Idaho National
Laboratory Site

Site Environmental Report

Calendar Year 2009

Environmental Surveillance, Education and Research Program

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U.S. Department of Energy Idaho Operations Office
September 2010

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To Our Readers

The Idaho National Laboratory Site Environmental Report for Calendar Year 2009 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, 2009. 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.

In addition to Stoller ESER, 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 USGS. Links to their websites may be found on this page or in the CD provided with the hard copy of this

Elk Antler on the INL Site

Collapsed Lava Tube on the INL Site

Executive Summary

The *Idaho National Laboratory Site Environmental Report Calendar Year 2009* was prepared to inform the public, regulators, stakeholders, and other interested parties of the Idaho National Laboratory (INL) Site environmental performance during 2009.

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, missions, 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.

Scarab beetle

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 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 890-square mile 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 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, which includes a landfill, evaporation ponds, and a storage and treatment facility. It is operated by the ICP contractor.

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

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

Bristly Cutworm Moth

The RWMC was established in 1952 as a burial location for low-level radioactive waste. Starting in 1954, however, transuranic waste and organic sludge from Rocky Flats, Colorado, were also buried in the Subsurface Disposal Area (SDA)—the actual burial grounds at the RWMC. In 1970, the federal government stopped burying transuranic waste at the RWMC and began placing it in retrievable storage for later transfer to a federal repository, but the INL Site continued to dispose of low-level radioactive waste in pits at the SDA. The ICP 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.

The Research and Education Campus (REC), 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. Other facilities house National Security programs and INL precision machining and glass shops. The REC also includes the Center for Advanced Energy Studies (CAES), which is a public/private partnership comprised of the three Idaho public universities, private industry, and the INL. CAES integrates resources, capabilities, and expertise to create new research capabilities, expand researcher-to-researcher collaborations, and enhance energy-related educational opportunities. From a broad energy perspective that includes fossil, renewable, alternative energy, environmental stewardship, energy policy studies, and a focus on the national renaissance of commercial nuclear power, CAES delivers innovative, cost-effective, credible energy research leading to sustainable technology-based economic development.

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 INL 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. Overall, the INL Site met all federal, state, and local regulatory commitments in 2009.

The INL Site attained ISO 14001 certification of its Environmental Management System effective November 24, 2005, and continues to maintain certification. The Pollution Prevention and Sustainability Program is part of the Environmental Management System. Its scope incorporates waste prevention and elimination, reduction of environmental releases,

Scarab beetle

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 2009, the INL Site reused and recycled more than three million kilograms (eight 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 (NESHAPs),” Subpart H, “National Emission Standards for Emissions of Radionuclides other than Radon from Department of Energy Facilities.” An estimated total of 7,320 curies of radioactivity, primarily in the form of short-lived noble gas isotopes, were released as airborne effluents in 2009. The highest releases were from INTEC (34 percent of total), MFC (33 percent of total), and the ATR Complex (27 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 2009, the INL contractor monitored ambient air at 17 INL Site locations and at four locations off the INL Site. The ICP contractor focused on ambient air monitoring of waste management facilities, namely INTEC and the RWMC. The ESER contractor sampled ambient air at three locations on the INL Site, at seven locations bounding the INL Site, and at six locations distant from the INL Site.

Air particulate samples were collected weekly and analyzed for gross alpha and gross beta activity. Charcoal cartridges were also collected weekly and analyzed for radioiodine. Weekly 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

Bristly Cutworm Moth

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.

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 2009, 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 11 drinking water systems at the INL Site in 2009. 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 2009. The dose, 0.3 mrem, is below the EPA standard of 4 mrem/yr for public drinking water systems.

Surface water was sampled at the SDA of the RWMC during the first, second, and fourth quarters of 2009. 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. Americium-241 and plutonium-239/240 were detected above historical measurements in the samples, but the concentrations are consistent with those detected in 2008. In addition, plutonium-238 was detected during the fourth quarter for the first time since samples have been collected at the SDA. 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 2009, 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 the past 15 years.

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 during 2009. Annual average concentrations of carbon tetrachloride in this well generally have increased over time. Concentrations of other organic compounds detected were below their respective primary contaminant standards.

Groundwater surveillance monitoring continued for the CERCLA Waste Area Groups (WAGs) on the INL Site in 2009. 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, tritium, and gross alpha activity. 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. Strontium-90 and technicium-99 show declining trends. The presence of elevated nitrate is attributed to past Tank Farm releases and has remained relatively constant over the past few years at INTEC. Monitoring of groundwater for the CFA landfills (WAG 4) consists of sampling wells for metals, volatile organic compounds, and anions. Nitrate exceeded its maximum contaminant level in 2009, but concentrations were within historic levels. None of the organic compounds exceeded any EPA maximum contaminant level. At the RWMC (WAG 7) carbon tetratchloride exceeded its maximum contaminant level in one aquifer well north of the facility. One well south of RWMC exhibited elevated levels of gross beta activity. Neither location demonstrated a concentration trend. 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. Groundwater monitoring wells located

Bristly Cutworm Moth

along the southern boundary of the INL Site (WAG 10) were sampled from volatile organic compounds, metals, anions, and alkalinity radionuclides. No contaminant exceeded a maximum contaminant level in fiscal year 2009.

Monitoring of Agricultural Products, 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 2009. The agricultural products were collected on, around, and distant from the INL Site by the ESER contractor. Wildlife sampling included collection of ducks from wastewater disposal 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 2009.

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 were consistent with historical and/or 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, 0.069 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 2009 to be 355 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 2009. 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 80 km (50 mi) 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 0.52 person-rem, below that expected from exposure to background radiation (108,608 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 0.006 mrem and 0.005 mrem, respectively. When summed with the dose estimated for the air pathway (0.069 mrem), the maximally exposed individual could potentially receive a total dose of 0.08 mrem in 2009. This is 0.08 percent of the DOE health-based dose limit of 100 mrem/yr from all pathways for the INL Site.

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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 ducks 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 2009 there were 19 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, University of Montana, Texas A&M University, Colorado State University, the U.S. Department of Agriculture, the Wildlife Conservation Society, the INL, and ESER.

The USGS INL Project Office drills and maintains research wells that 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 2009 the USGS published two research reports. One report summarized iodine-129 concentrations in well samples collected in 2003. The radionuclide was discharged in wastewater by INTEC directly into the aquifer from 1953 to 1988. Decreases in concentrations of iodine-129 are attributed to cessation of disposal into the aquifer and dilution and dispersion in the aquifer.

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Quality Assurance

Quality assurance (QA) and quality control programs are maintained by contractors conducting environmental monitoring and by laboratories performing environmental analyses to help provide confidence in the data and ensure data completeness. Programs involved in environmental monitoring developed quality assurance programs and documentation that 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 2009. 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 2009 were addressed with the laboratories and resolved.

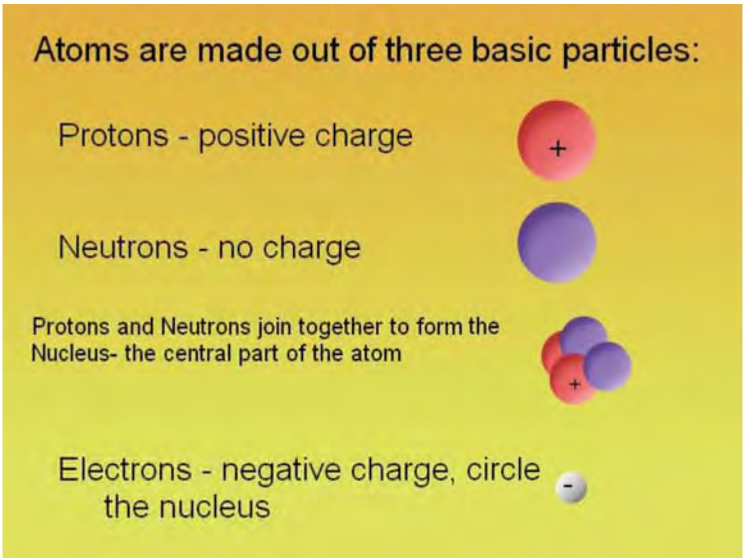
Big Lost River

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 a form 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 sheet 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 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,

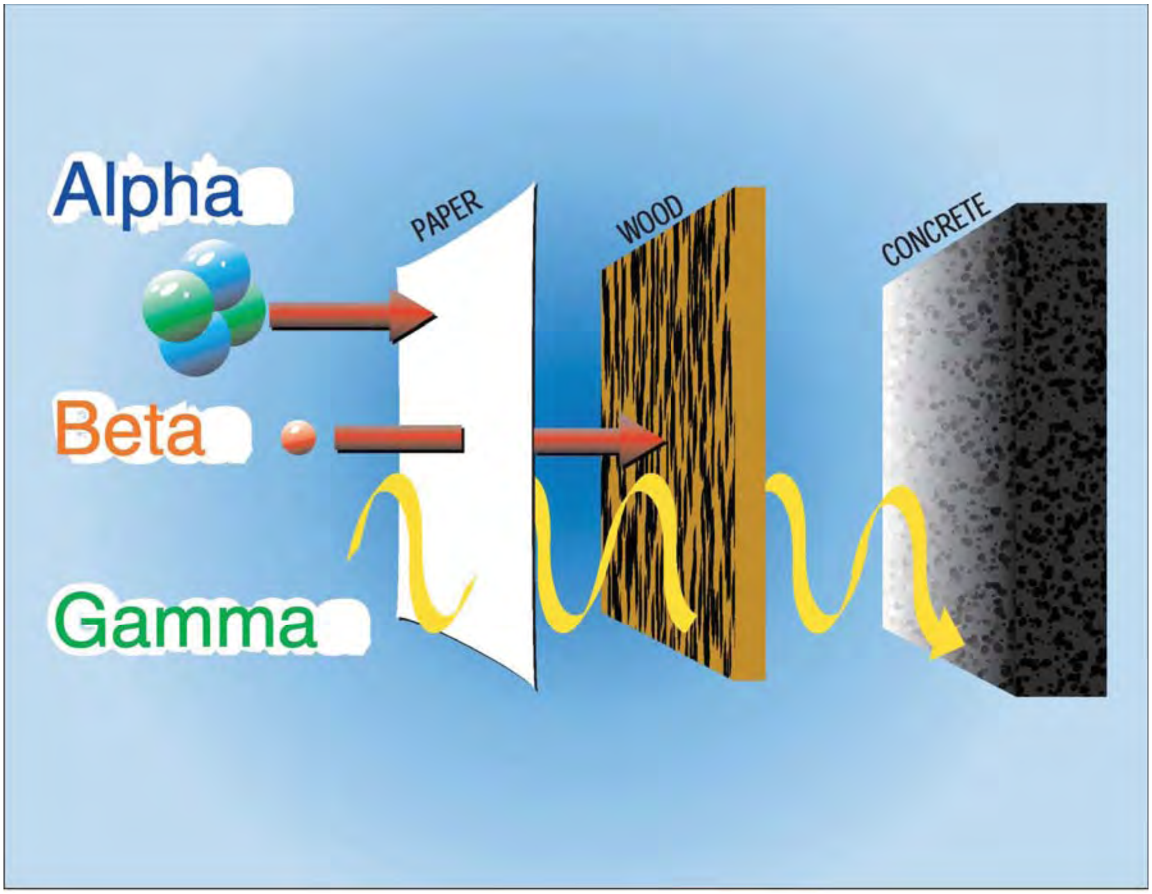


Figure HI-1. Comparison of Penetrating Ability of Alpha, Beta, and Gamma Radiation.

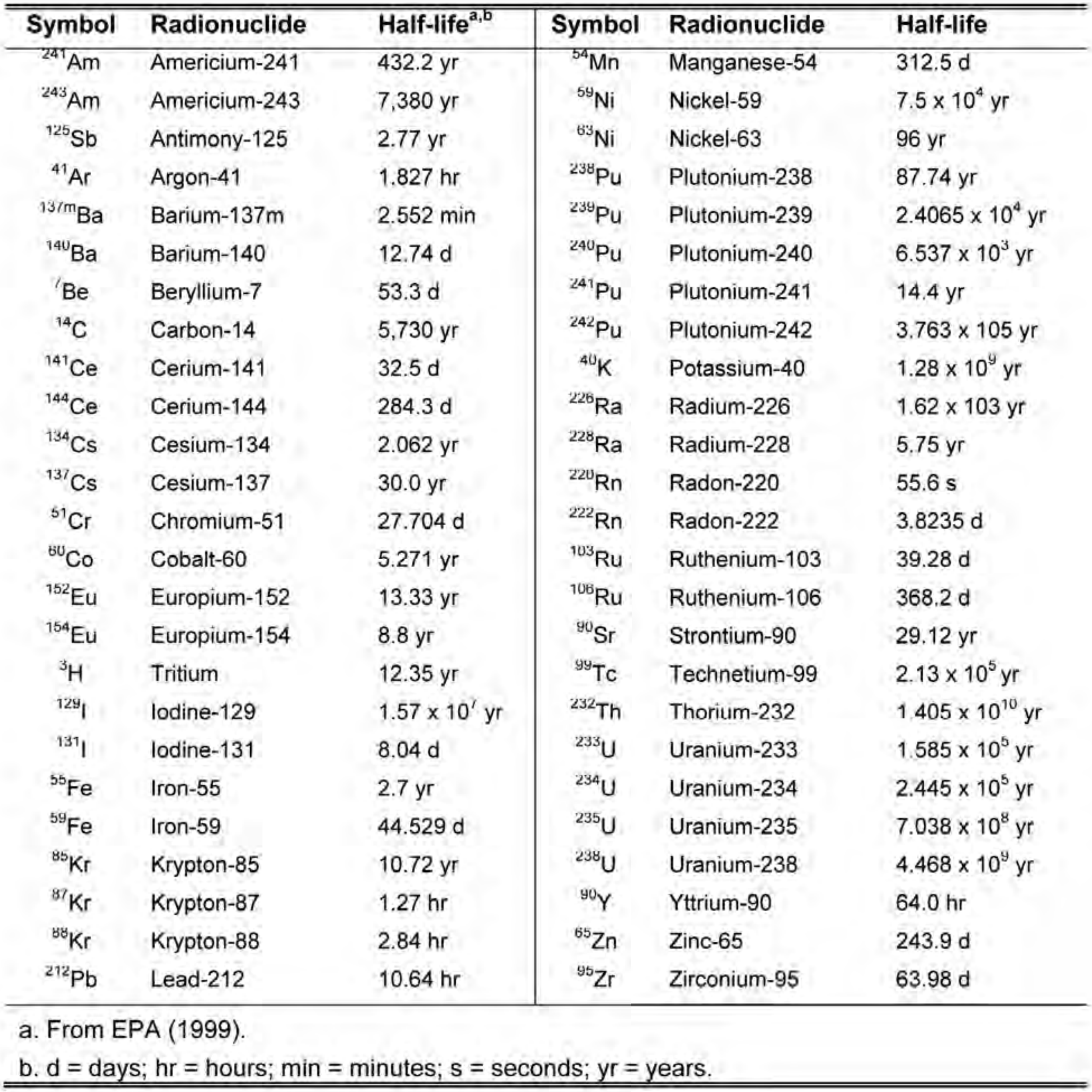
however, vary over a large range. The penetration of X-ray or gamma-ray photons depends on the energy of the photons, as well as the thickness, density, and composition of the shielding material. Concrete is a common material used to shield people from gamma-rays and X-rays (Figure HI-1). Examples of 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

Bristly Cutworm Moth

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 x 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 x 10^{4} yr
^{140}Ba	Barium-140	12.74 d	^{240}Pu	Plutonium-240	6.537 x 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 x 105 yr
^{141}Ce	Cerium-141	32.5 d	^{40}K	Potassium-40	1.28 x 10^{9} yr
^{144}Ce	Cerium-144	284.3 d	^{226}Ra	Radium-226	1.62 x 103 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 x 10^{5} yr
^{129}I	Iodine-129	1.57 x 10^{7} yr	^{232}Th	Thorium-232	1.405 x 10^{10} yr
^{131}I	Iodine-131	8.04 d	^{233}U	Uranium-233	1.585 x 10^{5} yr
^{55}Fe	Iron-55	2.7 yr	^{234}U	Uranium-234	2.445 x 10^{5} yr
^{59}Fe	Iron-59	44.529 d	^{235}U	Uranium-235	7.038 x 10^{8} yr
^{85}Kr	Krypton-85	10.72 yr	^{238}U	Uranium-238	4.468 x 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.

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.

How are Radioactivity and Radionuclides Detected?

Environmental samples of air, water, soil, and plants are collected in the field and then prepared and analyzed for radioactivity in a laboratory. A prepared sample is placed in a radiation

counting system with a detector that converts the ionization produced by the radiation into electrical signals or pulses. The number of electrical pulses recorded over a unit of time is called a “count rate.” The count rate is proportional to the amount of radioactivity in the sample.

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

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

Beta particles are easily detected by several types of instruments, including the common Geiger-Mueller (G-M) counter. However, detection of specific beta-emitting radionuclides, such as 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 thermoluminescent 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.

