Idaho National Laboratory Site

Site Environmental Report

Calendar Year 2010

Environmental Surveillance, Education, and Research Program

DOE/ID-12082(10)
ISSN 1089-5469
GSS-ESER-151
September 2011

DOE/ID-12082(10)

ISSN 1089-5469
GSS-ESER-151

IDAHO NATIONAL LABORATORY

SITE ENVIRONMENTAL REPORT

CALENDAR YEAR 2010

Environmental Surveillance, Education, and Research Program

U.S. Department of Energy, Idaho Operations Office

September 2011

This report was prepared for the
U.S. Department of Energy, Idaho Operations Office
Under Contract DE-AC07-06ID14680
By Gonzales-Stoller Surveillance, LLC
Environmental Surveillance, Education, and Research Program
120 Technology Drive
Idaho Falls, ID 83402

Acknowledgments

The following people have provided primary authorship and review of this report:

- Marilyn Case, Russell Mitchell, and Roger Blew with the Environmental Surveillance, Education and Research Program, managed by Gonzales-Stoller Surveillance, LLC.
- Bradley Anderson, David Frederick, Thomas Haney, John Giles, Jenifer Nordstrom, Chris Oertel, and Mark Verdoorn with Battelle Energy Alliance
- Roger Wilhelmsen, Michael MacConnel, Michael Roddy, and Robin VanHorn with CH2M-WG Idaho
- Katherine Medellin, Betsy Holmes, Richard Dickson, Mark Arenaz, Guy Backstrom, Greg Bass, Robert Boston, Nicole Brooks, Richard Denning, Jack Depperschmidt, Vanica Dugger, Robert Gallegos, Kathleen Hain, Nicole Hernendez, Tally Jenkins, James Malmo, Alan Obray, Robert Pence, Marcus Pinzel, Don Rasch, Tim Safford, Robert Shaw, David Sill, Jerry Wells, Ken Whitham, and Mary Willcox with the U.S. Department of Energy
- Kirk Clawson and Richard Eckman with the National Oceanic and Atmospheric Administration
- Roy Bartholomay with the United States Geological Survey

Technical editing of this report was provided by Susan White with Gonzales-Stoller Surveillance, LLC. Additional technical editing was performed by Pamela Lilburn with CH2M-WG Idaho and Jenifer Nordstom with Battelle Energy Alliance.

Publishing layout was executed by Brande Hendricks with S. M. Stoller Corporation and Alana Jensen with Gonzales-Stoller Surveillance, LLC.

Web design was implemented by Alana Jensen of Gonzales-Stoller Surveillance, LLC.

The primary authors would like to thank all those who provided data for the completion of this document. In particular, we wish to thank the following people for their assistance:

- Bryan Bybee, Kurt Edwards, Amy Forman, Jackie Hafla, Doug Halford, Jeremy Shive, and Jericho Whiting with the Gonzales-Stoller Surveillance, LLC
- Matt Anderson and Ryan Hruska with Idaho National Laboratory
- Quinn Shurtliff, Scott Bergen, and Kristy Howe with the Wildlife Conservation Society
- Ken Aho, Jocylene Benao, Richard Brey, Terry Bowyer, Marie-Anne deGraff, David Delehanty, Matthew Germino, Nancy Glenn, Amber Hoover, Lachy Ingram, John Kie, Kathleen Lohse, Ryan Long, Nancy Hampton, Niles Hasselquist, Nancy Huntly, Jessica Mitchell, Keith Reinhart, Joel Sankey, Teki Sankey, and Rosemary Smith with Idaho State University
- Amanda Price and Janet Rachlow with University of Idaho
- Tyler Brummer, Matt Lavin, Bruce Maxwell, and Lisa Rew with Montana State University
- Marie-Anne deGraff, Kevin Feris, and Pat Sorensen with Boise State University
- Lora Perkins and Robert Nowak with the University of Nevada Reno

- David Briske and Ben Wu with Texas A&M University
- Daniel Mummey with University of Montana
- Maria Fernandez-Gimenez with Colorado State University
- Brian Lamb with Washington State University
- Brandon Bestelmeyer with U.S. Department of Agriculture, Agricultural Research Service
- Peter Robichaud and Natalie Wagenbrenner with U.S. Forest Service, Rocky Mountain Research Station
- Matthew Germino and Joel Sankey with U.S. Geological Survey
- Daniel Ackerman, Linda Davis, Jason Fisher, John Nimmo, Katherine Potter, Gordon Rattray, Joseph Rousseau, and Brian Twining with U.S. Geological Survey, Idaho National Laboratory Project Office
- Bill Doering with POWER Engineers, Meridian, Idaho

To Our Readers

The Idaho National Laboratory Site Environmental Report for Calendar Year 2010 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, 2010. 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 of this page 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, 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 on this page or in the CD provided with the hard copy of this report.

Anderson Larkspur

Executive Summary

The *Idaho National Laboratory Site Environmental Report Calendar Year 2010* was prepared to inform the public, regulators, stakeholders, and other interested parties of the Idaho National Laboratory (INL) Site environmental performance during 2010.

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 231.1A, "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 Bechtel BWXT Idaho, 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. It 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 & 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.

Rough-legged Hawk

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, was 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 continued to dispose of low-level radioactive waste in pits at the SDA. The AMWTP contractor operates the SDA and is responsible for low-level waste management activities as well as monitoring and remediation activities associated with contamination from past waste disposal practices. Cleanup of 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, houses the Energy Policy Institute. 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 2010.

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 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 2010, the INL Site reused and recycled more than six million kilograms (fourteen million pounds) of materials.

Environmental Monitoring of Air

Airborne releases are reported by the INL contractor 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 5,089 curies of radioactivity, primarily in the form of short-lived noble gas isotopes, were released as airborne effluents in 2010. The highest releases were from INTEC (38 percent of total), the ATR Complex (42 percent of total) and MFC (13 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 2010, the INL contractor monitored ambient air outside 17 INL Site facilities 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, 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.

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. The results were within measurements made historically and by the EPA and were below DOE standards. Trtitum measured in these samples is most likely the result of natural production in the atmosphere and not the result of INL Site effluent releases.

Rough-legged Hawk

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 2010, liquid effluent and groundwater monitoring were conducted in support of wastewater reuse permit requirements. An annual report for each permitted facitlity 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 450.1A ("Environmental Protection Program") and 5400.5 ("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 13 drinking water systems at the INL Site in 2010. 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 2010. The dose, 0.27 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 and plutonium-239/240 were detected at levels slightly less than those measured in 2009. 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 2010, 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 tritium and strontium-90 over time.

Several purgeable organic compounds were detected by USGS in the production well at the RWMC. The concentration of tetrachloromethane (carbon tetrachloride) was above the EPA maximum contaminant level in one well during 2010. 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 2010. 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, strontium-90, and tritium. Only unfiltered chromium was detected above its maximum contaminant level in the ATR Complex aquifer wells but the levels are generally declining. 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: strontium-90, technetium-99 and nitrate. The source of strontium-90 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. Aluminum was detected above the secondary maximum contaminant level in one landfill well, but was attributed interaction of groundwater with grout placed below the well. Nitrate exceeded its maximum contaminant level in 2010, but concentrations were 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 two aquifer wells north of the facility in 2010. Wells at the MFC (WAG 9) are sampled for radionuclides, metals, total organic carbon, total organic halogens and other water quality parameters. 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 tritium. Tritium was not detected in any sample. 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.


Rough-legged Hawk

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 2010. 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 2010.

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, 0.058 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 2010 to be 382 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 2010. 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 305,938 people residing within an 80-km (50-mi) radius of any INL facility was calculated as 1.62 person-rem, below that expected from exposure to background radiation (116,868 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 0.059 mrem and 0.004 mrem, respectively. When summed with the dose estimated for the air pathway, (0.058 mrem) the maximally exposed individual could potentially receive a total dose of 0.12 mrem in 2010. This is 0.12 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 tritium 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 2010 there were 13 major ecological research projects taking place on the Idaho NERP. The researchers were from Idaho State University, University of Idaho, Boise State University, University of Nevada Reno, Montana State University, Colorado State University, Texas A&M, and Washington State University, Environmental Surveillance, Education, and Research Program, Wildlife Conservation Society, U.S. Department of Agriculture – Agricultural Research Service, U.S. Department of Agriculture – Forest Service Rocky Mountain Research Station, and POWER Engineers, Inc.

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 2010 the USGS published six research reports.

Quality Assurance

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

Adherence to procedures and quality assurance project plans was maintained during 2010. 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 2010 were addressed with the laboratories and have been or are being resolved.

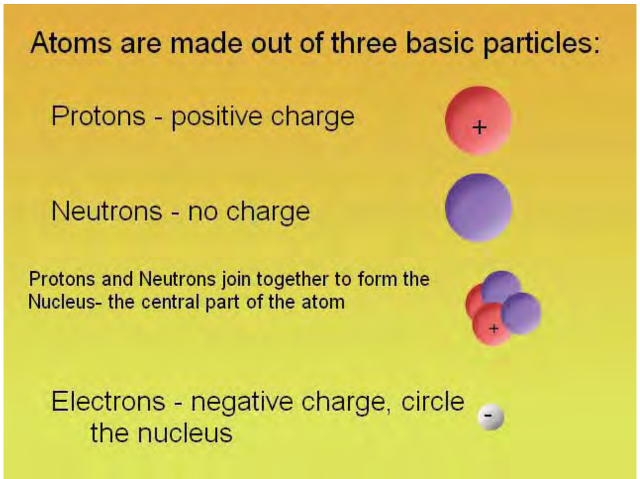
Western Bluebird

Badger

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 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.

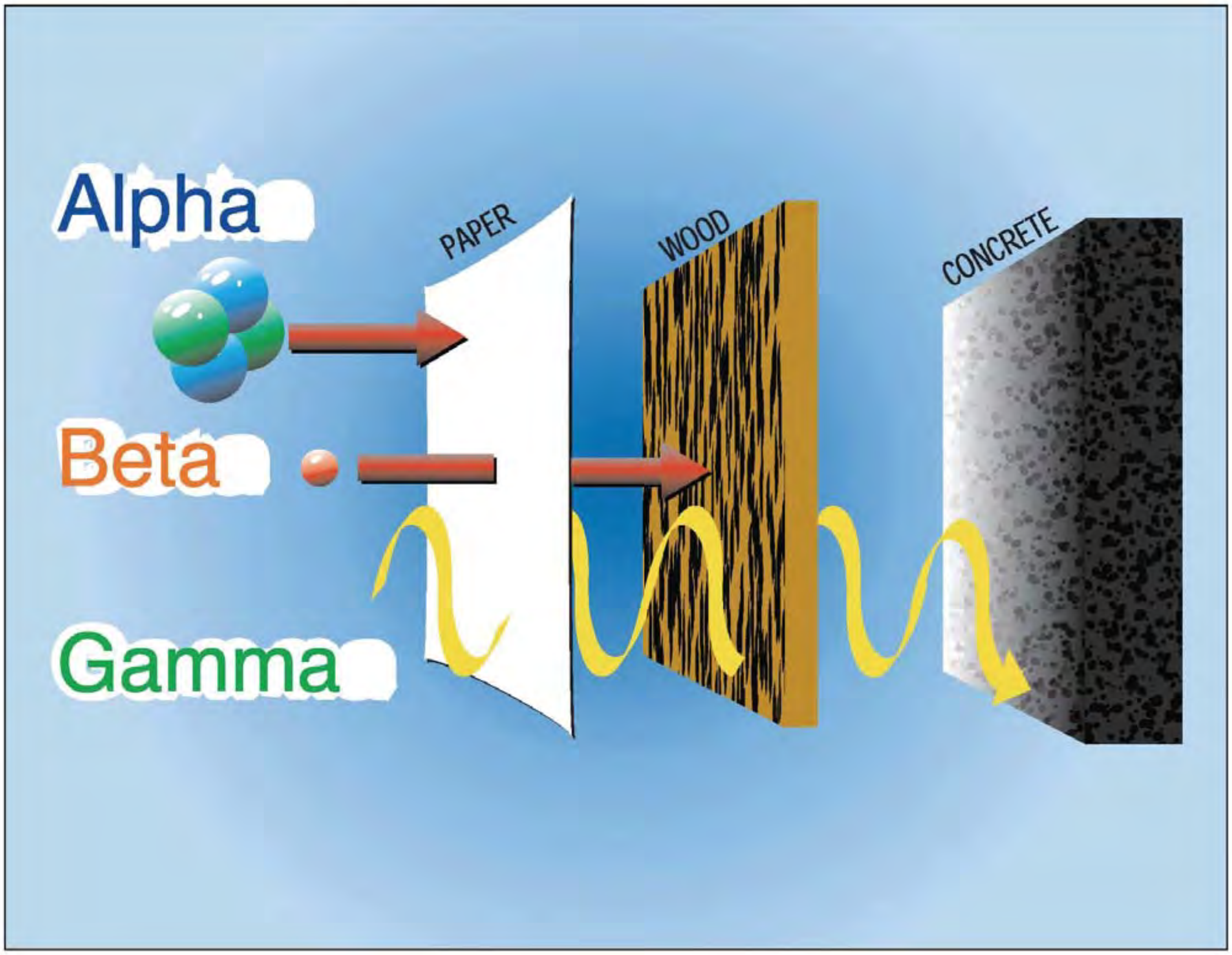


Figure HI-1. Comparison of Penetrating Ability of Alpha, Beta, and Gamma Radiation.

Rough-legged Hawk

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.

Western Bluebird

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 tritium (^{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.

Rough-legged Hawk

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

Table HI-2. Multiples of Units.

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

Units of Radioactivity. The basic unit of radioactivity used in this report is the curie (abbreviated Ci). 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.

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.

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)

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.

Annual human radiation exposure, measured by environmental dosimeters Milliroentgens (mR) or millirem (mrem), after being multiplied by an appropriate dose equivalent conversion factor

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


Rough-legged Hawk

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

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 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.

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.

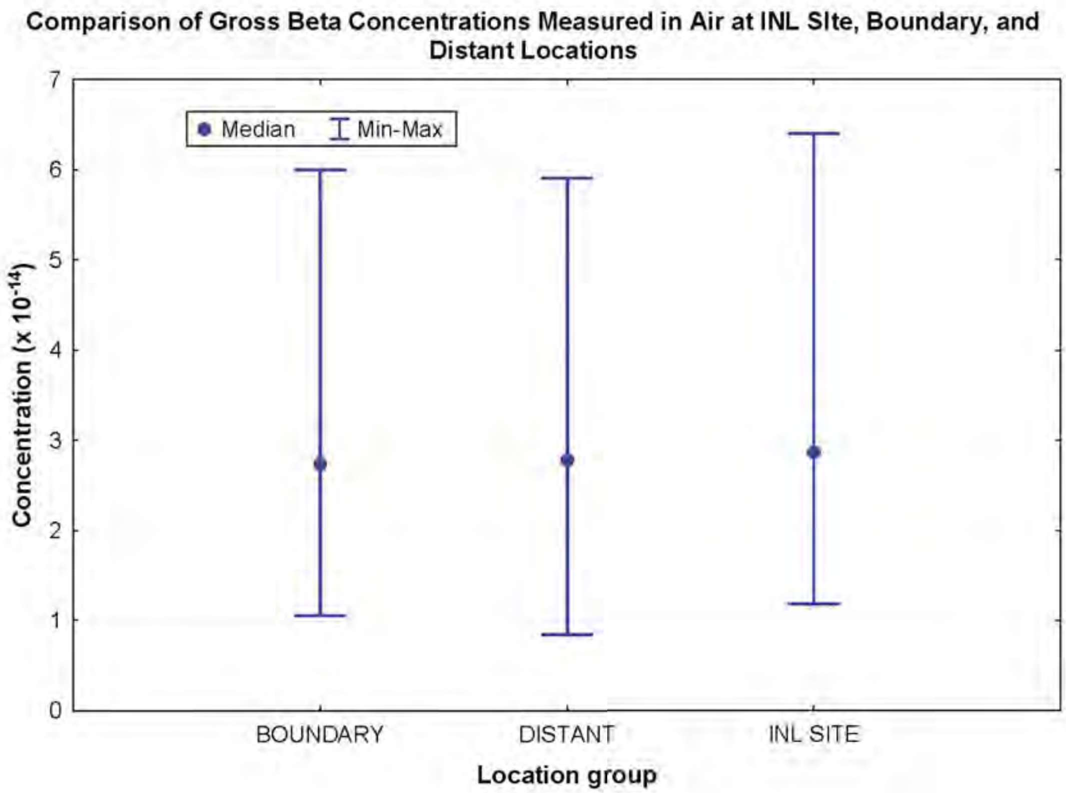
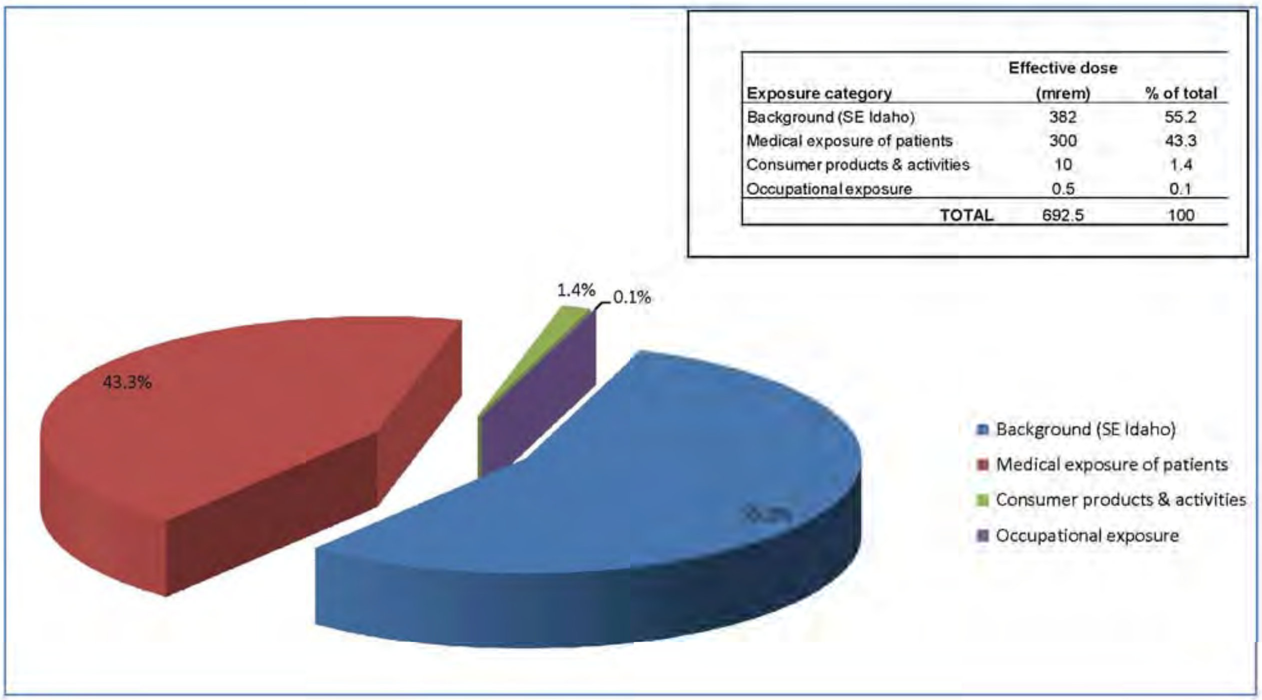


Figure HI-2. A Graphical Representation of Minimum, Median, and Maximum Results.

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 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,

Rough-legged Hawk



Exposure category	Effective dose (mrem)	% of total
Background (SE Idaho)	382	55.2
Medical exposure of patients	300	43.3
Consumer products & activities	10	1.4
Occupational exposure	0.5	0.1
TOTAL	692.5	100

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

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 tritium in groundwater around the Idaho Nuclear Technology and Engineering Center (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

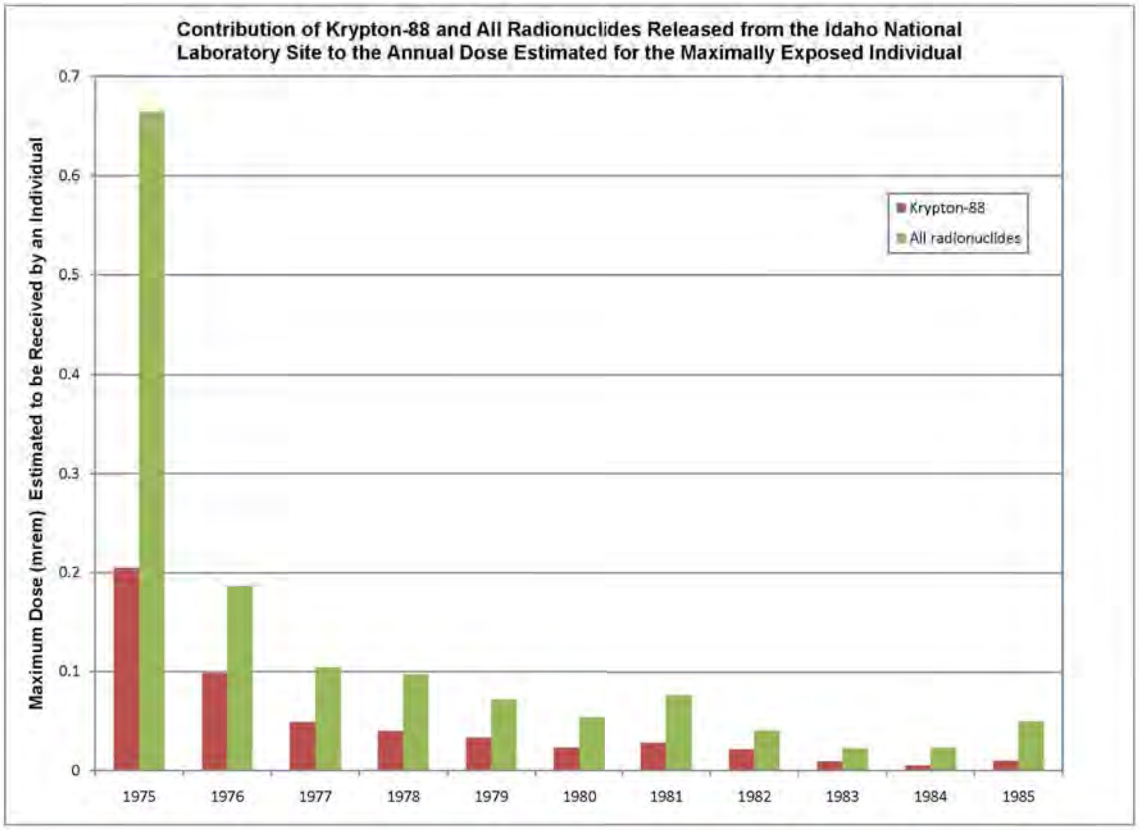


Figure HI-4. Data Plotted Using a Column Chart.

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.

Rough-legged Hawk

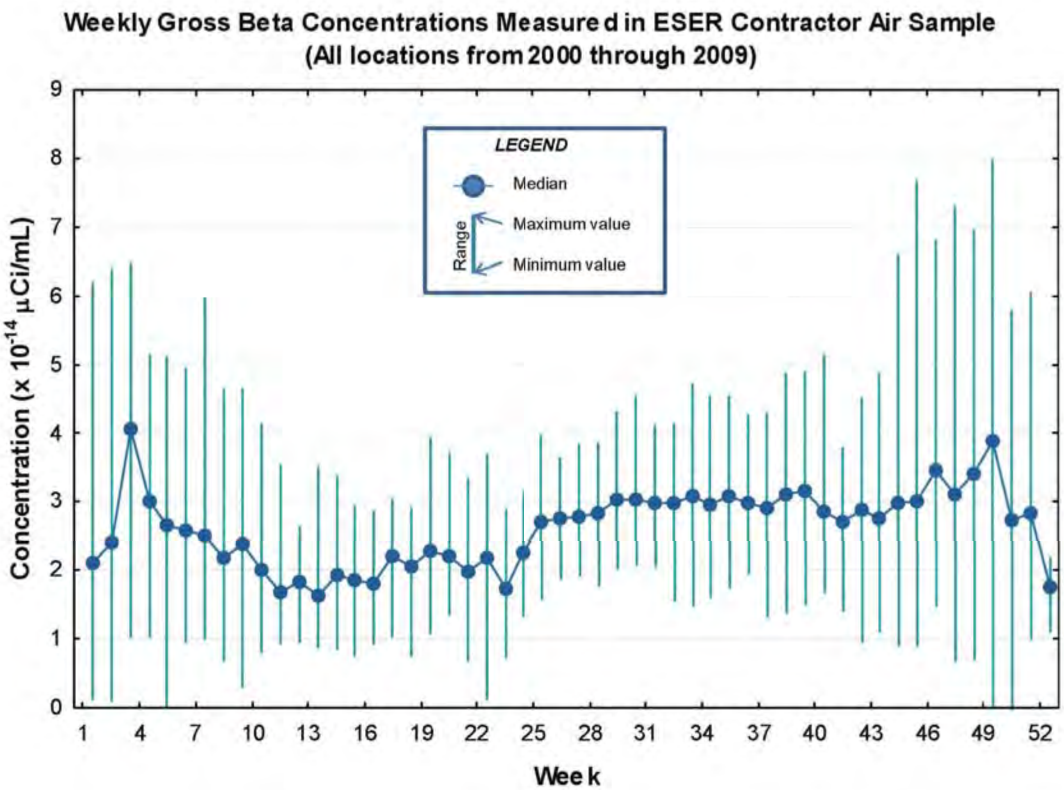


Figure HI-5. Data Plotted Using a Linear Plot.

- Comparison with background measurements. Humans are now, and always have been, continuously exposed to ionizing radiation from natural background sources. Background sources include natural radiation and radioactivity as well as radionuclides from human activities. These sources are discussed in the following section.

What is Background Radiation?

Radioactivity from natural and fallout sources is detectable as "background" in all environmental media. Natural sources of radiation include: 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.

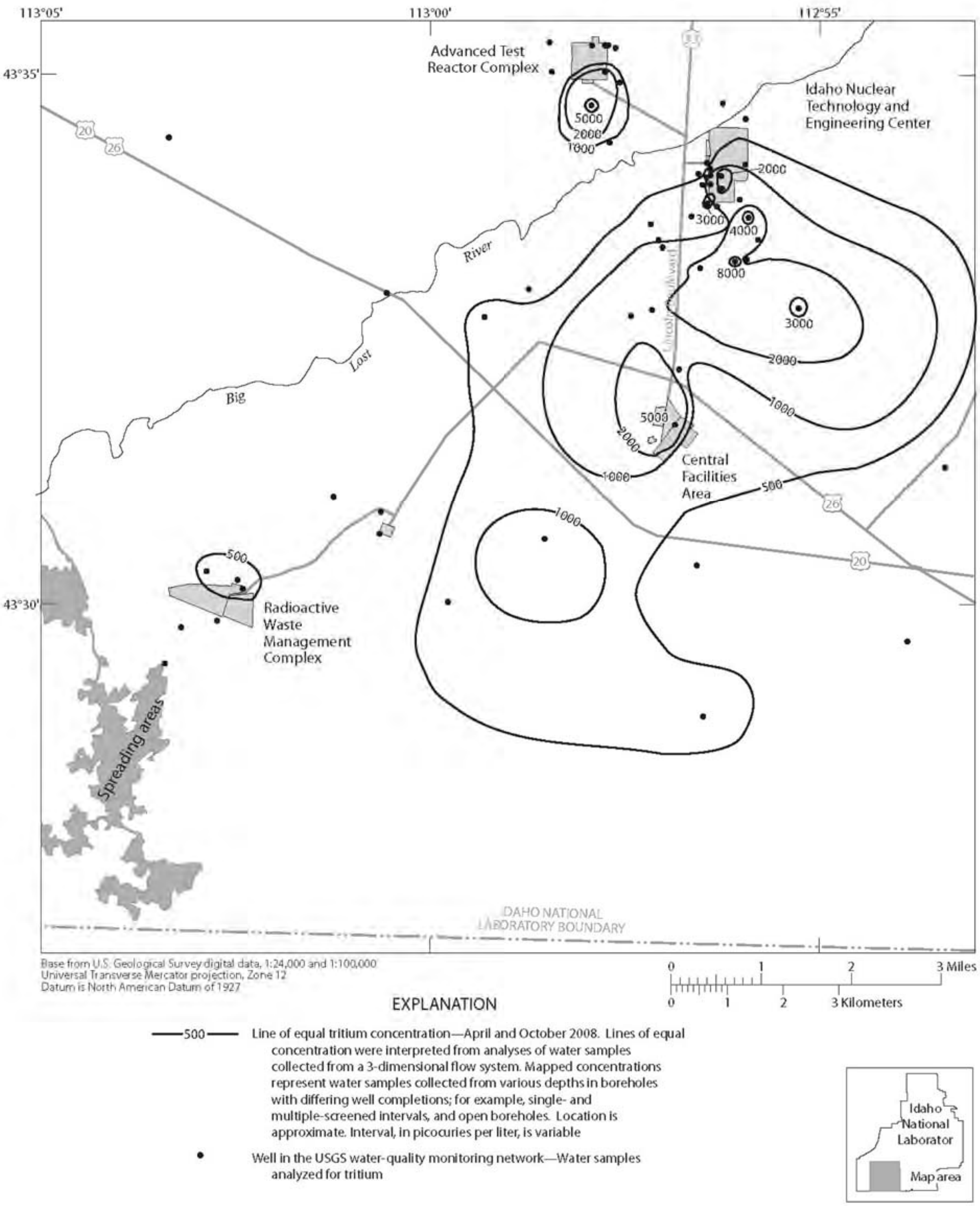


Figure HI-6. Data Plotted Using Contour Lines. Each contour line drawn on this map connects points of equal tritium concentration in water samples collected at the same depth from wells on the INL Site.

Rough-legged Hawk

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). 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 2010 to receive an average dose of about 382 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 tritium (^{3}H), beryllium-7 (^{7}Be), sodium-22 (^{22}Na), and carbon-14 (^{14}C). Cosmogenic radionuclides, particularly tritium 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.

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.

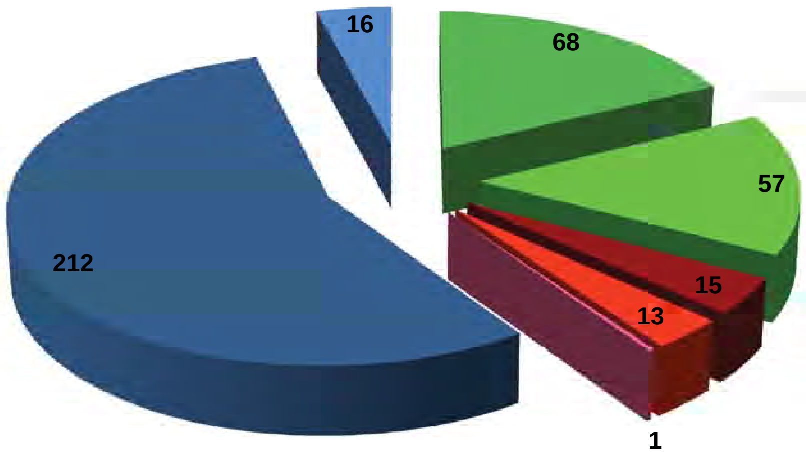


Figure HI-7. Calculated Doses (mrem per year) from Natural Background Sources for an Average Individual Living in Southeast Idaho (2010).

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

Rough-legged Hawk

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 strontium-90 (^{90}Sr) and cesium-137 (^{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 millirem), 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 5 or 6 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 5400.5). The doses estimated to maximally exposed individuals from INL Site releases are typically well below one mrem per year.

Rough-legged Hawk

REFERENCES

DOE Order 231.1A, 2004, “Environment, Safety, and Health Reporting,” Change 1, U.S. Department of Energy.

DOE Order 450.1A, 2008, “Environmental Protection Program,” U.S. Department of Energy.

DOE Order 5400.5, 1993, “Radiation Protection of the Public and the Environment,” Change 2, U.S. Department of Energy.

EPA, 1999. *Cancer Risk Coefficients for Environmental Exposure to Radionuclides*. EPA 402-R-99-001, U.S. Environmental Protection Agency.

EPA, 2010, *Understanding Radiation: Health Effects*, http://www.epa.gov/rpdweb00/understand/health_effects.html#whatlimits, Web page visited September 3, 2010.

NCRP, 1987, *Exposure of the Population in the United States and Canada from Natural Background Radiation*, NCRP Report No. 94 National Council on Radiation Protection and Measurements.

NCRP, 2009, *Ionizing Radiation Exposure of the Population of the United States*, NCRP Report No. 160, National Council on Radiation Protection and Measurements.

Taylor, Lauriston S., 1996, *What You Need to Know About Radiation*, http://www.physics.isu.edu/radinf/lst.htm

Roy Bartholomay, USGS, sampling water from an aquifer well

Acronyms

AEC	U.S. Atomic Energy Commission
AMWTP	Advanced Mixed Waste Treatment Project
ANL-W	Argonne National Laboratory-West
ANOVA	Analysis of Variance
ARA	Auxiliary Reactor Area
ARP	Accelerated Retrieval Project
ASME	American Society of Mechanical Engineers
ATR	Advanced Test Reactor
BBI	Bechtel Bettis, Inc.
BBWI	Bechtel BWXT Idaho, LLC
BCG	Biota Concentration Guides
BEA	Battelle Energy Alliance
BLM	U.S. Bureau of Land Management
BLR	Big Lost River
BNFL	British Nuclear Fuels Limited
BOD	Biochemical Oxygen Demand
CAP88-PC	Clean Air Act Assessment Package, 1988 Personal Computer
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERT	Controlled Environmental Radioiodine Test
CFA	Central Facilities Area
CFR	Code of Federal Regulations
CINB	Cinder Butte
CITRC/PBF	Critical Infrastructure Test Range Complex/Power Burst Facility
CMP	Conservation Management Plan
CMS	Community Monitoring Station
COD	Chemical Oxygen Demand
CRMP	Cultural Resource Management Plan
CTF	Contained Test Facility
CWA	Clean Water Act
CWI	CH2M-WG Idaho
DCG	Derived Concentration Guide
D&D	Decontamination, Decommissioning, and Demolition
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
EA	Environmental Assessment
EBR-I	Experimental Breeder Reactor - No. 1
EBR-II	Experimental Breeder Reactor - No. 2
ECF	Expended Core Facility
ECG	Environmental Concentration Guide
EDE	Effective Dose Equivalent
EFS	Experimental Field Station
EIS	Environmental Impact Statement

EM	DOE Office of Environmental Management
EML	Environmental Measurements Laboratory
EMS	Environmental Management System
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
EPP	Environmental Preferable Purchasing
ESER	Environmental Surveillance, Education and Research
ESRPA	Eastern Snake River Plain Aquifer
ESRP	Eastern Snake River Plain
ET	Evapotranspiration
ETR	Engineering Test Reactor
FAA	Federal Aviation Administration
FAST	Fluorinel Dissolution Process and Fuel Storage Facility
FEC	Federal Electronics Challenge
FEIS	Final Environmental Impact Statement
FFA/CO	Federal Facility Agreement and Consent Order
FR	Federal Register
FY	Fiscal Year
GEL	General Engineering Laboratories
GEM	Glovebox Excavator Method
GIS	Geographic Information System
GPRS	Global Positioning Radiometric Scanner
GPS	Global Positioning System
HAER	Historic American Engineering Record
HDR	Hydrogeological Data Repository
HHW	Household Hazardous Waste
HLW	High-Level Waste
HLW & FD EIS	High-Level Waste and Facilities Disposition Environmental Impact Statement
ICDF	Idaho CERCLA Disposal Facility
ICP	Idaho Cleanup Project
IDAPA	Idaho Administrative Procedures Act
IFSF	Irradiated Fuel Storage Facility
IFSFI	Irradiated Fuel Storage Facility Installation
IMPROVE	Interagency Monitoring of Protected Visual Environments
INEEL	Idaho National Engineering and Environmental Laboratory
INEL	Idaho National Engineering Laboratory
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center (formerly Idaho Chemical Processing Plant)
IRC	INL Research Center
ISB	In Situ Bioremediation
ISFSI	Independent Spent Fuel Storage Installation
ISO	International Organization for Standardization
ISU	Idaho State University

Rough-legged Hawk

IWTU	Integrated Waste Treatment Unit
LDRD	Laboratory Directed Research and Development
LLW	Low-Level Waste
LOFT	Loss-of-Fluid Test
LTS	Long-Term Stewardship
LTV	Long-Term Vegetation
M&O	Management and Operating
Ma	Million Years
MAPEP	Mixed Analyte Performance Evaluation Program
MCL	Maximum Contaminant Level
MDA	Minimum Detectable Activity
MDC	Minimum Detectable Concentration
MDIFF	Mesoscale Diffusion Model
MEI	Maximally Exposed Individual
MFC	Materials and Fuels Complex
MNA	Monitored Natural Attenuation
NCRP	National Council on Radiation Protection and Measurements
NE	Nuclear Energy
NEPA	National Environmental Policy Act
NERP	National Environmental Research Park
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
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
NOV	Notice of Violation
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NPTF	New Pump and Treatment Facility
NRC	U.S. Nuclear Regulatory Commission
NRF	Naval Reactors Facility
NRTS	National Reactor Testing Station
NS	No Sample
NSF	National Science Foundation
NWQL	National Water Quality Laboratory (USGS)
OU	Operable Unit
PBF	Power Burst Facility
PCB	Polychlorinated Biphenyls
PCBE	Protective Cap/Biobarrier Experiment
PCS	Primary Constituent Standard
PE	Performance Evaluation
PIDAS	Perimeter Intrusion Detection Access System
PM	Particulate Matter
POC	Purgeable Organic Compounds

PPOA	Pollution Prevention Opportunity Assessment
P2	Pollution Prevention
PSD	Prevention of Significant Deterioration
PTC	Permit to Construct
QA	Quality Assurance
QAP	Quality Assurance Program
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
RD/RA	Remedial Design/Remedial Action
RE	Removal Efficiencies
RESL	Radiological and Environmental Sciences Laboratory
RESRAD	Residual Radioactivity
RH	Remote-Handled
RI/FS	Remedial Investigation/Feasibility Study
RPD	Relative Percent Difference
ROD	Record of Decision
RSWF	Radioactive Scrap and Waste Facility
RTC	Reactor Technology Complex
RWMC	Radioactive Waste Management Complex
SAM	Sample and Analysis Management
SBW	Sodium-Bearing Waste
SCS	Secondary Constituent Standard
SD	Sample was Destroyed
SDA	Subsurface Disposal Area
SEM	Structural Equation Model
SHPO	State Historic Preservation Office
SI	International System of Units
SLYM-BART	Slime Bacteria Test
SMC	Specific Manufacturing Capability
SMCL	Secondary Maximum Contaminant Level
SNF	Spent Nuclear Fuel
SNOTEL	Snowpack Telemetry
SP	Suspended Particle
SRP	Snake River Plain
STF	Security Training Facility
STP	Sewage Treatment Plant
TAN	Test Area North
TBE	Teledyne Brown Engineering
TCE	Trichloroethylene
TDS	Total Dissolved Solids
TIC	Total Integrated Concentration
TLD	Thermoluminescent Dosimeter
TMI	Three-Mile Island
TRA	Test Reactor Area
TRU	Transuranic (waste)

TSCA	Toxic Substances Control Act
TSF	Technical Support Facility
TSS	Total Suspended Solids
UAV	Unmanned Aerial Vehicles
UCL	Upper Confidence Limit
USGS	U.S. Geological Survey
VOC	Volatile Organic Compounds
WAG	Waste Area Group
WERF	Waste Experimental Reduction Facility
WIPP	Waste Isolation Pilot Plant
WRP	Wastewater Reuse Permit
WRRTF	Water Reactor Research Test Facility
YSRP	Yellowstone-Snake River Plain

Burrowing Owl
Photo Credit: Quinn Shurtliff, WCS

Units

Bq	becquerel	μS	microsiemens
cfm	cubic feet per minute	μSv	microsieverts
C	Celsius	Ma	million years
Ci	curie	mg	milligram
cm	centimeter	MG	million gallons
cps	counts per second	mGy	milligrey
F	Fahrenheit	mi	mile
ft	feet	min	minutes
g	gram	mL	milliliter
gal	gallon	mm	millimeters
gpd	gallons per day	mmhos/cm	millimhos per centimeter
gpm	gallons per minute	mR	milliroentgen
ha	hectare	mrem	millirem
hr	hour	mSv	millisievert
in.	inch	ng	nanogram
KeV	kilo-electron-volts	oz	ounce
kg	kilogram	pCi	picocurie (10^{-12} curies)
km	kilometer	ppm	parts per million
L	liter	rad	radiation absorbed dose
lb	pound	rem	roentgen equivalent man
m	meter	Sv	sievert
μCi	microcurie (10^{-6} curies)	yd	yard
μg	microgram		

Russ Mitchell, ESER Program, collecting soil sample

Table of Contents


Rough-legged Hawk

Rough-legged Hawk

LIST OF FIGURES

Western Bluebird

Rough-legged Hawk

LIST OF TABLES


Rough-legged Hawk

Chapter 1. Introduction

1. INTRODUCTION

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

- DOE Order 231.1A, “Environment, Safety and Health Reporting”
- DOE Order 450.1A, “Environmental Protection Program”
- DOE Order 5400.5, “Radiation Protection of the Public and the Environment.”

The purpose of the report, as outlined in DOE Order 231.1A, 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 5400.5 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.

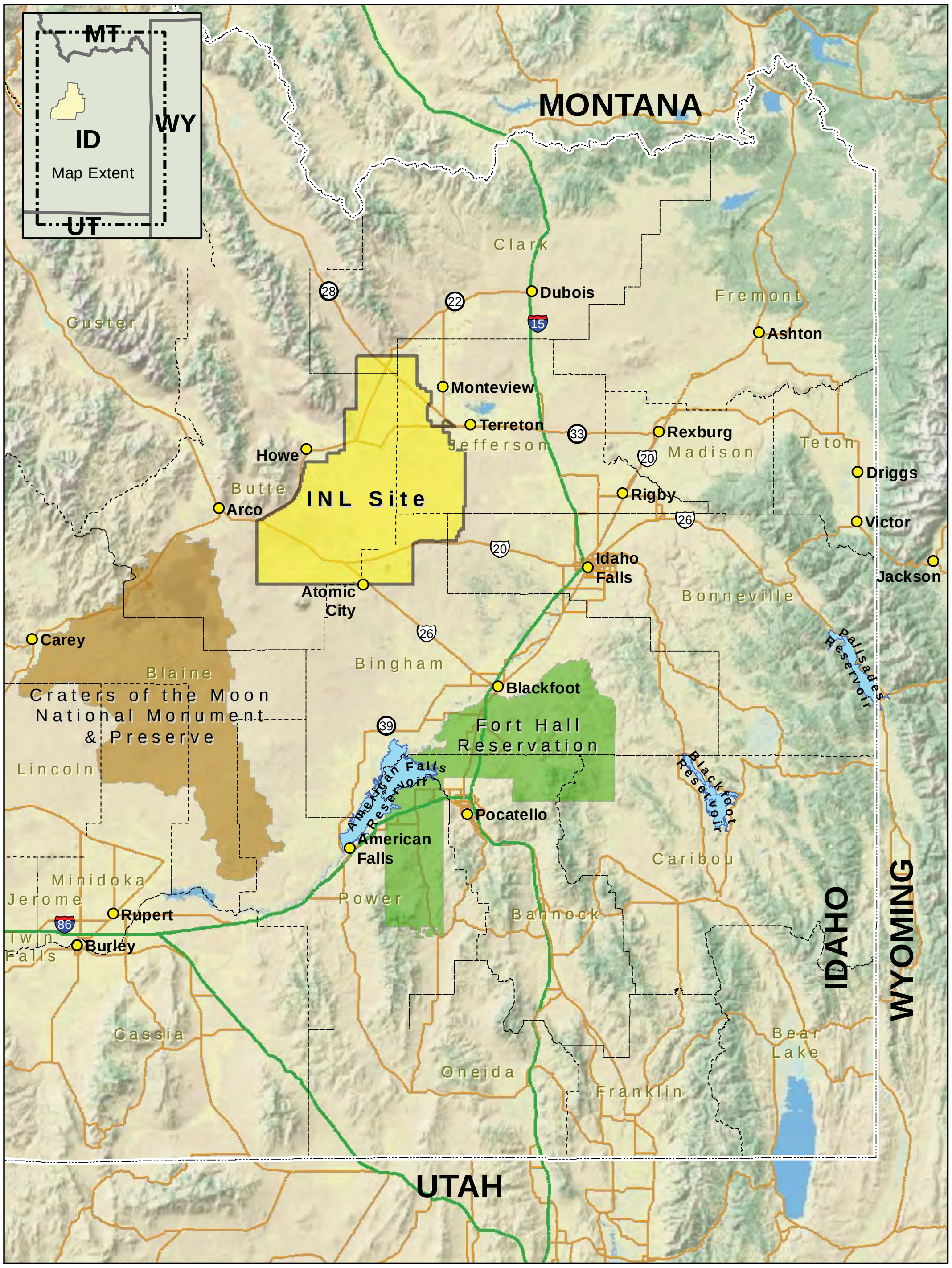


Figure 1-1. Location of the Idaho National Laboratory Site.

Rough-legged Hawk

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.

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.

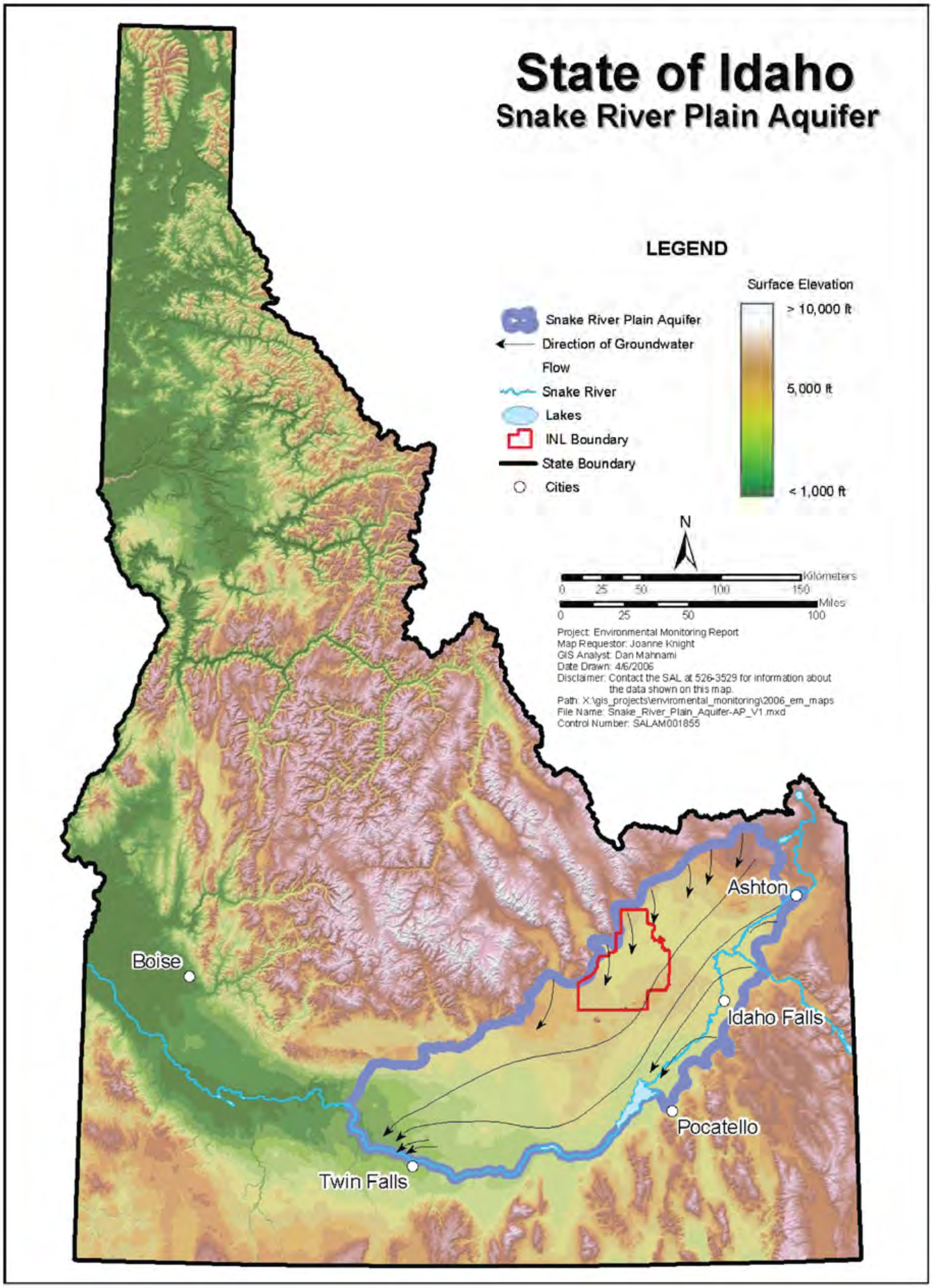


Figure 1-2. Idaho National Laboratory Site in Relation to the Eastern Snake River Plain Aquifer.

Rough-legged Hawk

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 Bechtel BWXT Idaho, 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 34,580 m^3 (45,194 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

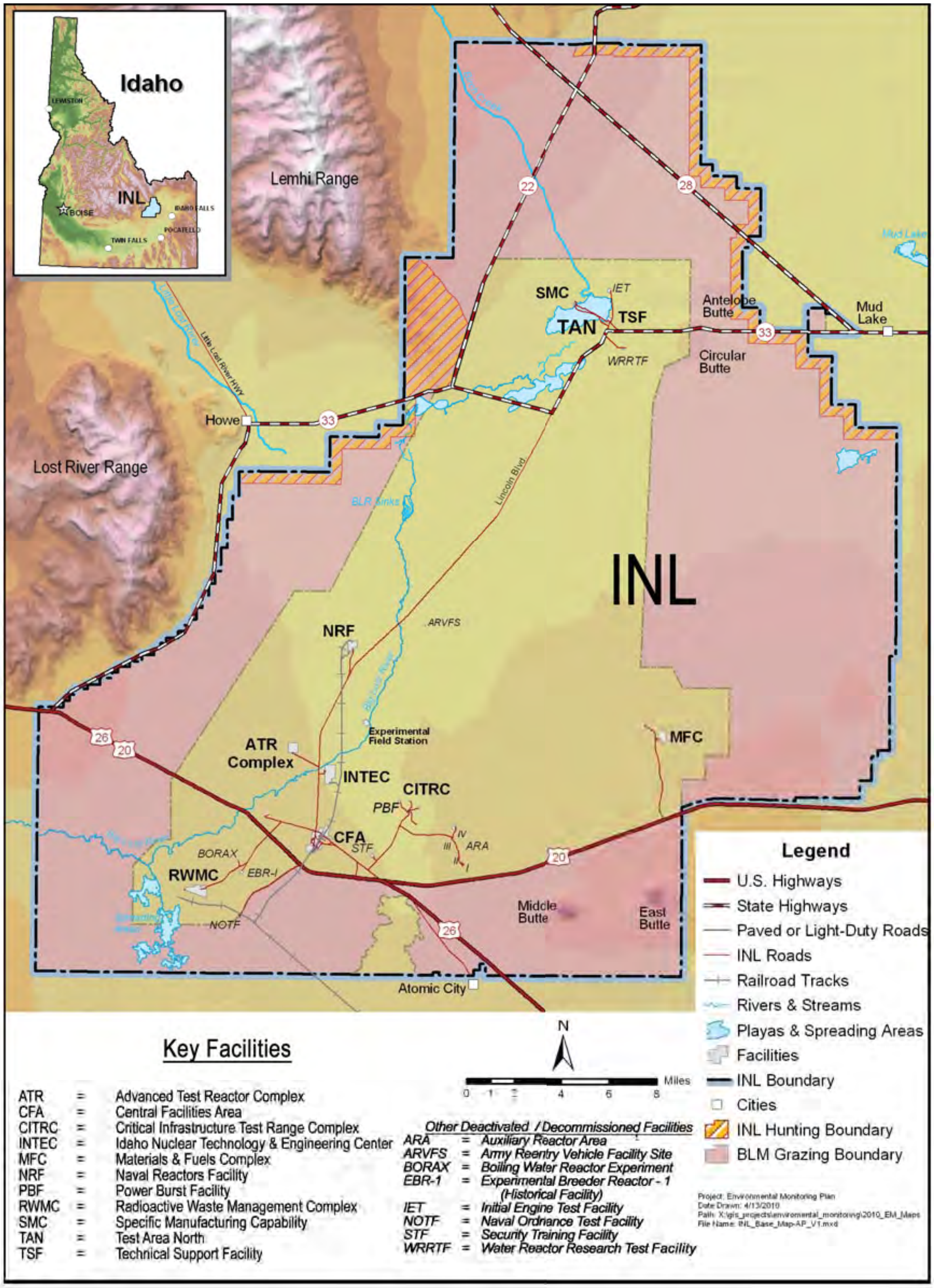


Figure 1-3. Location of the Idaho National Laboratory Site, Showing Facilities.

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 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 450.1A, 5400.5, 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 2011).

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 supports research projects dealing with waste retrieval and processing technology and provides temporary storage and treatment of transuranic waste destined for 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 is the major focus for remedial decisions at RWMC. The landfill has been 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 weapons production at other DOE facilities and reactor research. Most of the waste that would be considered transuranic by today's

Rough-legged Hawk

standards was received from the Rocky Flats Plant in Colorado prior to 1970 and buried at the SDA. Although transuranic waste does not threaten the aquifer, it could pose a threat through exposure at the surface if no action is taken to address that issue. However, organic solvents are found in the aquifer beneath the SDA. DOE developed a Record of Decision for remediating the buried waste (DOE-ID 2008), in coordination with the Environmental Protection Agency and the state of Idaho. The Record of Decision calls for exhuming a minimum of 6,238 m3 (8,159 yd3) of targeted waste from a minimum combined area of 2.3 hectares (5.69 acres). 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 approximately 300,000. Over half of this population (about 165,000) resides in about equal numbers in the census divisions of Idaho Falls and northern Pocatello. Another 25,000 live in the Rexburg census division. Approximately 16,000 reside in the Rigby census division and 15,000 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.”

REFERENCES

Anderson, J. E., K. T. Ruppel, J. M. Glennon, K. E. Holte, and R. C. Rope, 1996, *Plant Communities, Ethnoecology, and Flora of the Idaho National Engineering Laboratory*, ESRF-005, Environmental Science and Research Foundation.

BMPC, 2011, *2010 Environmental Monitoring Report for the Naval Reactors Facility*, NRFOSQ-ESH-EE-11-005, Bechtel Marine Propulsion Corporation.

Black, G., D. Holley, and J. Church, 2009, *Idaho National Laboratory Impacts 2009: An Analysis of the effects of Idaho National Laboratory Site Operations on Idaho's Economy*, Boise State University.

DOE, 1995, Settlement Agreement, U. S. Department of Energy, U.S. Department of the Navy, and State of Idaho.

DOE Order 231.1A, 2004, "Environment, Safety and Health Reporting," Change 1, U.S. Department of Energy.

DOE Order 414.1C, 2005, "Quality Assurance," U.S. Department of Energy.

DOE Order 450.1A, 2008, "Environmental Protection Program," U.S. Department of Energy.

DOE Order 5400.5, 1993, "Radiation Protection of the Public and the Environment," Change 2, U.S. Department of Energy.

DOE-ID, 1989, *Climatography of the Idaho National Engineering Laboratory, 2nd Edition, DOE/ID-12118*, U.S. Department of Energy Idaho Operations Office.

DOE-ID, 2008, *Record of Decision for Radioactive Waste Management Complex Operable Unit 7-13/14*, DOE/ID-11359, U.S. Department of Energy Idaho Operations Office.

Executive Order 12344, 1982, "Naval Nuclear Propulsion Program."

ESRF, 1996, "The Site, the Plain, the Aquifer, and the Magic Valley (Part One of Four)," Foundation Focus, Volume 3, Issue 3, Environmental Science and Research Foundation.

Lindholm, G. F., 1996, *Summary of the Snake River Plain Regional Aquifer-System Analysis in Idaho and Eastern Oregon*, U.S. Geological Survey Professional Paper 1408-A.

Reynolds, T. D., J. W. Connelly, D. K. Halford, and W. J. Arthur, 1986, "Vertebrate Fauna of the Idaho National Environmental Research," *Great Basin Naturalist*, Vol. 46, No. 3, pp. 513 – 527.

Smith, R. B. and L. J. Siegel, 2000, *Windows into the Earth, The Geologic Story of Yellowstone and Grand Teton National Parks*, Oxford University Press.

2010

Chapter 2. Environmental Compliance Summary

Chapter 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 2010, and programs are in place to address areas for continued improvement.

The *National Emission Standards for Hazardous Air Pollutants-Calendar Year 2010 INL Report for Radionuclides* report was submitted to U.S. Environmental Protection Agency, DOE Headquarters, and state of Idaho officials in June 2011, 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 2010 in compliance with the National Environmental Policy Act. DOE-ID also started work on a third EA.

The U.S. Fish and Wildlife Service (USFWS) issued two rulings in 2010 concerning two wildlife species documented at the INL Site. The USFWS determined 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. The Service also found that listing of the pygmy rabbit is not warranted at this time.

The *2010 Site Executable Plan for Energy and Transportation Fuels Management* was completed in compliance with the new Department of Energy Order 430.2B, “Departmental Energy, Utilities, and Transportation Management.” The document provides plans for providing continual energy efficiency, environmental improvements, and transportation fuels efficiency at the INL Site.

The *2010 Idaho Hazardous Waste Generator Annual Report* was submitted to the state of Idaho, which is authorized by Environmental Protection Agency (EPA) to regulate hazardous waste under the Resource Conservation and Recovery Act. The state of Idaho approved closure plans for three facilities in 2010. The State also conducted an annual hazardous waste compliance inspection of the INL Site and noted one violation. The Notice of Violation was closed after a penalty was paid.

In 2010, 27 INL Site projects were screened for potential impacts to archeological resources. In addition, 33 of INL Site's cultural resources locations were revisited.

There are 42 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 all elements of the CAA except for several subparts 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 2010 INL Report for Radionuclides* (DOE-ID 2011). 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.

- **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

Table 2-1. Environmental Permits for the INL Site (2010).

Permit Type	Active Permits
Air Emissions:	
Permit to Construct	15
Title V Operating Permit	2
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.

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 two Tier I operating permits for the INL Site.

2.1.2 DOE Order 5400.5, Radiation Protection of the Public and the Environment

DOE Order 5400.5, "Radiation Protection of the Public and the Environment," represents DOE's objective to operate its facilities and conduct its activities so that radiation exposures to members of the public are maintained within the limits established in the Order and to control radioactive contamination through the management of real and personal property. Another DOE objective is that potential exposures to members of the public be as far below the limits as is reasonably achievable and that DOE facilities have the capabilities, consistent with the types of operations conducted, to monitor routine and nonroutine releases, and to assess doses to members of the public. In addition to providing protection to members of the public, it is DOE's objective to protect the environment from radioactive contamination to the extent practical. DOE Order 5400.5 establishes requirements for:

- Measuring radioactivity in the environment
- Applying the as low as reasonably achievable process to DOE activities and facilities that cause public doses
- Evaluating radiation doses to demonstrate compliance with dose limits
- Managing radioactive waste
- Releasing property with residual radioactive material
- Records management and reporting.

The Order sets public dose limits of 10 mrem/yr (0.1 mSv/yr) from airborne emissions and a total of 100 mrem/yr (1 mSv/yr) above background for all exposure pathways. Chapter 8 presents dose calculations for INL Site releases for 2010.

In addition to public radiation dose limits, DOE Order 5400.5 establishes Derived Concentration Guide values, which serve as reference values for conducting radiological environmental protection programs at DOE facilities and sites. The Derived Concentration Guide values are presented for each of three exposure modes: (1) ingestion of water, (2) inhalation of air, and (3) immersion in a gaseous cloud. INL Site environmental monitoring data and dose to public calculations included in this report comply with the requirements of DOE Order 5400.5 Derived Concentration Guide values (Appendix A) and are used throughout this report for comparison to and interpretation of environmental monitoring and radiological dose data.

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 450.1A, Environmental Protection Program

The purpose of DOE Order 450.1A, “Environmental Protection Program,” is to implement sound stewardship practices that protect the air, water, land, and other natural and cultural resources affected by DOE operations, and to cost effectively meet or exceed applicable environmental, public health, and resource protection requirements. This is accomplished through environmental management systems that are part of an Integrated Safety Management System. The environmental management system must include the goals of Executive Order

13423, "Strengthening Federal Environmental, Energy, and Transportation Management." These goals include energy and water conservation, renewable energy, use of alternate fuels, and other "green" initiatives. The INL Site implements the requirements of DOE Order 450.1A through various environmental monitoring and protection programs, integrated environmental management and safety management systems, and pollution prevention/waste minimization programs. These programs are summarized in this chapter and elsewhere in this report.

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). No CERCLA-reportable chemicals were released at the INL Site during 2010.

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.

Table 2-2. INL Site EPCRA Reporting Status (2010).

EPCRA Section	Description of Reporting	2010 Status
Section 304	Extremely Hazardous Substance release notification	Not Required
Section 311-312	Material Safety Data Sheet/Chemical Inventory	Required
Section 313	Toxic Chemical Release Inventory Reporting	Required

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 chromium, ethylbenzene, lead, naphthalene, nickel, and nitric acid to EPA and the state of Idaho by the regulatory due date of July 1.

Reportable Environmental Releases – An environmental release at the Advanced Test Reactor (ATR) Complex was determined to be reportable to external agencies in 2010. This release involved the discovery of an area of stained soil related to the historic storage of refueling pipes, in a lean-to adjacent to building TRA-627. A sample was collected for laboratory analysis and determined to be fuel oil #6 from past facility operations. Investigation indicated that the spill could not be cleaned up within twenty-four hours, as required by Idaho regulations. Therefore, the spill was reportable.

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, 2010. 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 prepared two environmental assessments (EA) in 2010:

The first EA completed was the Environmental Assessment for the Multipurpose Haul Road within the Idaho National Laboratory Site (DOE/EA-1772). That document describes the potential impacts of constructing a haul road within the INL Site to allow the out of commerce shipment of materials and wastes between the Materials and Fuels Complex (MFC) and other INL Site facilities. Two action alternatives as well as the No Action Alternative were evaluated. The Department selected Alternative 1 – New route south of the T-25 road using the existing road to the extent possible and issued a finding of no significant impact.

The second EA completed was the Idaho National Laboratory Radiological Response Training Range Environmental Assessment (DOE/EA-1776). The document describes the potential impacts of creating and operating a radiological response training range on the INL Site. Two options for the proposed action were evaluated as well as the No Action Alternative. The proposed action (North and South Training Ranges) focuses radiological activities near Test Area North (North Training Range) and near the Radioactive Waste Management Complex (South Training Range). DOE divided the on-site locations into two sub-alternatives: Alternative 1a, "Maximize Project Flexibility," and Alternative 1b, "Minimize Project Impacts." DOE decided to implement Alternative 1a and issued a finding of no significant impact.

DOE-ID also started work on a third EA to analyze the potential of creating and operating a Stand-Off Experiment Range on the INL Site. Two alternatives are being considered: (1) the proposed action, and (2) no action. The proposed Range would enable INL experts to 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. Generation and detection of these signatures at a distance from the target object would be the focus of work at the Stand-Off Experiment Range. The draft EA was released for public comment on December 22, 2010.

2.2.5 Endangered Species Act

The Endangered Species Act:

- Provides a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved
- Provides a program for the conservation of such endangered species and threatened species
- 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 species 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.

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


Rough-legged Hawk

experimental populations. Wolves found on the INL Site would be considered part of the nonessential experimental population.

On March 5, 2010, the USFWS published a Notice of a 12-month petition finding for the Greater Sage-Grouse. The Service determination for the sage-grouse warrants the protection of the Endangered Species Act but listing the species at this time is precluded by the need to address higher priority species first. The sage-grouse will be placed on the candidate list for future action, meaning the species would not receive statutory protection under the Endanged Species Act and states would continue to be responsible for managing the bird. Sage-grouse are resident INL Site species.

On September 30, 2010, the USFWS published a Notice of a 12-month petition finding for the pygmy rabbit. The Service determined the listing of the pygmy rabbit under the Endangered Species Act was not warranted at this time. Pygmy rabbits are resident INL Site species.

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.

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.

Special Purpose Permit Annual Activity – In 2010, the ICP contractor attempted to relocate one barn swallow nest containing four eggs. The location of the nest was restricting remote-handled transuranic waste operations. The attempted relocation resulted in three eggs being destroyed and the remaining egg being relocated but becoming non-viable.

Barn Swallow Nest Destruction – In June 2010, Bechtel BWXT, Idaho (BBWI) notified DOE-ID four swallow nests were destroyed at AMWTP with at least two of those nests containing eggs. DOE-ID made the initial notification of the incident to the USFWS. BBWI conducted an internal investigation and determined the destruction of the nests was intentional but could not determine which person or persons committed the act. BBWI discussed the matter with the USFWS Special Agent and provided a copy of their internal investigation report. The USFWS Special Agent was satisfied with the investigation and the corrective actions that BBWI implemented.

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 2010, 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 (Figure 2-1). 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 (GHG) 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 is due from each of the agencies to the CEQ Chair and OMB Director.

Figure 2-1. President Barack Obama Participates in the Council on Environmental Quality Executive Order Signing in the Oval Office, Oct. 5, 2009.
(Official White House Photo by Pete Souza)

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 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


Rough-legged Hawk

Table 2-4. Executive Order 13514 Targets and Management Strategies for Federal Agencies (2010).

NUMERICAL TARGETS

- Reduce petroleum consumption by 2 percent per year through FY 2020[a]
- 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
- R.E. 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.

- Establishes a timeline for execution coupled with specific performance measures and deliverables designed to achieve established requirements.

DOE-ID submitted the *2010 INL Site Executable Plan for Energy and Transportation Fuels Management* to DOE Headquarters in December 2009. This plan contains strategies and activities for 2010 that are leading INL to continual energy efficiency, environmental improvements, and transportation fuels efficiency to facilitate the INL Site in meeting the goals and requirements of Executive Order 13514, DOE Order 430.2B and DOE Order 450.1A before the end of fiscal year 2020.

The INL Site as a whole spent over $15.6 M in 2010 for facility and equipment energy. Of this total $13.3 M was spent for building energy, $1.6 M was spent for process energy, and $621 K was spent on equipment fuel. The managed area consumes over 1.08 trillion Btu of energy and 473.3 million gallons of water annually. Energy consumption at the INL Site for 2010 on a Btu/ft^2 basis has been reduced by 9.4 percent, weather adjusted, when compared to the base year of 2003.

Transportation fuel use across the INL Site totaled over 898,266 gallons of various types of fuels for 2010. The INL Site fleet is comprised of light duty vehicles fueled by gasoline, E85, liquefied natural gas, and compressed natural gas. Heavy-duty vehicles include over-the-road buses fueled by diesel, biodiesel, and liquefied natural gas, and a complex assortment of trucks and equipment. Typically, 152.9 M km (95 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 (2010).

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 2010 *Idaho Hazardous Waste Generator Annual Report* in January 2011. 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 2010:

- ATR Complex TRA-004 TRA Hot Waste Management System
- Idaho Nuclear Technology and Engineering Center (INTEC) CPP-601/627/640 Landfill Closure Phase 2
- MFC EBR II Closure.

RCRA Inspection – On March 8 – 12, 2010, DEQ conducted an annual RCRA inspection of the INL Site. On June 1, 2010, DEQ sent a Notice of Violation (NOV) to DOE and an INL Site contractor stating that a violation was identified during this inspection. A penalty was paid and the NOV closed.

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 2010 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 6,904 m^3 (9,030 yd^3). In calendar year 2010, 3,973 m^3 (5,196 yd^3) of transuranic waste was shipped out of Idaho. This amount included 11 m^3 (14 yd^3) of remote-handled transuranic waste. In addition, 1,828 m^3 (2,391 yd^3) of mixed low-level waste historically managed as TRU was shipped.

In 2010, 1,565 m^3 (2,047 yd^3) of buried TRU waste was shipped.

The INL Site received five truck cask shipments containing a combined total of 0.0841 metric tons heavy metal (185 lb) of spent nuclear fuel. This included spent nuclear fuel from the University of Wisconsin (one shipment), General Atomics-San Diego (three shipments), and ANL-Chicago (one shipment).

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 2010 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 ("Rules for the Reclamation and Reuse of Municipal and Industrial Wastewater"). 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. DEQ modified the program in 2007 and changed the permit name from Wastewater Land Application Permit to Wastewater Reuse Permit.

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. Monitoring activities included measuring water levels in selected perched water and aquifer wells, checking for the presence of petroleum product (NAPL) in these wells, measuring product quantities removed, and collecting and analyzing groundwater samples.

Rough-legged Hawk

Except for Well ICPP-2018, a measurable thickness or other physical evidence of petroleum product (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. Toluene was undetected at the 1.0 µg/L detection level in all perched wells sampled, except for the sample collected from well CPP-55-06, for which laboratory analyses reported a concentration of 55.0 µg/L. Toluene has previously been detected at well CPP-55-06 at similar or lower levels, and these detectable concentrations have been reported to DEQ. Toluene continues to be a detectable constituent in CPP-55-06, but not above its respective Maximum Contaminant Level (MCL). Toluene was not detected in ICPP-2018 during the April 2010 sampling event.

During the April 2010 sampling event, three polycyclic aromatic hydrocarbon (PAH) compounds were detected in groundwater samples obtained from CPP-33-4-1 at very low concentrations: chrysene was reported at 0.052 µg/L, benzo(b) fluoranthene was reported at 0.12 µg/L, and benzo(k) fluoranthene was reported at 0.054 µg/L. Since the concentration for benzo(b) fluoranthene exceeded its respective initial default target level of 0.0765 µg/L, DEQ was notified of the exceedance per the DEQ-issued Schedule and Criteria. DEQ responded by acknowledging the information and making a note to the file of the occurrence, but the groundwater monitoring results did not justify additional samples.

Samples collected from the other perched wells, including ICPP-2018, reported no detectable PAH compounds, and none of the samples collected from the aquifer wells reported any detectable PAH compounds.

2.5 Cultural and Historic Resources Protection

2.5.1 National Historic Preservation Act

Preservation of historic properties on lands managed by DOE is mandated under Section 106 of the National Historic Preservation Act of 1966. A historic property is defined as a district, site, building, structure, or object significant in American history, architecture, engineering, archaeology, or culture at the national, state, or local level, that has integrity, and that meets the National Register criteria. Section 106 provides the legal process used to determine if adverse effects to historic properties will occur and, if so, the nature and extent of these adverse effects. The Idaho State Historic Preservation Office and interested parties then are consulted to mitigate these effects. Significant survey and research efforts 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.

The *INL Site Cultural Resources Management Plan* (DOE-ID 2009c) was written specifically for site resources, providing a tailored approach to comply with Section 106 of the National Historic Preservation Act. The Cultural Resources Management Plan is reviewed and updated annually. Additionally, a Programmatic Agreement 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), formally implements the Cultural Resources Management Plan.

Cultural Resources Surveys – Table 2-6 summarizes the cultural resources surveys performed at the INL Site by the INL Cultural Resources Management (CRM) Program. In 2010, 17 INL Site project areas were surveyed to ensure that no impacts to archaeological sites would occur as a result of proposed activities and one research-related test project was initiated. Cumulatively, the total number of acres surveyed for archaeological resources on the INL Site increased to 55,072 with the addition of these surveys and the total number of resources identified rose to 2,699.

In nine of the twenty-seven 2010 project reviews, archival information indicated that no archaeological resources would be affected by the activities proposed. In one case, feedback was provided on archaeological sensitivity for pre-project planning and initial facility siting analysis. In the remaining 17 cases, field investigations ranging from .5 – 379 acres in size were conducted on lands that had never been archaeologically surveyed or in areas where previous surveys were completed more than a decade ago. Approximately 1,432 acres were intensively examined during these project surveys and 59 new archaeological sites and several historic canals were identified and recommended for avoidance or other protective measures. The results of project-specific INL Site CRM surveys are documented in a number of ways per the guidelines of the INL Site “Cultural Resources Management Plan.” Recommendations tailored to specific projects and any archaeological resources that may require consideration are delivered in official e-mail notes that become part of the project’s National Environmental Policy Act-driven Environmental Checklist and permanent record.

INL Cultural Resources Management Office survey and research efforts in 2010, 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. A Section 110 data recovery project was initiated at select INL Site locations in 2010 based on a science-based research design. In brief, although it has long been known that humans have been present on the northeastern Snake River Plain (including the lands now occupied by the INL Site) for over 13,500 years, little is known about the human ecology and adaptive responses to climate changes over time in this region. Despite its high-

Table 2-6. Cultural Resources Surveys Performed at the INL Site (2010).

National Historic Preservation Act Section	Surveys Performed
Section 106	27[a]
Section 110	1[b]

a. This number does not include those surveys performed related to INL CRM Office research interests.
b. Includes a cave survey that revisited a previously surveyed cave, recorded nine caves for the first time and identified five additional cultural resources.

Rough-legged Hawk

desert landscape and arid appearance, the INL Site likely had a relative abundance of surface water since the end of the last ice age. Places where water was available provided valuable plant and animal resource patches for early humans and have the potential to provide important insights to human adaptations to desert landscapes. The natural sensitivity of desert streams and water catchments to climate change also will lead to better understanding of human response to fluctuating climates. However, a clearer understanding of the paleohydrology and paleoecology of the streams, shallow lakes and marshlands that once occupied much of the northern reaches of the INL Site is needed.

In the past, studies of human use of stream and wetland environments on the INL Site have been limited to analysis of surface archaeological sites. This has produced important information on site distribution and to some extent, data on site age based on morphological characteristics of surface artifacts (what locations were being used and roughly when). However, these data did not address the critical questions of precisely when and why sites were used. The 2010 Section 110 interdisciplinary project was undertaken at select riverine and marshland (playa-edge) environments to gather data to answer these questions. In 2010, geophysical investigations were conducted and identified anomalies at two archaeological sites located adjacent to the Big Lost River. Excavations were undertaken by INL archaeologists, geophysicists, and a Texas A&M geoarchaeology Ph.D. candidate. A total of eight one-by-one meter test units were excavated at the two locations and preliminary results were presented at the October 2010, Great Basin meetings. Additional test units at other locations are planned for the 2011 field season and artifact analysis is underway.

Cultural Resources Monitoring – The INL Cultural Resources Management Office implements a yearly program of cultural resource monitoring that includes many archaeological resources. In 2010, thirty-three cultural resources localities were revisited, including some that were visited more than once, including: two locations with Native American human remains, one of which is a cave, two additional caves, 26 prehistoric archaeological sites, two historic stage stations, 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 2010 INL Site cultural resources monitoring are documented in Idaho National Laboratory Cultural Resources Monitoring Report for FY 2010 (INL/EXT 10-20270).

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 are major stakeholders in INL Site activities. They are particularly concerned with how the remains of their ancestors and culture are treated by DOE-ID and its contractors. The Native American Graves Protection and Repatriation Act provides for the protection of Native American remains and the repatriation of human remains and associated burial objects. Repatriation refers to the formal return of human remains and cultural objects to the tribes with whom they are culturally affiliated.

Efforts to improve protection of archaeological sites at the INL Site are ongoing. An active security force monitors INL Site lands through ground patrols and security surveillance of public points of access. Trespassers are removed immediately upon detection and, when appropriate, prosecuted. Yearly on-line training modules remind INL Site employees of prohibitions on disturbing archaeological sites and targeted training is also conducted by INL CRM staff for INL Site employees likely to encounter archaeological sites in their work. Largely as a result of these restrictions, many archaeological sites on the INL Site display remarkable integrity and are virtually undisturbed.

To curtail a recurring pattern of unauthorized visitation to INL Site caves by the public as well as INL Site employees, INL Site staff took steps in 2010 to initiate a new productive working relationship with U.S. federal agents experienced in enforcing the Archaeological Resource Protection Act and successfully prosecuting individuals who have violated the law.

2.6 Summary of Environmental Permits

Table 2-1 summarizes active permits for the INL Site through year-end 2010 that were issued for sitewide or individual facility operations or both that have been referenced in previous sections of this chapter.

REFERENCES

10 CFR 1021, 2009, “National Environmental Policy Act Implementing Procedures,” *Code of Federal Regulations*, Office of the Federal Register.

10 CFR 1022, 2009, “Compliance with Floodplain and Wetland Environmental Review Requirements,” *Code of Federal Regulations*, Office of the Federal Register.

40 CFR 61, Subpart H, 2008, “National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities,” *Code of Federal Regulations*, Office of the Federal Register.

40 CFR 1500, 2007, “National Environmental Policy Act (NEPA), Purpose, Policy, and Mandate,” *Code of Federal Regulations*, Office of the Federal Register.

63 FR 31, 1998, “Reissuance of NPDES General Permits for Storm Water Discharges From Construction Activities,” Office of the Federal Register, U.S. Environmental Protection Agency, p. 7858.

Bureau of Reclamation, 2005, *Big Lost River Flood Hazard Study*, Idaho National Laboratory, Idaho, Report 2005-2.

DEQ, 1995, *Federal Facility Compliance Act Consent Order and Site Treatment Plan*, (transmittal letter and signed enclosure from Curt Fransen, Idaho Deputy Attorney General, to Brett R. Bowhan, U.S. Department of Energy Idaho Operations Office), Idaho Division of Environmental Quality.

DOE, 1991, *Idaho National Engineering Laboratory (“INEL”) Federal Facility Agreement and Consent Order*, Administrative Docket Number: 1088-06-120, U.S. Department of Energy, Office of Environmental Management; U.S. Environmental Protection Agency, Region 10; State of Idaho, Department of Health and Welfare.

DOE, 1995, *1995 Settlement Agreement*, U. S. Department of Energy, U.S. Department of the Navy, and State of Idaho.

DOE Order 430.2B, 2008, “Departmental Energy, Renewable Energy and Transportation Management,” U.S. Department of Energy.

DOE Order 435.1, 2001, “Radioactive Waste Management,” Change 1, U.S. Department of Energy.

DOE Order 450.1A, 2008, “Environmental Protection Program,” U.S. Department of Energy.

DOE Order 451.1B, 2001, “National Environmental Policy Act Compliance Program,” Change 1, U.S. Department of Energy.

DOE Order 5400.5, 1993, “Radiation Protection of the Public and the Environment,” Change 2, U.S. Department of Energy.

DOE-ID, 2004, *Programmatic Agreement between the Department of Energy Idaho Operations Office, the Idaho State Historic Preservation Office, and the Advisory Council on Historic*

Preservation Concerning Management of Cultural Resources on the Idaho National Engineering and Environmental Laboratory, signed by U.S. Department of Energy Idaho Operations Office, Idaho State Historic Preservation Office, Advisory Council on Historic Preservation.

DOE-ID, 2009a, *Spring 2009 Semiannual (III.H. and I.U.) Report for the HWMA/RCRA Post-Closure Permit for the INTEC Waste Calcining Facility at the INL Site*, DOE/ID-10997, Rev. 3, U.S. Department of Energy Idaho Operations Office.

DOE-ID, 2009b, *Fall 2009 Semiannual (III.H. and I.U.) Report for the HWMA/RCRA Post-Closure Permit for the INTEC Waste Calcining Facility at the INL Site*, DOE/ID-11410, Rev. 0, U.S. Department of Energy Idaho Operations Office.

DOE-ID, 2009c, *Idaho National Laboratory Cultural Resources Management Plan*, DOE/ID-10997, Revision 3, U.S. Department of Energy Idaho Operations Office.

DOE-ID, 2010, *INL Site Sustainability Plan*, with the FY-2010 Annual Report, DOE/ID-11383, U.S. Department of Energy Idaho Operations Office.

DOE-ID, 2011, *National Emission Standards for Hazardous Air Pollutants-Calendar Year 2010 INL Report for Radionuclides*, DOE/ID-10890(11), U.S. Department of Energy Idaho Operations Office.

Executive Order 11988, 1977, “Floodplain Management.”

Executive Order 11990, 1977, “Protection of Wetlands.”

Executive Order 13423, 2007, “Strengthening Federal Environmental, Energy, and Transportation Management.”

Executive Order 13514, 2009, “Federal Leadership in Environmental, Energy, and Economic Performance.”

ICP, 2010, *Spring 2010 Semiannual Summary Report Corrective Action/Monitoring Plan for Petroleum Release Associated with Well ICPP-2018*, RPT-626, Idaho Cleanup Project.

