysis and data reporting, to its final disposition. An item is considered to be in a person's custody if the item is (1) in the physical possession of that person, (2) within direct view of that person, or (3) placed in a secured area or container by that person.

collective effective dose equivalent: A measure of health risk to a population exposed to radiation. It is the sum of the total effective dose equivalents of all individuals within a defined population. The unit for collective effective dose equivalent is person-rem or person-sieverts.

committed effective dose equivalent: The total effective dose equivalent received over a 50-year period following the internal deposition of a radionuclide. It is expressed in rem or sieverts.

comparability: A measure of the confidence with which one data set or method can be compared to another.

composite sample: A sample of environmental media that contains a certain number of sample portions collected over a time period. The samples may be collected from the same location or different locations. They may or may not be collected at equal intervals over a predefined period (e.g., quarterly).

completeness: A measure of the amount of valid data obtained from a measurement system compared to the amount that was expected under optimum conditions.

confidence interval: A statistical range with a specified probability that a given parameter lies within the range.

contaminant: Any physical, chemical, biological, radiological substance, matter, or concentration that is in an unwanted location.

contaminant of concern: Contaminant in a given media (usually soil or water) above a risk level that may result in harm to the public or the environment. At the INL Site, a contaminant that is above a 10^{-6} (1 in 1 million) risk value.

control sample: A sample collected from an uncontaminated area that is used to compare INL Site analytical results to those in areas that could not have been impacted by INL Site operations.

curie (Ci): A quantitative measure of radioactivity. One Ci equals 3.7×10^{10} nuclear decays per second.

D

data gap: An area between all available data and the conclusions that are drawn from the data where the existing data are sparse or nonexistent. An example would be inferring the interactions in the environment of one radionuclide that has not been studied from a chemically similar radionuclide that has been studied.

data validation: A systematic review of a data set to identify outliers or suspect values. More specifically, data validation refers to the systematic process of independently reviewing a body of analytical data against established criteria to provide assurance that the data are acceptable for their intended use. This process may use appropriate statistical techniques to screen out impossible or highly unlikely values.

data verification: The scientific and statistical evaluation of data to determine if data obtained from environmental operations are of the right type, quality, and quantity to support their intended use. Data

verification also includes documenting those operations and the outcome of those operations (e.g., data do or do not meet specified requirements). Data verification is not synonymous with data validation.

decay product: A nuclide resulting from the radioactive disintegration of a radionuclide, being formed either directly or as a result of successive transformation in a radioactive series. A decay product may be either radioactive or stable.

derived concentration guide (DCG): The concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by a single pathway (e.g., air inhalation or immersion, water ingestion), would result in an effective dose equivalent of 100 mrem (1 mSv). U.S. Department of Energy Order 5400.5, "Radiation Protection of the Public and the Environment" establishes these values.

diffuse source: A source or potential source of pollutants that is not constrained to a single stack or pipe. A pollutant source with a large areal dimension.

diffusion: The process of molecular movement from an area of high concentration to one of lower concentration.

direct radiation: External radiation from radioactive plumes or from radionuclides deposited on the ground or other surfaces.

dispersion: The process of molecular movement by physical processes.

dispersion coefficient: An empirical concentration, normalized to a unit release rate, used to estimate the concentration of radionuclides in a plume at some distance downwind of the source. The National Oceanic and Atmospheric Administration, using data gathered continuously at meteorological stations on and around the INL Site and the MDIFF air dispersion model, prepared the dispersion coefficients for this report.

dose: Energy imparted to matter by ionizing radiation. The unit of absorbed dose is the rad, equal to 0.01 joules per kilogram in any medium.