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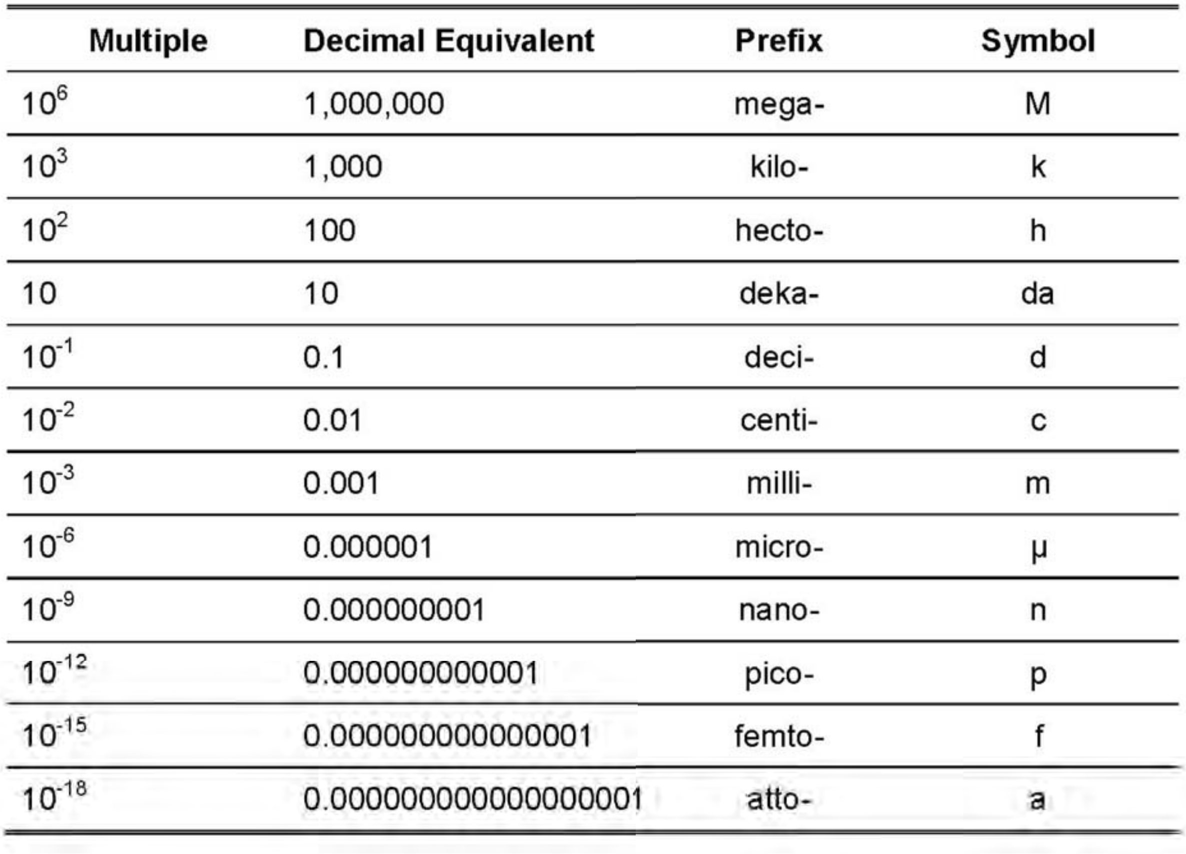
When considering large numbers with a positive exponent, such as 1.0 x 10^6, the decimal point is moved to the right by the number of places equal to the exponent. In this case, 1.0 x 10^6 represents one million and may also be written as 1,000,000.

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

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

Table HI-2. Multiples of Units.



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

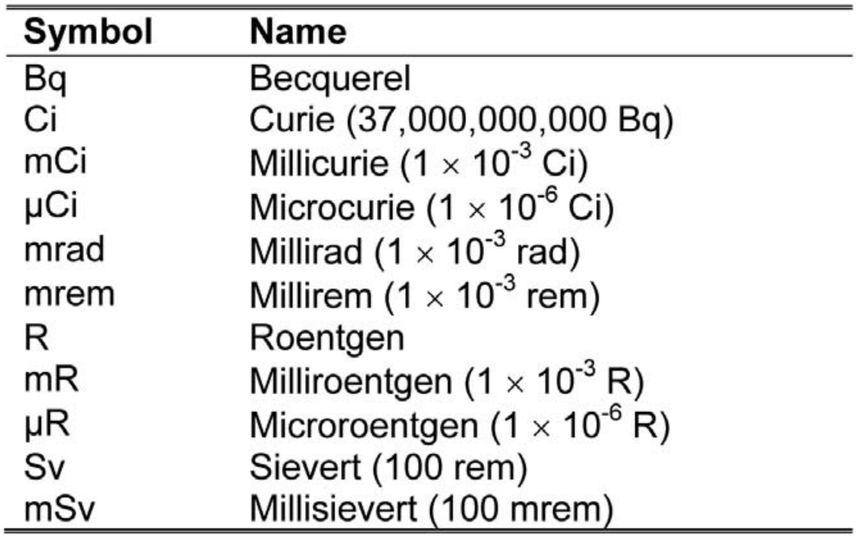
Units of Radiological Dose (Table HI-3). The amount of ionization produced by gamma or X-ray radiation in air is measured in terms of the roentgen (R). The ionization or exposure measured in air must be converted into a special unit called the equivalent dose in order to determine the impact on humans.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

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

The Système International also 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 x 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 Media. Table HI-4 shows the units used to identify the concentration of radioactivity in various media.

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)

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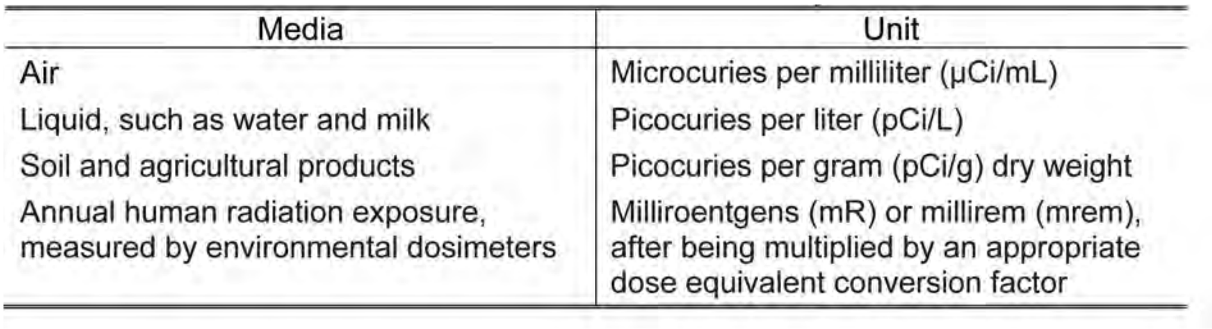
Table HI-4. Units of Radioactivity.



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

There is always uncertainty associated with the measurement of radioactivity in environmental samples. This is mainly because radioactive decay events are inherently random. Thus, when a radioactive sample is counted again and again for the same length of time, the results will differ slightly, but most of the results will be close to the “true value” of the activity of the radioactive material in the sample. Statistical methods are used to estimate the true value of a single measurement and the associated uncertainty of the measurement. The uncertainty of a measurement is reported by following the result with an uncertainty value which is preceded by the plus or minus symbol, ± (e.g., 10 ± 2 pCi/L). For concentrations of greater than or equal to three times the uncertainty, there is 95 percent or larger 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 2 × 3 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.

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

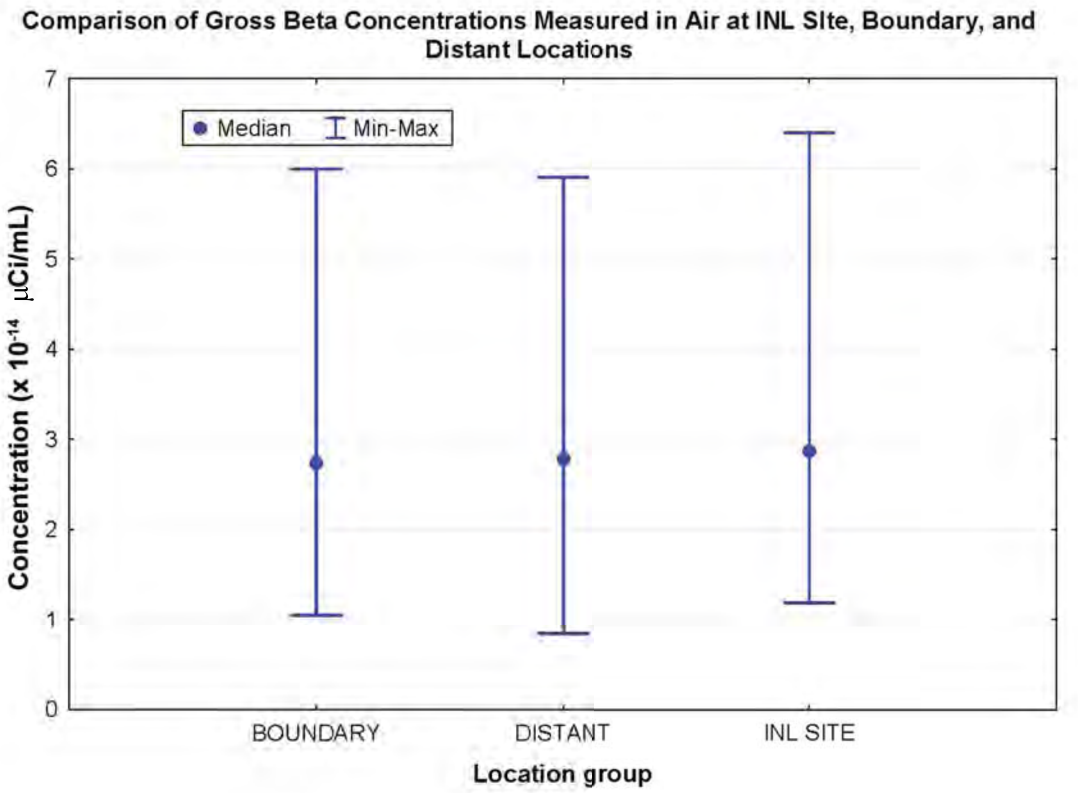


Figure HI-2. A Graphical Representation of Minimum, Median, and Maximum Results.

How are Data Represented Graphically?

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

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

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

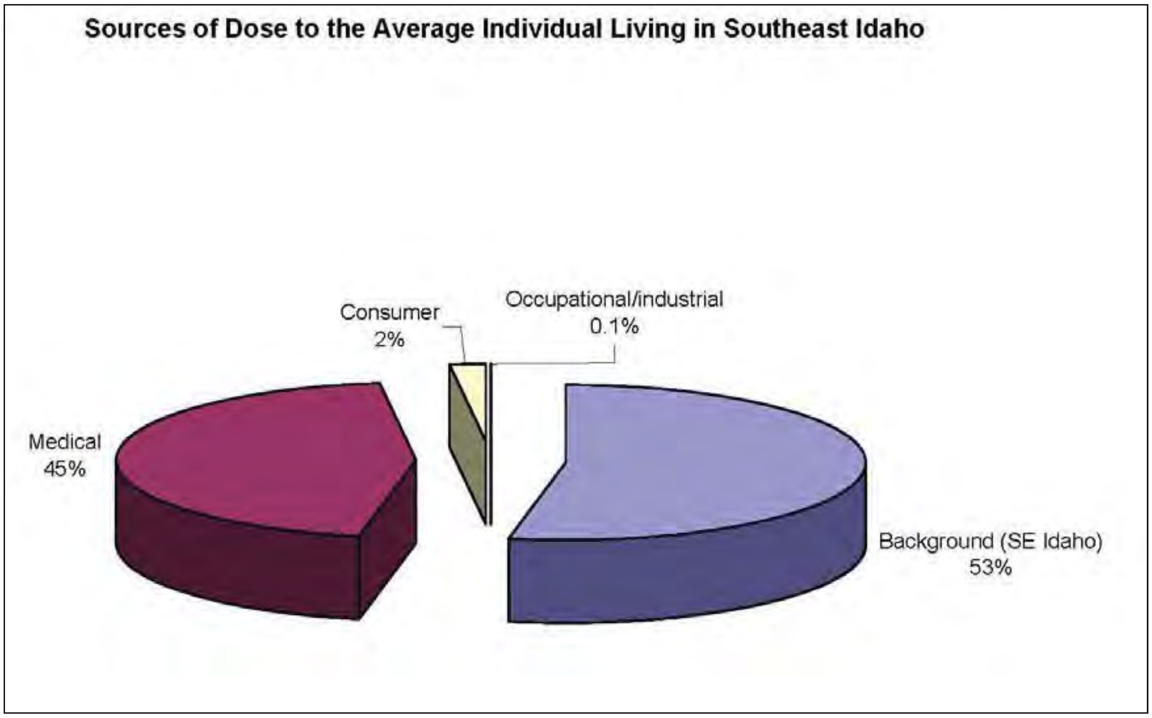


Figure HI-3. Data Presented Using a Pie Chart.

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

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

Contour lines are sometimes drawn on a map to discern patterns over a geographical area. For example, Figure HI-6 shows the distribution of iodine-129 (^{129}I) 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

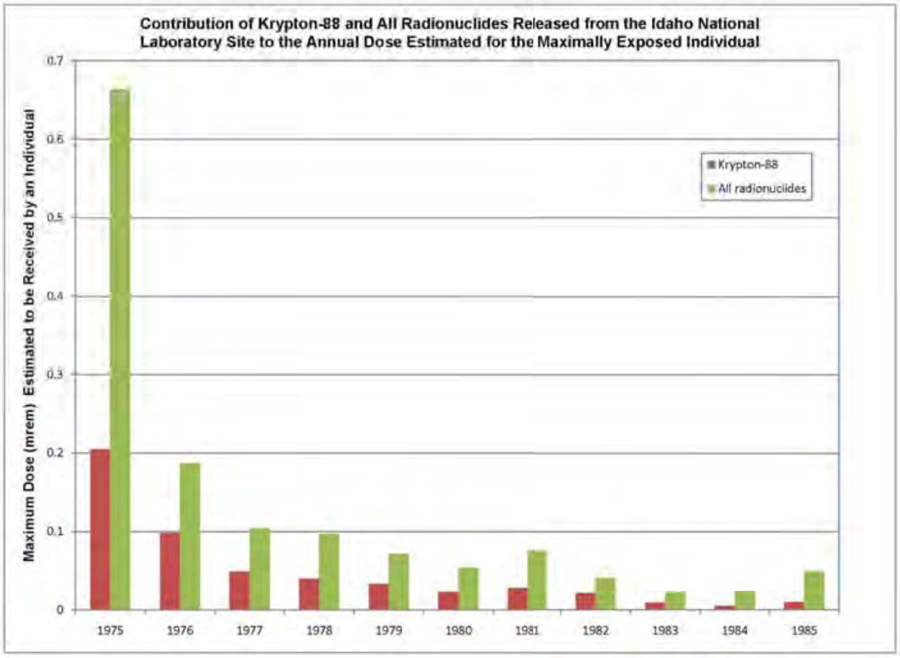


Figure HI-4. Data Plotted Using a Column Chart.

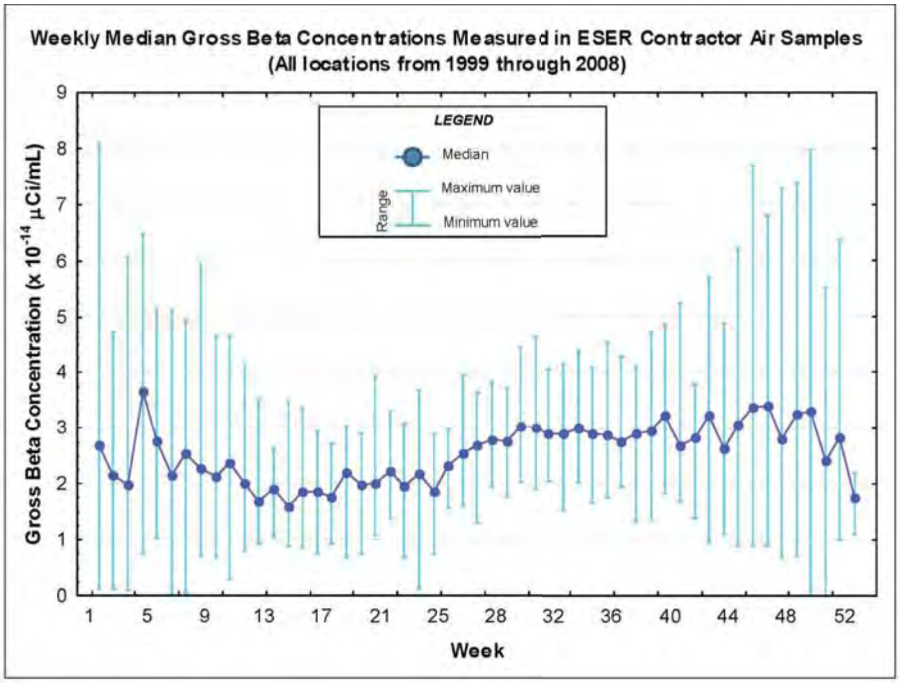
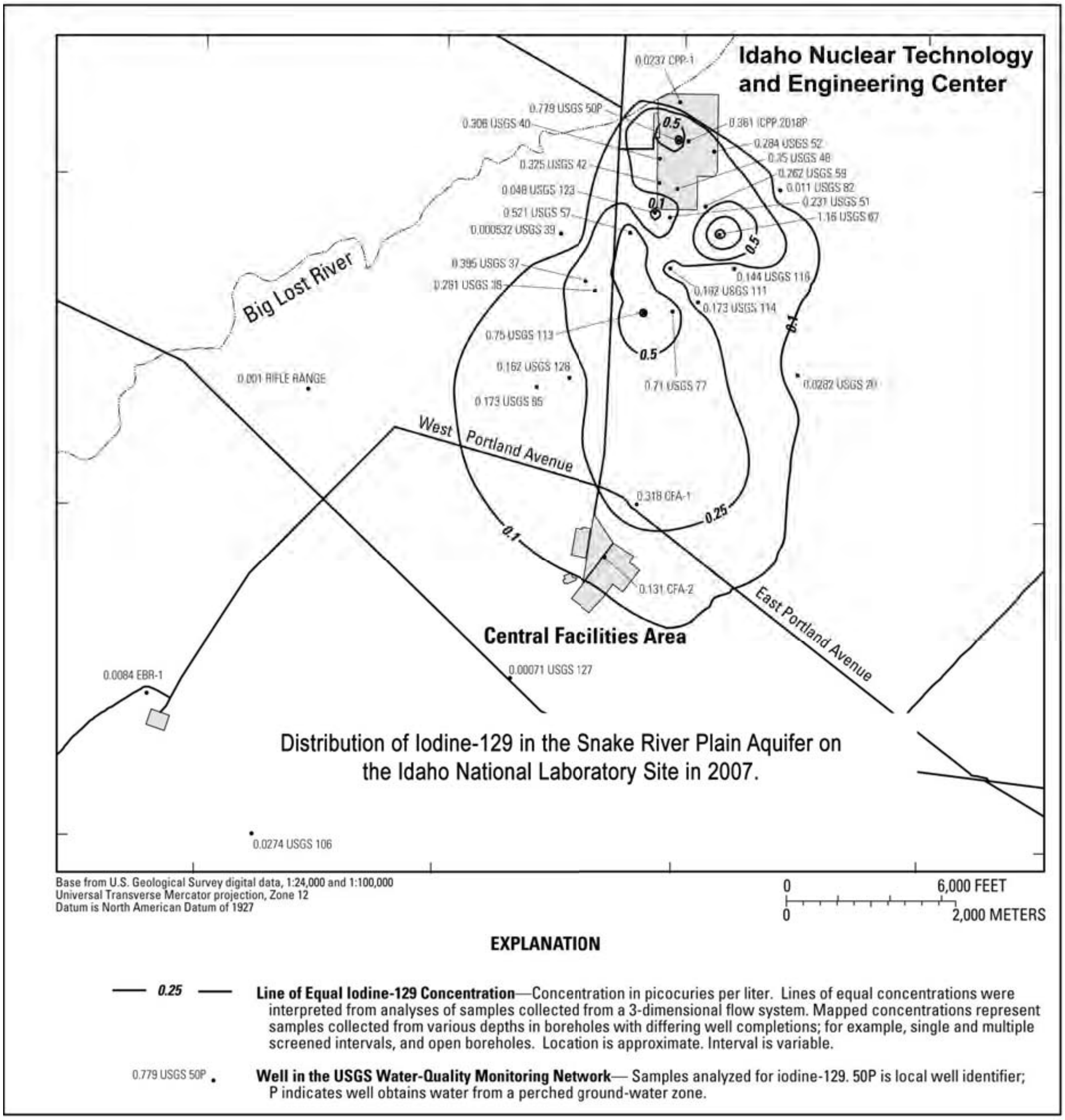