IDAPA 58.01.02, 2006, “Water Quality Standards,” Idaho Administrative Procedures Act.

IDAPA 58.01.17, 2009, “Rules for the Reclamation and Reuse of Municipal and Industrial Wastewater,” Idaho Administrative Procedures Act.

INL/EXT-10-20270, 2010, *Idaho National Laboratory Cultural Resources Monitoring Report for FY2010*.

USGS, 1997, *Simulation of Water-Surface Elevations for a Hypothetical 100-Year Peak Flow in Birch Creek at the Idaho National Engineering and Environmental Laboratory, Idaho*, U.S. Geological Survey Water-Resources Investigations Report 97-4083, DOE/ID-22138, U.S. Geological Survey.

Chapter 3. Environmental Program Information

Chapter 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 2010 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. Recommendations of the assessment team are being implemented.

Significant progress continues on INL Site cleanup activities. Among the 2010 accomplishments are:

- 3,965 m^3 (5,182 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
- 1,829 m^3 (2,390 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 1,234 m^3 (1,614 yd^3) of mixed low-level waste and 3,205 m^3 (4,192 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 24 m^3 (31 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 450.1A requirements. Two INL Site contractors successfully went through International Standards Organization 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 2010, 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 (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, S.M. Stoller Corporation, 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 2010. In addition to the monitoring constituents listed in Table 3-6, the USGS collected samples twice a year from 13 wells in cooperation with the Naval Reactors Facility (NRF), four times last year from one well 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 2010, 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).

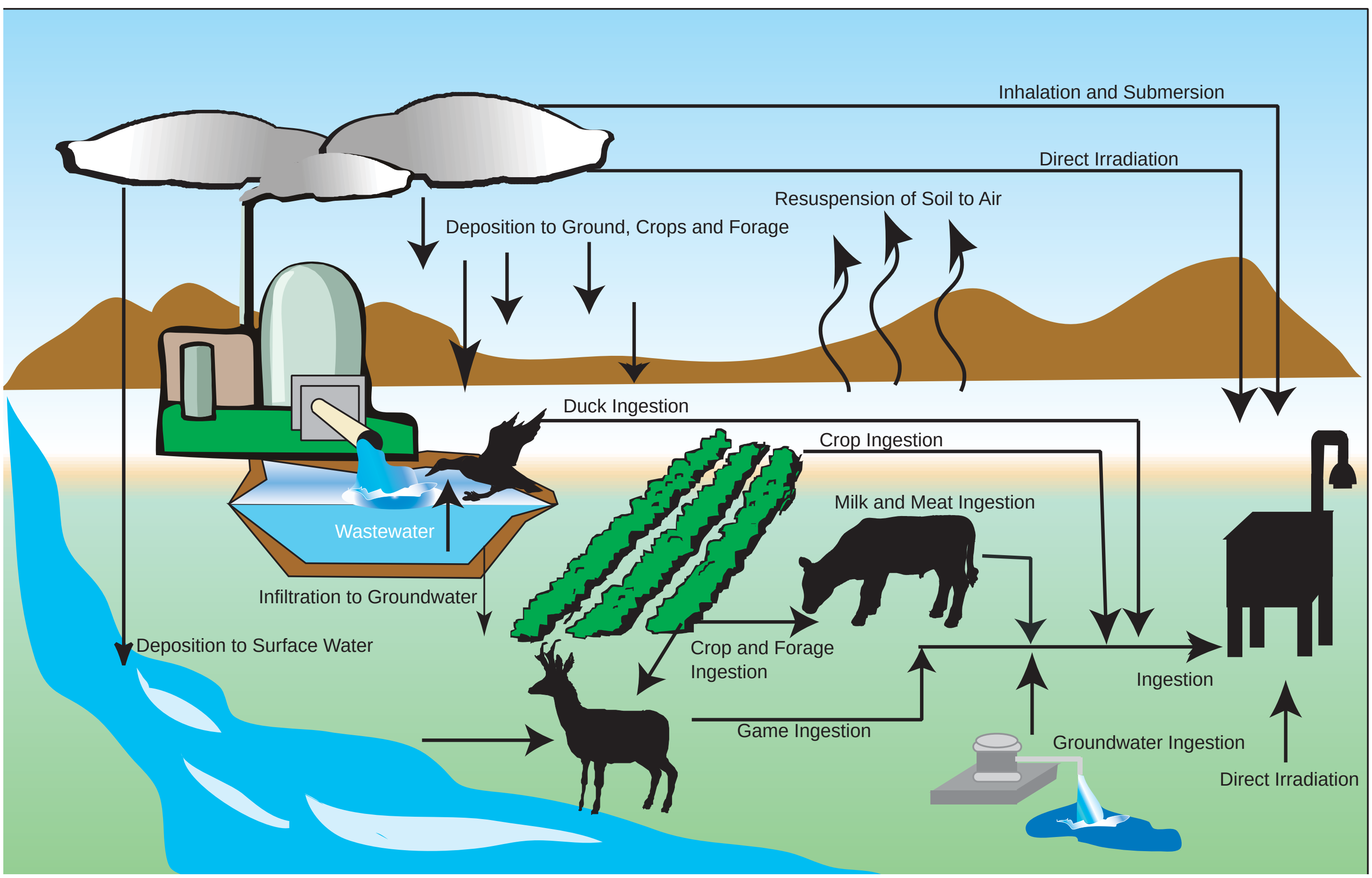


Figure 3-1. Potential Exposure Pathways to Humans from the Idaho National Laboratory Site.

Table 3-1. Environmental Surveillance, Education, and Research Program Summary (2010).

Medium Sampled	Type of Analysis	Locations and Frequency: Onsite	Locations and Frequency: Offsite	Minimum Detectable Concentration
Air (low volume)	Gross alpha Gross beta Specific gamma Plutonium-238 Plutonium-239/240 Americium-241 Strontium-90 Iodine-131 Total particulates	4 weekly[a] 4 weekly 4 quarterly 2 quarterly 2 quarterly 2 quarterly 2 quarterly 4 weekly 4 quarterly	15weekly[a] 15 weekly 15 quarterly 7 quarterly 7 quarterly 7 quarterly 7 quarterly 15 weekly 15 quarterly	1×10^{-15} µCi/mL 1×10^{-14} µCi/mL 3×10^{-16} µCi/mL 2×10^{-18} µCi/mL 2×10^{-18} µCi/mL 2×10^{-18} µCi/mL 6×10^{-17} µCi/mL 2×10^{-15} µCi/mL 10 µg/m^3
Air (high volume)[b]	Gross beta Gamma scan Isotopic U and Pu	None None None	1, twice per week If gross $\beta > 1$ pCi/m^3 1 annually	1×10^{-15} µCi/mL 1×10^{-14} µCi/mL 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 Iodine-131	Varies annually Varies annually	Varies annually Varies annually	5 pCi/g 3 pCi/g
Alfalfa	Specific gamma	None	1 annually	0.1 pCi/g
Agricultural products (milk)	Cesium-137 Iodine-131 Strontium-90 Tritium	None None None None	1 weekly 1 weekly/9 monthly 9 semiannually 9 semiannually	1 pCi/L 3 pCi/L 5 pCi/L 150 pCi/L
Agricultural products (potatoes)	Specific gamma Strontium-90	None None	8 –10 annually 8 –10 annually	0.1 pCi/g 0.2 pCi/g
Agricultural products (wheat)	Specific gamma Strontium-90	None None	10 –12 annually 10 –12 annually	0.1 pCi/g 0.2 pCi/g
Agricultural products (lettuce)	Specific gamma Strontium-90	1 annually 1 annually	7 – 9 annually 7 – 9 annually	0.1 pCi/g 0.2 pCi/g
Drinking Water[e]	Gross alpha Gross beta Tritium	None None None	4 annually 4 annually 4 annually	3 pCi/L 2 pCi/L 150 pCi/L
Surface Water[f]	Gross alpha Gross beta Tritium	5 annually 5 annually 5 annually	4 annually 4 annually 4 annually	3 pCi/L 2 pCi/L 150 pCi/L
Soil	Specific gamma Plutonium-238 Plutonium-239/240	None None None None	14 biennially[g] 14 biennially 14 biennially 14 biennially	0.001 pCi/g 0.005 pCi/g 0.1 pCi/g 0.005 pCi/g


Rough-legged Hawk

Table 3-1. Environmental Surveillance, Education, and Research Program Summary (2010) (continued).

	Americium-241 Strontium-90	None	13 biennially	0.05 pCi/g
Direct radiation exposure (thermoluminescent dosimeters)	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 and sent to the Environmental Protection Agency 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 Mindoka 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 at the public rest stop on highway 20/26, at two locations along Lincoln Boulevard, at EFS. 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.
g. A duplicate sample is also collected at one location.

Results of the environmental monitoring programs for 2010 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 2010 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.

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 bi-monthly 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.

Table 3-2. Idaho National Laboratory Contractor Air and Environmental Radiation Surveillance Summary (2010).

Medium Sampled	Type of Analysis	Locations and Frequency: Onsite[a]	Locations and Frequency: Offsite[a]	Detectable Concentration
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 (thermoluminescent dosimeters)	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.

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, stormwater, 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.

The INL Water Committee 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.

Rough-legged Hawk

Table 3-3. Idaho National Laboratory Contractor Drinking Water Program Summary (2010).

Medium/Contaminant Type	Type of Analysis	Frequency (onsite)	Maximum Contaminant Level
Drinking water/radiological	Gross alpha Gross beta Radium-226/228 Tritium Uranium Iodine-129	6 annually, 9 semiannually 6 annually, 9 semiannually 6 annually, 9 semiannually 6 annually, 9 semiannually 9 annually 2 semiannually	15 pCi/L 4 mrem/yr 5 pCi/L 20,000 pCi/L 0.03 pCi/L 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

3.1.2 DOE Headquarters Independent Assessment

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 addresses monitoring and meeting data quality objectives

- Review of the INL (BEA), ICP (CWI), and ESER (Stoller) 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

Table 3-4. Idaho Cleanup Project Contractor Environmental Surveillance Program Air, Surface Water, Vegetation, and Radiation Survey Summary (2010).

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	3 quarterly[c]	None	Varies by analyte
	Plutonium isotopes	3 quarterly[c]	None	0.02 pCi/L
	Uranium-233/234	3 quarterly[c]	None	0.06 pCi/L
	Uranium-235	3 quarterly[c]	None	0.04 pCi/L
	Uranium-238	3 quarterly[c]	None	0.04 pCi/L
	Americium-241	3 quarterly[c]	None	0.02 pCi/L
	Strontium-90	3 quarterly[c]	None	0.3 pCi/L
Vegetation	Specific gamma	5 annually[d]	None	Varies by analyte
	Plutonium isotopes	1 annually[d]	None	0.003 pCi/g
	Uranium-233/234	1 annually[d]	None	0.002 pCi/g
	Uranium-235	1 annually[d]	None	0.001 pCi/g
	Uranium-238	1 annually[d]	None	0.001 pCi/g
	Americium-241	1 annually[d]	None	0.0006 pCi/g
	Strontium-90	1 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. During 2010, samples were collected monthly per DOE-ID request.

d. Russian Thistle was not available for sampling in 2010.


Rough-legged Hawk

Table 3-5. Idaho Cleanup Project Contractor Drinking Water Program Summary (2010).

Medium Sampled	Type of Analysis	Location and Frequency: RWMC[a]	Location and Frequency: INTEC[a]	Maximum Contaminant Level, Action Level
Drinking water systems	**Microbiological Contaminants**	2 monthly	3 monthly	<40 samples/month, no more than one positive for total coliform
	Inorganic Chemicals			
	Nitrate (as nitrogen)	1 annually	1 annually	10 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			
	Pentachlorophenol	1 annually	None	0.001 mg/L
	Volatile Organic Chemicals[b]	2 quarterly	None	Varies

a. INTEC = Idaho Nuclear Technology and Engineering Center
RWMC = Radioactive Waste Management Complex.
b. Each volatile organic chemical sample is analyzed for 21 volatile organic chemicals.

Table 3-6. U.S. Geological Survey Monitoring Program Summary (2010).

Constituent	Groundwater Number of Sites[a]	Groundwater Number of Samples	Surface Water Number of Sites	Surface Water Number of Samples	Minimum Detectable Concentration
Gross alpha	54	53	4	4	3 pCi/mL
Gross beta	52	51	4	4	3 pCi/mL
Tritium	152	148	7	7	400 pCi/mL
Gamma-ray spectroscopy	89	86	4	4	—[b]
Strontium-90	103	100	—[c]	—	5 pCi/mL
Americium-241	24	24	—[c]	—	5 pCi/mL
Plutonium isotopes	24	24	—[c]	—	4 pCi/mL
Iodine-129	0	0	—[c]	—	<1aCi/L
Specific conductance	153	149	7	7	Not applicable
Sodium ion	140	136	—[c]	—	0.1 mg/L
Chloride ion	152	148	7	7	0.1 mg/L
Nitrates (as nitrogen)	112	111	—[c]	—	0.05 mg/L
Fluoride	6	6	—[c]	—	0.1 mg/L
Sulfate	101	98	—[c]	—	0.1 mg/L
Chromium (dissolved)	77	75	—[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 2 equipment blanks collected in 2010. 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.

- 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 BEA 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 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. The INL contractor is leading a team consisting of the ICP contractor and the ESER contractor to develop the technical basis. The contractors are also addressing other recommendations specifically applicable to their individual programs. The full Assessment Report is available at http://www.hss.doe.gov/indepoversight/reports/eshevals.html and as Appendix B.

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

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

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.

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) 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,

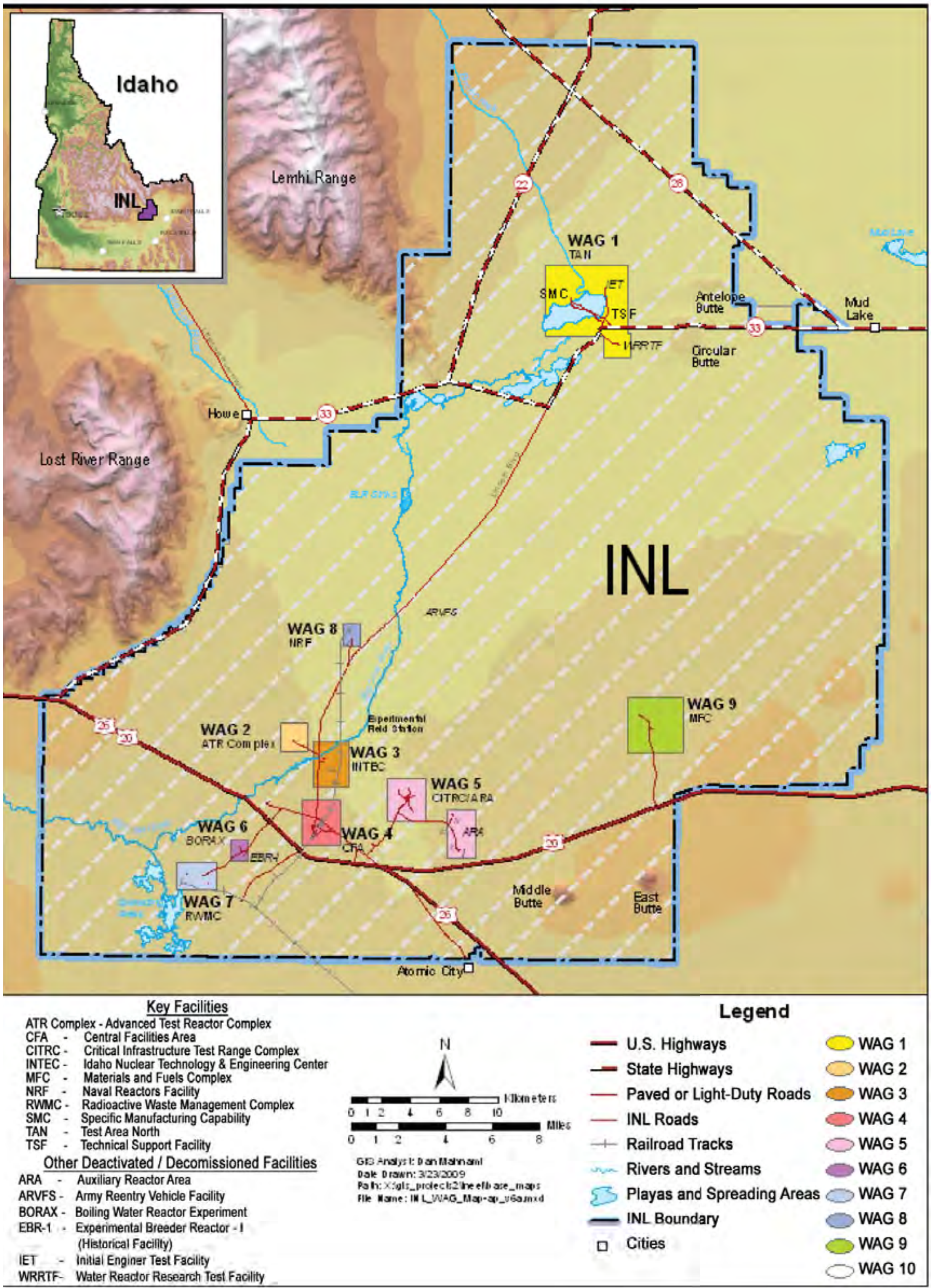


Figure 3-2. Map of the Idaho National Laboratory Site Showing Locations of the Facilities and Corresponding Waste Area Groups.

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.

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 2010. 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. Medial zone compliance wells had shown increased concentrations of trichloroethylene since the New Pump and Treat Facility was placed on standby last year to test rebound of the aquifer contamination levels; therefore, operation of the New Pump and Treat Facility was increased in 2010. All institutional controls were maintained in 2010.

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 were maintained in 2010.

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

Operations continued at the Idaho CERCLA Disposal Facility (ICDF) during 2010, 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 environment. In 2010, remediation of the two targeted Operable Unit 10-08 contaminated soils sites, as identified in the Operable Unit 10-08 ROD (DOE-ID 2009) was completed, with soils disposed of in the ICDF landfill cell. Remediation details will be documented in the final Remedial Action Report (scheduled to be finalized during the summer of 2011). Remedial actions required by the WAG 3, Operable Unit 3-14 ROD implemented in 2010 also included the reduction of approximately 7 million gallons of anthropogenic and storm water recharge to the northern perched water zones, and the installation of drainage ditches and low permeability pavement over the recharge control zone. Approximately 300 ft of lined drainage ditches were added to the existing 2,000 ft of drainage ditches, and 200 ft of culvert was 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 cause transport of 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 were maintained in 2010.

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 2010.

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 were maintained in 2010.

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. In 2010, the Operable Unit 10-08 Remedial Design/Remedial Action Work Plan was produced (DOE-ID 2010b). A Post-Record of Decision Groundwater Monitoring and Field Sampling Plan also was produced (DOE-ID 2010c). 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 draft 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 Record of Decision, continued in 2010. All institutional controls were maintained in 2010.

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 for 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 were disposed of, including process waste (e.g., sludge, graphite molds and fines, roaster oxides, and evaporator salts), equipment, and other waste incidental to production (e.g., contaminated gloves, paper, clothing, and other industrial trash). Much of the Rocky Flats Plant waste was contaminated with transuranic 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 (FY) 2008, and only the Naval Reactors remote handled, low-level waste is still

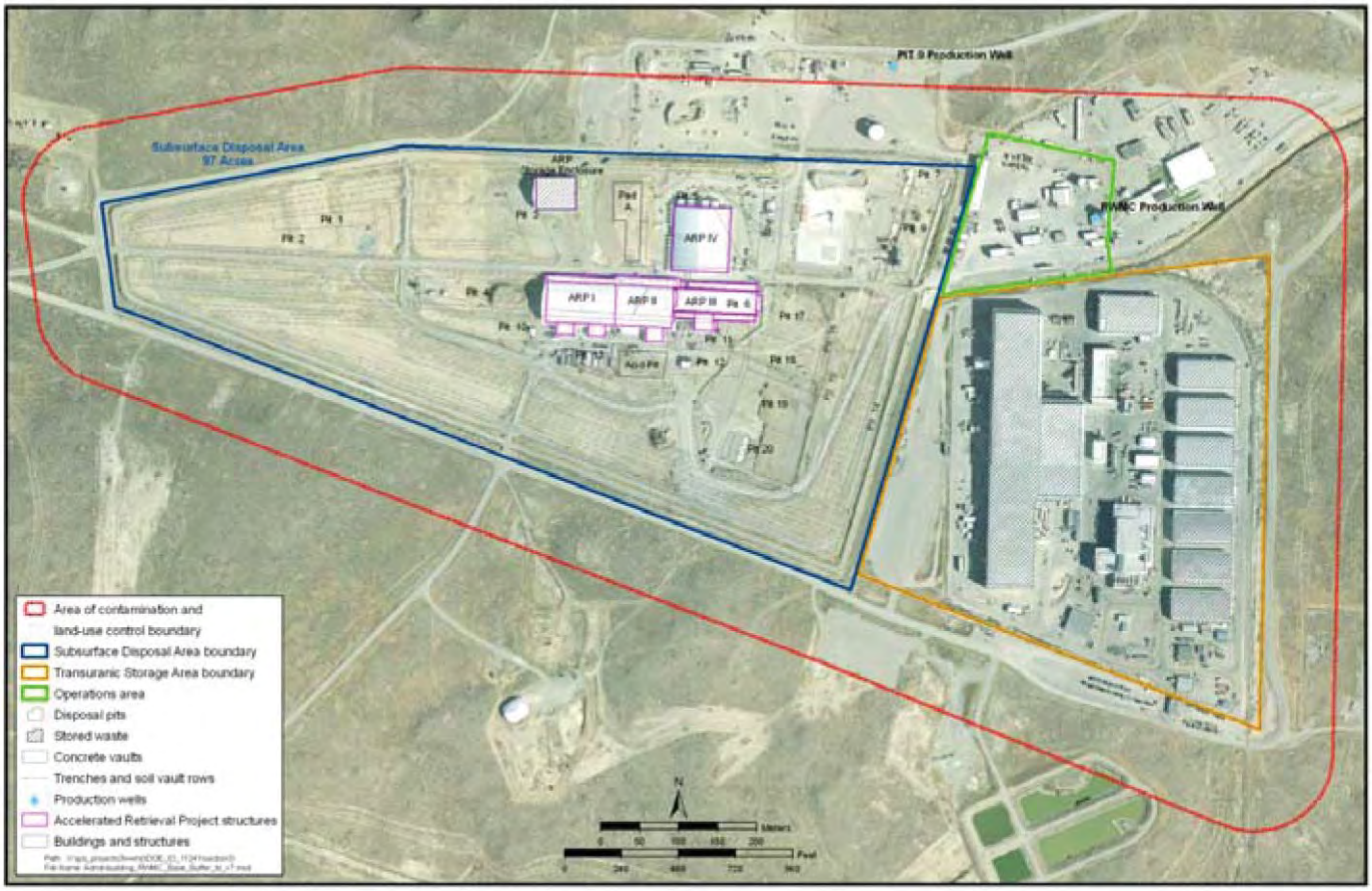


Figure 3-3. Radioactive Waste Management Complex Subsurface Disposal Area (2010).

disposed of in the Subsurface Disposal Area until the end of FY 2012. Disposal of waste from offsite generators was discontinued in the early 1990s.

The Operable Unit 7-13/14 ROD (DOE-ID 2008) was signed in 2008, which was a major accomplishment. 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 hectares (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 is expected to be completed in January 2011. The Accelerated Retrieval Projects have collectively retrieved and packaged more than 4,425 m^3 (5,787 yd^3) of targeted waste from a combined area of 0.8 hectares (2.0 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 2025, followed by construction of a surface barrier, which is expected to be completed in 2028.

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 INL Site Treatment Plan (ICP 2007).

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 2007), 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 2010, the INL Site treated or processed 5,233 m^3 (6,802.9 yd^3) of legacy mixed waste, 1,011 m^3 (1,314.3 yd^3) of mixed low-level waste, and 4,219 m^3 (5,484.7 yd^3) of mixed contact-handled transuranic waste. Additionally, 3 m^3 (3.9 yd^3) of remote-handled transuranic waste was shipped offsite for disposition, the majority of which was specified by the INL Site Treatment Plan.

Seven INL Site Treatment Plan milestones were completed on schedule in 2010, and the milestones associated with the Remote-handled Waste Disposition Project were revised to start in 2010. The following milestones were completed:

- Commercial backlog treatment/disposal –131 m^3 (170 yd^3)
- Advanced Mixed Waste Treatment Project 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 Processing - 0.5 m^3 (.64 yd^3)
- HEPA (high-efficiency particulate air) Filter Leach - 0.5 m^3 (0.64 yd^3)
- Calcine Disposition Project – Identify and Develop Technology
- Calcine Disposition Project – Submit Treatability Study Notification.

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 2010, the AMWTP shipped 3,965 m^3 (5,182 yd^3) of stored transuranic waste to the Waste Isolation Pilot Plant, for a cumulative total of 34,580 m^3 (45,194 yd^3) of waste shipped off the INL Site. The AMWTP also shipped offsite 1,829 m^3 (2,390 yd^3) of mixed low-level waste that historically had been managed as stored transuranic waste, for a cumulative total of 7,857 m^3 (10,269 yd^3) of waste shipped offsite. A combined cumulative total of 42,437 m^3 (55,463 yd^3) of stored transuranic waste has been shipped offsite. In addition, the AMWTP has shipped a cumulative total of 3,744 m^3 (4,893 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) belowgrade 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 2011. 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 beginning the 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 2010, more than 1,234 m^3 (1,614 yd^3) of mixed low-level waste and 3,205 m^3 (4,192 yd^3) of low-level waste was shipped off the INL Site for treatment or disposal or both. Approximately 23.96 m^3 (31 yd^3) of newly generated, low-level waste was disposed of at the Subsurface Disposal Area in 2010.

3.4 Environmental Management System

DOE Order 450.1A requires developing and implementing an EMS. The EMS must reflect the elements and framework of the International Organization for Standardization's (ISO) 14001, an international voluntary standard for EMSs. An EMS provides an underlying structure to make managing environmental activities more systematic and predictable. The 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.

The three main INL Site contractors have established EMSs for their respective operations. The ICP and INL contractors maintain ISO 14001 registered systems. The AMWTP contractor's EMS is based on requirements in DOE Orders 450.1A and 430.2B, and the elements and framework of ISO 14001. An audit and readiness review conducted in 2001 by an independent ISO 14001 auditor concluded that the INL Site was ready for a formal registration. A registration audit was conducted May 6-10, 2002, by a third-party registrar. No nonconformances were identified during the audit, and the lead auditor recommended ISO 14001 registration for the INL Site facilities, which was received in June 2002. Subsequent to registration, and most recently in April and October 2010, both the INL and ICP contractors went through semi-annual surveillance audits. No nonconformances were identified, and the auditor recommended continued ISO 14001 registration. In April 2009, the AMWTP contractor's EMS was the subject of an independent audit by a qualified auditor, and the auditor concluded that the EMS was in place, with no major nonconformances.

Rough-legged Hawk

Each INL Site contractor has established environmental aspects based upon the activities, products, and services that have the potential to impact the environment, the public, or result in a noncompliance with regulatory requirements. Each has identified which aspects have the potential to significantly impact the environment, in compliance with ISO 14001 requirements. In setting annual objectives and targets, each contractor considers these significant environmental aspects, as well as environmental policy, legal and other requirements, DOE's vision and goals for the INL Site, strategic plans, and the views of stakeholders. The environmental policy established by each contractor is available on their respective websites.

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 Executive Order 13514, *Federal Leadership in Environmental, Energy, and Economic Performance, and Department of Energy (DOE) Order 430.2B*, *Departmental Energy, Renewable Energy, and Transportation Management*. 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."

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; advance sustainable building designs; explore the potential use of renewable energy; reduce utility costs across the INL; and support 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 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.

Water Conservation – The INL 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.

INL included life-cycle cost effective measures in Energy Savings Performance Contract or Utility Energy Savings Contract projects, with minor deficiencies in obtaining the goal of a 6 percent water reduction from 2007 levels. Project ideas developed during the Research and Education Campus (REC) Utility Energy Savings Contract energy audit will provide an estimated 6,942,671 gallons of water reduction through fixture upgrades. When completed, the Materials and Fuels Complex (MFC) Energy Savings Performance Contract will contribute 3,479,000 gallons of estimated water use reduction. Together, these projects provide a 2.5 percent reduction of the INL's Total Reportable Water Usage as compared to the FY 2007 baseline. These reductions exceed the annual reduction goal of 2 percent and contribute to the cumulative goal of 6 percent for FY 2010. Water reduction was included as one of the major requirements for the next Energy Savings Performance Contract.

Green Building Strategy – The INL uses the INL Green Building Strategy to identify potential sustainable design criteria. The Green Building Strategy was developed around the Leadership in Energy and Environmental Design (LEED) process. The REC United Energy Services Co. energy audit resulted in 17.5 percent (nearly 550,000 square feet) of the total INL square footage being evaluated for conformance to the Guiding Principles associated with existing facilities. In addition, INL progressed with a LEED for Existing Buildings subcontract by prioritizing and evaluating 20 REC facilities to determine their status and potential for certification with the U.S. Green Building Council. By definition, LEED-DB validates the implementation of the Guiding Principles.

INL planned the new $48 million Energy Systems Laboratory to be built in Idaho Falls and is designed to meet LEED Gold designation in the LEED Green Building Rating system.

Infrastructure Improvement – INL analyzed 2 percent of the INL's enduring infrastructure for implementation of the Guiding Principles and showing plans for implementing all cost effective upgrade opportunities.

INL installed five Certified Cool Roofs at site facilities and applied a cool-roof finish to the Experimental Reactor Building (EBR)-I Reactor Building roof. This performance positively impacts DOE's cool roof program goals as noted by Secretary of Energy Chu during his visit to the INL on September 13, 2010.

Fleet Operations – Fleet Operations is committed to reducing its generation of greenhouse gases by increasing the use of alternative fuels, expanding the alternative fueling infrastructure, testing hybrid vehicles, preferentially using biobased products, and continually evaluating ways to improve fuel efficiency. INL has exceeded expectations for petroleum fuel reductions and alternative fuel increases from base year FY 2005. The use of petroleum fuels is down 26 percent (over 240,000 gallons) and the use of alternative fuels is up 59 percent (over 56,000 gallons) as compared to base year 2005. Activities exceed both fuel usage goals (i.e., decrease petroleum usage 10 percent and increase alternative fuel usage 50 percent from baseline FY 2005). In March 2010, INL received an agency EStar and Presidential GreenGov Award for this effort.

Greenhouse Gases – DOE has committed to reduce greenhouse gas (GHG) emissions by 28 percent before the end of FY 2020, as compared to the FY 2008 baseline. INL has calculated its initial Carbon Footprint. This GHG inventory supports a major Battelle Corporate initiative to lead GHG emissions reduction efforts and is an accepted method of identifying environmental impacts by assessing major GHG contributors and the best methods to reduce them. The INL


Rough-legged Hawk

Carbon Footprint indicates that GHG emissions for 2008 were slightly over 105,500 metric tons of CO_2 equivalent. Activities to reduce this baseline inventory are funded primarily from alternative sources by increasing infrastructure efficiency and switching to fuel with less GHG-intensive emissions. The INL is pursuing on-site transportation, business activities and employee commutes. GHG emissions are tracked and allocated on a program-by-program basis to incorporate accountability.

DOE-ID and the INL Site contractors are using their existing EMS to establish goals, track and review progress towards meeting the energy efficiency, water conservation, greenhouse gas reduction, and renewable energy goals. The primary means of funding energy and water reduction projects to satisfy these goals is through the alternative funding programs such as Energy Savings Performance Contracts and Utility Energy Savings Contracts. The INL Site is leveraging utility incentive programs to the maximum extent available.

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, Executive Order 13423, "Strengthening Federal Environmental, Energy, and Transportation Management," was passed. It consolidates and strengthens five executive orders 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, Executive Order 13514, "Federal Leadership in Environmental, Energy, and Economic Performance" was passed. 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 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 2010.

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 2010, the INL Site received the 2010 Federal Electronics Challenge Silver Award for reducing the environmental impacts of electronic equipment. The INL Site also received the Bronze Award in 2007 and 2008.

Earth Day – DOE-ID and the INL Site contractors participated in the organizing committee for the 2010 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 2010.

INL's recycling initiative, which includes commingled recycling and paper shredding, continued to expand through the fourth quarter of 2010. 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 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—Advanced Test Reactor (ATR) Complex, Central Facilities Area (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 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 Issues and Activities

3.5.1 Deactivation, Decontamination, and Decommissioning Activities

The ICP continued deactivating, decontaminating, and decommissioning (D&D) surplus DOE Environmental Management-owned buildings and structures at the INL Site. This effort


Rough-legged Hawk

Table 3-8. Reused and Recycled Materials (2010).

Material Reused or Recycled	Weight kg (lb)	
Antifreeze	630	(1,389)
Co-Mingled Waste	34,620	(76,324)
Excess computers and equipment to schools	160,209	(353,200)
Excess materials to other DOE sites, INL orgs, state, etc.	725,278	(1,598,965)
Excess materials to public	5,165,408	(11,387,775)
Batteries	10,200	(22,487)
Lead scrap	140	(309)
Mercury	8	(17)
Paper and cardboard at INL Site	61,035	(134,560)
Paper and cardboard in Idaho Falls	174,856	(385,492)
RCRA[a] scrap		(110)
Silver scrap	0	(0)
Toner cartridges	5,290	(11,662)
Universal waste lamps	7,500	(16,535)
Used oil	11,270	(24,846)
Wood chips	285,540	(629,508)
Total	**6,642,034**	**(14,643,179)**

a. RCRA = Resource Conservation Recovery Act significantly reduced life-cycle cost and risk by eliminating aging facilities that were no longer necessary for the INL Site mission. In 2009, 29 facilities were demolished, for a total footprint reduction of 29,786 m^2 (320,618 ft^2). Descriptions of specific projects at various facilities follow.

Test Area North (TAN) – At TAN, the TSF-07 Disposal Pond was decontaminated and demolished for a footprint reduction of 20,234 m^2 (217,800 ft^2).

Advanced Test Reactor Complex (ATR Complex) – In 2009, the TRA-661 Reactor Wing was demolished, for a footprint reduction of 786 m^2 (8,459 ft^2), and progress was made disassembling the Materials Test Reactor and characterizing the TRA-632 Hot Cells.

In 2010, the TRA-604 MTR Reactor Wing A, and the TRA-613 Hot Waste Pump Building were demolished for a footprint reduction of 3,919 m^2 (42,183 ft^2). Work continued on the TRA-632 Hot Cells and the TRA-603 MTR Reactor Building.

Idaho Nuclear Technology and Engineering Center (INTEC) – In 2009, D&D crews demolished 15 facilities, for a footprint reduction of 1,306 m^2 (14,057 ft^2). Progress was made dismantling the interior and grouting the process cells of CPP-601/640.

In 2010, 31 buildings/structures were demolished for a total footprint reduction of 6,784.5 m^2 (73,028 ft^2). The structures included tank vaults, pump houses, and monitoring stations. The most significant buildings demolished were the CPP-640 Headend Process Plant and the CPP-630 Safety/Spectrometry Building. Work on the final demolition of CPP-601 also continued.

Radioactive Waste Management Complex (RWMC) – At RWMC, the Intermediate Level Transuranic Storage Facility and the Glovebox Excavator Method Building were demolished, for a footprint reduction of 5,476 m^2 (58,943 ft^2).

Power Burst Facility (PBF) – Three facilities at the PBF area were transferred from DOE Nuclear Energy to Environmental Management for demolition. All three facilities, which included the Waste Experimental Reduction Facility Incinerator Building and Exhaust Stack, and the Spray Dryer Absorber, were demolished, for a footprint reduction of 1,430 m^2 (15,394 ft^2).

Materials and Fuels Complex (MFC) – In 2009, nine facilities at MFC were transferred from DOE Nuclear Energy to Environmental Management for demolition. The facilities included the Experimental Breeder Reactor II (EBR-II) Reactor Building, the MFC-766 Sodium Boiler Building, and other support buildings. Three facilities were demolished, for a footprint reduction of 238 m^2 (2,563 ft^2). Work also began on removing asbestos, lead, electrical panels, and other equipment from the MFC-767 Reactor Building and the MFC-766 Sodium Boiler Building.

In 2010, the MFC-795 Cover Gas Cleanup System and the two Sodium Components Maintenance Shop (SCMS) Storage Buildings were demolished for a footprint reduction of 625.5 m^2 (6,733 ft^2). Work on the MFC-767 EBR-II Reactor Building and the MFC-766 Sodium Boiler Building also continued.

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. Over 220 different types of 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. A Blue Ribbon Commission on America's Nuclear Future is reviewing spent nuclear fuel management policies.

In 2010, 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 million gal) 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. 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 was approximately 90 percent full at the end of 2010, and will continue to receive SNF from foreign and domestic research reactors in 2011.

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 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 Independent Spent Fuel Storage Installation. The Independent Spent Fuel Storage Installation 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 belowground-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.

Advanced Test Reactor (TRA-670) – The Advanced Test Reactor (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 0.5 miles north of the MFC perimeter fence. It is a fenced outdoor 4-acre 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 2010d) among 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/.

REFERENCES

71 FR 228, 2006, “Amended Record of Decision: Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement,” *Federal Register*, U.S. Department of Energy, pg. 68811-68813.

75 FR 1, 2010, “Amended Record of Decision: Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement Revised by State 12/21/09,” *Federal Register*, U.S. Department of Energy, pp. 137–140.

75 FR 7, 2010, “Amended Record of Decision: Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement; Correction,” *Federal Register*, U.S. Department of Energy, pp. 1615–1616.

DOE, 1991, *Idaho National Engineering Laboratory (“INEL”) Federal Facility Agreement and Consent Order*, Administrative Docket Number: 1088-06-120, U.S. Department of Energy, Office of Environmental Management; U.S. Environmental Protection Agency, Region 10; State of Idaho, Department of Health and Welfare.

DOE, 1995, 1995 *Settlement Agreement, U.S. Department of Energy*, U.S. Department of the Navy, and State of Idaho.

DOE, 2002, *Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement*, DOE/EIS-0287, U.S. Department of Energy.

DOE, 2005, *Record of Decision for the Idaho High-Level Waste and Facilities Disposition Final Environmental Impact Statement*, DOE/EIS-0287, U.S. Department of Energy.

DOE, 2008, *Agreement to Implement U.S. District Court Order Dated May 25, 2006*, Document 363-2, U.S. Department of Energy.

DOE, 2010, *Independent Oversight Assessment of Environmental Monitoring at the Idaho National Laboratory Site*, May 2010, U.S. Department of Energy Office of Independent Oversight, Office of Health, Safety and Security.

DOE Order 430.2B, 2008, “Departmental Energy, Renewable Energy, and Transportation Management,” U.S. Department of Energy.

DOE Order 450.1A, 2008, “Environmental Protection Program,” U.S. Department of Energy.

DOE Order 5400.5, 1993, “Radiation Protection of the Public and the Environment,” Change 2, U.S. Department of Energy.

DOE-ID, 2005, *Remedial Action Report for the Operable Unit 5-12 Remedial Action*, DOE/NE-ID-11205, U.S. Department of Energy Idaho Operations Office.

DOE-ID, 2008, *Record of Decision for Radioactive Waste Management Complex Operable Unit 7-13/14*, DOE/ID-11359, U.S. Department of Energy Idaho Operations Office.

DOE-ID, 2009, *Operable Unit 10-08 Record of Decision for Site-Wide Groundwater Miscellaneous Sites, and Future Sites*, DOE/ID-11385, Rev. 0, U.S. Department of Energy Idaho Operations Office.

DOE-ID, 2010a, *Idaho National Laboratory Environmental Monitoring Plan*, DOE/ID-10-11088, Rev. 2, U.S. Department of Energy Idaho Operations Office.

DOE-ID, 2010b, *Operable Unit 10-08 Remedial Design/Remedial Action Work Plan*, DOE/ID-11418, U.S. Department of Energy Idaho Operations Office.

DOE-ID, 2010c, *Post-record of Decision Groundwater Monitoring and Field Sampling Plan for Operable Unit 10-08*, DOE/ID-11420, U.S. Department of Energy Idaho Operations Office.

DOE-ID, 2010d, *Environmental Oversight and Monitoring Agreement (Agreement in Principle) Between the United States Department of Energy and the State of Idaho*, U.S. Department of Energy Idaho Operations Office.

Executive Order 13423, 2007, “Strengthening Federal Environmental, Energy, and ransportation Management,” Washington, D.C.

Executive Order 13514, “Federal Leadership in Environmental, Energy, and Economic Performance,” Washington, D.C.

ICP, 2007, *Idaho National Laboratory Site Treatment Plan*, INEEL-STP, Rev. 28, Idaho Cleanup Project.

Public Law 109.58, 2005, “Energy Policy Act of 2005,” U.S. Congress.

Chapter 4. Environmental Monitoring Programs (Air)

Chapter Highlights

An estimated total of 5,089 curies of radioactivity, primarily in the form of short-lived noble gas isotopes, was released as airborne effluents from Idaho National Laboratory (INL) Site facilities in 2010. The highest contributors to the total release were the Advanced Test Reactor Complex at 42 percent, the Idaho Nuclear Technology and Engineering Center at 38 percent, the Materials and Fuels Complex at 13 percent, and the Radioactive Waste Management Complex at 7 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 2010.

Approximately 2,050 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 2010. Iodine-131 was not detected in any sample.

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, 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. There was one positive detection of cesium-137, but the result was well below the Department of Energy health-based limit in air, was within historical measurements, and was most likely due to resuspension of soil contaminated from historical weapons testing fallout. Measurements in 2010 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 (CERCLA) 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 2010. No gamma-emitting radionuclides were detected at any waste management facility in 2010. Plutonium-239/240 and americium-241 detections were comparable to past measurements and are likely due to resuspended soils contaminated from past burial practices at the Subsurface Disposal Area. The results were below health-based regulatory limits.

Atmospheric moisture and precipitation samples were obtained at the INL Site and off the INL Site and analyzed for tritium. Tritium was detected in 33 of 102 atmospheric moisture samples collected and was detected in 21 of 48 precipitation samples collected during 2010. The tritium concentrations measured in moisture samples were within historical measurements. The highest concentrations detected in precipitation samples were within measurements made in Region 10 of the Environmental Protection Agency (Alaska, Idaho, Oregon, and Washington) for the past ten years, and were below the Department of Energy health-based limit for tritium in water. Tritium in these samples was most likely present due to natural production in the atmosphere.

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.

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 5400.5, “Radiation Protection of the Public and the Environment” and DOE Order 450.1A “Environmental Protection Program.” The INL contractor collected about 2,210 air samples (primarily on the INL Site) for radiological analyses in 2010. The INL contractor


Rough-legged Hawk

Table 4-1. Air Monitoring Activities by Organization.

	Airborne Effluent Monitoring Programs	Environmental Surveillance Programs					
Area/Facility[a]	Airborne Effluents[b]	Low-Volume Charcoal Cartridges (iodine-131)	Low-volumeGross 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 2010 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 semiannually. Strontium-90, plutonium-238, plutonium-239/240 and americium-241 are measured by the ICP and ESER contractors quarterly.
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.

also collects air moisture samples at a few 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 and Jackson, Wyoming, 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 2010. 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 at the Radioactive Waste Management Complex (RWMC) and at the Idaho Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Disposal Facility. 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 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 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 2010 INL Report for Radionuclides*, referred to hereafter as the NESHAPs Report (DOE-ID 2011).

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 2010, an estimated 5,089 Ci of radioactivity was released to the atmosphere from all INL Site sources. These emissions are within the range of releases from previous years, and continue a downward trend over the last ten years.

Approximately 83 percent of the radioactive effluent was in the form of 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. The following facilities were the highest contributors to the total emissions (Table 4-2 and Figure 4-1):

- **Idaho Nuclear Technology and Engineering Center (INTEC) Emissions Sources (38 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-year half-life. The dose potentially received from ^{85}Kr is primarily external exposure from immersion in a contaminated plume.

- **Materials and Fuels Complex (MFC) Emissions Sources (13 percent of total)** – Radiological air emissions are primarily associated with spent fuel treatment at the Fuel Conditioning Facility and waste characterization at the Hot Fuel Examination Facility. Both of these facilities are equipped with continuous emission monitoring systems. The effluent streams from the Fuel Conditioning Facility, Hot Fuel Examination Facility, and other noncontinuous emission monitoring radiological facilities are sampled monthly and analyzed for particulate radionuclides. The Fuel Conditioning Facility and Hot Fuel Examination Facility also are sampled monthly for gaseous radionuclides. Minor amounts of gaseous and particulate radionuclides also may be released during laboratory analysis, waste handling, and storage and maintenance operations. Both measured and estimated emissions from MFC sources are consolidated for NESHAPs reporting annually.

- **Advanced Test Reactor Complex (ATR Complex) Emissions Sources (42 percent of total)** – Radiological air emissions from the ATR Complex are primarily associated with operation of the 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.

- **Radioactive Waste Management Complex (RWMC) Emissions Sources (7 percent of total)** – Emissions from RWMC result from various activities conducted in the Subsurface Disposal Area to complete environmental cleanup of the area, including waste retrieval

Table 4-2. Radionuclide Composition of Idaho National Laboratory Site Airborne Effluents (2010)[a].

		Airborne Effluent (Ci)[b]						
Radionuclide	Half life[c]	ATR Complex[d]	CFA[d]	INTEC[d]	MFC[d]	RWMC[d]	TAN[d]	Total
Ag-108m	418 y	—[e]	—	—	—	—	—	0.00E+00
Ag-109m	39.6 s	—	—	—	6.12E-18	—	—	6.12E-18
Ag-110	24.6 s	1.65 E-14	—	—	1.60E-15	—	—	1.60E-15
Ag-110m	249.9 d	1.24E-12	—	1.96E-13	1.60E-15	—	—	1.44E-12
Ag-111	7.47 d	2.13E-12	—	—	—	—	—	2.13E-12
Am-241	432.2 y	1.58E-14	3.00E-03	4.65E-05	7.22E-09	4.86E-03	—	7.90E-03
Am-243	7380 y	1.09E-16	1.26E-03	6.22E-14	1.34E-09	—	—	1.26E-03
Ar-39	269 y	1.49E-19	—	—	—	—	—	1.49E-19
Ar-41	1.827 h	1.68E+03	—	—	9.96E-01	—	—	1.68E+03
Ba-133	10.5 y	—	—	—	6.04E-12	—	—	6.04E-12
Ba-136m	0.3 s	1.95E-12	—	—	—	—	—	1.95E-12
Ba-137m	2.552 m	—	2.96E-04	—	—	3.97E-05	—	3.36E-04
Ba-139	82.7 m	1.34E-01	—	—	—	—	—	1.34E-01
Ba-140	12.74 d	6.03E-09	—	—	—	—	—	6.03E-09
Ba-141	18.3 m	4.07E-09	—	—	—	—	—	4.07E-09
Be-10	1.6e+6 y	5.43E-20	—	—	2.67E-22	—	—	5.46E-20
Be-7	53.3 d	—	—	—	—	3.03E-09	—	3.03E-09
Bi-207	33 y	—	—	—	1.03E-16	—	—	1.03E-16
Bi-210	120 h	7.68E-22	—	—	—	—	—	7.68E-22
Bi-210m	3e6 y	5.73E-28	—	—	—	—	—	5.73E-28
Bi-212	60.6 m	—	—	4.34E-10	—	4.69E-07	—	4.70E-07
C-14	5730 y	3.30E-16	1.85E-08	1.00E-07	8.07E-11	4.20E-08	—	1.61E-07
Ca-45	162.61 d	3.27E-14	—	—	5.17E-19	—	—	3.27E-14
Cd-109	462.6 d	—	—	—	6.19E-13	—	—	6.19E-13
Cd-113m	14.1 y	1.14E-13	—	—	—	—	—	1.14E-13
Cd-115m	44.6 d	1.30E-11	—	—	2.38E-21	—	—	1.30E-11

Table 4-2. Radionuclide Composition of Idaho National Laboratory Site Airborne Effluents (2010) (continued) [a].

		Airborne Effluent (Ci)[b]						
Radionuclide	Half life[c]	ATR Complex[d]	CFA[d]	INTEC[d]	MFC[d]	RWMC[d]	TAN[d]	Total
Ce-139	137.64 d	—	1.00E-03	—	—	—	—	1.00E-03
Ce-141	32.5 d	3.96E-08	—	—	1.16E-16	—	—	3.96E-08
Ce-144	284.3 d	2.28E-08	—	2.46E-18	6.12E-12	4.78E-07	—	5.01E-07
Cl-36	3.01e5 y	—	—	—	1.30E-20	—	—	1.30E-20
Cm-242	162.8 d	9.27E-14	—	2.02E-13	—	—	—	2.95E-13
Cm-243	28.5 y	—	—	—	5.50E-20	—	—	5.50E-20
Cm-244	18.11 y	2.77E-15	6.00E-08	1.72E-12	5.38E-12	9.52E-06	—	9.58E-06
Co-57	270.9 d	1.16E-13	1.16E-10	—	1.63E-13	—	—	1.16E-10
Co-58	70.8 d	1.64E-06	2.14E-05	—	3.12E-11	—	—	2.30E-05
Co-60	5.271 y	1.81E-05	1.24E-03	2.20E-02	3.98E-09	3.98E-04	—	2.37E-02
Co-60m	10.5 m	1.03E-19	—	—	—	—	—	1.03E-19
Cr-51	27.704 d	2.26E-04	7.15E-05	—	4.95E-13	—	—	2.98E-04
Cs-132	6.479 d	2.48E-16	—	—	—	—	—	2.48E-16
Cs-134	2.062 y	2.08E-10	7.49E-06	4.30E-07	3.00E-07	2.06E-06	—	1.03E-05
Cs-135	2.3E06 y	8.19E-16	—	—	5.74E-19	—	—	8.20E-16
Cs-136	13.04 d	1.19E-11	—	—	—	—	—	1.19E-11
Cs-137	30.0 y	7.85E-05	3.12E-04	5.28E-02	2.17E-02	1.03E-02	—	8.52E-02
Cs-138	32.2 m	3.31E-01	—	—	—	—	—	3.31E-01
Cu-67	61.83 h	—	—	—	6.02E-36	—	—	6.02E-36
Eu-152	13.33 y	7.20E-15	6.60E-06	1.12E-03	3.47E-19	—	—	1.13E-03
Eu-154	8.8 y	—	3.00E-03	8.73E-04	2.02E-15	1.15E-07	—	3.87E-03
Eu-155	4.96 y	2.49E-17	—	2.59E-05	1.36E-15	—	—	2.59E-05
Fe-55	2.7 y	9.33E-10	4.24E-04	—	7.02E-11	1.99E-08	—	4.24E-04
Fe-59	44.4529 d	7.56E-12	3.76E-06	6.53E-03	7.23E-12	—	—	6.53E-03
Fe-60	1.5E06 y	1.03E-19	—	—	—	—	—	1.03E-19
Gd-152	1.08E+14 y	—	—	—	4.24E-48	—	—	4.24E-48
Gd-153	240.4 d	—	—	—	8.78E-19	—	—	8.78E-19
Ge-71	11.43 d	3.21E-19	—	—	—	—	—	3.21E-19

Table 4-2. Radionuclide Composition of Idaho National Laboratory Site Airborne Effluents (2010) (continued) [a].

		Airborne Effluent (Ci)[b]						
Radionuclide	Half life[c]	ATR Complex[d]	CFA[d]	INTEC[d]	MFC[d]	RWMC[d]	TAN[d]	Total
H-3	12.35 y	9.34E+01	1.05E+00	2.33E+02	2.59E+00	3.78E+02	2.66E-02	7.08E+02
Hf-175	70 d	—	—	—	1.49E-24	—	—	1.49E-24
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	9.54E-16	5.95E-07	—	6.75E-25	—	—	5.95E-07
Hf-182	9E+06 y	2.55E-23	—	—	2.22E-39	—	—	2.55E-23
Hg-203	46.6 d	8.66E-06	—	—	1.62E-13	—	—	8.66E-06
I-128	24.99 m	6.53E-02	—	—	—	—	—	6.53E-02
I-129	1.57E+07 y	6.26E-07	8.67E-09	3.31E-02	5.70E-15	8.61E-04	—	3.40E-02
I-131	8.04 d	1.06E+00	—	—	2.00E-38	—	—	1.06E+00
I-132	2.3 h	2.26E-03	—	—	—	—	—	2.26E-03
I-133	20.8 h	3.46E-04	—	—	—	—	—	3.46E-04
I-135	6.61 h	1.63E-03	—	—	—	—	—	1.63E-03
In-114	1.2 m	4.26E-17	—	—	—	—	—	4.26E-17
In-114m	49.5 d	4.44E-17	—	—	—	—	—	4.44E-17
In-115	4.4E+14 y	—	—	—	1.17E-53	—	—	1.17E-53
In-115m	4.5 h	9.21E-16	—	—	—	—	—	9.21E-16
Ir-192	74.02 d	5.76E-21	—	—	—	—	—	5.76E-21
K-40	1.277E+08 y	—	—	—	—	4.03E-09	—	4.03E-09
Kr-85	10.72 y	3.40E-01	—	1.70E+03	7.96E+00	1.21E-07	—	1.71E+03
Kr-85m	4.48 h	1.02E+01	—	—	—	—	—	1.02E+01
Kr-87	76.3 m	2.37E+01	—	—	—	—	—	2.37E+01
Kr-88	2.84 m	2.33E+01	—	—	—	—	—	2.33E+01
Lu-176	3.60E+10 y	—	—	—	5.41E-44	—	—	5.41E-44
Mn-53	3.7E06 y	7.20E-23	—	—	—	—	—	7.20E-23
Mn-54	312.5 d	1.28E-11	2.3E-05	—	2.15E-11	—	—	2.83E-05
Mo-93	3.5E+03 y	1.01E-09	2.49E-10	—	1.01E-16	—	—	1.26E-09
Mo-99	66.0 h	1.45E-05	—	—	—	—	—	1.45E-05

Table 4-2. Radionuclide Composition of Idaho National Laboratory Site Airborne Effluents (2010) (continued) [a].

		Airborne Effluent (Ci)[b]						
Radionuclide	Half life[c]	ATR Complex[d]	CFA[d]	INTEC[d]	MFC[d]	RWMC[d]	TAN[d]	Total
Na-22	2.6 y	—	—	—	9.10E-05	—	—	9.10E-05
Na-24	15.0 h	6.85E-03	—	—	3.80E-19	—	—	6.85E-03
Nb-93m	16.1 y	2.52E-16	—	—	2.47E-22	—	—	2.52E-16
Nb-94	2.03E+04 y	—	—	3.74E-11	2.25E-17	—	—	3.74E-11
Nb-95	35.15 d	6.48E-08	1.00E-03	—	4.02E-12	—	—	1.00E-03
Nb-95m	3.61 d	4.14E-10	—	—	1.54E-17	—	—	4.14E-10
Nb-97	1.23 h	—	—	—	1.74E-18	—	—	1.74E-18
Nd-147	10.98 d	1.17E-09	—	—	1.94E-19	—	—	1.17E-09
Ni-59	7.5E+04 y	1.67E-11	2.26E-07	—	8.34E-14	—	—	2.26E-07
Ni-63	96 y	2.11E-09	4.23E-05	1.60E-04	2.89E-09	6.35E-03	—	6.55E-03
Ni-66	54.7 h	—	—	—	2.92E-39	—	—	2.92E-39
Np-237	2.14E+06 y	7.02E-16	1.08E-09	6.36E-09	3.32E-11	1.03E-09	—	8.50E-09
Np-239	2.355 d	5.12E-12	—	—	—	—	—	5.12E-12
Os-185	93.6 d	4.44E-21	—	—	—	—	—	4.44E-21
Os-191	15.4 d	1.77E-06	—	—	—	—	—	1.77E-06
P-32	14.262 d	5.88E-18	1.29E-08	—	9.16E-16	—	—	1.29E-08
P-33	25.34 d	3.15E-21	1.50E-10	—	3.09E-18	—	—	1.50E-10
Pa-233	27.0 d	6.36E-16	—	2.30E-10	—	—	—	2.30E-10
Pa-234m	1.17 m	6.42E-16	—	7.74E-11	—	—	—	7.74E-11
Pb-205	1.53E+07 y	1.72E-21	—	—	—	—	—	1.72E-21
Pb-210	22.3 y	7.68E-22	—	—	—	9.12E-10	—	9.12E-10
Pb-212	13.6 h	—	—	4.34E-10	—	4.69E-07	—	4.70E-07
Pd-107	6.5E+06 y	1.45E-16	—	—	—	—	—	1.45E-16
Pm-145	17.7 y	—	—	—	9.52E-27	—	—	9.52E-27
Pm-146	5.53 y	3.90E-15	—	—	—	—	—	3.90E-15
Pm-147	2.6234 y	2.94E-09	6.23E-04	3.30E-05	1.73E-12	4.82E-07	—	6.56E-04
Pm-148	5.37 d	2.74E-12	—	—	—	—	—	2.74E-12

Table 4-2. Radionuclide Composition of Idaho National Laboratory Site Airborne Effluents (2010) (continued) [a].

		Airborne Effluent (Ci)[b]						
Radionuclide	Half life[c]	ATR Complex[d]	CFA[d]	INTEC[d]	MFC[d]	RWMC[d]	TAN[d]	Total
Pm-148m	41.3 d	1.28E-10	—	—	—	—	—	1.28E-10
Pm-149	53.08 h	1.02E-17	—	—	—	—	—	1.02E-17
Po-210	138.38 d	3.03E-21	—	—	5.00E-27	—	—	3.03E-21
Po-212	0.305 ms	—	—	—	—	3.00E-07	—	3.00E-07
Po-216	0.15 s	—	—	—	—	4.69E-07	—	4.69E-07
Pr-143	13.56 d	7.74E-09	—	—	—	4.80E-07	—	4.88E-07
Pr-144	17.3 m	2.28E-08	—	—	8.29E-12	—	—	2.28E-08
Pr-144m	7.2 m	2.74E-10	—	—	—	—	—	2.74E-10
Pu-236	2.9 y	4.35E-17	5.12E-14	1.12E-13	—	—	—	1.63E-13
Pu-237	45.3 d	2.28E-16	—	—	—	—	—	2.28E-16
Pu-238	87.74 y	5.13E-13	7.27E-09	1.08E-04	2.90E-09	7.98E-04	—	9.06E-04
Pu-239	24065 y	7.83E-13	2.73E-12	3.60E-04	1.06E-06	5.99E-04	—	9.60E-04
Pu-239/240	24065/6537 y	—	—	—	—	5.34E-06	—	5.34E-06
Pu-240	6537 y	2.51E-13	6.99E-09	1.89E-04	1.83E-09	1.23E-04	—	3.12E-04
Pu-241	14.4 y	3.60E-11	2.61E-06	7.10E-03	2.34E-08	1.26E-03	—	8.37E-03
Pu-242	3.8E+05 y	6.90E-17	2.30E-06	1.27E-14	9.90E-13	8.65E-09	—	2.31E-06
Ra-224	3.66 d	—	—	4.34E-10	—	4.69E-07	—	4.70E-07
Ra-226	1600 y	—	—	—	2.70E-17	—	—	2.70E-17
Rb-86	18.66 d	2.07E-12	—	—	—	—	—	2.07E-12
Rb-88	17.8 m	2.58E-01	—	—	—	—	—	2.58E-01
Rb-89	15.2 m	2.00E-01	—	—	—	—	—	2.00E-01
Re-184	38.0 d	3.06E-18	—	—	—	—	—	3.06E-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	5E10 y	3.45E-17	—	—	—	—	—	3.45E-17
Re-188	17.005 h	2.35E-05	—	—	—	—	—	2.35E-05
Rh-102	2.9 y	3.30E-16	—	—	—	—	—	3.30E-16
Rh-103m	56.12 m	2.22E-08	—	—	1.67E-15	—	—	2.22E-08

Rough-legged Hawk

Table 4-2. Radionuclide Composition of Idaho National Laboratory Site Airborne Effluents (2010) (continued) [a].

		Airborne Effluent (Ci)[b]						
Radionuclide	Half life[c]	ATR Complex[d]	CFA[d]	INTEC[d]	MFC[d]	RWMC[d]	TAN[d]	Total
Rh-106	368.2 d	—	—	—	8.71E-14	—	—	8.71E-14
Rh-106m	131 m	—	—	—	7.56E-13	—	—	7.56E-13
Ru-103	39.26 d	2.46E-08	—	—	5.19E-07	—	—	5.44E-07
Ru-106	373.59 d	1.60E-09	—	1.30E-14	8.65E-06	—	—	8.65E-06
S-35	87.44 d	—	1.48E-08	—	9.58E-14	—	—	1.48E-08
Sb-122	2.7238 d	1.34E-06	—	—	—	—	—	1.34E-06
Sb-124	60.2 d	6.52E-07	1.05E-06	—	3.13E-17	—	—	1.70E-06
Sb-125	2.77 y	5.94E-11	1.94E-06	3.00E-06	1.10E-05	2.91E-08	—	1.60E-05
Sb-126	12.4 d	9.84E-13	—	—	—	—	—	9.84E-13
Sb-126m	19.0 m	3.12E-15	—	—	—	—	—	3.12E-15
Sb-127	3.85 d	5.31E-06	—	—	—	—	—	5.31E-06
Sc-46	83.83 d	2.75E-13	2.69E-07	—	1.60E-15	—	—	2.69E-07
Se-79	65,000 y	3.36E-15	—	—	—	—	—	3.36E-15
Si-32	100 y	5.34E-18	—	—	—	—	—	5.34E-18
Sm-145	340 d	—	—	—	4.34E-25	—	—	4.34E-25
Sm-147	1.06E+11 y	—	—	—	9.56E-43	—	—	9.56E-43
Sm-151	90 y	5.13E-12	—	2.60E-04	4.37E-17	—	—	2.60E-04
Sn-113	115.09 d	—	—	—	1.82E-13	—	—	1.82E-13
Sn-117m	13.6 d	1.3E-15	—	—	—	—	—	1.23E-15
Sn-119m	293 d	1.29E-12	—	—	—	—	—	1.29E-12
Sn-121m	55.0 y	7.53E-16	—	—	—	—	—	7.53E-16
Sn-123	129.2 d	4.26E-11	—	—	—	—	—	4.26E-11
Sn-125	9.64 d	4.83E-12	—	—	—	—	—	4.83E-12
Sn-126	1E+05 y	3.12E-15	—	—	—	—	—	3.12E-15
Sr-85	64.84 d	—	4.00E-08	—	—	—	—	4.00E-08
Sr-89	50.5 d	4.05E-08	—	—	6.16E-17	—	—	4.05E-08
Sr-90	29.12 y	3.24E-07	6.23E-06	1.95E-02	2.19E-04	8.70E-03	8.34E-07	2.84E-02
Sr-91	9.5 h	5.03E-10	—	—	—	—	—	5.03E-10

Table 4-2. Radionuclide Composition of Idaho National Laboratory Site Airborne Effluents (2010) (continued) [a].

		Airborne Effluent (Ci)[b]						
Radionuclide	Half life[c]	ATR Complex[d]	CFA[d]	INTEC[d]	MFC[d]	RWMC[d]	TAN[d]	Total
Sr-92	2.7 h	5.42E-10	—	—	—	—	—	5.42E-10
Ta-179	1.8 y	1.34E-14	—	—	—	—	—	1.34E-14
Ta-180m	7.1E+15 y	5.03E-33	—	—	—	—	—	5.03E-33
Ta-182	114.43 d	2.96E-14	—	—	1.17E-14	—	—	4.13E-14
Tb-160	72.3 d	—	—	—	1.37E-24	—	—	1.37E-24
Tb-161	6.91 d	—	—	—	4.53E-24	—	—	4.53E-24
Tc-99	2.13E+05 y	1.16E-13	1.13E-03	4.66E-06	1.54E-15	1.77E-08	—	1.13E-03
Tc-99m	6.02 h	8.54E-05	—	—	—	—	—	8.54E-05
Te-123m	119.7 d	1.14E-15	—	—	—	—	—	1.14E-15
Te-127	9.35 h	1.81E-10	—	—	—	—	—	1.81E-10
Te-127m	109 d	1.85E-10	—	—	—	—	—	1.85E-10
Te-129	69.6 m	4.68E-10	—	—	1.45E-22	—	—	4.68E-10
Te-129m	33.6 d	7.20E-10	—	—	2.21E-22	—	—	7.20E-10
Te-132	78.2 h	5.19E-14	—	—	—	—	—	5.19E-14
Th-228	1.9116 y	—	—	4.60E-11	—	4.69E-07	—	4.70E-07
Th-229	7340 y	—	—	3.30E-18	—	—	—	3.30E-18
Th-230	7.7E+04 y	—	—	3.30E-16	—	—	—	3.30E-16
Th-231	25.5 h	2.15E-15	—	6.44E-10	—	—	—	6.44E-10
Th-232	1.405E+10 y	—	3.04E-12	1.95E-23	—	1.29E-07	—	1.29E-07
Th-234	24.1 d	6.42E-16	—	7.74E-11	—	—	—	7.74E-11
Tl-204	3.77 y	3.81E-21	—	—	—	—	—	3.81E-21
Tl-208	3.07 m	—	—	—	—	1.68E-07	—	1.68E-07
U-232	72 y	—	1.02E-12	4.38E-10	—	4.59E-07	—	4.60E-07
U-233	1.585E+05 y	—	—	4.66E-08	6.97E-08	1.80E-05	—	1.81E-05
U-234	2.457E+05 y	1.07E-16	4.13E-08	1.69E-07	8.90E-09	1.02E-07	1.80E-08	3.39E-07
U-235	7.038E+08 y	2.15E-15	6.96E-10	1.24E-07	4.27E-10	—	1.26E-09	1.26E-07
U-236	4.468E+09 y	3.57E-15	—	5.47E-09	4.60E-18	—	—	5.47E-09
U-237	6.75 d	1.83E-11	—	—	—	—	—	1.83E-11

Table 4-2. Radionuclide Composition of Idaho National Laboratory Site Airborne Effluents (2010) (continued) [a].

		Airborne Effluent (Ci)[b]						
Radionuclide	Half life[c]	ATR Complex[d]	CFA[d]	INTEC[d]	MFC[d]	RWMC[d]	TAN[d]	Total
U-238	4.5E+09 y	9.13E-10	—	9.95E-08	1.70E-10	—	9.99E-08	2.00E-07
V-49	330 d	3.21E-19	—	—	—	—	—	3.21E-19
W-181	121.2 d	4.08E-09	8.37E-08	—	—	—	—	8.78E-08
W-185	75.1 d	3.21E-08	6.99E-08	—	—	—	—	1.02E-07
W-187	23.9 h	7.77E-06	—	—	—	—	—	7.77E-06
W-188	69.78 d	8.46E-09	—	—	—	—	—	8.46E-09
Xe-127	36.4 d	1.29E-07	—	—	—	—	—	1.29E-07
Xe-129m	8.89 d	4.82E-07	—	—	—	—	—	4.82E-07
Xe-131m	11.8 d	2.15E-01	—	—	—	—	—	2.15E-01
Xe-133	5.245 d	5.38E+01	—	—	—	—	—	5.38E+01
Xe-133m	5.2 d	7.47E-09	—	—	—	—	—	7.47E-09
Xe-135	9.09 h	3.79E+01	—	—	—	—	—	3.79E+01
Xe-135m	15.29 m	1.28E+01	—	—	—	—	—	1.28E+01
Xe-138	14.17 m	5.46E+01	—	—	—	—	—	5.46E+01
Y-88	106.64 d	2.19E-06	—	—	—	—	—	2.19E-06
Y-90	64.0 h	—	6.23E-06	—	7.43E-14	3.57E-05	—	4.20E-05
Y-91	58.51 d	5.13E-08	—	—	7.23E-17	—	—	5.13E-08
Y-91m	49.71 m	3.05E-04	—	—	—	—	—	3.05E-04
Zn-65	243.9 d	9.45E-10	3.42E-05	—	1.38E-12	—	—	3.42E-05
Zr-93	1.5E+06 y	1.73E-14	—	—	9.78E-21	—	—	1.73E-14
Zr-95	63.98 d	5.61E-08	1.00E-03	—	4.28E-12	—	—	1.00E-03
Total		1.99E+03	1.06E+00	1.93E+03	1.16E+01	3.78E+02	2.66E-02	4.32E+03

a. Radionuclide release information provided by BEA.
b. Includes only those radionuclides with a total INL Site release that potentially contribute > 1E-05 mrem dose.
c. d = days, h = hours, m = minutes, ms = milliseconds, s = seconds, y = years
d. 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.
e. A long dash signifies the radionuclide was not reported to be released to air from the facility in 2010

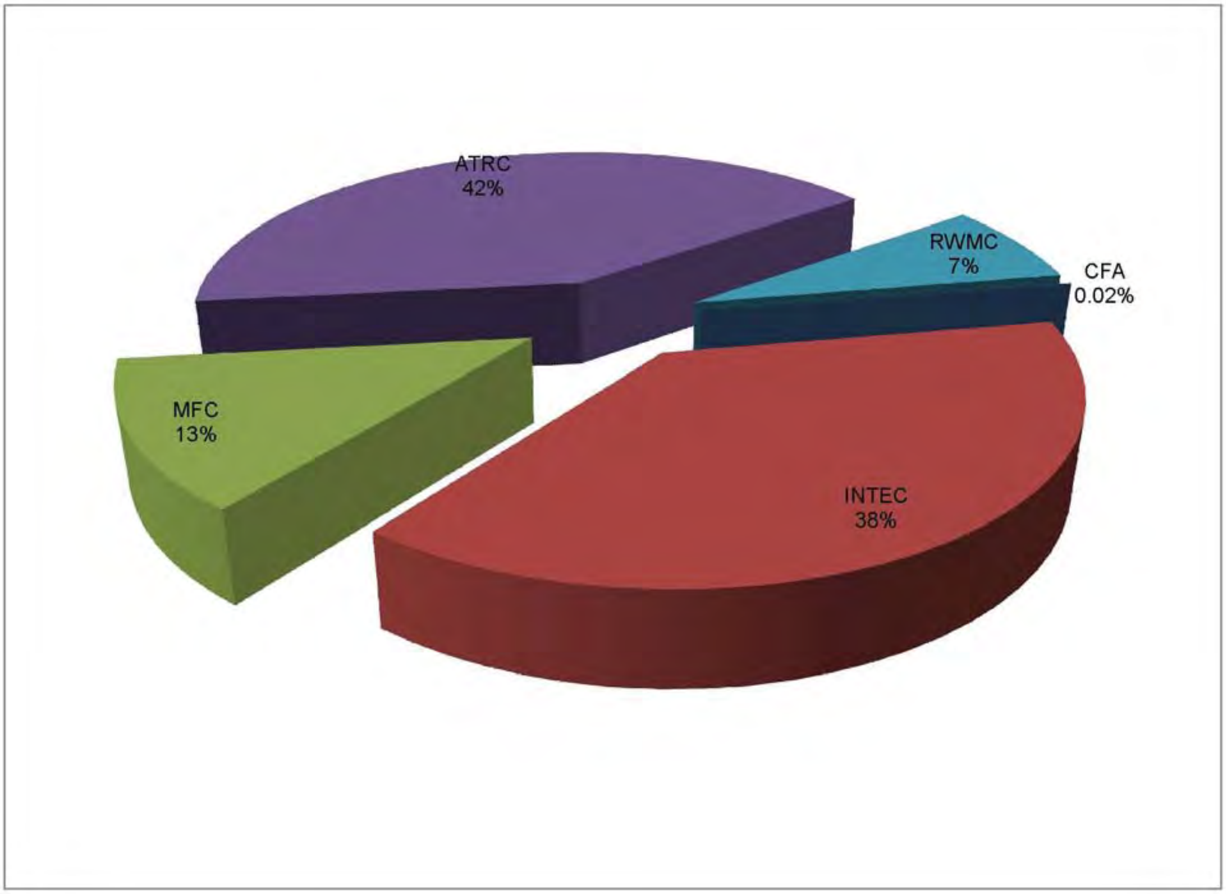


Figure 4-1. Percent Contributions, by Facility, to Total INL Site Airborne Radionuclide Releases (2010).

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.

The INL Site dose was calculated using all sources that emitted radionuclides to the environment (DOE-ID 2010). 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.

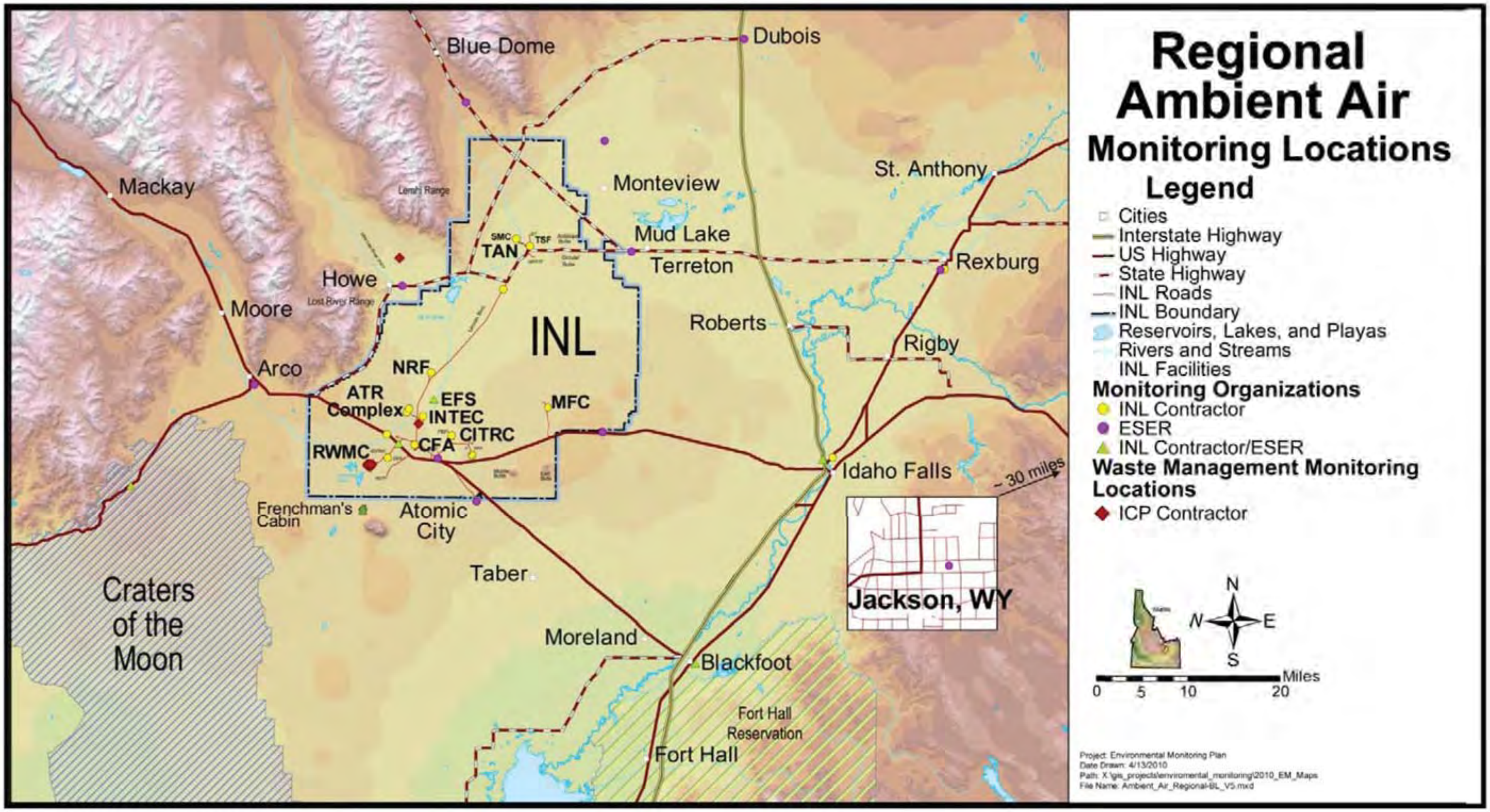


Figure 4-2. Idaho National Laboratory Site Environmental Surveillance Air Sampling Locations.

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/minute]) 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 contractor, monthly by the ICP contractor, and semiannually by the INL 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).[1] 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.

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 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

1 In June of 2008, the INL contractor ceased analyzing for ^{90}Sr and alpha-emmitting actinides and changed the gamma spectrometry analysis frequency to semiannual. This decision was based on the INL contractor's estimated dose for the maximally exposed individual (MEI) being less than 1.0 mR. The INL contractor currently screens for certain actinides (uranium-235, uranium-238, and ^{241}Am) using the semiannual gamma spectrometry analysis of the composited air samples.

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

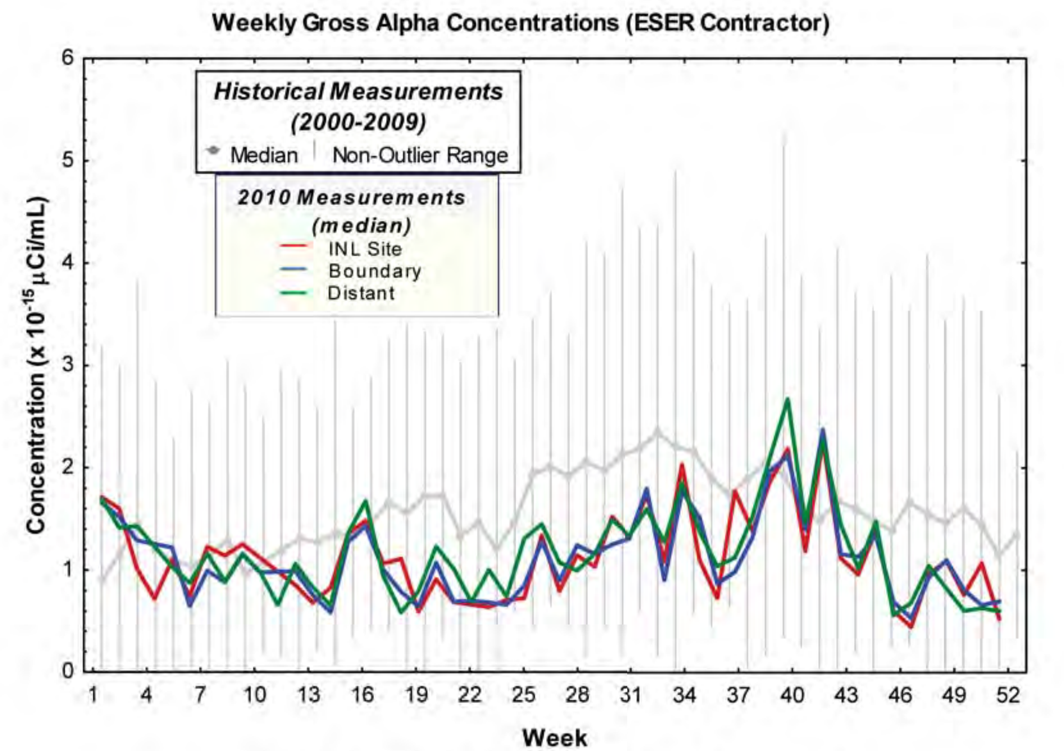
Gaseous Radioiodines – During 2010, the ESER contractor analyzed 936 cartridges, looking specifically for ^{131}I. Iodine-131 was not detected in any of the ESER samples.

The INL contractor collected and analyzed approximately 1,110 charcoal cartridges in 2010. Of these 1,110 cartridges, there were no statistically positive detections of ^{131}I; however, statistically positive activity concentrations are reported in some instances where minimum nuclide detection and identification criteria are not met. For example, the reported concentration for a given sample may be less than the method detection limit, which means it likely was a false positive. All ^{131}I sample concentrations reported were below the measurement method detection limit. In addition, no ^{131}I was detected by any other INL Site contractor sample collected in 2010.

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 $-8.0 \times 10^{-16} \pm 1.7 \times 10^{-15}$ µCi/mL collected at INTEC on April 28, 2010, to a high of $5.3 \times 10^{-15} \pm 1.3 \times 10^{-15}$ µCi/mL collected at the EFS on October 20, 2010. Gross alpha concentrations measured in weekly ESER contractor samples ranged from a minimum of -0.05×10^{-15} µCi/mL at the Federal Aviation Administration Tower during the week ending March 17, 2010, to a maximum of 3.4×10^{-15} µCi/mL during the week ending October 6, 2010, at Jackson. All results were within the range of historical measurements and less than the Derived Concentration Guide (DCG) of 2×10^{-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.