> **adsorbed dose:** Quantity of radiation energy adsorbed by an organ, divided by the organ's mass. Adsorbed dose is expressed in units of rad (or gray) (1 rad = 0.01Gy).
>
> **dose equivalent:** Product of the adsorbed dose (rad) in tissue and a quality factor. Dose equivalent is expressed in units of rem (or sievert) (1 rem = .01 sievert).
>
> **committed dose equivalent:** Calculated total dose equivalent to a tissue or organ over a 50-year period after known intake of a radionuclide into the body. Contributions from external dose are not included. Committed dose equivalent is expressed in units of rem (or sievert).
>
> **committed effective dose equivalent:** Sum of the committed dose equivalents to various tissues in the body, each multiplied by the appropriate weighting factor. Committed effective dose equivalent is expressed in units of rem (or sievert).
>
> **effective dose equivalent:** Sum of the dose equivalents received by all organs or tissues of the body after each one has been multiplied by an appropriate weighting factor. The effective dose equivalent includes the committed effective dose equivalent from internal deposition of radionuclides and the effective dose equivalent attributable to sources external to the body.
>
> **collective dose equivalent/collective effective dose equivalent:** Sums of the dose equivalents of effective dose equivalents of all individuals in an exposed population within a 50-mile (80-km) radius, and expressed in units of person-rem (or person-sievert). When the collective dose equivalent of interest is for a specific organ, the units would be organ-rem (or

organ-sievert). The 50-mile distance is measured from a point located centrally with respect to major facilities or U.S. Department of Energy program activities.

dosimeter: Portable detection device for measuring the total accumulated exposure to ionizing radiation.

dosimetry: The theory and application of the principles and techniques involved in the measurement and recording of radiation doses.

drinking water: Water for the primary purpose of consumption by humans.

duplicate sample: A sample collected from the same sampling location using the same equipment and sampling technique and placed into an identically prepared and preserved container. Duplicate samples are analyzed independently as an indication of gross errors in sampling techniques.

E

Eastern Snake River Plain Aquifer: One of the largest groundwater “sole source” resources in the United States. It lies beneath a rolling topography extending some 308 km (191 mi) from Ashton to King Hill, Idaho, and ranges in width from 64 to 130 km (40 to 80 mi). The plain and aquifer were formed by repeated volcanic eruptions that were the result of a geologic hot spot beneath the earth’s crust.

ecosystem: The interacting system of a biologic community and its nonliving environment.

effective dose equivalent (EDE): A value used to express the health risk from radiation exposure to a tissue in terms of an equivalent whole body exposure. It is a normalized value that allows the risk from radiation exposure received by a specific organ or part of the body to be compared with the risk due to whole body exposure. It is equal to the sum of products of the dose to each tissue or organ multiplied by their respective weighting factor for each tissue or organ. The weighting factor is used to put the dose to the different tissue and organs on an equal basis in terms of health risk. The EDE is expressed in units of rem or sieverts.

effluent: Any liquid discharged to the environment, including storm water runoff at a site or facility.

effluent waste: Treated wastewater leaving a treatment facility.

electrometallurgical treatment: The process of treating spent nuclear fuel using metallurgical techniques.

environment: Includes water, air, and land and the interrelationship that exists among and between water, air, and land and all living things.

environmental indicators: Animal and plant species that are particularly susceptible to decline related to changes, either physical or chemical, in their environment.

environmental media: Includes air, groundwater, surface water, soil, flora, and fauna.

environmental monitoring: Sampling for contaminants in air, water, sediments, soils, agricultural products, plants, and animals, either by direct measurement or by collection and analysis of samples. It is a combination of two distinct activities (effluent monitoring and environmental surveillance) that together provide information on the health of an environment.

equipment blank: Sample prepared by collecting uncontaminated water passed over or through the sampling equipment. This type of blank sample is normally collected after the sampling equipment has been used and subsequently cleaned. An equipment blank is used to detect contamination introduced by the sampling equipment either directly or through improper cleaning.

exposure: The interaction of an organism with a physical or chemical agent of interest. Examples of such agents are radiation (physical) and carbon tetrachloride (chemical).

exposure pathway: The mechanism through which an organism may be exposed to a contaminant. An example is the surface water pathway, whereby an organism may be exposed to a contaminant through the consumption of surface water containing that contaminant.

extremely hazardous chemical: A substance listed in the appendices to 40 CFR 355 "Emergency Planning and Notification."