Figure HI-5. Data Plotted Using a Linear Plot.



Distribution of Iodine-129 in the Snake River Plain Aquifer on the Idaho National Laboratory Site in 2007.

Base from U.S. Geological Survey digital data, 1:24,000 and 1:100,000
Universal Transverse Mercator projection, Zone 12
Datum is North American Datum of 1927

EXPLANATION

Line of Equal Iodine-129 Concentration—Concentration in picocuries per liter. Lines of equal concentrations were interpreted from analyses of samples collected from a 3-dimensional flow system. Mapped concentrations represent samples collected from various depths in boreholes with differing well completions; for example, single and multiple screened intervals, and open boreholes. Location is approximate. Interval is variable.

Well in the USGS Water-Quality Monitoring Network— Samples analyzed for iodine-129. 50P is local well identifier; P indicates well obtains water from a perched ground-water zone.

Figure HI-6. Data Plotted Using Contour Lines. Each contour line drawn on this map connects points of equal Iodine-129 concentration in water samples collected at the same depth from wells on the INL Site.

areas that have concentrations above the contour line value from those that have concentrations below that value. The figure shows the highest concentration gradient near INTEC and the lowest farther away. It reflects the movement of the radionuclide in groundwater from INTEC where it was injected into the aquifer in the past.

Scarab beetle

How are Results Interpreted?

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

1. 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).

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.

3. Comparison with regulatory standards. Regulations or guidance have been established to protect members of the public from radiation at U.S. Department of Energy (DOE) facilities. Results are compared with acceptable levels of radioactivity in the environment and dose limits set by DOE (DOE Order 231.1A; DOE Order 450.1A; DOE Order 5400.5) and other regulatory agencies, such as the Environmental Protection Agency. The radiation limits established by these standards are considered very conservative and well below levels that could actually cause harm.

4. 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?

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 which appeared at the time of the formation of the earth (called primordial radionuclides). Radiation that has resulted from the activities of modern man is primarily fallout from past atmospheric testing of nuclear weapons. One of the challenges to environmental monitoring on and around the INL Site is to distinguish between what may have been released from the INL Site and what is already present in background from natural and fallout sources. These sources are discussed in more detail below.

Natural Sources. Natural radiation and radioactivity in the environment, that is background, represent a major source of human radiation exposure (NCRP1987). 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 is estimated to receive an average dose of about 355 mrem/yr from natural sources of radiation on earth (Figure HI-7). These sources include cosmic radiation and naturally occurring radionuclides.

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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 to produce a dose of about 48 mrem/yr to an 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 dose that might be received by a person living in southeast Idaho. Tritium and ^{7}Be are routinely detected in environmental samples collected by environmental monitoring programs on and around the INL Site (Table HI-5).

Primordial radionuclides are those that were present when the earth was formed. The primordial radionuclides detected today are at least billions of years old. 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. The radiation dose

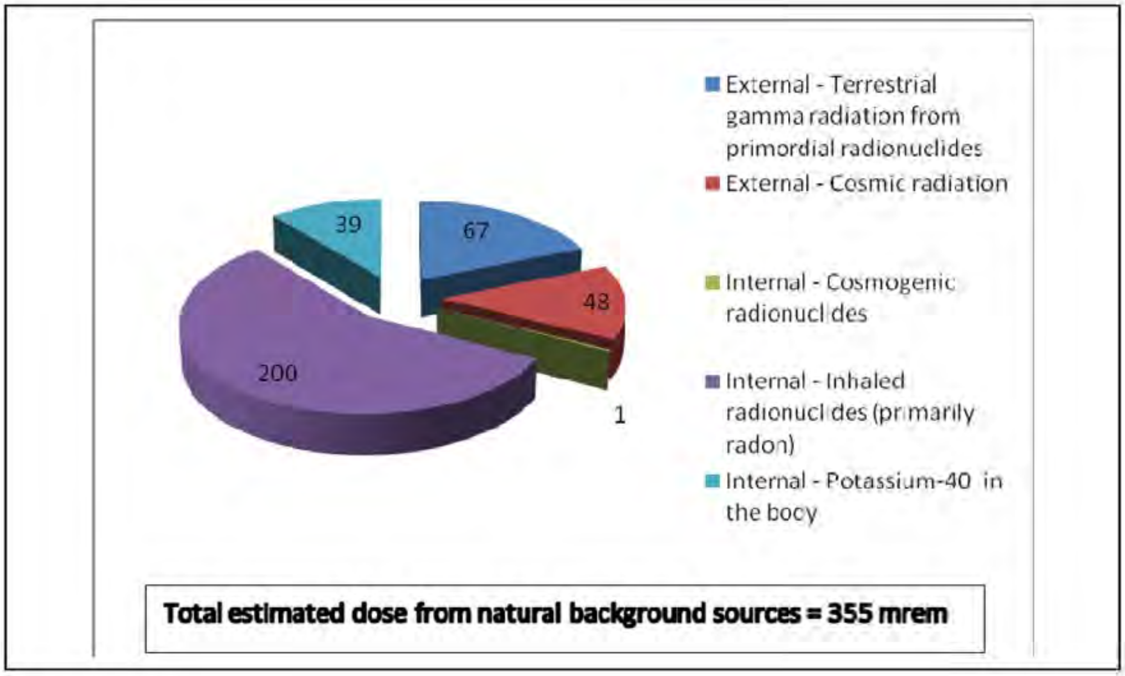


Figure HI-7. Calculated Doses (mrem per year) from Natural Background Sources for an Average Individual Living in Southeast Idaho.

Scarab beetle

to a person from primordial radionuclides comes from internally deposited radioactivity, inhaled radioactivity, and external radioactivity in soils and building materials.

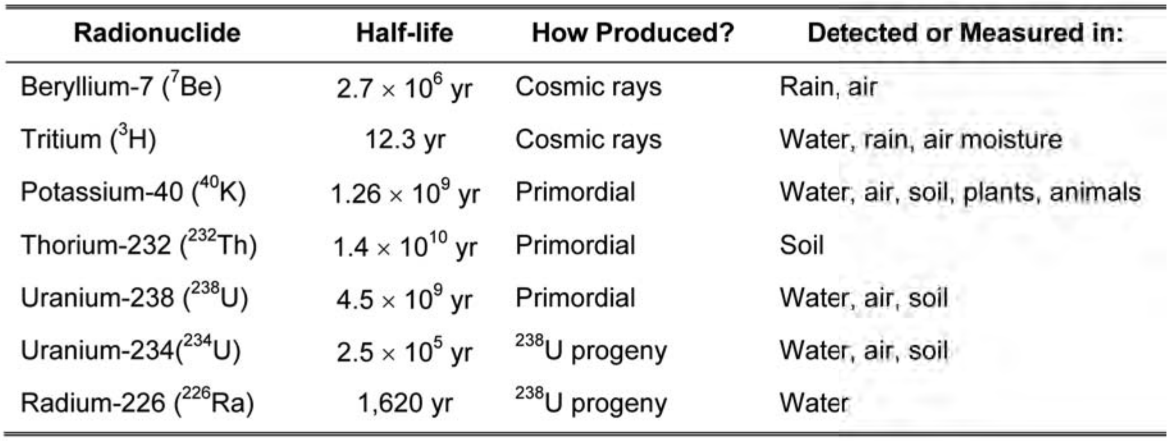
Potassium-40 is abundant and measured in living and nonliving matter (Table HI-5.) It is found in human tissue and is a significant source of internal dose (approximately 39 mrem/yr) to the human body (Figure HI-7.)

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 the “progeny” radionuclide. This system repeats, involving several different types of radioactivity. The parent radionuclide of the uranium series 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) 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.)

Primordial radionuclides and their progeny present in soil and rock produce penetrating gamma rays that result in external exposure at the earth’s surface. External radiation exposure levels from natural radionuclides in the terrestrial environment vary greatly geographically. Relatively high exposure rates are measured at locations such as Denver, Colorado, which borders the Colorado Front Range and contains high levels of uranium and thorium. A dose of 67 mrem/yr has been estimated for southeast Idaho, based on average measurements of ^{40}K, ^{238}U, and ^{232}Th in soil sampled on and around the INL Site (Figure HI-7.)

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

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

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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. There is no firm basis for setting a “safe” level of exposure above background. 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 life time, 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 dose to a member of the public from all sources and pathways to 100 mrem and dose from the air pathway only to 10 mrem (DOE Order 5400.5). Although this is a practical and convenient number to use to make calculations, it is unlikely in real life. The doses estimated to maximally exposed individuals from INL Site releases are typically well below one mrem per year.

For more information on radiation, go to Idaho State University's *The Radiation Information Network*, http://www.physics.isu.edu/radinf/.

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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
IWTU	Integrated Waste Treatment Unit
LDRD	Laboratory Directed Research and Development

Bristly Cutworm Moth

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

Bristly Cutworm Moth

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

Pronghorn Fawn

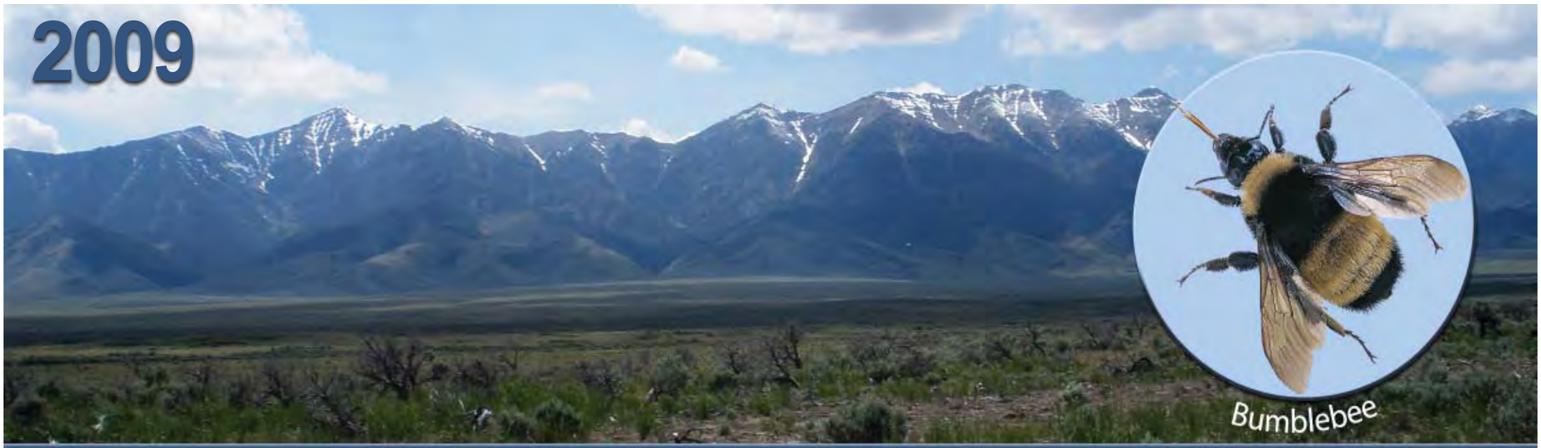
(Antilocapra americana)

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		

Greater Sage-Grouse
(Centrocercus urophasianus)

2009



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 INL 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

Scarab beetle

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.

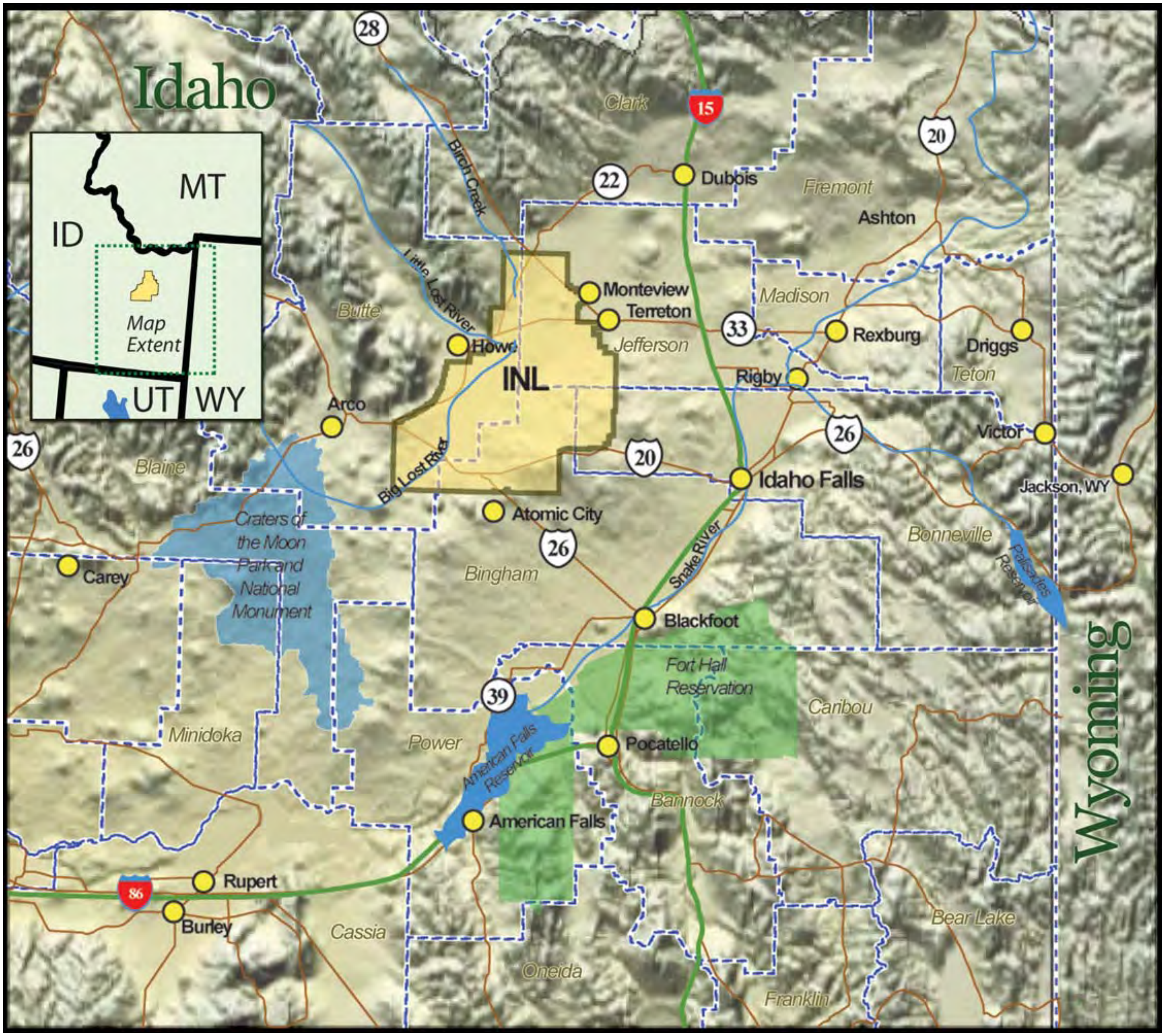


Figure 1-1. Location of the Idaho National Laboratory Site.