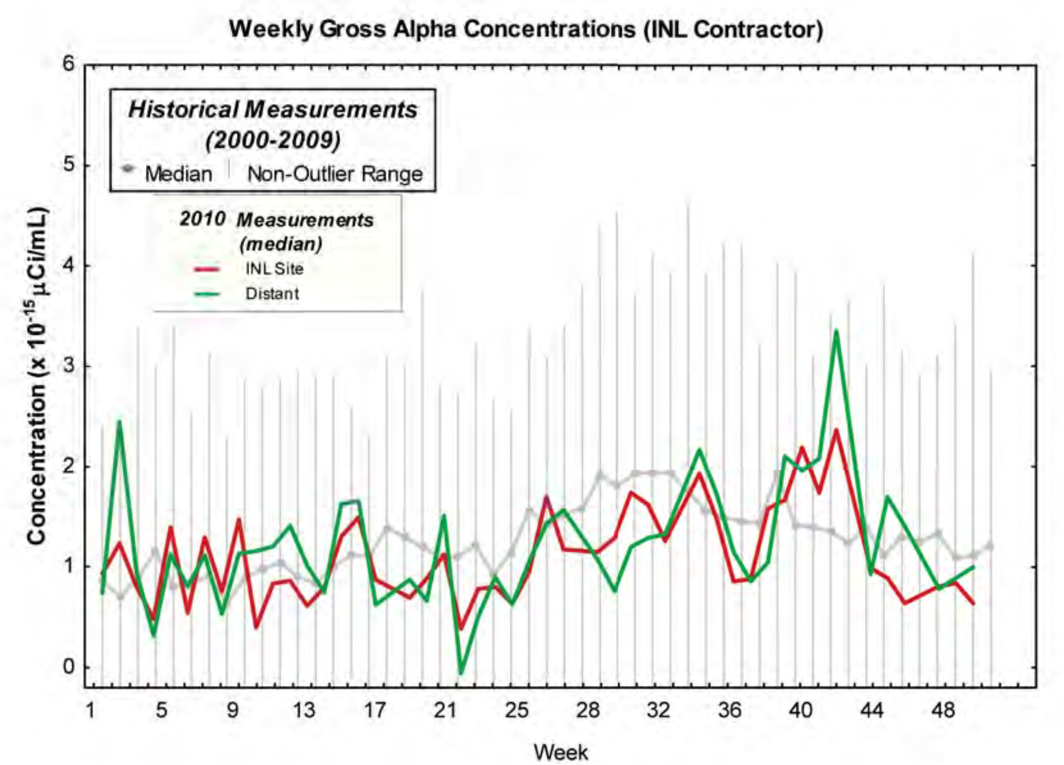


Figure 4-3. Median Weekly Gross Alpha Concentrations in Air (2010).

Median annual gross alpha concentrations calculated by the INL contractor ranged from 0.7×10^{-15} μCi/mL at Auxiliary Reactor Area (ARA) to 1.3×10^{-15} μCi/mL at Rexburg and RWMC. Median annual gross alpha concentrations calculated by the ESER contractor for each location ranged from 0.81×10^{-15} μCi/mL at Craters of the Moon 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.

- ***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 $2.0 \times 10^{-15} \pm 1.1 \times 10^{-15}$ μCi/mL on the north side of the RWMC on December 15, 2010, to a high of $6.0 \times 10^{-13} \pm 4.9 \times 10^{-14}$ μCi/mL at the MFC on February 24, 2010. Weekly gross beta concentrations detected in individual ESER contractor samples ranged from a low of 6.3×10^{-15} μCi/mL on February 17, 2010, at Dubois to a high of 6.9×10^{-14} μCi/mL on February 3, 2010, at Mud Lake. 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, as well as historical median and range of data measured by the ESER contractor during the ten-year period from 2000 through 2009. 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 concentration of gross beta activity was detected in the fourth quarter of 2010 by the INL contractor on the INL Site. Each median value was calculated using all measurements, including those statistically undetected or less than zero. The maximum median weekly gross beta concentration was 3.0×10^{-14} μCi/mL, which is significantly below the DCG of 300×10^{-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 2.1×10^{-14} μCi/mL at Craters of the Moon to 2.7×10^{-14} μCi/mL at Arco and Mud Lake (Table 4-4). INL contractor data ranged from

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.

Table 4-3. Median Annual Gross Alpha Concentrations in Air (2010).

Group	Location[a]	No. of Samples[b]	Range of Concentrations[c] (× 10^{-15} μCi/mL)	Annual Median[c] (× 10^{-15} μCi/mL)
		ESER Contractor		
Distant	Blackfoot CMS	50	0.30 – 2.7	1.0
	Craters of the Moon	50	0.25 – 2.3	0.81
	Dubois	52	0.03 – 2.4	1.0
	Idaho Falls	52	0.31 – 3.1	1.3
	Jackson	51	0.03 – 3.4	1.2
	Rexburg CMS	52	0.31 – 3.3	1.1
			Distant Median:	1.1
Boundary	Arco	52	0.08 – 2.4	1.1
	Atomic City	52	0.28 – 2.6	1.0
	Blue Dome	51	0.07 – 2.2	0.83
	Federal Aviation Administration Tower	48	-0.05 – 2.6	1.0
	Howe	51	0.27 – 2.6	1.0
	Monteview	52	0.21 – 2.3	1.1
	Mud Lake	52	0.23 – 2.5	1.2
			Boundary Median:	1.0
INL Site	EFS	52	0.04 – 2.7	1.0
	Main Gate	52	0.03 – 2.6	1.0
	Van Buren	52	0.12 – 2.4	1.0
			INL Site Median:	1.0
		INL Contractor		
Distant	Blackfoot	48	-0.31– 3.5	1.0
	Craters of the Moon	46	-0.21 – 3.6	1.2
	Idaho Falls	48	-0.34 – 3.8	1.2
	Rexburg	48	0.02 – 3.2	1.3
			Distant Median:	1.2
INL Site	ARA	38	-0.2 – 3.8	0.71
	ATR Complex (south side)	47	-0.35 – 3.9	1.0
	ATR Complex (NE corner)	48	-0.23 – 4.1	1.2
	CFA	48	-0.12 – 3.5	0.98
	CITRC	47	-0.15 – 4.6	0.95
	INTEC (west side)	48	-0.33 – 4.1	0.93
	EBR-I	48	-0.05 – 3.9	0.91
	EFS	48	0.21 – 5.3	0.93
	Gate 4	48	-0.26 – 2.3	1.1
	INTEC (NE corner)	48	-0.8 – 3.3	1.0
	MFC	48	-0.23 – 4.3	1.1
	NRF	48	-0.02 – 3.6	1.1
	Rest Area	48	0.16 – 2.5	1.0
	RWMC	48	-0.67 – 2.9	1.3
	SMC	47	-0.24 – 4.2	1.0
	TAN	46	-0.3 – 5.1	1.2
	Van Buren	47	-0.36 – 2.5	1.2
			INL Site Median:	1.0

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.

Rough-legged Hawk

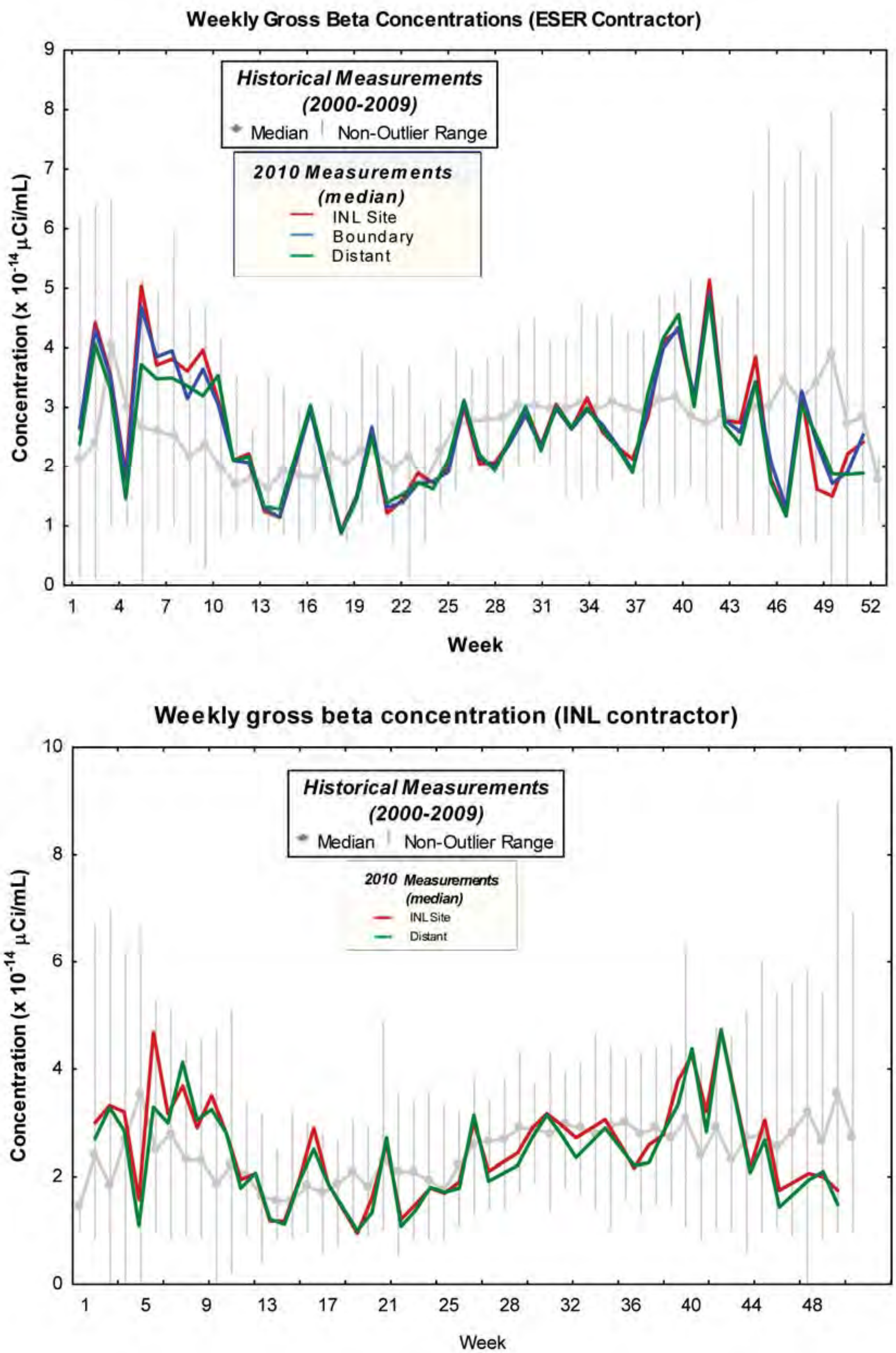


Figure 4-4. Median Weekly Gross Beta Concentrations in Air (2010).

Table 4-4. Median Annual Gross Beta Concentrations in Air (2010).

Group	Location[a]	No. of Samples[b]	Range of Concentrations[c] (× 10^{-14} µCi/mL)	Annual Median[c] (× 10^{-14} µCi/mL)
		ESER Contractor		
Distant	Blackfoot CMS	50	0.95 – 5.2	2.4
	Craters of the Moon	50	0.84– 4.7	2.1
	Dubois	52	0.63 – 4.9	2.3
	Idaho Falls	52	0.94– 5.1	2.5
	Jackson	51	1.0 – 4.9	2.5
	Rexburg CMS	52	0.81 – 4.8	2.5
			Distant Median:	2.4
Boundary	Arco	52	0.92 – 4.7	2.7
	Atomic City	52	0.90 – 5.5	2.4
	Blue Dome	51	0.76 – 4.3	2.4
	Federal Aviation Administration Tower	48	0.86 – 5.2	2.4
	Howe	51	0.89 – 4.9	2.6
	Monteview	52	0.88 – 5.1	2.5
	Mud Lake	52	0.85 – 6.9	2.7
			Boundary Median:	2.5
INL Site	EFS	52	0.98 – 6.6	2.5
	Main Gate	52	0.89 – 5.3	2.6
	Van Buren	52	0.91 – 5.5	2.5
			INL Site Median:	2.5
		INL Contractor		
Distant	Blackfoot	48	0.42 – 4.9	2.4
	Craters of the Moon	46	0.89 – 4.8	2.3
	Idaho Falls	48	0.91 – 4.7	2.3
	Rexburg	48	0.9 – 4.5	2.4
			Distant Median	2.3
INL Site	ARA	38	0.78 – 4.4	2.4
	ATR Complex (south side)	47	0.58 – 5.7	2.7
	ATR Complex (NE corner)	48	0.98 – 5.3	2.6
	CFA	48	0.95 – 4.5	2.5
	CITRC	47	0.82 – 5.2	2.6
	INTEC (west side)	48	0.94 – 4.8	2.4
	EBR-I	48	0.79 – 5.0	2.6
	EFS	48	1.1 – 5.3	2.7
	Gate 4	48	0.85 – 5.3	2.6
	INTEC (NE corner)	48	0.85 – 4.7	2.6
	MFC	48	0.91 – 60	2.4
	NRF	48	0.69 – 5.1	2.5
	Rest Area	48	0.86 – 5.1	2.4
	RWMC	48	0.2 – 6.7	2.6
	SMC	47	0.59 – 5.0	2.6
	TAN	46	0.96 – 5.8	2.3
	Van Buren	47	1.1 – 4.8	2.4
			INL Site Median:	2.6

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.

a median annual concentration of 2.3×10^{-14} μCi/mL at Craters of the Moon, Idaho Falls, and Test Area North (TAN) to 2.7×10^{-14} μCi/ mL at the ATR Complex (south side) and EFS. 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 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 2010. There were a few statistical differences between weekly boundary and distant data sets collected by the ESER contractor during the 52 weeks of 2010 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 – Cesium-137 was reported at just above the detection level for the composite from the ESER duplicate sampler located at the Van Buren Gate during the first quarter. A subsequent recount of the composite did not show ^{137}Cs above the detection level. In addition, the co-located sampler at the Van Buren location did not show a detectable ^{137}Cs concentration. Therefore, it can be concluded that ^{137}Cs was most likely not detected.

Additionally, ^{137}Cs was detected as a true positive at a concentration of $6.64 \times 10^{-16} \pm 6.6 \times 10^{-17}$ μCi/mL at the “TRA” location for the second semiannual composite collected by the INL contractor dated December 22, 2010. The ^{137}Cs detected in this composite sample is likely due to resuspension of activity deposited in soil from historical weapons testing fallout.

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 2010, 42 samples were collected. Two statistically positive detections occurred. Tritium was detected at EFS at a concentration of $6.3 \times 10^{-12} \pm 1.6 \times 10^{-12}$ μCi/mL on August 23, 2010, and at Idaho Falls at a concentration of $5.0 \times 10^{-12} \pm 1.5 \times 10^{-12}$ μCi/mL on September 8, 2010. The results probably represent 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 2010, the ESER contractor collected 60 atmospheric moisture samples at Atomic City, Blackfoot, Idaho Falls, and Rexburg. Table 4-5 presents the range of values detected at each station by quarter. Tritium was detected in 39 samples, ranging from a low of 5.3×10^{-13} µCi/mL at Rexburg to a high of 28×10^{-13} µCi/mL at Blackfoot. 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 DCG for tritium in air (as hydrogen tritium oxygen) of 1×10^{-7} 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 48 precipitation samples were collected during 2010 from the three sites. Tritium concentrations were detected in 21 samples, and results ranged from 99 pCi/L at EFS to 251 pCi/L at EFS. Table 4-6 shows the concentration ranges by quarter for each location. The highest concentration is well below the DCG level for tritium in water of 2×10^{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/).

4.3.4 Suspended Particulates Monitoring Results

In 2010, 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

Table 4-5. Ranges of Tritium Concentrations Detected in ESER Contractor Atmospheric Moisture Samples (2010).[a]

Location	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
		($\times 10^{-13}$ µCi/mL)		
Atomic City	5.9 ± 1.6 – 11 ± 1.4[a]	6.5 ± 1.9 – 10 ± 2.9	8.7 ± 2.5 – 13 ± 3.1	5.5 ± 1.4 – 16 ± 2.3
Blackfoot	8.3 ± 1.4[b]	11 ± 2.3	7.9 ± 2.1 – 28 ± 3.0	5.5 ± 1.6 – 11 ± 1.1
Idaho Falls	ND[c]	7.3 ± 2.3 – 14 ± 3.0	8.6 ± 2.3 – 13 ± 3.0	5.7 ± 1.8 – 8.0 ± 1.8
Rexburg	5.3 ± 1.5	8.2 ± 1.9 – 15 ± 2.6	9.9 ± 3.0 – 18 ± 3.3	7.0 ± 1.9

a. Result ± 1s. Results shown are ≥ 3s.
b. When a single value is reported, tritium was detected in only one sample.
c. ND = not detected.

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 6 μg/m^3 at Blue Dome to 26 μg/m^3 at Rexburg. In general, particulate concentrations were higher at offsite locations than at the INL Site stations. This is mostly 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 Subsurface Disposal Area 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 2010 (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 Subsurface Disposal Area 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.

On July 1, 2010, the analytical laboratory (Centauri Labs, Montgomery, Alabama), closed without notifying the ICP contractor. Consequently, gross alpha and gross beta samples that were collected from May 3, 2010, through June 15, 2010, were not analyzed or reported. Subsequently, a new laboratory (ALS Laboratory Group, Fort Collins, Colorado) was contracted to analyze and report waste management surveillance samples.

Table 4-6. Ranges of Tritium Concentrations Detected in ESER Contractor Precipitation Samples (2010).[a]

Location[b]	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
		(pCi/L)		
CFA	201 ± 35[c]	ND[d]	106 ± 33	101 ± 33
EFS	105 ± 33 – 168 ± 36	99 ± 33 – 251 ± 36	109 ± 34 – 132 ± 33	146 ± 36 – 203 ± 33
Idaho Falls	ND	107 ± 33	116 ± 34	137 ± 34

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

b. CFA = Central Facilities Area, EFS = Experimental Field Station.

c. When a single value is reported, tritium was detected in only one sample.

d. ND = not detected.

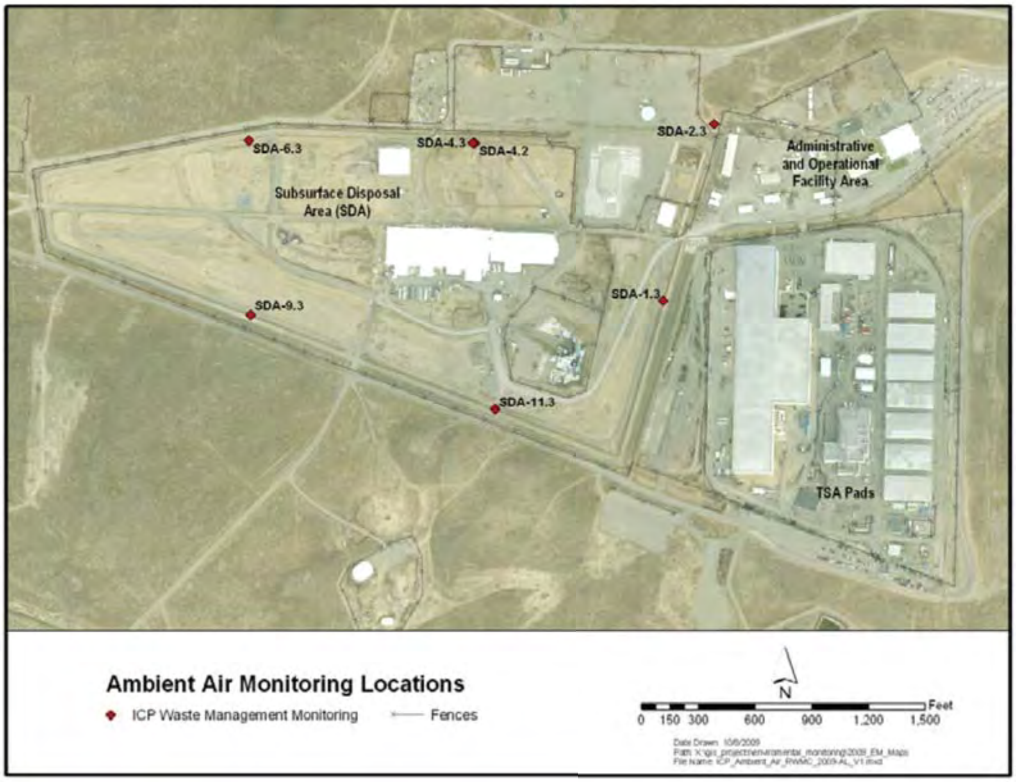


Figure 4-5. Locations of Low-volume Air Samplers at Waste Management Areas.
(Radioactive Waste Management Complex [top] and Idaho CERCLA Disposal Facility [bottom]).

Rough-legged Hawk

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

4.4.2 Specific Radionuclides

In 2010, no human-made, gamma-emitting radionuclides were detected at the Subsurface Disposal Area of RWMC and the Idaho CERCLA Disposal Facility at INTEC.

Table 4-8 shows alpha- and beta-emitting radionuclides detected in air samples analyzed using radiochemistry in 2010. 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 2009 to 2010; however, the number of ^{241}Am detections increased. Part of this increase is due to detections at the control location north of Howe. There were no positive ^{90}Sr results. All of the detections shown in Table 4-8 likely are due to resuspension of contaminated soils inside or

Table 4-7. Gross Activity Concentrations Measured in ICP Contractor Air Samples (2010).[a,b]

Activity	Low (µCi/mL)	High (µCi/mL)	Annual Mean (µCi/mL)
Subsurface Disposal Area (SDA)			
Gross Alpha	$(4.34 \pm 6.55) \times 10^{-16}$ 2nd half of January at SDA 9.3	$(1.14 \pm 0.15) \times 10^{-14}$ 1st half of July at SDA 1.3	3.52×10^{-15}
Gross Beta	$(5.70 \pm 0.89) \times 10^{-15}$ 2nd half of August at SDA 1.3	$(7.04 \pm 0.73) \times 10^{-14}$ 1st half of February at SDA 1.3	2.68×10^{-14}
Idaho CERCLA Disposal Facility (INT)			
Gross Alpha	$(1.32 \pm 0.48) \times 10^{-15}$ 1st half of November at INT 100.3	$(7.97 \pm 1.12) \times 10^{-15}$ 1st half of August at INT 100.3	3.60×10^{-15}
Gross Beta	$(1.25 \pm 0.15) \times 10^{-14}$ 1st half of April at INT 100.3	$(5.13 \pm 0.50) \times 10^{-14}$ 2nd half of October at INT 100.3	2.85×10^{-14}

a. Result ± 1s.
b. Results from May 3, 2010, to June 15, 2010, are missing due to laboratory closure.

Table 4-8. Human-made Radionuclides Detected in ICP Contractor Air Samples (2010).[a]

Radionuclide	Result (µCi/mL)	Location	Quarter Detected[b]
Am-241	$(1.12 \pm 0.30) \times 10^{-17}$	SDA[c] 1.3	2nd
	$(1.55 \pm 0.36) \times 10^{-17}$	SDA 2.3	2nd
	$(1.80 \pm 0.40) \times 10^{-17}$	SDA 4.2	2nd
	$(2.08 \pm 0.46) \times 10^{-17}$	SDA 4.3	2nd
	$(1.51 \pm 0.34) \times 10^{-17}$	SDA 6.3	2nd
	$(1.02 \pm 0.33) \times 10^{-17}$	SDA 9.3	2nd
	$(1.91 \pm 0.43 \times 10^{-17}$	SDA 11.3	2nd
	$(1.36 \pm 0.34) \times 10^{-17}$	INT[d] 100.3	2nd
	$(8.04 \pm 2.40) \times 10^{-18}$	Howe[e]	2nd
	$(7.23 \pm 1.72) \times 10^{-18}$	400.3	3rd
	$(5.01 \pm 1.32) \times 10^{-18}$	SDA 1.3	3rd
	$(7.08 \pm 1.63) \times 10^{-18}$	SDA 2.3	3rd
	$(1.24 \pm 0.24) \times 10^{-17}$	SDA 4.2	3rd
	$(4.71 \pm 1.32) \times 10^{-18}$	SDA 4.3	3rd
	$(4.60 \pm 1.31) \times 10^{-18}$	SDA 6.3	3rd
	$(3.57 \pm 1.15) \times 10^{-18}$	SDA 11.3	3rd
	$(3.83 \pm 1.19) \times 10^{-18}$	Howe 400.3	4th
	$(4.28 \pm 1.28) \times 10^{-18}$	SDA 1.3	4th
	$(1.18 \pm 0.22) \times 10^{-17}$	SDA 2.3	4th
	$(7.61 \pm 1.70) \times 10^{-18}$	SDA 4.2	4th
	$(5.55 \pm 1.67) \times 10^{-18}$	SDA 4.3	4th
		INT 100.3	
Pu-238	$(8.66 \pm 2.78) \times 10^{-18}$	SDA 2.3	2nd
	$(4.36 \pm 1.31) \times 10^{-18}$	INT 100.3	3rd
Pu-239/240	$(1.26 \pm 0.30) \times 10^{-17}$	SDA 4.2	1st
	$(8.21 \pm 2.55) \times 10^{-18}$	SDA 1.3	2nd
	$(1.07 \pm 0.23) \times 10^{-17}$	SDA 4.2	3rd
	$(7.68 \pm 2.01) \times 10^{-18}$	SDA 6.3	3rd
	$(8.73 \pm 1.85) \times 10^{-18}$	SDA 4.2	4th
	$(9.59 \pm 2.07) \times 10^{-18}$	SDA 4.3	4th

a. Result ± 1s. Results shown are ≥ 3s.
b. Results from April 1, 2010, to June 15, 2010, of the second quarter are missing due to laboratory closure.
c. SDA = Subsurface Disposal Area.
d. INT = Idaho CERCLA Disposal Facility.
e. Howe = Control.


Rough-legged Hawk

northeast of the Subsurface Disposal Area and fugitive emissions from the Accelerated Retrieval Project. The soils outside RWMC are contaminated as a result of early burial practices (Markham et al. 1978). Recent studies of radionuclide concentrations in soils (VanHorn et al. 2011) 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 Subsurface Disposal Area. Measureable amounts of ^{238}Pu also have been reported in subsurface soils north of the Subsurface Disposal Area 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

40 CFR 61, Subpart H, 2010, "National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities," *Code of Federal Regulations*, Office of the Federal Register.

DOE Order 435.1, 2001, "Radioactive Waste Management," Change 1, U.S. Department of Energy.

DOE Order 450.1A, 2008, "Environmental Protection Program," U.S. Department of Energy.

DOE Order 5400.5, 1993, "Radiation Protection of the Public and the Environment," Change 2, U.S. Department of Energy.

DOE-ID, 2010, *Idaho National Laboratory Environmental Monitoring Plan*, DOE/ID-06-11088, Rev. 1, U.S. Department of Energy Idaho Operations Office.

DOE-ID, 2011, *National Emissions Standards for Hazardous Air Pollutants—Calendar Year 2010 INL Report for Radionuclides*, DOE/ID-10890(11), U.S. Department of Energy Idaho Operations Office.

EG&G Idaho, Inc., 1993, *New Production Reactor Exposure Pathways at the Idaho National Engineering Laboratory*, EGG-NPR-8957, Idaho National Engineering Laboratory.

Markham, O. D., K. W. Puphal, and T. D. Filer, 1978. "Plutonium and Americium Contamination Near a Transuranic Storage Area in Southeastern Idaho," *Journal of Environmental Quality*, Vol. 7, No. 3, July – September 1978.

VanHorn R. L., L. S. Cahn, V. M. Kimbro, K. J. Holdren, 2011, *Operable Unit 10-4 Long-Term Ecological Monitoring Report for Fiscal Years 2003 to 2008*, DOE/ID 11390, Rev. 0, U.S. Department of Energy Idaho Operations Office.

Katie Moore, ESER Program, collecting air sample

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

Chapter Highlights

Liquid effluents, drinking water, and surface water runoff were monitored in 2010 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 2010, 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 2010.

Additional liquid effluent monitoring was performed in 2010 at ATR Complex, CFA, INTEC, and MFC to comply with environmental protection objectives of the Department of Energy (DOE). All reported concentrations were consistent with historical data, with the exception of two results for conductivity at INTEC. All parameters were below applicable health-based standards.

Thirteen drinking water systems were monitored in 2010 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 0.27 mrem for 2010. This is below the Environmental Protection Agency (EPA) 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 2010 for radionuclides in compliance with DOE limits. Most results were within historical measurements. Exceptions were americium-241 and plutonium-239/240, although these were below DOE derived concentration guides and EPA maximum contaminant levels, as well as slightly less than those detected in 2009. In addition, plutonium-238 was detected in three 2010 samples. However, these detections may be questionable because of false positive results during performance evaluation laboratory testing. Surface water runoff will be monitored closely during 2011 to identify any abnormal trends.

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.

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 water 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.


Rough-legged Hawk

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

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.

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

Site facilities that have wastewater reuse permits. Table 5-2 lists the status of each wastewater reuse-permitted facility as of December 2010.

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 constituent standards (IDAPA 58.01.11). The permits specify annual discharge volumes, application rates and effluent quality limits. Annual reports (ICP 2011a, 2011b; INL 2010a, 2010b, 2010c) were prepared and submitted to the state of Idaho Department of Environmental Quality (DEQ) as required for permitted facilities.

During 2010, 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

Table 5-2. Status of Wastewater Reuse Permits.

Facility	Permit Status at End of 2010	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-000141-02 on January 26, 2005, modified on October 19, 2005, and will expire on January 25, 2010.
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

- 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 Orders 450.1A and 5400.5. 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 2010 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-hectare (0.5-acre) lined, polishing pond to approximately 30 hectares (74 acres) of sagebrush steppe grassland through a computerized center pivot irrigation system. The permit limits wastewater application to 23 acre-in./acre/yr from April 1 through October 31.

Wastewater Monitoring Results for the Wastewater Reuse Permit – DEQ issued a new permit for the CFA Sewage Treatment Plant on March 17, 2010. The new permit requires effluent monitoring and soil sampling in the wastewater reuse area (see Chapter 7 for results pertaining to soils). The new permit does not require influent monitoring. In 2010, influent samples were collected monthly from the lift station at CFA (January-March), and effluent samples were collected from the pump pit (prior to the pivot irrigation system) in August. All samples were collected as 24-hour flow proportional composites, except pH and coliform samples, which were collected as grab samples. Tables C-1 and C-2 summarize the results.

Wastewater was intermittently applied via the center pivot irrigation system in August 2010. On the days it operated, discharge to the pivot irrigation system averaged 713,346 L/day (156,914 gallons/day).

A total of 2.20 million gallons (MG) of wastewater was applied to the land in 2010, which is equivalent to a loading rate of 1.1 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 (1.18 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 (11.92 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 (0.22 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 receives a combination of process water from various facilities at the ATR Complex. 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 2010, 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-3.

Concentrations of sulfate and total dissolved solids are higher during reactor operation because of evaporative concentration and additives used to control corrosion and the pH of 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 (Table C-4).

Table 5-3. Total Nitrogen and Total Suspended Solids Effluent Monitoring Results at Advanced Test Reactor Complex Cold Waste Pond (2010).

Parameter	Minimum	Maximum	Median	Permit Limit
Total nitrogen[a] (mg/L)	1.051	4.081	2.375	20
Total suspended solids (mg/L)	4 U[b]	6.8	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.

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 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 stormwater. 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-5 and C-6, 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 2010, 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-7.

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 2010.

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 5-1):

- One background aquifer well (ICPP-MON-A-167) upgradient of the INTEC New Percolation Ponds

Table 5-4. Total Nitrogen and Total Suspended Solids Effluent Monitoring Results at CPP-797 (2010).[a]

Parameter	Minimum	Maximum	Average[b]	Permit Limit
Total nitrogen[c] (mg/L)	2.82	6.39	4.27	20
Total suspended solids (mg/L)	2.0[d]	2.0[d]	2.0[e]	100

a. Duplicate samples were collected in February for nitrogen. 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.

e. 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.

Table 5-5. Hydraulic Loading Rates for Idaho Nuclear Technology and Engineering Center New Percolation Ponds (2010).

	2010 Flow	Permit Limit
Maximum daily (MG)	1.849	3
Yearly total (MG)	204.088	1,095

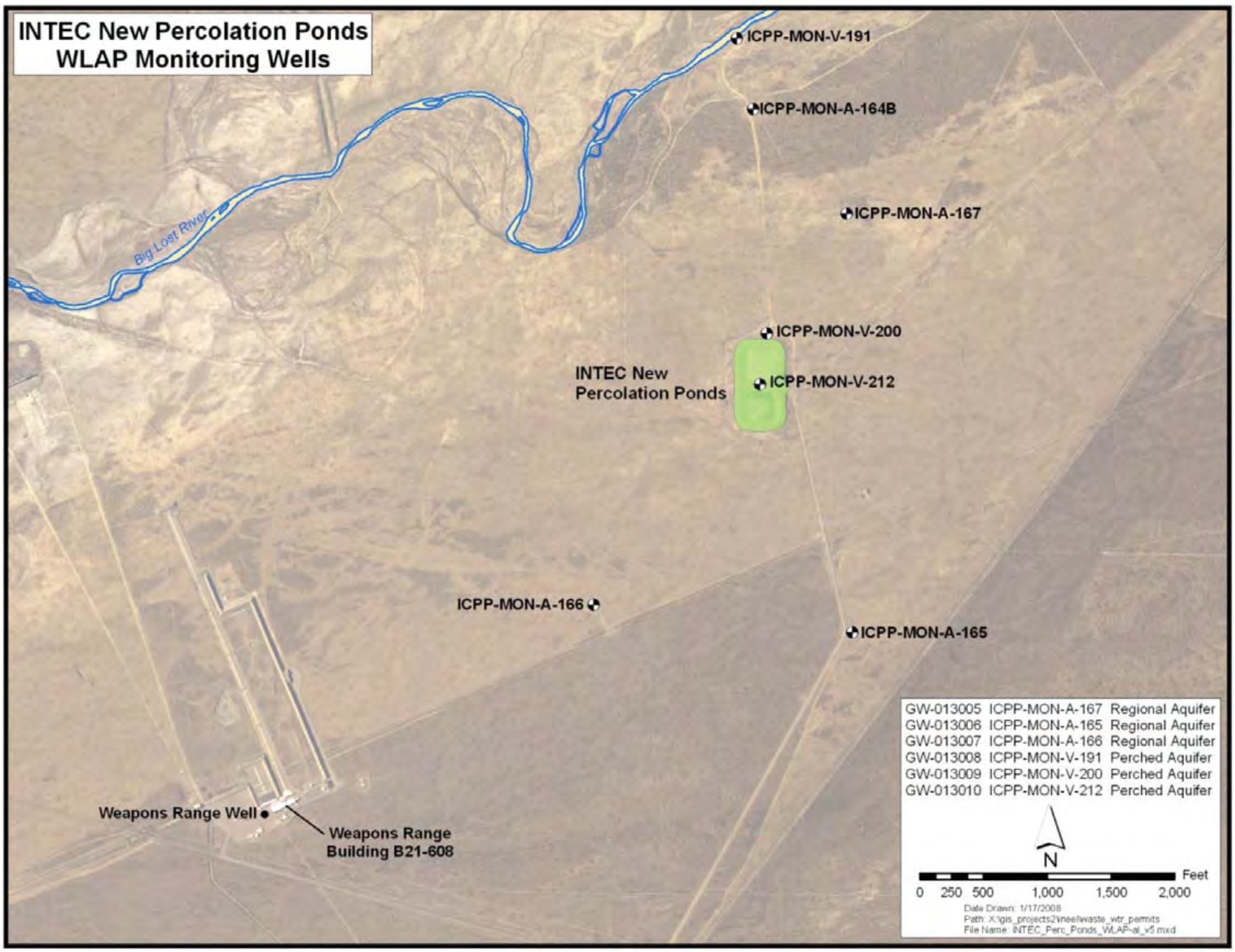


Figure 5-1. Permitted Monitoring Locations Southwest of the Idaho Nuclear Technology and Engineering Center *(Well ICPP-MON-A-164B and the Weapons Range Well are not permitted wells and are shown for location reference only*).

- 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-8 shows the 2010 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-9 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 2010 reporting year for all wells associated with the INTEC New Percolation Ponds. Additional information concerning groundwater concentrations for aluminum, iron, manganese, total dissolved solids, chloride, and pH is provided in the following paragraphs.

Samples were collected from upgradient aquifer Well ICPP-MON-A-167 during the April 2010 sampling event. During the October 2010 sampling event, the well only had 0.47 ft of water in it. The well was considered dry, and therefore, no samples were collected. The ICP contractor will continue to monitor Well ICPP-MON-A-167 as required (every April and October). If an adequate volume of water is present, then the well will be sampled, along with Well ICPP-MON-A-164B as an additional upgradient aquifer monitoring well (Figure 5-1). Because of the inability to obtain samples from Well ICPP-MON-A-167, the permit renewal application proposed replacing that well with Well ICPP-MON-A-164B (ICP 2009). Results of samples collected from Well ICPP-MON-A-164B in April 2010 and October 2010 are provided in Table C-8.

Perched water Well ICPP-MON-V-191 was dry during the April and October 2010 sampling events. The water level in this well is influenced by the presence or absence of flow in the Big Lost River. From June 9, 2010, until June 14, 2010, 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 June 16, 2010. This was only the third time this well has been sampled since the New Percolation Ponds began operating in August 2002.

Rough-legged Hawk

Groundwater Aluminum, Iron, and Manganese Concentrations – Concentrations of aluminum, iron, and manganese in aquifer Wells ICPP-MON-A-165, ICPP-MON-A-166, and ICPP-MON-A-164B were below their associated secondary constituent standards, as shown in Table C-8. Concentrations of aluminum, iron, and manganese exceeded the secondary constituent standards and the preoperational concentrations (Table 5-6) in aquifer Well ICPP-MON-A-167 in April 2010. There was not enough water in this well to sample during the October 2010 sampling event. Aquifer Well ICPP-MON-A-167 is an upgradient, noncompliance point and is outside the zone of influence of the New Percolation Ponds. Therefore, these exceedances are not considered permit noncompliances.

Concentrations of aluminum, iron, and manganese in perched water Well ICPP-MON-V-200 were below their associated secondary constituent standards, and concentrations of aluminum and manganese in Well ICPP-MON-V-212 were below their associated secondary constituent standards, as shown in Table C-9. The iron concentration in Well ICPP-MON-V-212 exceeded the associated secondary constituent standard in October 2010. As required by the permit, DEQ was notified of this groundwater noncompliance (Hutchison 2010).

Upgradient perched water Well ICPP-MON-V-191 was dry in April and October 2010, and samples could not be collected. However, Well ICPP-MON-V-191 was sampled in June 2010, and the concentrations of aluminum, iron, and manganese exceeded the associated secondary constituent standards (Table C-9). Perched water Well ICPP-MON-V-191 is an upgradient, noncompliance point, and is outside the zone of influence of the New Percolation Ponds. Therefore, these exceedances are not considered permit noncompliances.

In 2010, concentrations of aluminum, iron, and manganese in all filtered samples from Wells ICPP-MON-A-165, ICPP-MON-A-166, ICPP-MON-A-167, ICPP-MON-A-164B, ICPP-MON-V-200, and ICPP-MON-V-212 were below the associated secondary constituent standards, 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).

Table 5-6. Preoperational Concentrations and Secondary Constituent Standards.[a]

	Nov. 2001	Jan. 2001	Feb. 2001	March 2001	May 2001	SCS
Aluminum (mg/L)	32.8	27.2	17.7	23.7	14.9	0.2
Iron (mg/L)	19.2	16.6	10.2	14.2	10.4	0.3
Manganese (mg/L)	0.355	0.3	0.218	0.205	0.165	0.05

a. Preoperational concentrations from INEEL (2004); secondary constituent standards from Idaho Administrative Procedures Act 58.01.11.

Groundwater Total Dissolved Solids and Chloride Concentrations – Total dissolved solids concentrations in perched water Well ICPP-MON-V-200 were below the secondary constituent standard (500 mg/L) in 2010. Chloride concentrations also were below the secondary constituent standard (250 mg/L) in perched water wells ICPP-MON-V-200 and ICPP-MON-V-212. Total dissolved solids and chloride concentrations in the downgradient aquifer monitoring wells ICPP-MON-A-165 and ICPP-MON-A-166 were similar to, or less than, the 2009 concentrations. The October 2010 total dissolved solids result (515 mg/L) exceeded the secondary constituent standard in perched water Well ICPP-MON-V-212. As required by the permit, DEQ was notified of this groundwater noncompliance (Hutchison 2010). This is the first time a total dissolved solids exceedance has occurred in the perched water at the New Percolation Ponds since the INTEC Treated Water System Upgrade project was completed in December 2007. To reduce salt usage and maintain treated water quality at INTEC, the ICP contractor began using a phosphate-based anti-foulant product in September 2010. This change in operation is expected to reduce the total dissolved solids and chloride concentrations in the perched water in 2011.

Perched Water Well ICPP-MON-V-212 pH Results – Because of pH exceedances in perched water Well ICPP-MON-V-212 during 2009, pH was measured in April, June, July, and October 2010. All four pH results were within the secondary constituent standard of 6.5 to 8.5. An investigation into the cause of the pH increase in Well ICPP-MON-V-212 concluded that the source of the pH increase was not attributable to INTEC wastewater discharges but was related to well construction issues. Downhole video logs of the well taken in April 2007 and January 2010 were reviewed. The videos showed that the gaps at the PVC pipe joints were allowing high pH water from the seal material (calcium-hydroxide solution) to enter the well at multiple depths along the PVC riser pipe. A meeting was held with DEQ in March 2010 to discuss the results of the investigation and determine a path forward for Well ICPP-MON-V-212. The ICP contractor proposed to discontinue monitoring the well because it no longer provides useful data and comparable perched water data could be obtained from perched water Well ICPP-MON-V-200. The ICP contractor is awaiting DEQ's concurrence with the proposed action.

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 million gallons at a maximum water depth of 13 feet.

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.

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 5-7 and 5-8. During 2010, 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-10 and C-11.

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. The analytical results are summarized in Table C-12. Analyte concentrations in the downgradient wells were essentially indistinguishable from background levels in the upgradient well.

Table 5-7. Total Nitrogen and Total Suspended Solids Effluent Monitoring Results at MFC Industrial Waste Pipeline (May-December 2010).

Parameter	Minimum	Maximum	Median	Permit Limit
Total nitrogen[a] (mg/L)	2.165	3.12	2.515	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.

Table 5-8. Total Nitrogen and Total Suspended Solids Effluent Monitoring Results at MFC Industrial Waste Water Underground Pipe (May-December 2010).

Parameter	May 25, 2010	July 28, 2010	December 15, 2010	Permit Limit
Total nitrogen[a] (mg/L)	5.531	13.52	4.902	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.

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 5400.5.

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-13 lists wastewater surveillance monitoring results for those parameters with at least one detected result. Groundwater monitoring results are summarized in Table C-14. 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 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-15 lists surveillance monitoring results for 2010 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-16 summarizes the additional monitoring conducted during 2010 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 2010, 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 six wells (aquifer Wells ICPP-MON-A-164B, ICPP-MON-A-165, ICPP-MON-A-166, and ICPP-MON-A-167, and perched water Wells ICPP-MON-V-200 and ICPP-MON-V-212) near the INTEC New Percolation Ponds in April and October 2010. No samples were taken from ICPP-MON-A-167 in October 2010 because the well was dry. These samples were collected to satisfy the surveillance objectives of DOE Order 450.1A. Table C-16 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 six monitoring wells.

5.3.4 Materials and Fuels Complex

For the first four months of 2010, the Industrial Waste Pond was sampled monthly for iron, sodium, chloride, fluoride, sulfate, total dissolved solids, total suspended solids, gross alpha, gross beta, gamma spectrometry, tritium, and various other parameters. Based on historical information and data needs, sampling at the pond was reduced to quarterly sampling for radionuclides. Table C-17 summarizes the results for analytes detected in at least one sample.

Surveillance monitoring for radionuclides and other analytes was performed on samples collected from the Industrial Waste Pipeline, or Industrial Waste Ditch, in January through April 2010. In May 2010, the analyte list was updated to comply with the wastewater reuse permit (Section 5.2.5). The results of the surveillance monitoring are summarized in Table C-18.

From January to April 2010, the Secondary Sanitary Lagoon was sampled monthly for iron, sodium, chloride, fluoride, sulfate, biochemical oxygen demand, total dissolved solids, total suspended solids, gross alpha, gross beta, gamma spectrometry, and tritium. In May 2010, the sampling schedule was condensed to quarterly sampling for radionuclides and annual sampling for selected metals, nutrients, and various other parameters. Table C-19 summarizes the analytical results for parameters that were detected in at least one sample.

Radioactive parameters were monitored and reported when detected. The low activity of cesium-137 reported in the sample collected from the Industrial Waste Pond in April 2010 is probably a false positive as the radionuclide was not detected in any of the six other samples collected from the pond.

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 maximum contaminant levels must be monitored at least once every three years. Parameters with secondary maximum contaminant levels are monitored every three 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 (CFR) Parts 141 – 143. State regulations also require that analytical laboratories be certified by the state or by another state whose certification is recognized by Idaho. DEQ oversees the certification program and maintains a list of approved laboratories.

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 2010. In February 2010, the Main Gate Badging Facility Water System had a non-compliance (construction) sample that was positive for total coliform bacteria. After disinfecting, flushing, and re-sampling, it showed no bacteria, and the water system was put back into service. Since February 2010, no bacteria have been detected. 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 2010, the INL contractor collected 224 routine samples and 21 quality control samples from the nine INL Site drinking water systems. In addition to routine samples, the INL contractor also collected 20 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 nitrate, and all results were less than half the maximum contaminant level of 10.00 mg/L.

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 5-2) because of changes in disposal techniques, diffusion, dispersion, recharge conditions, and radioactive decay.

The mean tritium concentration is being tracked using three sampling locations within the CFA water distribution system. Prior to 2007, compliance samples were collected once per year from Well CFA #1 at CFA-651, once per year from Well CFA #2 at CFA-642, and quarterly from the distribution manifold at CFA-1603. All of the 2006 results were below the maximum contaminant level for tritium. Thus in 2007, the INL contractor decreased the tritium sampling frequency to semiannually and decreased the number of sampling locations to one location (CFA-1603 [manifold]).

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 2010 calculation was based on the mean tritium concentration for the CFA distribution system in 2010. For the 2010 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 2010 was 0.27 mrem (2.7 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 2010, the following drinking water samples were collected at INTEC:

- 29 routine (compliance) samples
- Two quality control samples (one field duplicate and one performance evaluation sample)
- 75 nonroutine samples (75 bacterial construction/special samples).

All parameters monitored at INTEC were below their respective drinking water limits in 2010.

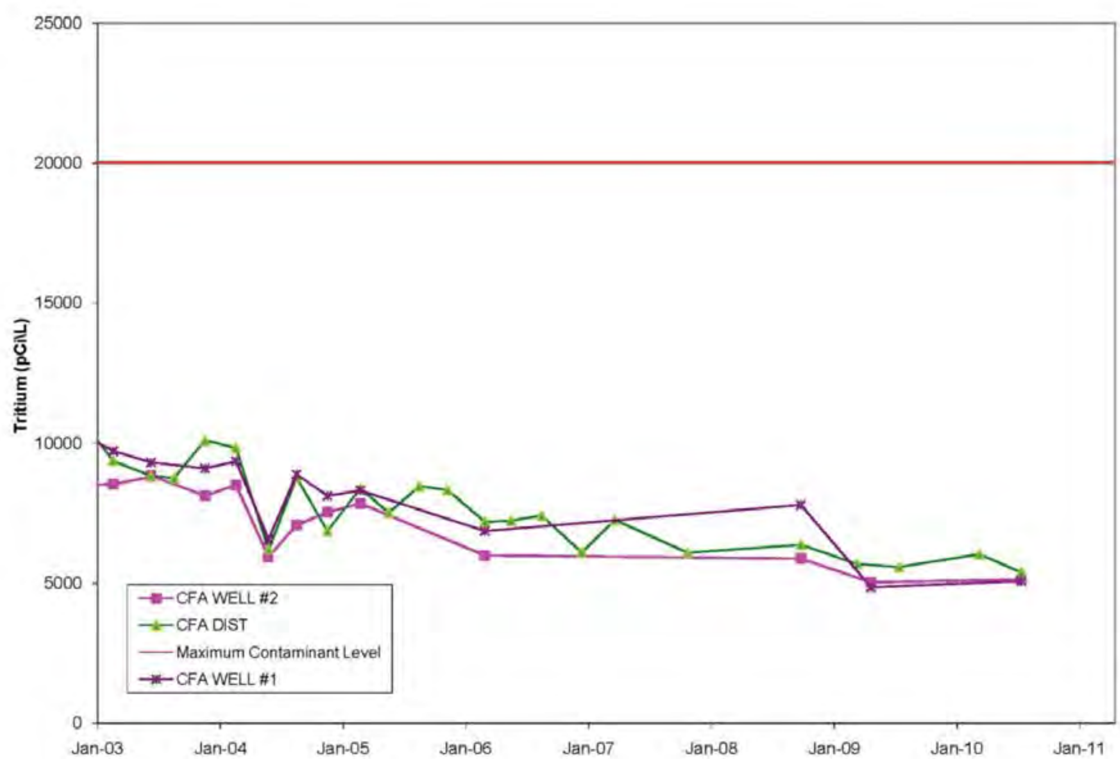


Figure 5-2. Tritium Concentrations in Two Central Facilities Area Wells and Distribution System (2003 – 2010).

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 2010, the following drinking water samples were collected at RWMC:

- 10 routine (compliance) samples
- 18 quality control samples (nine field duplicates, four trip blanks, five performance evaluation samples)
- 42 nonroutine samples (34 bacterial construction/special samples; eight samples for 524.2 volatile organics).

Historically, carbon tetrachloride had been detected in samples collected at the WMF-603 Production Well (Figure 5-3). In July 2007, a packed tower air stripping treatment system was placed into operation to treat the water. During 2010, 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 2010.

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 5-4 illustrates the trichloroethylene concentrations in both Well TSF #2 and the distribution system from 2001 through 2010. Table 5-9 summarizes the trichloroethylene concentrations at TSF #2 and the distribution system. The mean concentration at the distribution system for 2010 was less than the reporting limit of 0.5 µg/L.

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 5-5. Near the end of 2009, a lift station was installed, and the sampling point is now at the lift station. Surface

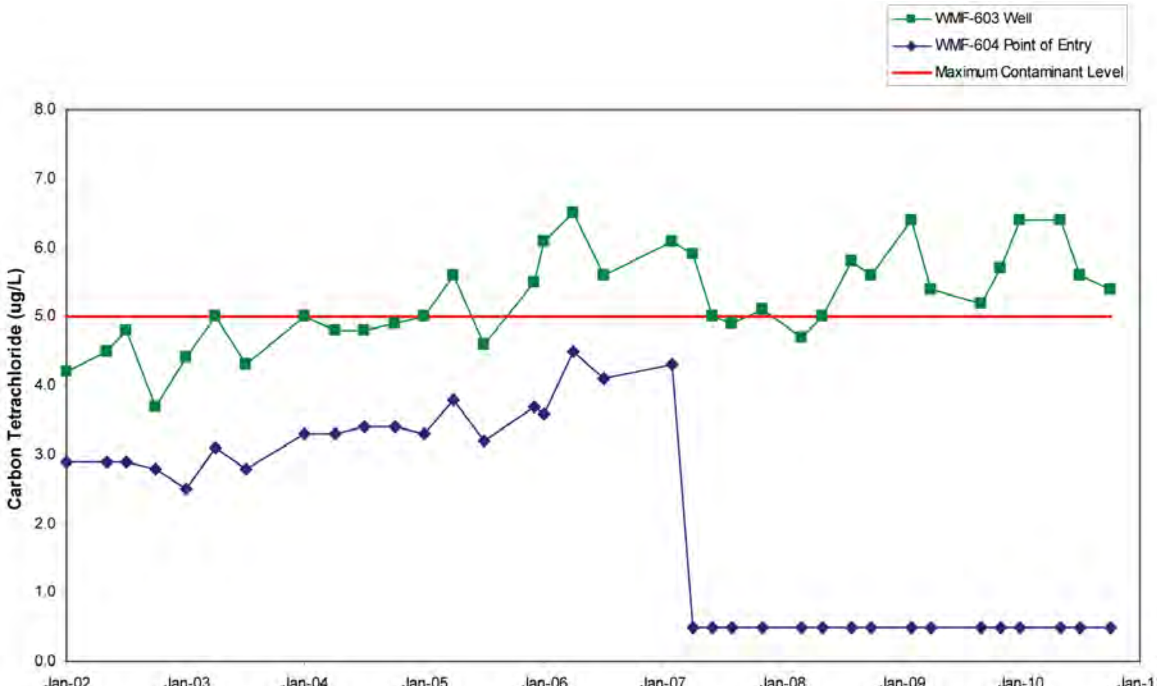


Figure 5-3. Carbon Tetrachloride Concentrations in RWMC WMF-603 Production Well and WMF-604 Point of Entry into the Distribution System (2002 – 2010).

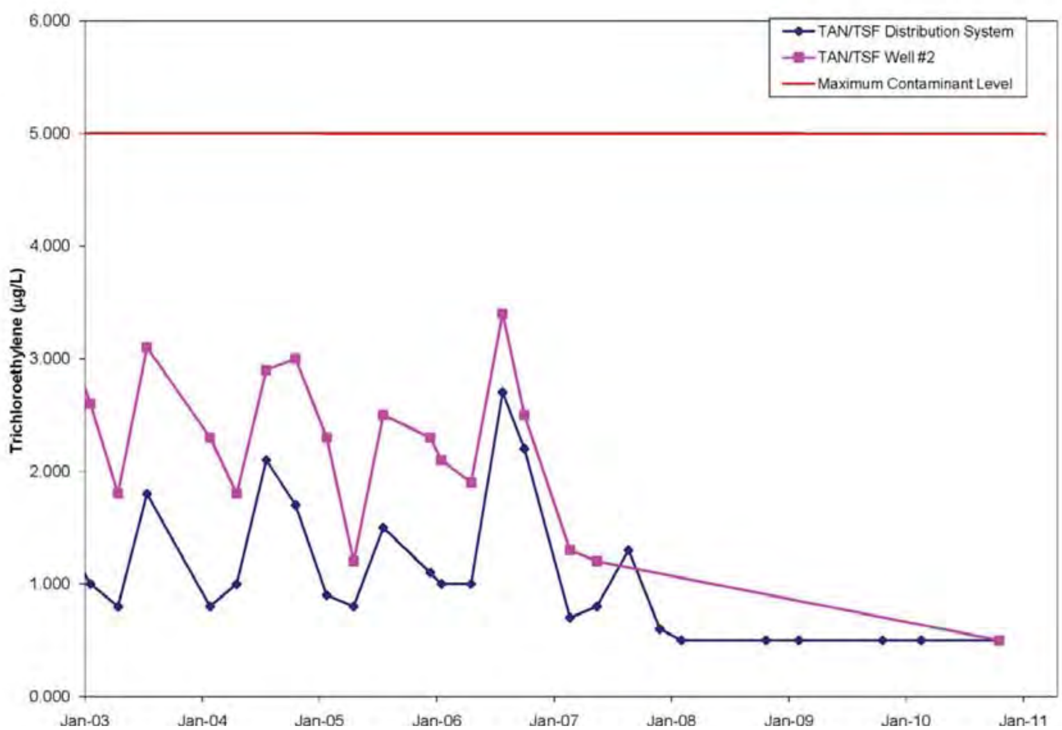


Figure 5-4. Trichloroethylene Concentrations in Technical Support Facility Drinking Water Well and Distribution System (2003 – 2010).

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 (when available) instead of quarterly during 2010 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.

Surface water runoff samples were unavailable for collection due to weather during January and February. Two sets of samples were collected in March. On July 1, 2010, the analytical laboratory (Centauri Labs, Montgomery, Alabama) closed without notifying the ICP contractor. Consequently, samples collected in April, May, and June were not analyzed or reported. Subsequently, a new laboratory (ALS Laboratory Group, Fort Collins, Colorado) was contracted to analyze and report environmental surveillance samples.

Samples were collected from August through November and sent to ALS Laboratory Group for analysis. Table 5-10 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 slightly less than those detected during 2009 and are well below the applicable derived concentration guides and maximum contaminant levels. Three positive plutonium-238 (^{238}Pu) detections near the minimum detectable activity occurred during 2010, one in the first, one in the third, and one in the fourth quarter. Plutonium-238 is not typically detected at the SDA. Based on false positive ^{238}Pu results in performance evaluation laboratory samples, these ^{238}Pu detections may be questionable. The ICP contractor will closely monitor during 2011, when water is available, and evaluate the results to identify any abnormal trends or the need to change sampling frequency.

Table 5-9. Trichloroethylene Concentrations at Test Area North/Technical Support Facility Well #2 and Distribution System (2010).

		Trichloroethylene Concentration (µg/L)			
Location	Number of samples	Minimum	Maximum	Mean	MCL
TAN/TSF #2 (612)[a]	1	<0.5	<0.5	<0.5	NA[b]
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. NA = Not applicable. Maximum contaminant level applies to the distribution system only.

Table 5-10. Radionuclides Detected in Surface Water Runoff at the RWMC Subsurface Disposal Area (2010).

Parameter	Maximum Concentration[a] (pCi/L)	% Derived Concentration Guide
Americium-241	3.14 ± 0.54	10.47
Plutonium-238	0.04 ± 0.07	0.1
Plutonium-239/240	1.99 ± 0.017	6.6
Strontium-90	1.73 ± 0.246	0.17

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

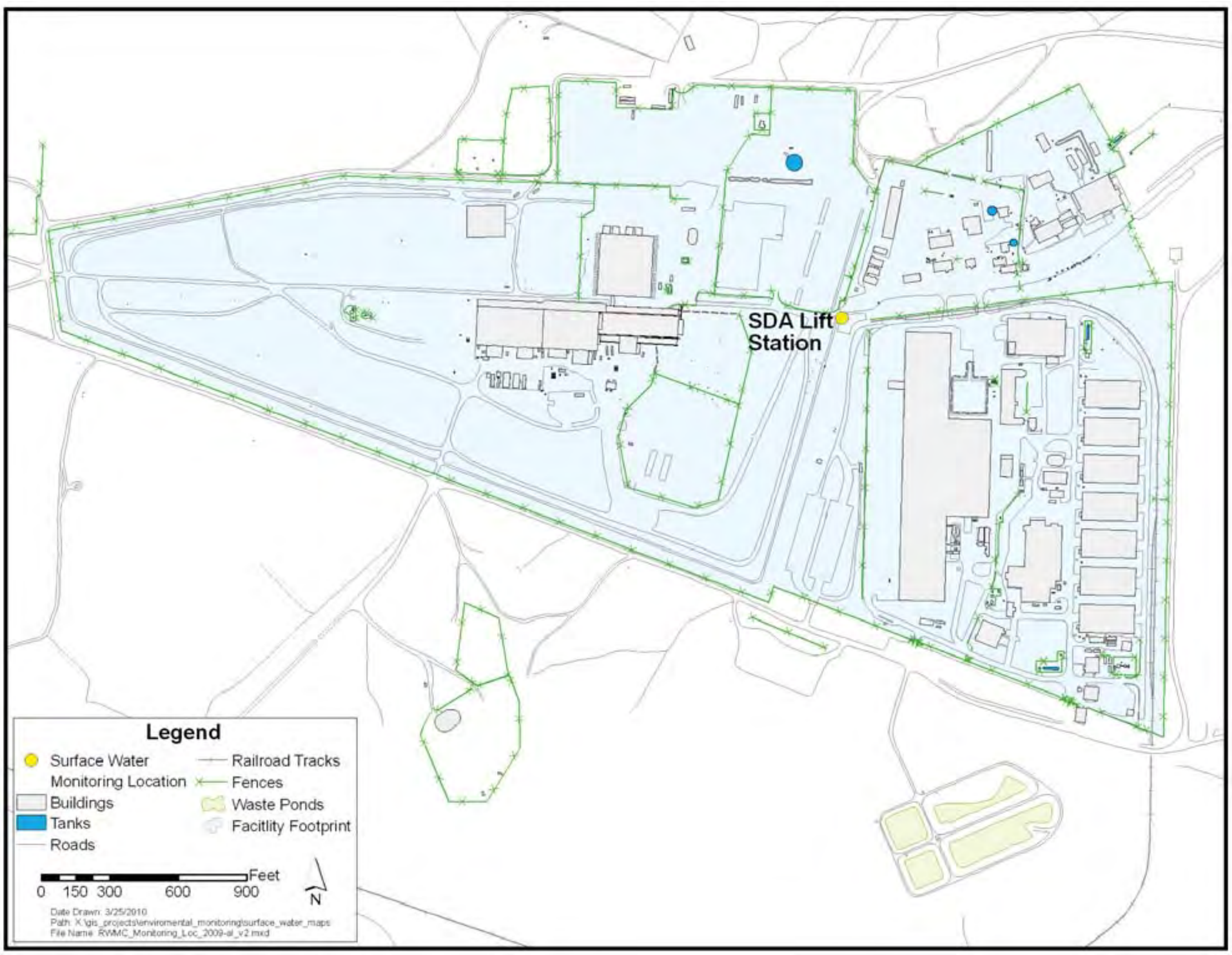


Figure 5-5. Surface Water Sampling Location at RWMC Subsurface Disposal Area.

REFERENCES

40 CFR 141, 2010, "National Primary Drinking Water Regulations," *Code of Federal Regulations*, Office of the Federal Register.

40 CFR 142, 2010, "National Primary Drinking Water Regulations Implementation," *Code of Federal Regulations*, Office of the Federal Register.

40 CFR 143, 2010, "National Secondary Drinking Water Regulations," *Code of Federal Regulations*, Office of the Federal Register.

CES, 1993, *Soil Suitability Investigation for Land Application of Waste Water, Central Facility Area, Idaho National Engineering Laboratory*, Cascade Earth Science.

DOE Order 435.1, 2001, "Radioactive Waste Management," Change 1, U.S. Department of Energy.

DOE Order 450.1A, 2008, "Environmental Protection Program," U.S. Department of Energy.

DOE Order 5400.5, 1993, "Radiation Protection of the Public and the Environment," Change 2, U.S. Department of Energy.

DOE-ID, 2010, *Idaho National Laboratory Environmental Monitoring Plan*, DOE/ID-10-11088, Rev. 2, U.S. Department of Energy Idaho Operations Office.

Hutchison, David P., CH2M-WG Idaho, LLC, to Thomas Rackow, Idaho Department of Environmental Quality, December 21, 2010, "November 2010 State Water Self-Disclosure Log," CCN 311226.

ICP, 2009, *Renewal Application for Wastewater Reuse Permit for the Idaho Nuclear Technology an Engineering Center New Percolation Ponds*, RPT-585, Idaho Cleanup Project.

ICP, 2011a, *2010 Wastewater Land Application Site Performance Report for the Idaho Nuclear Technology and Engineering Center New Percolation Ponds (LA-000130-04)*, RPT-769, Idaho Cleanup Project.

ICP, 2011b, *2010 Radiological Monitoring Results Associated with the Idaho Nuclear Technology and Engineering Center New Percolation Ponds*, RPT-770, Idaho Cleanup Project.

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 58.01.16, 2010, "Wastewater Rules," Idaho Administrative Procedures Act, Idaho Department of Environmental Quality.

IDAPA 58.01.17, 2010, "Rules for the Reclamation and Reuse of Municipal and Industrial Waste water," Idaho Administrative Procedures Act, Idaho Department of Environmental Quality.

Rough-legged Hawk

INEEL, 2004, *2003 Wastewater Land Application Site Performance Reports for the Idaho National Engineering and Environmental Laboratory (LA-000130-04)*, ICP/EXT-03-00009, Idaho National Engineering and Environmental Laboratory.

INL, 2010a, *2009 Wastewater Land Application Site Performance Report for the Idaho National Laboratory Site's Central Facilities Area Sewage Treatment Plant*, INL/EXT-10-17549, Idaho National Laboratory.

INL, 2010b, *2009 Annual Industrial Wastewater Reuse Report for the Idaho National Laboratory Site's Advanced Test Reactor Complex Cold Waste Pond*, INL/EXT-10-17575, Idaho National Laboratory.

INL, 2010c, *2009 Radiological Monitoring Results Associated with the Advanced Test Reactor Complex Cold Waste Pond*, INL/EXT-10-17611, Idaho National Laboratory.

Big Lost River
Idaho National Laboratory Site

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

Chapter 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 2010 in one well monitored by the USGS, and concentrations have increased with time in that well. Concentrations of six other purgeable organic compounds that were detected were below maximum contaminant levels and state of Idaho groundwater primary and secondary constituent standards for these constituents. Concentrations of chloride, nitrate, sodium, and sulfate were below the applicable standards in 2008, and results for 2010 were not evaluated. The chromium result in one well that had concentrations above the maximum contaminant level in the past was below the maximum contaminant level in 2010.

Groundwater surveillance monitoring required in area-specific Records of Decision under the Comprehensive Environmental Response, Compensation, and Liability Act was performed in 2010.

At Test Area North, 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 2010 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 eight well locations sampled. Technetium-99 and nitrate also exceeded the maximum contaminant level in at least one well but show stable or declining trends.

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. Aluminum was detected above the secondary maximum contaminant level in one landfill well, and was probably due to interaction of groundwater with grout placed below the well. Four 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. The nitrate concentration in one well exceeded its maximum contaminant level in 2010, and the concentration was within historic levels.

At the Radioactive Waste Management Complex, nearly 3,400 analyses were performed in 2010 for radionuclides, inorganic constituents, volatile organic compounds, and 1,4-dioxane for samples collected from 14 monitoring wells. Carbon tetrachloride slightly exceeded the maximum contaminant level in two wells north of the RWMC, but has shown a stable or declining trend.

Drinking water and springs were sampled downgradient 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 in 2010 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 sampling of the Eastern Snake River Plain Aquifer (SRPA) 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 health-based maximum contaminant levels (MCLs) for drinking water (40 CFR 141)
- U.S. Department of Energy (DOE) Derived Concentration Guide for ingestion of water (DOE Order 5400.5).

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 results of monitoring by the Environmental Surveillance, Education, and Research (ESER) contractor of surface water and offsite drinking water.

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 2010, 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.

As detailed in Chapter 3, Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) activities at the INL Site are divided into ten 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 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 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

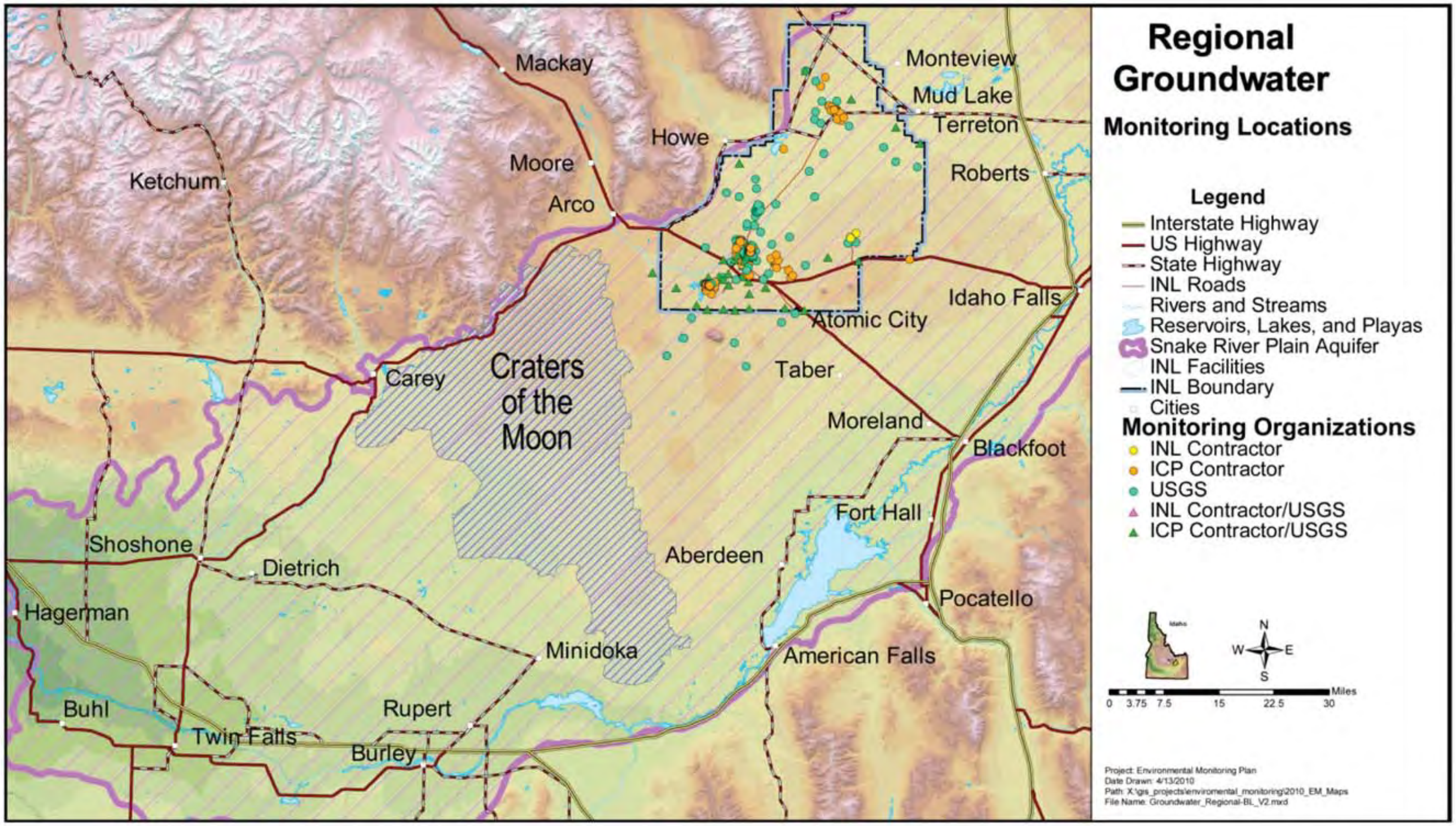


Figure 6-1. Regional Groundwater Monitoring Locations.

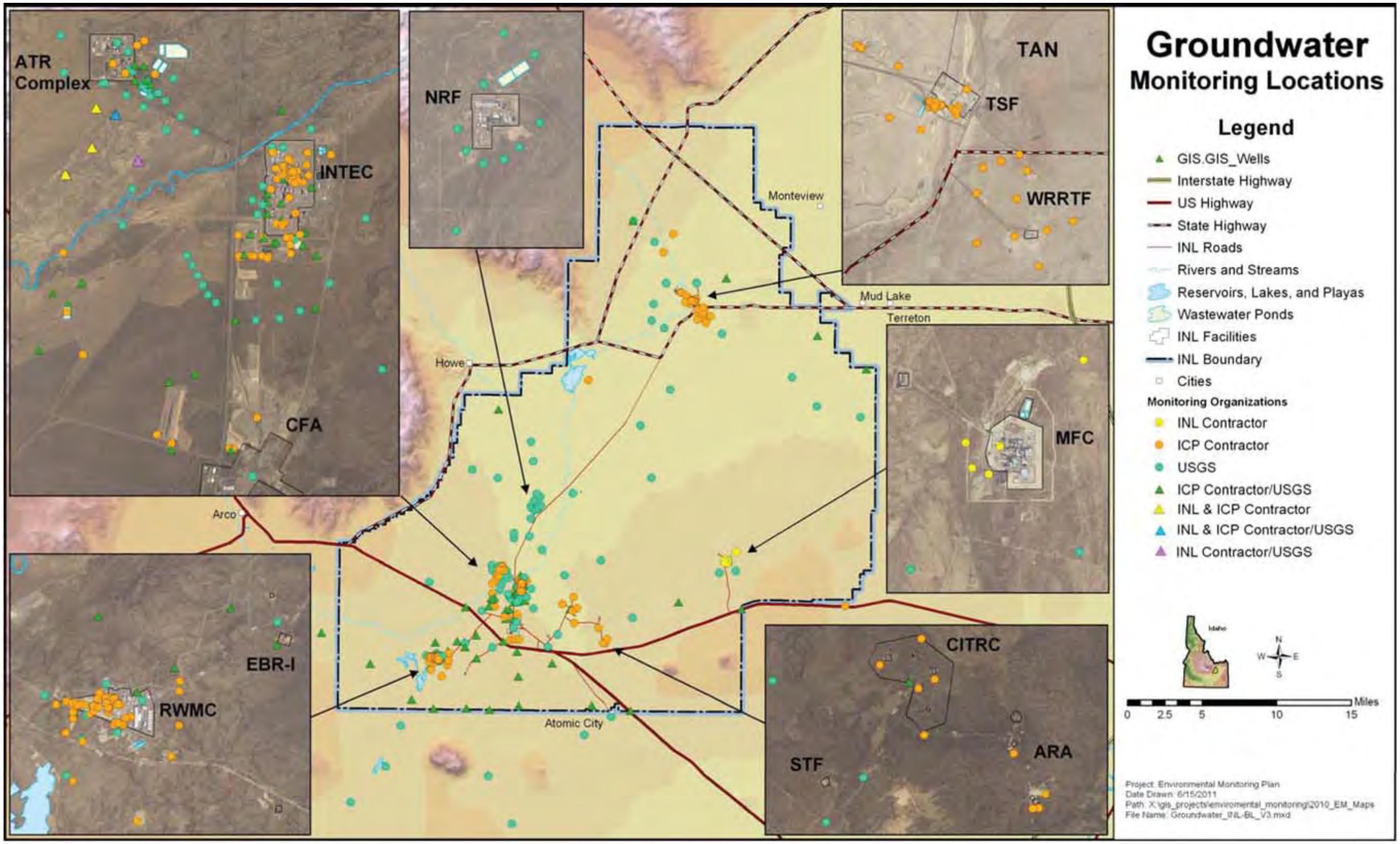


Figure 6-2. Idaho National Laboratory Site Groundwater Monitoring Locations.

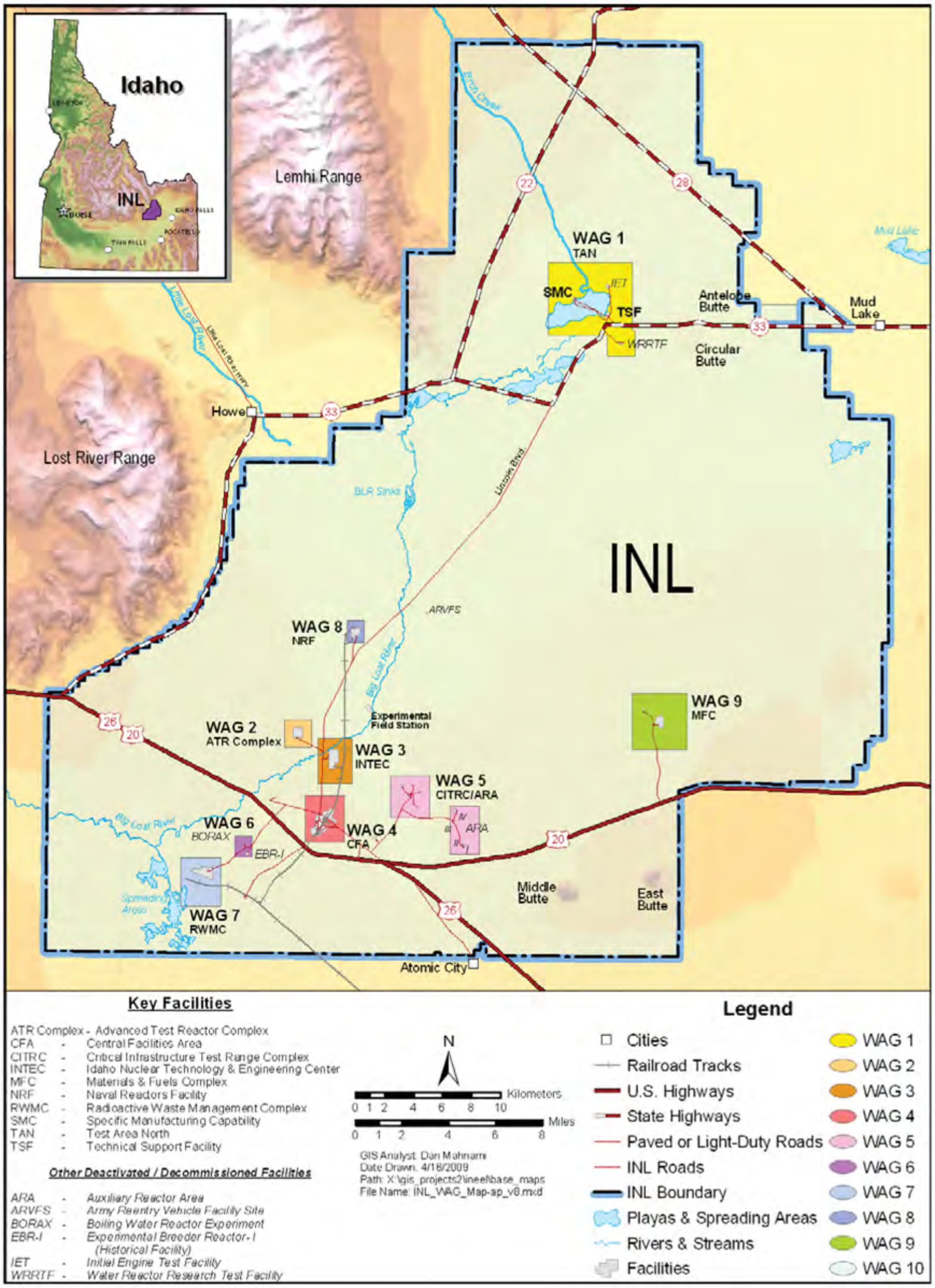


Figure 6-3. Map of the Idaho National Laboratory Site Showing Locations of Facilities and Corresponding Waste Area Groups.


Rough-legged Hawk

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

	Monitoring Activity				
Area/Facility	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.

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 INL 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.

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/publication.html or requested from the USGS INL Project Office by calling

Rough-legged Hawk

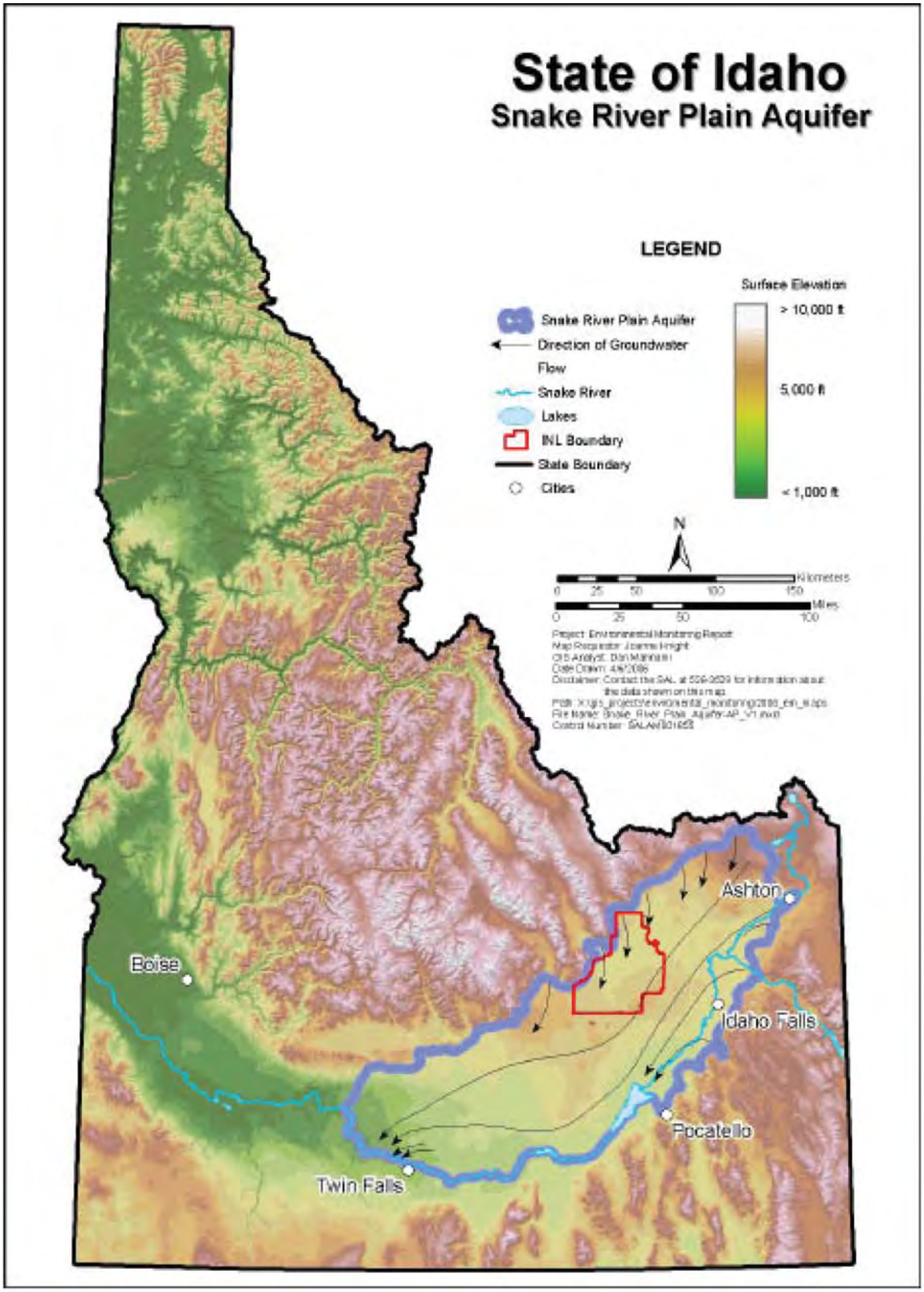


Figure 6-4. Location of the Idaho National Laboratory Site in Relation to the Eastern Snake River Plain Aquifer.