F

fallout: Radioactive material made airborne as a result of aboveground nuclear weapons testing that has been deposited on the earth's surface.

field blank: A blank used to provide information about contamination that may be introduced during sample collection, storage and transport. A known uncontaminated sample, usually deionized water, is exposed to ambient conditions at the sampling site and subjected to the same analytical or measurement process as other samples.

fissile material: Material capable of starting and sustaining a nuclear chain reaction.

fission: The nuclear reaction resulting from the splitting of atoms.

flood plain: Lowlands bordering a river that are subject to flooding. A flood plain is comprised of sediments carried by rivers and deposited on land during flooding.

G

gamma radiation: A form of electromagnetic radiation, like radio waves or visible light, but with a much shorter wavelength. It is more penetrating than alpha or beta radiation, capable of passing through dense materials such as concrete.

gamma spectroscopy: An analysis technique that identifies specific radionuclides that emit gamma radiation. It measures the particular energy of a radionuclide's gamma radiation emissions. The energy of these emissions is unique for each radionuclide, acting as a fingerprint to identify a specific radionuclide.

gross alpha activity: The total radioactivity due to alpha particle emission as inferred from measurements on a dry sample. See alpha radiation.

gross beta activity: The total radioactivity due to beta particle emission as inferred from measurements on a dry sample. See beta radiation.

groundwater: Water located beneath the surface of the ground (subsurface water). Groundwater usually refers to a zone of complete saturation containing no air.

H

half-life: The amount of time it takes for the radioactivity of a radioactive material to be reduced by half.

hazardous air pollutant: See hazardous substance.

hazardous chemical: Any hazardous chemical as defined under 29 CFR 1910.1200 ("Hazard Communication") and 40 CFR 370.2 ("Definitions").

hazardous material: Material considered dangerous to people or the environment.

hazardous substance: Any substance, including any isomers and hydrates, as well as any solutions

and mixtures containing these substances, designated as such under Section 311 (b) (2)(A) of the *Clean Water Act*; any toxic pollutant listed under Section 307 (a) of the *Clean Water Act*; any element, compound, mixture, solution, or substance designated pursuant to Section 102 of the *Comprehensive Environmental Response, Compensation and Liability Act*; any hazardous waste having the characteristics identified under or listed pursuant to Section 3001 of the *Solid Waste Disposal Act*; any hazardous air pollutant listed under Section 112 of the *Clean Air Act*; and any imminently hazardous chemical substance or mixture with respect to which the U.S. Environmental Protection Agency Administrator has taken action pursuant to Section 7 of the *Toxic Substances Control Act*. The term does not include petroleum, including crude oil or any fraction thereof that is not otherwise specifically listed or designated in the first paragraph, and does not include natural gas, natural gas liquids, liquefied natural gas, or synthetic gas usable for fuel (or mixtures of natural gas and such synthetic gas).

hazardous waste: A waste that is listed in the tables of 40 CFR 261 ("Identification and Listing Hazardous Waste") or that exhibits one or more of four characteristics (corrosiveness, reactivity, flammability, and toxicity) above a predefined value.

high-level radioactive waste: Waste material resulting from the reprocessing of spent nuclear fuel, including both liquid and solid materials containing enough radioactivity to require permanent isolation from the environment.

hot spot: (1) In environmental surveillance, a localized area of contamination or higher contamination in an otherwise uncontaminated area. (2) In geology, a stationary, long-lived source of magma coming up through the mantle to the earth's surface. The hot spot does not move, but remains in a fixed position. As the crust of the earth moves over a hot spot, volcanic eruptions occur on the surface.

I

infiltration: The process of water soaking into soil or rock.

influent waste: Raw or untreated wastewater entering a treatment facility.

inorganic: Relating to or belonging to the class of compounds not having a carbon basis; hydrochloric and sulfuric acids are called inorganic substances.

ionizing radiation: Any radiation capable of displacing electrons from atoms or molecules, thereby producing ions. Some examples are alpha, beta, gamma, x-rays, neutrons and light. High doses of ionizing radiation may produce severe skin or tissue damage.

isopleth: A line on a map connecting points having the same numerical value of some variable.

isotope: Two or more forms of an element having the same number of protons in the nucleus (or the same atomic number), but having different numbers of neutrons in the nucleus (or different atomic weights). Isotopes of a single element possess almost identical chemical properties. Examples of isotopes are plutonium-238, plutomium-239, and plutonium-241; each acts chemically like plutonium but have 144, 145, and 146 neutrons, respectively.