Bristly Cutworm Moth

1.2 Environmental Setting

The INL Site is located in a large, relatively undisturbed expanse of sagebrush steppe habitat. 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 (less than 22.8 cm/yr [9 in./yr]), warm summers (average daily temperature of 15.7°C [60.3°F]), and cold winters (average daily temperature of -5.2°C [22.6°F]) (DOE-ID 1989). 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. 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 flowering plants 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 fish, one amphibian, nine reptile, 164 bird, and 39 mammal species (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 267 km (165 mi) from St. Anthony to Bliss, Idaho, 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.

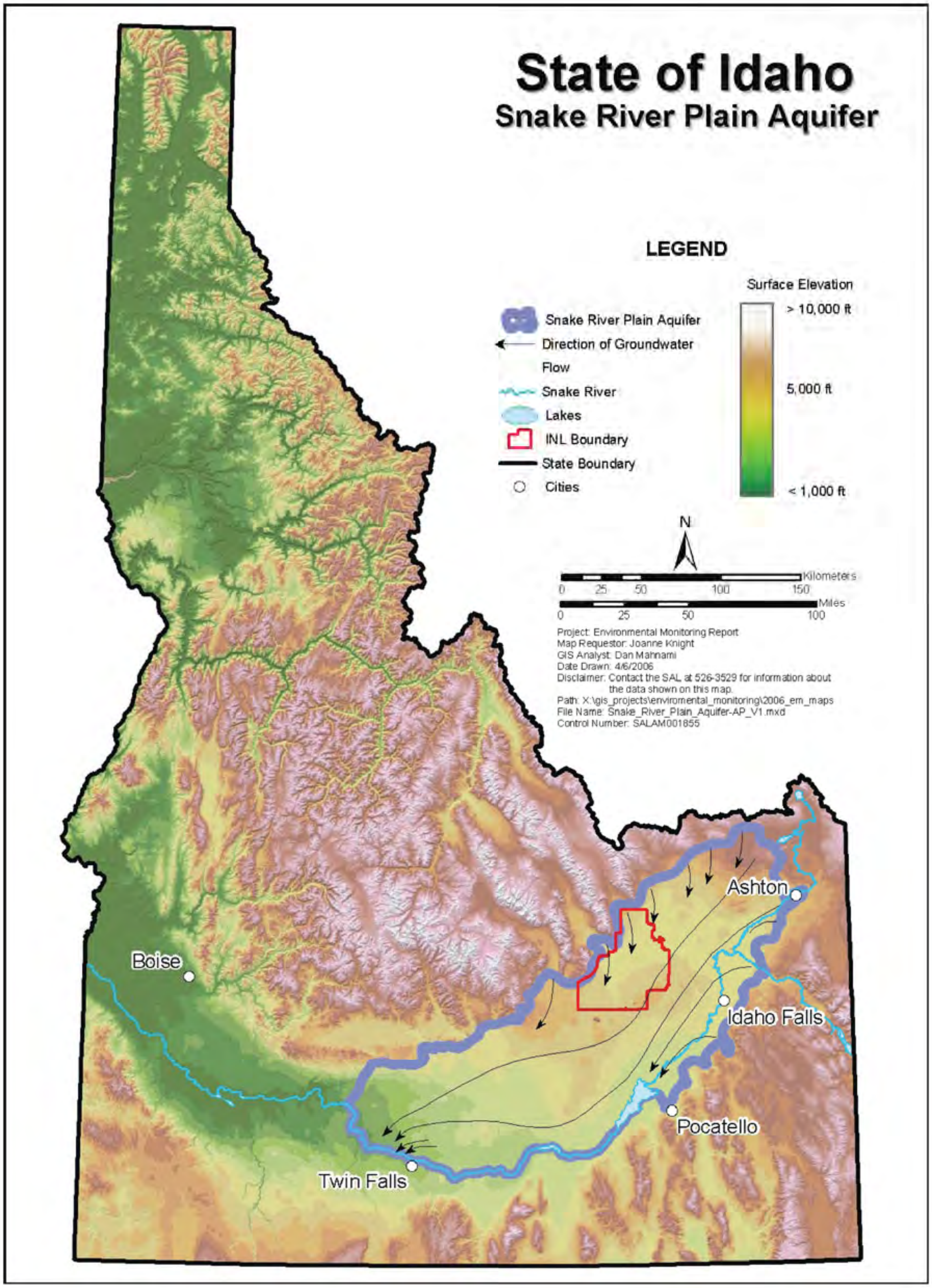


Figure 1-2. Idaho National Laboratory Site in Relation to the Eastern Snake River Plain.

Bristly Cutworm Moth

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 preeminent 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.

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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 25,000 m^3 (32,699 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

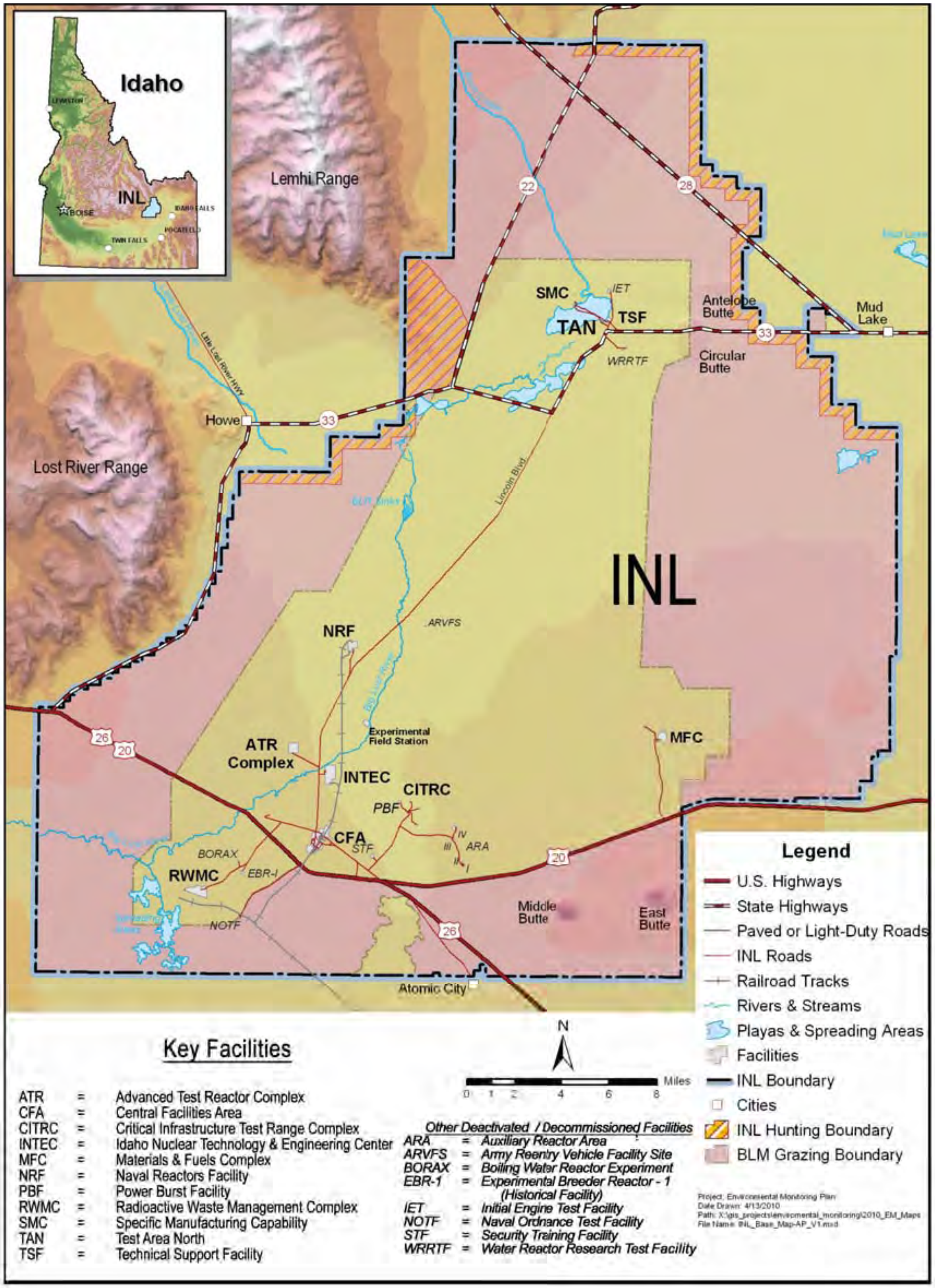

Figure 1-3. Location of the Idaho National Laboratory Site, Showing Facilities.

Scarab beetle

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 2010).

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

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 m^3 (8,159 yd^3) 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 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. ATR Complex also features the Advanced Test Reactor – Critical Facility, Hot Cell 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

Scarab beetle

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).

Bristly Cutworm Moth

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.

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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 24,000 live in the Rexburg census division. Approximately 14,000 reside in each of the Rigby and Blackfoot census divisions. 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 2006, 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. 2006). The Impacts 2006 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 2006 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 2006 include:

- The INL Site, when considered as a whole, is the third-largest employer in Idaho, with 8,452 employees, ranking behind only Micron and state government. (Recent downsizing by Micron has significantly reduced its Idaho workforce, however, and the company may no longer be Idaho's largest private employer.) When secondary and tertiary impacts on employment are analyzed, INL operations annually account for 19,860 jobs in Idaho.
- Wages and salaries to INL Site employees account for more than 2.5 percent of personal income in Idaho, with direct and secondary effects on personal income amounting to $1.108 billion annually.
- Fiscal impacts of Idaho state tax revenues by INL and its employees approach $85 million or nearly 3 percent of all tax revenues received by the state.
- These direct tax payments to the state of Idaho by INL employers and their workers exceed the cost of state-provided services by a broad margin.
- Annual property tax payments by INL employees approach $23 million.
- INL provides $3.4 million to Idaho colleges and universities for continuing education of its employees.

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The research for Impacts 2006 (which is currently being updated) 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. 2006).

In their summary comments, the researchers conclude, “Whether improving quality of life through the development and commercialization of cutting-edge technologies, reducing risks through accelerated environmental cleanup, providing much-needed tax revenues or stabilizing and strengthening Idaho’s economy by its mere presence, INL’s overall impacts on Idaho are unquestionably significant.”

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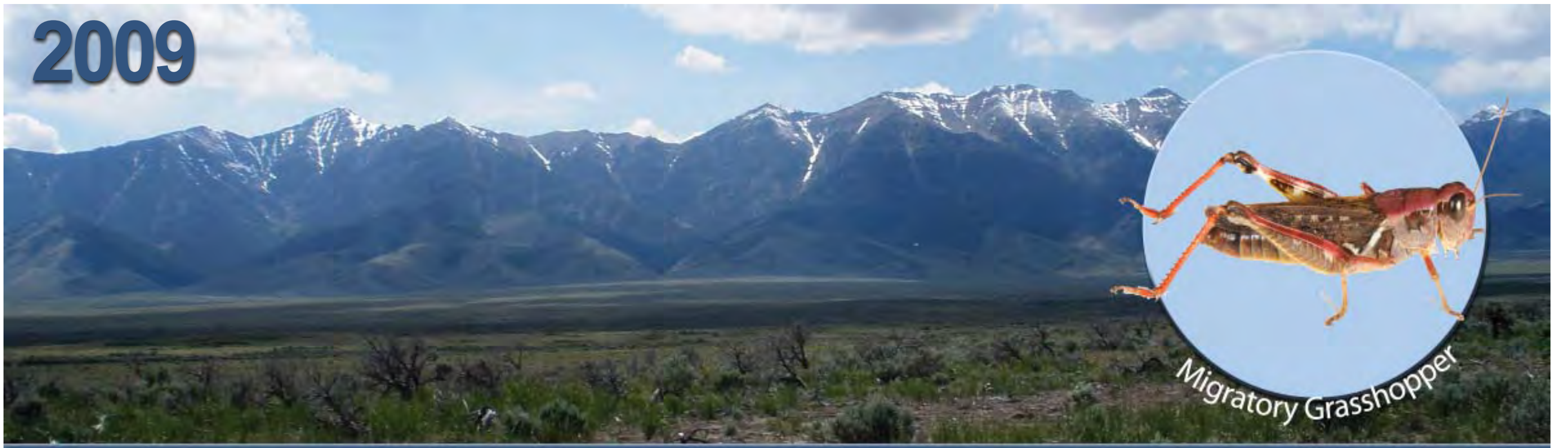

Chapter 2. Environmental Compliance Summary

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 nonpermitted hazardous materials to the environment must be documented. Overall, the INL Site met all its regulatory commitments in 2009, and programs are in place to address areas for continued improvement.

The *National Emission Standards for Hazardous Air Pollutants-Calendar Year 2009 INL Report for Radionuclides* report was submitted to U.S. Environmental Protection Agency, DOE Headquarters, and state of Idaho officials in June 2010, 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 *Annual National Environmental Policy Act (NEPA) Planning Summary* was issued, which informs the public of the status of ongoing and planned NEPA compliance activities.

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 *2008 Idaho Hazardous Waste Generator Annual Report* was submitted to the state of Idaho, which is authorized by Environmental Protection Agency to regulate hazardous waste under the Resource Conservation and Recovery Act. The state of Idaho approved closure plans for four facilities in 2009. The State also conducted a hazardous waste compliance inspection of the INL Site and noted no violations.

In 2009, 20 INL Site projects were screened for potential impacts to archeological resources. In addition, 36 of INL Site’s historic archeological sites were revisited and one lava tube cave was revisited and re-evaluated.

There are 53 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.

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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 nonmandatory 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 report; the latest report, *National Emission Standards for Hazardous Air Pollutants – Calendar Year 2009 INL Report for Radionuclides* (DOE-ID 2010), was submitted to EPA, DOE Headquarters, and state of Idaho officials. 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 tons or more of one hazardous air pollutant or 25 tons or more per year of any combination of hazardous air pollutants. 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

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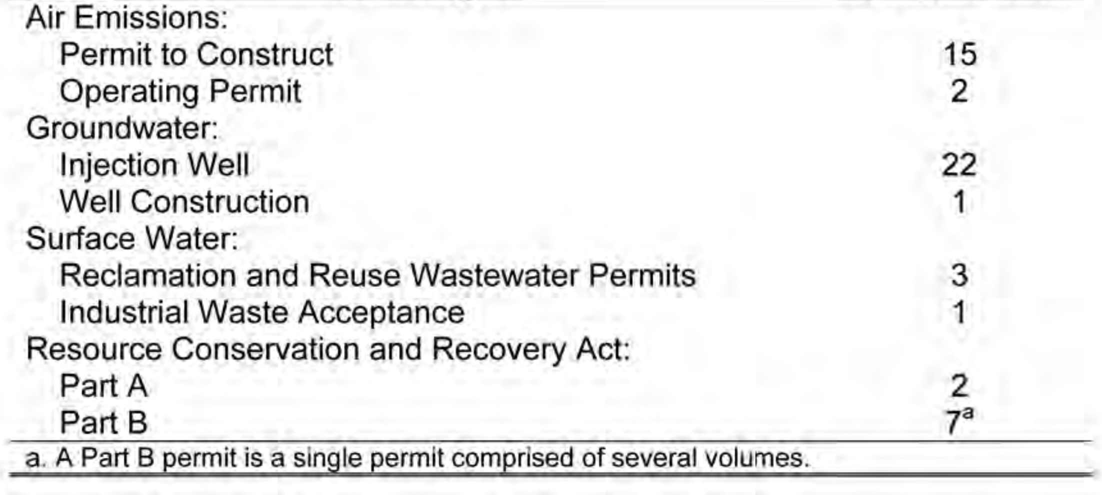
Table 2-1. Environmental Permits for the INL Site (2009).



Permit Type	Active Permits
Air Emissions:	
Permit to Construct	15
Operating Permit	2
Groundwater:	
Injection Well	22
Well Construction	1
Surface Water:	
Reclamation and Reuse Wastewater Permits	3
Industrial Waste 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.

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 caculations for INL Site releases for 2009.

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) 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

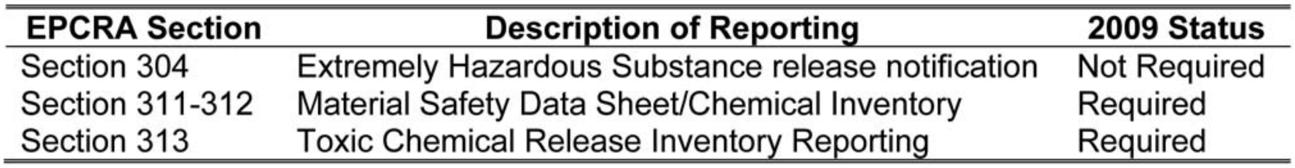
The purpose of DOE Order 450.1A, “Environmental Protection Program” is to implement sound stewardship practices that protect the air, water, land, and other natural and cultural resources affected by DOE operations, and to cost effectively meet or exceed applicable environmental, public health, and resource 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

Table 2-2. INL Site EPCRA Reporting Status (2009).



EPCRA Section	Description of Reporting	2009 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

authorities (i.e., state emergency response commissions and local emergency planning committees). No CERCLA-reportable chemicals were released at the INL Site during 2009.

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 exceeded regulatory thresholds.

Section 313 – Section 313 requires facilities to submit a Toxic Chemical Release Inventory Form annually for each of the more than 600 Toxic Release Inventory chemicals that are manufactured, processed, or otherwise used above applicable threshold quantities. Releases under EPCRA 313 reporting include transfers to waste treatment and disposal facilities off the INL Site, air emissions, recycling, and other activities. The INL Site submitted Toxic Chemical Release Inventory Forms for benzene, chromium, lead, naphthalene, and nickel 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 Complex was determined to be reportable to external agencies in 2009. A mechanical malfunction on a semi-tractor hydraulic line pump resulted in a release of approximately 19 L (5 gal) of hydraulic fluid to soil and gravel. The release occurred outside the perimeter fence east of the entrance gate. The spill-contaminated soil and gravel were removed and properly disposed on the INL Site. Although no reportable quantity limits were exceeded, the release was determined to be reportable because it could not be cleaned up within 24 hours.