(208) 526-2438. During 2010, USGS INL Project Office personnel published six 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 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, which should stop the input of radioactive wastewater to 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).

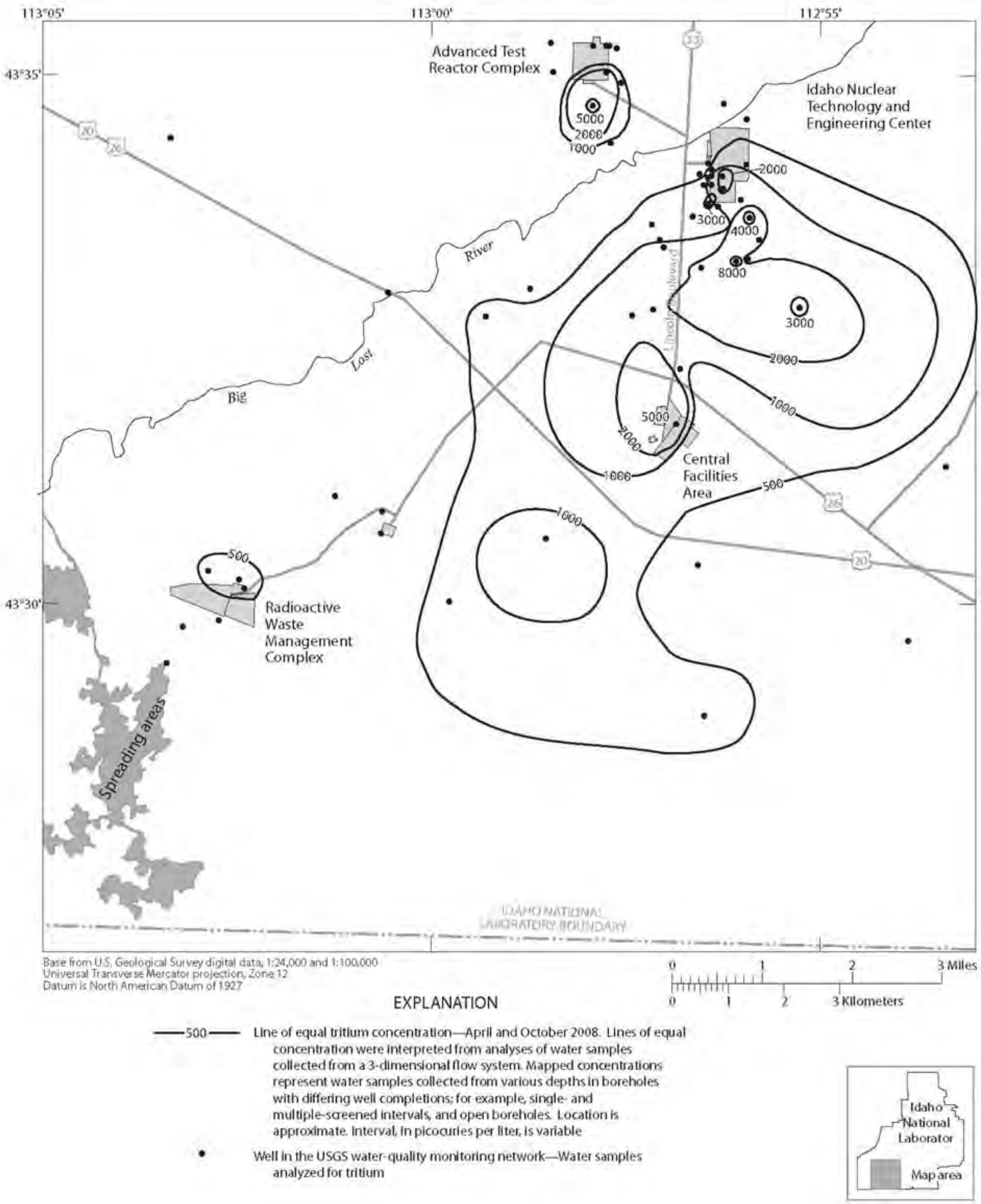


Figure 6-5. Distribution of Tritium in the eastern Snake River Plain Aquifer on the Idaho National Laboratory Site in 2008 (from Davis 2010).

The area of elevated tritium concentrations near CFA likely represents water originating at INTEC some years earlier when larger amounts of tritium were disposed of. 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 5,560 pCi/L in 2009 to 5,190 pCi/L in 2010; the tritium concentration in USGS-077 south of INTEC decreased from 5,480 pCi/L in 2009 to 4,290 pCi/L in 2010.

The Idaho primary constituent standard for tritium (20,000 pCi/L) in groundwater is the same as the Environmental Protection Agency MCL for tritium in drinking water. The values in both

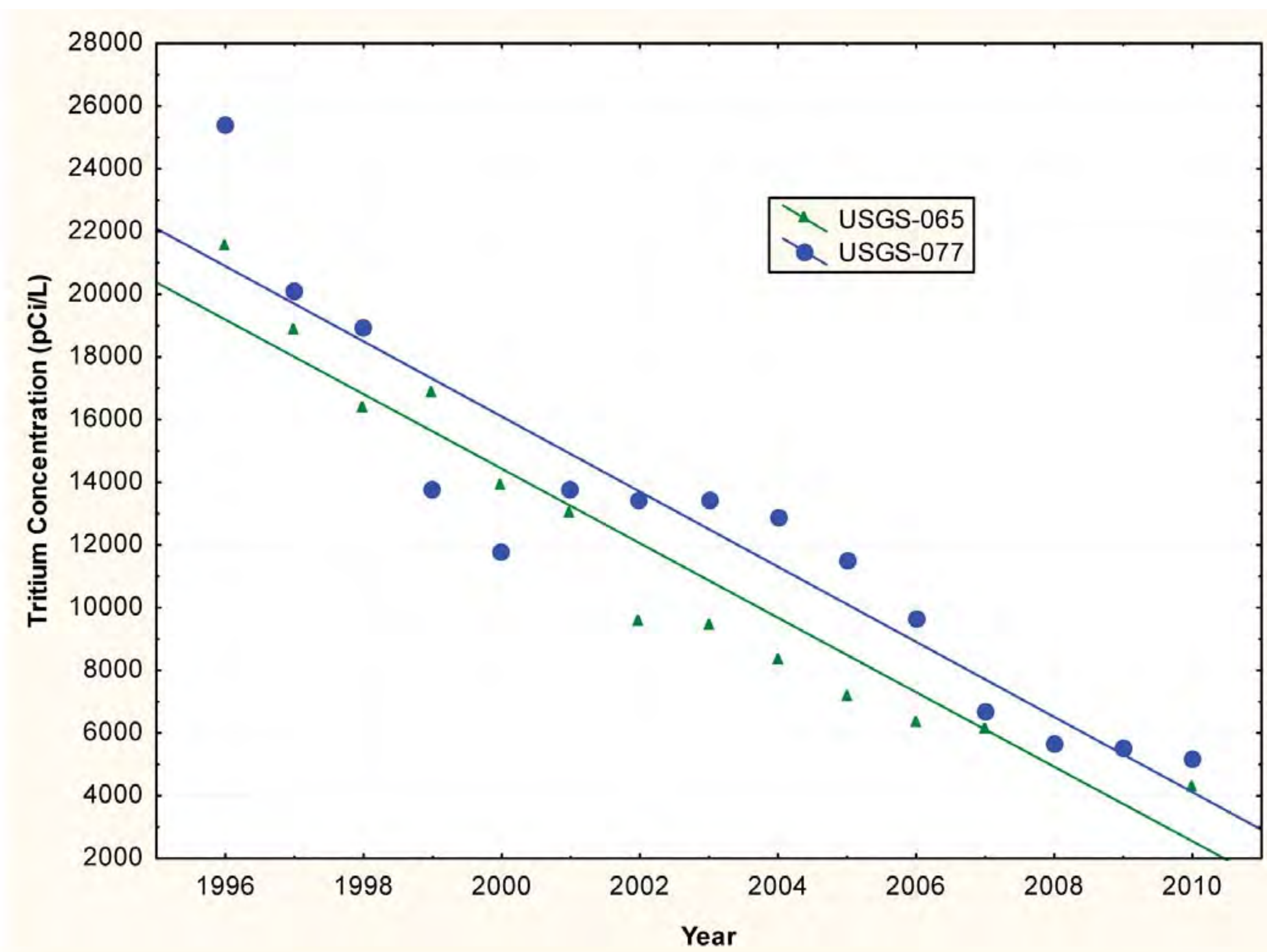


Figure 6-6. Long-Term Trend of Tritium in Wells USGS -065 and -077 (1995 – 2010).

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 earlier injection of wastewater. No ^{90}Sr was detected by USGS in the Snake River Plain Aquifer near ATR Complex during 2010. 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 (1990 – 2010) 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 spectroscopy analyses, and plutonium and americium isotopes (Table 3-6). Results for wells sampled in 2010 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) (as determined by gamma spectroscopy), 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).

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. 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

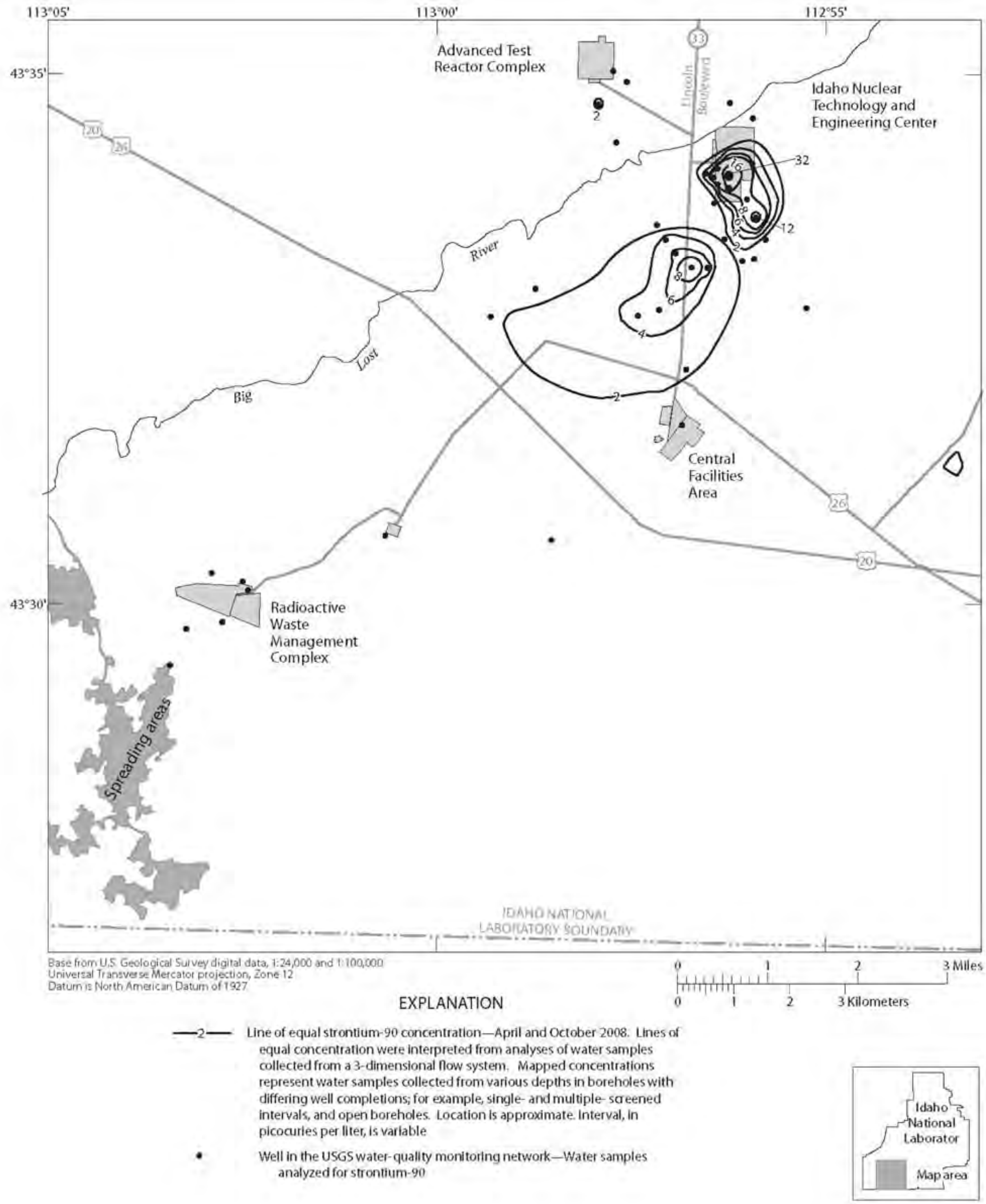


Figure 6-7. Distribution of Strontium-90 in the Eastern Snake River Plain Aquifer on the Idaho National Laboratory Site in 2008 (from Davis 2010).

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, are shown in Figure 6-9 (Bartholomay 2009).

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

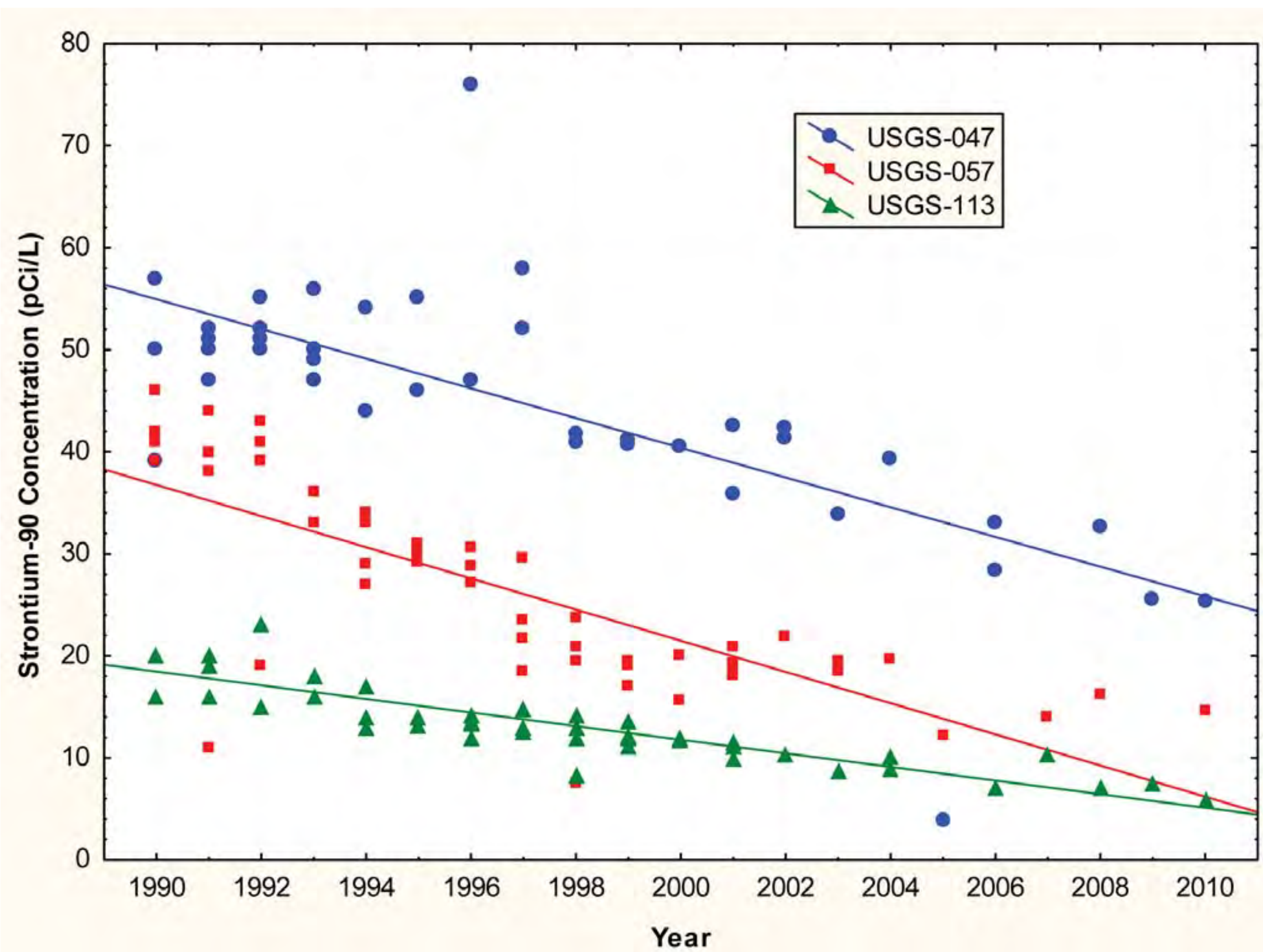


Figure 6-8. Long-Term Trend of Strontium-90 in Wells USGS-047,-057 and -113 (1990 – 2010).

of 100 µg/L in Well 65 in 2005 (Davis 2008) and 2009, but its concentration dropped below the MCL in 2010 to 85 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).

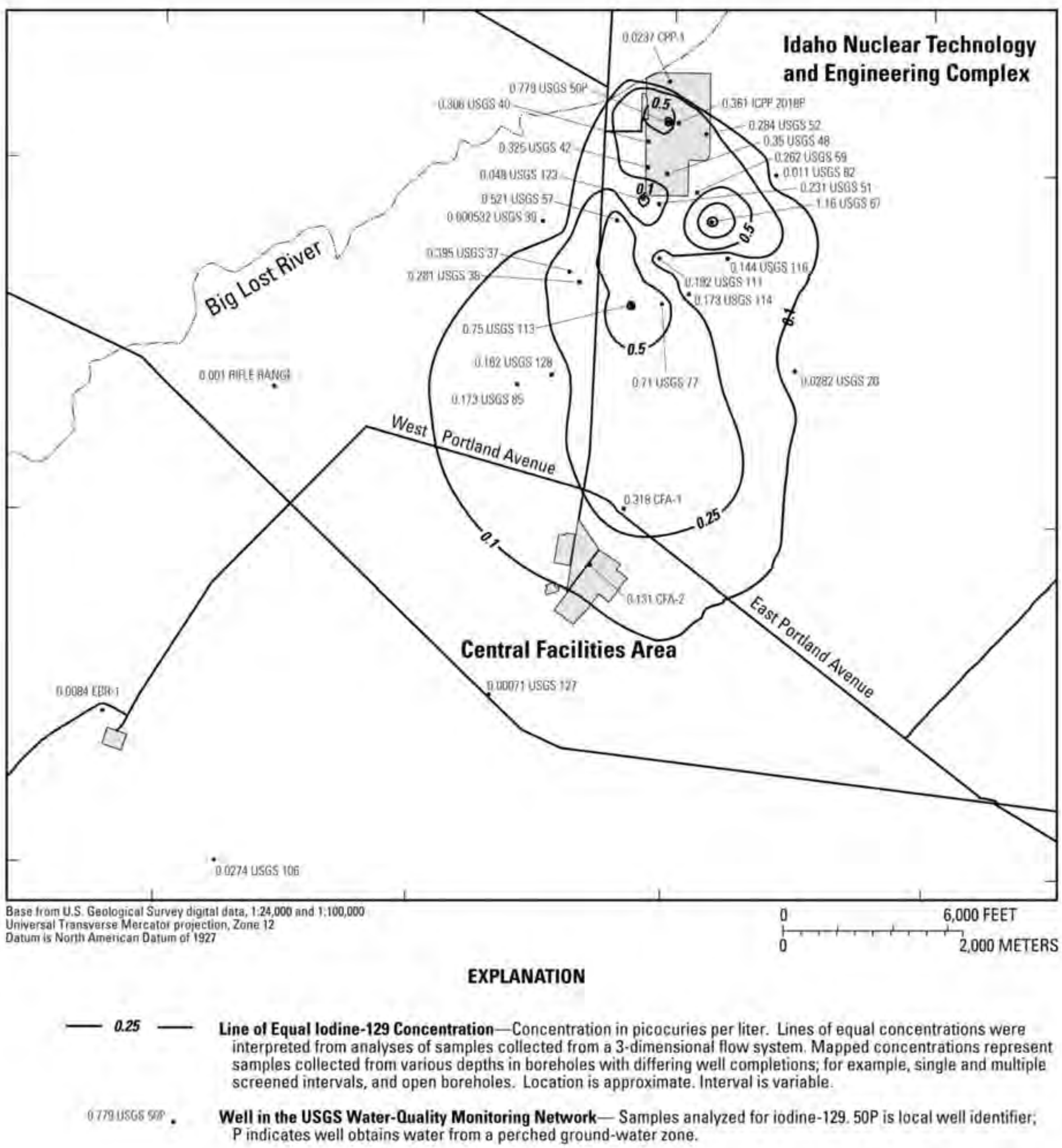


Figure 6-9. Distribution of Iodine-129 in the Snake River Plain Aquifer on the Idaho National Laboratory Site in 2007 (from Bartholomay 2009).


Rough-legged Hawk

USGS sampled for purgeable (volatile) organic compounds in groundwater at the INL Site during 2010. 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). Seven 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 Environmental Protection Agency MCL of 5 µg/L all 12 months in 2010 (Table 6-3). None of the other measured constituents was above their respective primary constituent standard. Annual average concentrations of tetrachloromethane in this well generally have increased through time (Davis 2010).

6.7 Comprehensive Environmental Response, Compensation, and Liability Act Groundwater Monitoring During 2010

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

Table 6-2. Purgeable Organic Compounds in Annual U.S. Geological Survey Well Samples (2010).

Constituent	USGS-065	USGS-087	USGS-088	USGS-120
Tetrachloromethane (µg/L) (MCL=5)[a]	ND[b]	4.67	0.523	0.691
Trichloromethane (µg/L)	ND	0.285	0.378	ND
1,1,1-Trichloroethane (µg/L) (PCS=200)[c]	0.111	0.179	ND	ND
Tetrachloroethene (µg/L) (MCL=5)	ND	0.113	ND	ND
Dichlorodifluoromethane (µg/L) (no standard established)	ND	1.87	ND	ND
Styrene (µg/L) (MCL=100)	ND	0.167	ND	ND
Trichloroethene (µg/L) (PCS=5)	ND	0.637	0.378	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 (2010).

Constituent	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Tetrachloromethane (μg/L) (MCL=5)[a]	8.64	9.87	7.54	5.82	6.35	9.32	7.13	8.17	8.88	5.58	7.71	8.55
Trichloromethane (μg/L) (MCL=100)[b]	2.10	2.33	2.06	2.38	1.80	2.74	1.84	1.84	1.81	1.40	2.21	2.14
Tetrachloroethene (μg/L) (PCS=5)[c]	0.396	0.451	0.376	0.427	0.336	0.428	0.304	0.346	0.390	0.285	0.391	0.400
1,1,1-Trichloroethane (μg/L) (PCS=200)	0.532	0.609	0.500	0.614	0.469	0.618	0.511	0.541	0.536	0.385	0.540	0.532
Trichloroethene (μg/L) (PCS=5)	3.76	4.31	3.77	4.26	3.43	4.68	3.42	3.78	3.79	2.88	4.12	4.12

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.

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. 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 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 the current concentrations (Figure 6-10).

The 2010 in situ bioremediation injection strategy consisted of multiple well injections of sodium lactate solution and whey powder to produce anaerobic conditions for efficient biologically mediated breakdown of TCE. The success of the current injection strategy is evidenced by complete degradation of TCE to ethene in the biologically active wells. Usually by the month after an injection, TCE concentrations are below maximum contaminant levels (MCLs).

To evaluate the impact of in situ bioremediation 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 2010 groundwater monitoring data indicate that the in situ bioremediation hot spot remedy is reducing the concentration of volatile organic compounds in the hot spot zone, and progress toward the remedial action objectives is being made (DOE-ID 2011a).

Medial Zone (TCE concentrations between 1,000 and 20,000 μg/L) – A pump and treat process has been used in the medial zone. During 2010, the pump and treat system was generally operated Monday through Thursday. 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. The TCE concentrations in medial zone Wells TAN-33, TAN-36, and TAN-44 were below 100 μg/L for most of 2010.

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

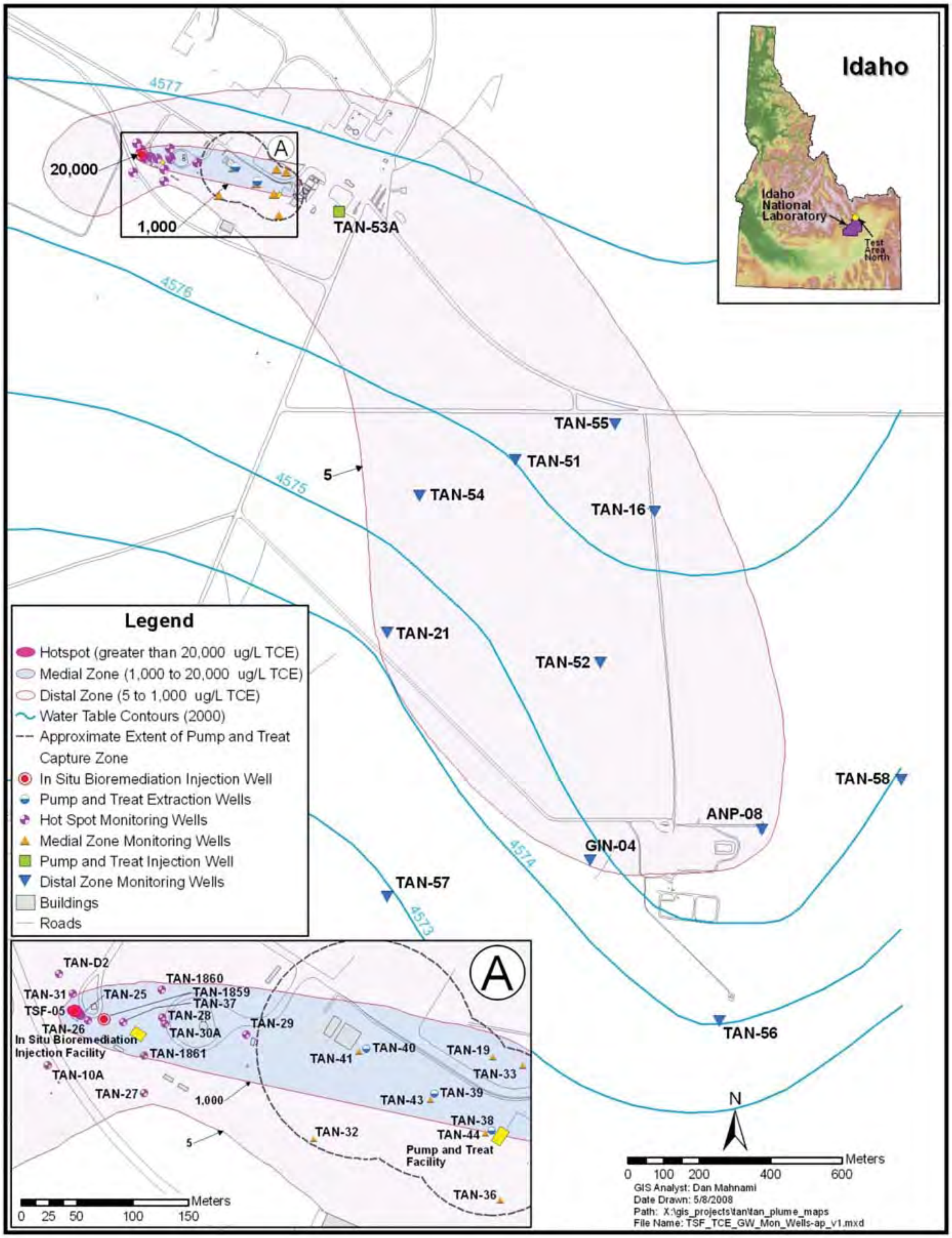


Figure 6-10. Trichloroethene Plume at Test Area North in 1997.

Rough-legged Hawk

contaminants in groundwater. Engineering and administrative controls are in place to protect current and future users from health risks associated with groundwater contamination.

The Monitored Natural Attenuation Remedial Action Work Plan (DOE-ID 2003) outlines three technical components to be evaluated. The first component is evaluation of TCE concentration data trends to determine the timing of peak TCE concentration at wells in the distal zone of the plume. The determination of peak TCE breakthrough is important to determine if the natural degradation rates will meet MCLs by 2095 and meet the remedial action objective. The data collected in 2010 are not conclusive to make the determination that monitored natural attenuation will meet the remedial action objective, but the 2010 data will be used along with data collected in the future to make the determination on the effectiveness of monitored natural attenuation.

The second monitored natural attenuation component is evaluation of TCE plume expansion. In 2010, samples were not collected from Wells TAN-56, TAN-57, and TAN 58 because annual sampling was not required; therefore, plume expansion was not evaluated in 2010. TCE concentrations in these wells will be determined in 2011.

The third natural attenuation component is evaluating radionuclide concentration data in the hot spot area to determine if radionuclides will decline below MCLs before 2095. Although ^{137}Cs and ^{90}Sr concentrations have increased recently at TSF 05 and TAN-25, possibly due to the effects of continued in situ bioremediation operations in the hot spot area of the plume, these increases have not resulted in increased radionuclide concentrations in downgradient wells outside the source area (e.g., TAN-28 and TAN-29).

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 2010. 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, gross alpha, gross beta, tritium, and chromium (unfiltered and filtered). Unfiltered samples obtain the total concentration of chromium in the sample, including chromium adsorbed onto suspended particulates; filtered samples are used to obtain the dissolved chromium concentration. The data for the October 2010 sampling event are included in the Fiscal Year 2011 Annual Report for WAG 2 (ICP 2011a). The October 2010 sampling data are summarized in Table 6-4.

Unfiltered chromium was the only analyte that occurred above its MCL in one aquifer well. The highest unfiltered chromium concentration occurred in Well TRA-07, but the filtered chromium concentration was 97 µg/L and was just below the MCL of 100 µg/L in this well. The filtered chromium concentration in Well USGS-065 was also close to the MCL at 90 µg/L. Although the chromium concentration in both TRA-07 and USGS-065 are close to the MCL, both of these wells show downward trends in chromium concentration.

Well TRA-08 is the only aquifer well that has had consistent ^{90}Sr concentrations, but ^{90}Sr was below detection limits in the October 2010 sample. The ^{90}Sr concentrations in TRA-08 had been decreasing since it first occurred in 2005.

Although tritium concentrations were above background concentrations in all aquifer wells sampled, all tritium concentrations were below the MCL of 20,000 pCi/L.

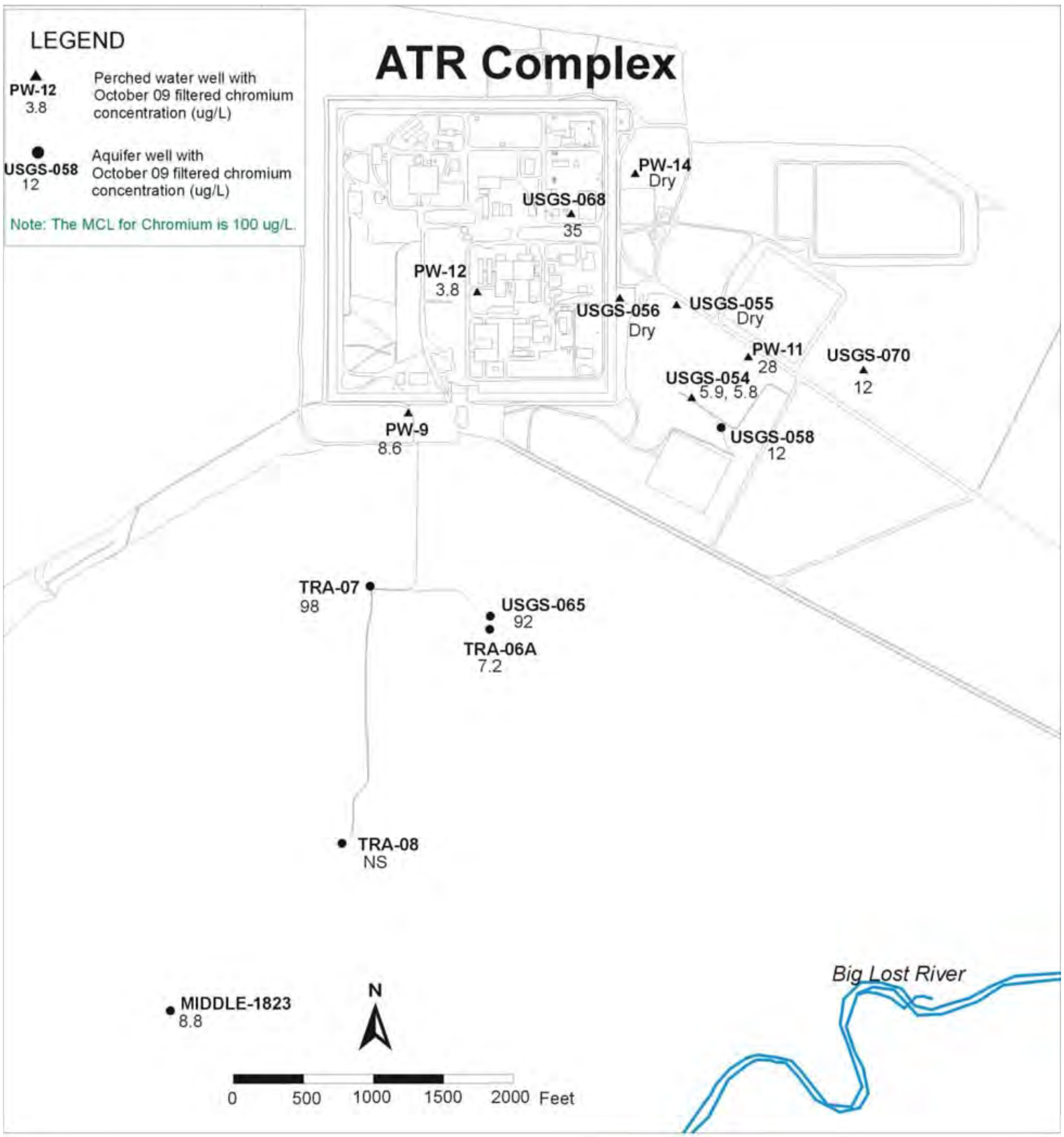


Figure 6-11. Locations of Waste Area Group 2 Monitoring Wells and Chromium Concentrations for 2010 *(Note: Highway 3 well is not shown on this map)*.

Table 6-4. Waste Area Group 2 Aquifer Groundwater Quality Summary (2010).

Analyte	EPA MCL[a]	Background[b]	Maximum	Minimum	Number of Wells above MCL
Chromium (filtered) (µg/L)	100	2 – 3	97	2.3	0
Chromium (unfiltered) (µg/L)	100	NA[c]	130	0.91	1
Strontium-90 (pCi/L)	8	0	ND[d]	ND	0
Tritium (pCi/L)	20,000	75 – 150	11,300	ND	0
Gross alpha (pCi/L)	15	0 – 3	4.12	ND	0
Gross beta (pCi/L)	NA[e]	0 – 7	4.04	ND	NA[e]

a. EPA = Environmental Protection Agency; MCL = maximum contaminant level.
b. Background concentrations are from Knobel et al. (1992), except tritium, which is from Orr et al. (1991).
c. NA = not applicable.
d. ND = not detected.
e. There is no applicable MCL for gross beta activity, however the EPA drinking water standard of 4 mrem/y for public drinking water systems is applied.

Chromium and tritium concentrations in the aquifer have declined faster than predicted by WAG 2 models used for the Operable Unit 2-12 Record of Decision (DOE-ID 1992) and the revised modeling performed after the first five-year review.

The October 2010 Snake River Plain Aquifer water table map prepared for the vicinity of ATR Complex was consistent with previous maps showing similar groundwater flow directions (ICP 2011a). Although water levels in the vicinity of ATR Complex have mostly declined over the last several years, water levels rose in the aquifer from October 2008 to October 2009 by an average of approximately 1 foot.

6.7.3 Summary of Waste Area Group 3 Groundwater Monitoring Results

At the Idaho Nuclear Technology and Engineering Center (INTEC), groundwater samples were collected from 14 SRPA monitoring wells during 2010 (Figure 6-12). Groundwater samples were analyzed for a suite of radionuclides and inorganic constituents, and the data are summarized in the 2010 annual report (DOE-ID 2011b). Table 6-5 summarizes the maximum concentrations observed, along with the number of MCL exceedances reported for each constituent.

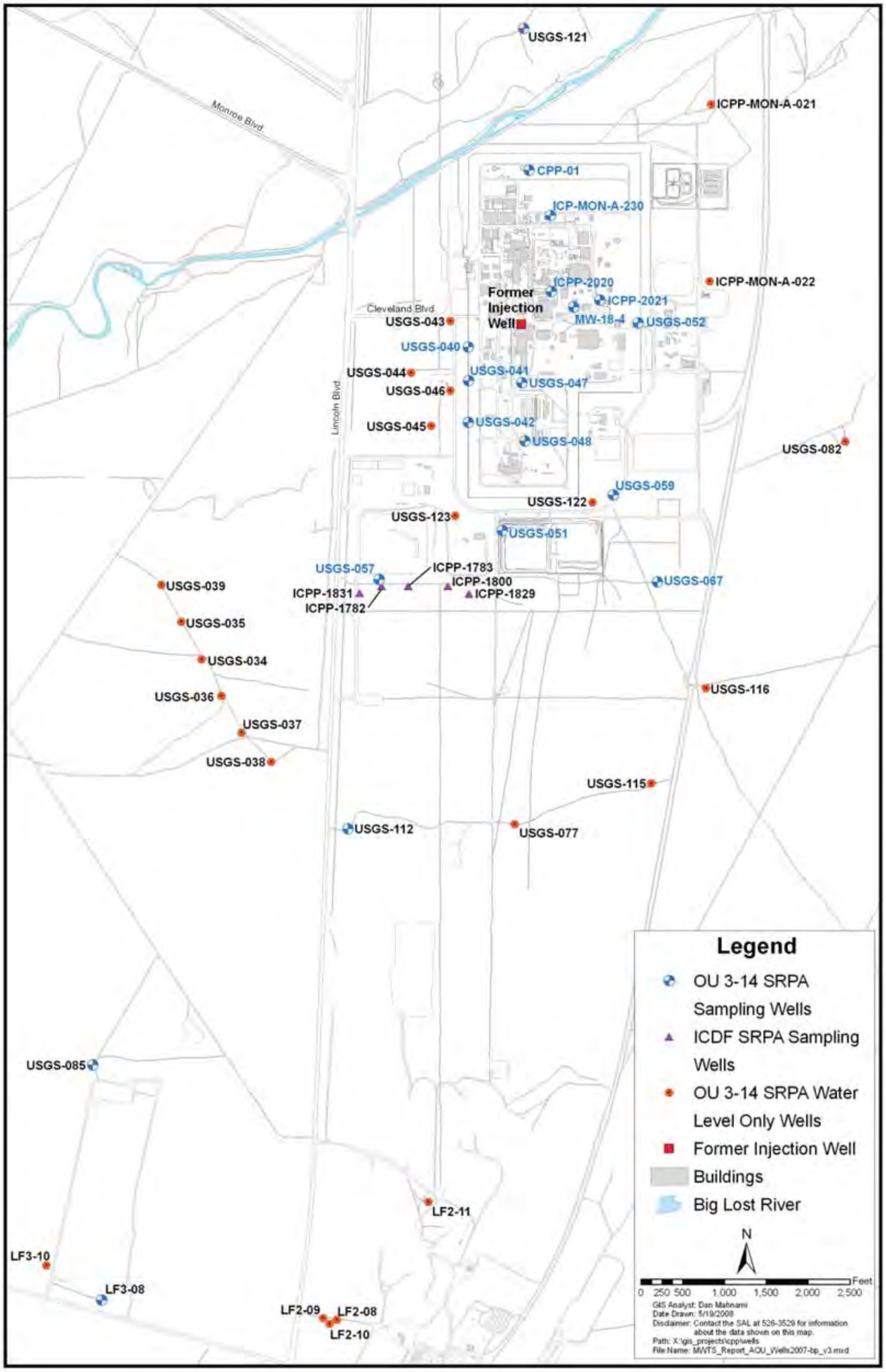


Figure 6-12. Locations of Waste Area Group 3 monitoring wells.

Rough-legged Hawk

Table 6-5. Constituents Detected in Waste Area Group 3 Monitoring Wells (2010).

			Snake River Plain Aquifer Groundwater – April 2010		
Constituent	EPA MCL[a]	Units	Maximum Reported Value	Number of Results[b]	Results > MCL[b]
Gross alpha	15	pCi/L	5.74	15	0
Gross beta	NA[c]	pCi/L	1,370	15	NA
Cesium-137	200	pCi/L	ND[d]	15	0
Strontium-90	8	pCi/L	**23**[e]	15	8
Technecium-99	900	pCi/L	**1,930**	15	2
Iodine-129	1	pCi/L	0.457	15	0
Tritium	20,000	pCi/L	6,540	15	0
Plutonium-239	15	pCi/L	ND	15	0
Plutonium-239/240	15	pCi/L	ND	15	0
Uranium-233/234	15	pCi/L	2.38	15	0
Uranium-235	15	pCi/L	0.192J[f]	15	0
Uranium-238	15	pCi/L	1.49	15	0
Alkalinity	NA	mg/L	155	15	NA
Calcium	NA	mg/L	69.3	15	NA
Chloride	250	mg/L	131	15	0
Magnesium	NA	mg/L	24.3	15	NA
Nitrate (as N)	10	mg/L	**16.7**	15	2
Potassium	NA	mg/L	5.05	15	NA
Sodium	NA	mg/L	35.6	15	NA
Sulfate	250	mg/L	44.6	15	0
Total dissolved solids	500	mg/L	**519**	15	1

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.

Strontium-90, ^{99}Tc, and nitrate exceeded their respective drinking water MCLs in one or more of the SRPA 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 eight 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 2010, the highest ^{99}Tc level in SRPA groundwater was at monitoring well ICPP-MON-A-230 (1,930 pCi/L) located north 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. Highest concentrations were reported at Wells ICPP-2021 (16.7 mg/L as N) and MW-18-4 (10.3 mg/L). These were the only locations where nitrate concentration exceeded the MCL (10 mg/L as N). These wells are located relatively close to the Tank Farm, and all show groundwater quality impacts attributed to past releases of Tank Farm liquid waste. At most locations, nitrate concentrations have remained relatively constant.

Iodine-129 concentrations were less than the MCL (1 pCi/L) at all SRPA monitoring wells, and below detection limits at most locations. The highest ^{129}I concentration was reported at Well USGS-67 (0.457 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 USGS-51 (6,220 pCi/L), near the former INTEC percolation ponds, and Well MW-18-4 (6,540 pCi/L), near the former Waste Calcining Facility. 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 SRPA groundwater samples. Uranium-238 was detected at all SRPA well locations, with the highest concentration at Well ICPP-MON-A-230 (1.49 pCi/L) north of the Tank Farm. The ^{238}U results are consistent with background concentrations reported for SRPA groundwater. Similarly, ^{234}U also was detected in all groundwater samples, with concentrations ranging as high as 2.38 pCi/L at Well ICPP-2020. Uranium-234 is the daughter product of alpha decay of the long-lived, naturally occurring ^{238}U. Ratios of $^{234U/238}$U were similar to background ^{234}U/^{238}U activity ratios of 1.5 to 3.1 reported for the eastern SRPA.

Uranium-235 was detected in five groundwater samples at concentrations ranging from 0.0886J to 0.192J pCi/L. An evaluation of uranium in groundwater near the Radioactive Waste Management Complex indicates that SRPA background ^{235}U activities are generally less than 0.15 pCi/L (95 percent upper tolerance limit). Reported ^{235}U concentrations were slightly above the background level, which is consistent with limited uranium impacts to groundwater from past operations at INTEC.

Rough-legged Hawk

The 2010 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 2005–2010 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), volatile organic compounds, and anions (nitrate, chloride, fluoride, and sulfate) and two wells for volatile organic compounds 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 CFA Landfills 2010 Monitoring Report (ICP 2011b).

In the four wells sampled downgradient of CFA for the nitrate plume, nitrate at 15.5 mg/L-N continued to exceed its groundwater MCL of 10 mg/L N in Well CFA-MON-A-002. 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 8.4 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.

In the CFA landfill monitoring wells, aluminum exceeded the lower limit for the secondary MCL in Well LF3-08 but was below the upper secondary MCL limit of 200 µg/L. The high aluminum concentration in LF3-08 was accompanied by an elevated pH. The elevated pH and aluminum concentration in Well LF3-08 is probably due to the interaction of groundwater with grout placed below the well screen.

The iron concentration of 356 µg/L in LF3-09 was above the secondary MCL of 300 µg/L. The high iron concentration in LF3-09 is inconsistent with the high dissolved oxygen level in LF3-09. It is possible that particles smaller than the filter openings (0.45 microns) may have gone through the filter and interacted with the acid used to preserve the sample to produce the elevated iron concentration.

Four volatile organic compounds were detected in groundwater downgradient of the CFA landfills: acetone, toluene, chloroform, and 2-butanone; however, all detections were well below established MCLs. The source of the four compounds is uncertain because soil vapor concentrations for these compounds collected at depths from 11 to 473 feet below the surface near the landfills were low.

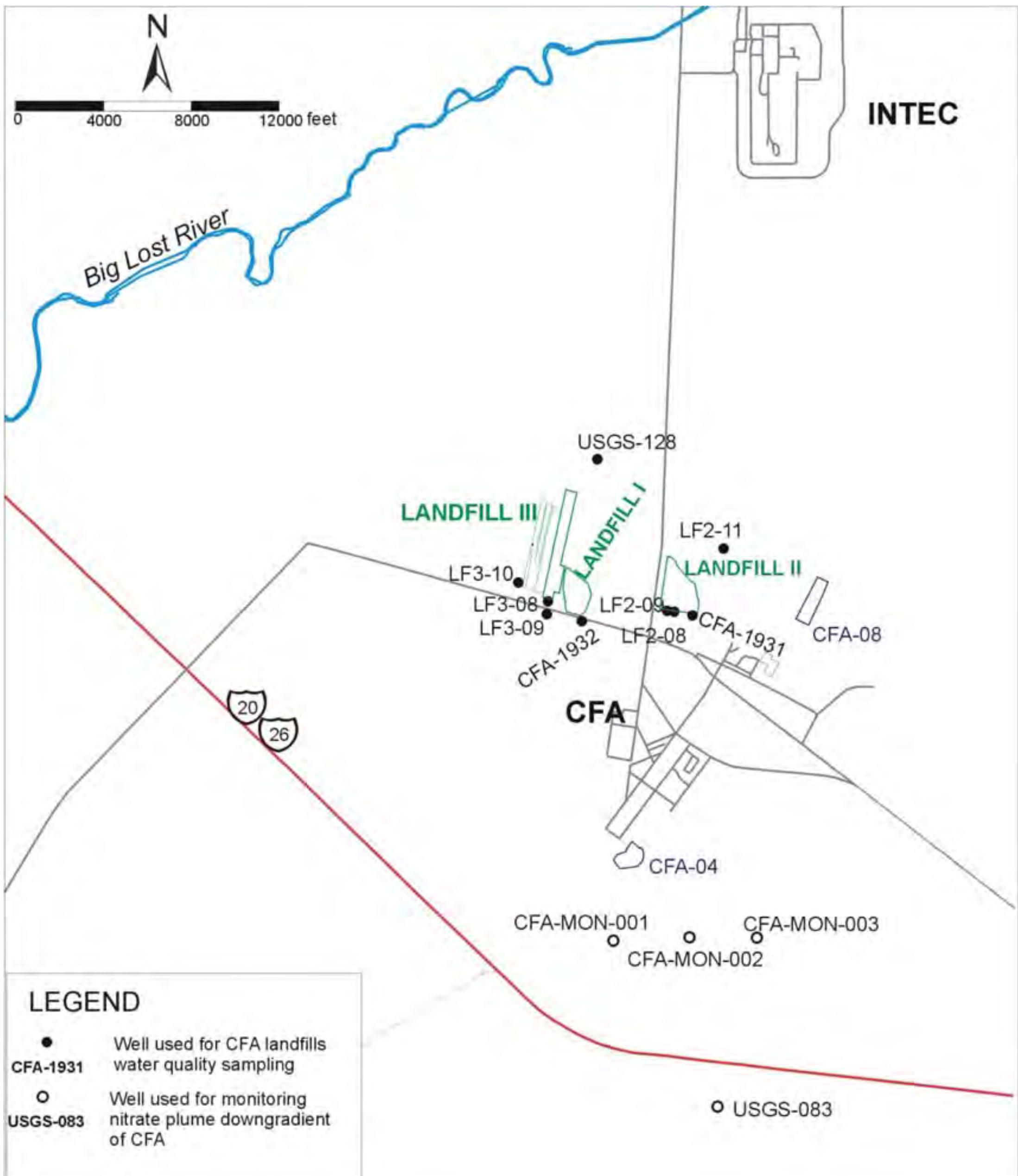


Figure 6-13. Locations of Waste Area Group 4/Central Facilities Area Monitoring Wells Sampled in 2010.

Rough-legged Hawk

Table 6-6. Comparison of Waste Area Group 4 Groundwater Sampling Results to Regulatory Levels (2010).

Compound	EPA MCL or SMCL[a]	Maximum Detected Value	Number of Wells above MCL or SMCL
Downgradient Central Facilities Area Wells			
Chloride (mg/L)	250	57.5	0
Fluoride (mg/L)	2	0.344	0
Sulfate (mg/L)	250	30.7	0
Nitrate/nitrite (mg-N/L)	10	**15.5**[b]	1
Central Facilities Area Landfill Wells[c]			
Anions			
Chloride (mg/L)	250	77.4	0
Fluoride (mg/L)	2	0.344	0
Sulfate (mg/L)	250	39.1	0
Nitrate/nitrite (mg-N/L)	10	2.71	0
Common Cations			
Calcium (µg/L)	None	59,200	NA[d]
Magnesium (µg/L)	None	15,700	NA
Potassium (µg/L)	None	4,060	NA
Sodium (µg/L)	None	34,700	NA
Inorganic Analytes			
Antimony (µg/L)	6	ND[e]	0
Aluminum (µg/L)	50–200	113	1
Arsenic (µg/L)	10	ND	0
Barium (µg/L)	2,000	112	0
Beryllium (µg/L)	4	ND	0
Cadmium (µg/L)	5	ND	0
Chromium (µg/L)	100	24.6	0
Copper (µg/L)	1,300/1,000	ND	0
Iron (µg/L)	300	**356**	1
Lead (µg/L)	15[f]	ND	0
Manganese (µg/L)	50	6.97	0
Mercury (µg/L)	2	ND	0
Nickel (µg/L)	None	53.8	NA
Selenium (µg/L)	50	2.04	0
Silver (µg/L)	100	ND	0
Thallium (µg/L)	2	ND	0
Vanadium (µg/L)	None	ND	NA
Zinc (µg/L)	5,000	173	0
Detected Volatile Organic Compounds			
Acetone (µg/L)		20.1	NA
Chloroform	100	1	0
2-butanone (µg/L)	None	2.07	NA
Toluene (µg/L)	1,000	9.5	0

a. EPA = Environmental Protection Agency; MCL = maximum contaminant level; SMCL = secondary MCL. Numbers in *italics* are for the SMCL.
b. **Bold** values exceed an MCL.
c. Metals results for LF2-08 and LF2-09 are not included in this summary because these wells are not required to be sampled.
d. NA = not applicable.
e. ND = not detected.
f. The action level for lead is 15 µg/L.

Water-level measurements taken in the CFA area in 2010 suggest that after the sharp drop in water levels from 2000 to 2005, water levels appear to be stabilizing because they have changed little in the past five years (i.e., 2005 to 2010). A water table map produced from water levels collected in August 2010 was consistent with previous maps in terms of gradients and groundwater flow directions (ICP 2011b).

6.7.5 Summary of Waste Area Group 5 Groundwater Monitoring Results

Groundwater was not monitored for WAG 5 in 2010. Groundwater monitoring for WAG 5 was concluded in November 2006 in accordance with the recommendations from the first five-year review (DOE-ID 2005).

6.7.6 Summary of Waste Area Group 7 Groundwater Monitoring Results

Aquifer samples collected in the vicinity of the RWMC in 2010 were analyzed for radionuclides, inorganic constituents, volatile organic compounds, and 1,4 dioxane. Nearly 3,400 analyses were performed on RWMC aquifer samples in 2010, and 20 exceeded background reporting thresholds or quantitation limits. Table 6-7 lists WAG 7 contaminants of concern that were detected above reporting thresholds or quantitation limits.

Carbon tetrachloride, attributed to waste buried in the landfill at RWMC, is the only contaminant of concern consistently detected in the aquifer at WAG 7. Carbon tetrachloride was detected at concentrations above the reporting (quantitation) limit of 1 µg/L at six monitoring locations in 2010 and slightly exceeded the MCL of 5 µg/L at Wells M7S and M16S north of RWMC (Figure 6-14). In general, trends 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 [Figure 6-15] [ANL-W 1998]) 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 (ANL-W 1998) and the Industrial Wastewater Reuse Permit for the Industrial Waste Ditch and Pond. The reported concentrations of analytes that were detected in at least one sample are summarized in Table 6-8. All results were below their respective water quality limits. Overall, the data show no discernable impacts from activities at the Materials and Fuels Complex.

6.7.8 Summary of Waste Area Group 10 Groundwater Monitoring Results

In 2010, a Post-Record of Decision Groundwater Monitoring Plan (DOE-ID 2010b) was prepared. Figure 6-16 shows the selected WAG 10 sampling locations. Groundwater monitoring for WAG 10 will be conducted every two years starting in 2011. In accordance with the monitoring plan, no groundwater samples were collected for WAG 10 in 2010.

Rough-legged Hawk

Table 6-7. Summary of Waste Area Group 7 Aquifer Sampling and Analyses Data for Relevant Analytes (2010).

Analyte	Number of Wells Sampled	Number of Analyses[a]	Number of Reportable Detections[b]	Concentration: Maximum ± 1σ	Concentration: Units	Number of Detections Greater Than Maximum Contaminant Level	MCL[c]
Carbon tetrachloride	14	29	12	7.01	µg/L	3	5 µg/L
Trichloroethylene	14	29	5	3.01	µg/L	0	5 µg/L
Uranium-234	14	29	1	1.90 ± 0.17	pCi/L	NA[d]	NA
Uranium-238	14	29	1	0.86 ± 0.09	pCi/L	NA	NA
Total uranium[e]	14	29	1	2.6 ± 0.3[e]	µg/L	0	30 µg/L

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. NA = not applicable. The MCL is not applicable to each individual uranium isotope, but to total uranium only.

e. Total uranium is derived by converting isotopic uranium results (pCi/L) to mass units (µg/L) and summing the results.

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 2010. 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) (see http://www.deq.idaho.gov/media/557033-2010_env_surv_q4.pdf). An upgradient sample was collected at Mud Lake. The samples were analyzed for gross alpha and beta activities and for tritium. The results are shown in Table 6-9.

Gross alpha activity was detected in duplicate samples collected from Shoshone. They were not detected in any of the DEQ IOP samples collected at the same locations. However, the measurements 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.

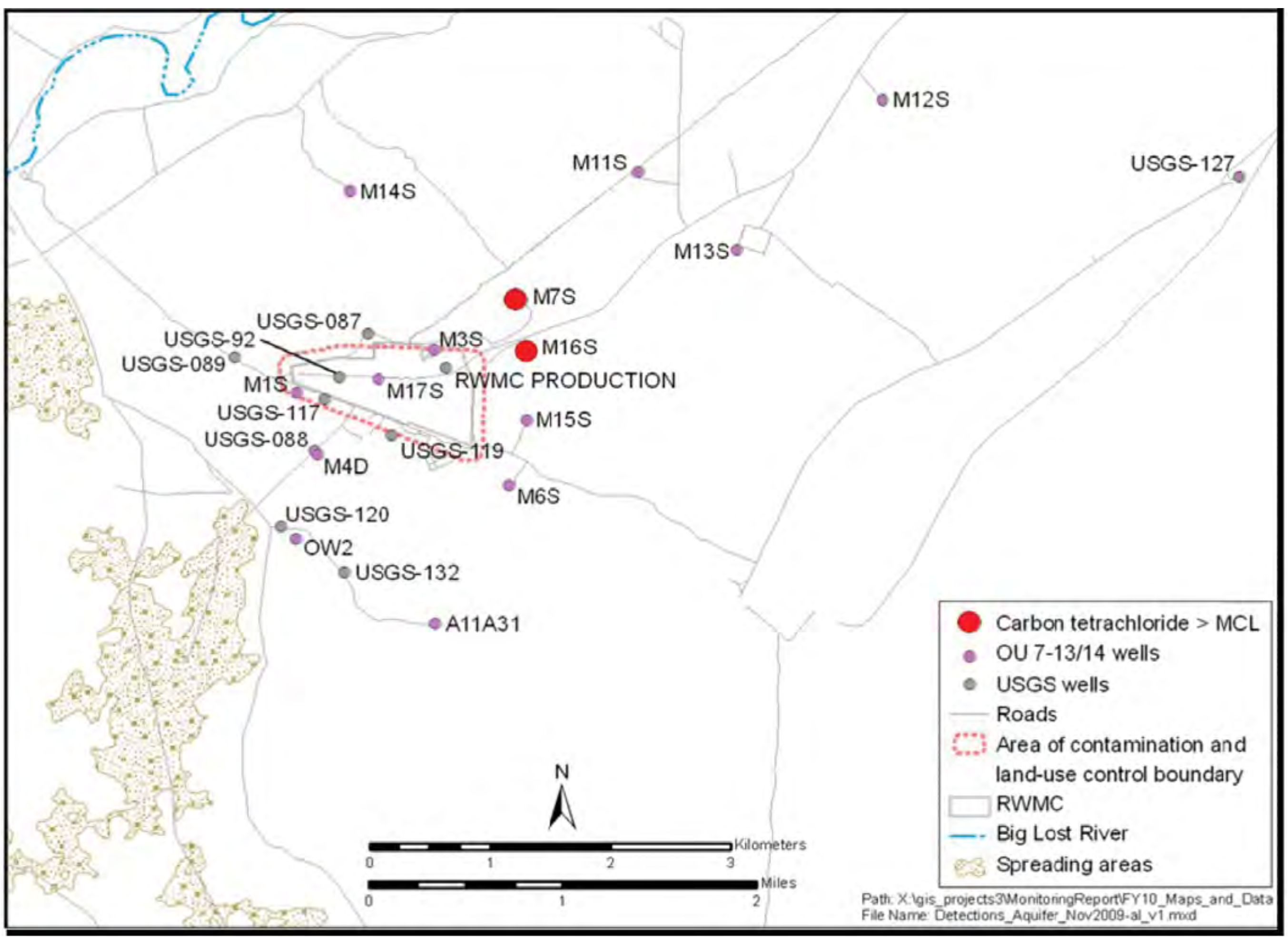


Figure 6-14. Locations of Waste Area Group 7 Aquifer Monitoring Wells where Carbon Tetrachloride Exceeded the Maximum Contaminant Level (2010).

Gross beta activity was also detected in the samples collected from Shoshone. 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 sample. 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.

Tritium was not detected in any of the drinking water samples.

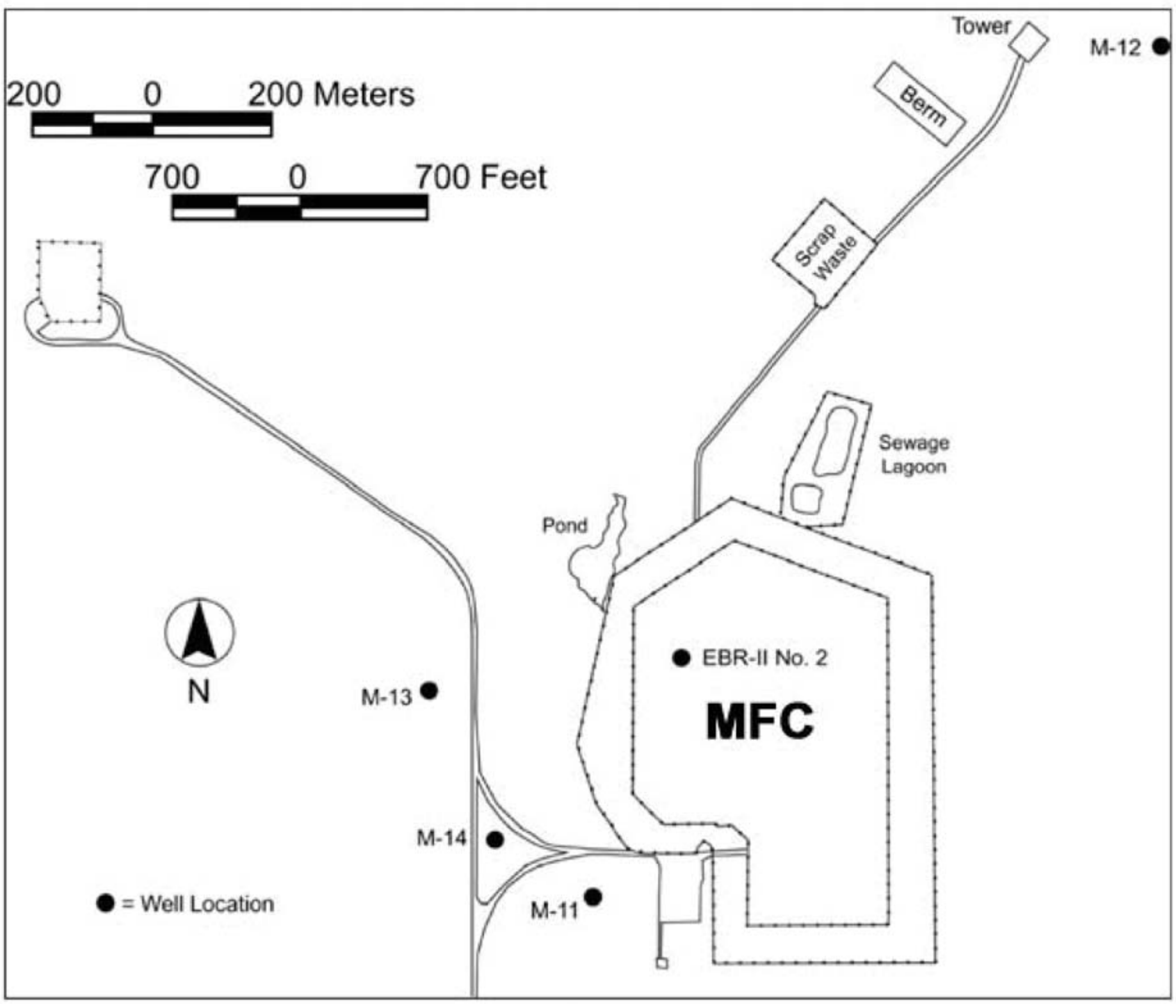


Figure 6-15. Locations of Waste Area Group 9 Monitoring Wells Sampled in 2010.

Western Bluebird

Table 6-8. Comparisons of Detected Analytes to Drinking Water Standards at Waste Area Group 9 Monitoring Wells (2010).

Well:	M-11		M-12		M-13		M-14		EBR-II[a] No. 2		PCS/SCS[b]
Sample Date:	5/20/10	9/28/10	5/19/10	9/28/10	5/19/10	9/28/10	5/19/10	9/28/10	5/20/10	9/28/10	
Radionuclides[c]											
Gross beta (pCi/L)	2.93 ± 1.09 U	0.643 ± 0.915 U	2.43 ± 1.01 U	3.1 ± 1.15 U	4.49 ± 1.16	3.49 ± 1.08	2.2 ± 0.98 U	3.59 ± 1.12	3.74 ± 1.07	3.72 ± 1.08 (4.47 ± 1.29)[f]	4 mrem/yr
Uranium-233/234 (pCi/L)	1.41 ± .225	1.36 ± 0.215	1.34 ± 0.25	1.07 ± 0.173	1.41 ± 0.218	1.6 ± 0.241	1.07 ± 0.175	1.26 ± 0.197	1.78 ± 0.288	1.59 ± 0.232 (1.55 ± 0.244)	186,000
Uranium-238 (pCi/L)	0.648 ± 0.138	0.607 ± 0.129	0.346 ± 0.113	0.555 ± 0.116	0.794 ± 0.151	0.839 ± 0.158	0.594 ± 0.122	0.697 ± 0.136	0.657 ± 0.153	0.544 ± 0.117 (0.434 ± 0.102)	9.9
Metals											
Aluminum (µg/L)	5.7	3.5	9.6	6.9	13.7	7.7	6.7	18	4.5	2.7 (2.7)	200
Arsenic (µg/L)	1.9	2.4	2	2.6	2.3	3	2.1	2.4	2	2.5 (2.6)	50
Barium (µg/L)	34.8	36.7	38.5	40.2	36.2	37.2	35.7	37.6	35.6	37.3 (37.4)	2,000
Calcium (mg/L)	35.5	38.3	36.7	39	36.4	38.7	36.3	38.6	36.3	38.7 (38.8)	NE[e]
Chromium (µg/L)	2.6	2.7	2.5 U	2.5 U	4.1	2.7	3.9	3.4	2.5 U	2.5 U (2.5 U)	100
Copper (µg/L)	2.5 U	4.6	2.5 U	18.6	2.5 U	14	2.5 U	3	3.8	6.1 (5.1)	1,300
Iron (µg/L)	75.4	51	50 U	68.9	120	105	138	208	50 U	50 U (50 U)	300
Lead (µg/L)	0.67	0.61	0.5 U	3.0	0.71	1.6	0.5 U	1.3	2	1.3 (0.94)	15
Magnesium (mg/L)	11.5	12.2	11.1	11.9	11.8	12.4	11.6	12.2	11.7	12.2 (12.3)	NE
Nickel (µg/L)	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	33.2	9.6 (33.4)	NE
Potassium (mg/L)	3.07	3.16	3.32	3.37	3.07	3.15	3.11	3.15	3.06	3.05 (3.2)	NE
Selenium (µg/L)	0.5 U	0.56	0.5	0.7	0.53	0.68	0.51	0.83	0.58	0.55 (0.54)	50
Sodium (mg/L)	16.2	16.7	16.5	17	18.1	17.8	16.6	16.8	16.6	16.7 (16.9)	NE
Vanadium (µg/L)	4.7	5.7	4.6	5.8	5.2	6	4.8	5.2	4.7	5.4 (5.4)	NE
Zinc (µg/L)	2.5 U	2.9	2.9	11.6	2.5 U	7.8	2.5 U	2.5 U	18.3	36.8 (11.3)	5,000
Anions											
Chloride (mg/L)	19	18.7	17.8	18	18.3	19	19.2	18.9	20.3	19.4 (19.4)	250
Nitrate-as nitrogen (mg/L)	2	1.95	1.82	1.86	1.95	1.94	1.91	1.93	1.97	1.92 (1.93)	10
Nitrite-as nitrogen	0.05 U	0.05 U	0.0803	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

Rough-legged Hawk

Table 6-8. Comparisons of Detected Analytes to Drinking Water Standards at Waste Area Group 9 Monitoring Wells (2010) (continued).

Well:	M-11		M-12		M-13		M-14		EBR-II[a] No. 2		PCS/ SCS[b]
Sample Date:	5/20/10	9/28/10	5/19/10	9/28/10	5/19/10	9/28/10	5/19/10	9/28/10	5/20/10	9/28/10	
(mg/L)											
Phosphorus (mg/L)	0.0357	0.0115	0.0215	0.0207	0.0331	0.0126	0.0181	0.0136	0.0137	0.0124 (0.0188)	NE
Sulfate (mg/L)	17	17.2	16.2	16.7	19.5	19.1	18	17.8	18	17.6 (17.8)	250
Water Quality Parameters											
Alkalinity (mg/L)	137	140	138	142	137	144	135	145	135	140 (145)	NE
Bicarbonate alkalinity (mg/L)	137	140	138	142	137	144	135	145	135	140 (145)	NE
Total dissolved solids (mg/L)	202	234	208	231	216	237	216	235	209	241 (239)	500
Total organic carbon (mg/L)	1 U	1 U	1.23	1 U	1 U	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. 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.

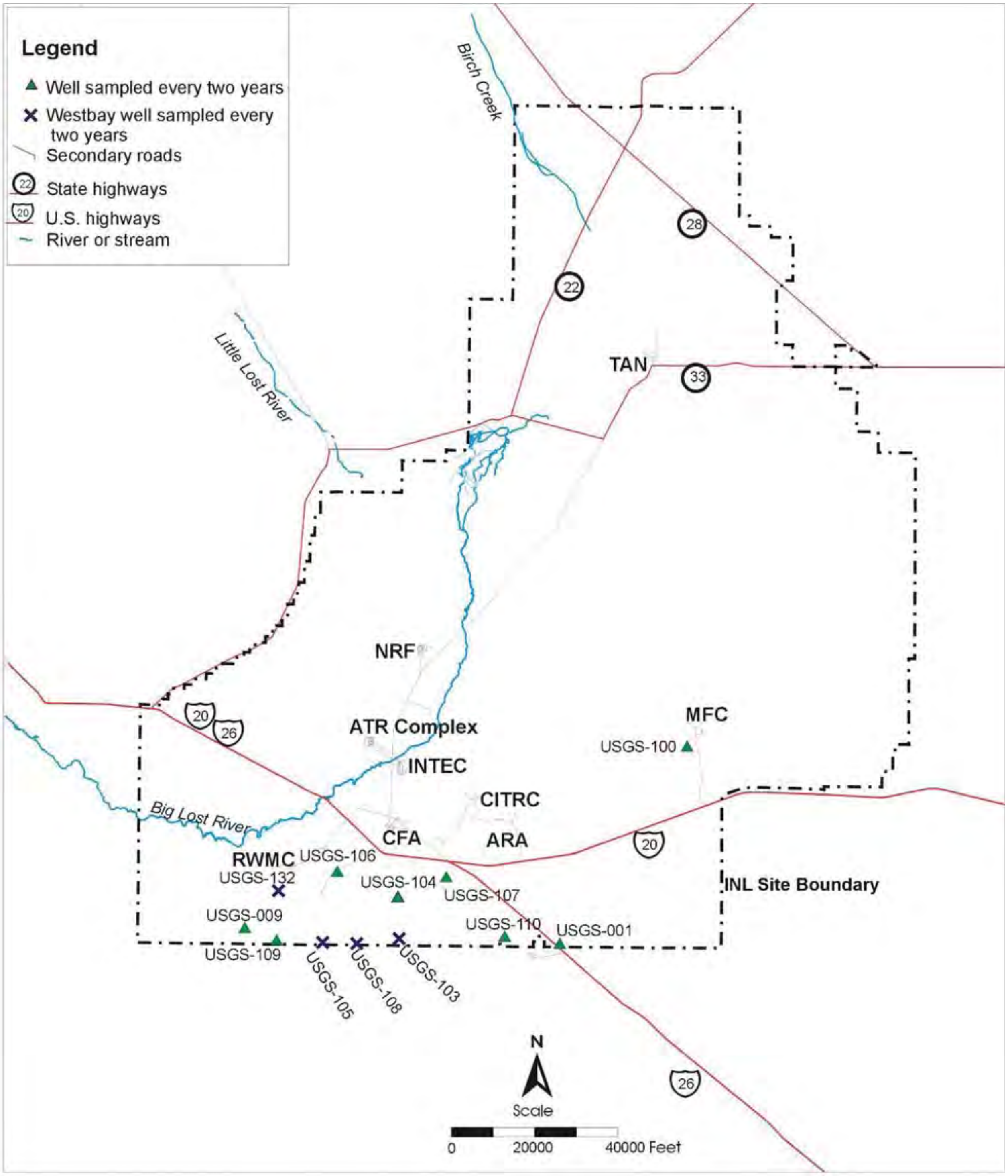


Figure 6-16. Locations and Sampling Frequency for Wells to be Sampled for Operable Unit 10-08 (*Note that wells were not sampled in 2010, but will be sampled in 2011*).

Table 6-9. Gross Alpha, Gross Beta, and Tritium Concentrations in Offsite Drinking Water Samples Collected by the ESER Contractor in 2010.

Location	Sample Results (pCi/L)[a]	EPA MCL[b]
	Gross Alpha	
Minidoka	ND[c]	15 pCi/L
Shoshone	2.16 ± 0.41	15 pCi/L
Shoshone (duplicate)	2.00 ± 0.41	15 pCi/L
Mud Lake (Well #2)	ND	15 pCi/L
	Gross Beta	
Minidoka	ND	4 mrem/yr[d]
Shoshone	4.23 ± 0.25	4 mrem/yr
Shoshone (duplicate)	4.56 ± 0.25	4 mrem/yr
Mud Lake (Well #2)	ND	4 mrem/yr
	Tritium	
Minidoka	ND	20,000 pCi/L
Shoshone	ND	20,000 pCi/L
Shoshone (duplicate)	ND	20,000 pCi/L
Mud Lake (Well #2)	ND	20,000 pCi/L

a. Result ± 1s
b. EPA = Environmental Protection Agency; MCL = Maximum Contaminant Level.
c. ND = not detected (results < 3s)
d. 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.

6.9 Surface Water Sampling

Surface water was co-sampled with DEQ IOP 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 6-1). ESER contractor results are shown in Table 6-10. Gross alpha activity was detected in two of three 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. The result measured in the sample collected by the ESER contractor at Alpheus Springs (8.3 pCi/L) is slightly higher than the MCL for ^{90}Sr

Table 6-10. Gross Alpha, Gross Beta, and Tritium Concentrations in Surface Water Samples Collected by the ESER Contractor in 2010.

Location	Sample Results (pCi/L)[a]	EPA MCL[b]
Gross Alpha		
Alpheus Springs (Twin Falls)	1.12 ± 0.33	15
Clear Springs (Buhl)	2.08 ± 0.56	15
Bill Jones Hatchery (Hagerman)	ND[c]	15
BLR[d] at Highway 20/26 rest area	1.12 ± 0.33	15
BLR at EFS	1.39 ± 0.29	15
BLR at EFS (duplicate)	1.62 ± 0.29	15
BLR near INTEC	1.46 ± 0.28	15
BLR near NRF	1.71 ± 0.31	15
Gross Beta		
Alpheus Springs (Twin Falls)	8.31 ± 0.26	4 mrem/yr[e]
Clear Springs (Buhl)	4.88 ± 0.48	4 mrem/yr
Bill Jones Hatchery (Hagerman)	3.61 ± 0.47	4 mrem/yr
BLR at Highway 20/26 rest area	1.68 ± 0.51	4 mrem/yr
BLR at EFS	2.07 ± 0.51	4 mrem/yr
BLR at EFS (duplicate)	1.42 ± 0.52	4 mrem/yr
BLR near INTEC	2.18 ± 0.51	4 mrem/yr
BLR near NRF	0.90 ± 0.50	4 mrem/yr
Tritium		
Alpheus Springs (Twin Falls)	ND	20,000
Clear Springs (Buhl)	ND	20,000
Bill Jones Hatchery (Hagerman)	ND	20,000
BLR at Highway 20/26 rest area	114 ± 32.2	20,000
BLR at EFS	163 ± 33.2	20,000
BLR at EFS (duplicate)	147 ± 32.9	20,000
BLR near INTEC	ND	20,000
BLR near NRF	115 ± 32.2	20,000

a. Result ± 1s
b. EPA = Environmental Protection Agency; MCL = Maximum Contaminant Level.
c. ND = not detected (results < 3s).
d. BLR = Big Lost River.
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 and a conservative screening level of 8 pCi/L (the MCL for strontium-90) is used.

Rough-legged Hawk

(8 pCi/L). The DEQ IOP result was a little less (7.2 pCi/L). This location 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 not detected in any of the surface water samples collected by the ESER contractor. However, it was detected by DEQ IOP at very low levels (< 50 pCi/L) in two of their samples. This is due to the fact that DEQ, unlike the ESER contractor, uses an electrolytic enhancement process for samples with tritium concentrations that cannot be detected below 150 pCi/L. The results were consistent with measurements made historically by DEQ IOP.

The ESER contractor also collected surface water samples from the Big Lost River. 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 6-2). The river then emerges about 100 miles (160 km) away at Thousand Springs near Hagerman and other springs downstream of Twin Falls.

In 2010, the Big Lost River had sufficient water flowing through it to collect samples at the following locations: the public rest stop on State Highway 20/26; along Lincoln Boulevard near INTEC; along Lincoln Boulevard near the Naval Reactors Facility; and at the Experimental Field Station (a duplicate sample was also collected here). There was no water in the Big Lost River Sinks to sample. Gross alpha activity was detected in all of the samples, at similar, low levels and below the MCL. Gross beta results were detected in all five 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 four Big Lost River samples, however, at levels well below the MCL. The source of the tritium is most likely natural production in the atmosphere which then enters surface water through precipitation.

REFERENCES

40 CFR 141, 2010, "National Primary Drinking Water Regulations," *Code of Federal Regulations*, Office of the Federal Register.

ANL-W, 1998, *Final Record of Decision for Argonne National Laboratory-West*, W7500-00-ES-04, Argonne National Laboratory-West.

Bartholomay, R. C., B. J. Tucker, L. C. Davis, and M. R. Greene, 2000, *Hydrogeologic Conditions and Distribution of Selected Constituents in Water, Snake River Plain Aquifer, Idaho National Engineering and Environmental Laboratory, Idaho, 1996 Through 1998*, U.S. Geological Survey Water-Resources Investigation Report 2000-4192 (DOE/ID-22167), U.S. Geological Survey.

Bartholomay, R. C., L. L Knobel, and J. P. Rousseau, 2003, *Field Methods and Quality-Assurance Plan for Quality-of-Water Activities*, U.S. Geological Survey Open-File Report 2003-42 (DOE/ID 22182), U.S. Geological Survey.

Bartholomay, R. C., 2009, *Iodine-129 in the Snake River Plain Aquifer at and near the Idaho National Laboratory, Idaho, 2003 and 2007*, U.S. Geological Survey Scientific Investigations Report 2009-5088 (DOE/ID-22208), U.S. Geological Survey.

Cahn, L. S., M. A. Abbott, J. F. Keck, P. Martian, A. L. Schafer, and M. C. Swenson, 2006, *Operable Unit 3-14 Tank Farm Soil and Groundwater Remedial Investigation/Baseline Risk Assessment*, DOE/NE-ID-11227, Rev. 0., U. S. Department of Energy Idaho Operations Office.

Davis, L. C., 2008, *An Update of Hydrologic Conditions and Distribution of Selected Constituents in Water, Snake River Plain Aquifer and Perched-Water Zones, Idaho National Laboratory, Idaho, Emphasis 2002–05*, U.S. Geological Survey Scientific Investigations Report 2008-5089 (DOE/ID-22203), U.S. Geological Survey.

Davis, L.C., 2010, A*n Update of Hydrologic Conditions and Distribution of Selected Constituents in Water, Snake River Plain Aquifer and Perched Groundwater Zones, Idaho National Laboratory, Idaho, Emphasis 2006-08*, U.S. Geological Survey Scientific Investigations Report 2010-5197 (DOE/ID-22212), U.S. Geological Survey.

DOE Order 5400.5, 1993, "Radiation Protection of the Public and the Environment," Chapter III, "Derived Concentration Guides for Air and Water," Change 2, U.S. Department of Energy.