L

laboratory blank: A sample, usually deionized water, that is intended to contain none of the analytes of interest and is subjected to the same analytical or measurement process as other samples to establish a zero baseline or laboratory background value. Laboratory blanks are run before and after regular samples are analyzed to measure contamination that may have been introduced during sample handling, preparation or analysis. A laboratory blank is sometimes used to adjust or correct routine analytical results.

liquid effluent: A liquid discharged from a treatment facility.

M

management and operating (M&O) contract: An agreement under which the government contracts for the operation, maintenance, or support, on its behalf, of a government-owned or -controlled research, development, special production, or testing establishment wholly or principally devoted to one or more major programs of the contracting federal agency.

matrices/matrix/media: Refers to the physical form (solid, liquid, or gas) or composition (soil, filter, groundwater, or air) of a sample.

maximally exposed individual (MEI): A hypothetical member of the public whose location and living habits tend to maximize his or her radiation dose, resulting in a dose higher than that received by other individuals in the general population.

millirem (mrem): A unit of radiation dose that is equivalent to one one-thousandth of a rem.

millisievert (mSv): The International System of Units (SI) for radiation dose and effective dose equivalent. The SI equivalent of the millirem (1 millisievert = 100 millirem).

minimum detection concentration (MDC): The lowest concentration to which an analytical parameter can be measured with certainty by the analytical laboratory performing the measurement. While results below the MDC are sometimes measurable, they represent values that have a reduced statistical confidence associated with them (less than 95 percent confidence).

multi-media: Covering more than one environmental media (e.g., an inspection that reviews groundwater, surface water, liquid effluent, and airborne effluent data).

N

natural background radiation: Radiation from natural sources to which people are exposed throughout their lives. Natural background radiation is comprised of several sources, the most important of which are:

- Cosmic radiation: Radiation from outer space (primarily the sun)
- Terrestrial radiation: Radiation from radioactive materials in the crust of the earth
- Inhaled radionuclides: Radiation from radioactive gases in the atmosphere, primarily radon-222.

natural resources: Land, fish, wildlife, biota, air, water, groundwater, drinking water supplies, and other such resources belonging to, managed by, held in trust by, appertaining to, otherwise controlled by the United States, any state or local government, any foreign government, or Indian tribe.

noble gas: Any of the chemically inert gaseous elements of the helium group in the periodic table.

noncommunity water system: A public water system that is not a community water system. A noncommunity water system is either a transient noncommunity water system or a nontransient noncommunity water system.

nontransient noncommunity water system: A public water system that is not a community water system and that regularly serves at least 25 of the same persons over six months per year. These systems are typically schools, offices, churches, factories, etc.

O

organic: Relating or belonging to the class of chemical compounds having a carbon basis; hydrocarbons are organic compounds.

P

perched water well: A well that obtains its water from a water body above the water table.

performance evaluation sample: Sample prepared by adding a known amount of a U.S. Environmental Protection Agency reference compound to reagent water and submitting it to the analytical laboratory as a field duplicate or field blank sample. A performance evaluation sample is used to test the accuracy and precision of the laboratory's analytical method.

person-rem: Sum of the doses received by all individuals in a population.

pH: A measure of hydrogen ion activity. A low pH (0 – 6) indicates an acid condition; a high pH (8 – 14) indicates a basic condition. A pH of 7 indicates neutrality.

playa: A depression that is periodically inundated with water and will retain such water over time. An intermittent or seasonal water body.