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 January 28, 2009. The summary is a requirement of DOE Order 451.1B, and it 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 (EISs) 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 – The Idaho High-Level Waste and Facilities Disposition Environmental Impact Statement (DOE 2002) describes the potential environmental impacts of various alternatives for treating and managing high-level radioactive waste and related radioactive wastes and facilities at the Idaho Nuclear Technology and Engineering Center (INTEC). DOE received and considered agency and public comments on a draft EIS. In response to those comments and updated information, DOE incorporated changes into the final EIS, which was issued in the fall of 2002.

DOE planned for a phased decision-making process. In December 2005, DOE issued a record of decision for the Idaho High-Level Waste and Facilities Disposition Environmental Impact Statement (HLW & FD EIS) (DOE 2005). DOE decided to:

- Treat sodium-bearing liquid waste using the steam reforming technology
- Conduct performance-based closure on all existing facilities directly related to the High-Level Waste Program at INTEC, except for the INTEC Tank Farm Facility and bin sets, once their missions are complete
- Design and construct new waste processing facilities needed to implement the decisions in the record of decision consistent with clean closure methods and planned to be clean-closed when their missions are complete
- Develop high-level waste calcine retrieval demonstration process and conduct risk-based analysis, including disposal options, focused on the calcine stored at INTEC.

An amended record of decision (71 FR 228) addressing closure of the INTEC Tank Farm Facility was issued in November 2006 in coordination with the Secretary of Energy’s determination and in consultation with the Nuclear Regulatory Commission. Under Section 3116 of the Fiscal Year 2005 Ronald W. Reagan National Defense Authorization Act, DOE signed a second amended record of decision (75 FR 7) for the treatment of high-level waste calcine. The Department decided to deploy hot isostatic pressing to cost-effectively treat the calcine waste.

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The Environmental Assessment for the Idaho National Laboratory Remote-Handled Waste Disposition (formerly known as the Remote Treatment Project), proposes to provide heavily shielded handling services for the sodium-contaminated remote-handled (RH) waste stored at the Materials and Fuels Complex, other INL Site legacy RH waste, and, potentially, a limited quantity of sodium-contaminated RH waste from the Hanford Site. The project would provide shielded facilities with equipment for sorting, characterizing, treating, and repackaging highly radioactive transuranic, mixed, and other radioactive waste. The mission of the project is to make RH radioactive wastes ready for shipment to disposal locations. Much of the proposed action was analyzed in the *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement* (DOE-ID 1995) as the Remote Mixed Waste Treatment Facility Project. DOE notified the state of Idaho and Shoshone-Bannock Tribes in January 2001. The draft environmental assessment was released for public comment on December 17, 2008. The public comment period ended January 19, 2009. On February 18, 2009, the DOE-ID Interim Manager signed the finding of no significant impact for the project.

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 and Idaho Fish and Game Department.

On April 2, 2009, the U.S. Fish and Wildlife Service published a decision to delist the Northern Rocky Mountain gray wolf distinct population segment. The Northern Rocky Mountain gray wolf distinct population segment included wolves in Idaho. Effective May 4, 2009, wolves in Idaho were removed from the federal list of threatened and endangered species.

Sage-grouse and pygmy rabbits are resident INL Site species. The U.S. Fish and Wildlife Service is performing a status review of the Greater sage-grouse to determine if the species should be protected under the Endangered Species Act throughout its range or any significant

portion of its range. The Service is also performing a status review of the pygmy rabbit to determine whether to propose adding the species to the federal list of endangered and threatened wildlife.

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.

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 2009, one Barn Swallow nest containing two hatchlings was removed from a structure in conjunction with the demolition of the Waste Experimental Reduction Facility. The hatchlings were taken to a licensed rehabilitator for rearing.

Table 2-3. 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.
Pygmy rabbit (*Brachylagus idahoensis*)	Proposed for listing	Many colonies present on INL Site.

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Barn Swallow Nest Destruction – In July 2009, the ICP contractor notified DOE-ID that a swallow nest with young attached to a building at INTEC had been intentionally destroyed. DOE-ID notified the U.S. Fish and Wildlife Service (USFWS). A USFWS special agent investigated the incident but could not identify the person or persons who destroyed the nest. USFWS determined that the incident was not consistent with the contractor’s approach to complying with the Migratory Bird Treaty Act and was an isolated act.

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 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 nonregulated sites with ecological, environmental, and future development significance. In 2009, no actions took place or impacted potentially jurisdictional wetlands on the INL Site, and no future actions are planned that would impact wetlands. However, private parties do conduct cattle grazing in the Big Lost River Sinks area under Bureau of Land Management permits.

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

Executive Order (EO) 13514, "Federal Leadership in Environmental, Energy, and Economic Performance," was signed by President Obama on October 5, 2009 (Figure 2-1). This EO does not rescind or eliminate the requirements of EO 13423. Instead, it expands on the energy reduction and environmental performance requirements for federal agencies identified in EO 13423.

The goal of EO 13514 is "to establish an integrated strategy towards sustainability in the Federal Government and to make reduction of greenhouse gas emissions (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 EO:

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).

- By 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, is due to the CEQ Chair and OMB Director
- On June 2, 2010, Scope 3 targets and the Strategic Sustainability Performance Plan are due to the CEQ Chair and the OMB Director
- On January 5, 2011, the comprehensive GHG inventory is due from each of the agencies to the CEQ Chair and OMB Director.

In addition to guidance, recommendations, and plans that are due by specific dates, EO 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, EO 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 appropriations and budgeted funds
- 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* (DOE-ID 2008) to DOE Headquarters in December 2009. This plan contains strategies and activities that will lead to continual energy efficiency, environmental improvements, and transportation fuels efficiency to facilitate the INL Site to meet 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 $13.5 M in 2009 for facility and equipment energy. Of this total, $12.9 M was spent for building energy, and $600 K was spent on equipment fuel. The managed area consumes over 1.05 trillion Btu of energy and over 915 million L of water annually. Energy consumption at the INL Site for 2009 on a Btu/ft^2 basis has been reduced by 10.7 percent, weather adjusted, when compared to the base year of 2003.

Transportation fuel use across the INL Site totaled over 1,119,036 gallons of various types of fuels for 2009. The INL Site fleet is comprised of light duty vehicles fueled by gasoline, E85,

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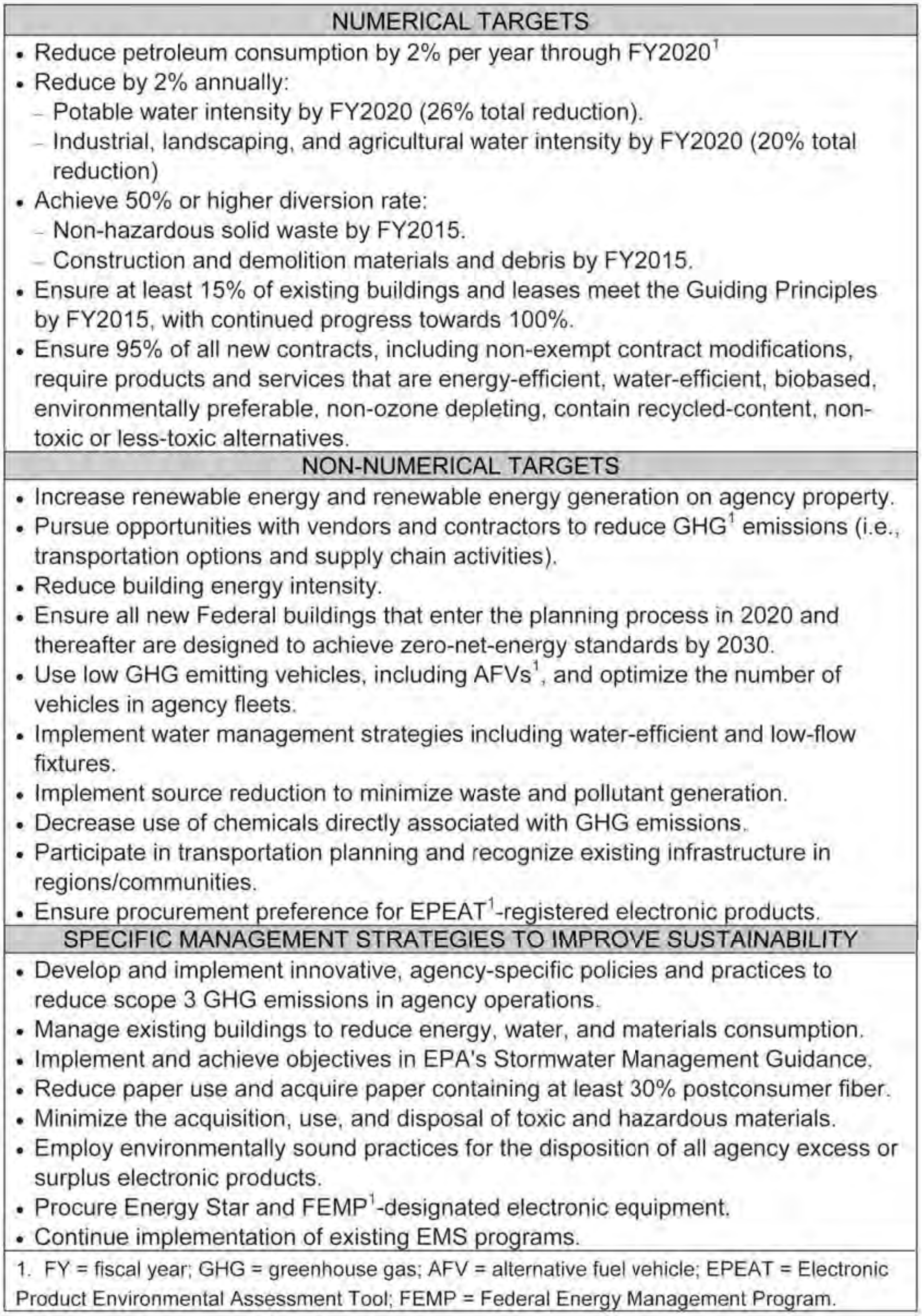
Table 2-4. Executive Order 13514 Targets and Management Strategies for Federal Agencies (2009).



NUMERICAL TARGETS

- Reduce petroleum consumption by 2% per year through FY2020[1]
- Reduce by 2% annually:
  - Potable water intensity by FY2020 (26% total reduction).
  - Industrial, landscaping, and agricultural water intensity by FY2020 (20% total reduction)
- Achieve 50% or higher diversion rate:
  - Non-hazardous solid waste by FY2015.
  - Construction and demolition materials and debris by FY2015.
- Ensure at least 15% of existing buildings and leases meet the Guiding Principles by FY2015, with continued progress towards 100%.
- Ensure 95% 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.

NON-NUMERICAL TARGETS

- Increase renewable energy and renewable energy generation on agency property.
- Pursue opportunities with vendors and contractors to reduce GHG[1] 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[1], 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[1]-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% 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[1]-designated electronic equipment.
- Continue implementation of existing EMS programs.

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

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.

2.3 Waste Management

2.3.1 Resource Conservation and Recovery Act

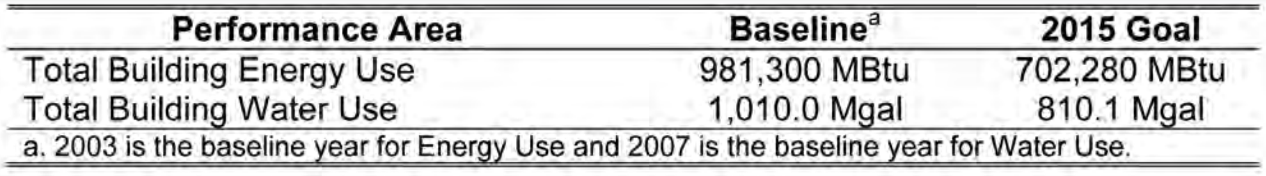
The Resource Conservation and Recovery Act (RCRA) established regulatory standards for generation, transportation, storage, treatment, and disposal of hazardous waste. The Idaho Department of Environmental Quality (DEQ) is authorized by EPA to regulate hazardous waste and the hazardous components of 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 *2008 Idaho Hazardous Waste Generator Annual Report* (INL 2009a). 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 2009:

- INTEC CPP-602 Laboratory Lines
- INTEC Tank Farm Facility-Phase V for Tanks VES-WM-187, VES-WM-188, VES-WM-189, and VES-WM-190 and remaining RCRA Tank Farm Facility piping

Table 2-5. Estimated Future Energy and Water Use Reduction for the INL Site (2009).



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.

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- VCO-5.8.d Courtyard Component
- INTEC CPP-601 Deep Tanks System Landfill.

RCRA Inspection – On June 1-5, 2009, DEQ conducted an annual RCRA inspection of the INL Site. On July 16, 2009 DEQ, sent a letter to DOE and the INL Site contractors stating that no violations were noted during this inspection.

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 2009 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 7,210 m^3 (9,430 yd^3). In calendar year 2009, 5,384 m^3 (7,042 yd^3) of transuranic waste was shipped out of Idaho. This amount included 7 m^3 (9 yd^3) of remote-handled transuranic waste.

The INL Site received three truck cask shipments containing a combined total of 0.0494 metric tons heavy metal (109 lb) of spent nuclear fuel. This included spent nuclear fuel from the University of Wisconsin (one shipment), Oregon State University (one shipment), and Washington State University (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 2009 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

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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.

It is anticipated that DEQ will issue a Wastewater Reuse Permit for the Materials and Fuels Complex Industrial Waste Pond in spring of 2010.

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 2006 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).

No measureable thickness of petroleum product was observed in any of the monitoring wells except Well ICPP-2018. 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 October 2009. Toluene was detected at lower concentrations in aquifer wells directly adjacent to Well ICPP 2018. Thus, toluene continues to be a detectable constituent in perched water and aquifer groundwater near Well ICPP-2018. During the October 2009 sampling event, two polycyclic aromatic hydrocarbons (PAH) compounds were detected in groundwater samples from Well ICPP-2018 at very low concentrations. Chrysene was reported at 0.33 µg/L (0.33 ppb) and benzo(a)pyrene was reported at 0.072 µg/L (0.072 ppb). Samples collected from the other perched wells reported no detectable PAH compounds, and none of the samples collected from the aquifer wells reported any detectable PAH compounds. Monitoring of petroleum products will continue in accordance with the Corrective Action/Monitoring Plan.

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 Resource 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 Program. In nearly half of the 37 project reviews, archival information indicated that no archaeological resources would be affected by the activities proposed. In 2009, 20 INL Site projects were screened for potential impacts to archaeological resources. In many of these cases, archival information indicated that no archaeological resources would be affected by the activities proposed. In three cases, feedback was provided on archaeological sensitivity for large scale siting studies or NEPA analyses. In 20 cases, field investigations ranging from 0.4 to 263 hectares (1 to 650 acres) were conducted on lands that had never been archaeologically surveyed or in areas where previous surveys were completed more than a decade ago. Approximately 591 hectares (1,460 acres) were intensively examined during these project surveys, and 89 new archaeological sites were identified and recommended for avoidance or other protective measures.

INL Cultural Resources Management Office survey and research efforts in 2009 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. One significant cave survey project was initiated in 2009. During this survey, one previously recorded cave was revisited and re-evaluated, nine caves were recorded for the first time, and five additional archaeological resources were identified and

Table 2-6. Cultural Resources Surveys Performed at the INL Site (2009).

National Historic Preservation Act Section	Surveys Performed
Section 106	37[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.

Scarab beetle

recorded in surveys of approximately three acres surrounding the caves. These important efforts will continue into the future. In addition, INL Cultural Resources Management staff produced two technical reports on previous years' Section 110 efforts in 2009, including *Report on Trace Element Analysis of INL Obsidian Artifacts* (INL 2009b) and *Geophysical Investigations of the Archaeological Resources at the Powell Stage Station* (INL 2009c).

INL staff traveled to the Idaho State Archive in Boise in 2009. Through days of research, they were able to identify approximately 50 INL Site homesteaders from the late 1800s and early 1900s. These data were used to put names to previously recorded archaeological homestead sites; thus, opening the door to further research on immigration patterns to and from southeastern Idaho.

Cultural Resources Monitoring – The INL Cultural Resources Management Office implements a yearly program of cultural resource monitoring that includes many archaeological resources. In 2009, 36 archaeological localities were revisited, including two locations with Native American human remains (one of which is a cave), two additional caves, twenty-two prehistoric archaeological sites, six historic homesteads, two historic stage stations, and two historic trails. Also, one previously recorded lava tube cave was revisited and re-evaluated during the year. Representatives from the Shoshone-Bannock Tribes are important partners in these efforts. Results of 2009 INL cultural resource monitoring are documented in *Idaho National Laboratory Cultural Resource Monitoring Report for FY2009* (INL 2009d).

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.

In 2009, several sites of tribal sensitivity were monitored, with tribal participation. Sites included caves, buttes, craters, and locations of known remains. In 2009, three trespassers (two adults and one minor) were apprehended by INL Site security officers during an unauthorized visit to an INL Site cave. Formal charges were pressed by DOE-ID in Bingham County, and the two adults were cited with misdemeanor trespassing violations, assessed fines of $187.50 each, and one individual was sentenced to one year in jail (suspended). Fortunately, the cave and its

sensitive tribal interests, rock art, and archaeological deposits sustained no damage as a result of this unauthorized visit.