DOE-ID, 1992, *Record of Decision for the Test Reactor Area Perched Water System, Operable Unit 2-12*, Document ID: 5230, U.S. Department of Energy Idaho Operations Office, U.S. Environmental Protection Agency, Idaho Department of Health and Welfare.

DOE-ID, 2003, *Monitored Natural Attenuation Operations, Monitoring, and Maintenance Plan for Test Area North, Operable Unit 1-07B*, DOE/ID-11066, Rev. 0, U.S. Department of Energy Idaho Operations Office.

DOE-ID, 2005, *Five-Year Review of CERCLA Response Actions at the Idaho National Laboratory*, DOE/NE-ID-11201, Rev. 0, U.S. Department of Energy Idaho Operations Office.

DOE-ID, 2007, *Groundwater Monitoring and Field Sampling Plan for Operable Unit 10-08*, DOE/NE-ID-11210, Rev. 2, U.S. Department of Energy Idaho Operations Office.

DOE-ID, 2009, *Long-term Monitoring and Field Sampling Plan for the Central Facilities Area Landfills I, II, and III under Operable Unit 4-12*, DOE/ID-11374, Rev. 0, U.S. Department of Energy Idaho Operations Office.

DOE-ID, 2010a, *Idaho National Laboratory Environmental Monitoring Plan*, DOE/ID-10-11088, Rev. 2, U.S. Department of Energy Idaho Operations Office.

DOE-ID, 2010b, *Post-Record of Decision Groundwater Monitoring and Field Sampling Plan for Operable Unit 10-08*, DOE/ID-11420, Rev. 0, U.S. Department of Energy Idaho Operations Office.

DOE-ID, 2011a, *Annual Report for the Final Groundwater Remediation, Test Area North, Operable Unit 1-07B, Fiscal Year 2010*, DOE/ID-11440, Rev. 0, U.S. Department of Energy Idaho Operations Office.

DOE-ID, 2011b, *Fiscal Year 2010 Annual Report for Operable Unit 3-14, Tank Farm Soil and INTEC Groundwater*, DOE/ID-11442, Rev. 0, U.S. Department of Energy Idaho Operations Office.

Geslin, J. K., P. K. Link, and C. M. Fanning, 1999, "High-precision Provenance Determination Using Detrital-zircon Ages and Petrography of Quaternary Sands on the Eastern Snake River Plain Idaho," *Geology*, Vol. 27, No. 4, pp. 295 – 298.

ICP, 2011a, *Annual Groundwater Monitoring Status Report for Waste Area Group 2 for Fiscal Year 2011*, RPT-823, Rev. 0, Draft, Idaho Cleanup Project.

ICP, 2011b, *Central Facilities Area Landfills I, II, and III Annual Monitoring Report – 2010*, RPT-779, Rev. 0, Idaho Cleanup Project.

IDAPA 58.01.11, 2009, "Ground Water Quality Rule," Idaho Administrative Procedures Act.

Knobel, L. L., B. R. Orr, and L. D. Cecil, 1992, "Summary of Concentrations of Selected Radiochemical and Chemical Constituents in Groundwater from the Snake River Plain Aquifer, Idaho: Estimated from an Analysis of Previously Published Data," *Journal of Idaho Academy of Science*, Vol. 28, No. 1, pp. 48-61, June 1992.

Knobel, L. L., B. J. Tucker, and J. P. Rousseau, 2008, *Field Methods and Quality-Assurance Plan for Quality-of-Water Activities*, U.S. Geological Survey, Idaho National Laboratory, Idaho, U. S. Geological Survey Open-File Report 2008-1165 (DOE/ID-22206), U. S. Geological Survey.

Mann, L. J., 1996, *Quality-Assurance Plan and Field Methods for Quality-of-Water Activities*, U.S. Geological Survey, Idaho National Engineering Laboratory, Idaho, U.S. Geological Survey Open-File Report 96-615 (DOE/ID-22132), U.S. Geological Survey.

Mann, L. J., E. W. Chew, E. J. S. Morton, and R. B. Randolph, 1988, *Iodine-129 in the Snake River Plain Aquifer at the Idaho National Engineering Laboratory, Idaho*, U.S. Geological Survey Water-Resources Investigations Report 88-4165 (DOE/ID-22076), U.S. Geological Survey.

Mann, L. J., and T. M. Beasley, 1994, *Iodine-129 in the Snake River Plain Aquifer at and near the Idaho National Engineering Laboratory, Idaho, 1990-91*, U.S. Geological Survey Water-Resources Report 94-4053, U.S. Geological Survey.

Orr, B. R., L. D. Cecil, and L. L. Knobel, 1991, *Background Concentrations of Selected Radionuclides, Organic Compounds, and Chemical Constituents in Ground Water in the Vicinity of the Idaho National Engineering Laboratory*, U.S. Geological Survey Water-Re sources Investigations Report 91-4015 (DOE/ID-22094), U.S. Geological Survey.

Smith, R. P. 2004, "Geologic Setting of the Snake River Plain Aquifer and Vadose Zone," *Vadose Zone Journal*, Vol. 3. pp. 47 – 58.

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

Chapter 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 sampled by the Environmental Surveillance, Education, and Research contractor 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, wheat, and potatoes) collected in 2010. However, the results could not be directly linked to operations at the INL Site. 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 12 road-killed, large game animals sampled in 2010. 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 radionuclides associated with past INL Site operations. Cesium-137 and strontium-90 were detected in soil samples collected outside the INL Site boundary. The concentrations of these radionuclides have been decreasing over time and appear to be associated with global fallout.

Direct radiation measurements made at boundary and distant locations were consistent with background levels. The average annual dose equivalent from external exposure was 128 mrem at boundary locations and 127 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 those made historically at that location. This is due to the fact that the active pit was covered in 2009.

Ecological monitoring at the INL Site was conducted under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Yearly sampling and surveys were performed from 2003 through 2008 and focused on contaminant analysis and effects on terrestrial and aquatic biota. The results decreased uncertainties in the INL Site-wide ecological risk assessment and increased confidence that the no-action decision is protective.

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 2010. 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

INL Site-released radionuclides may be assimilated by agricultural products and game animals which humans may then consume. These media 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 2010, 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


Rough-legged Hawk

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				•				

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.

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.

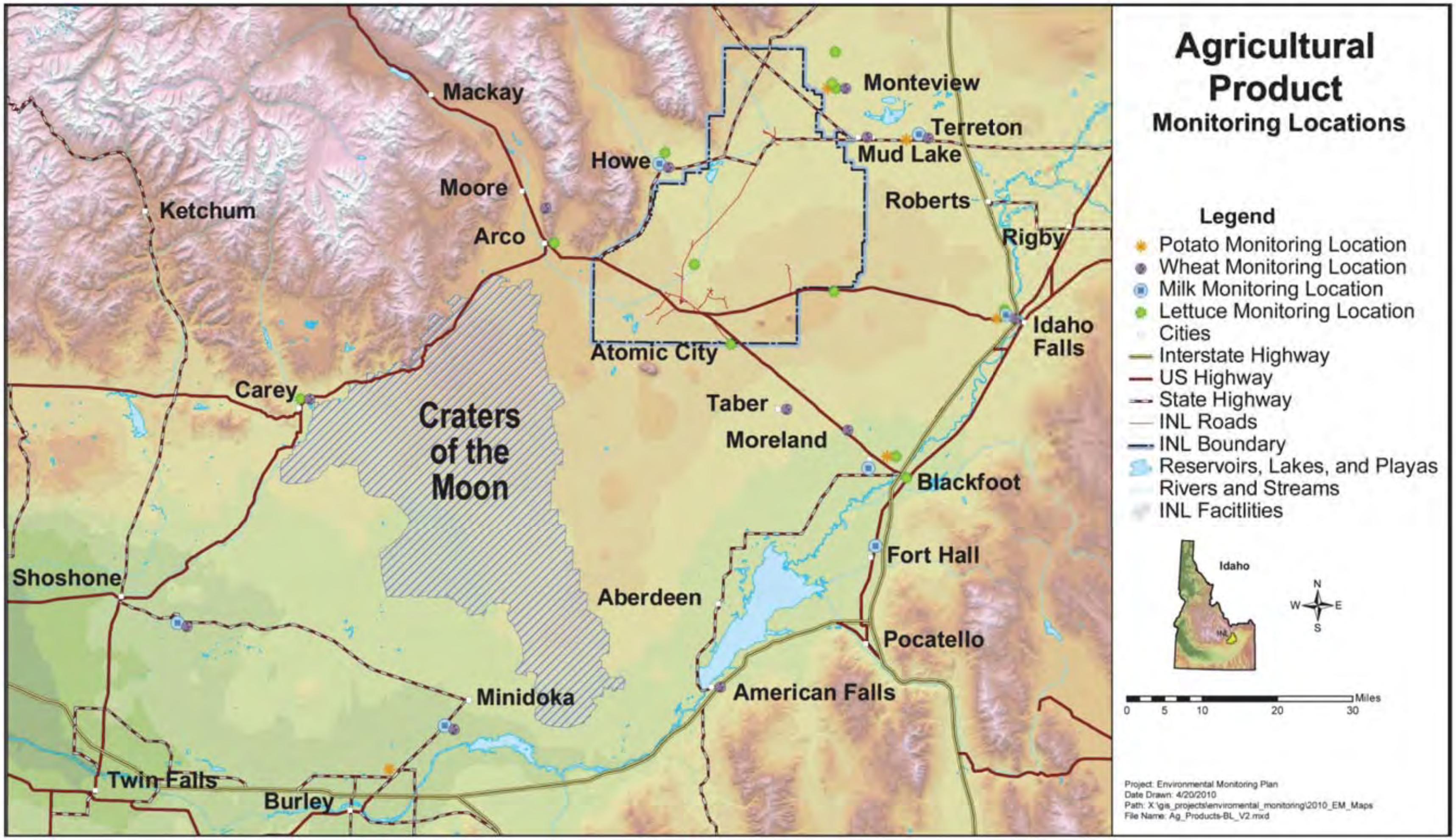


Figure 7-1. Locations of Agricultural Product Samples Collected (2010).

Rough-legged Hawk

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 reactors or weapons, is readily detected and, along with cesium-134 and ^{137}Cs, can dominate the ingestion dose regionally after a severe nuclear event such as the Chernobyl accident (Kirchner 1994). 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 long gone. A small amount of ^{131}I (approximately 5.5 mCi in 2010) 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 was not detected in any milk sample in 2010.

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 initially detected in one milk sample collected in 2010 at just above the detection limit. However, both a subsequent recount of the sample and analysis of a laboratory split sample failed to confirm the presence of ^{137}Cs.

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 12 of 15 milk samples analyzed, including the two control samples from outside the state. Concentrations ranged from 0.06 pCi/L at Howe to 1.84 pCi/L at Rupert (Figure 7-2). These levels were consistent with levels reported by the U.S. Environmental Protection Agency as resulting from worldwide fallout deposited on soil and taken up by cows through ingestion of grass. Results from Environmental Protection Agency Region X (which includes Idaho) of five samples collected over the years covered (e.g., 2006-2010) ranged from 0 to 1.0 pCi/L (EPA 2010).

DOE has established Derived Concentration Guides (DCGs) for radionuclides in air and water. A DCG 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 DCG for foodstuffs such as milk. For reference purposes, the DCG for ^{90}Sr in water is 1,000 pCi/L. The maximum observed value in milk samples (1.8 pCi/L) is, therefore, just under 0.2 percent of this DCG for drinking water.

Tritium, with a half-life of about 12 years, is an important radionuclide because it is a radioactive form of hydrogen, which combines with oxygen to form tritiated water. The environmental behavior of tritiated water is like that of water, and 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

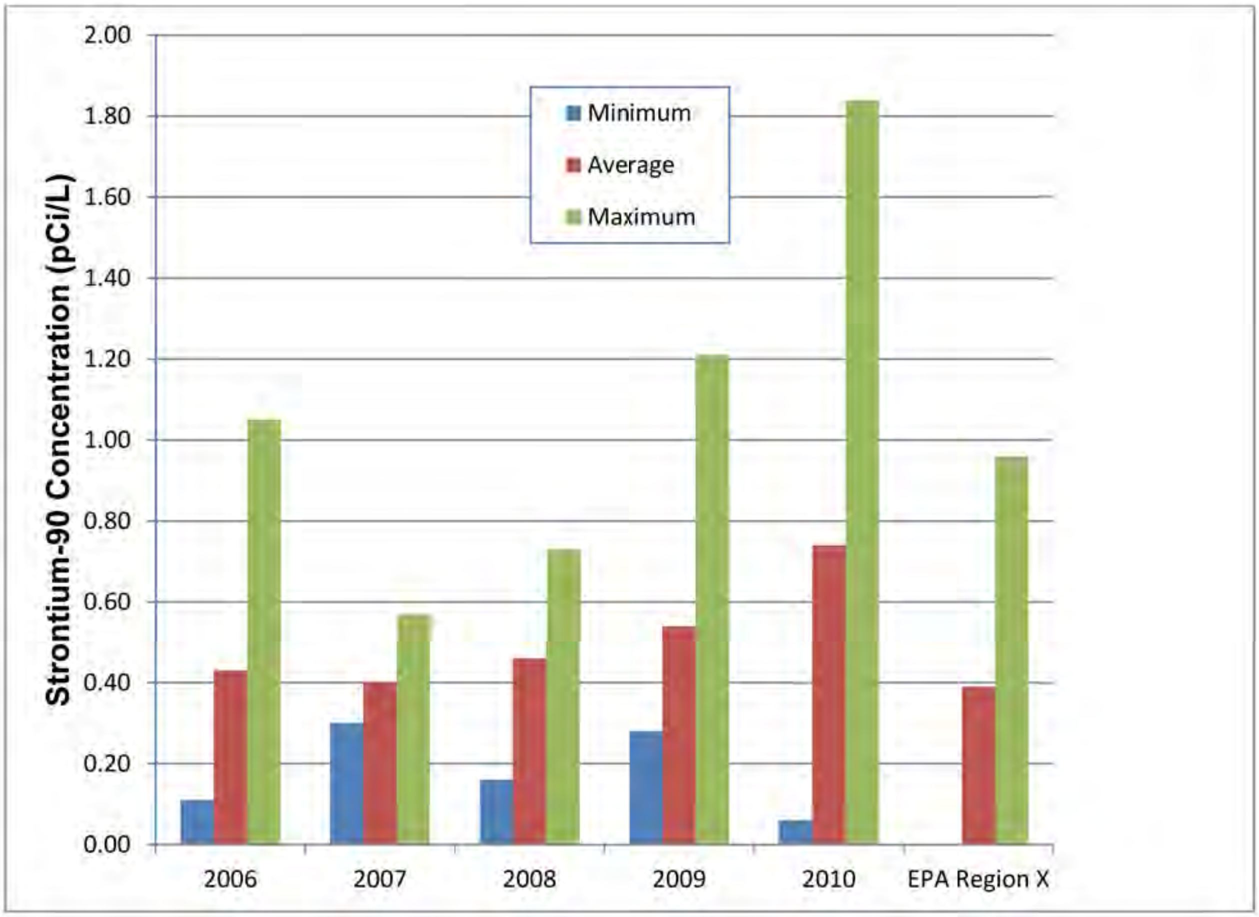


Figure 7-2. Strontium-90 Concentrations in Milk (2006 – 2010).

surface water that animals drink, as well as from plants that contain water. Tritium was detected in three of 16 milk samples analyzed at concentrations of 112 pCi/L in Blackfoot, 113 pCi/L in Fort Hall, and 219 pCi/L in Rupert. These concentrations are similar to those of previous years and are consistent with those found in atmospheric moisture and precipitation samples. The DCG for tritium in water is 20,000 pCi/L. The maximum observed value in milk samples is approximately one percent of the DCG.

In addition to analyzing milk, the ESER contractor collected 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* (Appendix B). 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 alfalfa sample was analyzed for gamma-emitting radionuclides. No man-made radionuclides were detected in the sample.

7.1.2 Lettuce

Lettuce was sampled in 2010 because radionuclides in air can be deposited on soil and plants (especially leafy vegetables), 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 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

Figure 7-3. Portable Lettuce Planter.

deposited from air to accumulate on the soil and plant surfaces throughout the growth cycle. The planters are set out 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, Howe, and Idaho Falls. A control sample from an out-of-state location was obtained and a duplicate sample was collected at Carey. The samples were analyzed for ^{90}Sr and gamma-emitting radionuclides.

Strontium-90 was detected in two of the 11 lettuce samples collected. The maximum ^{90}Sr concentration of 74 pCi/kg, measured in the lettuce sample from the Federal Aviation Administration Tower, was within the range of concentrations detected in the past 5 years (0-96 pCi/kg) and was most likely from weapons testing fallout. 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

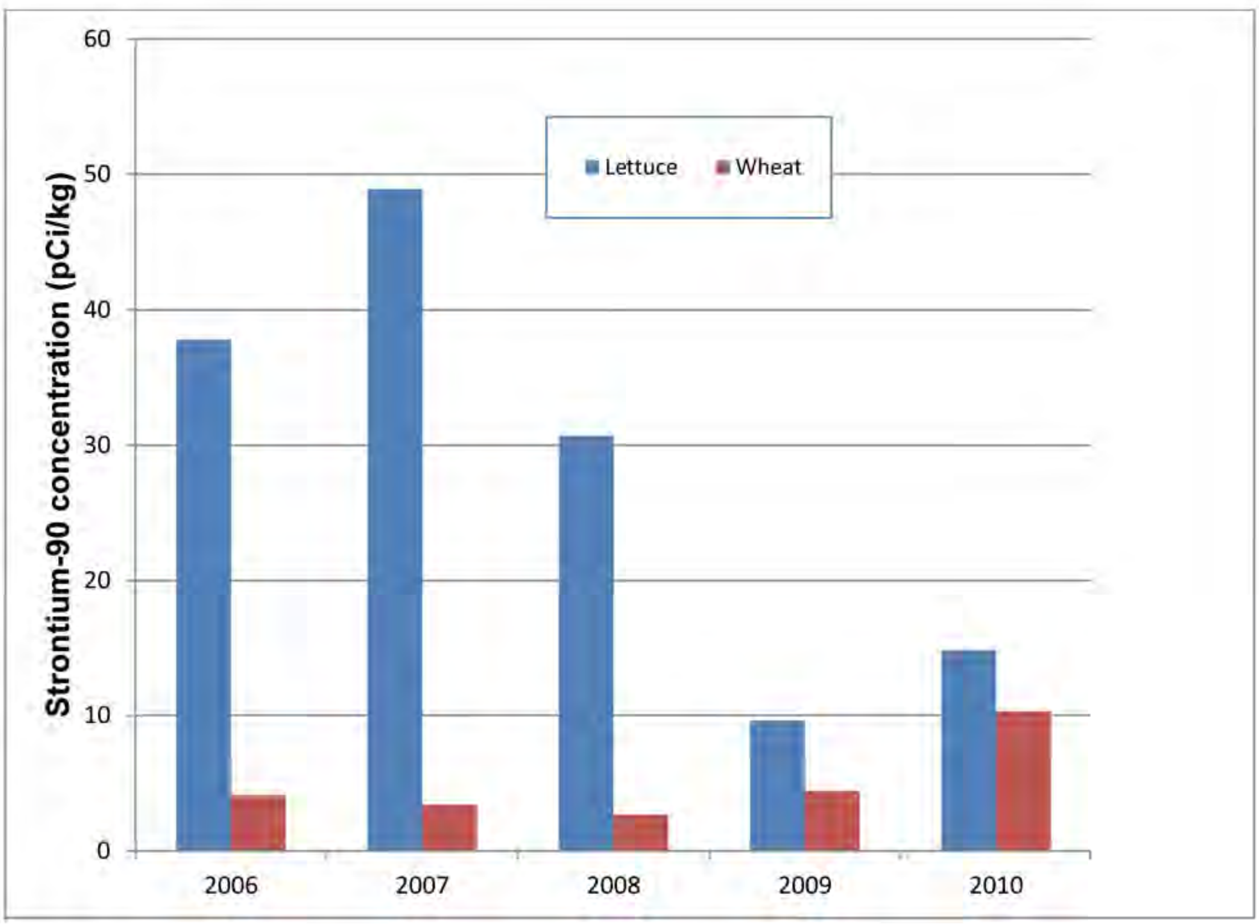


Figure 7-4. Average Strontium-90 Concentrations in Lettuce and Wheat (2006 – 2010).

Rough-legged Hawk

below detection levels) from 2006 through 2010. A general decreasing trend is apparent, most likely due to radioactive decay.

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 Wheat

Wheat is sampled because it is a staple crop in the region. The ESER contractor collected 14 wheat samples from areas surrounding the INL Site in 2010 and obtained one commercially-available sample from outside the state of Idaho. The locations were selected because they are typically farmed for wheat and are encompassed by the air surveillance network. Exact locations may change as wheat growers rotate their crops. Six of the 14 wheat samples (including the out-of-state sample) collected in 2010 contained detectable concentrations of ^{90}Sr, with a maximum result of 20 pCi/kg detected in the Mud Lake sample. This is the maximum concentration measured in the last 5 years. Average current and historical results are presented in Figure 7-4. There does not appear to be a clear trend in the mean ^{90}Sr concentrations measured in wheat, although the last two collection cycles appear somewhat higher than the previous three. The concentrations measured in wheat 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 is.

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 nine locations in the vicinity of the INL Site and at one location off the INL Site (Oregon). One of the 10 potato samples collected during 2010 contained a detectable concentration of any human-made, gamma-emitting radionuclides. Strontium-90 was detected at just above the detection limit (1.57 pCi/kg) in the sample from Rupert.

7.1.5 Large Game Animals

Muscle samples were collected by the ESER contractor from 12 game animals (seven pronghorn, four mule deer, and one elk) accidentally killed on INL Site roads. Thyroid samples were obtained for eight of the animals, and liver samples were collected from six 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 2010.

Of the muscle and liver samples collected in 2010, ^{137}Cs was detected at a concentration of 2.77 pCi/kg from only one muscle sample collected in October. This value was just below 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.

7.1.6 Waterfowl

Waterfowl are collected each year by the ESER contractor at ponds on the INL Site and at a location off the INL Site. Nine ducks were collected during 2010: three each from the ATR Complex wastewater ponds, the Materials and Fuels Complex wastewater ponds, and a control location at the Fort Hall Bottoms. 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 ^{241}Am, ^{137}Cs, cobalt-60 (^{60}Co), ^{238}Pu, $^{239/240}Pu$, ^{90}Sr, and zinc-65. Except for ^{241}Am, all these radionuclides also were found in at least one edible tissue sample. Samples from Materials and Fuels Complex ponds and the Fort Hall control location contained only ^{90}Sr, and only one of the detections was in edible tissue from a control sample. Radionuclide concentrations measured in the edible tissues of waterfowl from the ATR Complex in 2010 are shown in Figure 7-5. Plutonium and the one detection of ^{90}Sr from the control location are not displayed because the low concentrations do not show up on the scale of the graph.

Because most of the detected human-made radionuclides were found in ducks from the 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 the detected radionuclides from the ATR Complex were slightly higher than those from 2006 through 2009, but ^{137}Cs concentrations were much lower than in 2005. In addition, concentrations were lower in 2009 than those of a 1994 – 1998 study (Warren et al. 2001). Further information on potential doses from consuming waterfowl is presented in Chapter 8.

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

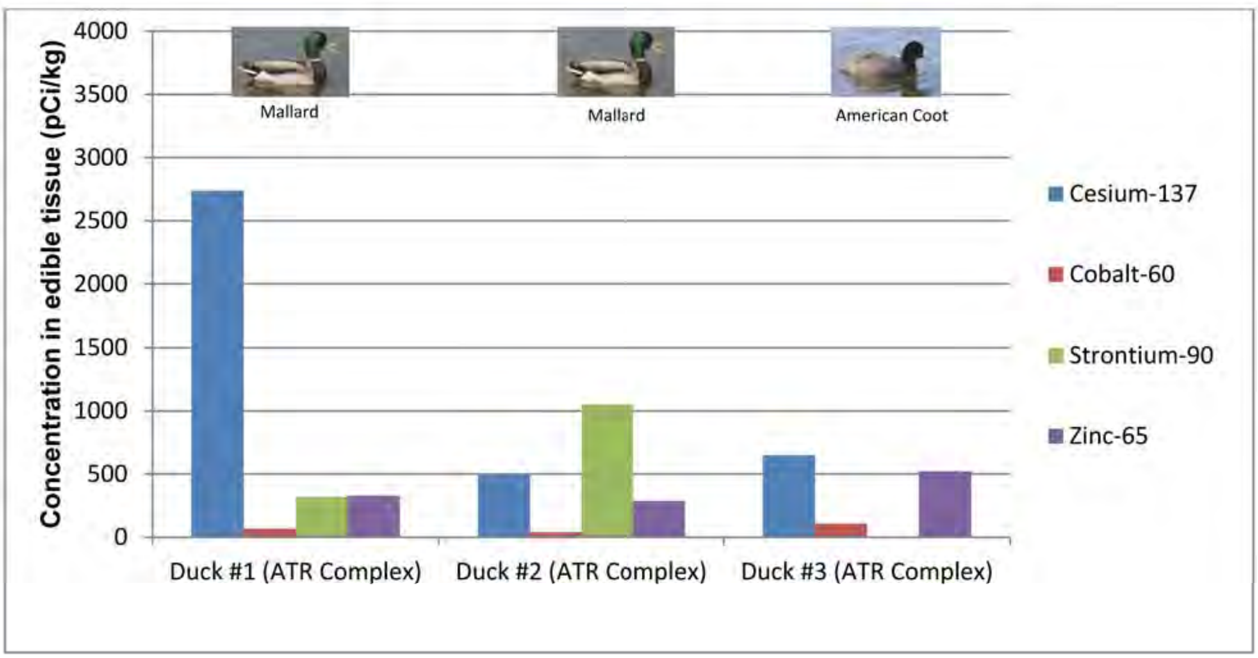


Figure 7-5. Radionuclide Concentrations Detected in Edible Tissues of Waterfowl (2010).

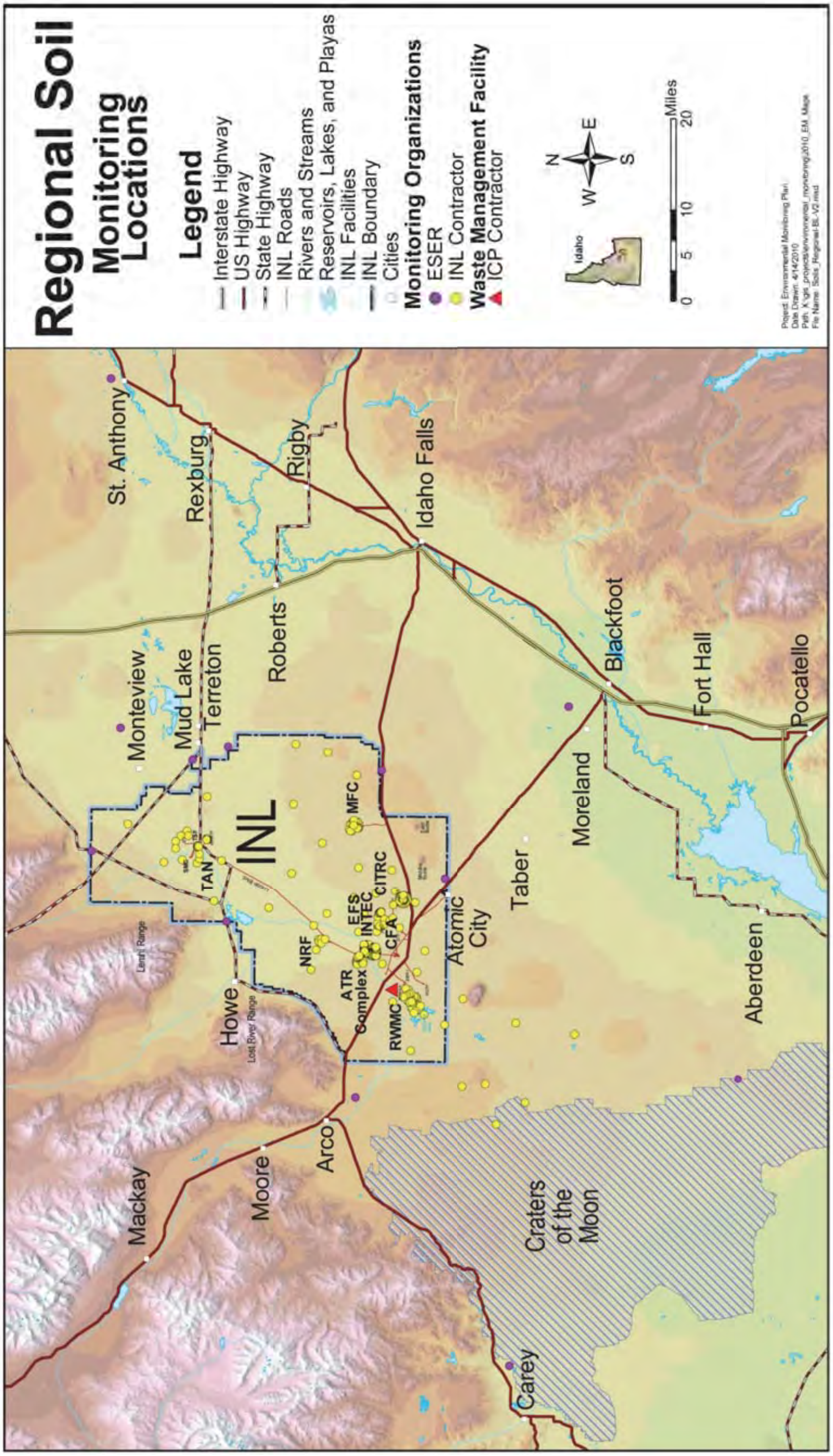


Figure 7-6. Soil Sampling Locations.

Rough-legged Hawk

Cabin located at the southern boundary of the INL Site. This location has been the site of the maximally exposed individual for dose calculation purposes for several years (see Chapter 8). Soil samples are analyzed for gamma-emitting radionuclides, ^{90}Sr, ^{241}Am, and plutonium radionuclides.

Soil was 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. Above-ground 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. 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. Soils are sampled at 10 locations within the land application area following each application season. Subsamples are taken from 0 to 30 cm (0 to 12 in.), 30 to 61 cm (12 to 24 in.), and 61 to 91 cm (24 to 36 in.) at each location and composited for each depth interval, yielding three samples, one from each depth. These samples are analyzed for pH, electrical conductivity, sodium adsorption ratio, percent organic matter, extractable phosphorus, and nitrogen, in accordance with the Wastewater Reuse Permit, to determine if wastewater application is adversely affecting soil chemistry. The analytical results for the soil samples are summarized in Table 7-2. The analytical results for 2009 are included for comparison.

Idaho Department of Environmental Quality guidance (DEQ 2007) states that “bacteria that decompose organic matter function best at a pH range between 6.5 and 8.5.” The 2010 soil pH for all soil depths was within this range (Table 7-2).

Excessive salts can adversely affect soil and plant health. Conversely, low to moderate salinity, measured as electrical conductivity, may actually improve the physical conditions of some soils.

Currently, the soil salinity in the application area is below the 6-mmhos/cm level expected to result in a decrease in relative growth of crested wheatgrass (Blaylock 1994) and sagebrush (Swift 1997).

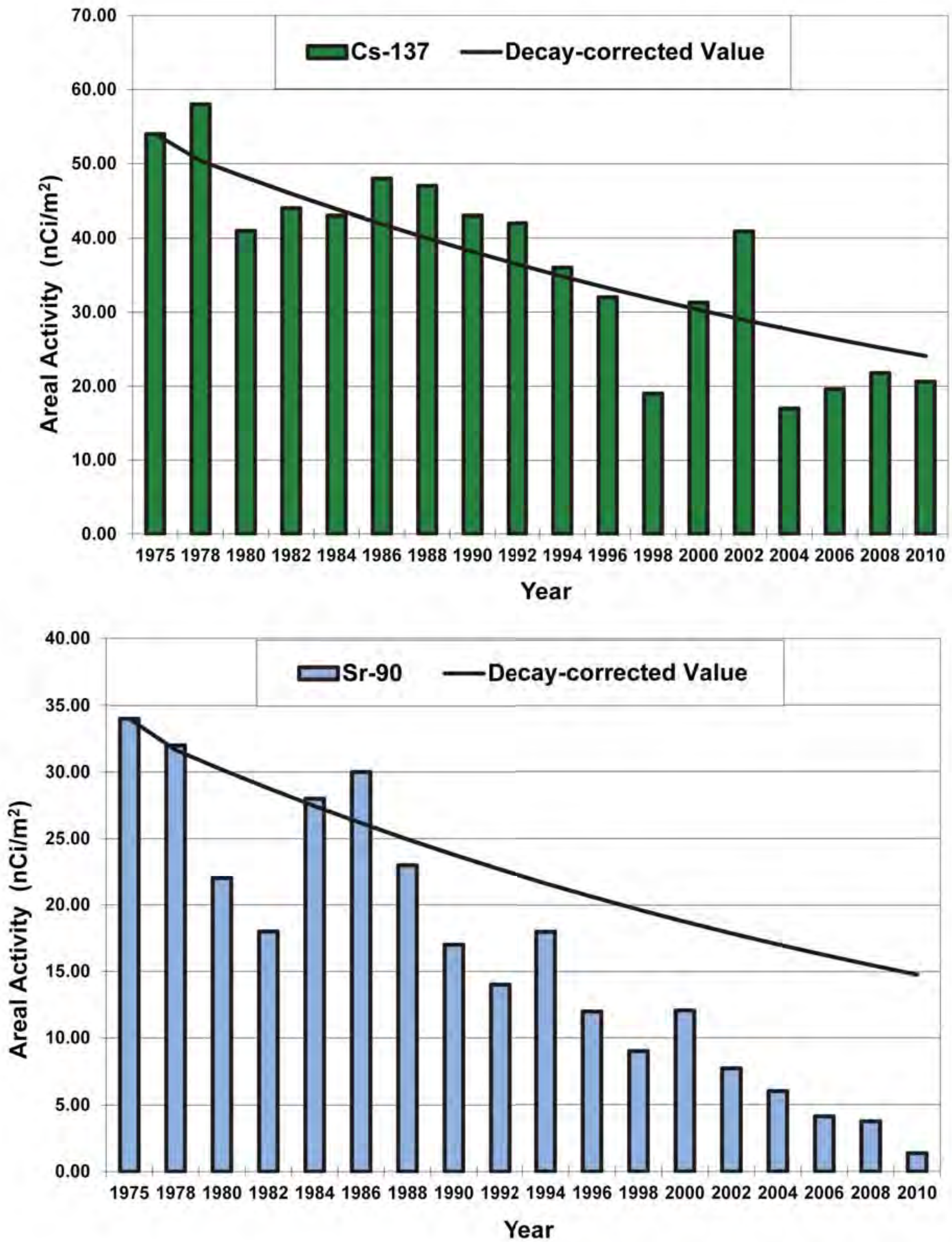


Figure 7-7. Mean Activities in Surface (0 – 12 cm [0 – 5 in.]) Soils off the INL Site (1975 – 2010).

Rough-legged Hawk

Soils with sodium adsorption ratios below 15 and electrical conductivity levels below 2 mmhos/cm are generally classified as not having sodium or salinity problems (Bohn et al. 1985). The sodium adsorption ratio indicates the exchangeable sodium levels in soil. Soils with high exchangeable sodium levels tend to crust badly or disperse, which greatly decreases soil hydraulic conductivity. All sodium adsorption ratios remained well below 15 at all depth intervals. Idaho Department of Environmental Quality guidance (DEQ 2007) states, "For most crops grown on land treatment sites, soil sodium adsorption ratios of less than ten are acceptable."

The nitrogen data in Table 7-2 suggest negligible nitrogen accumulation from wastewater application. The low soil-available nitrogen (ammonium and nitrate) concentrations suggest that sagebrush and grass vegetation use all the plant-available nitrogen and that the total nitrogen application is low. Increased nutrients and water from wastewater application may be stimulating

Table 7-2. Soil Monitoring Results for the Central Facilities Area Sewage Treatment Facility Wastewater Reuse Permit Area (2009 and 2010).

Parameter	Depth (in.)	2009	2010
pH	0 – 12	8.26	7.97
	12 – 24	7.95	7.85
	24 – 36	8.05	7.85
Electrical conductivity (mmhos/cm)	0 – 12	0.675	1.091
	12 – 24	2.49	2.660
	24 – 36	1.937	2.590
Organic matter (%)	0 – 12	1.51	1.72
	12 – 24	0.655	0.828
	24 – 36	0.424	0.603
Nitrate as nitrogen (ppm)	0 – 12	1.62	1.41
	12 – 24	0.998 U[a]	1.02 U
	24 – 36	0.996 U	1.01 U
Ammonium nitrogen (ppm)	0 – 12	0.818	0.512 U
	12 – 24	0.499 U	0.508 U
	24 – 36	0.498 U	0.507 U
Extractable phosphorus (ppm)	0 – 12	7.77	15.4
	12 – 24	1.72	3.64
	24 – 36	1.28	4.34
Sodium adsorption ratio	0 – 12	3.83	4.32
	12 – 24	4.19	5.10
	24 – 36	2.5	4.62

a. U flag indicates that the result was reported as below the detection limit.

plant growth, which in turn rapidly uses plant-available nitrogen. The ammonium and nitrate concentrations are comparable to those of nonfertilized agricultural soils.

Idaho Department of Environmental Quality guidance (DEQ 2007) recommends that total phosphorus should be less than 30 ppm (Olsen method used in these analyses) in the 24–36-in. soil depth to ensure there are no groundwater contamination concerns. Table 7-2 shows the phosphorus concentrations are well below the level of concern at all depths.

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 cost effective way to assay surface soil for gamma-emitting radionuclides, especially as part of site characterization. In 2010, several other naturally occurring and anthropogenic radionuclides were measured for this work. These included the following naturally-occurring radioactive materials (NORM) isotopes: bismuth-214, actinium-228, lead-214, radium-226, thallium-208, uranium-234, and uranium-238 (^{238}U). Anthropogenic isotopes measured in 2010 (in addition to Cs-137) include the following: uranium-235, antimony-125, europium-152 (^{152}Eu), ^{60}Co, and ^{241}Am. Results reported for this report are those that are true positive detects. This means that the reported isotopic concentration is above three times the reported uncertainty for that isotope.

The INL contractor performed 300 field-based gamma spectrometry measurements in 2010 using several HPGe detector measurement systems based on the methodology described in the Environmental Measurements Laboratory Procedures Manual (DOE 1997). A summary of results is presented in Table 7-3. Statistical results in Table 7-3 are based on positive detect values at each site. Appendix D (Figures D-1 through D-7) shows facility maps with the positive detect values. At the Radioactive Waste Management Complex (RWMC), elevated values of ^{241}Am- were detected along the east and north boundary areas. Elevated count rates were also observed along the east boundary during the annual perimeter survey performed in 2010 (BEA 2011). These values are likely due to the shine from above-ground waste storage and disposal operations sites. Confirmatory measurements will be made in calendar year 2011 at these locations using collimated detector systems to minimize the effects of shine, and provide a better estimate of the ^{241}Am soil concentrations.

A single elevated ^{238}U value was also noted, but this value is not statistically different from normal background concentrations for this isotope. At ATR Complex, several locations showed very low concentrations of ^{60}Co and one location showed a positive detect for ^{152}Eu. Idaho Nuclear Technology and Engineering Center results showed two ^{60}Co positive detects near waste storage areas. Both values were near historical levels (Jessmore et al 1994). Two elevated ^{238}U values were noted for points in the large grid. These values are between 2 and 3 pCi/g, which is slightly higher than the nominal background value of 1 pCi/g (Rood et al. 1996).

Rough-legged Hawk

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. The dosimetry packets are replaced in May and November of each year. The sampling periods for 2010 were from November 2009 through April 2010 (spring collection) and from May through October 2010 (fall collection).

Table 7-3. In Situ Gamma Scan Results for INL Site Locations (2010) (all values in pCi/g).

Location	Radionuclide detected	Number of Observations	Minimum	Maximum	Mean
ARA	Cesium-137	58	0.134	3.99	0.826
CITRC	Cesium	14	0.0924	0.219	0.172
INTEC	Cesium	87	0.0233	3.92	1.154
INTEC	Cobalt-60	4	0.0163	0.036	0.023
Large Grid	Cesium-137	40	0.0865	0.337	0.199
Large Grid	Uranium-238	6	0.693	2.85	1.478
MFC	Cesium-137	15	0.0718	0.329	0.202
MFC	Cobalt-60	2	0.0155	0.032	0.0238
NRF	Cesium	5	0.131	0.28	0.207
RTC	Cesium	24	0.0862	0.77	0.324
RTC	Cobalt-60	18	0.0029	0.0436	0.0177
RTC	Europium-152	1	1.28	1.28	1.28
RWMC	Americium-241[a]	4	1.14	37.7	12.93
RWMC	Cesium-137	39	0.0495	0.306	0.182
RWMC	Uranium-238	1	1.81	1.81	1.81
TAN-SMC	Cesium-137	17	0.0976	0.83	0.227

a. The maximum result is most likely from shine from material containing Am-241, which is stored near where the surface activity was measured. Additional measurements will be taken using a collimated in situ detector in 2011. The result was left in the table to be conservative.

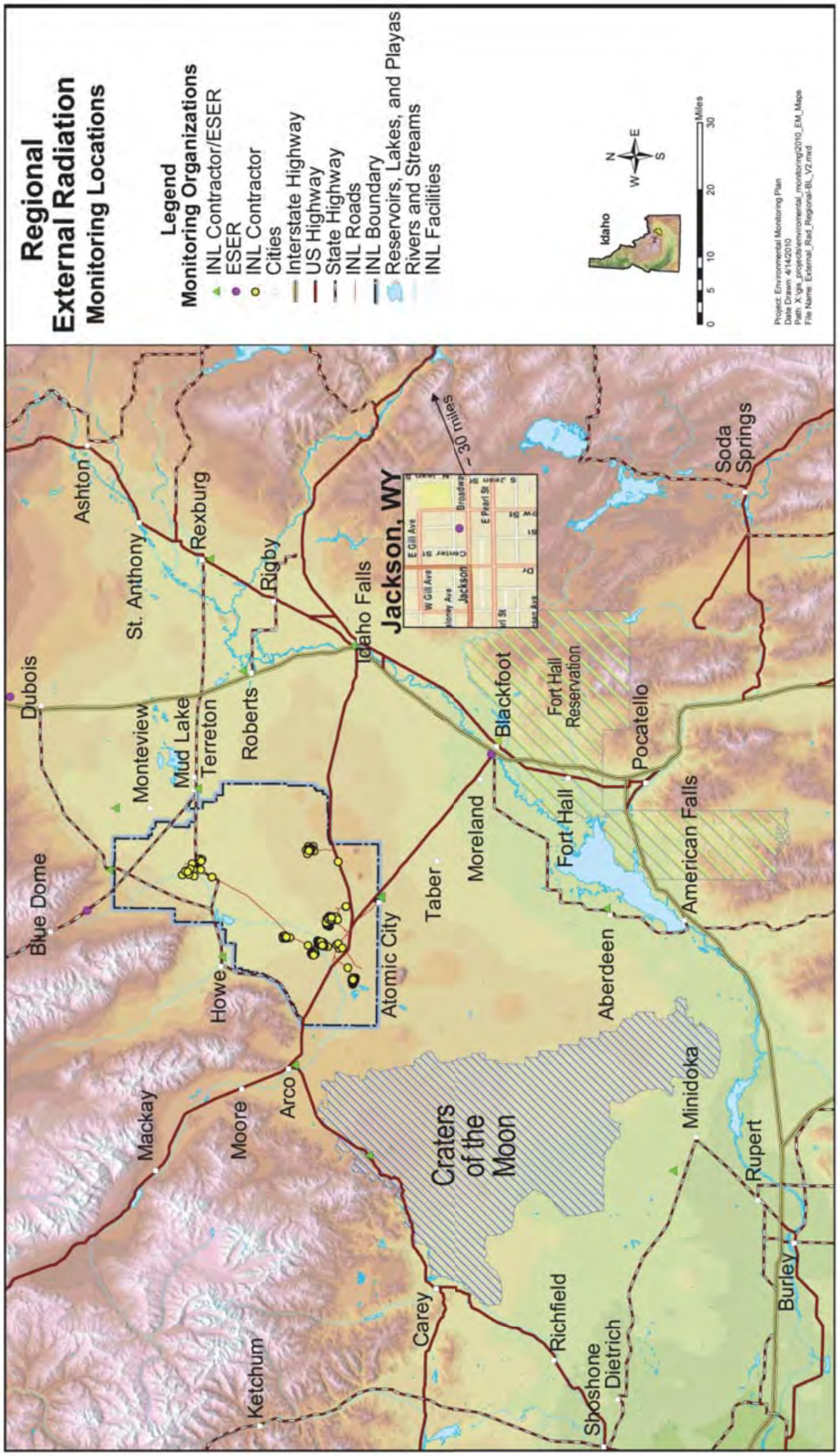


Figure 7-8. Regional Direct Radiation Monitoring Locations.

The measured cumulative environmental radiation exposure for locations off the INL Site from November 2009 through October 2010 is shown in Table 7-4 for two adjacent sets of dosimeters maintained by the ESER and INL contractor. For purposes of comparison, annual exposures from 2006 to 2009 also are included for each location.

The mean annual exposures from distant locations in 2010 were 120 milliroentgens (mR) measured by the ESER contractor dosimeters and 126 mR measured by the INL contractor dosimeters. For boundary locations, the mean annual exposures were 122 mR measured by the ESER contractor dosimeters and 127 mR measured by the INL contractor dosimeters. Using both ESER and INL contractors' data, the average dose equivalent of the distant group was 127 mrem when a dose equivalent conversion factor of 1.03 mrem/mR (for 662 keV gamma rays) was used to convert from mR to mrem in tissue (ANSI/HPS 2009). The average dose equivalent for the boundary group was 128 mrem.

TLDs 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, and 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 TLDs 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.

The maximum exposure (dose equivalent) recorded by a TLD on the INL Site during 2010 was 544 mR (560 mrem) at the ATR Complex. This location, TRA 13, is near controlled radioactive material areas where movement and storage of materials affect the exposure rate. This exposure is significantly higher than those of 2009 and 2008, which were 193 mR and 148 mR, respectively.

At some point during the April 2010 retrieval and analysis of the TLDs, the TLD packet for location ICPP Tree Farm was misplaced, and there is no data reported for that location and time period in Table D-1. The exposure reported for the subsequent sampling period was 88 mR, or 91 mrem, which is consistent with the average of 81 mR (83 mrem) from the six sampling periods from the previous three years.

Table 7-5 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).

Western Bluebird

Table 7-4. Annual Environmental Radiation Exposures (2006 – 2010).

Location	2006 ESER[a]	2006 INL[b] Contractor	2007 ESER	2007 INL Contractor	2008 ESER	2008 INL Contractor	2009 ESER	2009 INL Contractor	2010 ESER	2010 INL Contractor
	(mR)									
Distant Group										
Aberdeen	129 ± 6	127 ± 6	128 ± 9	132 ± 9	130 ± 6	128 ± 9	130 ± 6	128 ± 9	130 ± 6	133 ± 9
Blackfoot	119 ± 6	109 ± 5	118 ± 8	111 ± 8	122 ± 6	113 ± 8	122 ± 6	113 ± 8	120 ± 6	114 ± 8
Blackfoot (CMS)[c,d]	109 ± 5	N/A	110 ± 8	N/A	110 ± 6	NA	110 ± 6	NA	113 ± 6	NA
Craters of the Moon	120 ± 6	129 ± 6	116 ± 8	117 ± 8	120 ± 5	125 ± 9	120 ± 5	125 ± 9	121 ± 5	135 ± 9
Dubois[d]	101 ± 5	N/A	100 ± 7	N/A	103 ± 5	NA	103 ± 5	NA	104 ± 5	NA
Idaho Falls	123 ± 2	119 ± 6	121 ± 8	117 ± 8	120 ± 6	121 ± 8	120 ± 6	121 ± 8	124 ± 6	121 ± 8
Jackson[d]	97 ± 5	N/A	102 ± 7	N/A	102 ± 5	NA	102 ± 5	NA	102 ± 5	NA
Minidoka	109 ± 5	111 ± 5	109 ± 8	112 ± 8	111 ± 5	111 ± 8	111 ± 5	111 ± 8	114 ± 6	119 ± 8
Rexburg	145 ± 7	120 ± 6	135 ± 9	116 ± 8	138 ± 7	118 ± 8	138 ± 7	118 ± 8	152 ± 7	128 ± 9
Roberts	137 ± 7	133 ± 7	129 ± 9	132 ± 9	130 ± 6	130 ± 9	130 ± 6	130 ± 9	--[e]	143 ± 10
Mean	119 ± 6	121 ± 6	117 ± 8	120 ± 8	119 ± 6	121 ± 8	119 ± 6	121 ± 8	120 ± 6	126 ± 9
Boundary Group										
Arco	115 ± 8	111 ± 8	127 ± 6	125 ± 6	119 ± 8	121 ± 8	121 ± 6	124 ± 9	128 ± 6	129 ± 9
Atomic City	119 ± 8	112 ± 8	129 ± 6	124 ± 6	126 ± 9	120 ± 8	122 ± 6	120 ± 8	127 ± 6	122 ± 8
Blue Dome[d]	101 ± 7	N/A	104 ± 5	N/A	106 ± 7	N/A	107 ± 5	NA	105 ± 5	NA
Howe	108 ± 8	105 ± 7	118 ± 6	120 ± 6	117 ± 8	116 ± 8	116 ± 6	117 ± 8	117 ± 6	119 ± 8
Monteview	110 ± 8	107 ± 7	115 ± 6	119 ± 6	115 ± 8	120 ± 8	116 ± 5	119 ± 8	119 ± 6	128 ± 9
Mud Lake	119 ± 8	120 ± 8	128 ± 6	132 ± 6	128 ± 9	129 ± 9	130 ± 6	135 ± 9	134 ± 7	138 ± 10
Birch Creek Hydro	104 ± 7	103 ± 7	111 ± 5	109 ± 5	110 ± 8	114 ± 8	112 ± 6	113 ± 8	--[f]	NA
Mean	111 ± 8	110 ± 8	119 ± 6	121 ± 6	117 ± 8	120 ± 8	118 ± 6	121 ± 8	122 ± 6	127 ± 9

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.


Rough-legged Hawk

Table 7-5. Calculated Effective Dose Equivalent from Natural Background Sources (2010).

Source of Radiation Dose Equivalent		Total Average Annual Dose Calculated (mrem)	Total Average Annual Dose Measured (mrem)
External irradiation			
	Terrestrial	68[a]	NA[b]
	Cosmic	57[c]	NA
	Subtotal	125	127
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		382	

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 an 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

2010, this resulted in a corrected dose of 68 mrem/yr because of snow cover, which ranged from 2.54 to 40.6 cm (1 to 16 in.) deep over 95 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 2010 was calculated to be 126 mrem/yr (Table 7-5). This is approximately the same as the 127 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 7-5 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 (Rn-220), 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 382 mrem/yr (Table 7-5). The total effective dose equivalent from natural background radiation for residents in the INL Site vicinity actually may be higher or lower than 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 the 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 and a control location approximately seven miles south of the Subsurface Disposal Area at the base of Big Southern Butte. Crested wheatgrass and perennials (invasive species) are collected in odd-numbered years if available.

Rough-legged Hawk

Therefore, crested wheatgrass and perennials were not collected in 2010. Russian thistle was scheduled to be sampled during 2010; however, due to the amount of ongoing work on the Subsurface Disposal Area, there was not enough Russian thistle to obtain a representative sample.

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 Subsurface Disposal Area to complement soil sampling. The system utilizes a Trimble Global Positioning System and two plastic scintillation detectors connected to a personal computer on board the vehicle. The global positioning radiometric scanner system information 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 7-9 shows the radiation readings from the 2010 annual survey. Although readings vary slightly from year to year, the 2010 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 2010, the maximum gross gamma radiation measurement on the Subsurface Disposal Area was 18,710 cps, compared to the 2009 measurement of 23,489 cps. Both the 2010 and 2009 maximum readings were measured at the western end of the SVR-7 soil vault row.

7.5 CERCLA Ecological Monitoring

Ecological monitoring at the INL Site is 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 is no action with long-term ecological monitoring to reduce uncertainties in the INL Site-wide ecological risk assessment.

Yearly sampling and surveys were performed 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 A*gropyron 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

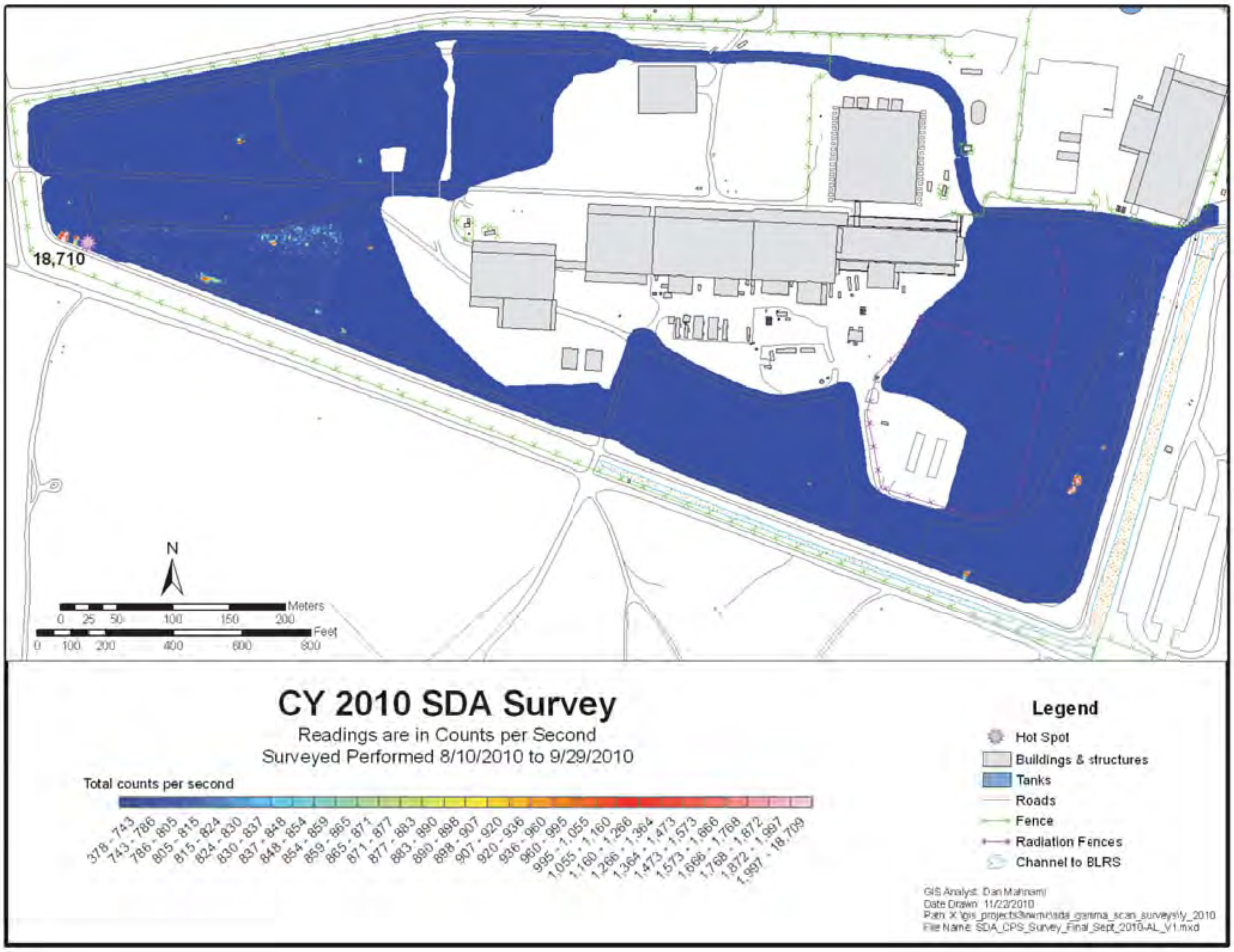


Figure 7-9. Radioactive Waste Management Complex Surface Radiation Survey (2010).

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. 2011) that concluded that monitoring substantially reduced uncertainties in the INL Site-wide ecological risk assessment and increased confidence that the no action decision is protective. Observed effects are limited and may be attributable wholly or partly to natural variability. Additional sampling under the Record of Decision will be conducted under a new monitoring plan that should be available in Fiscal Year 2012.


Rough-legged Hawk

REFERENCES

42 USC § 9601 et seq., 1980, “Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA/Superfund),” *United States Code*.

Amaral, E. C. S., H. G. Paretzke, M. J. Campos, M. A. Pires do Rio, and M. Franklin, 1994, “The Contribution of Soil Adhesion to Radiocaesium Uptake by Leafy Vegetables,” *Radiation and Environmental Biophysics*, Vol. 33, pp. 373-379.

ANSI/HPS N13.11-2009, *American National Standard, Personnel Dosimetry Performance Criteria for Testing*, Health Physics Society, McLean, VA.

BEA, 2011, *CDRL F.11 – Surface Radiation Survey Reports for 2010*, CCN 223140, Idaho National Laboratory.

Blaylock, A. D., 1994, *Soil Salinity, Salt Tolerance, and Growth Potential of Horticultural and Landscape Plants*, University of Wyoming, Cooperative Extension Service, Department of Plant, Soil, and Insect Sciences, College of Agriculture.

Bohn, H. L., B. L. McNeal, and G. A. O’Connor, 1985, *Soil Chemistry*, 2nd edition, New York: Wiley and Sons, Inc.

DEQ, 2007, *Guidance for Reclamation and Reuse of Municipal and Industrial Wastewater*, Idaho Department of Environmental Quality.

DOE, 1997, *EML Procedures Manual*, HASL-300, Vol. 1, 28th Edition, available at

http://www.eml.st.dhs.gov/publications/procman.cfm, Environmental Measurements Laboratory, U.S. Department of Energy.

DOE Order 435.1, 2001, “Radioactive Waste Management,” Change 1, U.S. Department of Energy.

DOE-ID, 1999, *Idaho National Engineering and Environmental Laboratory Site Environmental Report for Calendar-Year 1999*, DOE/ID-12082 (99), U.S. Department of Energy Idaho Operations Office.

DOE-ID, 2002, *Record of Decision, Experimental Breeder Reactor-1/Boiling Water Reactor Experiment Area and Miscellaneous Sites*, DOE/ID-10980, U.S. Department of Energy Idaho Operations Office.

DOE-ID, 2010, *Idaho National Laboratory Environmental Monitoring Plan*, DOE/ID-10-11088, Rev. 2, U.S. Department of Energy Idaho Operations Office.

EPA, 2010, *RadNet – Tracking Environmental Radiation Nationwide*, http://www.epa.gov/narel/radnet/, U.S. Environmental Protection Agency, Web page updated March 30, 2011, Web page visited May 22, 2011.

Fuhrmann, M. M. Lasat, S. Ebbs, J. Cornish, and L. Kochian, 2003, “Uptake and Release of Cesium-137 by Five Plant Species as Influenced by Soil Amendments in Field Experiments,” *Journal of Environmental Quality*, Vol. 32.

Jessmore, P. J., L. A. Lopez, and T. J. Haney, 1994, *Compilation and Evaluation of INEL Radiological and Environmental Sciences Laboratory Surface Soil Sample Data for Use in Operable Unit 10-06 Baseline Risk Assessment*, EGG-ER-11227, Rev. 0, Idaho National Engineering Laboratory.

Kirchner, G., 1994. "Transport of Cesium and Iodine Via the Grass-Cow-Milk Pathway After the Chernobyl Accident," *Health Physics*, Vol. 66, No. 6.

Mitchell, R. G., D. Peterson, D Roush, R. W. Brooks, L. R. Paulus, and D. B. Marton, 1997, *Idaho National Engineering and Environmental Laboratory Site Environmental Report for Calendar Year 1996*, DOE/ID-12082(96), August 1997.

NCRP, 2009, *Exposure of the Population in the United States and Canada from Natural Background Radiation*, NCRP Report No. 160, National Council on Radiation Protection.

Ng, Y. C., C. S. Colsher, and S. E. Thompson, 1982, *Soil-to-plant Concentration Factors for Radiological Assessments*, NUREG/CR-2975, Lawrence Livermore National Laboratory.

Pinder, J. E. III, K. W. McLeod, D. C. Adriano, J. C. Corey, and L. Boni, 1990, "Atmospheric Deposition, Resuspension and Root Uptake of Pu in Corn and Other Grain-Producing Agroecosystems Near a Nuclear Fuel Facility," *Health Physics*, Vol. 59, pp. 853-867.

Rood, S. M., G. A. Harris, G. J. White, 1996, *Background Dose Equivalent Rates and Surficial Soil Metal and Radionuclide Concentrations for the Idaho National Engineering Laboratory*, INEL-94/0250, Rev. 1, Idaho National Engineering Laboratory.

Schulz, R. K., 1965, "Soil Chemistry of Radionuclides," *Health Physics*, Vol. 11, No. 12, December 1965.

Shebell, P., S. Faller, M. Monetti, F. Bronson, R. Hagenauer, C. L. Jarrell, D. Keefer, J. R. Moos, N. Panzarino, R. T. Reiman, B. J. Sparks, and M. Thisell, 2003, "An In Situ Gamma-Ray Spectrometry Intercomparison," *Health Physics*, Vol. 85, No. 6, pp. 662 – 677.

Swift, C. E., Ph.D., 1997, *Salt Tolerance of Various Temperate Zone Ornamental Plants*, Area Extension Agent, Colorado State University.

Warren, R. W, S. J. Majors, and R. C. Morris, 2001, *Waterfowl Uptake of Radionuclides from the TRA Evaporation Ponds and Potential Dose to Humans Consuming Them*, Stoller-ESER-01-40, Environmental Surveillance, Education and Research.

VanHorn, Robin, and Thomas Haney, 2007, *Long-Term Ecological Monitoring Plan for the Idaho National Laboratory*, INEEL/EXT-02-01191, Rev. 3, Idaho Cleanup Project.

VanHorn, Robin L., Lorie S. Cahn, Valerie M. Kimbro, and K. Jean Holdren, 2011, *Operable Unit 10-04 Long Term Ecological Monitoring Report for Fiscal Years 2003 to 2008*, DOE/ID-11390, Rev. 0, Idaho Cleanup Project.

Chapter 8. Dose to the Public and Biota

Chapter 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 2010, as determined by this program, was 0.058 mrem, well below the applicable standard of 10 mrem per year.

The maximum potential population dose to the approximately 305,938 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 2010, the estimated potential dose was 1.62 person-rem. This dose is about 0.0014 percent of that expected from exposure to natural background radiation (116,868 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 0.006 mrem for ingestion of waterfowl and 0.004 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 2010, and, therefore, no doses 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 450.1A). DOE Order 5400.5 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 from operations at the Idaho National Laboratory (INL) Site, based on 2010 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

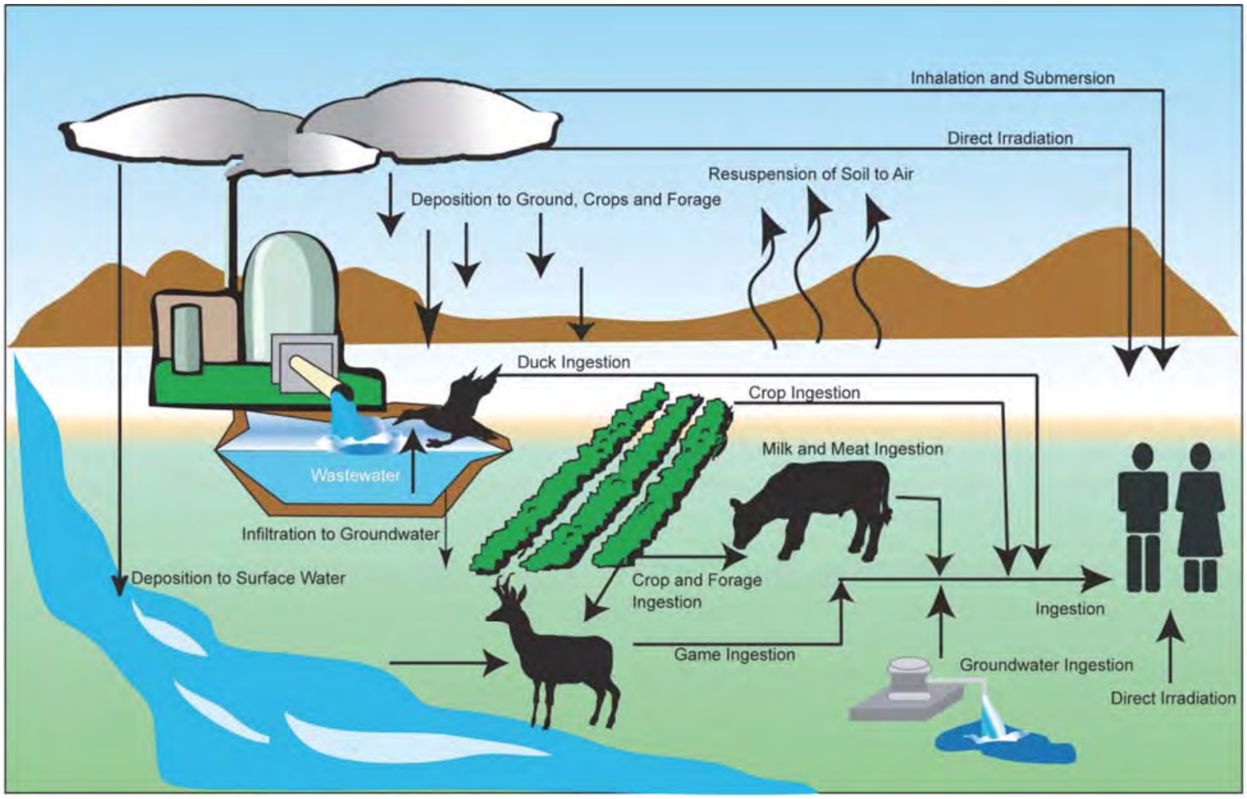


Figure 8-1. Potential Exposure Pathways to Humans from the INL Site.

Rough-legged Hawk

concentrations from routine releases are too small to measure at locations around the INL Site, so atmospheric dispersion models were used to estimate the downwind concentration of air pollutants and the potential doses from these projected offsite concentrations. Conservative doses were also calculated from 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).

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 2010, 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, 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 5400.5.

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 possible 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. In 2010, this hypothetical person lived at Frenchman's Cabin, just south of the INL Site boundary (Figure 4-2).

Table 8-1. Summary of Radionuclide Composition of Idaho National Laboratory Site Airborne Effluents (2010).

	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]
CFA	1.05	N/A	0.00E+00	2.96E-04	8.68E-03	8.67E-09	6.27E-06	7.32E-07	4.92E-06	4.26E-03	1.27E-03
INTEC	233	1,703	0.00E+00	4.34E-10	0.06	0.03	0.02	4.45E-07	7.76E-03	4.65E-05	0.03
MFC	46.2	610	1.00	9.04E-12	0.02	5.70E-15	2.21E-04	7.92E-08	1.38E-06	8.59E-09	4.09E-09
RTC	218	0.34	1,897	0.92	0.05	1.14	0.03	5.22E-07	4.84E-04	1.88E-04	0.01
RWMC	378	1.21E-07	0.00E+00	4.16E-05	0.02	8.61E-04	8.70E-03	1.86E-05	2.78E-03	4.87E-03	3.98E-04
TAN	0.03	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.34E-07	1.19E-07	0.00E+00	0.00E+00	0.00E+00
Total	**876**	**2,313**	**1,898**	**0.92**	**0.15**	**1.17**	**0.06**	**2.05E-05**	**1.10E-02**	**9.36E-03**	**0.04**

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.

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 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. 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 2010 INL Report for Radionuclides* (DOE-ID 2011). 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 0.058 mrem (0.58 μSv) was calculated for a hypothetical person living at Frenchman's Cabin during 2010.

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, cesium-137, strontium-90, 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 38 percent of the calculated dose in 2010.

Figure 8-2 compares the maximum individual doses calculated for 2001 through 2010. 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 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 2010 on and around the INL Site (see Meteorological Monitoring, a supplement to this ASER). The transport and dispersion of contaminants by winds was projected by the MDIFF model and the results were used to prepare a contour map showing calculated annual air concentrations called time integrated concentrations (Figure 8-3). The higher numbers on the map represent higher annual average concentrations. So, for example, the annual air

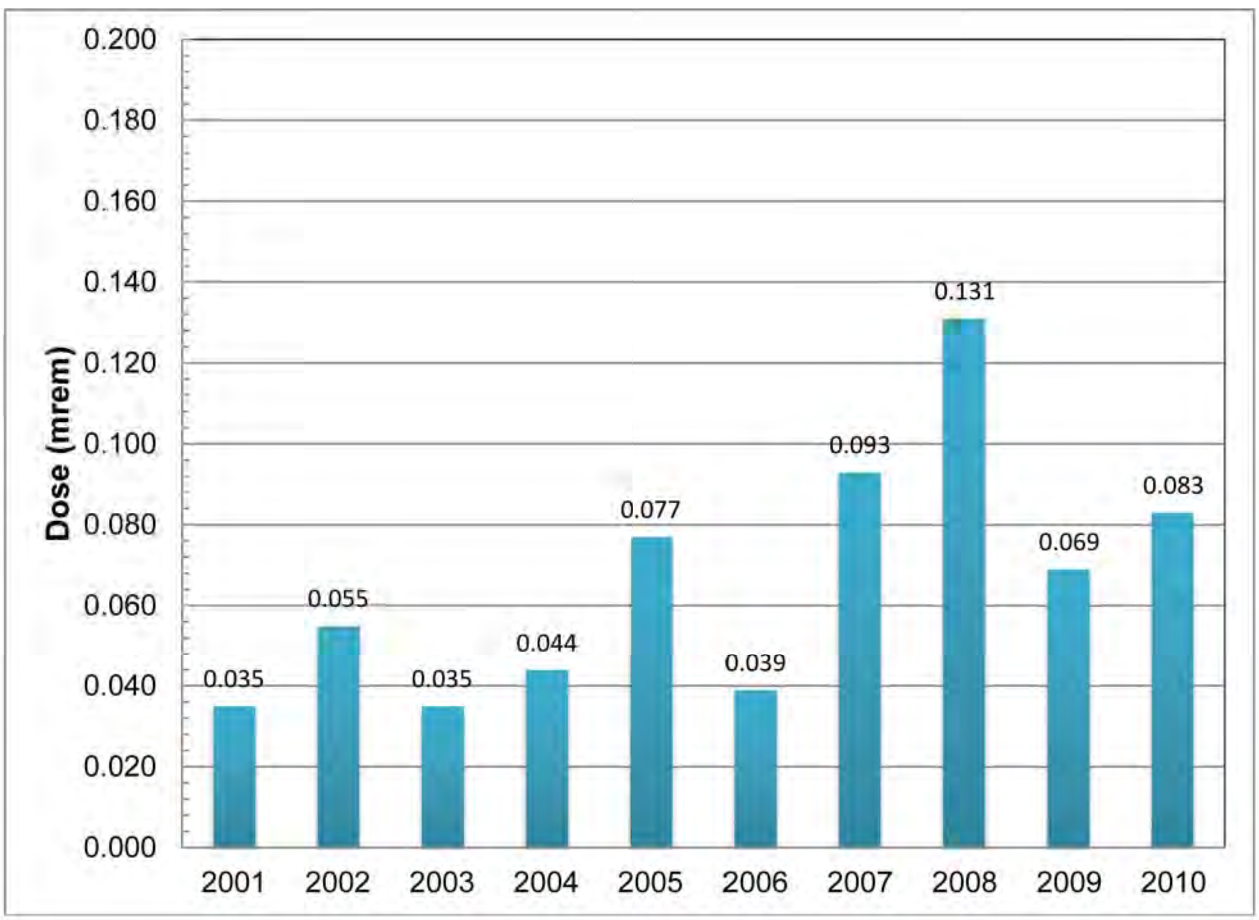


Figure 8-2. Maximum Individual Doses from INL Site Airborne Releases Estimated for 2001 – 2010.

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 the maximally exposed individual might live and what the annual air concentration at that location was for calculation of the eighty kilometer population dose. In 2010 the maximally exposed individual was projected to live south of the INL Site boundary at Frenchman's Cabin, shown on Figure 4-2.

The average modeled air concentration at Frenchman's Cabin (about 70 on Figure 8-3) 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)

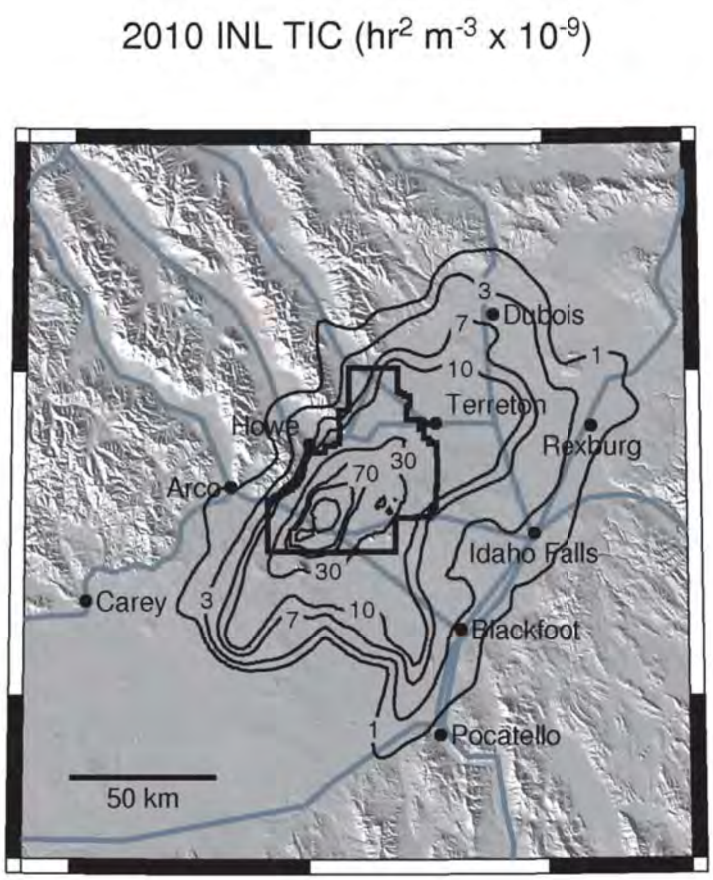


Figure 8-3. INL Site Time Integrated Concentrations (2010).

- The population in each census division within that county division
- The dose calculated to be received by the maximally exposed individual.

The estimated dose at each census division was then summed over all census divisions to result in the 50-mile (80-km) population dose (Table 8-2).

The estimated potential population dose was 1.62 person-rem (1.6 x 10^{-2} person-Sv) to a population of approximately 307,074. When compared with the approximate population dose of 109,318 person-rem (1,093 person-Sv) estimated to be received from natural background radiation, this represents an increase of only about 0.001 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 americium-241, contributing about 36 percent of the total population dose, and three isotopes of plutonium, plutonium-238, plutonium-239, and plutonium-241, which together contributed approximately 50 percent of the dose (Figure 8-4). Strontium-90 and plutonium-240 each accounted for about 3 percent of the dose, followed by iodine-129, cesium-137, and argon-41, which each contributed about 2 percent.

For 2010, the Radioactive Waste Management Complex contributed nearly 87 percent to the total population dose because its location in the southern portion of the INL Site places it in the closest proximity to the Frenchman's Cabin location at the southern boundary. Most of the remaining 13 percent of the total dose was by the Advanced Test Reactor (ATR) Complex (7 percent) and the Idaho Nuclear Technology and Engineering Center (6 percent).

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 2010, three 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 (at the Fort Hall Bottoms) as control samples. The maximum potential dose from eating 225 g (8 oz) of duck meat collected in 2010 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 0.059 mrem (0.6 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

Rough-legged Hawk

Table 8-2. Dose to Population within 80 Kilometers (50 miles) of INL Site Facilities (2010).

Census Division[a,b]	Population[c]	Population Dose: Person-rem	Population Dose: Person-Sv
Aberdeen	3,235	3.34×10^{-3}	3.34×10^{-5}
Alridge	573	2.21×10^{-4}	2.21×10^{-6}
American Falls	6,166	3.91×10^{-3}	3.91×10^{-5}
Arbon (part)	29	5.42×10^{-5}	5.42×10^{-7}
Arco	2,533	1.05×10^{-1}	1.05×10^{-3}
Atomic City (division)	2,679	5.47×10^{-2}	5.47×10^{-4}
Blackfoot	14,694	4.59×10^{-2}	4.59×10^{-4}
Carey (part)	1,001	3.03×10^{-3}	3.03×10^{-5}
East Clark	78	1.95×10^{-4}	1.95×10^{-6}
Firth	3,329	6.53×10^{-3}	6.53×10^{-5}
Fort Hall (part)	4,284	8.91×10^{-3}	8.91×10^{-5}
Hailey-Bellevue (part)	5	1.90×10^{-4}	1.90×10^{-6}
Hamer	2,338	1.02×10^{-1}	1.02×10^{-3}
Howe	358	7.99×10^{-4}	7.99×10^{-6}
Idaho Falls	95,095	7.65×10^{-1}	7.65×10^{-3}
Idaho Falls, west	1,738	2.20×10^{-3}	2.20×10^{-5}
Inkom (part)	614	1.29×10^{-3}	1.29×10^{-5}
Island Park (part)	90	1.85×10^{-6}	1.85×10^{-8}
Leadore (part)	6	4.28×10^{-5}	4.28×10^{-7}
Lewisville-Menan	4,096	1.37×10^{-5}	1.37×10^{-7}
Mackay (part)	1,207	1.26×10^{-4}	1.26×10^{-6}
Moody (part)	5,921	7.27×10^{-3}	7.27×10^{-5}
Moreland	10,134	1.06×10^{-1}	1.06×10^{-3}
Pocatello	71,722	1.63×10^{-1}	1.63×10^{-3}
Rexburg	25,058	7.27×10^{-2}	7.27×10^{-4}
Rigby	16,274	5.62×10^{-2}	5.62×10^{-4}
Ririe	1,781	1.41×10^{-3}	1.41×10^{-5}
Roberts	1,651	2.10×10^{-2}	2.10×10^{-4}
Shelley	8,203	2.34×10^{-2}	2.34×10^{-4}
South Bannock (part)	312	5.83×10^{-4}	5.83×10^{-6}
St. Anthony (part)	2,469	6.43×10^{-3}	6.43×10^{-5}
Sugar City	6,416	2.89×10^{-2}	2.89×10^{-4}
Swan Valley (part)	5,976	9.88×10^{-4}	9.88×10^{-6}
Ucon	6,125	2.38×10^{-2}	2.38×10^{-4}
West Clark	904	2.62×10^{-3}	2.62×10^{-5}
Total	**307,074**	**1.619**	**1.62×10^{-2}**

a. The U.S. Census Bureau divides the country into four census regions and nine census divisions. The bureau also divides counties (or county equivalents) into census county divisions.

b. (Part) means only a part of the county census division lies within the 80-km (50-mi) radius of a major INL Site facility.

c. Population from 2010 Census Report for Idaho.