PM_{10}: Particle with an aerodynamic diameter less than or equal to 10 microns.

pollutant: Pollutant or contaminant as defined by Section 101(33) of the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA), shall include, but not be limited to, any element, substance, compound, or mixture, including disease-causing agents, which after release into the environment and upon exposure, ingesting, inhalation, or assimilation into an organism, either directly from the environment or indirectly by ingestion through food chains, will or may reasonably be anticipated to cause death, disease, behavioral abnormalities, cancer, genetic mutation, physiological malfunctions (including malfunctions in reproduction), or physical deformation, in such organisms or their offspring. The term does not include petroleum, including crude oil or any fraction thereof which is not otherwise specifically listed or designated as a hazardous substance under Section 101(14) (A) through (F) of CERCLA, nor does it include natural gas, liquefied natural gas, or synthetic gas of pipeline quality (or mixtures of natural gas and such synthetic gas). For purposes of the National Oil and Hazardous Substances Pollution Contingency Plan, the term pollutant or contaminant means any pollutant or contaminant that may present an imminent and substantial danger to public health or welfare of the United States.

plume: A body of contaminated groundwater or polluted air flowing from a specific source. The movement of a groundwater plume is influenced by such factors as local groundwater flow patterns, the character of the aquifer in which groundwater is contained, and the density of contaminants. The movement of an air contaminant plume is influenced by the ambient air motion, the temperatures of the ambient air, and of the plume and the density of the contaminants.

polychlorinated biphenyl: Any chemical substance that is limited to the biphenyl molecule that has been chlorinated to varying degrees or any combination of substances that contain such substance.

pollutant: Any hazardous or radioactive material naturally occurring or added to an environmental media, such as air, soil, water, or vegetation.

precision: A measure of mutual agreement among individual measurements of the same property. Precision is most often seen as a standard deviation of a group of measurements.

public water system: A system for the provision to the public of water for human consumption through pipes or other constructed conveyances, if such system has at least 15 service connections or regularly

serves an average of at least 25 individuals daily at least 60 days out of the year. Includes any collection, treatment, storage, and distribution facilities under control of the operator of such system and used primarily in connection with such system and any collection or pretreatment storage facilities not under such control that are used primarily in connection with such system. Does not include any special irrigation district. A public water system is either a community water system or a noncommunity water system.

purgeable organic compound: An organic compound that has a low vaporization point (volatile).

Q

quality assurance: Those planned and systematic actions necessary to provide adequate confidence that a facility, structure, system, or component will perform satisfactorily and safely in service. Quality assurance includes quality control. If quality is the degree to which an item or process meets or exceeds the user's requirements, then quality assurance is those actions that provide the confidence that quality was in fact achieved.

quality control: Those actions necessary to control and verify the features and characteristics of a material, process, product, service, or activity to specified requirements. The aim of quality control is to provide quality that is satisfactory, adequate, dependable, and economic.

R

rad: short for radiation absorbed dose; a measure of the energy absorbed by any material.

radioactivity: The spontaneous transition of an atomic nucleus from a higher energy to a lower energy state. This transition is accompanied by the release of a charged particle or electromagnetic waves from the atom. Also known as activity.

radioactive decay: The process of a material giving off particles to reach a stable state.

radioecology: The study of the behavior and the effects of radioactive materials on the environment. Also includes the use of radioisotopes to study the structure and function of ecosystems and their component parts.

radionuclide: A type of atom that emits energy in the form of photons or particles (radiation) during transformation.

radiotelemetry: The tracking of animal movements through the use of a radio transmitter attached to the animal of interest.

reagent blank: A sample of any reagent used for sample preparation subjected to the same analytical or measurement process as a normal sample. A reagent blank is used to show that the reagent used in sample preparation does not contain any of the analytes of interest.

rehabilitation: The planting of a variety of plants in an effort to restore an area's plant community diversity after a loss (e.g., after a fire).

relative percent difference: A measure of variability adjusted for the size of the measured values. It is used only when the sample contains two observations, and it is calculated by the equation:

$$RPD = \frac{|R_1 - R_2|}{(R_1 + R_2)/2} \times 100$$

where R_1 and R_2 are the duplicate sample measurement results.

release: Spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing of a hazardous substance, pollutant, or contaminant into the environment.

rem: Stands for roentgen equivalent man, a unit by which human radiation dose is assessed. This is a risk-based value used to estimate the potential health effects to an exposed individual or population.

reportable quantity: Any *Comprehensive Environmental Response, Compensation, and Liability Act* hazardous substance, the reportable quantity for which is established in Table 302.4 of 40 CFR 302 ("Designation, Reportable Quantities, and Notification"), the discharge of which is a violation of federal statutes and requires notification of the regional U.S. Environmental Protection Agency administrator.