To curtail a recurring pattern of unauthorized visitation to INL Site caves by the public as well as INL employees, INL staff took steps in 2009 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. To initiate a dialog in 2009, two special agents with the Department of the Interior U. S. Fish and Wildlife Service Division of Law Enforcement and a DOE-ID security specialist were escorted to several key archaeological sites on the INL Site that are particularly sensitive and that are occasionally or regularly visited by site employees or the public or both.

2.6 Summary of Environmental Permits

Table 2-1 summarizes active permits for the INL Site through year-end 2009 that were issued for sitewide or individual facility operations or both that have been referenced in previous sections of this chapter.

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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.

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Scarab beetle

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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.

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

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

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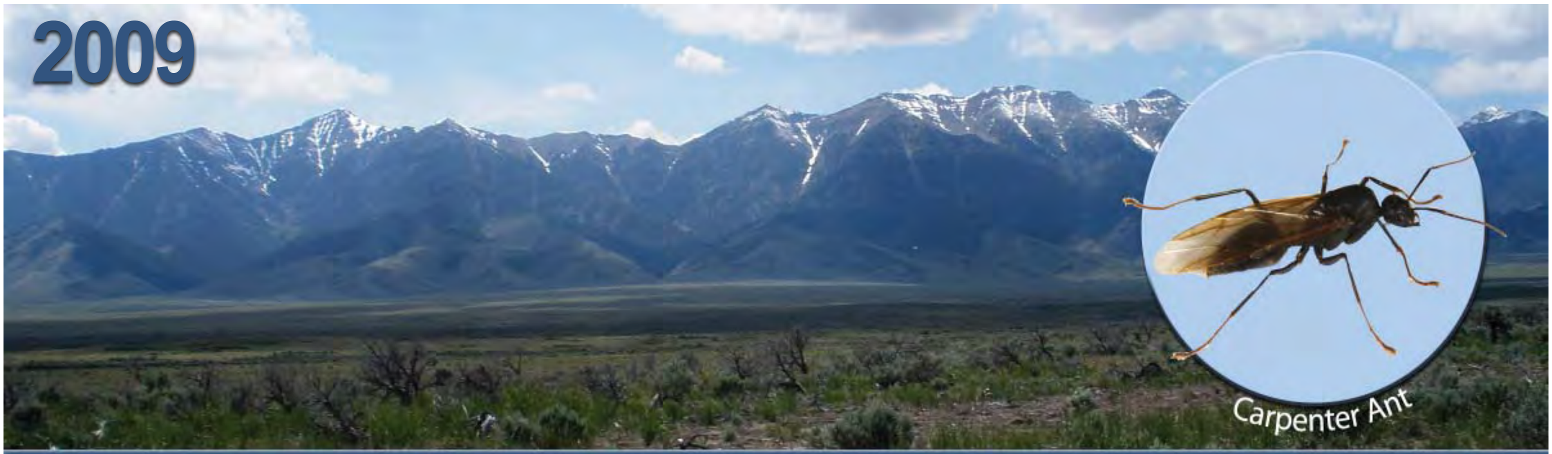
INL, 2009c, *Geophysical Investigations of the Archaeological Resources at the Powell Stage Station*, INL/CON-09-15269, Idaho National Laboratory.

INL 2009d, *Idaho National Laboratory Cultural Resource Monitoring Report for FY2009*, INL/EXT-09-17202, Idaho National Laboratory.

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.

Rock Formation at the INL Site



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 2009 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.

Significant progress continues on INL Site cleanup activities. Among the 2009 accomplishments are:

- Three Site Treatment Plan milestones involving the backlog of mixed waste were completed on schedule
- 5,384 m^3 (7,042 yd^3) of treated transuranic waste were sent from the Advanced Mixed Waste Treatment Project to the Waste Isolation Pilot Plant in Carlsbad, New Mexico for disposal
- 4,042 m^3 (5,287 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
- Approximately 6,029 m^3 (7,836 yd^3) of legacy mixed waste, 216.7 m^3 (281.7 yd^3) of mixed low-level waste, and 5,812 m^3 (7,556 yd^3) of mixed contact-handled transuranic waste, were received from off-INL-Site locations and treated or processed at the INL Site
- More than 721 m^3 (943 yd^3) of mixed low-level waste and 1,664 m^3 (2,176 yd^3) of low-level waste were shipped off the INL Site from the Radioactive Waste Management Complex for treatment and/or disposal.

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 ISO 14001 reregistration audits without any nonconformances and a third contractor was audited by a qualified auditor who concluded that there were no major nonconformances.

In 2009, the Pollution Prevention Program successfully accomplished the goals of the INL Site Pollution Prevention Plan through projects such as pollution prevention opportunity assessments.

Scarab beetle

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 are protective of human health and the environment and in compliance 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.

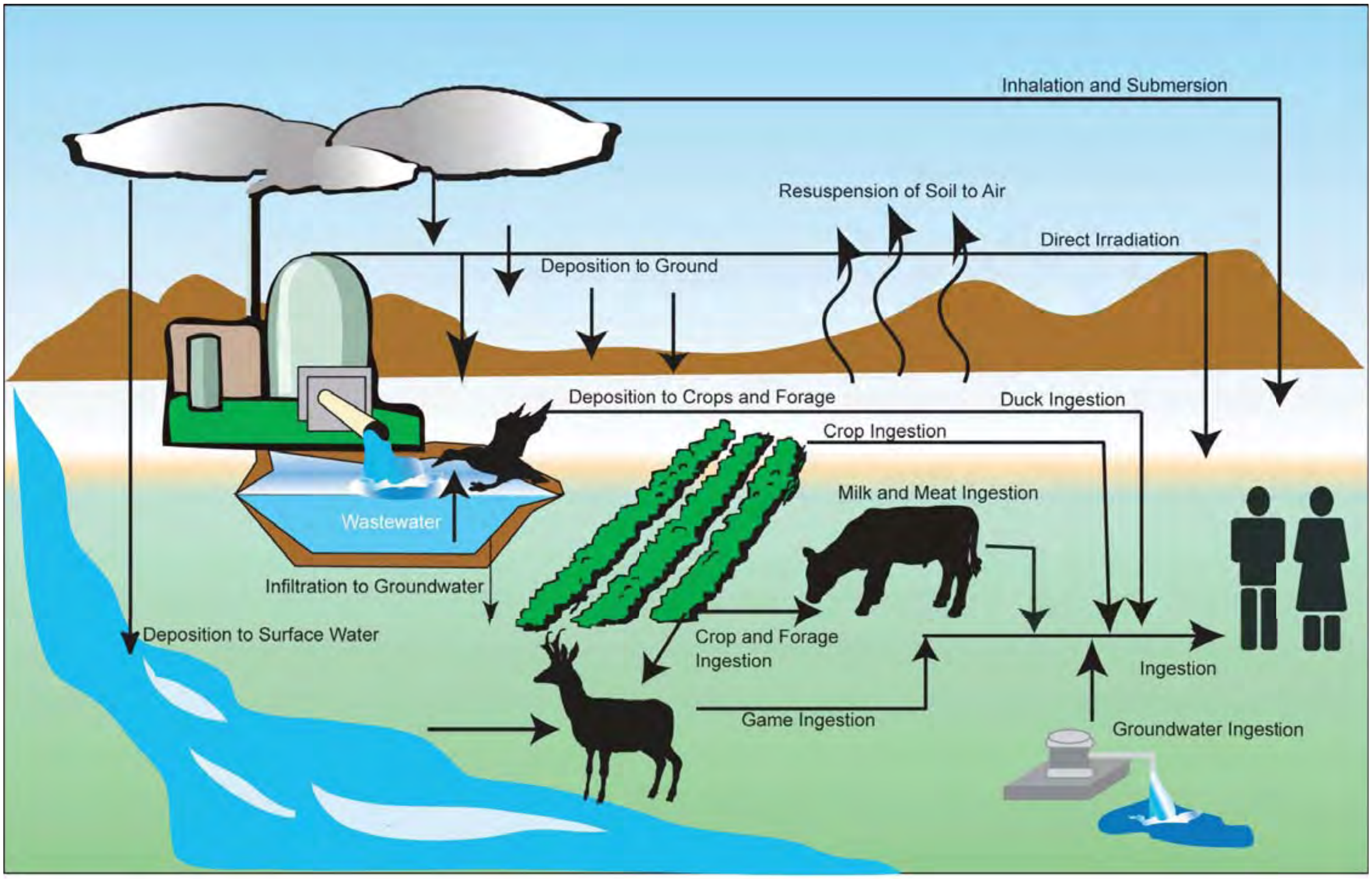


Figure 3-1. Potential Exposure Pathways to Humans from the Idaho National Laboratory Site.

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 2009. In addition to the monitoring constituents listed in Table 3-6, the USGS collects samples twice a year from 13 wells in cooperation with the Naval Reactors Facility and collects an expanded list of constituents from eight 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 2009 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 2008a).

Scarab beetle

Table 3-1. Environmental Surveillance, Education and Research Program Summary (2009).

		Locations and Frequency		Minimum
Medium Sampled	**Type of Analysis**	**Onsite**	**Offsite**	**Detectable Concentration**
Air (low volume)	Gross alpha	4 weekly[a]	14 weekly[a]	1×10^{-15} μCi/mL
	Gross beta	4 weekly	14 weekly	1×10^{-14} μCi/mL
	Specific gamma	4 quarterly	14 quarterly	3×10^{-16} μCi/mL
	Plutonium-238	2 quarterly	7 quarterly	2×10^{-18} μCi/mL
	Plutonium-239/240	2 quarterly	7 quarterly	2×10^{-18} μCi/mL
	Americium-241	2 quarterly	7 quarterly	2×10^{-18} μCi/mL
	Strontium-90	2 quarterly	7 quarterly	6×10^{-17} μCi/mL
	Iodine-131	4 weekly	14 weekly	2×10^{-15} μCi/mL
	Total particulates	4 quarterly	14 quarterly	10 μg/m^3
Air (high volume)[b]	Gross beta	None	1, twice per week	1×10^{-15} μCi/mL
	Gamma scan	None	If gross $\beta > 1$ pCi/m^3	1×10^{-14} μCi/mL
	Isotopic U and Pu	None	1 annually	2×10^{-18} μCi/mL
Air (atmospheric moisture)	Tritium	None	4 locations, 2 to 4 per quarter	2×10^{-13} μCi/mL (air)
Air (precipitation)	Tritium	1 weekly/ 1 monthly[c]	1 monthly	100 pCi/L
Animal tissue (big game and waterfowl)[d]	Specific gamma	Varies annually	Varies annually	5 pCi/g
	Iodine-131	Varies annually	Varies annually	3 pCi/g
Agricultural products (milk)	Cesium-137	None	1 weekly	1 pCi/L
	Iodine-131	None	1 weekly/9 monthly	3 pCi/L
	Strontium-90	None	9 annually	5 pCi/L
	Tritium	None	9 annually	300 pCi/L
Agricultural products (potatoes)	Specific gamma	None	8 – 10 annually	0.1 pCi/g
	Strontium-90	None	8 – 10 annually	0.2 pCi/g
Agricultural products (wheat)	Specific gamma	None	11 annually	0.1 pCi/g
	Strontium-90	None	11 annually	0.2 pCi/g
Agricultural products (lettuce)	Specific gamma	None	7 – 9 annually	0.1 pCi/g
	Strontium-90	None	7 – 9 annually	0.2 pCi/g
Soil	Specific gamma	None	12 biennially	0.001 pCi/g
	Plutonium-238	None	12 biennially	0.005 pCi/g
	Plutonium-239/240	None	12 biennially	0.1 pCi/g
	Americium-241	None	12 biennially	0.005 pCi/g
	Strontium-90	None	12 biennially	0.05 pCi/g
Direct radiation exposure (thermoluminescent dosimeters)	Ionizing radiation	None	17 semiannually	5 mR

a. Onsite includes three locations and a blank; off INL Site includes 13 locations and a blank.

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.

Table 3-2. Idaho National Laboratory Contractor Air and Environmental Radiation Surveillance Summary (2009).

Medium Sampled	Type of Analysis	Locations and Frequency		Detectable Concentration
		Onsite[a]	**Offsite[a]**	
Air (low volume)	Gross alpha	19 weekly[b]	4 weekly[b]	1×10^{-15} µCi/mL
	Gross beta	19 weekly[b]	4 weekly[b]	5×10^{-15} µCi/mL
	Specific gamma	19 semiannually	4 semiannually	Varies by analyte[c]
	Iodine-131	19 weekly[b]	4 weekly[b]	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[d]	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. Samples were collected at 1 cfm every other week from January 2009 through March 4, 2009, then collected at 2 cfm weekly through the remainder of 2009.

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

d. 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.

Table 3-3. Idaho National Laboratory Contractor Drinking Water Program Summary (2009).

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

Scarab beetle

Table 3-4. Idaho Cleanup Project Contractor Environmental Surveillance Program Air, Surface Water, Vegetation, and Radiation Survey Summary (2009).

Medium Sampled	Type of Analysis	Location and Frequency RWMC^{a}	 INTEC^{a}	Minimum Detectable Concentration^{b}
Air (low volume)	Gross alpha	8 bimonthly	1 bimonthly	7 x 10^{-13} μCi/mL
	Gross beta	8 bimonthly	1 bimonthly	2 x 10^{-12} μCi/mL
	Specific gamma	8 monthly	1 monthly	Varies by analyte
	Specific alpha	8 quarterly	1 quarterly	8 x 10^{-18} μCi/mL
	Strontium-90	8 quarterly	1 quarterly	1 x 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.

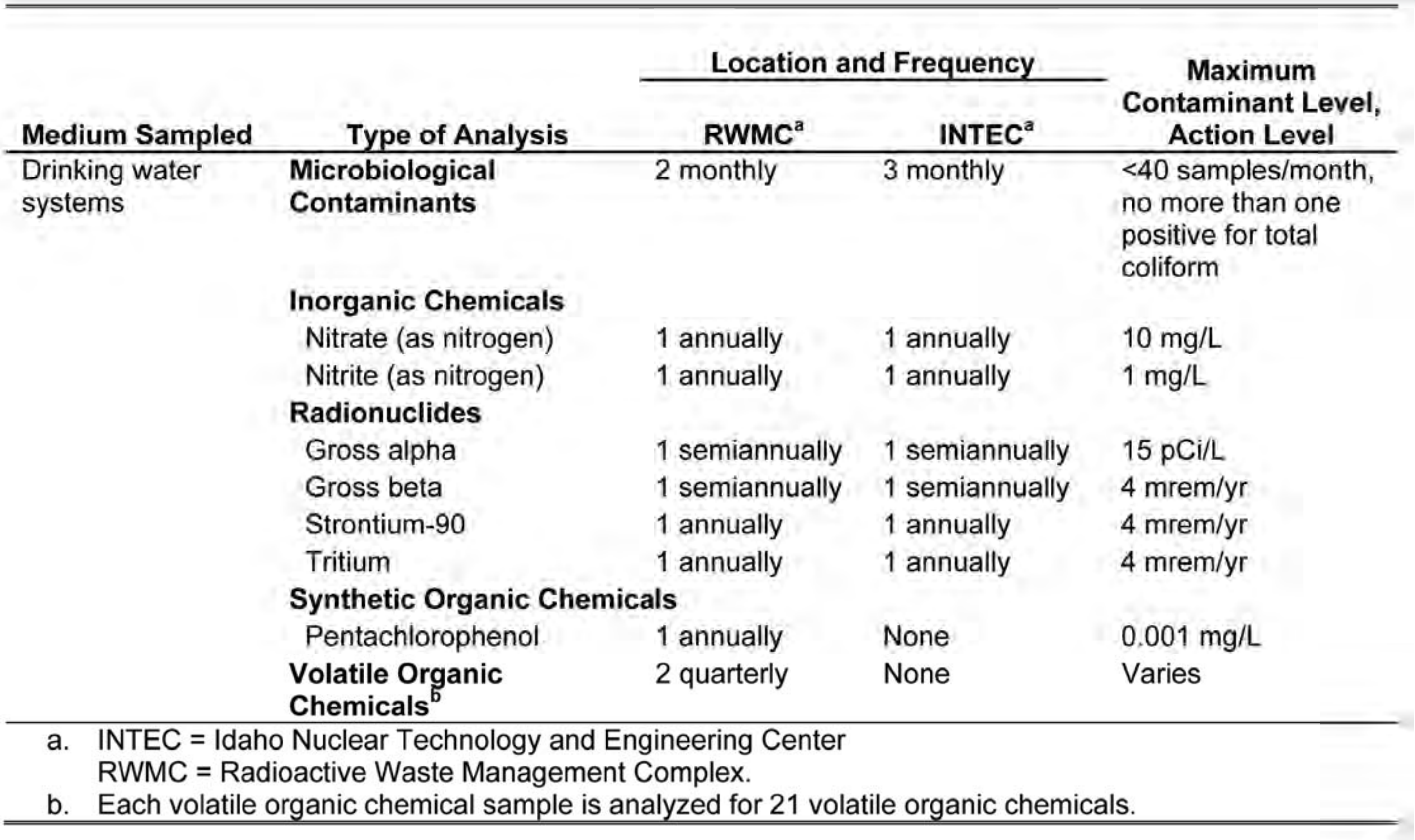
c. Precipitation occurred to cause a surface water runoff event only during the first, second, and fourth quarters of 2009.

d. Crested wheat grass was available for sampling in 2009.

Results of the environmental monitoring programs for 2009 are presented in Chapter 4 (air), Chapters 5 and 6 (water), and Chapter 7 (agricultural, wildlife, soil and direct radiation). Chapter 8 discusses radiological doses to humans and biota, and Chapter 9 presents 2009 results on ecological and USGS 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, and statistical methods used in this report are provided as supplemental reports.