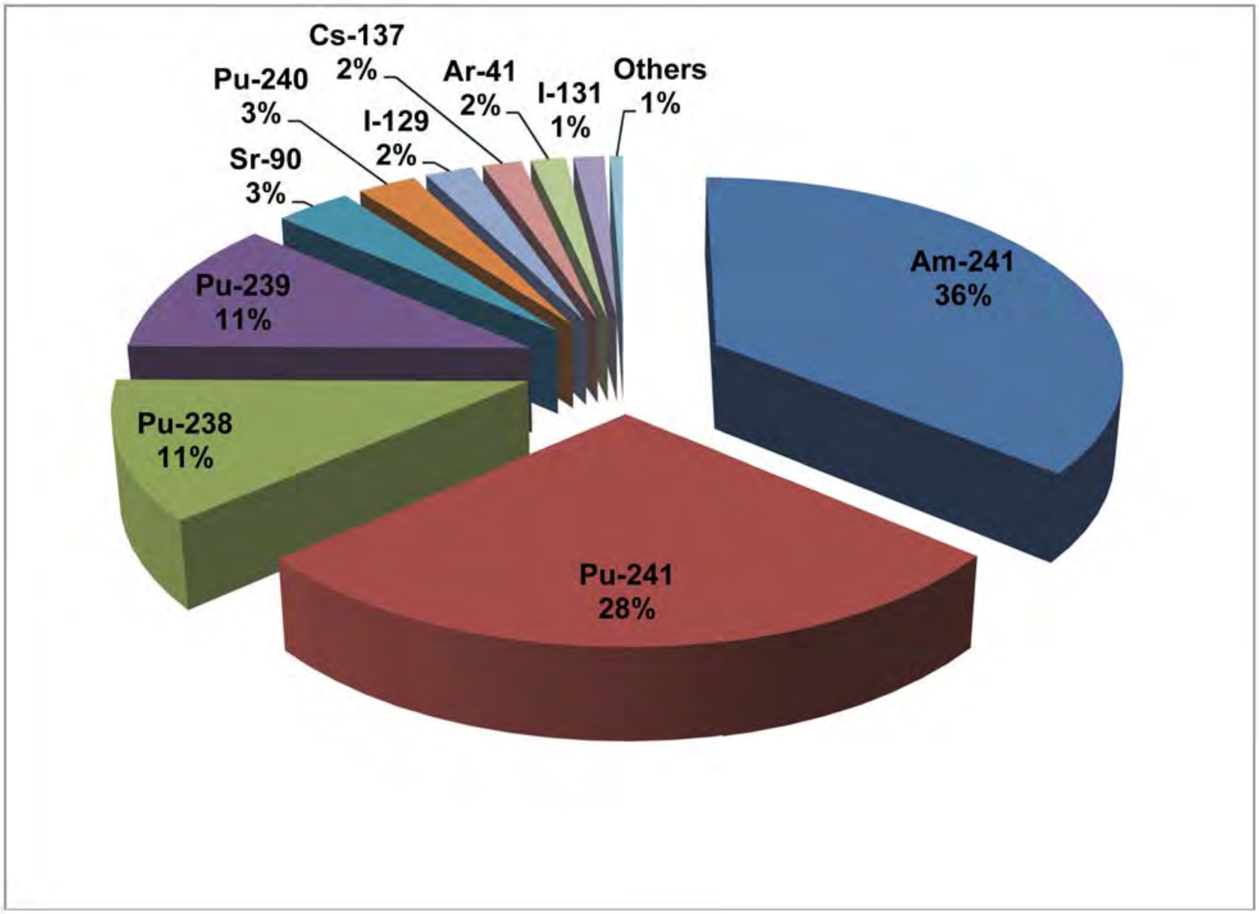


Figure 8-4. Radionuclides Contributing to Dose to Population Dose from INL Site Airborne Effluents as Calculated Using the MDIFF Air Dispersion Model (2010).

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.

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. Only one pronghorn had a detectable concentration of cesium-137. The potential dose from consuming the meat was estimated to be approximately 0.004 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

Table 8-3. Maximum Annual Potential Dose from Ingestion of Edible Waterfowl Tissue Using INL Site Wastewater Disposal Ponds in 2010.[a]

Radionuclide	ATR Complex Maximum Dose[b] (mrem/yr)	MFC Maximum Dose[b] (mrem/yr)	Control Sample Maximum Dose[b] (mrem/yr)
Cobalt-60	3.01×10^{-4}	0	0
Cesium-137	3.09×10^{-2}	0	0
Plutonium-238	8.62×10^{-5}	0	0
Plutonium-239/240	1.91×10^{-3}	0	0
Strontium-90	2.41×10^{-2}	0	3.74×10^{-4}
Zinc-65	1.71×10^{-3}	0	0
Total Dose	**5.91×10^{-2}**	**0**	**3.74×10^{-4}**

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.

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 (Figure 7-8). In 2010, 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 5400.5 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 2010, 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 2010 (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 2010 (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 cesium-137 measured in 2010 (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 0.12 mrem for 2010. For comparison, the total dose received by the maximally exposed individual in 2009 was calculated to be 0.08 mrem, mostly via the air pathway.

The total dose calculated to be received by the hypothetical maximally exposed individual for 2010 (0.12 mrem) represents about 0.003 percent of the dose expected to be received from background radiation (Table 7.5) 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.

The dose received by the entire population within 50 miles of INL Site facilities was calculated to be 1.62 person-rem. This is approximately 0.0014 percent of the dose (116,868 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:


Rough-legged Hawk

Table 8-4. Contribution to Dose by Pathway (2010).

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	0.058	0.00058	0.058	1.62	0.016	307,074	116,868
Waterfowl ingestion	0.059	0.00059	0.059	NA[b]	NA	NA	NA
Big game animals	0.004	0.00004	0.004	NA	NA	NA	NA
Total pathways	**0.12**	**0.0012**	**0.12**	**NA**	**NA**	**NA**	**NA**

a. The individual dose from background was estimated to be 382 mrem in 2010 (Table 7-5).
b. NA = Not applicable

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 2010 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/Specific Manufacturing Capability.

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 cesium-137 and other gamma-emitting radionuclides in surface soils. The results of these surveys (Table 7-3) are also included in Table 8-5.


Rough-legged Hawk

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	1.34×10^{-1}	3.99
	Strontium-90	2.10×10^{-1}	3.70×10^{-1}
	Plutonium-238	NA	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	2.90×10^{-3}	4.36×10^{-2}
	Cesium-137	8.62×10^{-2}	7.70×10^{-1}
	Europium-152	1.28	1.28
	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}
	Americium-241	5.60×10^{-3}	1.13×10^{-2}
CITRC	Cesium-137	9.24×10^{-2}	2.19×10^{-1}
MFC	Cobalt-60	2.55×10^{-2}	3.20×10^{-2}
	Cesium-137	7.18×10^{-1}	5.29×10^{-1}
	Plutonium-239/240	1.50×10^{-2}	2.90×10^{-2}
	Americium-241	4.30×10^{-3}	1.20×10^{-2}
INTEC	Cobalt-60	1.63×10^{-2}	3.60×10^{-2}
	Cesium-137	2.33×10^{-2}	3.92
	Strontium-90	4.90×10^{-1}	7.10×10^{-1}
	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	8.65×10^{-2}	3.37×10^{-1}
	Uranium-238	6.93×10^{-2}	2.85
	Strontium-90	1.10×10^{-1}	1.10×10^{-1}
	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	1.31×10^{-1}	2.80×10^{-1}
	Plutonium-239/240	5.70×10^{-3}	1.60×10^{-2}
	Americium-241	4.30×10^{-3}	9.70×10^{-3}
RWMC	Cesium-137	4.95×10^{-2}	3.06×10^{-1}
	Uranium-238	1.81	1.81
	Plutonium-239/240[c]	6.20×10^{-2}	9.20×10^{-2}
	Americium-241[d]	1.14	3.77×10^{1}
TAN/SMC	Cesium-137	9.26×10^{-2}	8.3×10^{-1}

Table 8-5. Concentrations of Radionuclides in INL Site Soils, by Area (continued).

Location[a]	Radionuclide	Detected Concentration (pCi/g)[b] Minimum	Maximum
	Plutonium-239/240	1.25×10^{-2}	1.74×10^{-2}
	Americium-241	3.20×10^{-3}	5.70×10^{-3}
ALL	Cobalt-60	2.90×10^{-3}	4.36×10^{-2}
	Cesium-137	2.33×10^{-2}	3.99
	Europium-152	1.28	1.28
	Strontium-90	5.82×10^{-2}	7.10×10^{-1}
	Uranium-238	6.93×10^{-2}	2.85
	Plutonium-238	3.30×10^{-3}	4.30×10^{-2}
	Plutonium-239/240	5.70×10^{-3}	9.20×10^{-2}
	Americium-241[d]	1.14	3.77×10^{1}

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:
- (yellow) Results measured in 2010 using in situ gamma spectroscopy (see Table 7-3.)
- (green) Results measured by laboratory analyses of soil samples collected in 2005
- (blue) Results measured by laboratory analyses of soil samples collected in 2006
- (red) Results measured by laboratory analyses of soil samples collected in 2009.

c. Soil samples collected within RWMC by the ICP contractor.

d. The results shown are from in situ surveillance of soils around the RWMC. The maximum result is questionable and is possibly from shine from material containing americium-241, which is stored near where the surface activity was measured. Additional measurements will be taken using a collimated in situ detector in 2011. The result was left in the table to be conservative.

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 (0.24) and plants (0.004) 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.

Table 8-6. RESRAD Biota 1.5 Biota Dose Assessment (Screening Level) of Terrestrial Ecosystems on the INL Site (2010).

Terrestrial Animal								
	Water				Soil			
Nuclide	Concentration (pCi/L)	BCG (pCi/L)	Ratio	Limiting Organism	Concentration (pCi/g)	BCG (pCi/g)	Ratio	Limiting Organism
Am-241	0	2.02E+05	0.00E+00	Yes	37.7	3.89E+03	9.68E-03	Yes
Co-60	0	1.19E+06	0.00E+00	Yes	0.0436	6.92E+02	6.30E-05	Yes
Cs-137	0	5.99E+05	0.00E+00	Yes	3.99	2.08E+01	1.92E-01	Yes
Eu-152	0	2.55E+06	0.00E+00	Yes	1.28	1.52E+03	8.41E-04	Yes
H-3	2810	2.31E+08	1.22E-05	Yes	0	1.74E+05	0.00E+00	Yes
Pu-238	0	1.89E+05	0.00E+00	Yes	0.043	5.27E+03	8.16E-06	Yes
Pu-239	0	2.00E+05	0.00E+00	Yes	0.092	6.11E+03	1.50E-05	Yes
Sr-90	0	5.45E+04	0.00E+00	Yes	0.71	2.25E+01	3.16E-02	Yes
U-233	1.5	4.01E+05	3.74E-06	Yes	0	4.83E+03	0.00E+00	Yes
U-234	1.5	4.04E+05	3.71E-06	Yes	0	5.13E+03	0.00E+00	Yes
U-238	0.69	4.06E+05	1.70E-06	Yes	2.85	1.58E+03	1.81E-03	Yes
Summed	-	-	**2.13E-05**	-	-	-	**2.36E-01**	-
Terrestrial Plant								
	Water				Soil			
Nuclide	Concentration (pCi/L)	BCG (pCi/L)	Ratio	Limiting Organism	Concentration (pCi/g)	BCG (pCi/g)	Ratio	Limiting Organism
Am-241	0	7.04E+08	0.00E+00	No	37.7	2.15E+04	1.75E-03	No
Co-60	0	1.49E+07	0.00E+00	No	0.0436	6.13E+03	7.12E-06	No
Cs-137	0	4.93E+07	0.00E+00	No	3.99	2.21E+03	1.81E-03	No
Eu-152	0	3.06E+07	0.00E+00	No	1.28	1.47E+04	8.70E-05	No
H-3	2810	7.04E+09	3.99E-07	No	0	1.68E+06	0.00E+00	No
Pu-238	0	3.95E+09	0.00E+00	No	0.043	1.75E+04	2.46E-06	No
Pu-239	0	7.04E+09	0.00E+00	No	0.092	1.27E+04	7.25E-06	No
Sr-90	0	3.52E+07	0.00E+00	No	0.71	3.58E+03	1.98E-04	No
U-233	1.5	1.06E+10	1.42E-10	No	0	5.23E+04	0.00E+00	No
U-234	1.5	3.08E+09	4.87E-10	No	0	5.16E+04	0.00E+00	No
U-238	0.69	4.28E+07	1.61E-08	No	2.85	1.57E+04	1.81E-04	No
Summed	-	-	**4.16E-07**	-	-	-	**4.04E-03**	-

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 was conservatively assumed that it was strontium-90. 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 2010 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

Table 8-7. RESRAD Biota 1.5 Assessment (Screening Level) of Aquatic Ecosystems on the INL Site (2010).

Aquatic Animal								
	Water				Sediment			
Nuclide	Concentration (pCi/L)	BCG (pCi/L)	Ratio	Limiting Organism	Concentration (pCi/g)	BCG (pCi/g)	Ratio	Limiting Organism
H-3	2810	4.99E+09	5.63E-07	No	0.00281	7.04E+06	3.99E-10	No
U-233	1.5	2.00E+02	7.51E-03	Yes	0.075	1.06E+07	7.08E-09	No
U-234	1.5	2.02E+02	7.44E-03	Yes	0.075	3.08E+06	2.44E-08	No
U-238	0.69	2.23E+02	3.09E-03	Yes	0.0345	4.28E+04	8.05E-07	No
Summed	-	-	**1.80E-02**	-	-	-	**8.37E-07**	-
Riparian Animal								
	Water				Sediment			
Nuclide	Concentration (pCi/L)	BCG (pCi/L)	Ratio	Limiting Organism	Concentration (pCi/g)	BCG (pCi/g)	Ratio	Limiting Organism
H-3	2810	2.65E+08	1.06E-05	Yes	0.00281	3.74E+05	7.50E-09	Yes
U-233	1.5	6.76E+02	2.22E-03	No	0.075	5.28E+03	1.42E-05	Yes
U-234	1.5	6.83E+02	2.20E-03	No	0.075	5.27E+03	1.42E-05	Yes
U-238	0.69	7.56E+02	9.13E-04	No	0.0345	2.49E+03	1.39E-05	Yes
Summed	-	-	**5.34E-03**	-	-	-	**4.23E-05**	-

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.

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 BIODOSE 1.5 to be 2.12 x 10^{-4} rad/d (2.12 x 10^{-3} mGy/d). 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 2010. As such, there are no doses associated with unplanned releases during 2010.

Table 8-8. RESRAD Biota 1.5 Assessment (Level 3 Analysis) of Aquatic Ecosystems on the INL Site Using Measured Waterfowl Tissue Data (2010).

	Waterfowl Dose (rad/d)				
Nuclide	**Water[a]**	**Soil[b]**	**Sediment**	**Tissue[c]**	**Summed**
Am-241	0.00E+00	3.98E-09	0.00E+00	0.00E+00	3.98E-09
Co-60	0.00E+00	2.17E-06	0.00E+00	3.55E-06	5.72E-06
Cs-137	0.00E+00	8.34E-06	0.00E+00	5.42E-05	6.26E-05
Eu-152	0.00E+00	2.87E-05	0.00E+00	0.00E+00	2.87E-05
H-3	0.00E+00	8.81E-11	0.00E+00	2.59E-06	2.59E-06
Pu-238	0.00E+00	2.23E-11	0.00E+00	4.89E-05	4.89E-05
Pu-239	0.00E+00	2.10E-08	0.00E+00	5.98E-05	5.98E-05
Sr-90	0.00E+00	0.00E+00	0.00E+00	3.78E-06	3.78E-06
U-233	0.00E+00	3.98E-09	0.00E+00	0.00E+00	3.98E-09
U-234	0.00E+00	2.17E-06	0.00E+00	3.55E-06	5.72E-06
U-238	0.00E+00	8.34E-06	0.00E+00	5.42E-05	6.26E-05
Total	**0.00E+00**	**3.92E-05**	**0.00E+00**	**1.73E-04**	**2.12E-04**

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 radionuclides measured in soil at the ATR Complex were used (Table 8-5).

c. Internal doses to waterfowl were calculated using maximum concentrations in tissue shown in Figure 7-5.

Rough-legged Hawk

REFERENCES

40 CFR 61, 2010, "National Emission Standards for Hazardous Air Pollutants," *Code of Federal Regulations*, Office of the Federal Register.

40 CFR 61, Subpart H, 2010, "National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities," *Code of Federal Regulations*, Office of the Federal Register.

DOE, 2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*, DOE-STD-1153-2002, U.S. Department of Energy, available from http://homer.ornl.gov/oepa/public/bdac/.

DOE, 2004, *RESRAD-BIOTA: A Tool for Implementing a Graded Approach to Biota Dose Evaluation*, DOE/EH-0676, U.S. Department of Energy, Interagency Steering Committee on Radiation Standards, available from http://homer.ornl.gov/oepa/public/bdac/.

DOE Order 450.1A, 2008, "Environmental Protection Program," U.S. Department of Energy.

DOE Order 5400.5, 1993, "Radiation Protection of the Public and the Environment," Change 2, U.S. Department of Energy.

DOE-ID, 2010, *National Emissions Standards for Hazardous Air Pollutants – Calendar Year 2010 INL Report for Radionuclides*, DOE/ID-10890(11), U.S. Department of Energy Idaho Operations Office.

Eckerman, K. F. and J. C. Ryman, 1993, *External Exposure to Radionuclides in Air, Water, and Soil*, Federal Guidance Report 12, EPA-402-R-93-081, U.S. Environmental Protection Agency.

Eckerman, K. F., A. B. Wolbarst, and A. C. B. Richardson, 1988, *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion*, Federal Guidance Report 11, EPA-520/1-88-020, U.S. Environmental Protection Agency.

EPA, 1998, *Guidelines for Ecological Risk Assessment*, EPA/630/R-95/002F, U.S. Environmental Protection Agency.

EPA, 2002, *Cancer Risk Coefficients for Environmental Exposure to Radionuclides*, Federal Guidance Report 13, EPA-402-R-99-001, U.S. Environmental Protection Agency.

EPA, 2007, *Clean Air Act Assessment Package-1988 (CAP88-PC)*, Version 3.0, http://www.epa.gov/radiation/assessment/CAP88/index.html, updated August 26, 2008, Web page visited July 13, 2009, U.S. Environmental Protection Agency.

Halford, D. K., O. D. Markham, and G. C. White, 1983, "Biological Elimination of Radioisotopes by Mallards Contaminated at a Liquid Radioactive Waste Disposal Area," Health Physics, Vol. 45, pp. 745 – 756, September.

Jessmore, P. J., L. A. Lopez, and T. J. Haney, 1994, *Compilation and Evaluation of the Idaho National Engineering Laboratory Radiological and Environmental Sciences Laboratory Surface Soil Sample Data for Use in Operable Unit 10-06 Baseline Risk Assessment*, EGG-ER-11227, Rev. 0, EG&G Idaho.

Markham, O. D., D. K. Halford, R. E. Autenrieth, and R. L. Dickson, 1982, "Radionuclides in Pronghorn Resulting from Nuclear Fuel Reprocessing and Worldwide Fallout," *Journal of Wildlife Management*, Vol. 46, No. 1, pp. 30 – 42, January.

NRC, 1977, *Regulatory Guide 1.109 Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix 1*, NRC 1.109, Rev. 1, U.S. Nuclear Regulatory Commission.

Sagendorf, J. F., R. G. Carter, and K. L. Clawson, 2001, *MDIFFF Transport and Diffusion Models, NOAA Air Resources Laboratory, NOAA Technical Memorandum OAR ARL 238*, National Oceanic and Atmospheric Administration.

Warren, R. W., S. J. Majors, and R. C. Morris, 2001, *Waterfowl Uptake of Radionuclides from the TRA Evaporation Ponds and Potential Dose to Humans Consuming Them*, Stoller-ESER 01-40, S. M. Stoller Corporation.

Chapter 9. Envirionmental Research at the Idaho National Laboratory Site

Chapter 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 2010, 13 ecological research projects were conducted on the Idaho NERP:

- Determining Greater Sage-Grouse Abundance and Seasonal Landscape Use Patterns on the Idaho National Laboratory Site
- Surveys for Historical Sage-Grouse Leks on the Idaho National Laboratory Site
- Common Raven (*Corvus corax*) Abundance in Relation to Anthropogenic Resources within the Idaho National Laboratory Site 2010
- Vegetation Community Classification and Mapping at the Idaho National Laboratory Site
- Minimizing Risk of Cheatgrass Invasion and Dominance at the Idaho National Laboratory
- Surveying, Monitoring and Predicting the Occurrence and Spread of Native and Non-Native Plant Species at the Idaho National Laboratory Site
- Distribution, Abundance and Movements of Mammals on the Idaho National Laboratory Site
- Evaluating Transient Habitat Use by Migrating Tree-Roosting Bat Species (Hoary Bats and Silver-Haired Bats)
- Development of a Data-Based Validation Network for State-and-Transition Models

- Sagebrush Canopy Height and Shape Measurements Using Small-Footprint Discrete-Return LiDAR
- Dynamics of Post-wildfire Wind Erosion of Soil in Semiarid Rangelands, Idaho
- Spectroscopic Detection of Nitrogen Concentrations in Sagebrush: Implications for Hyperspectral Remote Sensing
- The Influence of Precipitation, Vegetation and Soil Properties on the Ecohydrology of the Eastern Snake River Plain

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. Six reports were published in 2010 by the INL Project Office:

- Steady-State and Transient Models of Groundwater Flow and Advective Transport, Eastern Snake River Plain Aquifer, Idaho National Laboratory and Vicinity, Idaho
- Chemical Constituents in Groundwater from Multiple Zones in the Eastern Snake River Plain Aquifer at the Idaho National Laboratory, Idaho, 2005-08
- An Update of Hydrologic Conditions and Distribution of Selected Constituents in Water, Snake River Plain Aquifer and Perched Groundwater Zones, Idaho National Laboratory, Idaho, Emphasis 2006–08
- Theory for Source-Responsive and Free-Surface Film Modeling of Unsaturated Flow
- Subsurface Stratigraphy of the Arco-Big Southern Butte Volcanic Rift Zone and Implications for Late Pleistocene Rift Zone Development, Eastern Snake River Plain, Idaho
- Completion Summary for Well NRF-16 near the Naval Reactors Facility, Idaho National Laboratory, Idaho

9. ENVIRONMENTAL RESEARCH AT THE IDAHO NATIONAL LABORATORY SITE

This chapter summarizes ecological research performed at the Idaho National Laboratory (INL) Site (Section 9.1) and research conducted on the Snake River Plain aquifer by the United States Geological Survey (Section 9.2) during 2010.

9.1 Ecological Research at the Idaho National Environmental Research Park

The INL Site was designated as a National Environmental Research Park in 1975. The National Environmental Research Park Program was established in response to

Rough-legged Hawk

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 43 graduate students, post-doctoral students, faculty, and agency and contractor scientists participated in 13 research projects on the Idaho National Environmental Research Park in 2010. Several undergraduate students and technicians also gained valuable experience through participation in these research activities. The 13 projects include eight graduate student research projects, with students and faculty from Idaho State University, University of Idaho, Boise State University, University of Nevada Reno, Montana State University, Colorado State University, Texas A&M, and Washington State University. Other researchers represented the Environmental Surveillance, Education, and Research Program, Wildlife Conservation Society, U.S. Department of Agriculture – Agricultural Research Service, U.S. Department of Agriculture – Forest Service Rocky Mountain Research Station, and POWER Engineers, Inc.

Four 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. Eight of the 13 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, Wildlife Conservation Society, Idaho State University, Nevada Agricultural Experiment Station, Department of Energy, U.S. Department of Agriculture - Cooperative State Research, Education, and Extension Service Rangeland Research Program, 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, and National Science Foundation.

Most of the DOE-ID-funded research and much of the research 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*) and pygmy rabbit (*Brachylagus idahoensis*) 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.

9.1.1 Determining Greater Sage-Grouse Abundance and Seasonal Landscape Use Patterns on the Idaho National Laboratory Site

Investigators and Affiliations

Quinn R. Shurtliff, Ph.D., Associate Conservation Scientist, North America Program – Lost River Sinks Project, Wildlife Conservation Society, Idaho Falls, Idaho

Kristy Howe, M.S. Candidate, Idaho State University, Pocatello, Idaho; and North America Program – Lost River Sinks Project, Wildlife Conservation Society, Idaho Falls, Idaho

Funding Sources

U.S. Department of Energy, Idaho Operations Office

Objectives

- Track radio-collared sage-grouse from point of capture until the bird dies or the transmitter expires
- Use telemetry data to develop a spatial model that will characterize nesting, brood-rearing, and winter habitats
- Document nest locations and monitor nest success
- Develop statistical models to estimate survivorship and population trajectory.

Summary

The U.S. Department of Energy, Idaho Operations Office (DOE-ID) recognized that if sage-grouse or other sagebrush-obligate species were listed under the Endangered Species Act, further development and current activities on the INL Site potentially could be delayed or halted to assess the possible effects on sage-grouse. Radio telemetry data gathered from sage-grouse fitted with radio transmission collars will be used to delineate the areas most used by sage-grouse on the INL Site and locate and document nest success.

Fifty-two sage-grouse, including 31 hens, have been collared in 2008 and 2009. In 2008, 20 nests were initiated, six of which were successful (30 percent), meaning that at least one egg hatched. Four of the six broods survived until the end of September 2008. In 2009, 24 nests were initiated, 11 of which were successful (46 percent apparent nest success). At least seven of the 11 broods survived until the end of the season in September 2009, and the fates of two broods were unknown. In 2010, five males and six females captured in previous years were still being monitored. Males and females exhibited high lek and nest site fidelity. After a mortality in March, five females were tracked into nesting season, but only one nest was documented.

The telemetry study concluded in 2010. Over the two-year study, sage-grouse exhibited high variation in annual distance traveled. Some sage-grouse remained on or near the INL Site year round, whereas others traveled large distances seasonally. The greatest one-way seasonal movements were 108 km (67 miles) and 66 km (41 miles) for a male and female, respectively. After the breeding season and throughout the summer, both males and females tended to disperse off of the INL Site, so that the lowest occurrence of collared sage-grouse on the INL Site was in September.

Much of the telemetry data collected since 2008 has yet to be analyzed. Consequently, significant effort will be devoted in 2011 to data analysis so that decisions regarding conservation measures in the Candidate Conservation Agreement and Conservation Management Plan are based on rigorous statistical analysis.

9.1.2 Surveys for Historical Greater Sage-Grouse Leks on the Idaho National Laboratory Site

Investigators and Affiliations

Jericho C. Whiting, Ph.D., Wildlife Biologist, Environmental Surveillance, Education, and Research Program, S.M. Stoller Corporation, Idaho Falls, Idaho

Bryan Bybee, Wildlife Technician, Environmental Surveillance, Education, and Research Program, S.M. Stoller Corporation, Idaho Falls, Idaho

Funding Sources

- U.S. Department of Energy, Idaho Operations Office

Objective

Our objective was to conduct a multi-year survey of historic leks that were previously identified by the Idaho Department of Fish and Game and National Environmental Research Park researchers over the past 40 years to determine if those sites were still used by Greater Sage-Grouse.

Summary

Currently, 26 sage-grouse leks are known to be active on the INL Site. In addition, 61 leks are documented that were historically active but for which the current status is unknown. Surveys of historically documented leks were conducted on and adjacent to the INL Site in 2009. Only 57 of the historical leks were surveyed because the remainder either had been displaced by human activity, or a known active lek was close by.

The 57 historical lek sites were visited one or more times (101 total visits). Sage-grouse were detected visually or audibly on or near 17 historic and 3 previously undocumented leks. At least two males were detected on all but five of the 20 sites during the survey period. Of the 39 leks where sage-grouse were not detected, 13 (33 percent) were surveyed twice.


Rough-legged Hawk

Each lek was classified according to the Idaho Department of Fish and Game criteria for our results in 2010. At five leks, only one male was observed at each site. As such, there were insufficient data to assign those leks an active status. There were seven leks that were designated as active in 2009 that had < 2 males during our surveys in 2010. Those seven leks remain designated as active. The other 16 leks where sage-grouse were detected (including three that were previously undocumented) were designated as active. Of the 16 leks, there were five historic leks that were designated unknown in 2009 that are now determined to be active. In addition, six leks were designated as inactive and 33 as unknown.

Each spring in the future, all historical leks will be surveyed again. Ultimately, once all active sites are identified, the broader objective will be to quantify the number of males visiting leks from year to year (i.e., lek census) to understand population trends on the INL Site.

9.1.3 Common Raven (Corvus corax) Abundance in Relation to Anthropogenic Resources within the Idaho National Laboratory Site in 2010

Investigators and Affiliations

Kristy Howe, M.S. Candidate, Idaho State University, Pocatello, Idaho; and North America Program – Lost River Sinks Project, Wildlife Conservation Society, Idaho Falls, Idaho

David Delehanty, Ph.D., Professor, Ornithology Laboratory, Department of Biological Sciences, Idaho State University, Pocatello, Idaho

Funding Sources

- U.S. Department of Energy, Idaho Operations Office
- Bureau of Land Management, Idaho Falls Field Office, Grant monies
- Wildlife Conservation Society, Cost-share match through equipment
- Idaho State University, Cost-share match through equipment.

Objectives

This study examines how proximity to anthropogenic resources affects common raven abundance. Determining how anthropogenic resources influence raven density in sagebrush steppe habitat will provide Bureau of Land Management (BLM) land managers with information necessary to identify sources of human disturbance. Specific objectives include the following:

- Calculate resource selection functions of habitat use for territorial and non-territorial ravens on the INL Site
- Develop predictive model of broad-scale raven habitat use
- Identify anthropogenic factors that affect raven presence.

Summary

Common raven (*Corvus corax*) populations in the western United States have increased substantially during the last 50 years. Ravens typically are more abundant in human-altered landscapes than in intact ecosystems. This is cause for concern among land managers because ravens are considered a synanthropic predator (a predator benefiting from anthropogenic resources and land actions) of numerous sensitive species, including Greater Sage-Grouse (*Centrocercus urophasianus*) eggs and chicks. Increases in linear infrastructures (roads and power lines) are likely to further increase raven abundances and subsequently increase sage-grouse nest depredation by ravens. The potential for ravens to limit sage-grouse populations constitutes a need to assess the presence of ravens over large spatial scales within sagebrush steppe habitat.

For surveyed ravens, the simplest and most meaningful models included distance from transmission lines, facilities, and non-native grasslands. For every 1 km (0.6 miles) increase in distance to transmission lines and facilities, the odds of raven presence decreased by 9.3 percent and 4.5 percent, respectively. Also, for every 10 ha (25 acre) increase of non-native vegetation, the odds of raven presence increased by 2.7 percent. In post hoc analyses, the odds of raven presence increased with greater habitat edge length of big sagebrush (*Artemisia tridentata* spp.) and non-native vegetation.

For nesting ravens, the odds of nesting were greater with decreased distance to transmission lines and increased amount of vegetation type edge. For every 1 km (0.6 miles) increase in distance away from a power line there was a 37 percent decrease in odds of raven nesting. Habitat fragmentation indices were 3.1 times greater at nest sites than at random sites. For every 100 m (328 feet) of added vegetation edge, there was an estimated 20 percent increase in the odds of raven nesting.

9.1.4 Vegetation Community Classification and Mapping at the Idaho National Laboratory Site

Investigators and Affiliations

Jeremy P. Shive, GIS/Remote Sensing Specialist, Environmental Surveillance, Education, and Research Program, S.M. Stoller Corporation, Idaho Falls, Idaho

Amy D. Forman, Plant Ecologist, Environmental Surveillance, Education, and Research Program, S.M. Stoller Corporation, Idaho Falls, Idaho

Ken A. Aho, Ph.D., Department of Biological Sciences, Idaho State University, Pocatello, Idaho

Jackie R. Hafla, Natural Resources Scientist, Environmental Surveillance, Education, and Research Program, S.M. Stoller Corporation, Idaho Falls, Idaho

Roger D. Blew, Ph.D., Ecologist, Environmental Surveillance, Education, and Research Program, S.M. Stoller Corporation, Idaho Falls, Idaho


Rough-legged Hawk

Kurt T. Edwards, GIS Analyst, Environmental Surveillance, Education, and Research Program, S.M. Stoller Corporation, Idaho Falls, Idaho

Funding Sources

- United States Department of Energy, Idaho Operations Office

Objectives

The goal of the vegetation community classification and mapping project is to develop an updated vegetation map detailing the distribution of plant communities on the INL Site. Specific objectives are to:

- Characterize the vegetation community types present on the INL Site
- Define the spatial distribution of those community types
- Conduct a quantitative accuracy assessment of the resulting map.

The approach is based on a process developed by the U.S. Geological Survey and National Park Service for use in land management planning and includes two parallel tasks, plant community classification and map unit delineation. Plant community classification entails multivariate analysis of applicable historical vegetation data sets and a current project-specific vegetation data set, resulting in a statistically definable list of vegetation classes that can be reconciled with U.S. National Vegetation Classification System-defined vegetation associations. The map unit delineation process consists of generating polygons using current digital color-infrared aerial imagery, several ancillary data layers, and image processing techniques to define areas of similarity or dissimilarity across the INL Site. Products of these efforts then are reconciled by assigning vegetation classes to map units, resulting in a map that will be assessed for accuracy.

Summary

The final classification combined with the subsequent iterations of classification refinement resulted in 26 vegetation classes for the INL Site. Of the 26 vegetation classes identified, two are wooded or woodland types, seven are shrubland types, four are shrub herbaceous types, five are dwarf shrubland or dwarf-shrub herbaceous types, five are herbaceous types, and three are semi-natural herbaceous types. Semi-natural types are generally defined as being dominated by non-native species. Upon completion of the final classification, the resulting plant community class list was used to identify polygons delineated through the mapping process. A dichotomous key to the vegetation classes was also developed.

The final vegetation map contains a total of 2,038 polygons, of which 1,964 (96.4 percent) represent vegetation communities. The remaining 74 polygons (3.6 percent) represent non-vegetation or agriculture classes we included in the map. The smallest mapped polygon is 0.0021 km^2 (0.52 acres). The largest polygon mapped is 236.3 km^2 (58,399.6 acres) located in the undisturbed interior portion of the INL Site.

The accuracy assessment found highly accurate results for the overall map and also individual class accuracies for most vegetation classes. Although there has never been a quantitative evaluation of previous INL Site vegetation maps, the new map is the most detailed and likely the most accurate vegetation map ever produced for the INL Site.

The final project report includes a detailed description of statistical and image processing methods and results, field sampling protocols, the statistical community classification report, a dichotomous field key to the INL Site vegetation classes, vegetation class Fact Sheets that provide summary statistics and descriptions for each class identified during the plant community classification process, and a vegetation map book intended for field use or for individuals without GIS capabilities.

9.1.5 Minimizing Risk of Cheatgrass Invasion and Dominance at the Idaho National Laboratory Site

Investigators and Affiliations

Lora Perkins, Ph.D. Candidate, Department of Natural Resources and Environmental Science, University of Nevada Reno, Reno, Nevada

Robert S. Nowak, Ph.D., Professor, Department of Natural Resources and Environmental Science, University of Nevada Reno, Reno, Nevada

Funding Sources

- U.S. Department of Energy, Idaho Operations Office
- Nevada Agricultural Experiment Station.

Objectives

The goal of this project is to use a combination of field surveys and mechanistic-hypothesis-driven greenhouse experiments to determine the influences of environment, plant community, and land management on cheatgrass invasion success. Specific objectives include the following:

- Conduct comparative surveys along a latitudinal climatic gradient from central Nevada, where cheatgrass dominates much of the landscape, to the INL Site, collecting information ranging in scale from microscopic (soil nutrients) to community (vegetation and animal) to landscape (climate and land use patterns) to parameterize a structural equation model and specifically test hypotheses about how site characteristics affect invasion success of cheatgrass
- Use controlled-environment experiments that involve individual species and constructed communities to establish a mechanistic understanding of competition between cheatgrass and native species.

Summary

From 2007 to 2009, over 400 field sites were visited. Several plant community characteristics, signs of disturbance, and physical environment variables were measured. Soil samples were collected and analyzed for soil nutrients, texture, and seed bank. Most of the field sites were visited only once, enabling investigators to sample across a wide area and providing the maximum variation in most landscape and vegetation variables. The rest of the field sites were visited for multiple years, allowing investigators to examine effects of inter-annual variation on cheatgrass distribution. In this study the most important variables associated with cheatgrass presence were grass and forb cover, soil phosphorus (P), and mean temperatures in the fall and spring. The most important variables associated with cheatgrass abundance were shrub canopy and soil P. Shrub canopy, grass and forb cover, and biological soil crust may offer some biotic resistance to the initial stages of cheatgrass invasion. However, once cheatgrass is present on a site, shrub canopy, and grass and forb cover are positively associated with increasing abundance.

The comparative surveys have also led to a theory paper, in which an invasion triangle model is proposed that incorporates attributes of the potential invader, the biotic characteristics of the site, and the environmental conditions of the site, and introduces the influence of external factors. This model also incorporates external influences (such as grazing or fire). This model can be used qualitatively, as well as quantitatively, to examine the contributing factors and overall risk of invasion.

The researchers conducted an experiment examining how invasive and native grasses influence soil nutrients and how those changes influence subsequent plant growth. They found little support for the hypothesis that, as a group, invasive grasses like cheatgrass affect soil nutrients differently than native grasses do. Instead, the results strongly point to a more complex response with the effect dependent upon the species rather than simply a general trait of invasive species. However, alteration of soil nutrients may still be an important mechanism promoting invasion by individual species, but not a general trait of invasive grasses.

The researchers also investigated the role that soil-plant feedback mechanisms may play in re-enforcing invasions. Feedbacks that are positive or suppressive promote the same species returning while feedbacks that are negative or facilitative promote other species. In this study, every invasive grass induced feedbacks that promoted the same species in at least one soil type. Depending on soil type, cheatgrass specifically induced positive and suppressive feedbacks which promoted return by the same species.

9.1.6 Surveying, Monitoring and Predicting the Occurrence and Spread of Native and Non-Native Plant Species at Idaho National Laboratory Site

Investigators and Affiliations

Lisa Rew, Ph.D., Assistant Professor, Department of Land Resources and Environmental Sciences, Montana State University, Bozeman, Montana

Bruce Maxwell, Ph.D., Professor, Department of Land Resources and Environmental Sciences, Montana State University, Bozeman, Montana

Matt Lavin, Ph.D., Professor, Department of Plant Sciences and Plant Pathology, Montana State University, Bozeman, Montana

Tyler Brummer, M.S. Candidate, Department of Land Resources and Environmental Sciences, Montana State University, Bozeman, Montana

Funding Source

- U.S. Department of Energy, Idaho Operations Office

Objectives

The goal of this study is to determine the current distribution of nonindigenous plant species (NIS) and rare plant species (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. Specific objectives include:

- Evaluate existing data on NIS and RPS at the INL Site and assemble spatial environmental data for further modeling exercises
- Conduct an NIS and RPS field survey of all NIS and RPS in the INL Site Conservation Management Plan Development Zone
- Develop probability of occurrence models for NIS and RPS and generate maps from these models
- Repeat transects in multiple years to calculate Markov transition probabilities and predict further invasion or extinction dynamics of NIS and RPS throughout the INL Site Development Zone
- Simulate metapopulation dynamics for a range of development scenarios at the INL Site using the multistate Markov transition probabilities.

Summary

The presence/absence of NIS and RPS were surveyed along 114 10-m wide belt transects extending 2 km away from roads or facility boundaries in 2009 and 2010. Twenty NIS were observed on the transects and no federally or state protected RPS were found on the transects.

These data were imported to a geographic information system in order to test two modeling methods that could result in predictive models relating individual NIS occurrence to predictor variables. Those predictors were associated with disturbance, dispersal, and environmental conditions. The study showed no differences in the predictive performance of the two models tested, and predictive maps will be generated for both models to assess the potential differences between them for management interpretation.

Rough-legged Hawk

A simulation model was also evaluated to determine sample size requirements for generating predictive models at the spatial resolution needed to meet INL Site land management needs. Results of these simulations indicate that adequate sampling has been done to generate reliable predictive maps for informing management decisions.

Mean monthly precipitation was the most explanatory variable causing similarity in species among the sampling site. Geographic distance was the next most important variable suggesting a biogeographical effect on local community composition in sagebrush steppe. The next most important predictor variable was whether or not an area had experienced disturbance. The similarity of burned area to areas that were unburned and undisturbed in sagebrush steppe suggests that in the absence of disturbance (e.g. due to overgrazing, road construction, routine herbicide application along roads, etc.), burning of sagebrush steppe does not necessarily change the abundance or biodiversity of native species other than the removal of specific species such as big sagebrush. The results also suggest that road construction that does not also involve routine blading, weed control, and similar disturbances can be re-invaded by the native plant biodiversity otherwise limited to undisturbed sagebrush steppe.

9.1.7 Distribution, Abundance and Movements of Mammals on the Idaho National Laboratory Site

Investigators and Affiliations

Ryan A. Long, Ph.D. Candidate, Department of Biological Sciences, Idaho State University, Pocatello, Idaho

Rosemary J. Smith, Ph.D., Professor, Department of Biological Sciences, Idaho State University, Pocatello, Idaho

R. Terry Bowyer, Ph.D., Chair and Professor, Department of Biological Sciences, Idaho State University, Pocatello, Idaho

John G. Kie, Ph.D., Research Professor, Department of Biological Sciences, Idaho State University Pocatello, Idaho

Funding Sources

- U.S. Department of Energy, Idaho Operations Office

Objectives

- Review all previously published literature on small mammal research conducted on the INL Site and compile species-specific results into a searchable database
- Conduct trapping surveys to determine presence and absence of both common and rare small mammals in the Development Zone
- Use ultrasonic detection equipment to conduct “digital mist-netting” of bats in the Development Zone

- Fit 20 elk with Global Positioning System collars to determine (1) the extent to which critical habitat (e.g., calving grounds) for that species occurs within the Development Zone; and (2) when, where, and to what extent elk move between the INL Site and surrounding agricultural lands.

Summary

All previously published data for small mammals on the INL Site were reviewed, and a database containing information on the publications and species trapped, observed, etc. was compiled. Trapping surveys were conducted for small mammals in the Development Zone between May and August of 2009 and 2010. The trapping resulted in the capture of 634 individuals of five different species in 2009 and 1,226 individuals of ten species in 2010. For each animal captured, location, sex, and weight were recorded.

An ultrasonic bat call detector was deployed in a cave in the Conservation Management Plan Development Zone during autumn and early winter of 2010. Analysis of data collected by this equipment is forthcoming.

Twenty female elk were captured and fit with GPS collars in March, 2010, and during the capture data on body condition, morphology, and blood parameters were collected. Collars remained on study animals through November, 2010, at which time they were remotely released from animals and recovered via radio-telemetry so that location data could be downloaded.

9.1.8 Evaluating Transient Habitat use by Migrating Tree-Roosting Bat Species (Hoary Bats and Silver-Haired Bats)

Investigators and Affiliations

Bill Doering, M.S., Wildlife Biologist, POWER Engineers, Meridian, Idaho

Funding Sources

- Investigator Funded

Objectives

The objective was to document activity by migrating tree bat species at INL caves in order to identify stopover habitat to be investigated by further study. The two target species were hoary bat (*Lasiurus cinereus*) and silver-haired bat (*Lasionycteris noctivagans*). These two species comprise the bulk of bats killed by wind turbines, with hoary bats comprising half of known fatalities.

Summary

The 2009 field season resulted in the collection of 42,978 files of bat call sequences from two INL Site caves and a single off-site cave (Crystal Ice Cave) over 93 sampling nights. Data collection during the 2010 field season continued from early September until midwinter; these data are still being analyzed.

The original intent of this work was to focus on two target species (hoary bats and silver-haired bats); however, the methodology employed at cave entrances revealed aspects of INL Site bat communities and bat behavior not previously described. Late summer and fall activity presents a mix of summer resident, transient migrators, and pre-hibernation swarming bats all converging at cave features to obtain resources. Review of call files has revealed the presence of the little brown bat (*Myotis lucifugus*, a species at risk from white-nose syndrome) as well as several species that may be new records for INL (Yuma myotis, *Myotis yumanensis* and pallid bat, *Antrozous pallidus*).

9.1.9 Development of a Data-Based Validation Network for State-and-Transition Models

Investigators and Affiliations

David Briske, Ph.D., Department of Ecosystem Science and Management, Texas A&M University, College Station, Texas

Ben Wu, Ph.D., Department of Ecosystem Science and Management, Texas A&M University, College Station, Texas

Brandon Bestelmeyer, Ph.D., U.S. Department of Agriculture, Agricultural Research Service Jornada Experimental Range

Maria Fernandez-Gimenez, Ph.D., Department of Forest, Rangeland, and Watershed Stewardship, Colorado State University, Fort Collins, Colorado

Funding Sources

- US Department of Agriculture Cooperative State Research, Education, and Extension Service Rangeland Research Program 2007-04903
- U.S. Department of Energy, Idaho Operations Office.

Objectives

Great Basin shrub steppe ecosystems are one target ecosystem for this project. Researchers will use the Long-Term Vegetation (LTV) monitoring data from the INL Site to evaluate state-and-transition models constructed for this ecosystem. They will characterize Ecological Sites at the Long-Term Vegetation Transects to facilitate this analysis.

Summary

This project seeks to assess the construction rules and ecological validity of U.S. Department of Agriculture Natural Resources Conservation Service-approved state-and-transition models by comparing them to empirical models that will be constructed from long-term ecological data and related information for major Ecological Sites throughout the Great Plains and West. This research approach will enable researchers to (1) explore new protocols to construct state-and-transition models that are based on empirical, long-term ecological data, (2) evaluate the ecological validity of existing qualitative state-and-transition models for representative Ecological

Sites by comparing them to recently constructed data-based models, and (3) investigate rules and assumptions associated with construction of state-and-transition models to improve their consistency and ecological validity.

In August and September 2010, Jornada Experimental Range staff characterized soil profiles at 59 LTV plots cleared the previous summer. At each site, select soil properties were described in the field for the A horizon(s), B1 horizon, and one or more diagnostic subsurface horizons. Soil properties recorded for each sampled horizon included top and bottom depths, coarse fragment content, hand texture, percent clay (estimated), effervescence, structure, stage of pedogenic carbonate development, and hue/value/chroma. Additional data were collected at each site in order to describe basic topographic, soil, and ecological conditions at the time of soil sampling. These data were based on a 20 x 20 m square plot centered on the soil pit and included community phase, parent material, landform, slope component, percent slope, aspect, slope complexity, slope shape, soil depth, soil surface fragment cover, pedoderm class, resource retention measures, and soil redistribution class.

9.1.10 Sagebrush Canopy Height and Shape Measurements Using Small-Footprint Discrete-Return LiDAR

Investigators and Affiliations

Jessica J. Mitchell, Ph.D., Postdoctoral Associate, Idaho State University and Idaho National Laboratory, Idaho Falls, Idaho

Nancy F. Glenn, Ph.D., Research Associate Professor, Geosciences Department, Idaho State University, Boise, Idaho

Teki Sankey, Ph.D., Research Assistant Professor, Geosciences Department, Idaho State University, Boise, Idaho

Matt Anderson, Idaho National Laboratory, Idaho Falls, Idaho

Ryan Hruska, Idaho National Laboratory, Idaho Falls, Idaho

Funding Sources

- Idaho Space Grant Consortium Graduate Student Fellowship
- National Oceanic and Atmospheric Administration Office of Oceanic and Atmospheric Research, Earth Systems Research Laboratory, Physical Sciences Division, Grant #NA06OAR460012.

Objectives

The objective is to finalize and publish shrub height and shape prediction errors results obtained by comparing LiDAR point-cloud data to sagebrush canopy characteristics measured in the field.

Summary

From May to October 2009, height and shrub measurements were collected for 107 individual sagebrush, and bare earth elevations were collected throughout 11 circular plots 20 m in diameter. The sagebrush ground reference data were used to evaluate high density (average density of 9.46 points/m^2), small-footprint, discrete-return LiDAR data collected over portions of the INL Site on December 13, 2006.

The results demonstrated that the LiDAR-derived sagebrush height estimates were significantly and strongly correlated with corresponding field-based height estimates, with observed coefficients of determination of 0.84 – 0.86. Similarly, LiDAR predictions of shrub shape and area were significantly and strongly correlated, with field-based measurements resulting in coefficients of determination of 0.65 – 0.78. Although LiDAR tended to underestimate shrub area, this study provided the first shape and area estimates for LiDAR-based measurements of low-height vegetation (i.e., shrubs). Error in height estimates are thought to be associated with greater canopy penetration by the LiDAR signal and error in area estimates are likely associated with failure to properly delineate individual shrubs in the LiDAR data.

9.1.11 Dynamics of Post-wildfire Wind Erosion of Soil in Semiarid Rangelands, Idaho

Investigators and Affiliations

Matthew J. Germino, Ph.D., Research Ecologist, United States Geological Survey, Boise Idaho

Nancy F. Glenn, Ph.D., Professor, Geosciences Department, Idaho State University, Boise, Idaho

Joel Sankey, Ph.D., Mendenhall Fellow-Research Physical Scientist, United States Geological Survey Southwest Geographic Science Center and USA-National Phenology Network, Tuscon, Arizona

Amber N. Hoover, M.S., Research Technician, Biological Sciences Department, Idaho State University, Pocatello, Idaho

Jeremy P. Shive, GIS/Remote Sensing Analyst, Environmental Surveillance, Education, and Research Program, S.M. Stoller Corporation, Idaho Falls, ID

Natalie Wagenbrenner, Engineer, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Moscow, Idaho

Brian Lamb, Washington State University, Laboratory for Atmospheric Research, Pullman, Washington

Peter Robichaud, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Moscow, Idaho

Funding Sources

- U.S. Department of Defense
- Bureau of Land Management
- USDA Forest Service Rocky Mountain Research Station

Objectives

This is a large and multifaceted research program with the overall goal being to determine and describe wildland fire effects on wind erosion potential of shrub steppe in southeastern Idaho, including some research areas on the INL Site. The specific objectives for the research include the following:

- To evaluate how dust emissions, sediment supply, and erodibility varied among the strong microsite soil patterns consisting of shrub islands and relatively bare interspaces
- To determine the relationship between variations in the soil surface morphology and vegetation in unburned and burned sagebrush steppe, and to experimentally determine how this variability affects native and exotic grasses
- To determine the presence of burned and unburned vegetation and exposed soil susceptible to wind erosion associated with the 2010 Jefferson Fire
- To quantify the role of wind erosion and dust emissions in post-fire environments as well as the associated potential impacts on air quality, facilitate a better understanding of the mechanics governing post-fire wind erosion and dust emissions, including a detailed linkage of erosion rates to site energy and water balance, with a focus on soil "skin" moisture and create a modeling framework capable of forecasting future post-fire wind events
- To investigate wind erosion immediately following fire on areas previously either unburned or burned within the last 3 years
- 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.

Summary

Large pulses of wind erosion and resulting dust plumes are an increasingly important attribute of Idaho rangelands, particularly as wildfire occurrence and size increases. Fire increases erosivity by removing plant cover, but whether supply of erodible sediment and erodibility also increase has not been determined. The researchers determined that greater emission rates were due to greater sediment supply, but not greater erodibility. The results demonstrated that dust supply increases appreciably in initial post-fire years on previous shrub microsites. The abundance of shrubs is highly responsive to management practices that affect pre-fire vegetation, such as grazing-induced increases in shrubs that could render a site more vulnerable to dust emissions following fire.

Rough-legged Hawk

The researchers hypothesized that coppice-interspace heterogeneity would remain after post-fire wind erosion, and that seed availability, germination, and growth were factors inhibiting plant establishment on interspaces. They surveyed coppice and interspace soils and plant communities at burned and unburned sites, and conducted a common-garden study of a native grass and an exotic grass on coppices and interspaces. Success of native grasses appears limited by a different combination of mechanisms than exotic grasses. Results indicate the importance of coppice-interspace heterogeneity for native plant communities. Exotic plants may decrease coppice-interspace heterogeneity, negatively affecting native plants.

Hyperspectral remote sensing imagery collected in August 2010, following the Jefferson Fire, were used to classify areas of unburned from burned vegetation, bare mineral soil, unaltered rock (basalt), and ash/soil mixture. Such information is valuable in differentiating fire effects to the vegetation and soil across the landscape using remote-sensing data. This remote-sensing data can be used to map areas of burned and unburned vegetation and exposed soil susceptible to wind erosion. These results can be used for calculating the total area of potential for soil erosion and deposition, and track recovery of vegetation in the years following fire.

Researchers installed two air quality instrumentation towers in the downwind portion of the burned area of the Jefferson Fire in August 2010, and monitored the site for three months. Real-time concentrations of particulate matter with a diameter of less than or equal to 10 µm (PM10) were monitored at each tower location. Elevated PM10 concentrations were detected since the fire was contained, but the largest dust event to date occurred over September 4-5, 2010, during the passage of a frontal system. A dust plume originating from the burned area on September 4 is visible in satellite imagery and clearly extends 30 to 60 miles (50 to 100 km) downwind of the burned area. The frontal system had sustained winds of 40 mph during mid-day and nighttime winds around 13.5 mph. Early morning winds were from the northeast, with the stronger mid-day winds from the southwest. This appears to be the first study to report PM10 concentrations in a post-fire environment. The observed two-day dust event demonstrates that particulate emissions from burned areas can be large and potentially result in both local and downwind impacts.

The recent Middle Butte Fire burned 14,000 acres (5,698 ha) in summer 2010, including areas that had previously been either unburned or burned by the 2007 Twin Buttes Fires. Researchers investigated wind erosion immediately following the Middle Butte Fire in areas that were previously unburned or previously burned by the Twin Buttes Fire. Data were collected to calculate horizontal movement of sediment and deflation of the soil surface to determine if wind erosion differed between burned sites and re-burned sites.

To determine how stable aerodynamic properties (friction velocity, roughness length, displacement height) are over time in burned sagebrush steppe and relate these changes to the developing vegetation community, the researchers collected aerodynamic and vegetation data during spring and summer of 2008 and 2009 at the site of the 2007 Twin Buttes Fire. In 2010, they analyzed the aerodynamic data to determine friction velocity, roughness length, and displacement height over months. In 2011, they plan to analyze the vegetation data to begin making comparisons of aerodynamic properties to vegetation cover and height.

9.1.12 Spectroscopic Detection of Nitrogen Concentrations in Sagebrush: Implications for Hyperspectral Remote Sensing

Investigators and Affiliations

Jessica J. Mitchell, Ph.D., Postdoctoral Associate, Idaho State University and Idaho National Laboratory

Nancy F. Glenn, Ph.D., Research Associate Professor, Geosciences Department, Idaho State University, Boise, Idaho

Teki Sankey, Ph.D., Research Assistant Professor, Geosciences Department, Idaho State University, Boise, Idaho

Matt Anderson, Idaho National Laboratory, Idaho Falls, Idaho

Ryan Hruska, Idaho National Laboratory, Idaho Falls, Idaho

Funding Sources

- Idaho Space Grant Consortium Graduate Student Fellowship
- National Oceanic and Atmospheric Administration Office of Oceanic and Atmospheric Research, Earth Systems Research Laboratory, Physical Sciences Division, Grant # NA06OAR4600124.

Objectives

- Examine differences between sagebrush N concentration and spectral response at leaf and shrub scales
- Identify transformed bandwidth intervals most closely related to N concentrations
- Determine if the strength at which narrow absorption features are expressed using a field radiometer warrants extending the investigation to an airborne platform
- Acquire and ground-validate airborne hyperspectral imagery to determine if sagebrush canopy signals are strong enough to support detection of sagebrush N at the canopy scale.

Summary

Encouraging final results were obtained 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 August 13, 2010, using an airborne HyMap sensor. Plot level field data was collected from August 9-10, 2009, to support the HyMap collection. A total of 35 plots were sampled for percent cover (sagebrush, shrubs other than sagebrush, grass/herbaceous, bare ground, and dead wood), and average sagebrush height and foliar N content. Foliar N content was analyzed by collecting green-leaf samples from four randomly-

selected sagebrush individuals in each plot. Leaf area measurements were then used to scale N concentrations from leaf level to plot level. Plot level sagebrush N estimations were then related to corresponding reflectance data in the HyMap imagery by extracting pixels located within the plot boundaries.

Sagebrush dry leaf spectra produced models that could predict N concentrations within the dataset more accurately than models generated from live shrub spectra because noise (e.g., soil, atmosphere, sampling error, leaf water) was minimized. Including wavelengths associated with leaf water appeared to improve these results. Since leaf water plays an obvious role in estimating N at the shrub scale, August may be an optimal time for acquiring additional sagebrush reflectance spectra because leaf water is lowest in late summer.

HyMap spectra transformed using standard derivative analysis was capable of detecting sagebrush canopy N concentrations using regression with an R^2 value of 0.72 and an R^2 predicted value of 0.42. Subsetting the HyMap dataset to minimize the influence of bare ground increased R^2 to 0.95 (R^2 predicted = 0.42). The results of this study represent an important step in addressing the confounding influence of bare ground, which was found to be a significant challenge in remote sensing of foliar N in semi-arid landscapes, possibly more so than leaf water.

9.1.13 The Influence of Precipitation, Vegetation and Soil Properties on the Ecohydrology of the Eastern Snake River Plain

Investigators

Matthew J. Germino, Ph.D., Research Ecologist, United States Geological Survey, Boise Idaho

Keith Reinhardt, Ph.D., Postdoctoral Fellow, Idaho State University, Pocatello, Idaho

Collaborators

Kevin Feris, Ph.D., Assistant Professor, Boise State University, Boise, Idaho

Patrick Sorenson, M.S. candidate, Boise State University, Boise, Idaho

Jocylene Benao, B.S. candidate, Idaho State University, Pocatello, Idaho

Kathleen Lohse, Ph.D., Assistant Professor, Idaho State University, Pocatello, Idaho

Marie-Anne deGraff, Ph.D., Assistant Professor, Boise State University, Boise, Idaho

Funding Sources

- Experimental Program to Stimulate Competitive Research (EPSCoR), National Science Foundation.

Objectives

The objectives of this study are as follows:

- 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 of plots to assess whether fundamental ecosystem changes to treatments are occurring and could feed back on water flow patterns
- Investigate changes in soil carbon pools due to vegetation and precipitation differences.

Other biogeochemical and soil physical aspects of plots, such as stable isotope compositions that can reveal changes in water patterns and plant water use among plots, also are being evaluated. The ultimate objective is to determine how plot responses to the treatments feed back on water infiltration, availability and use.

Summary

Researchers are evaluating long-term impacts of different plant communities commonly found throughout Idaho subject to different precipitation regimes and to different soil depths. These treatments allow researchers to investigate how vegetation, precipitation and soil interact to influence patterns of water infiltration, uptake, and storage. This information will be used to improve a variety of models, as well as provide data for these models.

The researchers observed no differences in rates of photosynthesis, plant water potential, leaf chlorophyll fluorescence, or specific leaf area among the treatments. However, differences in carbon isotopes suggested that shrubs in the ambient moisture plots used water more efficiently than did shrubs on the plots winter irrigation plots. Vegetation cover was greatest on the winter irrigation plots and least on the ambient plots. Shrub cover was greatest on the winter irrigation plots with deeper soil. Shrub cover was reduced on winter irrigated plots that had shallow soils.

Soil microbial studies suggested that winter precipitation may promote storage of soil carbon deeper in the soil profile while summer precipitation may promote greater carbon inputs from the overlying plants at shallower soil depths. Higher heterotrophic soil respiration was observed in summer irrigated plots. These higher rates of soil carbon mineralization and lower carbon storage could be a climate change feedback process in semi-arid ecosystems.

9.2 U.S. Geological Survey 2010 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 (CSL).

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/.)

Six reports were published by the USGS INL Project Office in 2010. The abstracts of these studies and the publication information associated with each study are presented below.

9.2.1 Steady-State and Transient Models of Groundwater Flow and Advective Transport, Eastern Snake River Plain Aquifer, Idaho National Laboratory and Vicinity, Idaho (Daniel J. Ackerman, Joseph P. Rousseau, Gordon W. Rattray, and Jason C. Fisher)

Three-dimensional steady-state and transient models of groundwater flow and advective transport in the eastern Snake River Plain aquifer were developed by the U.S. Geological Survey in cooperation with the U.S. Department of Energy. The steady-state and transient flow models cover an area of 1,940 square miles that includes most of the 890 square miles of the Idaho National Laboratory (INL). A 50-year history of waste disposal at the INL has resulted in measurable concentrations of waste contaminants in the eastern Snake River Plain aquifer. Model results can be used in numerical simulations to evaluate the movement of contaminants in the aquifer.

Saturated flow in the eastern Snake River Plain aquifer was simulated using the MODFLOW-2000 groundwater flow model. Steady-state flow was simulated to represent conditions in 1980 with average streamflow infiltration from 1966–80 for the Big Lost River, the major variable inflow to the system. The transient flow model simulates groundwater flow between 1980 and 1995, a period that included a 5-year wet cycle (1982–86) followed by an 8-year dry cycle (1987–94). Specified flows into or out of the active model grid define the conditions on all boundaries except the southwest (outflow) boundary, which is simulated with head-dependent flow. In the transient flow model, streamflow infiltration was the major stress, and was variable in time and location. The models were calibrated by adjusting aquifer hydraulic properties to match simulated and observed heads or head differences using the parameter-estimation program incorporated in MODFLOW-2000. Various summary, regression, and inferential statistics, in addition to comparisons of model properties and simulated head to measured properties and head, were used to evaluate the model calibration.

Model parameters estimated for the steady-state calibration included hydraulic conductivity for seven of nine hydrogeologic zones and a global value of vertical anisotropy. Parameters estimated for the transient calibration included specific yield for five of the seven hydrogeologic zones. The zones represent five rock units and parts of four rock units with abundant interbedded sediment. All estimates of hydraulic conductivity were nearly within 2 orders of magnitude of the maximum expected value in a range that exceeds 6 orders of magnitude. The estimate of vertical anisotropy was larger than the maximum expected value. All estimates of specific yield and their confidence intervals were within the ranges of values expected for aquifers, the range of values for porosity of basalt, and other estimates of specific yield for basalt.

The steady-state model reasonably simulated the observed water-table altitude, orientation, and gradients. Simulation of transient flow conditions accurately reproduced observed changes in the flow system resulting from episodic infiltration from the Big Lost River and facilitated understanding and visualization of the relative importance of historical differences in infiltration in time and space. As described in a conceptual model, the numerical model simulations demonstrate flow that is (1) dominantly horizontal through interflow zones in basalt and vertical anisotropy resulting from contrasts in hydraulic conductivity of various types of basalt and the interbedded sediments, (2) temporally variable due to streamflow infiltration from the Big Lost River, and (3) moving downward downgradient of the INL.

The numerical models were reparameterized, recalibrated, and analyzed to evaluate alternative conceptualizations or implementations of the conceptual model. The analysis of the reparameterized models revealed that little improvement in the model could come from alternative descriptions of sediment content, simulated aquifer thickness, streamflow infiltration, and vertical head distribution on the downgradient boundary. Of the alternative estimates of flow to or from the aquifer, only a 20 percent decrease in the largest inflow, the northeast boundary underflow, resulted in a recalibrated parameter value just outside the confidence interval of the base-case calibrated value.

Particle-tracking calculations using the particle-tracking program MODPATH were used to evaluate (1) how simulated groundwater flow paths and travel times differ between the steady-state and transient flow models, (2) how wet- and dry-climate cycles affect groundwater flow paths and travel times, and (3) how well model-derived groundwater flow directions and velocities compare to independently derived estimates. Particle tracking also was used to simulate the growth of tritium (3H) plumes originating at the Idaho Nuclear Technology and Engineering Center and the Reactor Technology Complex over a 16-year period under steady state and transient flow conditions (1953–68). The shape, dimensions, and areal extent of the 3H plumes were compared to a map of the plumes for 1968 from 3H releases at the Idaho Nuclear Technology and Engineering Center and the Reactor Technology Complex beginning in 1952.

Collectively, the particle-tracking simulations indicate that average linear groundwater velocities, based on estimates of porosity, and flow paths are influenced by two primary factors: (1) the dynamic character of the water table and (2) the large contrasts in the hydraulic properties of the media, primarily hydraulic conductivity. The simulated growth and decay of groundwater mounds as much as 34 ft above the steady-state water table beneath the Big Lost River spreading areas, sinks, and playas, and to a lesser extent beneath the Big Lost River channel lead to non-uniform changes in the altitude of the water table throughout the model area. These changes affect the orientation and magnitude of water-table gradients and affect groundwater flow directions and velocities to a greater or lesser degree depending on the magnitude, duration, and proximity of the transient stress. Simulation results also indicate that temporal changes in the local hydraulic gradient can account for some of the observed dispersion of contaminants in the aquifer near the major sources of contamination at the INTEC and the RTC and perhaps most observed dispersion several miles downgradient of these facilities. The distance downgradient of the INTEC that simulated particle plumes were able to reasonably reproduce the shape and dimensions of the 1968 3H plume extended only to the boundary of zones of abundant sediment, about 4 miles downgradient of the INTEC. This boundary encompasses the entire area represented by the 1968 25,000 picocuries/liter 3H isopleths. Particle plumes simulated beyond this boundary were narrow and long, and did not reasonably reproduce the shape, dimensions, or position of the leading edge of the 3H plume as shown in earlier reports; however, as noted in an assessment of the interpreted plume, few data were available in 1968 to characterize its true areal extent and shape.

9.2.2 Chemical Constituents in Groundwater from Multiple Zones in the Eastern Snake River Plain Aquifer at the Idaho National Laboratory, Idaho, 2005-08 (Roy C. Bartholomay and Brian V. Twining)

From 2005 to 2008, the U.S. Geological Survey's Idaho National Laboratory (INL) Project office, in cooperation with the U.S. Department of Energy, collected water-quality samples from multiple water-bearing zones in the eastern Snake River Plain aquifer. Water samples were collected from six monitoring wells completed in about 350–700 feet of the upper part of the aquifer, and the samples were analyzed for major ions, selected trace elements, nutrients, selected radiochemical constituents, and selected stable isotopes. Each well was equipped with a multilevel monitoring system containing four to seven sampling ports that were each isolated by permanent packer systems. The sampling ports were installed in aquifer zones that were highly transmissive and that represented the water chemistry of the top four to five model layers of a steady-state and transient groundwater-flow model. The model's water chemistry and particle-tracking simulations are being used to better define movement of wastewater constituents in the aquifer.

The results of the water chemistry analyses indicated that, in each of four separate wells, one zone of water differed markedly from the other zones in the well. In four wells, one zone to as many as five zones contained radiochemical constituents that originated from wastewater disposal at selected laboratory facilities. The multilevel sampling systems are defining the vertical distribution of wastewater constituents in the eastern Snake River Plain aquifer and the concentrations of wastewater constituents in deeper zones in wells Middle 2051, USGS 132, and USGS 103 support the concept of groundwater flow deepening in the southwestern part of the INL.

9.2.3 An Update of Hydrologic Conditions and Distribution of Selected Constituents in Water, Snake River Plain Aquifer and Perched Groundwater Zones, Idaho National Laboratory, Idaho, Emphasis 2006–08 (Linda C. Davis)

Since 1952, radiochemical and chemical wastewater discharged to infiltration ponds (also called percolation ponds), evaporation ponds, and disposal wells at the Idaho National Laboratory (INL) has affected water quality in the eastern Snake River Plain aquifer and perched groundwater zones underlying the INL. The U.S. Geological Survey, in cooperation with the U.S. Department of Energy, maintains groundwater monitoring networks at the INL to determine hydrologic trends, and to delineate the movement of radiochemical and chemical wastes in the aquifer and in perched groundwater zones. This report presents an analysis of water-level and water-quality data collected from aquifer and perched groundwater wells in the USGS groundwater monitoring networks during 2006–08.

Water in the Snake River Plain aquifer primarily moves through fractures and interflow zones in basalt, generally flows southwestward, and eventually discharges at springs along the Snake River. The aquifer primarily is recharged from infiltration of irrigation water, infiltration of streamflow, groundwater inflow from adjoining mountain drainage basins, and infiltration of precipitation.

From March–May 2005 to March–May 2008, water levels in wells generally remained constant or rose slightly in the southwestern corner of the INL. Water levels declined in the central and northern parts of the INL. The declines ranged from about 1 to 3 feet in the central part of the INL, to as much as 9 feet in the northern part of the INL. Water levels in perched groundwater wells around the Advanced Test Reactor Complex (ATRC) also declined.

Detectable concentrations of radiochemical constituents in water samples from wells in the Snake River Plain aquifer at the INL generally decreased or remained constant during 2006–08. Decreases in concentrations were attributed to decreased rates of radioactive-waste disposal, radioactive decay, changes in waste-disposal methods, and dilution from recharge and underflow. In April or October 2008, reportable concentrations of tritium in groundwater ranged from 810 ± 70 to 8,570 ± 190 picocuries per liter (pCi/L), and the tritium plume extended south-southwestward in the general direction of groundwater flow. Tritium concentrations in water from wells completed in shallow perched groundwater at the ATRC were less than the reporting levels. Tritium concentrations in deep perched groundwater exceeded the reporting level in 11 wells during at least one sampling event during 2006–08 at the ATRC. Tritium concentrations from one or more zones in each well were reportable in water samples collected at various depths in six wells equipped with multi-level Westbay™ packer sampling systems.

Concentrations of strontium-90 in water from 24 of 52 aquifer wells sampled during April or October 2008 exceeded the reporting level. Concentrations ranged from 2.2 ± 0.7 to 32.7 ± 1.2 pCi/L. Strontium-90 has not been detected within the eastern Snake River Plain aquifer beneath the ATRC partly because of the exclusive use of waste-disposal ponds and lined evaporation ponds rather than using the disposal well for radioactive-wastewater disposal at ATRC. At the ATRC, the strontium-90 concentration in water from one well completed in shallow perched groundwater was less than the reporting level. During at least one sampling event during 2006–08, concentrations of strontium-90 in water from nine wells completed in deep perched groundwater at the ATRC were greater than reporting levels. Concentrations ranged from 2.1±0.7 to 70.5±1.8 pCi/L. At the Idaho Nuclear Technology and Engineering Center (INTEC), the reporting level was exceeded in water from two wells completed in deep perched groundwater. During 2006–08, concentrations of cesium-137, plutonium-238, and plutonium-239, -240 (undivided), and americium-241 were less than the reporting level in water samples from all

wells and all zones in wells equipped with multi-level Westbay™ packer sampling systems at the INL.

The concentration of chromium in water from one well south of the ATRC steadily decreased from 2006 to 2008 and was 93 micrograms per liter (µg/L) in 2008, just less than the maximum contaminant level (MCL). Concentrations in water samples from other wells ranged from 1.2 to 28.3 µg/L. During 2006–08, chromium was detected in one well completed in shallow perched groundwater at a concentration of 3 µg/L. Dissolved chromium was detected in water from 14 wells completed in deep perched groundwater at the ATRC during 2006–08.

Concentrations of sodium in water from wells south of the INTEC during 2006–08 generally were equal to or less than sodium concentrations detected in October 2005, with the exception of concentrations in water from well USGS 47 which was slightly higher in 2008 than in 2005. In October 2008, sodium concentrations in water from two wells near the Radioactive Waste Management Complex (RWMC) were 45 and 26 milligrams per liter (mg/L), slightly higher than the October 2005 concentrations. During 2006–08, analyses were not made for dissolved sodium concentrations in shallow perched groundwater at the ATRC. During April or October 2008, dissolved sodium concentrations in water from 16 wells completed in deep perched groundwater ranged from 6 to 23 mg/L; concentration in water from one well was 476 mg/L. The vertical distribution of sodium concentrations in wells equipped with WestbayTM systems were fairly consistent with depth, with the exception of sodium concentrations in water from well USGS 132, which were much higher (26–30 mg/L) in the uppermost zone than in the deeper zones (9–12 mg/L).

Chloride concentrations in water from wells near the INTEC generally decreased since the late 1990s. During 2006–08, concentrations in most wells either generally were constant or increased slightly. Trends in concentrations in water from wells downgradient from the percolation ponds correlated with discharge rates into the ponds when travel time was considered. During 2008, chloride concentrations in water from wells USGS 88 and 89 at the RWMC were 91 and 41 mg/L. Concentrations of chloride in all other wells near the RWMC ranged from 11 to 25 mg/L. In 2008, concentrations in water from all wells at or near the ATRC ranged between 10 and 18 mg/L. During April 2008, dissolved chloride concentrations in shallow perched groundwater near the ATRC ranged from 11 to 13 mg/L; concentrations in deep perched groundwater during April or October 2008 ranged from 4 to 43 mg/L.

In 2008, sulfate concentrations ranged from 40 to 157 mg/L in water samples from nine aquifer wells in the south-central part of the INL, which exceeds the 40-mg/L background concentration of sulfate. The greater-than-background concentrations of sulfate in water from these wells probably resulted from sulfate disposal at the ATRC infiltration ponds. In October and April 2008, sulfate concentrations in water samples from two wells near the RWMC were greater than background levels and could have resulted from the well construction and (or) waste disposal at the RWMC. During 2007–08, sulfate concentrations from three wells southwest of the INTEC were 45, 47, and 46 mg/L. The maximum dissolved sulfate concentration in shallow perched groundwater near the ATRC was 399 mg/L in well CWP 1 in November 2006. During April–October 2008, the maximum concentration of dissolved sulfate in deep perched groundwater was 1,477 mg/L in well USGS 68, which is located west of the chemical-waste pond. Concentrations of sulfate in two wells completed in deep perched groundwater near the INTEC were 36 and 39 mg/L. Overall the vertical distribution of sulfate in water from wells equipped with Westbay™ systems generally was consistent in most zones in wells during 2006–08.

The regional background concentration for nitrate (as N) is about 1 mg/L. In October 2008, concentrations of nitrate (as N) in water from most wells at and near the INTEC exceeded the background concentration and ranged from 2.2 to 5.97 mg/L. Near the ATRC, the concentration of nitrate (as N) in water from well USGS 65 was 1.5 mg/L. In 2008, concentrations of nitrate (as N) in water from wells USGS 88, 89, and 119 were 0.9, 1.7, and 1.4 mg/L, respectively. All concentrations measured in aquifer wells at the INL in 2008 were less than the MCL for drinking water of 10 mg/L as N, with the exception of a concentration of 18.9 mg/L from well USGS 50 at the INTEC.

During April or October 2008, fluoride concentrations in water samples from four aquifer wells ranged from 0.2 to 0.3 mg/L. These concentrations are similar to the background concentrations, which indicate that wastewater disposal has not appreciably affected fluoride concentrations in the Snake River Plain aquifer near the INTEC.

During 2006–08, water samples from 30 aquifer wells were collected and analyzed for volatile organic compounds (VOCs). Twelve VOCs were detected. Concentrations of from 1 to 10 VOCs were detected in water samples from 11 wells. Primary VOCs detected included carbon tetrachloride, trichloromethane, 1,1-dichloroethane, 1,1,1-trichloroethane, trichloroethylene, and tetrachloroethylene.

During April or October 2008, water samples from 50 wells completed in the Snake River Plain aquifer at the INL were analyzed for total organic carbon (TOC); detected concentrations ranged from 0.43 to 1.9 mg/L.

Well USGS 92 is in the Subsurface Disposal Area (SDA) at the RWMC and is completed in a sedimentary interbed 214 ft below land surface. Perched groundwater in this well has moved through overlying sediments and basalt, and may contain waste constituents leached from radiochemical and organic chemical wastes buried in the SDA. During 2006–08, tritium concentrations in water samples from well USGS 92 exceeded the reporting level and ranged from 490±110 pCi/L in April 2006 to 300±80 pCi/L in June 2008. Water from well USGS 92 was sampled for VOCs in April 2007, and 9 VOCs were detected which was a decrease from the 15 compounds detected in 2002–03. Additionally, all VOC concentrations detected in 2007 were significantly lower than those detected during 2002–03, with the exception of toluene, which was not detected in 2002–03.

9.2.4 Theory for Source-Responsive and Free-Surface Film Modeling of Unsaturated Flow (John R. Nimmo)

A new model explicitly incorporates the possibility of rapid response, across significant distance, to substantial water input. It is useful for unsaturated flow processes that are not inherently diffusive, or that do not progress through a series of equilibrium states. The term source-responsive is used to mean that flow responds sensitively to changing conditions at the source of water input (e.g., rainfall, irrigation, or ponded infiltration). The domain of preferential flow can be conceptualized as laminar flow in free-surface films along the walls of pores. These films may be considered to have uniform thickness, as suggested by field evidence that preferential flow moves at an approximately uniform rate when generated by a continuous and ample water supply. An effective facial area per unit volume quantitatively characterizes the medium with respect to source-responsive flow. A flow-intensity factor dependent on conditions within the medium represents the amount of source-responsive flow at a given time and position. Laminar flow theory provides relations for the velocity and thickness of flowing source-responsive films. Combination with the Darcy–Buckingham law and the continuity equation leads to expressions for both fluxes and dynamic water contents. Where preferential flow is sometimes or always significant, the interactive combination of source-responsive and diffuse flow has the potential to improve prediction of unsaturated-zone fluxes in response to hydraulic inputs and the evolving distribution of soil moisture. Examples for which this approach is efficient and physically plausible include (i) rainstorm-generated rapid fluctuations of a deep water table and (ii) space- and time-dependent soil water content response to infiltration in a macroporous soil.

9.2.5 Subsurface Stratigraphy of the Arco-Big Southern Butte Volcanic Rift Zone and Implications for Late Pleistocene Rift Zone Development, Eastern Snake River Plain, Idaho (Katherine Potter)

Core from USGS 135, a corehole located on the eastern Snake River Plain, Idaho, provides an approximately 1.06 million year record of basalt volcanism associated with the Arco-Big Southern Butte volcanic rift zone. Lithologic, geochemical, and paleomagnetic data confirm the presence of 14 basalt flowgroups and 116 flow units. The predominance of proximal-facies flow units and accumulation rates calculated since 780 ka demonstrate periods of intense volcanic activity. A hiatus of more than 200 ka has followed the emplacement of the last flowgroup at approximately 352 ka.

Variations in major and trace element concentrations and paleomagnetic inclinations were used to correlate flowgroups between USGS 135 and coreholes to its east and northeast. Regionally persistent flowgroups E, F, G, and H are present in corehole USGS 135, but younger correlative flowgroups are absent. The representation of flowgroups indicates that corehole 135 was differentially offset relative to coreholes to its east.

9.2.6 Completion Summary for Well NRF-16 near the Naval Reactors Facility, Idaho National Laboratory, Idaho (Brian V. Twining, Jason C. Fisher, and Roy C. Bartholomay)

In 2009, the U.S. Geological Survey in cooperation with the U.S. Department of Energy's Naval Reactors Laboratory Field Office, Idaho Branch Office cored and completed well NRF-16 for monitoring the eastern Snake River Plain (SRP) aquifer. The borehole was initially cored to a depth of 425 feet below land surface and water samples and geophysical data were collected and analyzed to determine if well NRF-16 would meet criteria requested by Naval Reactors Facility (NRF) for a new upgradient well. Final construction continued after initial water samples and geophysical data indicated that NRF-16 would produce chemical concentrations representative of upgradient aquifer water not influenced by NRF facility disposal, and that the well was capable of producing sustainable discharge for ongoing monitoring. The borehole was reamed and constructed as a Comprehensive Environmental Response Compensation and Liability Act monitoring well complete with screen and dedicated pump.

Geophysical and borehole video logs were collected after coring and final completion of the monitoring well. Geophysical logs were examined in conjunction with the borehole core to identify primary flow paths for groundwater, which are believed to occur in the intervals of fractured and vesicular basalt and to describe borehole lithology in detail. Geophysical data also were examined to look for evidence of perched water and the extent of the annular seal after cement grouting the casing in place. Borehole videos were collected to confirm that no perched water was present and to examine the borehole before and after setting the screen in well NRF-16.

Two consecutive single-well aquifer tests to define hydraulic characteristics for well NRF-16 were conducted in the eastern SRP aquifer. Transmissivity and hydraulic conductivity averaged from the aquifer tests were 4.8×10^3 ft^2/d and 9.9 ft/d, respectively. The transmissivity for well NRF-16 was within the range of values determined from past aquifer tests in other wells near NRF of 4.4×10^2 to 5.1×10^5 ft^2/d.

Water samples were analyzed for metals, nutrients, total organic carbon, volatile organic compounds, semi-volatile organic compounds, herbicides, pesticides, polychlorinated biphenols, and radionuclides. All chloride, nitrate, and sulfate concentrations were less than background concentrations for the eastern SRP aquifer north of the NRF. Concentrations in water samples for most of the organic compounds and radionuclides were less than the reporting limits and reporting levels.

References for Section 9.2

Ackerman, D.J., Rousseau, J.P., Rattray, G.W., and Fisher, J.C., 2010, *Steady-state and transient models of groundwater flow and advective transport, Eastern Snake River Plain aquifer, Idaho National Laboratory and vicinity, Idaho.* U.S. Geological Survey Scientific Investigations Report 2010-5123, 220 p.

Bartholomay, R.C., and Twining, B.V., 2010, *Chemical constituents in groundwater from multiple zones in the Eastern Snake River Plain Aquifer at the Idaho National Laboratory, Idaho, 2005–08*. U.S. Geological Survey Scientific Investigations Report 2010-5116, 82 p.

Davis, L.C., 2010, *An update of hydrologic conditions and distribution of selected constituents in water, Snake River Plain aquifer and perched groundwater zones, Idaho National Laboratory, Idaho, emphasis 2006–08*. U.S. Geological Survey Scientific Investigations Report 2010–5197 (DOE/ID-22212), 80 p.