representativeness: A measure of a laboratory's ability to produce data that accurately and precisely represent a characteristic of a population, a parameter variation at a sampling point, a process condition, or an environmental condition.

reprocessing: The process of treating spent nuclear fuel for the purpose of recovering fissile material.

resuspension: Windblown reintroduction to the atmosphere of material originally deposited onto surfaces from a particular source.

rhyolite: A usually light-colored, fine-grained, extrusive igneous rock that is compositionally similar to granite.

risk assessment: The identification and quantification of the risk resulting from a specific use or occurrence of a chemical, taking into account the possible harmful effects on individuals or society of using the chemical in the amount and manner proposed and all the possible routes of exposure. Quantification ideally requires the establishment of dose-effect and dose-response relationships in likely target individuals and populations.

roentgen (R): The amount of ionization produced by gamma radiation in air. The unit of roentgen is approximately numerically equal to the unit of rem.

S

shielding: The material or process used for protecting workers, the public and the environment from exposure to radiation.

sievert (Sv): A unit for assessing the risk of human radiation dose, used internationally. One sievert is equal to 100 rem.

sigma uncertainty: The uncertainty or margin of error of a measurement is stated by giving a range of values likely to enclose the true value. These values follow from the properties of the normal distribution, and they apply only if the measurement process produces normally distributed errors, e.g., the quoted standard errors are easily converted to 68.3 percent (one sigma), 95.4 percent (two sigma), or 99.7 percent (three sigma) confidence intervals; usually are denoted by error bars on a graph or by the following notations:

- measured value ± uncertainty
- measured value (uncertainty).

sink: Similar to a playa with the exception that it rapidly infiltrates any collected water.

spent nuclear fuel: Uranium metal or oxide and its metal container that have been used to power a nuclear reactor. It is highly radioactive and typically contains fission products, plutonium, and residual uranium.

split sample: A single sample, usually divided by the analytical laboratory, split into two separate samples. Each sample is prepared and analyzed independently as an indication of analytical variability and comparability.

spreading areas: At the INL Site, a series of interconnected low areas used for flood control by dispersing and evaporating or infiltrating water from the Big Lost River.

stabilization: The planting of rapid growing plants for the purpose of holding bare soil in place.

standard: A sample containing a known quantity of various analytes. A standard may be prepared and certified by commercial vendors, but it must be traceable to the National Institute of Standards and Technology.

storm water: Water produced by the interaction of precipitation events and the physical environment (buildings, pavement, ground surface).

surface water: Water exposed at the ground surface, usually constrained by a natural or human-made channel (stream, river, lake, ocean).

surveillance: Parameters monitored to observe trends but not required by a permit or regulation.

T

thermoluminescent dosimeter (TLD): A device used to measure radiation dose to occupational workers or radiation levels in the environment. A dosimeter is made of one or more lithium fluoride chips that measure cumulative exposure to ionizing radiation. Lithium fluoride absorbs the energy of radiation and releases it as light when heated.

total organic carbon: A measure of the total organic carbon molecules present in a sample. It will not identify a specific constituent (e.g., benzene), but will detect the presence of a carbon-bearing molecule.

toxic chemical: Chemical that can have toxic effects on the public or environment above listed quantities. See also hazardous chemical.

traceability: The ability to trace history, application or location of a sample standard and like items or activities by means of recorded identification.

transient noncommmunity water system: A water system that is not a community water system, and serves 25 nonresident persons per day for six months or less per year. These systems are typically restaurants, hotels, large stores, etc.

transuranic (TRU): Elements on the periodic table with an atomic number greater than uranium (>92). Common isotopes of transuranic elements are neptunium-239 and plutonium-238.

transuranic waste: Waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes (radionuclide isotopes with atomic numbers greater than uranium [92]) per gram of waste with half-lives greater than 20 years.

tritium: A radioactive isotope of hydrogen, having three times the mass of ordinary hydrogen.