Bristly Cutworm Moth

Table 3-5. Idaho Cleanup Project Contractor Drinking Water Program Summary (2009).



		Location and Frequency		
Medium Sampled	**Type of Analysis**	**RWMC[a]**	**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
	Nitrite (as nitrogen)	1 annually	1 annually	1 mg/L
	Radionuclides			
	Gross alpha	1 semiannually	1 semiannually	15 pCi/L
	Gross beta	1 semiannually	1 semiannually	4 mrem/yr
	Strontium-90	1 annually	1 annually	4 mrem/yr
	Tritium	1 annually	1 annually	4 mrem/yr
	Synthetic Organic Chemicals			
	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.

3.1.1 Sitewide Monitoring Committees

Sitewide monitoring committees include the Monitoring and Surveillance Committee, the Drinking Water Committee, and the Water Resources Committee.

The Monitoring and Surveillance Committee was formed in March 1997 and meets bimonthly 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, Naval Reactors Facility, and USGS. The Monitoring and Surveillance Committee has served as a valuable forum to review monitoring, analytical and quality assurance methodologies; to coordinate efforts, and to avoid unnecessary duplication.

The Drinking 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. The committee includes DOE-ID, INL Site contractors, and the Naval Reactors Facility.

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Table 3-6. U.S. Geological Survey Monitoring Program Summary (2009).

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	52	51	4	4	3 pCi/mL
Gross beta	52	51	4	4	3 pCi/mL
Tritium	150	143	7	7	400 pCi/mL
Gamma-ray spectroscopy	88	83	4	4	—[b]
Strontium-90	101	95	—[c]	—	5 pCi/mL
Americium-241	22	21	—[c]	—	5 pCi/mL
Plutonium isotopes	22	21	—[c]	—	4 pCi/mL
Iodine-129	0	0	—[c]	—	<1aCi/L
Specific conductance	151	144	7	7	Not applicable
Sodium ion	141	135	—[c]	—	0.1 mg/L
Chloride ion	150	142	7	7	0.1 mg/L
Nitrates (as nitrogen)	110	106	—[c]	—	0.05 mg/L
Fluoride	4	4	—[c]	—	0.1 mg/L
Sulfate	99	92	—[c]	—	0.1 mg/L
Chromium (dissolved)	88	83	—[c]	—	0.005 mg/L
Purgeable organic compounds[d]	29	39	—[c]	—	Varies
Total organic carbon	49	47	—[c]	—	0.1 mg/L
Trace elements	11	11	—[c]	—	Varies

a. Number of samples does not include 16 replicates and 2 equipment blanks collected in 2009. 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 41 zones from 8 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.

The Water Resources Committee serves as a forum for coordinating and exchanging technical information on water-related activities. The committee was established in 1991 and includes DOE-ID, INL Site contractors, USGS, the National Oceanic and Atmospheric Administration, and other agencies that have an interest in INL Site water issues but are not necessarily part of the governing agencies.

3.1.2 DOE Headquarters Independent Assessment

DOE-ID requested that the DOE Headquarters Office of Independent Oversight within the Office of Health, Safety, and Security perform an independent assessment of the INL Site environmental monitoring program. Planning for the assessment started in late 2009 and the assessment is scheduled to be conducted in 2010. The scope for the assessment will cover:

- 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 Site Annual Site Environmental Report (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.

The results of the independent assessment will be reported in the calendar year 2010 ASER.

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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.

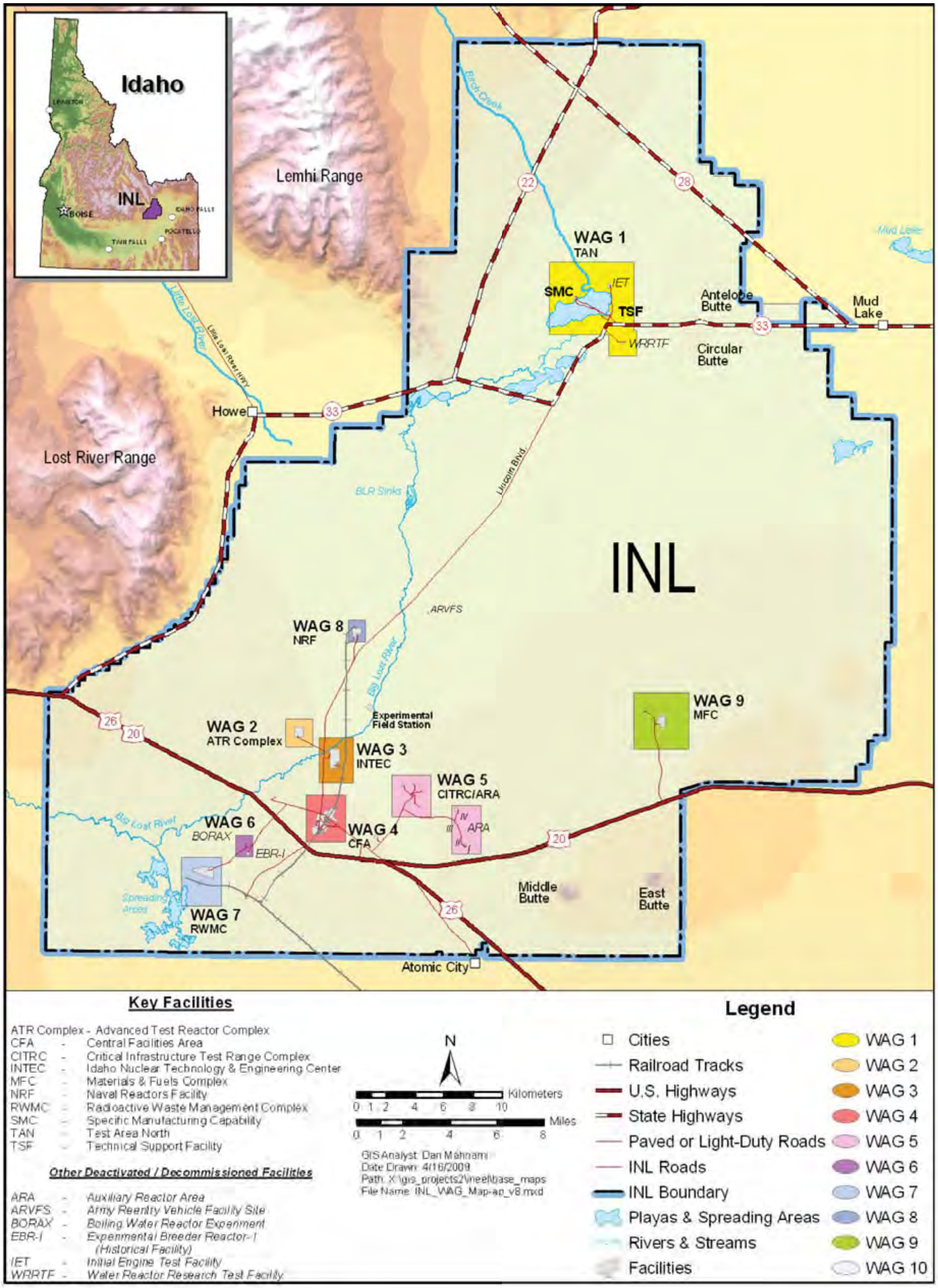
The INL Site is divided into ten waste area groups (WAGs) (Figure 3-2) as a result of the FFA/CO, and each WAG is further divided into smaller cleanup areas called operable units. Field investigations are used to evaluate potential release sites within each WAG and operable unit when existing data are 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 or further investigation using a remedial investigation/feasibility study. The remedial investigation/feasibility study is used to determine the nature and extent of the problem presented by the past release of contamination and to develop and evaluate options for remedial action. Results from the remedial investigation/feasibility study form the basis for risk assessments and alternative cleanup actions. This information, along with the regulatory agencies’ proposed cleanup plan, is presented to the public in a document called a proposed plan. Proposed plans present cleanup alternatives and recommend a preferred cleanup alternative to the public. After consideration of public comments, DOE, the Environmental Protection Agency, and the state of Idaho develop a record of decision (ROD) selecting a cleanup approach from the alternatives evaluated. Cleanup activities then can be designed, implemented, and completed.

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



Key Facilities

ATR Complex - Advanced Test Reactor Complex
CFA - Central Facilities Area
CITRC - Critical Infrastructure Test Range Complex
INTEC - Idaho Nuclear Technology & Engineering Center
MFC - Materials & Fuels Complex
NRF - Naval Reactors Facility
RWMC - Radioactive Waste Management Complex
SMC - Specific Manufacturing Capability
TAN - Test Area North
TSF - Technical Support Facility

Other Deactivated / Decommissioned Facilities

ARA - Auxiliary Reactor Area
ARVFS - Army Reentry Vehicle Facility Site
BORAX - Boiling Water Reactor Experiment
EBR-I - Experimental Breeder Reactor-I (Historical Facility)
IET - Initial Engine Test Facility
WRRTF - Water Reactor Research Test Facility

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

Scarab beetle

the aquifer. The New Pump and Treat Facility operated one week per month to manage purge water and 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, but trichloroethylene concentrations were maintained below the trigger levels for full operation of the New Pump and Treat Facility. All institutional controls were maintained in 2009.

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 2009.

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

Operations continued at the Idaho CERCLA Disposal Facility during 2009, disposing of contaminated soil and debris in the landfill cell and liquid waste to the evaporation pond. The Idaho CERCLA Disposal Facility disposes of contaminated soils and debris from CERCLA cleanup operations to reduce risk to the public and environment. In 2009, remediation of all the WAG 3, Operable Unit 3-13, Group 3, Other Surface Soils, was completed as required by the ROD (DOE-ID 1999). The final Remedial Action Report (DOE-ID 2009b) was completed in November 2009. Actions were maintained 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 the facility area will continue until the risk posed by contamination left in place is acceptable. All institutional controls were maintained in 2009.

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 2009.

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 2005a) was completed in 2005. All institutional controls were maintained in 2009.

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 2009a). Operable Unit 10-08 addresses Eastern Snake River Plain Aquifer concerns not covered by other WAGs and future sites that may be discovered. Groundwater monitoring continued during 2009 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 Operable Unit 6-05 and 10-04, Phase II, TNT/RDX (trinitrotoluene/ cyclotrimethylene trinitramine) was completed and documented in the final Remedial Action Report (DOE-ID 2009b) in March 2009. All institutional controls were maintained in 2009.

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 abovegrade 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

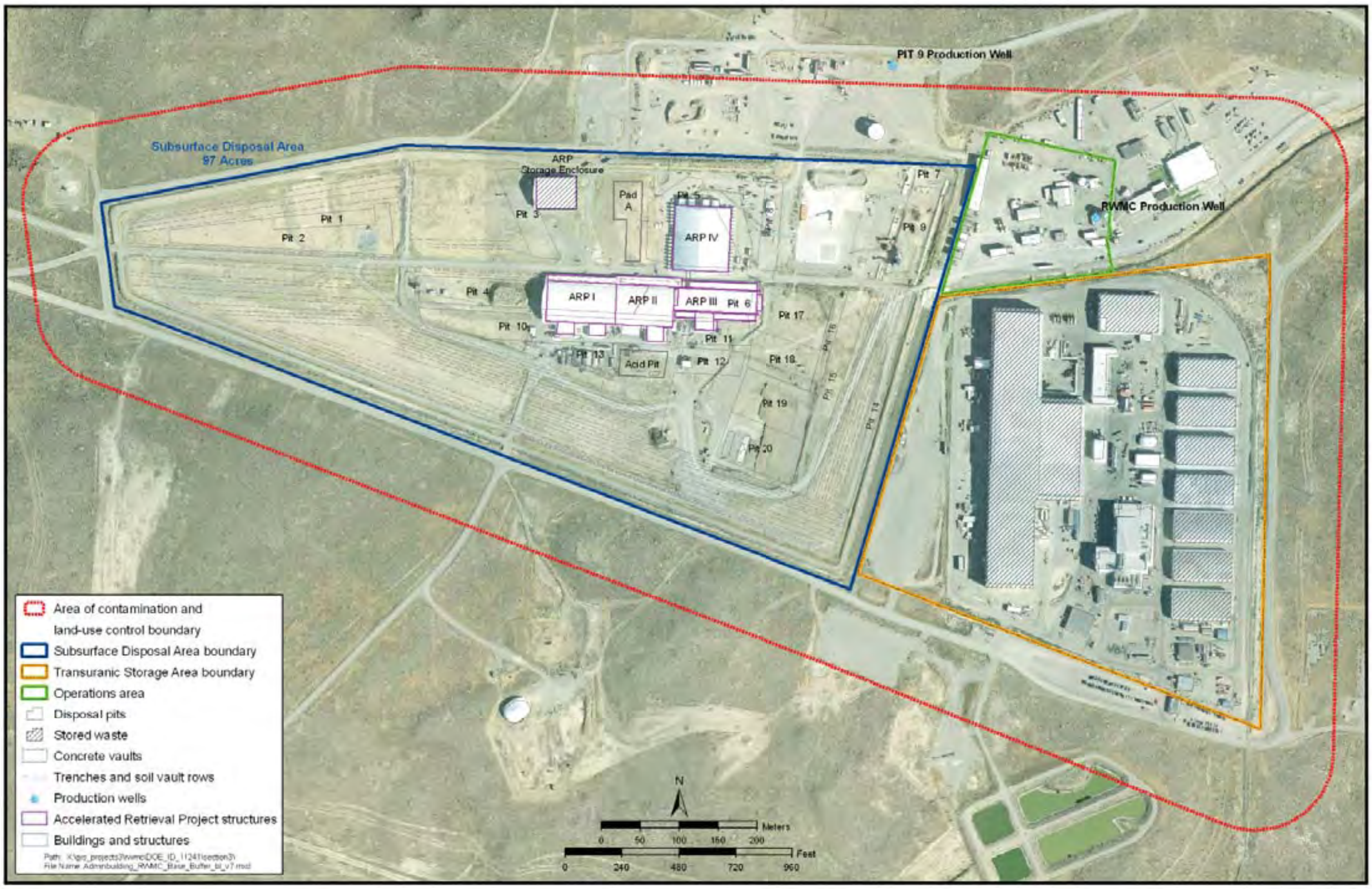


Figure 3-3. Radioactive Waste Management Complex Subsurface Disposal Area. (2009).

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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 has been disposed of in the Subsurface Disposal Area. 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 2008b). 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 was completed in early 2008. A second excavation commenced in July 2007 in other parts of Pit 4 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. The Accelerated Retrieval Projects have collectively retrieved and packaged more than 3,546 m^3 (4,520 yd^3) of targeted waste from a combined area of 0.50 hectares (1.24 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, 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.

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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 2009, the INL Site treated or processed 6,028.7 m^3 (7,836.75 yd^3) of legacy mixed waste, 216.7 m^3 (281.7 yd^3) of mixed low-level waste, and 5,812 m^3 (7,555.6 yd^3) of mixed contact-handled transuranic waste. Additionally, 15 m^3 (19.5 yd^3) of remote-handled transuranic waste was shipped offsite for disposition, the majority of which was specified by the INL Site Treatment Plan.

Three INL Site Treatment Plan milestones were completed on schedule in 2009, 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 – 97 m^3 (126 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).

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 and tested to determine its contents. Characterized waste containers that need further treatment


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before they can be shipped are sent to the AMWTP Treatment Facility where the waste can be size-reduced, sorted, and repackaged. 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.

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 categorizing the waste into four different groups consisting of 55-gallon drums or pucks (compacted drums). Then, these four separate payloads are individually 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 2009, the AMWTP shipped 5,384 m^3 (7,042 yd^3) of stored transuranic waste to the Waste Isolation Pilot Plant, for a cumulative total of 30,695 m^3 (40,148 yd^3) of waste shipped off the INL Site. The AMWTP also shipped offsite 4,042 m^3 (5,287 yd^3) of mixed low-level waste that historically had been managed as stored transuranic waste, for a cumulative total of 6,028 m^3 (7,884 yd^3) of waste shipped offsite. A combined cumulative total of 36,723 m^3 (48,031 yd^3) of stored transuranic waste has been shipped offsite. In addition, the AMWTP has shipped a cumulative total of 2,189 m^3 (2,863 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 the Idaho Nuclear Technology and Engineering Center (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* (FEIS) (DOE 2002) that included alternatives other than calcination for treatment of the sodium-bearing waste. DOE-ID issued a ROD for this FEIS 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. It should be noted that the Settlement

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Agreement does not require removing calcine from the state by a particular time; rather, it requires having the calcine in a “road-ready” configuration by a target date of December 31, 2035. 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 FEIS 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 2009, more than 720.9 m^3 (943 yd^3) of mixed low-level waste and 1,664 m^3 (2,176 yd^3) of low-level waste was shipped off the INL Site for treatment or disposal or both. Approximately 18.6 m^3 (24 yd^3) of newly generated, low-level waste was disposed of at the Subsurface Disposal Area in 2009.

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 November 2009, both the INL and ICP contractors went through a reregistration audit. 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.

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 (see Table 3-7). 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 Pollution Prevention and Sustainability

The Pollution Prevention and Sustainability 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 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 Pollution Prevention and Sustainability 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

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Table 3-7. EMS Environmental Aspects for INL Site Contractors (2009).