Nimmo, J.R., 2010, Theory for source-responsive and free-surface film modeling of unsaturated flow, *Vadose Zone Journal*, v. 9, p. 295-306.

Potter, K.E., 2010, *Subsurface stratigraphy of the Arco-Big Southern Butte Volcanic rift zone and implications for Late Pleistocene rift zone development, eastern Snake River Plain, Idaho*. Idaho State University Master's thesis

Twining, B.V., Fisher, J.C., and Bartholomay, R.C., 2010, *Completion summary for well NRF-16 near the Naval Reactors Facility, Idaho National Laboratory, Idaho*. U.S. Geological Survey Scientific Investigations Report 2010-5101, 36 p.

Idaho Fish and Game and Idaho State University biologists fitting elk on the INL Site with Global Positioning System collars

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 2010 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 DOE activities are provided in DOE Order 414.1C, “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 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 414.1C that are required as part of a quality program are shown in the box on the right. Each 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 2010, 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, Idaho National Laboratory (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 Program Requirements Documents* (INL 2010) 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.

Rough-legged Hawk

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 Device 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

Western Bluebird

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
Decontamination Documents	GDE-149, Cleaning of Environmental Services Project (ESP) Sampling Equipment
Documentation Documents	MCP-9227, Environmental Project Support 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, “Liquid Effluent Monitoring Program Plan”
- PLN-730, “Idaho Cleanup Project Drinking Water Program Plan”
- PLN-1305, “Groundwater Monitoring Program Plan.”

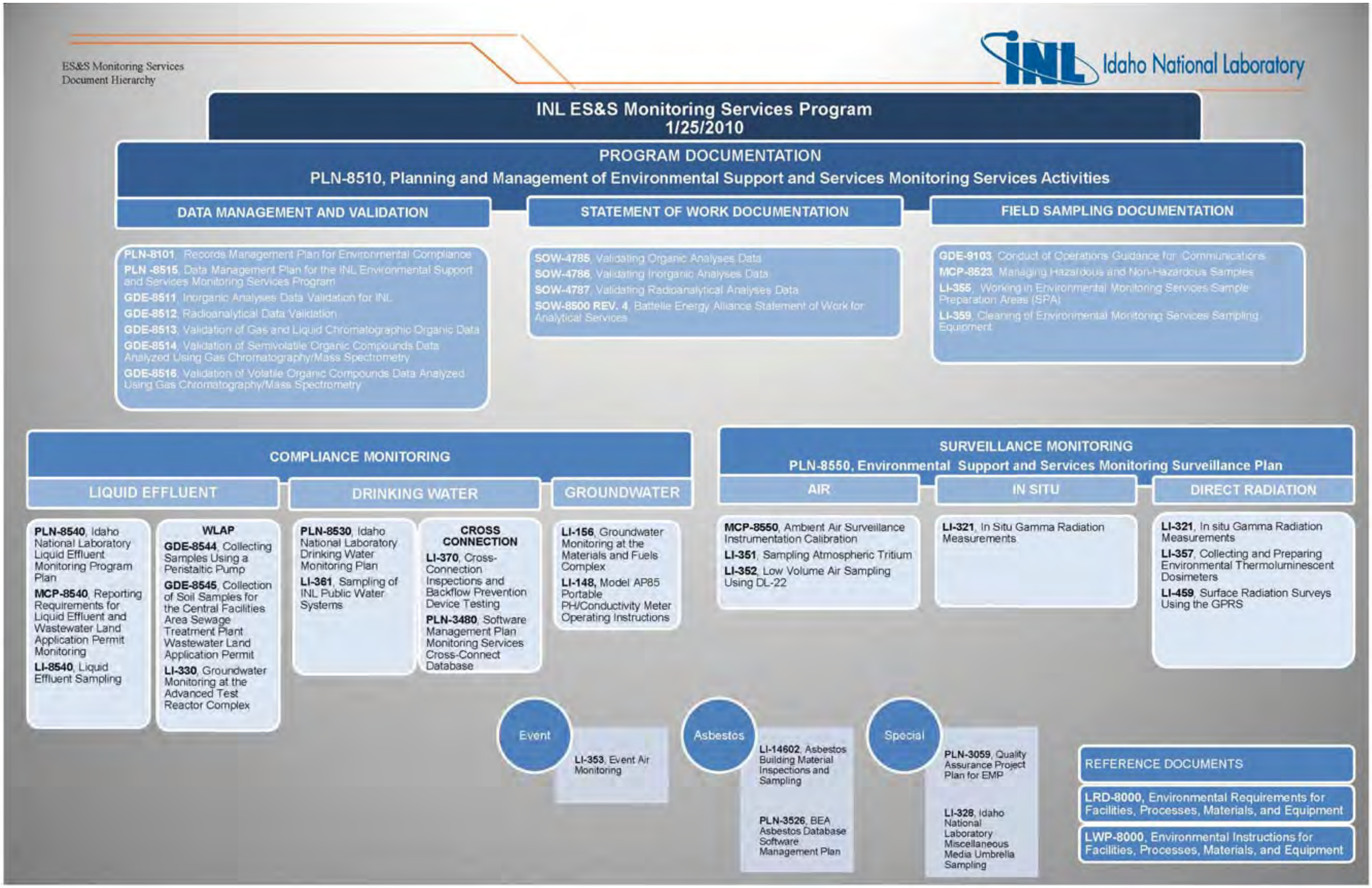


Figure 10-1. Idaho National Laboratory Environmental Support and Services Program Documentation.

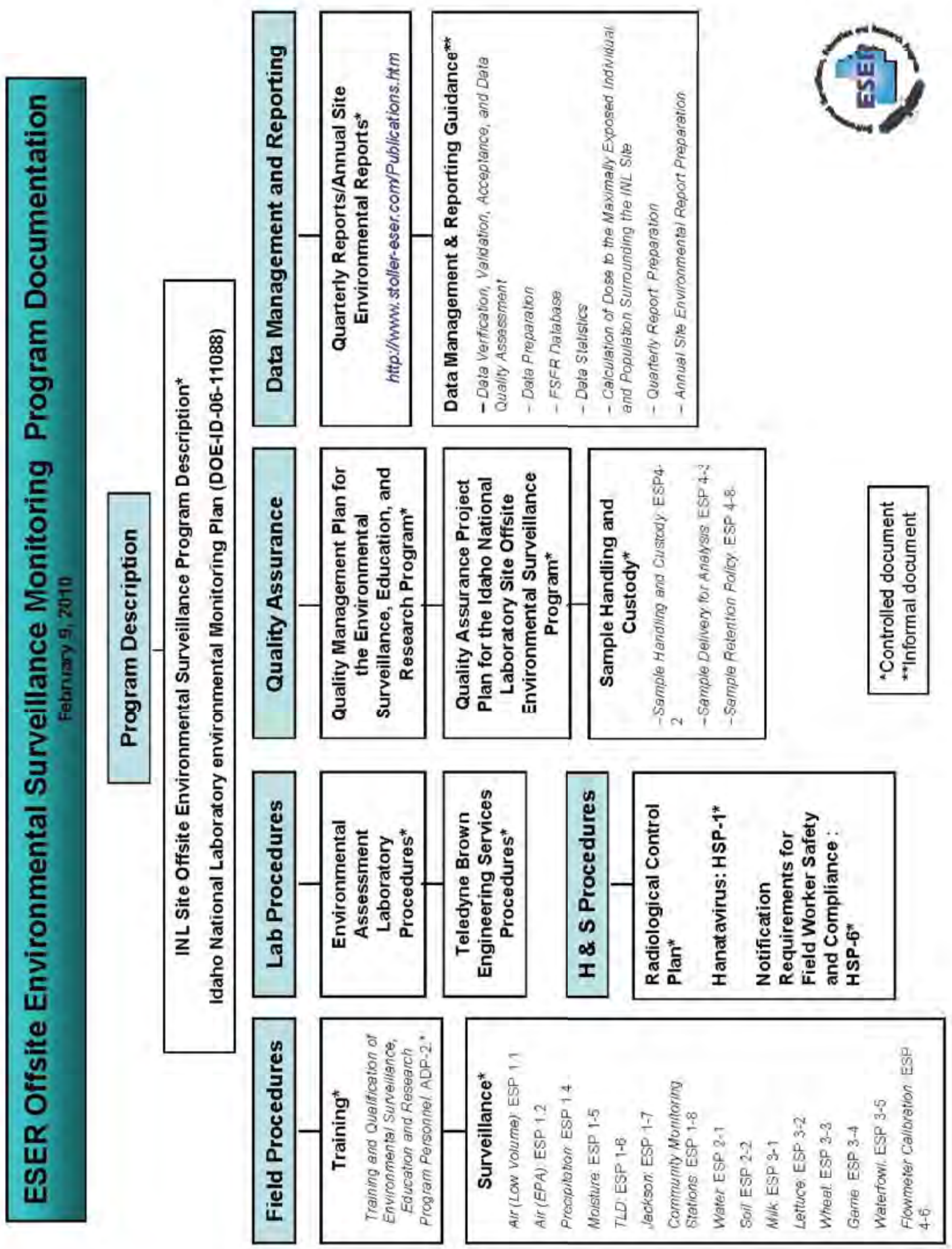


Figure 10-2. Environmental Surveillance, Education and Research Program Offsite Environmental Surveillance Documentation.

Rough-legged Hawk

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.

Radioanalytical 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 interlaboratory 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 2010

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 control samples measure precision and accuracy of sampling and analysis activities. **Precision**

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	General Engineering Laboratories, LLC	Radiological
	Intermountain Analytical Service – EnviroChem	Microbiological
	Underwriters Laboratories, Inc.	Inorganic and organic
ICP Environmental Program	GPL Laboratories Alabama, LLC (aka Centauri Labs)	Radiological
	ALS Laboratory Group – Fort Collins	Radiological
ICP Effluent Monitoring Program	ICP Wastewater Laboratory	Microbiological
	General Engineering Laboratories, LLC	Radiological
	Southwest Research Institute	Inorganic
ICP Groundwater Monitoring Program	General Engineering 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
	Teledyne Brown Engineering of Knoxville, Tennessee	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 isotope
	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


Rough-legged Hawk

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 2010 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 2010, field duplicates were collected at the Central Facilities Area Lift Station, Materials and Fuels Complex Industrial Waste Pipeline, EBR-II, and USGS-065.

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 2010.

Accuracy was assessed using the results of the laboratory's continuing calibration and matrix spikes.

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 that 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.

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 2010 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 2010, performance evaluation samples were submitted to the laboratory with routine monitoring samples on March 17, 2010, June 9, 2010, August 11, 2010, and October 20, 2010. 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 September 15, 2010. The RPD between the duplicate samples is used to assess data precision. For 2010, 88 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 April 21, 2010. 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 2010, 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 2010, 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 2010 or October 2010. However, samples were collected from that well in June 2010. Samples were not collected from upgradient aquifer Well ICPP-MON-A-167 in October 2010. However, samples were collected from the proposed replacement well, Well ICPP-MON-A-164B. All other permit-required samples were collected.

All groundwater sample results were usable, except the April 2010 total and fecal coliform sample results for Well ICPP-MON-V-212, which were rejected based on historical results, results of follow-up sampling, and sample collection irregularities associated with this well.

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 2010.

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 2010 and July 2010 sampling events, performance evaluation samples were analyzed for fecal and total coliforms. The April 2010 performance evaluation sample results were outside the performance acceptance limits, and the supplier and laboratory were notified so they could evaluate whether corrective action was necessary. The July 2010 performance evaluation results were within the performance acceptance limits.

During the October 2010 groundwater sampling event, performance evaluation samples were analyzed for fecal and total coliforms and inorganics. The laboratory was notified of the total phosphorus 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.

Rough-legged Hawk

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 2010, the INL contractor had one 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:

$$\left| R_1 - R_2 \right| \leq 3\left(\sigma_1^{\,2} + \sigma_2^{\,2}\right)^{1/2} \qquad (2)$$

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 2010, 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 DQOs 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 2010.

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 2010 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 2010.

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. The laboratory was notified of the results outside the performance acceptance limits, and the laboratory implemented a corrective action plan.

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 2010 – blank samples, field duplicate samples, laboratory split samples, and performance evaluation samples (i.e., blind spike samples).

The ESER contractor met greater than 98 percent of its completeness goals in 2010. Twelve air samples were considered invalid because insufficient volumes were collected due to power interruptions. A few milk samples were not collected in 2010 because they were not available for collection. All other samples were collected as planned.

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 2010, the majority of blanks were within one to two standard deviations of zero. However, one blank air composite result indicated that the sample set may have become contaminated and prompted an assessment by ESER QA personnel. Another set of air samples collected during the same time period was then sent to the laboratory to replace

Rough-legged Hawk

the disqualified set. No indication of contamination was observed in these samples and the results were determined to be usable for reporting.

Field duplicate samples were collected for air and for milk, potatoes, and wheat 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 3 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 greater than 95 percent of all environmental samples collected during 2010 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 2010 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. Teledyne Brown Engineering recounts a sample if a radionuclide is positively detected in the sample to confirm the detection. No issues were reported with the recounted data.

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. The results were all acceptable during 2010. However, one result for strontium-90 (^{90}Sr) in soil was acceptable with warning because it was biased low and one result for cesium-134 in vegetation was with warning because it was biased low (see Section 10.6.1).

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 soil, air, and milk samples. All results showed satisfactory agreement with the known activities except the following: air samples showed poor agreement for ^{90}Sr and plutonium-238 and may be biased low and soil samples showed poor agreement for plutonium-239/240 and ^{90}Sr and may also be biased low. In addition, false positives were reported for plutonium-239 in an air filter and cobalt-60 in a soil sample. The nonconforming results will assessed further with the laboratory and ESER QA personnel for acceptable resolution in 2011.

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 laboratories met the performance objectives specified by MAPEP and the National Center for Environmental Research.

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.

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 2010 for the Waste Management Surveillance Program showed satisfactory agreement except the following: the air samples showed poor agreement and may be biased low for cesium-134, and false positives were reported for plutonium-239/240 in air and water samples.

The ICP Waste Management Surveillance Program did not meet its completeness goal for air samples due to the laboratory closure; however, it did meet its 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 2010, the results for the analyzed samples 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 2010, the USGS collected 22 replicate samples, four equipment blank samples, two blank samples, and four trip blank samples. 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 ten 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 Mixed Analyte Performance Evaluation Program (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 22 was distributed in March 2010, and Series 22 was distributed in September 2010.

Both radiological and nonradiological constituents are included in MAPEP. Results can be found at http://www.inl.gov/resl/mapep/reports.html (DOE 2010).

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 2010.

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 U.S. Department of Energy (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 2010 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 2010 is not yet available, however according to the INL Oversight Program Annual Report 2009 (available at http://www.deq.state.id.us/inl_oversight/library/2009_annual.pdf):

> A total of 554 filters from total suspended particle samplers were collected during 2009. The results from the analyses of off-site location samples were indistinguishable from those of on-site locations. Gross alpha and beta screening results for 2009 are well below federal regulatory limits (40 CFR 61). For 2009, gross alpha particle results agreed for more than 80 percent of the paired samples. Gross beta particle results for DEQ-INL (OP), were not in overall statistical agreement with those of ESER, or BEA. These differences have been an ongoing for several years and were investigated by DEQ-INL (OP) in 2008-2009. Variations in results were quantified and effort was made to identify differences in sampling methods that might be leading to differing results among the monitoring organizations. Results of the year long study showed that flow rate and filter size had little impact on the measured concentrations of alpha and beta particles detected during analyses. During the course of the study it was discovered that the air volume (the amount of air passing through the filter) was not being corrected for Southeast Idaho's atmospheric pressure by DEQ-INL (OP). All of DEQ-INL (OP) samplers are calibrated at STP (standard temperature and pressure). Standard pressure is higher than SE Idaho's atmospheric pressure. The results reported for 2009 reflect the change in calculation by including the pressure correction that accounts for ~17 percent of the variation in results. A temperature correction was not used as it only accounted for ~2 percent of the variation. Variations in sampling schedule and equipment configuration may also contribute to observed differences. Despite the improvement in volume measurement for 2009, Overall, DEQ-INL (OP) air monitoring results agreed with the results obtained by DOE and its contractors either (1) by direct comparison or, (2) by the fact that all results are well below regulatory limits and pose no health concerns for the citizens of Idaho. DEQ-INL (OP) has placed several EICs (electrets ionization chambers) at locations monitored by DOE contractors, using thermoluminescent dosimetry (TLD). Ambient penetrating radiation measurements during 2009 showed 100 percent of BEA's TLD measurements and 100 percent of ESER Stoller'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.

REFERENCES

10 CFR 830, 2002, Subpart A, “Quality Assurance Requirements,” *Code of Federal Regulations*, Office of the Federal Register.

40 CFR 61, 2010, Appendix B, “Test Methods, Method 114, Test Methods for Measuring Radionuclide Emissions from Stationary Sources, *Code of Federal Regulations*, Office of the Federal Register.

40 CFR 61, 2010, Subpart H, “National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities,” *Code of Federal Regulations*, Office of the Federal Register.

AMWTP-PD-EC&P-02, current revision, “Quality Assurance Project Plan for the WMF-676 NESHAPs Stack Monitoring System,” Advanced Mixed Waste Treatment Project.

ANSI/ANS 3.11 2005, 2005, “Determining Meteorological Information at Nuclear Facilities,” American National Standards Institute/American Nuclear Society.

ANSI/ASQC E4-1994, 1994, “Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs,” American National Standards Institute/American Society for Quality Control.

ASME NQA-1, 2008, “Quality Assurance Requirements for Nuclear Facility Applications,” American Society of Mechanical Engineers.

Bartholomay, R. C. and B. V. Twining, 2010, “Chemical Constituents in Groundwater from Multiple Zones in the Eastern Snake River Plain Aquifer at the Idaho National Laboratory, Idaho, 2005-08,” U.S. Geological Survey Scientific Investigations Report, 2010-5116 (DOE/ID-22211), U.S. Geological Survey, Available at http://pubs.usgs.gov/sir/2010/5116/.

DOE, 2010, “Mixed Analyte Performance Evaluation Program,” U.S. Department of Energy, Available at http://www.inl.gov/resl/mapep/reports.html.

DOE Order 414.1C, 2005, “Quality Assurance,” U.S. Department of Energy.

DOE/EH 0173T, 1991, “Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance,” U.S. Department of Energy.

DOE-ID, 2009, *Quality Assurance Project Plan for Waste Area Groups 1, 2, 3, 4, 5, 6, 7, 10 and Removal Actions*, DOE/ID 10587, Rev. 10, U.S. Department of Energy Idaho Operations Office.

EPA, 1988, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, EPA/540/G 89/004, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency.

EPA, 2001, *EPA Requirements for Quality Assurance Project Plans (EPA QA/R-5*), EPA/240/B-01/003, U.S. Environmental Protection Agency.

ESER, current revision, “Quality Management Plan for the Environmental Surveillance, Education and Research Program,” Environmental Surveillance, Education and Research Program, S. M. Stoller Corporation.

ESER, current revision, “Quality Assurance Project Plan for the INL Offsite Environmental Surveillance Program,” Environmental Surveillance, Education and Research Program, S. M. Stoller Corporation.

International Commission on Radiation Units and Measurements (ICRU), 1994, Gamma-Ray Spectrometry in the Environment (Report 53).

INL, 2010, Manual 13A–Quality Assurance Program Requirements Documents, Idaho National Laboratory.

Knobel, L. L., B. J. Tucker, and J. P. Rousseau, 2008, *Field Methods and Quality-Assurance Plan for Quality-of-Water Activities*, U.S. Geological Survey, Idaho National Laboratory, Idaho, U.S. Geological Survey Open-File Report 2008 1165 (DOE/ID 22206), U.S. Geological Survey, Available at http://pubs.usgs.gov/of/2008/1165/.

NOAA-ARLFRD, 1993, *Quality Program Plan, NOAA Air Resources Laboratory Field Research Division*, National Oceanic and Atmospheric Administration- Air Resources Laboratory Field Research Division.

PLN 720, 2010, “Environmental Surveillance Program Plan,” Rev. 7, Idaho Cleanup Project.

PLN 729, 2010, “Idaho Cleanup Project Liquid Effluent Monitoring Program Plan,” Rev. 7, Idaho Cleanup Project.

PLN 730, 2009, “Idaho Cleanup Project Drinking Water Program Plan,” Rev. 11, Idaho Cleanup Project.

PLN 1305, 2009, “Groundwater Monitoring Program Plan,” Rev. 11, Idaho Cleanup Project.

PLN-8510, 2010, “Planning and Management of Environmental Support and Services Monitoring Services Activities,” Idaho National Laboratory.

PLN-8515, 2010, “Data Management Plan for the INL Environmental Support and Services Monitoring Services Program,” Idaho National Laboratory.

PLN-8550, “Environmental Support and Services Monitoring Services Surveillance Plan,” Idaho National Laboratory.

Wegner, S. J., 1989, *Selected Quality Assurance Data for Water Samples Collected by the U.S. Geological Survey, Idaho National Engineering Laboratory, 1980-1988*, U.S. Geological Survey Water-Resources Investigations Report 89-4168, U.S. Geological Survey, Available at http://pubs.er.usgs.gov/.

Williams, L. M., 1996, *Evaluation of Quality Assurance/Quality Control Data Collected by the U.S. Geological Survey for Water-Quality Activities at the Idaho National Engineering Laboratory, Idaho, 1989 through 1993*, U.S. Geological Survey Water-Resources

Investigations Report 96-4148 (DOE/ID-22129), U.S. Geological Survey, Available at http://pubs.er.usgs.gov/.

Williams, L. M., 1997, *Evaluation of Quality Assurance/Quality Control Data Collected by the U.S. Geological Survey for Water-Quality Activities at the Idaho National Engineering Laboratory, Idaho, 1994 through 1995*, U.S. Geological Survey Water-Resources Investigations Report 97-4058 (DOE/ID-22136), U.S. Geological Survey, Available at http://pubs.er.usgs.gov/.

Williams, L. M., R. C. Bartholomay, and L. J. Campbell, 1998, *Evaluation of Quality Assurance/Quality Control Data Collected by the U.S. Geological Survey from Wells and Springs between the Southern Boundary of the Idaho National Engineering and Environmental Laboratory and the Hagerman Area, Idaho, 1989 through 1995*, U.S. Geological Survey Water-Resources Investigations Report 98-4206 (DOE/ID-22150), U.S. Geological Survey, Available at http://pubs.er.usgs.gov/.

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 Federal Regulations*, Office of the Federal Register

- 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 450.1A, 2008, “Environmental Protection Program,” U.S. Department of Energy
- DOE Order 5400.5, 1993, “Radiation Protection of the Public and the Environment,” Change 2, 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.

Derived Concentration Guides are based on U.S. Department of Energy (DOE) Order 5400.5, “Radiation Protection of the Public and the Environment,” (1993) and have been calculated using DOE models and parameters for internal (DOE 1988a) and external (DOE 1988b) exposure. The Derived Concentration Guides are shown in Table A-1. The most restrictive Derived Concentration Guide is listed when the soluble and insoluble chemical forms differ. The Derived Concentration Guides consider only inhalation of air, ingestion of water, and submersion in air.

DOE Order 5400.5 provides the principal standards and guides for release of radionuclides at the INL Site. The DOE standard is shown in Table A-2, along with the Environmental Protection Agency statute for protection of the public, for the airborne pathway only.

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).

Table A-1. Derived Concentration Guides for Radiation Protection.

Derived Concentration Guide[a]			Derived Concentration Guide		
Radionuclide	In Air (µCi/ml)	In Water (µCi/ml)	Radionuclide	In Air (µCi/ml)	In Water (µCi/ml)
Gross Alpha[b]	2×10^{-14}	3×10^{-8}	Antimony-125	1×10^{-9}	5×10^{-5}
Gross Beta[c]	3×10^{-12}	1×10^{-7}	Iodine-129	7×10^{-11}	5×10^{-7}
Tritium	1×10^{-7}	2×10^{-3}	Iodine-131	4×10^{-10}	3×10^{-6}
Carbon-14	5×10^{-7}	7×10^{-5}	Iodine-132	4×10^{-8}	2×10^{-4}
Sodium-24[d]	4×10^{-9}	1×10^{-4}	Iodine-133	2×10^{-9}	1×10^{-5}
Argon-41[d]	1×10^{-8}	—	Iodine-135	1×10^{-8}	7×10^{-5}
Chromium-51	5×10^{-8}	1×10^{-3}	Xenon-131m[d]	2×10^{-6}	—
Manganese-54	2×10^{-9}	5×10^{-5}	Xenon-133[d]	5×10^{-7}	—
Cobalt-58	2×10^{-9}	4×10^{-5}	Xenon-133m[d]	6×10^{-7}	—
Cobalt-60	8×10^{-11}	5×10^{-6}	Xenon-135[d]	8×10^{-8}	—
Zinc-65	6×10^{-10}	9×10^{-6}	Xenon-135m[d]	5×10^{-8}	—
Krypton-85[d]	3×10^{-6}	—	Xenon-138[d]	2×10^{-8}	—
Krypton-85m[d,e]	1×10^{-7}	—	Cesium-134	2×10^{-10}	2×10^{-6}
Krypton-87[d]	2×10^{-8}	—	Cesium-137	4×10^{-10}	3×10^{-6}
Krypton-88[d]	9×10^{-9}	—	Cesium-138	1×10^{-7}	9×10^{-4}
Rubidium-88[d]	3×10^{-8}	8×10^{-4}	Barium-139	7×10^{-8}	3×10^{-4}
Rubidium-89[d]	9×10^{-9}	2×10^{-3}	Barium-140	3×10^{-9}	2×10^{-5}
Strontium-89	3×10^{-10}	2×10^{-5}	Cerium-141	1×10^{-9}	5×10^{-5}
Strontium-90	9×10^{-12}	1×10^{-6}	Cerium-144	3×10^{-11}	7×10^{-6}
Yttrium-91m	4×10^{-7}	4×10^{-3}	Plutonium-238	3×10^{-14}	4×10^{-8}
Zirconium-95	6×10^{-10}	4×10^{-5}	Plutonium-239	2×10^{-14}	3×10^{-8}
Technetium-99m	4×10^{-7}	2×10^{-3}	Plutonium-240	2×10^{-14}	3×10^{-8}
Ruthenium-103	2×10^{-9}	5×10^{-5}	Plutonium-241	1×10^{-12}	2×10^{-6}
Ruthenium-106	3×10^{-11}	6×10^{-6}	Americium-241	2×10^{-14}	3×10^{-8}

a. Derived concentration guides are from DOE Order 5400.5 and are based on committed effective dose equivalent of 100 mrem/yr for ingestion or inhalation of 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 DCG for air immersion is used because it is more restrictive than the inhaled air DCG 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.


Rough-legged Hawk

Table A-2. 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-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 same 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."

Western Bluebird

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.

	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	0.15
Mercury (mg/L)	0.002	0.002
Nitrate (as N) (mg/L)	10	10
Nitrite (as N) (mg/L)	1	1
Total Nitrate and Nitrite(mg/L)	10	10
Selenium (mg/L)	0.05	0.05
Thallium (mg/L)	0.002	0.002

a. Treatment technique action level, the concentration of a contaminant which, if exceeded, triggers treatment or other requirements that a water system must follow.

Rough-legged Hawk

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
para-Dichlorobenzene	0.075	0.075
1,2 – Dichloroethane	0.005	0.005
1,1 – Dichloroethylene		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	10
Bromate	0.01	
Bromodichloromethane		0.1
Chlorobromomethane		0.1
Chloroform		0.002
Chlorite	1.0	
Haloacetic acids (five)	0.0.6	
Trihalomethanes (chloroform)	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
Aldicarb	0.003	
Aldicarb sulfoxide	0.004	
Aldicarb sulfone	0.002	
Atrazine	0.003	0.002
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
Picrolam	0.5	0.5
Simazine	0.004	0.004
2,3,7,8-TCDD (dioxin)	3×10^{-8}	3×10^{-8}


Rough-legged Hawk

Table A-7. Environmental Protection Agency Maximum Contaminant Levels for Public Drinking Water Systems and State of Idaho Groundwater Quality Standards for Secondary Contaminants.

Constituent	Maximum Contaminant Levels[a]	Groundwater Quality Standards
Aluminum (mg/L)	–	0.2
Chloride (mg/L)	–	250
Color (color units)	–	15
Foaming agents (mg/L)	–	0.5
Iron (mg/L)	–	0.3
Manganese (mg/L)	–	0.05
Odor (threshold odor number)	–	3.0
pH	–	6.5 to 8.5
Silver (mg/L)	–	0.1
Sulfate (mg/L)	–	250
Total dissolved solids (mg/L)	–	500
Zinc (mg/L)	–	5

a. The Environmental Protection Agency only has secondary maximum contaminant levels for these constituents.

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 5400.5, 1993, “Radiation Protection of the Public and the Environment,” Change 2, U.S. Department of Energy.

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.

Independent Oversight Assessment of Environmental Monitoring at the

Idaho National Laboratory Site

May 2010

Office of Independent Oversight
Office of Health, Safety and Security

HSS
Office of Health, Safety and Security

Table of Contents

Abbreviations Used in This Report

AMWTP	*Advanced Mixed Waste Treatment Project*
ASER	*Annual Site Environmental Report*
ATR	*Advanced Test Reactor*
BEA	*Battelle Energy Alliance, LLC*
BBWI	*Bechtel BWXT Idaho, LLC*
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act*
CWI	*CH2M Washington Group Idaho, LLC*
DCG	*Derived Concentration Guide*
DOE	*U.S. Department of Energy*
DOE-ID	*DOE Idaho Operations Office*
EM	*Office of Environmental Management*
ESER	*Environmental Surveillance, Education and Research*
HSS	*Office of Health, Safety and Security*
ICP	*Idaho Cleanup Project*
IDFG	*State of Idaho Department of Fish and Game*
INL	*Idaho National Laboratory (facilities operated by BEA)*
INL Site	*Idaho National Laboratory Site (cumulative site area and facilities owned by DOE)*
IRC	*INL Research Center*
LTEM	*Long-term Ecological Monitoring*
M&O	*Management and Operating*
MAPEP	*Mixed Analyte Performance Evaluation Program*
MFC	*Materials and Fuels Complex*
MSC	*Monitoring and Surveillance Committee*
NE	*Office of Nuclear Energy*
NERP	*National Environmental Research Park*
PT	*Proficiency Testing*
RESL	*Radiological and Environmental Sciences Laboratory*
SAP	*Sampling and Analysis Plan*
WAG	*Waste Area Group*

This page intentionally left blank.

Executive Summary

This report presents the results of an assessment of environmental monitoring and surveillance activities at the U.S. Department of Energy (DOE) Idaho National Laboratory (INL) Site during March through April 2010. The assessment was performed by the DOE Office of Independent Oversight, within the Office of Health, Safety and Security at the request of the DOE Idaho Operations Office. The purpose of the assessment was to evaluate the adequacy of the INL Site environmental monitoring and surveillance program in meeting the objectives of DOE Order 450.1A, Sections 4(c)(2)(a-d) for protection of public health and the environment, and (c)(5-6) for conducting monitoring and assuring data quality, and DOE Order 5400.5 for assessing potential pathways of contaminant emissions that may impact the local environment and public living near the INL Site.

Overall, environmental monitoring and surveillance activities at the INL Site are comprehensive and meet the basic objectives of applicable DOE requirements. A number of positive attributes associated with the program were identified, including the use of data management tools and protocols, staff qualifications, plan and procedure infrastructure, and community outreach and stakeholder relationships. These positive attributes provide a sound foundation for basic program elements.

Environmental monitoring and surveillance activities are comprehensive and effectively support the overall assertions about the levels and extent of releases of radionuclides to the environment in the Site Annual Environmental Report. The effectiveness of the overall program in ensuring full understanding of potential environmental impacts could be optimized through various enhancements. These enhancement opportunities exist in a few areas of program design and/or implementation, including concerns with the technical basis for some program elements, coordination and communication among contractors, and clarity and accuracy in some published reports. Other enhancement opportunities involved the implementation of certain quality assurance protocols, as well as several media-specific monitoring and surveillance concerns. From a public health perspective, the potential impact of these concerns is not significant because the monitoring and surveillance activities are designed to be able to detect site impacts that are only slightly in excess of normal background levels. Nevertheless, it is DOE's objective to strive for excellence in environment safety and health programs and to ensure that information provided to the public is accurate and that the basis for the information is sound and transparent. As such, recommendations for enhancement and refinement of the environmental monitoring and surveillance program in the areas of potential concern described in this report are also presented.

This page intentionally left blank.

1 Introduction

The U.S. Department of Energy (DOE) Office of Independent Oversight, within the Office of Health, Safety and Security (HSS), performed an assessment of environmental monitoring and surveillance at the DOE Idaho National Laboratory (INL) Site during March through April 2010. The assessment was performed at the request of the DOE Idaho Operations Office (DOE-ID). HSS reports directly to the Secretary of Energy, and this INL sitewide environmental monitoring program assessment was performed by Independent Oversight's Office of Environment, Safety and Health Evaluations with support from assessment team members from Nuclear Energy's Integrated Safety and Program Assurance Office, HSS's Office Of Analysis, and National Security Technologies, LLC. This report discusses the results of the review of the INL Site environmental monitoring and surveillance program.

Consistent with the DOE-ID request, this independent assessment focused on determining whether the current INL Site environmental monitoring program components are adequate to evaluate all significant potential impacts from laboratory and cleanup operations on the surrounding environment and the public; potential pathways of contaminant emissions; and on identifying strengths, lessons-learned, and opportunities for improvement in the INL Site environmental monitoring and surveillance program.

Consistent with the DOE-ID's requested scope, the environmental monitoring assessment did not assess compliance with environmental laws and regulations, permit requirements, or certain Federal compliance-driven environmental monitoring activities, such as air effluent (stack) monitoring and dose calculation (National Emission Standards for Hazardous Air Pollutants) and drinking water and groundwater monitoring. The assessment did not evaluate the adequacy of contractor software quality assurance or validation and verification associated with the database tools being utilized.

The Office of Nuclear Energy (NE), within the Office of the Under Secretary of Energy, has line management responsibility for INL. NE provides programmatic direction and funding for advanced civilian nuclear technology research and development, facility infrastructure activities, and emergency management program implementation at INL. At the site level, line management responsibility for operations and emergency management falls under the DOE-ID Manager. Under contract to DOE-ID, INL is managed and operated by Battelle Energy Alliance, LLC (BEA), which has operated INL since February 2005.

In addition to INL programmatic operations, one of the important INL Site missions is to cleanup INL Site facilities that are no longer operational or functionally needed. The DOE Headquarters Office of Environmental Management (EM) is responsible for managing the Idaho Cleanup Project (ICP), which addresses waste management and cleanup of facilities and materials at the INL Site. EM coordinates certain sitewide functions with NE. At the site level, line management responsibility for ICP also falls under the DOE-ID Manager and is implemented primarily by DOE-ID's Office of the Deputy Manager for ICP. Under contract to DOE-ID, the ICP is managed by CH2M Washington Group Idaho, LLC (CWI), which took over responsibility for the ICP in May 2005.

Environmental monitoring and surveillance for DOE-ID is conducted by several contractors and government agencies as follows:

1. BEA - the INL management and operating (M&O) contractor (onsite monitoring)
2. Stoller Corporation - the environmental surveillance, education and research (ESER) contractor (offsite monitoring, onsite wildlife and game, Annual Site Environmental Report (ASER) preparation)
3. CWI - the ICP contractor (onsite monitoring)
4. Bechtel BWXT Idaho, LLC (BBWI) - the Advanced Mixed Waste Treatment Project (AMWTP) contractor (limited onsite monitoring)
5. US Geological Survey (supplementary groundwater monitoring)
6. National Oceanic and Atmospheric Administration (meteorological data).

CWI is also responsible for various Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and Resource Conservation and Recovery Act actions associated with their operations.

This review focused principally on the environmental monitoring being performed by the first three contractors listed above, who have the bulk of the responsibility for INL Site environmental monitoring and surveillance. Specific media and environmental monitoring activities assessed 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 addresses monitoring and meeting data quality objectives.
- Review of the INL (BEA), ICP (CWI), and ESER (Stoller) 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 (State of Idaho Department of Fish and Game (IDFG), 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 BEA 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 ASER 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 in the ASER.

2 Positive Attributes

As discussed in the following paragraphs, this assessment identified several positive attributes and strengths associated with the environmental monitoring and surveillance program at the INL Site.

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. Each contractor makes good use of electronic data management and automation tools to manage large amounts of environmental monitoring data generated from sampling activities. The INL and ICP contractors use tailored versions of database software called the Sampling and Analysis Plan (SAP) and Environmental Data Warehouse applications. These databases effectively automate much of the day-to-day logistical, quality control, and recordkeeping requirements associated with implementation of the environmental monitoring programs for the INL Site. For example, the SAP provides automation for many of the repetitive actions needed to complete routine air and liquid sampling evolutions, such as manually recording key sampling parameters (e.g., flow rate, times) as well as generation of chain of custody forms and laboratory shipping labels. Laboratory results are also electronically transmitted back to SAP following sample analysis. These types of automation greatly reduce the potential for data transcription errors associated with traditional sampling methods. Upon completion of the laboratory data validation process, final analytical results are transferred to the Environmental Data Warehouse database, which is capable of providing data presentation in a variety of formats that facilitate generation of graphs and tables published in the ASER.

The ESER contractor does not have access to the site databases but has developed its own customized Microsoft Access-based relational database that it uses to facilitate data generation and reporting for ESER sampling activities. This approach to record keeping and use of databases and tables greatly enhances the ability of the ESER contractor to manage and trend monitoring data and generate data queries that are incorporated into various reports, including the ASER.

Technical and professional staffs are well qualified and knowledgeable. All contractors had well-qualified, experienced, and competent staff managing and executing environmental monitoring programs. Many staff members have professional degrees and/or certifications in their areas of expertise, such as wildlife biology, ecology, or chemistry, and most have several years of relevant experience in environmental sciences at INL Site or other institutions.

INL Site contractors have good working relationships with external stakeholders and regulators. Independent Oversight team interviews with the IDFG staff indicated good interaction and sharing of data collected by Stoller and IDFG. As examples, the coordination and sharing of sage grouse data for population trending, the winter raptor count data, and the Breeding Bird Survey data were effective, and these data are also valuable to the IDFG. Good working relationships were also noted with the State of Idaho INL Oversight Program, as discussed in Section 4 of this report.

Plan and procedure infrastructure in support of the environmental monitoring and surveillance programs is comprehensive. A comprehensive document hierarchy is in place to ensure proper implementation of environmental monitoring programs at the INL Site. This hierarchy includes overarching plans and management requirements that define the goals and necessary programmatic elements and laboratory instructions and/or implementing procedures governing the conduct of media-specific sampling.

Monitoring of potential Endangered Species Act listed species is proactive. Monitoring activities for the sage grouse and pygmy rabbit are being conducted on the INL Site and have been for several years. Data from these studies are crucial to understanding population trends, potential and occupied habitat, natural history and ecology, and potential impacts from INL Site operations on these species. These data will be invaluable during formal consultation with the U.S. Fish and Wildlife Service in the event these potential Endangered Species Act listed species become listed.

Research and collaboration with institutions of higher learning enhances the knowledge base and the effectiveness of environmental monitoring activities. The INL Site was designated a National Environmental Research Park (NERP) in 1975 and is one of the largest remaining areas of intact sagebrush steppe in North America. As such, the INL Site is an important area for conducting ecological research, training researchers, and attracting new researchers and projects. Several universities and other entities are currently conducting research on the INL Site in collaboration with the ESER contractor as part of the Idaho NERP. Current and potential uses for information from NERP projects include: (1) providing data for enhancing environmental monitoring programs; (2) better land-use planning and ecosystem management; (3) conservation planning purposes; (4) identifying sensitive areas that may require protection or restoration; and (5) providing interpreted research results to support the National Environmental Policy Act process, radionuclide pathway analysis, and ecological risk assessment.

3 Program Enhancements

The environmental monitoring and surveillance activities at the INL Site are comprehensive and effectively support the overall statements in the ASER, and the independent assessment did not identify any program vulnerabilities that would affect the ability of the INL Site to detect significant site impacts. However, several enhancements to the program to ensure full understanding of potential environmental impacts may be hindered by weaknesses in program design and implementation. Addressing these enhancements will optimize the program and ensure that DOE fully meets its goal of achieving the highest standards of technical defensibility in its environment, safety, and health programs and in published reports.

The main areas for enhancement are briefly summarized below and discussed further in Sections 4.2 and 4.3, which include recommendations for program enhancements and refinements for consideration by site management.

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. While a significant amount of environmental monitoring and surveillance is being performed to characterize the potential for impact from INL Site operations, there is no well-defined technical basis for each media sampled to support or defend the adequacy of protocols to meet current objectives (i.e., what is sampled, the frequency of sampling, the locations chosen, specific analytes being measured).

Some aspects of the program were not sufficiently coordinated and communicated among contractors. Responsibilities for environmental monitoring and surveillance at the INL Site are split among several contractors, and, in some cases, the coordination and communication between these contractors is not fully effective in ensuring comprehensive and accurate sampling, analysis and reporting, and long-term transition planning.

Some information in published environmental reports was not fully accurate and clear. A summary of overall environmental monitoring and surveillance activities is published annually in the INL Site ASER. While the overall ASER is effective in conveying necessary annual environmental protection and performance information, there are several underlying weaknesses in the presentation and technical defensibility of some of the reported information.

Implementation of certain quality assurance protocols and media specific monitoring and surveillance actions were not fully effective. Quality assurance of laboratory analyses and data reporting is adequate but does not employ consistent application of enhanced techniques, such as consistent use of double blind sampling by each contractor to supplement the mixed analyte performance evaluation program (MAPEP) goal of ensuring high quality and accuracy in laboratory analyses. In general, media-specific environmental monitoring and surveillance activities were adequate to meet DOE requirements. However, for several media types, weaknesses in the rigor of implementation and/or design of sampling programs have the potential to affect the INL Site's ability to fully characterize the magnitude of potential impacts.

4 INL Site Environmental Monitoring Program

4.1 Overall Assessment

Overall environmental monitoring and surveillance activities at the INL Site are comprehensive and meet the overall objectives of DOE environmental orders. While the positive attributes discussed in Section 2 provide a sound foundation for program effectiveness, the Independent Oversight team identified various weaknesses that hinder the cohesiveness and technical defensibility of environmental monitoring and reporting activities. These weaknesses generally fall into two basic categories: (1) crosscutting concerns that were broad based and spanned all media (i.e., air, liquid, soil, vegetation, food chain) and organizations reviewed and which generally related to program design and management, and (2) media-specific weaknesses that were related to implementation of the program. Specific examples are provided of instances where crosscutting concerns may be responsible for impacting the quality or suitability of environmental monitoring and surveillance activities. These two areas and related recommended opportunities for improvement and program refinement are addressed in detail in this section.

4.2 Crosscutting Concerns and Recommendations

Several crosscutting gaps or weaknesses were identified relating to sampling design and management that reduce the effectiveness of overall environmental monitoring and surveillance programs at the INL Site.

The technical basis for sitewide environmental monitoring and surveillance activities is not fully defined and documented. There is a significant amount of environmental monitoring and surveillance being performed to characterize the potential for impact from INL Site operations on the public and the environment. The information gathered from these activities is comprehensive and generally sufficient to meet regulatory requirements and demonstrates that there are no undue risks being posed by the site. However, the sampling design of many existing environmental monitoring activities dates back to their origins many years ago and there is no well-defined technical basis to support or defend the adequacy of protocols to meet current objectives. For example, the current ambient air monitoring locations have been the same for decades, although there have been many changes in facility operations and site missions that bring into question the current adequacy of the original placement of samplers.

For potentially affected environmental media (air, liquid, soil, vegetation, food chain), the INL Site does not have a sufficiently documented technical basis to justify the sampling strategy (i.e., what is sampled, the frequency of sampling, the locations chosen, and the specific analytes being measured).

(Also see Section 4.3.) Without a sound technical basis in these areas, the monitoring program is inherently vulnerable to any challenge to demonstrate that each element of the monitoring program is meeting associated objectives, including requirements of applicable regulations and DOE orders. This concern applies to environmental monitoring only, since the technical basis for sampling conducted as part of CERCLA actions, specific regulatory permits, and/or required by DOE Order 435.1A was not evaluated as part of this assessment.

Another area where the technical basis has not been fully developed is in the establishment of an overarching strategy for transferring restoration/natural attenuation functions from EM to NE, including transition of responsibility for maintaining data and continued long-term monitoring at restored sites. As restoration sites are closed, they may be transitioned from the responsibility of the ICP or other contractors to the INL M&O contractor. Discussions and planning for future monitoring (e.g., organizational responsibility for conducting and integrating the monitoring into the sitewide monitoring plan, and maintaining monitoring data) are not well defined. Based on concerns found at other DOE sites where restoration actions have been in place for years, particular attention is needed for long-term monitoring to determine if items, such as bio-intrusion or cover cap failure, are allowing contaminants to be released into the environment. Realizing there are specific CERCLA requirements for environmental monitoring during cleanup activities and possibly thereafter, attention must also be paid to monitoring requirements per DOE Order 450.1A or other applicable DOE orders. It may be necessary to transition individual locations within waste area groups (WAGs) to the INL M&O contractor before the overarching strategy for transition is implemented. (See additional discussion and recommendation in Section 5.2.)

> **Recommendation:** Consider establishing formal criteria for preparation of technical basis documents for all aspects of environmental monitoring and surveillance activities. Ensure the technical basis for all monitoring activities (i.e., type, frequency, analytes) is clearly documented, justifiable to meet overall objectives for each media, and ensures minimum standards of consistency across different contractors. Include a mechanism for periodic review of monitoring and surveillance activities based on changes to INL Site mission and operations.

> **Recommendation:** Consider establishing a schedule and preparing one or more technical basis documents that define the technical details associated with all environmental monitoring actions. Use the results of this effort to identify any gaps in current protocols, and implement revisions as necessary.

Coordination and communication among contractors is not sufficiently mature to ensure all program objectives are met. One of the numerous sampling activities conducted at the INL Site is the sampling of areas impacted (close by or within) CERCLA Sites (WAGs 1-9) and those areas away from locations where actions are ongoing (i.e., WAG 10 "Site-wide WAG"). Although the results of these sampling efforts are reported to the various agencies as required and a Long-Term Ecological Monitoring (LTEM) Plan is developed and submitted for approval, much of the monitoring data is not being included or incorporated (either directly or by reference) into the ASER where the data would convey a more complete picture of the actual ongoing environmental monitoring activities at the INL Site. Additionally, the LTEM (WAG10-04) states as one of its purposes "to allow coordination with ongoing environmental monitoring efforts." However, the various site contractors acknowledge that they are not fully knowledgeable about the LTEM sampling results, and do not take advantage of coordinating sampling efforts or utilization of LTEM data. Additionally, long-term monitoring (i.e., bio intrusion, incidental release) for closed CERCLA operable units or completed actions has not been coordinated between contractors.

As stated above, the technical basis for many sampling activities is undocumented, and existing sampling has not been coordinated among various onsite contractors (i.e., LTEM, BEA/CWI environmental monitoring) or considered in terms of its overall adequacy. For example, sampling from within AMWTP is not integrated or coordinated with the ESER or site contractors, as this is a BBWI managed activity. Although the site contractors and stakeholders voluntarily established a Monitoring and Surveillance Committee (MSC) in 1997, with a charter to address the coordination of environmental surveillance and monitoring at the INL Site, participation by other than the principal site contractors has been limited. This lack of participation has impacted the effectiveness, since BBWI does not actively participate in the MSC.

Recommendation: Consider increasing the formality and rigor of communications between contractors through development of an overarching communications protocol/plan defining the specific elements to be addressed (i.e., MSC, sampling efforts between LTEM and site contractors) and formal roles and responsibilities for achieving the objectives.

Recommendation: Consider incorporating LTEM program data into the ASER and reporting data collection periodically to the MSC.

Recommendation: Consider soliciting information from members of the MSC in advance of meetings for distribution to compensate for scheduling conflicts and/or other obligations which may impact attendance. Ensure distribution of the minutes of the meeting with topics from the previous meeting and for the next meeting to assist the members in planning attendance and participation.

Recommendation: Consider holding ad-hoc meetings under the direction of DOE-ID that focus on specific coordination issues that cannot be accommodated through the mode of casual information exchange among the various entities during the MSC.

There are clarity and accuracy concerns associated with some technical information published in the ASER. While the overall ASER is effective in conveying necessary annual environmental protection and performance information, there are underlying weaknesses in the technical defensibility of some of the reported information.

Some of the narrative contained in the ASER was misleading and/or did not contain sufficient explanation. For example, regarding soil sampling, the second paragraph of Section 7.2 implies that all isotopes of concern are sampled both onsite and offsite. However, the INL contractor only performs in-situ gamma measurements and only reports results for Cs-137 (see Section 4.3.3 for additional details).

In addition, some statements made in the ASER are not technically defensible or accurate. For example, when comparing data on Cesium-137 (Cs-137) levels detected on the INL Site, the narrative states that reported levels were consistent with background or fallout levels. However, this statement did not consider a 2008 in-situ gamma result in excess of 10 pCi/g from the INL contractor, which was also published in this section of the ASER. This value was more than ten times the reported average INL Site fallout levels presented in other INL Site documents.

Similarly, comparisons of anomalous data are sometimes made out of context against the DOE Order 5400.5 air and liquid Derived Concentration Guides (DCGs), without explaining what the DCGs actually represent (i.e., 100 mrem annual exposure). In the Quality Assurance section (Section 10.1.2), the impact of one of the laboratories' failures to meet MAPEP acceptable tolerance for a Pu-238 analysis was not explained, calling into question the validity of sampling results for Pu-238 for that particular laboratory. Other examples include the inclusion of anomalous data without sufficient explanation of the published results (i.e., reported U-234 data without detection of U-238 and similar detection of a short-lived medical isotope on an air sample at an offsite background location).

Recommendation: Consider a formal DOE-ID-approved protocol for review and concurrence of the ASER by all contractors, with concurrence on predefined deadlines and joint accountability for accuracy and technical defensibility of data tables and narrative prior to ASER publication.

Recommendation: Consider including other entities with expertise and independence, such as the Radiological and Environmental Sciences Laboratory (RESL), in the ASER review and comment cycle to gain additional insights and quality assurance of technical content in their areas of expertise.

Recommendation: Consider documenting a common set of defensible data quality objectives defining background radiation levels, including fallout for all media at the INL Site, that can be used by all contractors for standardized evaluation and interpretation of laboratory-reported results being published in the ASER.

Quality assurance of laboratory analyses and data reporting is adequate but could be improved further with enhanced laboratory oversight and accountability. The MAPEP, administered by the DOE RESL, on behalf of HSS, is an excellent tool to evaluate whether a contracted laboratory has the capability and resources to perform accurate radiological analysis of environmental samples containing known quantities of radioactivity. All laboratories used by INL Site contractors participate in the Department's corporate proficiency testing (PT) program. However, because PT is performed semi-annually for certain analytes within particular matrices (i.e., soil, water, vegetation, and air filters) it cannot be completely relied upon to ensure the validity and reliability of analytical environmental data. This PT weakness was discovered because laboratories participating in the MAPEP have unknowingly been sent double blind spiked and/or blank samples and, in some cases, have failed to report accurate analytical PT results.

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. The 2008 ASER section on quality assurance discusses the use of MAPEP-qualified laboratories but does not discuss the use and importance of double blind sampling by INL Site contractors. Various reported data anomalies and inconsistencies in the 2008 ASER call into question laboratory reporting and analysis capabilities for some media and nuclides. For example, reporting of positive U-234 results with corresponding non-detects for U-238 by the same laboratory does not appear reasonable given that both uranium isotopes should be present naturally in measurable quantity. Similarly, I-131 is shown as a positive detection at an offsite background location, which would be highly unlikely for a short half life radioisotope not present naturally. It should be noted that the MAPEP process does not evaluate laboratory capability for the analyte, radioiodine.

Recommendation: As part of the technical basis document development, consider establishing minimum standards that include double blind sampling by all contractors to complement the MAPEP process in the overall quality assurance program for environmental monitoring.

4.3 Media-Specific Perspectives and Recommendations

4.3.1 Air Monitoring

The review of air monitoring focused on sampling for environmental surveillance of air being conducted, pursuant to DOE Order 5400.5 and DOE Order 450.1A, as a means of detecting changes in ambient air concentrations attributable to operations at the INL Site. This review did not evaluate the compliance-based effluent air monitoring conducted by some INL Site facilities, as required by the Clean Air Act under 40 CFR 61. All three contractors perform low volume air sampling at predefined locations to measure ambient air concentrations in the environment.

The locations and/or types of some ambient air monitoring stations may not be representative of the best-suited locations for detecting air releases from current operations. In some cases, placement of sampling heads is not consistent with *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (DOE/EH-0173T) that calls for placement in downwind areas unaffected by vehicular traffic and other environmental factors (i.e., building wake) that could affect the ability to properly detect radioactivity. At the Materials and Fuels Complex (MFC), for example, the only sampler is located directly in the flow of vehicular and bus traffic in the parking lot, which is also upwind of the prevailing wind direction. At the Advanced Test Reactor (ATR) Complex, one of the most significant potential release points is a fugitive emission source, the recently constructed evaporation pond. However, the two existing ambient air monitors at ATR Complex were in place prior to construction of the pond and are not ideally situated downwind of the pond, which would be the best location for reliably detecting and quantifying the magnitude of fugitive emissions. Since the pond is considered a diffuse rather than point source, releases can be estimated via calculations, and there are no Federal requirements for effluent monitoring as with a point source (i.e., stack). Also, all ambient air sampling being performed at the site is considered low volume sampling. There are no high volume samplers being run for comparison and that may have better capability to detect contaminants during adverse meteorological conditions, such as high winds.

> **Recommendation:** For the INL contractor, consider enhancing the current ambient air monitoring around the most significant potential release sources at the INL Site by moving and/or adding low volume samplers complemented by several high volume samplers in the prevalent downwind direction from these sources (i.e., MFC, ATR stack and evaporation pond, transuranic waste retrieval).

> **Recommendation:** For the ESER contractor, consider comparing data from high volume air sampling being performed at the same locations by other entities (State of Idaho, etc) to existing low volume sampling results.

Other than one background location, there is no ambient air monitoring performed in Idaho Falls to detect potential impacts from the INL Research Center (IRC) and related facility operations. Several contractors operate a background air monitoring station situated near the Idaho Falls airport. While the potential for significant emissions from Idaho Falls INL operations is low, there is a potential for radionuclide air releases from various locations and IRC stacks and other Research and Education Campus facilities. This situation is clearly documented in the site Environmental Monitoring Plan and related documents. The impending move of RESL and other radiological operations to Idaho Falls may marginally increase the magnitude of air emissions. Based on the existing and future continued potential for radionuclide air releases, the basis for the lack of any ambient air monitoring near potential sources within Idaho Falls is not well defined.

Recommendation: Consider adding ambient air monitoring station(s) for source characterization downwind of radionuclide operations being conducted in Idaho Falls. Alternatively, ensure a well-defined technical basis is established to support the lack of any ambient air sampling.

4.3.2 Liquid Effluent Monitoring

The INL Site contractor performs most of the liquid effluent sampling, the requirements of which are defined in State and local wastewater discharge or reuse permits. Composite samplers are used to collect representative samples at effluent discharge points and analyzed for parameters defined in the discharge permits. With one exception noted below, liquid effluent sampling protocols adequately characterize potential impacts to wastewater collection systems.

Permit-driven requirements for liquid effluent sampling are rigorously followed; however, these requirements alone do not always ensure sufficient sampling or analysis of radionuclides as needed to demonstrate compliance with DOE Order 5400.5 requirements for radionuclide concentrations in liquid effluent. Although radionuclides are used in various locations in the IRC, the INL contractor performs no radionuclide sampling of liquid effluent as a means of demonstrating compliance with liquid effluent DCG limits defined in DOE Order 5400.5. Wastewater discharge permits for IRC do not currently require the sampling of radionuclides. The ability to demonstrate compliance with the provisions of DOE Order 5400.5 can only be achieved through sampling and/or radionuclide quantity limits low enough to ensure the DCGs cannot be exceeded based on concentration calculations using average facility-specific discharge volumes.

Recommendation: Consider addressing these factors in technical basis documentation for liquid effluent environmental monitoring, and include requirements for radionuclide sampling or calculational methodology that is sufficient to characterize the potential liquid effluent radionuclide concentrations and demonstrate that they are consistent with DOE Order 5400.5 criteria.

4.3.3 Soil Monitoring

Soils are sampled by each of the three contractors to detect trends and determine whether long-term deposition of airborne materials from the INL Site have resulted in any buildup of radionuclides. The following concerns were identified with respect to the current soil sampling activities at the INL Site.

Soil sampling approaches and level of rigor vary between contractors, making comparison of results and ASER interpretation of impacts difficult. Both the ESER and ICP contractor perform traditional soil sampling and report results for various isotopes of interest and concern. Additionally, the LTEM 10-04 program conducts traditional soil sampling, which is comparable but currently not reported in the ASER. However, the INL contractor relies on an in-situ gamma spectroscopy system, which offers the ability to cover much more territory than traditional sampling, but is not capable of detecting some radionuclides of interest being measured by other contractors. In addition, the INL contractor is only currently reporting data for Cs-137. The basis and suitability of this approach for detecting impacts and trends from all site sources and radionuclides are not documented (see Section 4.2 under technical basis discussion). In addition, internal program requirements for soil sampling are not being rigorously followed. For example, PLN-8550 requires that isotopes other than Cs-137 be sampled and reported and requires follow-up investigation and additional sampling if Cs137 results exceed three times the background levels. While these criteria were exceeded in 2008 sampling, no additional sampling or reporting was performed. Furthermore, the rationale for selection of sampling locations is not well documented (see Section 4.2) and, in some cases, provides no basis for comparison of other media sampled.

Recommendation: Consider collection of some fraction of soil samples concurrently with other media, such as air, to provide comparable results.

Recommendation: Consider formal coordination of sampling protocols and reporting between contractors, including additional information sources (i.e., LTEM) as appropriate.

Recommendation: Consider increasing the level of rigor in performing required soil sampling and reporting consistent with institutional requirements.

4.3.4 Agricultural Products and Game Animals Monitoring

The Independent Oversight assessment of agricultural products and game animals focused on determining whether a monitoring program was in place for evaluating the potential dose to the public through the consumption of these items and if INL Site operations are contributing to this dose, based on the guidelines found in DOE/EH-0173T. It did not evaluate the compliance status of the monitoring results. The ESER contractor is mainly responsible for sampling agricultural products and game animals.

Some products in the food chain are not being fully sampled to assess potential impacts from INL Site operations. Pathway analysis at the INL Site has been ongoing since the 1950s; however, sampling of some biota has decreased over the years, and the current sampling (i.e., wheat, potatoes) is based largely on stakeholder interest. Alfalfa is a medium that is not currently being sampled and is a potential dose pathway for local livestock, as well as livestock in other areas of the country, that consume this forage. Additionally, forage source data are not being collected in conjunction with milk sampling to determine whether dairy cows are eating forage grown locally (i.e., potentially impacted by INL Site operations) or forage brought in from other regions. A questionnaire was completed by local farmers in 2002 in an attempt to identify local sources; however, changes that have taken place in the farming community have not been captured through any update to the questionnaire. Also, a large portion of the INL Site contains cattle and sheep grazing allotments managed by the Bureau of Land Management. Forage at these locations is not routinely sampled, either statistically or from within the known isopleths (wind rose data) in downwind areas potentially impacted from deposition or redistribution of contaminants.

Although ESER monthly reports state that there is routine harvesting of game animals that have foraged on the INL Site, sampling of game animals is limited primarily to animals killed accidentally onsite. Livestock grazing on INL Site used to be sampled for radiological analysis, but this has not occurred for several years.

Recommendation: Consider sampling locally grown alfalfa offsite and native vegetation in grazing allotments or concentrated big game foraging areas onsite from areas with the highest potential to be impacted based on known isopleths and wind rose data. Ensure data are collected on usage.

Recommendation: Consider sampling big game animals that are killed onsite by hunters and livestock that have foraged in areas with the highest potential to be impacted by INL Site operations.

Control samples for agricultural and food chain products may not be sufficient to determine whether any impacts are from INL Site activities or from other causes. Currently, control samples for many media are not being sampled, or, in the case of milk, the control sample is water from a deep well. Using well water may not be a valid comparison, per DOE/EH-0173T, to determine whether any radiation detected is from world-wide fallout, because fallout most likely would not make it into the aquifer. To determine whether any radiation detected in any media is from INL Site operations or due to other causes, such as world-wide fallout, control samples from other states or regions for each media would need to be collected and analyzed. Results from these samples would need to be compared with samples collected from areas likely to be impacted by INL Site operations to defensibly determine whether impacts are due to INL Site operations or not. DOE/EH-0173T suggests using a commercially available sample of known origin if applicable.

Recommendation: Consider adopting procedures that ensure control samples for each media are from other states or regions that would not be impacted by INL Site operations.

4.3.5 Biota Dose and Ecological Surveillance

The review of the biota dose and ecological surveillance programs was conducted to determine if these programs were sufficient to evaluate the dose to biota and minimize the impact of INL Site operations on the flora and fauna on the INL Site. This review did not evaluate the results of these programs for compliance with regulatory limits.

The biota dose assessment could be optimized, and a list of important species occurring on the INL Site is incomplete. The biota dose assessment program follows the DOE guidelines. Data from the MFC Industrial Waste Pond are being used for the aquatic evaluation; however, data from the ATR pond are likely to have higher concentrations of radionuclides than the MFC Pond and may result in a more conservative dose assessment. Also, waterfowl and other species, such as sage grouse, small mammals, and big game animals, have been sampled in the past. The current list of sensitive species at the INL Site is limited to the U.S. Fish and Wildlife Service list and does not consider other sources, such as the Natural Heritage At-Risk Species list or state protected/regulated species.

Recommendation: Consider using data from the ATR pond instead of MFC pond for the aquatic evaluation in the biota dose assessment. Calculate the dose to waterfowl, sage grouse, small mammals (historic dose exceeds 0.1 rad/day), and big game with data already collected to determine if the value of 0.1 rad/day is being exceeded and include in the biota dose assessment. Continue to pursue using the revised vegetation map with current soil sampling results, including data from LTEM 10-04, to update evaluation areas.

Recommendation: Consider formulating a new list of important or sensitive and protected/regulated species using data from the Natural Heritage At-Risk Species list or state protected/regulated species, including invertebrates and bats. Consider including this list in the ASER, and look for these species during National Environmental Policy Act surveys to demonstrate to stakeholders that important species that occur on the INL Site are being protected.

5 Federal and State Agency Items

Due to the breadth of environmental surveillance and monitoring programs at the INL Site, a number of agencies and stakeholders have been involved with these programs for many years. These include the US Geological Survey, which has been providing groundwater monitoring and support since the site's inception; the National Oceanic and Atmospheric Administration, which performs meteorological monitoring and modeling to support environmental monitoring and emergency management activities; the IDFG, which provides support for managing wildlife resources on the INL Site; and the State of Idaho INL Oversight Program, which conducts independent surveillance and monitoring activities on the site.

The Independent Oversight team met with several of these agencies to discuss their interaction with the site, their expectations for how the site reports environmental monitoring results, and whether their expectations were being met. While the Independent Oversight team and DOE-ID personnel met with each agency without the contractors present to discuss concerns and expectations, the team also had the opportunity to observe the interaction between the agencies and contractor surveillance and monitoring personnel during the bimonthly MSC meeting. Site contractors were also queried on their interaction with these agencies and any concerns they may be having with these interactions.

5.1 Agency Perspectives

The agencies reported that they had excellent working relationships with the site. Personnel from these agencies stated that they received good support during sampling activities. For example, site personnel provided the portable generator used to power the sampling equipment used by each agency. These personnel also reported that they were provided site access training and were allowed reasonable access for performing their independent surveillance and monitoring activities. The site contractors also confirmed an effective working relationship with the agencies.

Agency personnel were aware that sampling results are included in the ASER. However, because of their direct involvement in monitoring activities, they do not rely on ASER reporting to review and compare site results. Instead, they receive monitoring data through required regulatory reporting and are often provided with contractor monitoring data on an ongoing basis.

The State of Idaho INL Oversight Program issues bi-monthly (technical) and annual (public) reports on monitoring results; these results are not reported in the ASER. There is, however, a reference and internet link to these Oversight Program monitoring reports in the ASER. The goal for this Oversight Program is to selectively sample 10-15% of the sampling performed by the site contractors. Results from this independent sampling are not compared with site monitoring on a regular basis unless there is an unexpected result. The data are compared annually and a variation of less than 20% is considered acceptable. The State Oversight Program expressed a concern that sampling groundwater wells for tracking tritium going off the INL Site may not be identified and included for continued funding for the long-term monitoring as cleanup actions are completed and restoration funding ends. The State Oversight Program questioned DOE regarding how required monitoring would continue as facilities transition from the cleanup program to the M&O contractor.

IDFG interfaces with DOE-ID and its contractors to manage the wildlife resources on the INL Site. The IDFG provides scientific collection permits to DOE-ID and its contractors to conduct wildlife surveys. The ESER contractor then conducts wildlife surveys and makes this data available to IDFG. This working arrangement greatly benefits IDFG by providing good quality data without having to expend resources to conduct the wildlife surveys. IDFG is also contacted for other wildlife issues on the INL Site, such as dealing with problem wildlife (e.g., mountain lion in a facility).

During the bimonthly MSC meeting, those in attendance are queried to determine whether they have had sampling results that exceed normal historical range. Several environmental monitoring assessment review team members attended the March 2010 meeting. This meeting was rescheduled from its normal time and several standing members were not in attendance; however, discussions during this meeting indicated that several standing members do not routinely attend the bi-monthly meeting. Meeting minutes from the January 2010 meeting were presented and discussed, including a discussion about the reasons sampling results from one contractor varied from previous years.

5.2 Independent Oversight Perspectives and Recommendations

The meetings and discussions with the agencies revealed that there is effective communication between INL Site contractors and these agencies, resulting in good working relationships between the site and outside agencies. These relationships provide a means to obtain peer review and input on needed improvements and potential concerns. The discussions also revealed a level of trust between the agencies and site personnel involved in surveillance and monitoring. The minutes from the last MSC meeting indicate that variations in expected monitoring results were discussed. At the March meeting, crosscutting items of interest and future actions, such as the requirements for the next ASER, as well as sampling results outside expected norms, were discussed.

Not having full attendance at the MSC inhibits communication across agencies and contractors. Although the minutes convey major items, there are discussions where only those in attendance would be able to ask a question on a specific interest item or make a request for more information. For example, while discussing wells, attendees learned that there is a list showing organizational leads for maintaining specific wells. As a result, several in attendance requested the list so that they would be able to notify the appropriate organization when a well they needed to sample was in need of repair.

> **Recommendation:** Consider listing the attendees in the MSC minutes and sending an invitation to non-attending standing members and their managers to remind them about the importance of the MSC.

DOE-ID has not adequately explained to stakeholders how long-term monitoring will continue after cleanup is completed. To ensure continued good relations, any concerns expressed by outside agencies need to be evaluated and addressed, and any identified program gaps that require additional management attention need to be addressed to ensure a sustainable surveillance and monitoring program. The State of Idaho INL Oversight Program expressed concern with transition of monitoring from the cleanup program to the laboratory when cleanup is completed, what will happen to funding associated with monitoring cleaned-up sites, and how DOE-ID will meet requirements for long-term monitoring. The Life Cycle Baseline developed by the ICP contractor contains a requirement for developing a transition process plan to transition between ICP and the M&O contractor. However, while some transitions are already taking place (e.g., Test Area North, buildings at the Idaho National Technology and Engineering Center), current agreements and/or plans between NE and EM on such transitions do not address long-term monitoring. Contamination below the cleanup standard will still be present, and the plan for how the long-term monitoring for this remaining contamination will be managed has not been defined.

Recommendation: Consider developing and implementing a transition plan for continuing the monitoring at locations where cleanup activities have been completed. This plan should also address the continued sitewide monitoring currently being managed as part of the restoration program. This plan could be incorporated into the technical basis for the overall sitewide monitoring program and included in the sitewide Environmental Monitoring Plan. Ensure actions taken to address concerns expressed by stakeholders are communicated to these outside agencies.

6 INL Contractor Self-Assessments

BEA has developed guidance for conducting management assessments. This guidance, LWP-13750, *Performing Management Assessments*, is being used by BEA's Environmental Support and Services to evaluate environmental monitoring program effectiveness.

The Independent Oversight team reviewed the last two assessment activities performed by Environmental Support and Services and compared the concerns identified by these assessments to the concerns from this Independent Assessment of Environmental Monitoring in order to develop recommendations for improving the effectiveness of management assessments. The first assessment, INL Air Monitoring Assessment, was conducted in 2007. For the second assessment, Independent Audit Implementation of Monitoring Program, field observations had been completed and the draft report was under review at the time of this Independent Oversight assessment. To prevent a possible perception that these assessment results influenced the Independent Oversight team, a copy of the draft report was not provided until the Independent Assessment had completed data collection and areas of concern had been identified.

6.1 BEA Environmental Monitoring Assessments

The 2007 INL Air Monitoring Assessment resulted in seven improvement and/or cost saving observations and two positive observations. This 2007 INL assessment found that the ambient air monitoring program was effectively meeting DOE regulatory requirements. Corrective actions were developed and documented for five improvement items; two were dispositioned without corrective action based on a technical justification.

As stated, for the second reviewed assessment, Independent Audit Implementation of Monitoring Program, BEA had completed the data collection phase of a management assessment of environmental monitoring and the report was being validated and reviewed by BEA management. Although still in draft, the overall conclusion in the report was that the monitoring services program is effective, listing eight issues and 68 observations (62 negative and 6 positive). The assessment was led by the BEA Regulatory and Monitoring Services Manager and included members from an environmental peer organization, a mentor for assessments, and a manager from the organization being assessed. The BEA assessment took a number of months because team members were responsible for completing their normal work assignments in addition to the assessment, which involved document review as well as an appropriate strategy to observe field sampling events. As an improvement item, timely issuance of assessment reports should receive additional emphasis to ensure that timely information is provided those being assessed, while they are still focused on the assessment process and results.

6.2 Independent Oversight Perspectives and Recommendations

The 2007 BEA self-assessment focused on compliance of the air monitoring program with requirements outlined in DOE Order 5400.5 and 450.1A and Environmental Regulatory Guide DOE/EH-0173T. The self-assessment concluded that the ambient air monitoring program was effective in meeting these requirements. Although action was taken to resolve most improvement observations, two items were closed without any corrective action. For example, the recommendation to update the 1993 exposure pathway was considered to be a low priority based on an expectation that the pathways were unlikely to have changed, without confirming this expectation. Overall, this BEA self-assessment focused principally on compliance aspects and therefore did not evaluate the effectiveness of air monitoring system design and basis to the same extent as this Independent Oversight assessment.

The Independent Audit Implementation of Monitoring Program had an extensive breadth and scope, and included review of most environmental surveillance and monitoring programs being conducted by Environmental Support and Services. The exceptions were biota, event, and asbestos monitoring. The assessment identified numerous concerns with the suite of documents that set forth the requirements for environmental monitoring. As discussed in the BEA draft report and confirmed by this Independent Assessment, corrective actions were in process to update these documents.

The two BEA assessments determined that overall environmental monitoring programs conducted by Environmental Support and Services were effective. Although this Independent Oversight assessment does not disagree with BEA's overall determination, additional concerns identified in this HSS assessment were not addressed in either of the recent BEA self-assessments. The following observation may need additional management attention to ensure the continued effectiveness of the assessment programs for environmental monitoring.

The BEA 2007 assessment and the ongoing Independent Audit Implementation of Monitoring Program focused on the mechanics of existing surveillance and monitoring programs, but did not address the design adequacy of these programs. As discussed in this Independent Oversight assessment under crosscutting weaknesses, the technical basis for environmental monitoring and surveillance activities is not well defined and documented. There were also concerns with the defensibility of the ASER and data quality.

> **Recommendation:** Consider expanding the scope for the next environmental monitoring self-assessment to include the effectiveness in addressing concerns regarding the mechanics of the documented program, as identified by this Independent Oversight assessment. These concerns would include the adequacy of the technical basis, the adaptability of the monitoring program to changing operations, the defensibility of ASER data, and the supportability of data quality objectives.

Appendix A
Supplemental Information

A.1 Dates of Review

Planning Visit	March 9-11, 2010
Onsite Review Visit	March 22-26, 2010
Report Validation and Closeout	April 13-15, 2010

A.2 Review Team Composition

A.2.1 Management

Glenn S. Podonsky, Chief Health, Safety and Security Officer
William Eckroade, Deputy Chief for Operations, Office of Health, Safety and Security
John Boulden, Acting Director, Office of Independent Oversight and Office of Enforcement
Thomas Staker, Director, Office of ES&H Evaluations

A.2.2 Quality Review Board

Bill Eckroade	John Boulden	Thomas Staker
Bill Miller	Mike Kilpatrick	George Armstrong

A.2.3 Assessment Team

Victor Crawford, Team Leader

Ross Natoli	Rajendra Sharma (NE)	Joe Lischinsky
Mario Vigliani	Derek Hall (NSTec)	

A.2.4 Administrative Support

Tom Davis
Mary Anne Sirk

Appendix C. Chapter 5 Addendum

Table C-1. Central Facilities Area Sewage Treatment Facility Influent Monitoring Results (2010).[a,b]

Parameter	1/13/10	2/24/10	3/16/10
Biochemical oxygen demand (5-day) (mg/L)	32.8	62.2 (187)	39.4
Chemical oxygen demand (mg/L)	98.7	265 (499)	296
Nitrogen, nitrate + nitrite (mg/L)	1.24	0.509 (0.495)	1.04
Nitrogen, total Kjeldahl (mg/L)	18.5	32.5 (34.3)	25
pH[c]	8.01	8.08	8.02
Total suspended solids (mg/L)	56.8	270 (280)	573

a. Duplicate samples were collected in February for all parameters (excluding pH), and the duplicate results are included in parentheses.
b. There are no permit limits set for these parameters.
c. Grab sample.

Table C-2. Central Facilities Area Sewage Treatment Facility Effluent Monitoring Results (2010).[a]

Parameter	Result of Sample Collected 8/10/10
Chemical oxygen demand (mg/L)	47.6
Coliform, total[b] (/100 mL)	3
Nitrogen, nitrate + nitrite (mg/L)	0.151
pH[b]	9.11
Nitrogen, total Kjeldahl (mg/L)	4.58
Total dissolved solids (mg/L)	1200
Total phosphorus (mg/L)	0.888

a. There are no permit limits for these parameters.
b. Grab sample.

Table C-3. Advanced Test Reactor Complex Cold Waste Pond Effluent Monitoring Results (2010).

Parameter	Minimum	Maximum	Median
Arsenic (mg/L)	0.005 U[a]	0.0075	0.005 U
Barium (mg/L)	0.0479	0.171	0.0988
Chloride (mg/L)	10.4	40.9	32.9
Chromium (mg/L)	0.0034	0.0111	0.0055
Conductivity (µS/cm)	413	1,549	855.5
Copper (mg/L)	0.001 U	0.0043	0.0021
Fluoride (mg/L)	0.131	0.491	0.332
Iron (mg/L)	0.025 U	0.199	0.0623
Manganese (mg/L)	0.0025 U	0.0025	0.0025 U
Nitrogen, nitrate + nitrite (mg-N/L)	0.851	3.55	2.01
Nitrogen, total Kjeldahl (mg/L)	0.157	0.531	0.335
Selenium (mg/L)	0.001	0.0052	0.0029
Sulfate (mg/L)	21.6	709	307
Total dissolved solids (mg/L)	241	1,290	682
Total suspended solids (mg/L)	4 U	6.8	4 U

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

Rough-legged Hawk

Table C-4. Advanced Test Reactor Complex Cold Waste Pond Industrial Wastewater Reuse Permit Monitoring Well Results (2010).

Well Name:	USGS-065		TRA-07		USGS-076		TRA-08		Middle-1823		PCS/SCS[a]
Sample Date:	04/06/10	10/14/10	04/20/10	10/12/10	04/07/10	10/12/10	04/29/10	10/14/10	04/07/10	10/12/10	
pH	8.22	8.05	8.03	8.02	8.1	8.0	8.22	8.11	8.09	8.05	6.5 – 8.5
Total Kjeldahl nitrogen (mg/L)	0.119 [0.116][c]	0.1 U	0.154	0.17	0.162	0.138	0.35	0.119	0.157	0.179	NA[b]
Nitrite nitrogen (mg/L)	0.05 U[d] [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)	1.43 [1.42]	1.39	1.04	1.05	1.05	1.04	0.84	0.985	0.958	0.952	10
Total nitrogen[e] (mg/L)	1.574 [1.561]	1.465	1.219	1.245	1.237	1.203	1.215	1.129	1.14	1.156	NA
Total dissolved solids (mg/L)	434 [437]	431	420	443	276	283	273	290	269	282	500
Aluminum (mg/L)	0.0043 [0.0042] (0.0038)[f] [0.004]	0.0153 (0.0152)	**1.280**[g] (0.0088)	**1.580** (0.0136)	0.0043 (0.0032)	0.003 (0.0026)	**94.9** (0.0418)	**1.080** (0.0042)	0.0509 (0.0025)	0.126 (0.0016)	0.2
Antimony (mg/L)	0.0005 U [0.0005 U] (0.0005 U) [0.0005 U]	0.0004 U (0.0004 U)	0.0004 U (0.0004 U)	0.0004 U (0.0004 U)	0.0005 U (0.0005 U)	0.0004 U (0.0004 U)	0.0004 U (0.0004 U)	0.0004 U (0.0004 U)	0.0005 U (0.0005 U)	0.0004 U (0.0004 U)	0.006
Arsenic (mg/L)	0.0012 [0.00082] (0.00052) [0.00097]	0.0013 (0.001)	0.0005 U (0.00093)	0.00076 (0.0012)	0.0013 (0.0015)	0.0012 (0.0015)	0.0005 U (0.0015)	0.0015 (0.0017)	0.0016 (0.0016)	0.0013 (0.00096)	0.05
Barium (mg/L)	0.0475 [0.0479] (0.047) [0.0477]	0.0457 (0.0452)	0.0845 (0.0622)	0.113 (0.0595)	0.0741 (0.0732)	0.0721 (0.0724)	0.816 (0.0343)	0.0699 (0.0514)	0.065 (0.0644)	0.0662 (0.0648)	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 (0.00025 U)	0.00025 U (0.00025 U)	0.0005 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)	19.6 [19.5]	19	19.4	20.2	14.0	14.1	11.8	12.4	11.9	11.9	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)	0.0027 (0.0025 U)	0.0025 U (0.0025 U)	0.0025 U (0.0025 U)	0.0383 (0.0025 U)	0.0025 U 0.0025 U	0.0025 U (0.0025 U)	0.0025 U (0.0025 U)	NA

Table C-4. Advanced Test Reactor Complex Cold Waste Pond Industrial Wastewater Reuse Permit Monitoring Well Results (2010) (continued).

Well Name:	USGS-065		TRA-07		USGS-076		TRA-08		Middle-1823		PCS/SCS[a]
Copper (mg/L)	[0.0025 U] 0.0025 U [0.0025 U] (0.0025 U) [0.0025 U]	0.0025 U (0.0025 U)	0.0281 (0.0025 U)	0.038 (0.0026)	0.0999 (0.0025 U)	0.0065 (0.0025 U)	0.194 (0.0025 U)	0.0032 (0.0025 U)	0.0025 U (0.0025 U)	0.0025 U (0.0025 U)	1.3
Fluoride (mg/L)	0.237 [0.212]	0.207	0.201	0.188	0.195	0.152	0.191	0.18	0.197	0.155	4
Iron (mg/L)	0.050 U [0.050 U] (0.050 U) [0.050 U]	0.0539 (0.050 U)	**1.570** (0.050 U)	**3.850** (0.051)	0.050 U (0.050 U)	0.0863 (0.0536)	**87.5** (0.050 U)	**0.644** (0.0502)	0.050 U (0.050 U)	0.0838 (0.050 U)	0.3
Manganese (mg/L)	0.0025 U [0.0025 U] (0.0025 U) [0.0025 U]	0.0025 U (0.0025 U)	0.0239 (0.0025 U)	**0.0614** (0.0025 U)	0.0025 U (0.0025 U)	0.0025 U (0.0025 U)	**1.170** (0.0121)	0.0117 (0.0025 U)	0.0036 (0.0025 U)	0.0037 (0.0027)	0.05
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 (0.0002 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)	0.0015 [0.0016] (0.0014) [0.0014]	0.0014 (0.0016)	0.00095 (0.0011)	0.00092 (0.0011)	0.00096 (0.001)	0.001 (0.0011)	0.002 (0.00099)	0.00099 (0.0011)	0.00096 (0.00096)	0.0009 (0.0011)	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)	158 [162]	160	155	155	33.2	32.4	47.1	51.4	35.1	34.3	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. NA = not applicable.
c. Values shown in brackets are the results from field duplicate samples. Each bracketed value is the field duplicate for the sample value reported immediately above the respective bracketed value.
d. U flag indicates the result was reported as below the instrument detection limit by the analytical laboratory.
e. Total nitrogen is calculated as the sum of the total Kjeldahl nitrogen, nitrite nitrogen, and nitrate nitrogen. Half the nitrite nitrogen detection limit was used in the total nitrogen calculations.
f. Sample results in parentheses are from filtered metals sample.
g. 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.