V

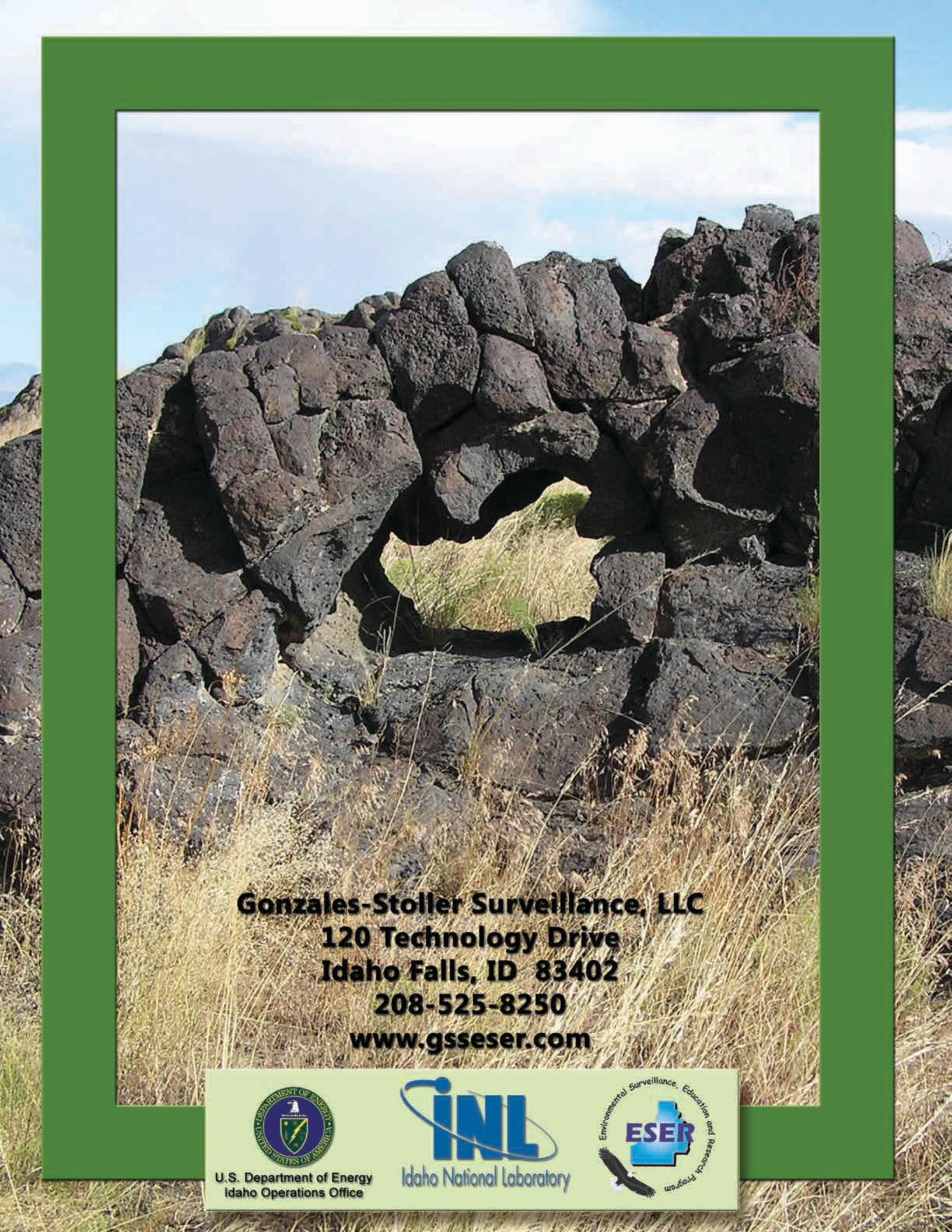
vadose zone: That part of the subsurface between the ground surface and the water table.

W

water quality parameter: Parameter commonly measured to determine the quality of a water body or sample (i.e., specific conductivity, pH, temperature, dissolved oxygen content).

weighting factor: A factor that, when multiplied by the dose equivalent delivered to a body organ or tissue, yields the equivalent risk due to a uniform radiation exposure of the whole body.

wetland: An area inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include playa lakes, swamps, marshes, bogs, and similar areas as sloughs, prairie potholes, wet meadows, prairie river overflows, mudflats, and natural ponds.



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