Rough-legged Hawk

Table C-5. Idaho Nuclear Technology and Engineering Center Sewage Treatment Plant Influent Monitoring Results at CPP-769 (2010).[a]

Parameter	Minimum	Maximum	Average[b]
Biochemical oxygen demand (5-day) (mg/L)	217	828	347
Nitrate + nitrite, as nitrogen (mg/L)	0.025[c]	0.358	0.174
Total Kjeldahl nitrogen (mg/L)	79.1	153	106
Total phosphorus (mg/L)	5.61	16.50	9.88
Total suspended solids (mg/L)	113	381	224

a. Duplicate samples were collected in September 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-6. Idaho Nuclear Technology and Engineering Center Sewage Treatment Plant Effluent Monitoring Results at CPP-773 (2010).[a]

Parameter	Minimum	Maximum	Average[b]
Biochemical oxygen demand (5-day) (mg/L)	7.24	50.8	18.73
Chloride (mg/L)	147	389	214
Conductivity (µS/cm) (composite)	1,221	1,790	1,428
Nitrate + nitrite, as nitrogen (mg/L)	0.499	9.74	2.85
pH (standard units) (grab)	7.74	8.73	8.00
Sodium (mg/L)	103	187	130
Total coliform (colonies/100 mL)	94	5,100	1,472
Total dissolved solids (mg/L)	593	853	697
Total Kjeldahl nitrogen (mg/L)	28.0	65.8	42.7
Total phosphorus (mg/L)	3.75	10.4	7.58
Total suspended solids (mg/L)	4.9	49.8	18.3

a. Duplicate samples were collected in September 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.

Table C-7. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Effluent Monitoring Results at CPP-797 (2010).[a]

Parameter	Minimum	Maximum	Average[b]
Aluminum (mg/L)	0.0125[c]	0.0125[c]	0.0125[d]
Arsenic (mg/L)	0.00125[c]	0.0034	0.0014
Biochemical oxygen demand (5-day) (mg/L)	1.0[c]	20.3	6.5
Cadmium (mg/L)	0.0005[c]	0.0005[c]	0.0005[d]
Chloride (mg/L)	19.5	260	123
Chromium	0.0032	0.0084	0.0052
Conductivity (µS/cm) (composite)	416	1,126	742
Copper (mg/L)	0.001	0.0079	0.0036
Fluoride (mg/L)	0.205	0.256	0.222
Iron (mg/L)	0.0125[c]	0.1150	0.0360
Manganese (mg/L)	0.00125[c]	0.0043	0.0016
Mercury (mg/L)	0.0001[c]	0.0001[c]	0.0001[d]
Nitrate + nitrite, as nitrogen (mg/L)	1.37	3.64	2.38
pH (grab)	7.60	8.59	8.09
Selenium (mg/L)	0.0011	0.0055	0.0016
Silver (mg/L)	0.0025[c]	0.0025[c]	0.0025[d]
Sodium (mg/L)	14.4	149	86.0
Total coliform (colonies/100 mL)	3	120	35
Total dissolved solids (mg/L)	262	707	432
Total Kjeldahl nitrogen (mg/L)	0.619	3.39	1.92
Total nitrogen[e] (mg/L)	2.82	6.39	4.30
Total phosphorus (mg/L)	0.374	1.31	0.701
Total suspended solids (mg/L)	2.0[c]	2.0[c]	2.0[d]

a. Duplicate samples were collected in September 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 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.

Rough-legged Hawk

Table C-8. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Aquifer Monitoring Well Groundwater Results (2010).

Well Name:	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:	4/27/2010	10/11/2010	4/22/2010	10/7/2010	4/22/2010	4/22/2010[c]	10/7/2010	4/26/2010	10/6/2010	
Depth to water table (ft below brass cap)	499.96	Dry[d]	502.96	504.06	509.30	509.30	510.75	502.11	504.84	NA[e]
Water table elevation at brass cap (ft)[f]	4,450.25	—	4,450.04	4,448.94	4,450.19	4,450.19	4,448.74	4,450.11	4,447.38	NA
Aluminum (mg/L)	224[g]	—	0.0250 U[h]	0.0250 U	0.0491	0.0739	0.0912	0.0385	0.0250 U	0.2
Aluminum-filtered (mg/L)	0.0250 U	—	0.0250 U	0.0250 U	0.0250 U	0.0250 U	0.0250 U	0.0250 U	0.0250 U	0.2
Arsenic (mg/L)	0.0109	—	0.0050 U	0.0020 U	0.0050 U	0.0050 U	0.0020 U	0.0050 U	0.0020 U	0.05
Arsenic-filtered (mg/L)	0.0050 U	—	0.0050 U	0.0020 U	0.0050 U	0.0050 U	0.0020 U	0.0050 U	0.0020 U	0.05
Biochemical oxygen demand (mg/L)	6.0 U	—	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	NA
Cadmium (mg/L)	0.0035	—	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.005
Cadmium-filtered (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	0.005
Chloride (mg/L)	10.4	—	62.5	55.6	8.28	8.27	8.54	9.45	11.0	250
Chromium (mg/L)	0.128[g]	—	0.0142	0.0126	0.0062	0.0066	0.0059	0.010	0.0120	0.1
Chromium-filtered (mg/L)	0.0025 U	—	0.0074	0.0080	0.0052	0.0063	0.0045	0.0089	0.0116	0.1
Coliform, fecal (colonies/100 mL)	Absent	—	Absent	Absent	Absent	Absent	Absent	Absent	Absent	NA
Coliform, total (colonies/100 mL)	Absent	—	Absent	Absent	Absent	Absent	Absent	Absent	Absent	1 col/100 mL
Copper (mg/L)	0.445	—	0.0050 U	0.0050 U	0.0050 U	0.0050 U	0.0050 U	0.0050 U	0.0050 U	1.3
Copper-filtered (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	1.3
Fluoride (mg/L)	0.210	—	0.200	0.193	0.267	0.267	0.261	0.205	0.188	4
Iron (mg/L)	168[g]	—	0.0500 U	0.0500 U	0.0526	0.0702	0.114	0.050 U	0.050 U	0.3
Iron-filtered (mg/L)	0.0500 U	—	0.0500 U	0.0500 U	0.0500 U	0.0500 U	0.0500 U	0.050 U	0.050 U	0.3
Manganese (mg/L)	2.46[g]	—	0.0025 U	0.0025 U	0.0272	0.0267	0.0376	0.0025 U	0.0025 U	0.05
Manganese-filtered (mg/L)	0.0246	—	0.0025 U	0.0025 U	0.0286	0.0258	0.0290	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	0.002
Mercury-filtered (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	0.002
Nitrate, as nitrogen (mg/L)	0.384	—	0.921	0.935	0.245	0.246	0.227 U	0.672	0.848	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	1
pH	8.05	—	7.35	7.95	7.47	7.47	7.80	7.86	7.53	6.5–8.5
Selenium (mg/L)	0.0033	—	0.0010	0.0011	0.00085	0.00063	0.0010 U	0.0010	0.0011	0.05
Selenium-filtered (mg/L)	0.00086	—	0.0011	0.0010 U	0.00066	0.00059	0.0010 U	0.0010	0.0010	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	0.1
Silver-filtered (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	0.1
Sodium (mg/L)	60.6	—	18.2	17.7	8.45	8.47	8.89	7.97	9.27	NA
Sodium-filtered (mg/L)	22.2	—	18.5	17.9	8.57	8.55	8.82	8.07	9.22	NA
Total dissolved solids (mg/L)	239	—	336	341	195	196	196	232	252	500
Total Kjeldahl nitrogen (mg/L)	0.855	—	0.156	0.242	0.100 U	0.100 U	0.106	0.140	0.173	NA
Total phosphorus (mg/L)	7.36	—	0.0428	0.0385	0.0197	0.0283	0.0273	0.0279	0.0205	NA

a. Well ICPP-MON-A-164B is an additional upgradient aquifer monitoring well. Because of the inability to obtain samples from Well ICPP-MON-A-167, the permit renewal application proposed replacing that well 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. ICPP-MON-A-167 only had 0.47 ft of water and was considered dry. Therefore, the well could not be sampled.
e. NA—Not applicable.
f. Water level elevations referenced to North American Vertical Datum of 1988 (NAVD 88).
g. 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.
h. U flag indicates the result was below the detection limit.

Table C-9. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Perched Water Monitoring Well Groundwater Results (2010).

Well Name:	ICPP-MON-V-191 (GW-013008)			ICPP-MON-V-200 (GW-013009)					ICPP-MON-V-212 (GW-013010)				PCS/SCS[a]
Sample Date:	April 2010	6/16/2010	October 2010	4/27/2010	6/15/2010	7/28/2010	10/11/2010	10/11/2010[b]	4/27/2010	6/15/2010	7/28/2010	10/11/2010	
Depth to water table (ft below brass cap)	Dry[c]	113.72[d]	Dry[c]	108.09	109.57	117.54	113.08	113.08	235.34	235.52	235.78	236.68	NA[e]
Water table elevation at brass cap (ft)[f]	—	4,834.24[d]	—	4,844.93	4,843.45	4,835.48	4,839.94	4,839.94	4,723.04	4,722.86	4,722.60	4,721.70	NA
Aluminum (mg/L)	—	1.61[g]	—	0.0526	—	—	0.0343	0.0306	0.0740	—	—	0.0853	0.2
Aluminum-filtered (mg/L)	—	—	—	0.0250 U[h]	—	—	0.0492	0.0250 U	0.0250 U	—	—	0.0250 U	0.2
Arsenic (mg/L)	—	0.0050 U	—	0.0092	—	—	0.0049	0.0051	0.0050 U	—	—	0.0020 U	0.05
Arsenic-filtered (mg/L)	—	—	—	0.0062	—	—	0.0049	0.0045	0.0050 U	—	—	0.0020 U	0.05
Biochemical oxygen demand (mg/L)	—	2.0 U	—	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	3.22	—	—	4.00	NA
Cadmium (mg/L)	—	0.0025 U	—	0.0025 U	—	—	0.0025 U	0.0025 U	0.0025 U	—	—	0.0025 U	0.005
Cadmium-filtered (mg/L)	—	—	—	0.0025 U	—	—	0.0025 U	0.0025 U	0.0025 U	—	—	0.0025 U	0.005
Chloride (mg/L)	—	2.73	—	131	—	—	111	111	151	—	—	163	250
Chromium (mg/L)	—	0.0091	—	0.0055	—	—	0.0064	0.0058	0.0053	—	—	0.0051	0.1
Chromium-filtered (mg/L)	—	—	—	0.0049	—	—	0.0057	0.0057	0.0052	—	—	0.0035	0.1
Coliform, fecal (colonies/100 mL)	—	Absent	—	Absent	Absent	Absent	Absent	Absent	3.00 R[i]	Absent	Absent	Absent	NA
Coliform, total (colonies/100 mL)	—	Absent	—	Absent	Absent	Absent	Absent	Absent	9.00 R[i]	Absent	Absent	Absent	1 col/100 mL
Copper (mg/L)	—	0.0219	—	0.0050 U	—	—	0.0050 U	0.0050 U	0.0050 U	—	—	0.0050 U	1.3
Copper-filtered (mg/L)	—	—	—	0.0050 U	—	—	0.0050 U	0.0050 U	0.0050 U	—	—	0.0050 U	1.3
Fluoride (mg/L)	—	0.288	—	0.233	—	—	0.234	0.235	0.217	—	—	0.217	4
Iron (mg/L)	—	0.924[g]	—	0.0500 U	—	—	0.0500 U	0.0500 U	0.0842	—	—	**0.417**[g]	0.3
Iron-filtered (mg/L)	—	—	—	0.0500 U	—	—	0.0050 U	0.0500 U	0.0500 U	—	—	0.050 U	0.3
Manganese (mg/L)	—	0.0647[g]	—	0.0025 U	—	—	0.0025 U	0.0025 U	0.0025 U	—	—	0.0055	0.05
Manganese-filtered (mg/L)	—	—	—	0.0025 U	—	—	0.0025 U	0.0025 U	0.0025 U	—	—	0.0034	0.05
Mercury (mg/L)	—	0.00020 U	—	0.00020 U	—	—	0.00020 U	0.00020 U	0.00020 U	—	—	0.00020 U	0.002
Mercury-filtered (mg/L)	—	—	—	0.00020 U	—	—	0.00020 U	0.00020 U	0.00020 U	—	—	0.00020 U	0.002
Nitrate, as nitrogen (mg/L)	—	0.725	—	2.56	—	—	2.71	2.71	1.89	—	—	2.09	10
Nitrite, as nitrogen (mg/L)	—	0.0657	—	0.100 U	—	—	0.0500 U	0.0500 U	0.100 U	—	—	0.0500 U	1
pH	—	7.75	—	7.55	7.52	7.59	7.73	7.73	7.57	7.52	7.50	7.83	6.5–8.5
Selenium (mg/L)	—	0.0016	—	0.0014	—	—	0.0013	0.0013	0.0014	—	—	0.0010	0.05
Selenium-filtered (mg/L)	—	—	—	0.0012	—	—	0.0012	0.0013	0.0012	—	—	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	0.1
Silver-filtered (mg/L)	—	—	—	0.0050 U	—	—	0.0050 U	0.0050 U	0.0050 U	—	—	0.0050 U	0.1
Sodium (mg/L)	—	9.44	—	87.4	—	—	88.1	86.7	65.5	—	—	73.6	NA
Sodium-filtered (mg/L)	—	—	—	88.6	—	—	88.8	88.9	66.5	—	—	73.7	NA
Total dissolved solids (mg/L)	—	198	—	458	—	—	431	435	482	—	—	**515**[g]	500
Total Kjeldahl nitrogen (mg/L)	—	0.395	—	0.324	—	—	0.349	0.355	0.306	—	—	0.388	NA
Total phosphorus (mg/L)	—	0.0924	—	0.0946	—	—	0.107	0.0878	0.0202	—	—	0.0252	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 is a perched well and was dry in April and October 2010.
d. Measurement was taken on 6/15/2010.
e. NA—Not applicable.
f. Water level elevations referenced to North American Vertical Datum of 1988 (NAVD 88).
g. **Bold** = Exceedance of groundwater quality standard. Well ICPP-MON-V-191 is an upgradient, noncompliance point, and it outside the zone of influence of the New Percolation Ponds. Therefore, exceedances in this well are not considered permit noncompliances.
h. U flag indicates the result was below the detection limit.
i. R flag indicates the reported result was rejected based on historical results and sampling irregularities associated with this well.

Table C-10. Materials and Fuels Complex Industrial Waste Pipeline Monitoring Results (May-December 2010).

Parameter	Minimum	Maximum	Median
Arsenic (mg/L)	0.0025 U[a]	0.0025 U	0.0025 U
Barium (mg/L)	0.0331	0.0389	0.00356
Cadmium (mg/L)	0.001 U	0.001 U	0.001 U
Chloride (mg/L)	21.6	98.9	55
Chromium (mg/L)	0.0025 U	0.0025 U	0.0025 U
Fluoride (mg/L)	0.545	0.7	0.605
Lead (mg/L)	0.00035	0.0012	0.00056
Mercury (mg/L)	0.0002 U	0.0002 U	0.0002 U
Nitrogen, nitrate + nitrite (mg-N/L)	1.94	2.21	2.08
Nitrogen, total Kjeldahl (mg/L)	0.175	1.04	0.4
pH	8.34	8.63	8.5
Phosphorus, total	0.129	0.609	0.268
Selenium (mg/L)	0.00056	0.0017	0.00073
Silver (mg/L)	0.005 U	0.005 U	0.005 U
Sulfate (mg/L)	17.5	19.9	19.1
Total dissolved solids (mg/L)	260	374	311
Zinc (mg/L)	0.0082	0.0244	0.0097

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

Table C-11. Materials and Fuels Complex Industrial Waste Water Underground Pipe Monitoring Results (May-December 2010).

Parameter	May 25, 2010	July 28, 2010	December 15, 2010
Arsenic (mg/L)	0.0052	0.011	0.0042
Barium (mg/L)	0.0881	0.145	0.0845
Cadmium (mg/L)	0.001 U[a]	0.001 U	0.001 U
Chloride (mg/L)	52.8	128	44.6
Chromium (mg/L)	0.0187	0.0099	0.0034
Fluoride (mg/L)	1.52	2.74	1.41
Lead (mg/L)	0.00051	0.0022	0.00047
Mercury (mg/L)	0.0002 U	0.0002 U	0.0002 U
Nitrogen, nitrate + nitrite (mg-N/L)	4.89	12.3	4.35
Nitrogen, total Kjeldahl (mg/L)	0.641	1.22	0.552
pH	8.37	8.66	8.24
Phosphorus, total	0.713	0.886	0.884
Selenium (mg/L)	0.0013	0.0035	0.0013
Silver (mg/L)	0.005 U	0.005 U	0.005 U
Sulfate (mg/L)	44.1	109	39
Total dissolved solids (mg/L)	600	1160	538
Zinc (mg/L)	0.0165	0.111	0.020

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

Rough-legged Hawk

Table C-12. 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		ANL-MON-A-013		ANL-MON-A-014		PCS/SCS[a]
Sample Date:	5/19/10	9/28/10	5/19/10	9/28/10	5/19/10	9/28/10	
pH	8.39	8.23	8.26	8.14	8.20	8.12	6.5 to 8.5 (SCS)
Temperature	13.7	12.8	13.5	13.6	13.4	13.6	NA[b]
Conductivity (µS/cm)	356	365	370	374	374	371	NA
Nitrate nitrogen (mg/L)	1.82	1.86	1.95	1.94	1.91	1.93	10 (PCS)
Phosphorus (mg/L)	0.0215	0.0207	0.0331	0.0126	0.0181	0.0136	NA
Total dissolved solids (mg/L)	208	231	216	237	216	235	500 (SCS)
Sulfate (mg/L)	16.2	16.7	19.5	19.1	18.0	17.8	250 (SCS)
Arsenic (µg/L)	2.0	2.6	2.3	3.0	2.1	2.4	50 (PCS)
Barium (µg/L)	38.5	40.2	36.2	37.2	35.7	37.6	2000 (PCS)
Cadmium (µg/L)	0.25 U[c]	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	5 (PCS)
Chloride (mg/L)	17.8	18.0	18.3	19.0	19.2	18.9	250 (SCS)
Chromium (µg/L)	2.5 U	2.5 U	4.1	2.7	3.9	3.4	100 (PCS)
Iron (µg/L)	50 U	68.9	120	105	138	208	300 (SCS)
Lead (µg/L)	0.50 U	3.0	0.71	1.6	0.50 U	1.3	15 (PCS)
Manganese (µg/L)	2.5 U	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)	0.50	0.70	0.53	0.68	0.51	0.83	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)	16500	17000	18100	17800	16600	16800	NA
Zinc (µg/L)	2.9	11.6	2.5 U	7.8	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. NA-Not applicable.
c. U flag indicates the result was reported as below the instrument detection limit by the analytical laboratory.

Table C-13. Advanced Test Reactor Complex Cold Waste Pond Results (2010).[a]

Parameter	Minimum	Maximum	Median
Antimony (mg/L)	0.00025 U[b]	0.0011	0.00047
Gross alpha (pCi/L ± 1s)	1.03 ± 0.603 U	4.46 ± 1.08	Not calculated
Gross beta (pCi/L ± 1s)	-0.451 ± 0.837 U	23.3 ± 2.18	Not calculated
pH (standard units)	7.75	8.43	8.11
Potassium-40 (pCi/L ± 1s)	-16.7 ± 9.54 U	24.1 ± 10.8	Not calculated
Sodium (mg/L)	8.49	38.5	28.2
Zinc	0.0025 U	0.0186	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-14. Advanced Test Reactor Complex Cold Waste Pond Aquifer Monitoring Well Groundwater Results (2010).

Monitoring Well	Sample Date	Parameter	Sample Result[a] (pCi/L)
USGS-065	04/06/10	Gross Alpha	ND[b]
			1.97 ± 0.789[c]
		Gross Beta	3.88 ± 1.11
			3.91 ± 0.98[c]
		Potassium-40	ND
			26.2 ± 12.6[c]
		Tritium	5,680 ± 600
			5,110 ± 544[c]
	10/14/10	Gross Beta	6.95 ± 1.26
		Tritium	4,640 ± 485
TRA-07	04/20/10	Tritium	11,200 ± 1,140
	10/12/10	Gross Alpha	3.82 ± 1.02
		Gross Beta	6.49 ± 1.39
		Tritium	10,400 ± 1,050
TRA-08	04/29/10	Gross Alpha	7.55 ± 1.43
		Gross Beta	7.69 ± 1.49
		Potassium-40	37.4 ± 14.7
		Tritium	1,390 ± 201
	10/14/10	Gross Alpha	3.02 ± 0.987
		Gross Beta	5.5 ± 1.3
		Tritium	1,640 ± 199
USGS-076	04/07/10	Potassium-40	42.4 ± 14.1
		Tritium	765 ± 140
	10/12/10	Tritium	583 ± 122
Middle-1823	04/07/10	Tritium	1,150 ± 172
	10/12/10	Tritium	1,280 ± 173

a. Result ± one sigma uncertainty.
b. ND – Not detected.
c. Analytical result from field duplicate.

Table C-15. Liquid Influent and Effluent Surveillance Monitoring Results for Central Facilities Area (2010).[a]

Parameter	Result[b]
Influent to CFA Sewage Treatment Plant	
Total phosphorus	2.93 (minimum), 5.48 (maximum), 4.73 (median)
Effluent from CFA Sewage Treatment Plant to Pivot Irrigation System	
Chloride (mg/L)	429
Fluoride (mg/L)	0.382
Sulfate (mg/L)	65.8
Barium (mg/L)	0.0551
Copper (mg/L)	0.0013
Iron (mg/L)	0.0937
Manganese (mg/L)	0.0036
Selenium (mg/L)	0.00089
Sodium (mg/L)	176
Gross beta (pCi/L ± 1s)	14.9 ± 1.85
Tritium (pCi/L ± 1s)	2,870 ± 326

a. Only parameters with at least one detected result are shown.

b. If only one result is shown, the parameter was analyzed for only in the sample collected in August.

Table C-16. Liquid Influent and Effluent and Groundwater Surveillance Monitoring Results for Idaho Nuclear Technology and Engineering Center (2010).

Parameter[a]	Minimum	Maximum	Average[b]
Influent to INTEC Sewage Treatment Plant (CPP-769)			
Conductivity (µS/cm) (grab)	847	8,990	1,966
pH (standard units) (grab)	8.21	9.02	8.61
Effluent from INTEC Sewage Treatment Plant (CPP-773)			
Conductivity (µS/cm) (grab)	1,199	1,820	1,418
Gross beta (pCi/L ± 2s uncertainty)	15.3 ± 4.38	22.4 ± 5.08	17.6 ± 2.53
pH (standard units) (composite)	7.89	9.07	8.25
Effluent to INTEC New Percolation Ponds (CPP-797)			
Conductivity (µS/cm) (grab)	395	1,265	567
Gross alpha (pCi/L ± 2s uncertainty)	0.18 ± 0.97[c]	3.23 ± 2.14	1.17 ± 0.47
Gross beta (pCi/L ± 2s uncertainty)	3.91 ± 2.06	12.0 ± 3.54	6.63 ± 0.78
pH (standard units) (composite)	7.55	8.18	7.85
Groundwater at INTEC New Percolation Ponds			
Gross alpha (pCi/L ± 2s uncertainty)	0.65 ± 0.39	2.69 ± 0.68	1.29 ± 0.15
Gross beta (pCi/L ± 2s uncertainty)	-0.28 ± 0.26	7.84 ± 1.21	1.18 ± 0.15

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.

Western Bluebird

Table C-17. Monitoring Results for Material and Fuels Complex Industrial Waste Pond (2010).[a]

Parameter	Minimum	Maximum	Median
Chloride (mg/L)	34.4	59.5	38.6
Fluoride (mg/L)	0.315	0.688	0.618
Iron (mg/L)	0.025 U	4.29	0.0323
Nitrogen, nitrate + nitrite (mg-N/L)	0.261	1.74	1.625
Nitrogen, total Kjeldahl (mg/L)	0.32	1.55	0.339
Sodium (mg/L)	28.2	40.3	30.1
Sulfate (mg/L)	12	21.1	20.1
Total dissolved solids (mg/L)	258	325	282
Total phosphorus (mg/L)	0.158	0.36	0.218
Total suspended solids (mg/L)	4 U[c]	40.6	4 U
Cesium-137 (pCi/L ± 1s)	-1.55 ± 1.29 U	1.75 ± 0.709	Not calculated
Gross alpha (pCi/L ± 1s)	0.726 ± 0.587 U	3.57 ± 1.15	Not calculated
Gross beta (pCi/L ± 1s)	1.56 ± 1.16 U	6.72 ± 0.689	Not calculated
Uranium-233/234[b] (pCi/L ± 1s)	1.5 ± 0.199	1.5 ± 0.199	Not calculated
Uranium-238[b] (pCi/L ± 1s)	0.69 ± 0.117	0.69 ± 0.117	Not calculated

a. Only parameters with at least one detected result are shown.

b. Parameter was analyzed in July only; therefore, the minimum and maximum are the same.

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

Table C-18. Surveillance Monitoring Results for Materials and Fuels Complex Industrial Waste Pipeline, also known as the Industrial Waste Ditch (January- April 2010).[a]

Parameter	Minimum	Maximum	Median
Chloride (mg/L)	23.1	67.5	35.8
Fluoride (mg/L)	0.561	0.693	0.635
Iron[b] (mg/L)	0.025 U[c]	0.162	0.0688
Nitrogen, nitrate + nitrite (mg-N/L)	1.94	2.01	1.98
Nitrogen, total Kjeldahl (mg/L)	0.101	0.801	0.192
Sodium (mg/L)	20	46.9	31.6
Sulfate[b] (mg/L)	17.5	19.9	19.1
Total dissolved solids (mg/L)	252	315	280
Total phosphorus (mg/L)	0.136	0.588	0.204
Gross alpha (pCi/L ± 1s)	0.405 ± 0.243 U	2.67 ± 1.04	Not calculated
Gross beta (pCi/L ± 1s)	2.15 ± 0.458	4.12 ± 1.07	Not calculated
Potassium-40 (pCi/L ± 1s)	-23.7 ± 10.3 U	23.7 ± 10.5	Not calculated

a. Only parameters with at least one detected result are shown.
b. Results are for samples collected from January to December.
c. U flag indicates the result was below the detection limit.

Table C-19. Surveillance Monitoring Results for Materials and Fuels Complex Secondary Sanitary Lagoon (2010).[a]

Parameter	Minimum	Maximum	Median
Barium[b] (mg/L)	0.049	0.049	Not calculated
Biochemical Oxygen Demand (mg/L)	32.1	94.1	66.2
Chemical Oxygen Demand[b] (mg/L)	288	288	Not calculated
Chloride (mg/L)	113	177	143
Fluoride (mg/L)	0.23	0.347	0.259
Iron (mg/L)	0.101	0.406	0.115
Lead[b] (mg/L)	0.00078	0.00078	Not calculated
Manganese[b] (mg/L)	0.0584	0.0584	Not calculated
Nitrogen, nitrate + nitrite (mg-N/L)	0.1 U[c]	0.344	0.182
Nitrogen, total Kjeldahl (mg/L)	19.3	53.4	42.1
Selenium[b] (mg/L)	0.0017	0.0017	Not calculated
Sodium (mg/L)	88.3	132	108
Sulfate (mg/L)	34.6	54.9	40
Total dissolved solids (mg/L)	546	900	693
Total phosphorus (mg/L)	6.11	9.21	8.38
Total suspended solids (mg/L)	23.9	73.4	34.1
Zinc[b] (mg/L)	0.0224	0.0224	Not calculated
Gross beta (pCi/L ± 1s)	34 ± 2.8	50.6 ± 3.95	Not calculated
Potassium-40 (pCi/L ± 1s)	0 ± 12.1 U	85.4 ± 10.1	Not calculated
Uranium-233/234[b] (pCi/L ± 1s)	0.438 ± 0.101	0.438 ± 0.101	Not calculated
Uranium-238[b] (pCi/L ± 1s)	0.189 ± 0.0625	0.189 ± 0.0625	Not calculated

a. Only parameters with at least one detected result are shown.

b. Parameter was only analyzed in the samples collected in July.

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

Appendix D . In Situ Soil and Onsite Dosimeter Measurements and Locations

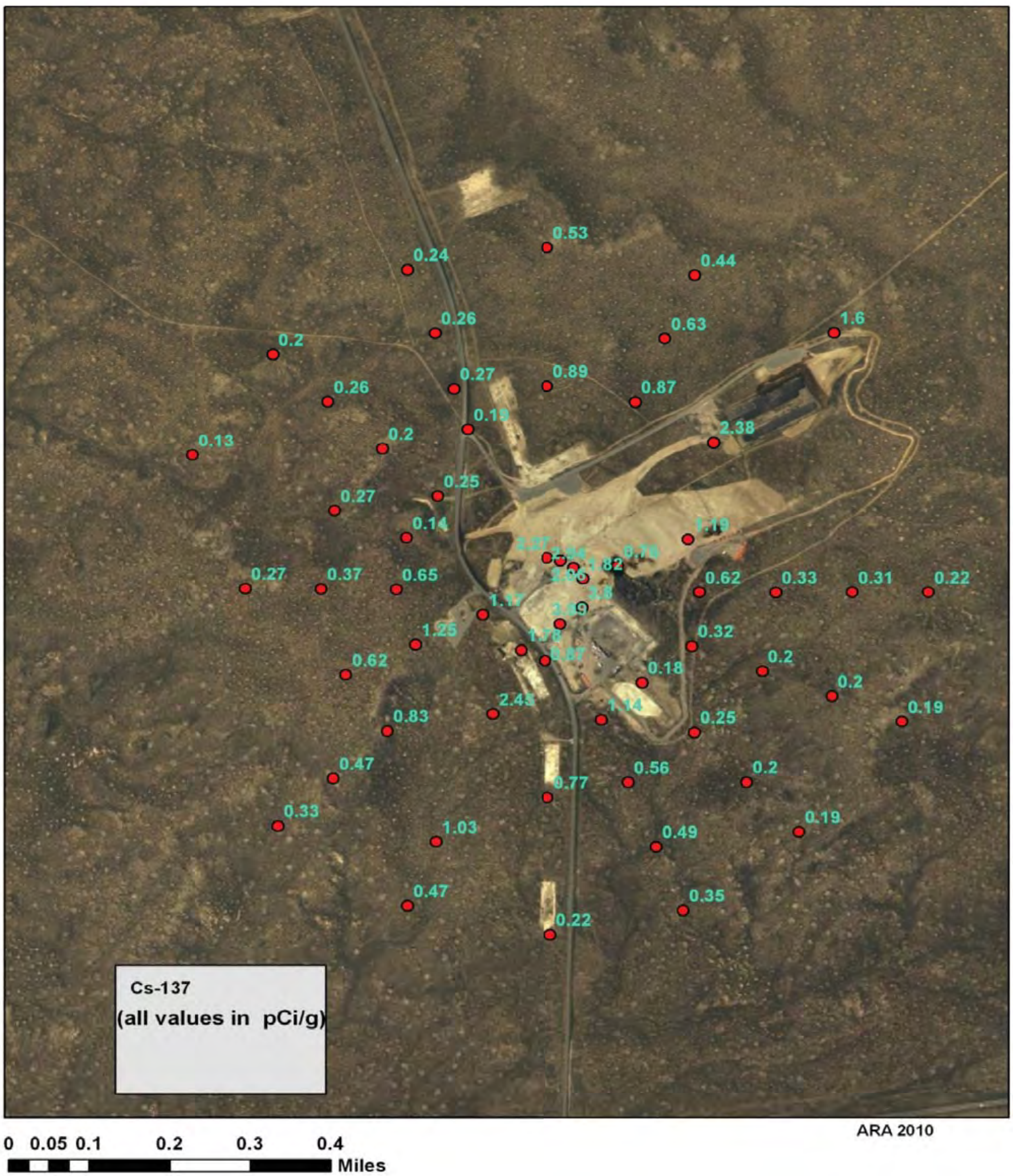


Figure D-1. In Situ Soil Measurements at Auxiliary Reactor Area (2010).

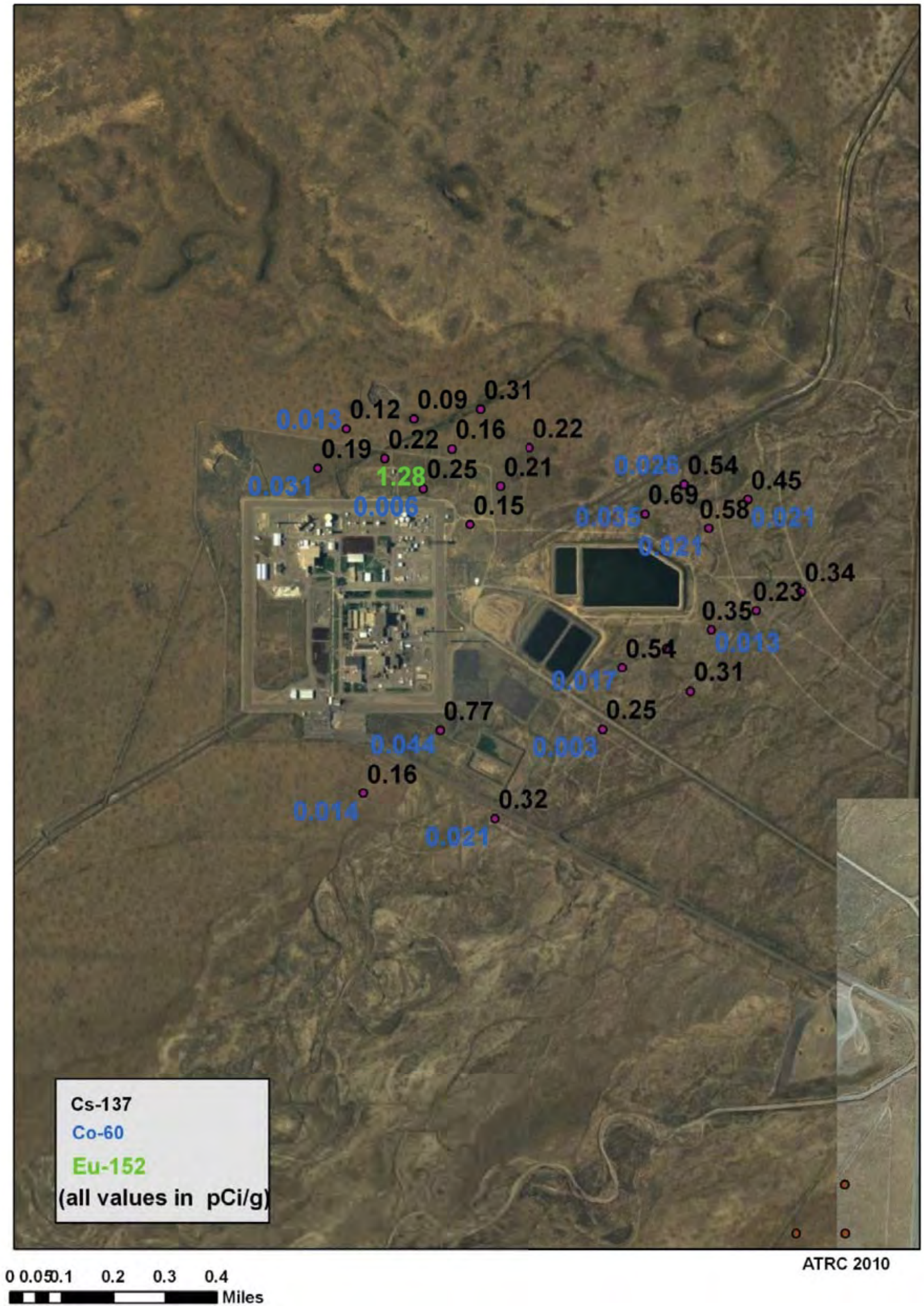


Figure D-2. In Situ Soil Measurements at Advanced Test Reactor Complex (2010).

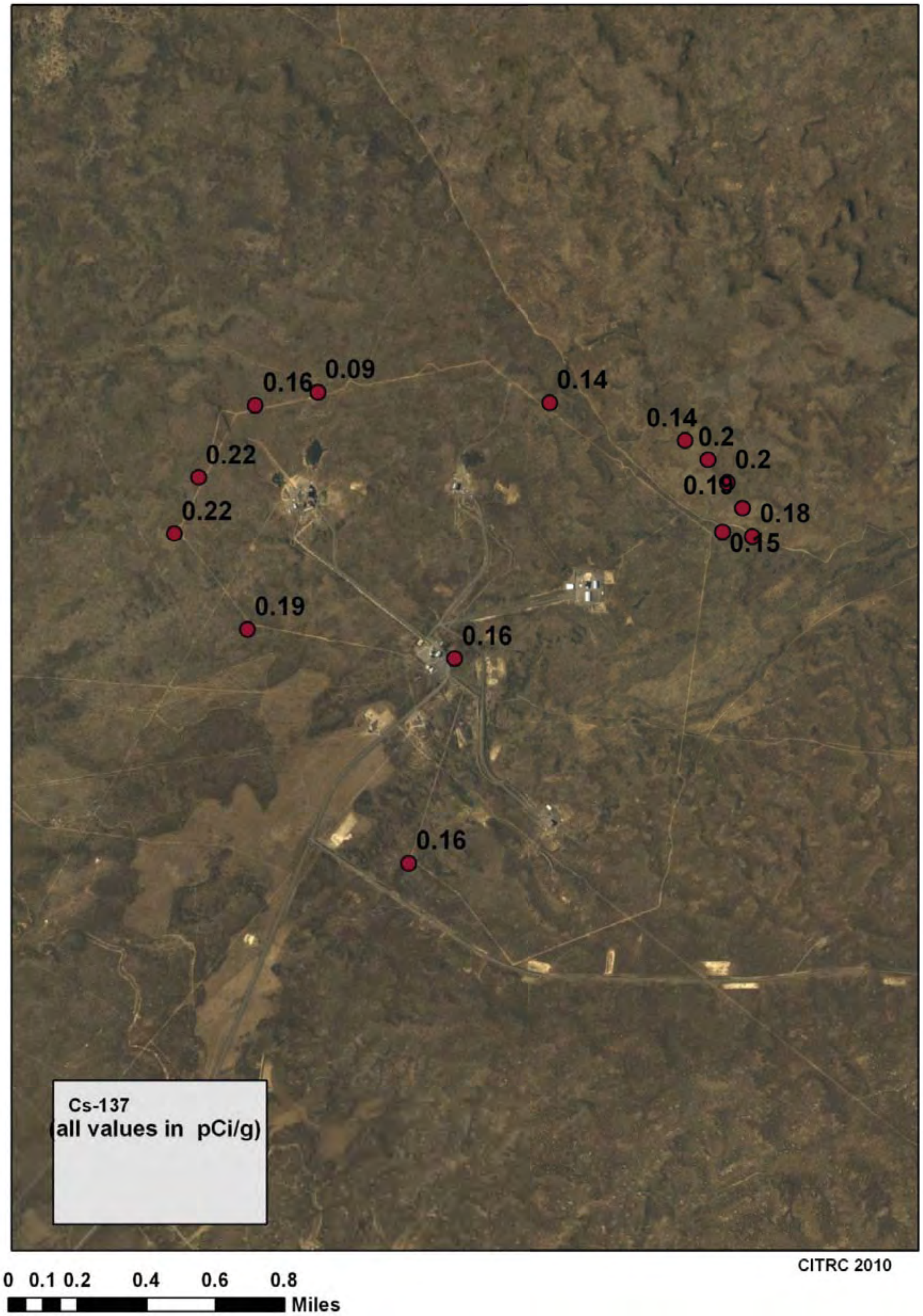


Figure D-3. In Situ Soil Measurements at Critical Infrastructure Test Range Complex (2010).

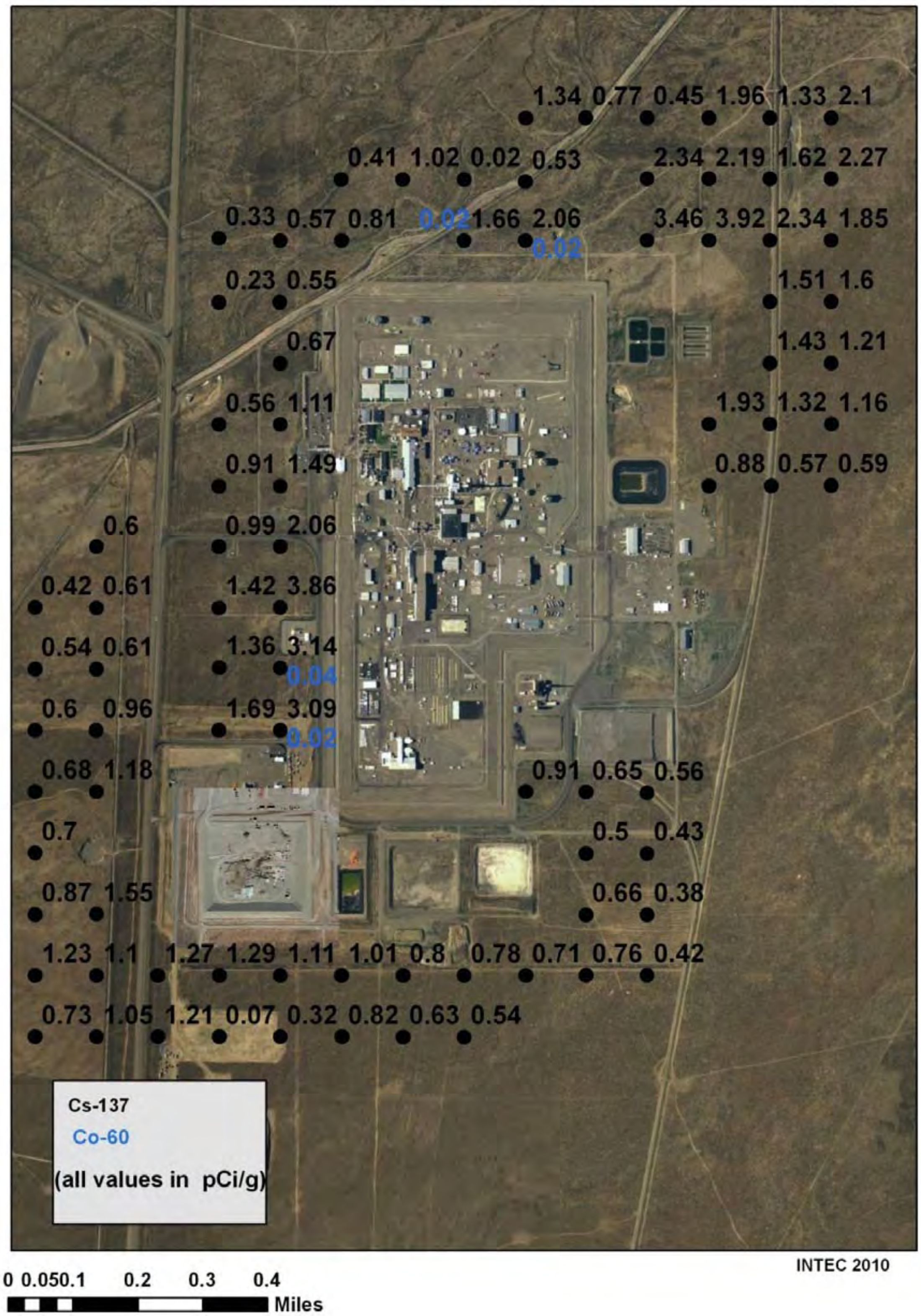


Figure D-4. In Situ Soil Measurements at Idaho Nuclear Technology and Engineering Center (2010).

Figure D-5. In Situ Soil Measurements at Materials and Fuels Complex (2010).

Figure D-6. In Situ Soil Measurements at Naval Reactors Facility (2010).

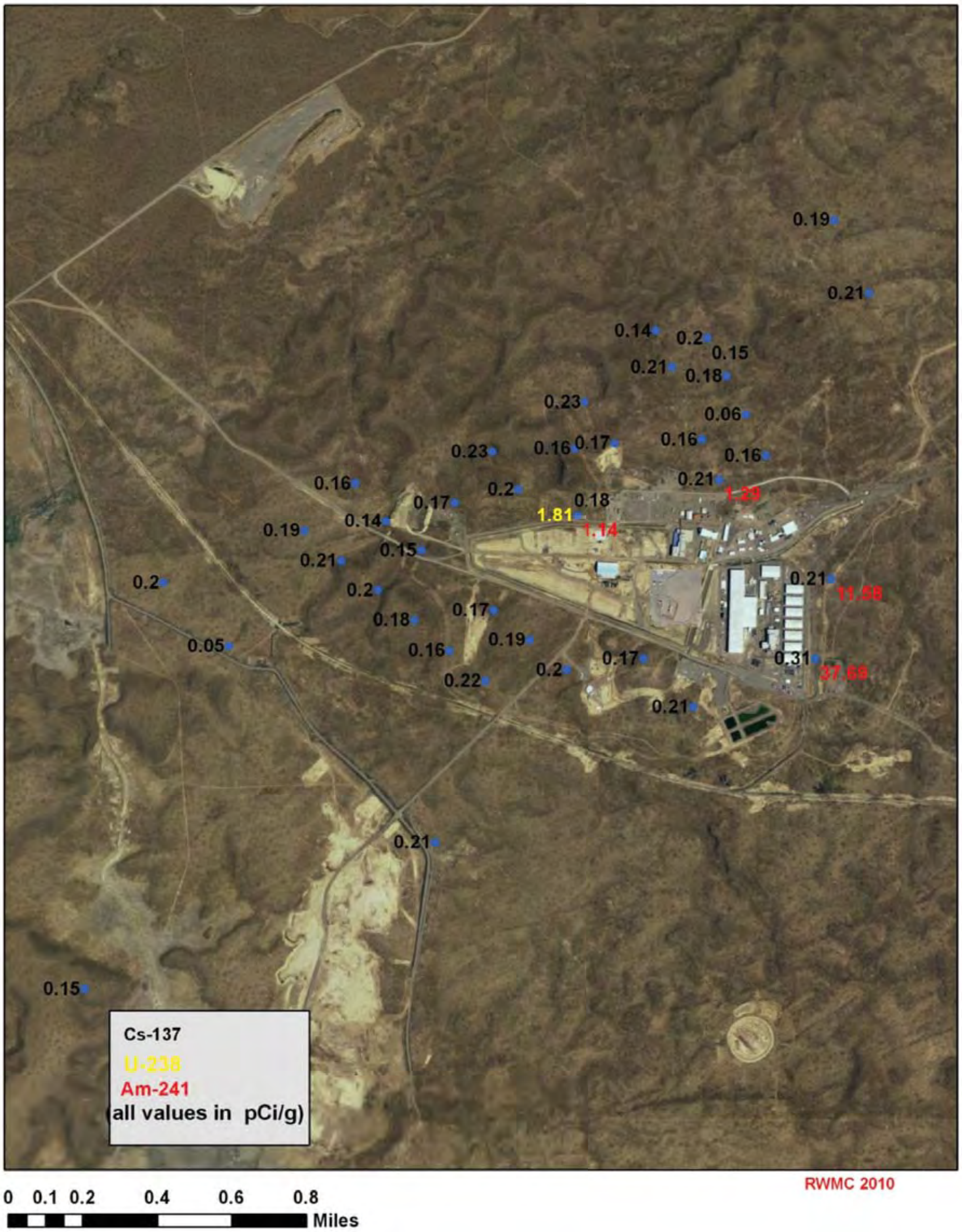


Figure D-7. In Situ Soil Measurements at Radioactive Waste Management Complex (2010). *(Note: the two highest measurements for Am-241 may not reflect actual soil concentrations but rather shine from material containing Am-241, which is stored near where the surface activity was measured. This will be confirmed in 2011 with additional measurements.)*

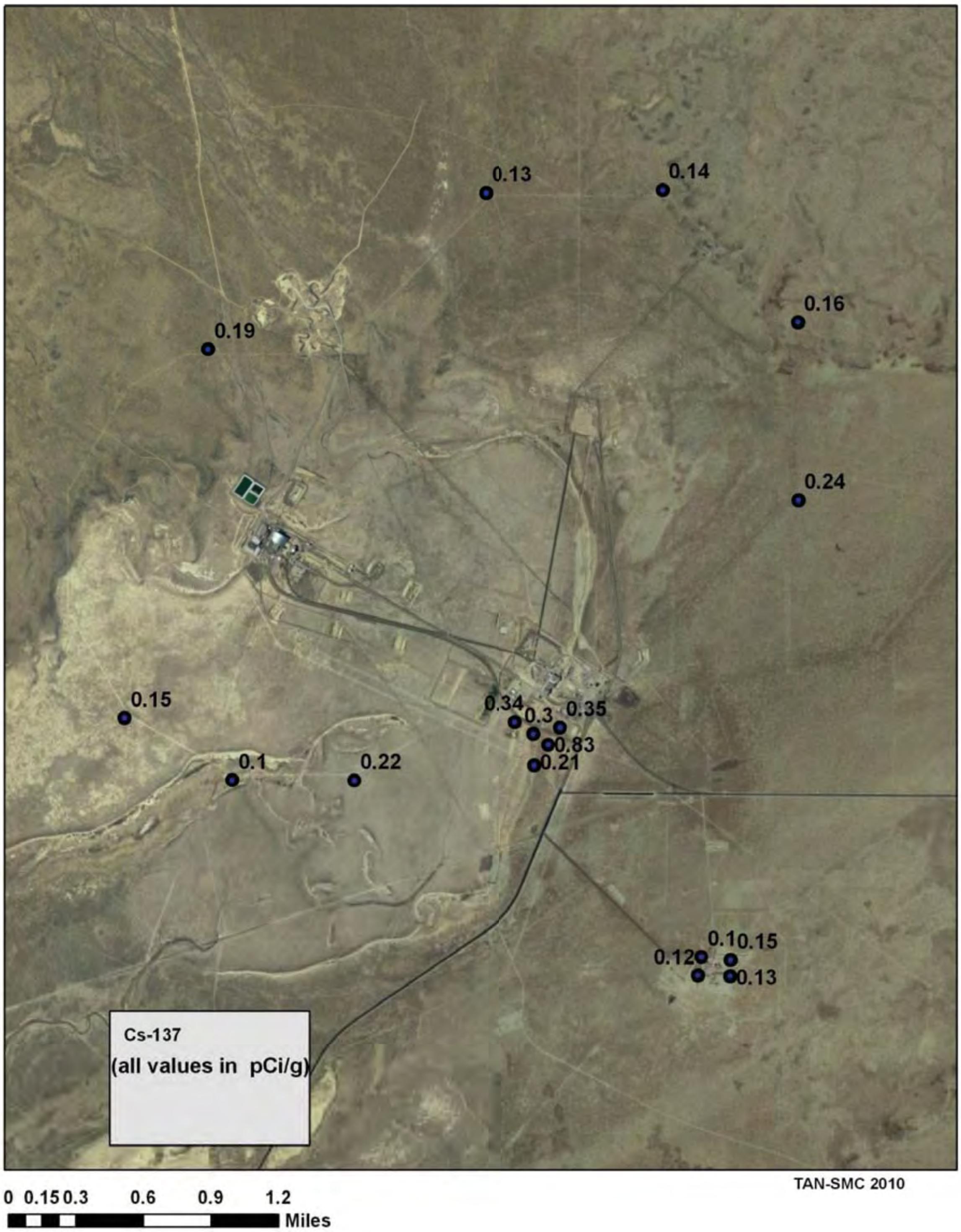


Figure D-8. In Situ Soil Measurements at Test Area North (2010).

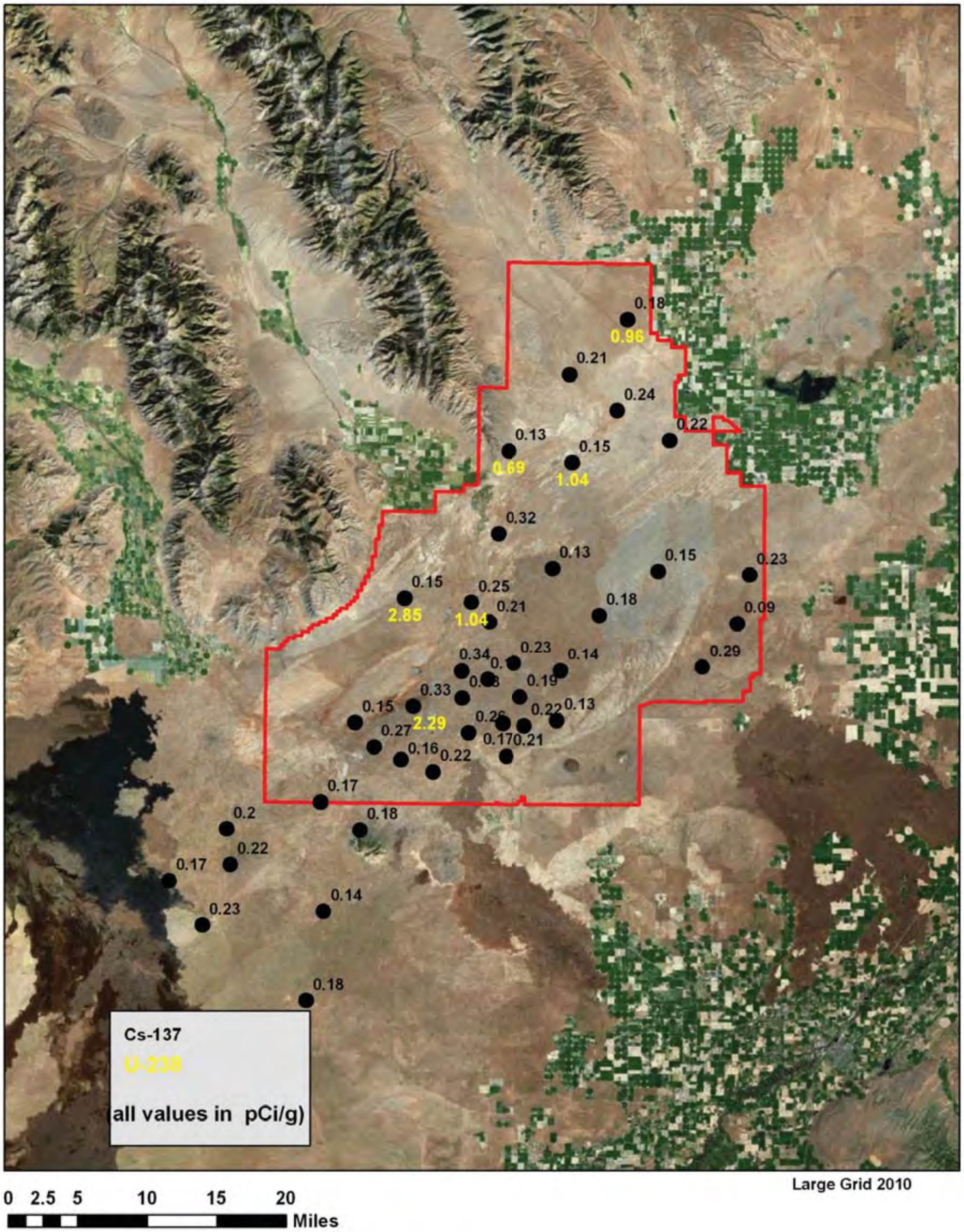


Figure D-9. In Situ Soil Measurements at Large Grid Locations (2010).

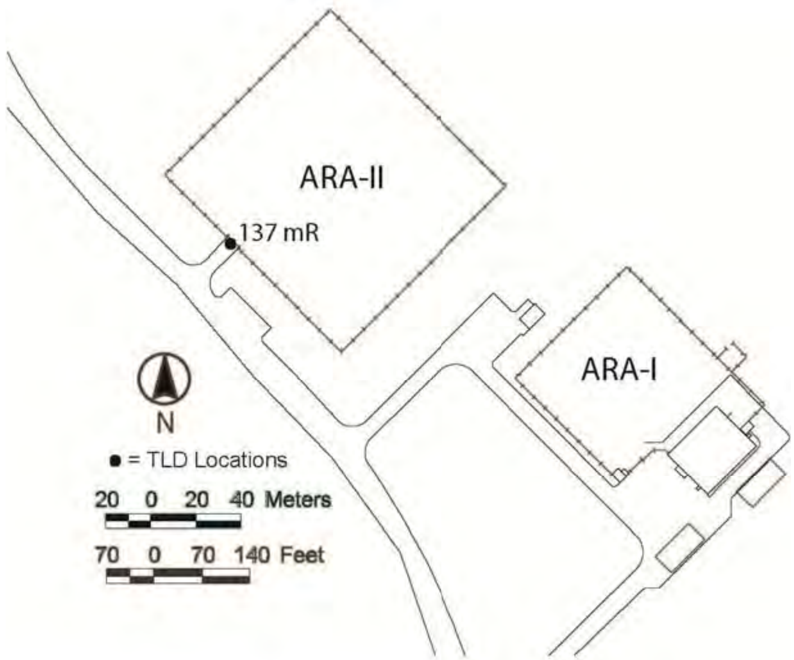


Figure D-10. Environmental Radiation Measurements at Auxiliary Reactor Area (2010).

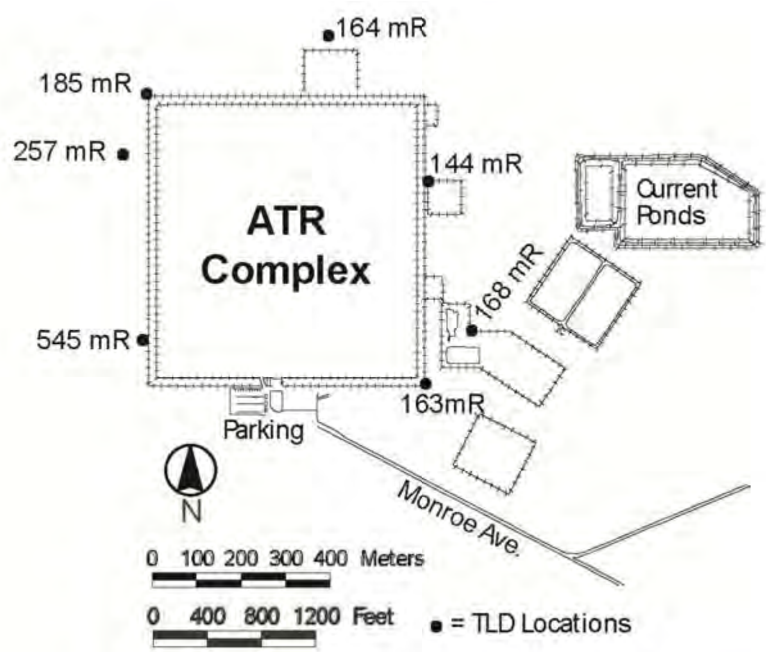


Figure D-11. Environmental Radiation Measurements at Advanced Test Reactor Complex (2010).

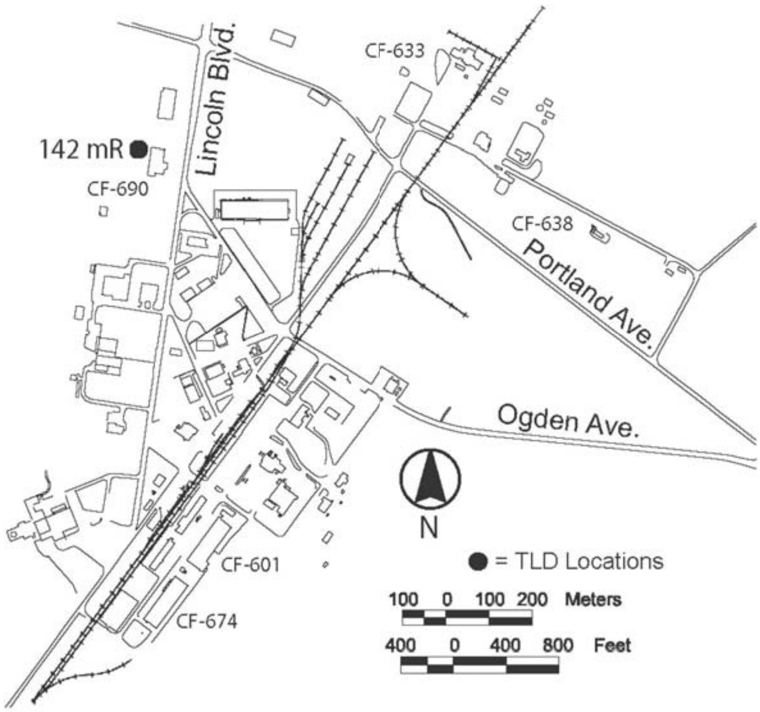


Figure D-12. Environmental Radiation Measurements at Central Facilities Area (2010).

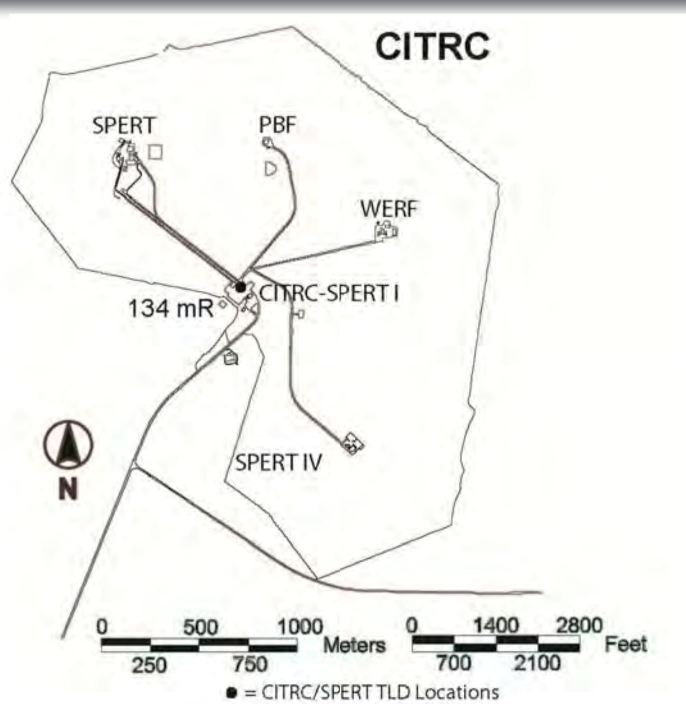


Figure D-13. Environmental Radiation Measurements at Critical Infrastructure Test Range Complex (2010).

Western Bluebird

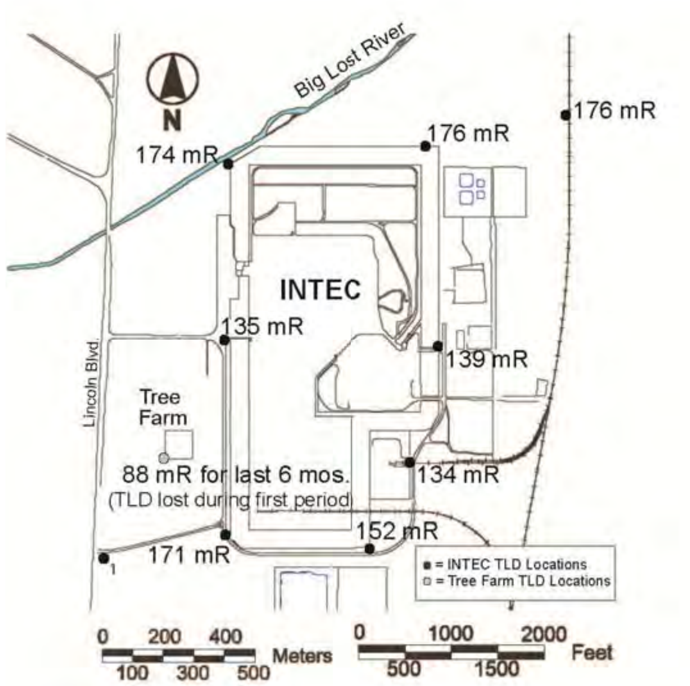


Figure D-14. Environmental Radiation Measurements at Idaho Nuclear Technology and Engineering Center (2010).

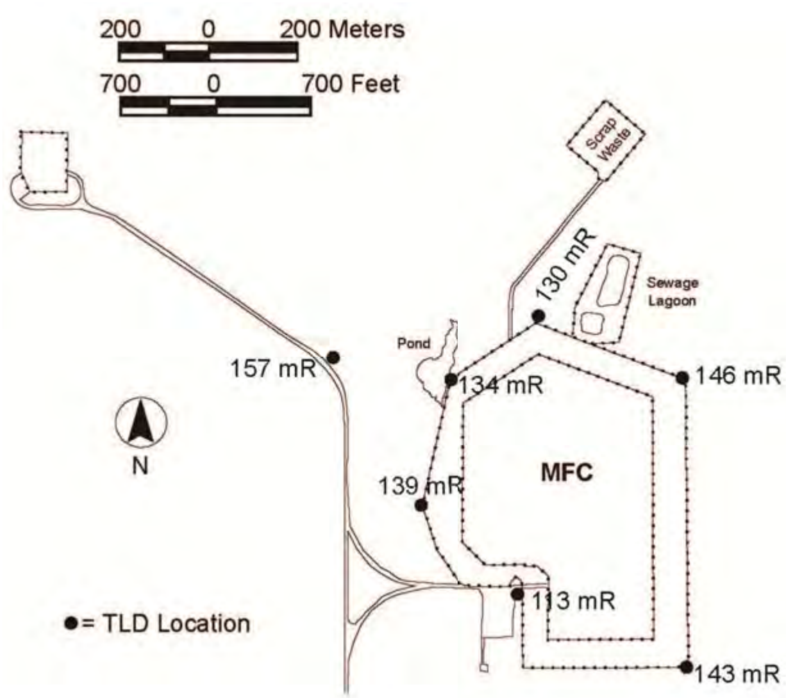


Figure D-15. Environmental Radiation Measurements at Materials and Fuels Complex (2010).

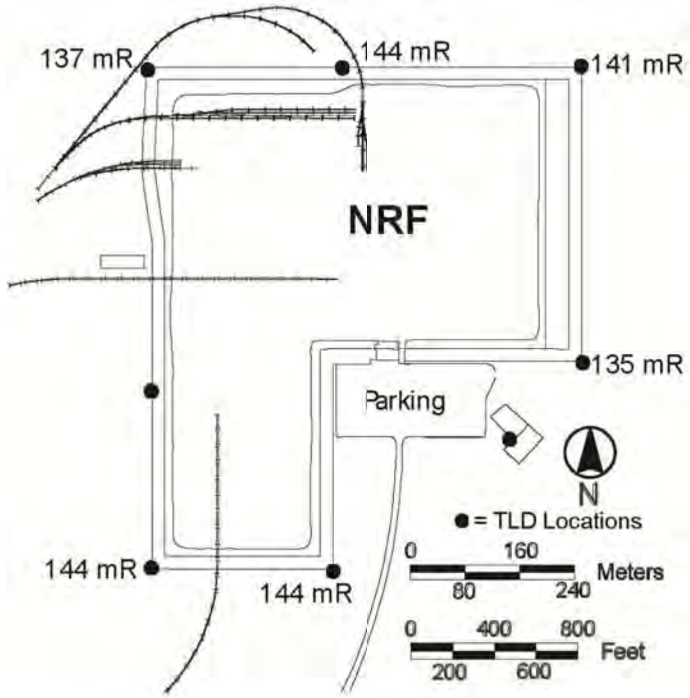


Figure D-16. Environmental Radiation Measurements at Naval Reactors Facility (2010).

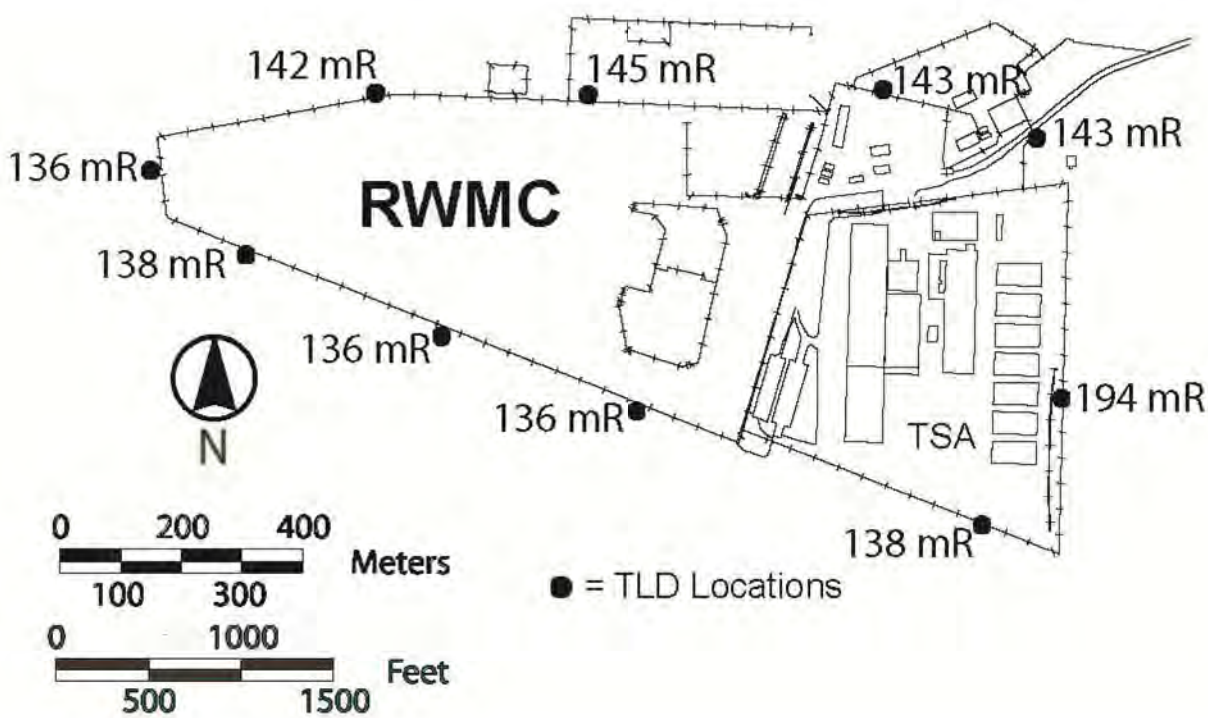


Figure D-17. Environmental Radiation Measurements at Radioactive Waste Management Complex (2010).

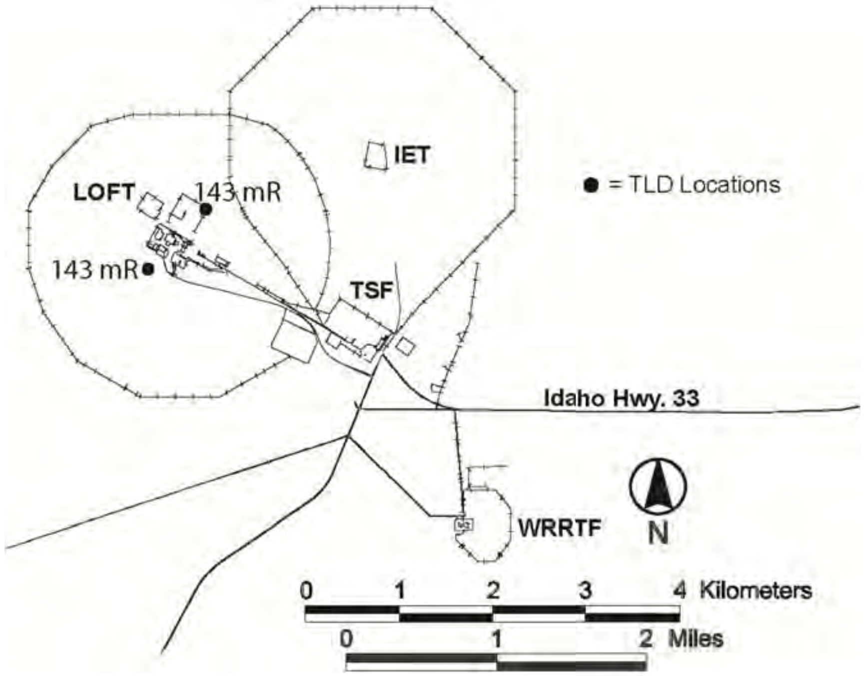


Figure D-18. Environmental Radiation Measurements at Test Area North (2010).

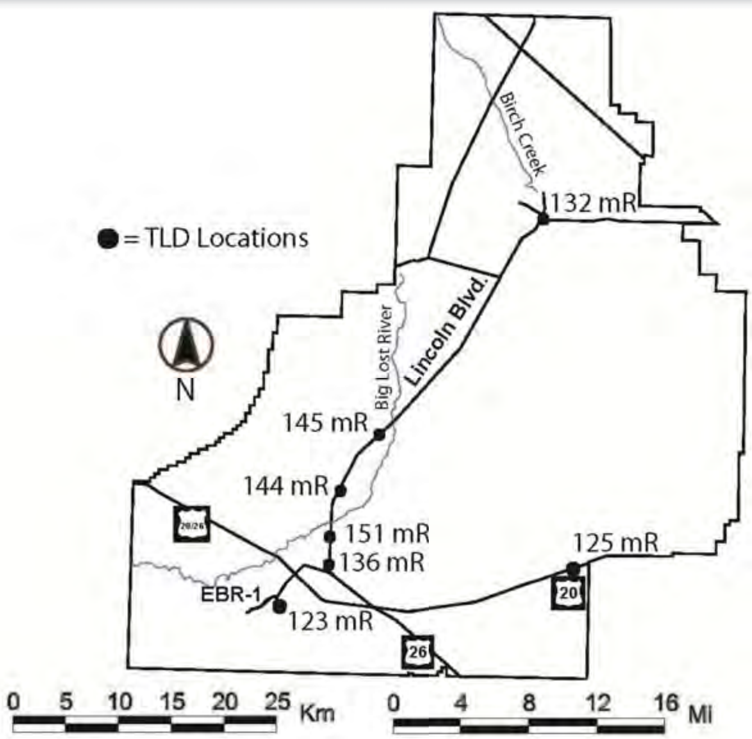


Figure D-19. Environmental Radiation Measurements at Sitewide Locations (2010).


Rough-legged Hawk

Table D-1. INL Contractor Environmental Radiation Measurements (November 2009 through November 2010).

Location	November 2009-April 2010 (TLD), mR ± 2σ	May 2010-November 2010 (TLD), mR ± 2σ
	INL Onsite Group	
ANL W EBR II, O-7	68.9 ± 13.5	70.3 ± 13.8
ANL W EBR II, O-12	56.8 ± 11.1	56.6 ± 11.1
ANL W EBR II, O-13	64.9 ± 12.7	77.7 ± 15.2
ANL W EBR II, O-15	66.4 ± 13.0	79.4 ± 15.6
ANL W EBR II, O-17	61.8 ± 12.1	68.5 ± 13.4
ANL W EBR II, O-18	65.1 ± 12.8	69.4 ± 13.6
ANL W TREAT, O-9	76.4 ± 15.0	80.3 ± 15.7
ARA-I II, O-1	65.4 ± 12.8	71.2 ± 14.0
CFA, O-1	68.1 ± 13.3	73.5 ± 14.4
EBR-I, O-1	59.2 ± 11.6	64.0 ± 12.5
Hwy 20, Mile 276, O-276	63.1 ± 12.4	66.6 ± 13.0
ICPP, O-9	82.8 ± 16.2	92.8 ± 18.2
ICPP, O-15	83.6 ± 16.4	92.2 ± 18.1
ICPP, O-17	66.9 ± 13.1	72.0 ± 14.1
ICPP, O-19	61.9 ± 12.1	72.9 ± 14.3
ICPP, O-21	80.1 ± 15.7	91.1 ± 17.9
ICPP, O-23	73.3 ± 14.4	79.1 ± 15.5
ICPP, O-25	62.9 ± 12.3	71.2 ± 14.0
ICPP, O-26	67.6 ± 13.2	71.1 ± 13.9
ICPP Tree Farm, O-3	TLD Lost	88.4 ± 17.3
Lincoln Blvd, O-1	66.4 ± 13.0	69.7 ± 13.7
Lincoln Blvd, O-3	71.3 ± 14.0	79.3 ± 15.5
Lincoln Blvd, O-5	68.2 ± 13.4	75.3 ± 14.8
Lincoln Blvd, O-9	71.3 ± 14.0	73.6 ± 14.4
Lincoln Blvd, O-25	64.3 ± 12.6	67.6 ± 13.3
NRF, O-4	67.2 ± 13.2	74.1 ± 14.5
NRF, O-5	69.5 ± 13.6	74.0 ± 14.5
NRF, O-12	65.2 ± 12.8	69.5 ± 13.6
NRF, O-16	66.7 ± 13.1	70.6 ± 13.8
NRF, O-19	69.7 ± 13.7	74.0 ± 14.5
NRF, O-20	68.2 ± 13.4	75.4 ± 14.8
PBF SPERT, O-1	65.4 ± 12.8	69.1 ± 13.5
RWMC, O-39	68.2 ± 13.4	75.2 ± 14.7
RWMC, O-41	93.8 ± 18.4	99.8 ± 19.6
RWMC, O-43	68.1 ± 13.3	70.4 ± 13.8
RWMC, O-46	67.4 ± 13.2	75.2 ± 14.7
RWMC, O-9A	70.4 ± 13.8	74.3 ± 14.6
RWMC, O-13A	66.8 ± 13.1	74.8 ± 14.7
RWMC, O-17A	64.1 ± 12.6	72.2 ± 14.1
RWMC, O-21A	65.9 ± 12.9	72.3 ± 14.2
RWMC, O-25A	64.2 ± 12.6	71.6 ± 14.0
RWMC, O-29A	64.0 ± 12.5	71.8 ± 14.1
TAN-LOFT, O-6	68.6 ± 13.4	74.1 ± 14.5
TAN-LOFT, O-7	70.0 ± 13.7	73.1 ± 14.3
TRA, O-2	78.1 ± 15.3	85.3 ± 16.7

Table D-1. INL Contractor Environmental Radiation Measurements (November 2009 through November 2010) (continued).

TRA, O-4	79.6 ± 15.6	88.9 ± 17.4
TRA, O-6	68.2 ± 13.4	75.5 ± 14.8
TRA, O-8	78.9 ± 15.5	85.6 ± 16.8
TRA, O-10	84.4 ± 16.5	100.9 ± 19.8
TRA, O-11	116.2 ± 22.8	141.5 ± 27.7
TRA, O-13	233.0 ± 45.7	311.1 ± 61.0
INL Boundary Group		
Arco	62.5 ± 12.2	66.8 ± 13.1
Atomic City	59.6 ± 11.7	62.6 ± 12.3
Howe	59.4 ± 11.6	59.3 ± 11.6
Monteview	59.4 ± 11.6	68.7 ± 13.5
Mud Lake	67.0 ± 13.1	70.7 ± 13.8
INL Distant Group		
Aberdeen	65.1 ± 12.8	67.7 ± 13.3
Blackfoot	57.1 ± 11.2	57.2 ± 11.2
Craters of the Moon	58.7 ± 11.5	76.4 ± 15.0
Idaho Falls	57.9 ± 11.3	63.3 ± 12.4
Minidoka	59.6 ± 11.7	59.8 ± 11.7
Reno Ranch	54.0 ± 10.6	57.6 ± 11.3
Rexburg	61.0 ± 12.0	66.9 ± 13.1
Roberts	67.2 ± 13.2	75.6 ± 14.8

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.

Rough-legged Hawk

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.

Rough-legged Hawk

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

Rough-legged Hawk

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.

Gonzales-Stoller
Surveillance, LLC
120 Technology Drive
Idaho Falls, ID 83402
208-525-8250
www.gsseser.com

U.S. Department of Energy
Idaho Operations Office

INL
Idaho National Laboratory

ESER
Environmental Surveillance, Education and Research Program