AMWTP Environmental Aspects	ICP Environmental Aspects	INL Environmental Aspects
• Air Pollutants • Chemical Use and Storage • Discharge to Wastewater Systems or Groundwater • Drinking Water Contamination • Waste Movement and Storage • Industrial Waste Generation and Management • Managing Surplus Property and Materials • Polychlorinated Biphenyl Contamination • Radioactive Material Use and Storage • Newly Generated Waste Management • Vehicle Fleet Management/Use • Energy Use	• Asbestos emissions • Biological hazards • Chemical use and storage • Contaminated sites disturbance • Cultural/historical resource disturbance • Discharge to wastewater systems or groundwater • Drinking water contamination • Regulated, hazardous, or radioactive material or waste packaging and transportation • Regulated, hazardous, or mixed waste generation and management • Industrial waste generation and management • Interaction with wildlife/habitat • Managing and dispositioning surplus property and materials • Polychlorinated biphenyl (PCB) contamination • Radioactive material use and storage • Radioactive waste generation and management • Storage of regulated hazardous or radioactive materials or waste in tanks • Use, reuse, recycling, and conservation of resources • Work within areas subject to flooding	• Air Emissions • Discharging to Surface-, Storm-, or Groundwater • Disturbing Cultural/Biological Resources • Generating and Managing Waste (Industrial, Hazardous, Radioactive) • Releasing Contaminants (to Soil, Potable Water, Wastewater, Flood-prone Areas) • Using, Reusing, and Conserving Natural Resources (Energy, Water, Land)


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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 and sustainability (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 2009.

Pollution Prevention Opportunity Assessment – A pollution prevention opportunity assessment was performed on the INTEC water pumps. Historically, INTEC has used approximately 1.89 billion L/yr (500 million gal/yr) of water, accounting for about 50 percent of the total use of the INL Site. Over the last several years, numerous activities have been conducted to reduce the INTEC water use. Under CERCLA regulation ICP has been in the process of eliminating and repairing water sources that contribute to the perched aquifers and move contaminants further down to the aquifer. Repair of multiple fire line leaks and disconnecting leaking water lines eliminated millions of gallons per year in water losses.

ICP personnel continued to investigate water-using processes, and upon further evaluation of the water system, it was determined the two original groundwater pumps were oversized for the needs of the current INTEC mission, resulting in excess water being pumped. The INTEC water system was originally sized for the reprocessing of spent nuclear fuel, which is no longer conducted. Throughout the years, numerous facilities have been decommissioned and demolished, which also reduced the water supply demands. However, to operate the now oversized pumps, excess water was being pumped. Operating the existing pumps at the lowest flow rate achievable was also using excess electricity because the pumps were not operating at optimal conditions. The excess water was being pushed from pump to pump in the system, going through the reverse osmosis system, increasing electrical use and resulting in needless flow to the service waste system. ICP personnel were able to down-size two 200-horsepower water pumps to 75-horsepower units to meet the water supply demands. Additionally, they concluded they could reroute water flows and eliminate passing unnecessary water through the reverse osmosis units and into the service waste system. Rerouting water flow resulted in the elimination of three 75-horsepower pumps and six 60-horsepower pumps from the system. The new system configuration will reduce the use of electricity, water, supplies, salt, and maintenance, for an estimated annual savings of $70,000 a year. ICP worked with the INL energy manager and determined they could potentially receive a substantial rebate for the costs associated with the replacement based on reducing energy demand. The INL and ICP contractors met with Idaho Power and submitted a proposal based on the electricity savings projected, and Idaho Power committed to pay for part of the upgrade based on expected savings.

In total, the improvements made over the last several years have reduced water use by over 526 million L/yr (139 million gal/yr), a 35 percent reduction.

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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. At the INL Site, alternative fuel vehicles now comprise 85 percent of the fleet and are growing every year. In 2009, the INL Site implemented an initiative to purchase more fuel efficient flex fuel vehicles, expand E85 fueling stations to meet the needs of the increased flex fuel vehicles, and increase alternative fuel use to 25 percent of the total fuel use. The INL Site vehicle fleet includes buses and automobiles that use alternative fuels, such as liquefied natural gas, compressed natural gas, E85 ethanol, and biodiesel. INL Site Fleet Operations developed the alternative fueling infrastructure to include three E85 fueling stations, two biodiesel fueling stations, one compressed natural gas fueling station, and one liquefied natural gas fueling station. The use of alternative fuels at the INL Site saved over an estimated 378,541 L (100,000 gal) of diesel petroleum and over 189,271 L (50,000 gal) of petroleum gasoline during 2009.

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 leads the DOE complex in its electronics stewardship program. In 2009, the INL Site received the 2009 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.

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. INL designed a new Advanced Test Reactor (ATR) Complex Common Support Building that will be ten percent more energy efficient than a typical baseline building and will be LEED certifiable. In addition, the new Test Train Assembly Facility at the ATR Complex is also LEED certifiable. In Idaho Falls, the new Center for Advanced Energy Studies achieved LEED Gold Certification. In 2009, three new designs were developed that will meet LEED Gold requirements when complete. The facilities – the Radiological Environmental Sciences Laboratory, Research and Education Laboratory, and Testing and Demonstration Laboratory – have incorporated sustainable design practices developed in the INL Green Building Strategy.

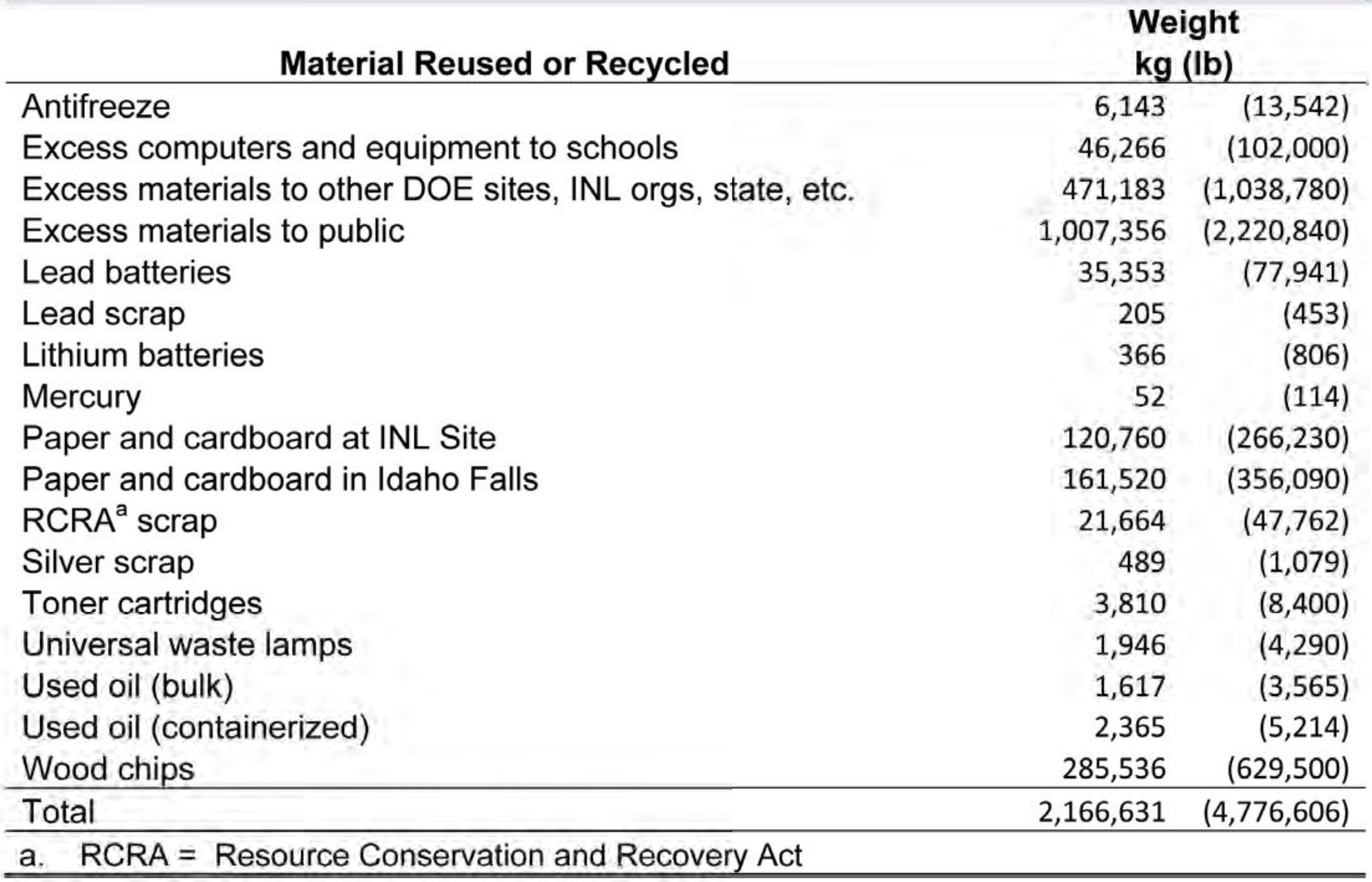
Infrastructure Improvement – A landmark $33 million infrastructure improvement project at the Materials and Fuels Complex (MFC) continued. The project modernizes heating, lighting and other utility equipment, systems, and controls. The project involves lighting upgrades, heating, ventilation and air conditioning improvements, compressed air optimization, solar transpired heating, and digital controls for buildings. The carbon emissions reduction and energy savings will be equivalent to planting nearly 728 hectares (1,800 acres) of trees, or the equivalent of removing over 1,100 cars from the roads. Carbon emissions will be reduced by removing oil-fired boilers, which currently burn more than 2,195,539 L (580,000 gal) of fuel annually. The project enables the INL Site to meet the energy reduction milestones of the 2005 Energy Policy Act (Public Law 109-58) and DOE's *Transformational Energy Action Management Initiative* (DOE

2007) by reducing energy use by over 5 percent and reducing carbon dioxide emissions by 5.8M kg (12.8M lb) per year. It also provides many other important benefits to the INL Site, such as improved reliability of mechanical equipment, major reductions in air pollution emissions, safer working environment, improved occupant comfort, and advanced metering of steam, water, and electricity.

Earth Day – DOE-ID and the INL Site contractors participated in the organizing committee for the 2009 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 2009.

Table 3-8. Reused and Recycled Materials (2009).



Material Reused or Recycled	Weight kg	(lb)
Antifreeze	6,143	(13,542)
Excess computers and equipment to schools	46,266	(102,000)
Excess materials to other DOE sites, INL orgs, state, etc.	471,183	(1,038,780)
Excess materials to public	1,007,356	(2,220,840)
Lead batteries	35,353	(77,941)
Lead scrap	205	(453)
Lithium batteries	366	(806)
Mercury	52	(114)
Paper and cardboard at INL Site	120,760	(266,230)
Paper and cardboard in Idaho Falls	161,520	(356,090)
RCRA[a] scrap	21,664	(47,762)
Silver scrap	489	(1,079)
Toner cartridges	3,810	(8,400)
Universal waste lamps	1,946	(4,290)
Used oil (bulk)	1,617	(3,565)
Used oil (containerized)	2,365	(5,214)
Wood chips	285,536	(629,500)
Total	2,166,631	(4,776,606)

a. RCRA = Resource Conservation and Recovery Act

In summary, the INL Site Pollution Prevention Program continued to successfully meet the five 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 Idaho Cleanup Project continued deactivating, decontaminating, and decommissioning (D&D) surplus DOE Environmental Management-owned buildings and structures at the INL Site. This effort 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.

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.

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 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.

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3.5.2 Spent Nuclear Fuel

Spent nuclear fuel (SNF) is fuel that has been irradiated in a nuclear reactor, has produced power, has been removed from the reactor, and has not been reprocessed to separate any constituent elements. 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 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 2009, 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 SNF in dry storage. The Nuclear Materials Disposition team transferred 2,641 of 3,186 fuel handling units to dry storage and has three SNF types left to transfer. All ICP-managed SNF was consolidated at INTEC in 2003. 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. 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. ICP-managed SNF is being removed from the basins and stored in the INTEC dry storage facilities described below. All ICP-managed SNF is expected to be in dry storage by the end of 2010. 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 2009 and will continue to receive SNF from the CPP-666 basin and foreign and domestic research reactors in 2010.

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 are generally 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. In 2009, this facility received Shippingport SNF from the CPP-666 basins.

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, 20 metric tons (44,093 lb) of SNF, mostly from the deactivated Experimental Breeder Reactor II, is stored in the steel pipe storage vaults.

Since 1996, 3.4 metric tons (7,496 lb) of the original Experimental Breeder Reactor 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 a ceramic and a stainless steel, solid, high-level waste. The extracted 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 2005 Environmental Oversight and Monitoring Agreement (DOE-ID 2005b) 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

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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 144 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/.

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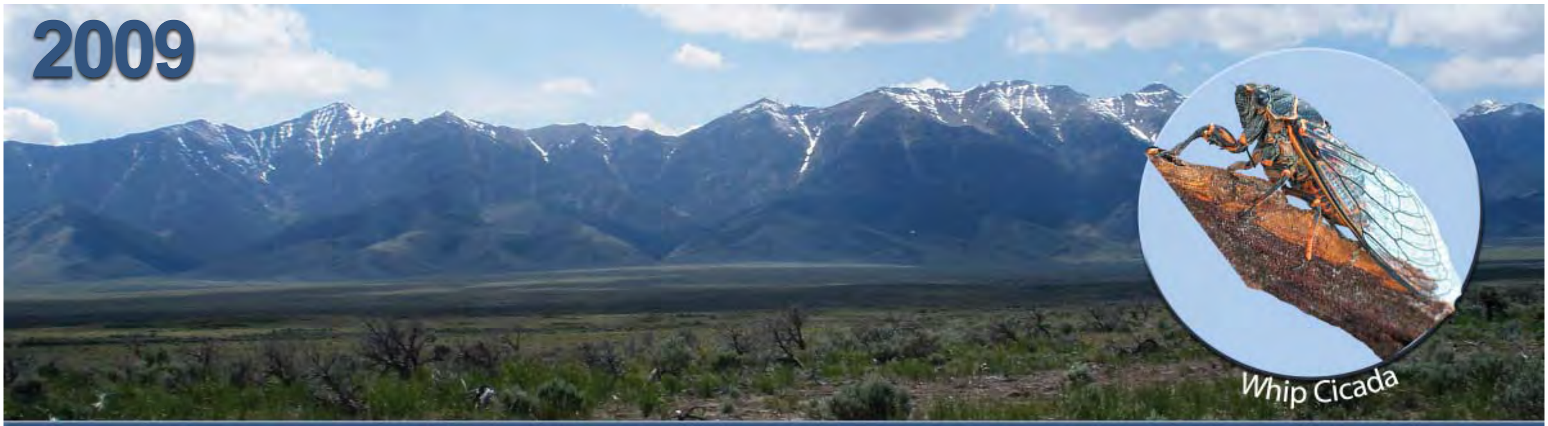

Chapter 4. Environmental Monitoring Programs (Air)

Chapter Highlights

An estimated total of 7,320 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 2009. The highest contributors to the total release were the Idaho Nuclear Technology and Engineering Center (INTEC) at 34 percent, the Materials and Fuels Complex at 33 percent, and the Advanced Test Reactor Complex at 27 percent. 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 2009.

Approximately 2,000 charcoal cartridges, typically collected on a weekly basis using a network of low-volume air samplers, were analyzed for radioiodine during 2009. Iodine-131 was detected in one sample obtained from a location at the Idaho Nuclear Technology and Engineering Center, but it was well below the Department of Energy (DOE) health-based limit for radioiodine in air and was most likely a false positive detection (i.e., not really present in the 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. 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 were a few detections of specific radionuclides, but results were well below DOE health-based limits for specific radionuclides in air and within historical measurements. Measurements made in 2009 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 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 INTEC. Gross alpha and gross beta activities measured on the filters were comparable with historical results and no new trends were identified in 2009. No gamma-emitting radionuclides

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were detected at any waste management facility in 2009. Strontium-90, plutonium-239/240, and americium-241 detections were comparable to past measurements and are likely due to resuspended soils from increased human activity 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 31 of 111 atmospheric moisture samples collected and was detected in 32 of 51 precipitation samples collected during 2009. The tritium concentrations measured in moisture samples were within historical measurements. The highest concentration detected in a precipitation sample was measured at the Experimental Field Station, was within measurements made by the EPA in Region 10 (Alaska, Idaho, Oregon, and Washington) for the past ten years, and was below the DOE 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 2008).

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 2009. The INL contractor

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-volume Gross Alpha	Low-volume Gross Beta	Specific Radionuclides[c]	Atmospheric Moisture	Precipitation
ICP Contractor: CH2M-WG Idaho, LLC (CWI)[d]							
INTEC	●		●	●	●		
RWMC	●		●	●	●		
INL Contractor: Battelle Energy Alliance (BEA)[e]							
MFC	●						
INL/Regional		●	●	●	●	●	
Environmental Surveillance, Education and Research Program[f]							
INL/Regional		●	●	●	●	●	●

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

b. Facilities with stacks that required continuous monitoring during 2009 for compliance with 40 CFR 61, Subpart H, "National Emissions Standards for Hazardous Air Pollutants."

c. Gamma-emitting radionuclides and strontium-90, plutonium-238, plutonium-239/240 and americium-241 are measured by the ICP and ESER contractors quarterly. Gamma-emitting radionuclides are measured semi-annually by the INL contractor.

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 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 2009. 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.

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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 2009 INL Report for Radionuclides*, referred to hereafter as the NESHAPs Report (DOE-ID 2010).

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 2009, an estimated 7,320 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 86 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


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Table 4-2. Radionuclide Composition of Idaho National Laboratory Site Airborne Effluents (2009).

	Curies Released										
Facility[a]	Tritium	Krypton-85	Noble Gases[b] (T½ < 40 days)	Short-lived Fission and Activation Products[c] (T½ < 3 hours)	Fission and Activation Products[d] (T½ > 3 hours)	Total Radiodine[e]	Total Radiostrontium[f]	Total Uranium[g]	Plutonium[h]	Other Actinides[i]	Other[j]
ATR Complex	266	11	1,690	0.98	3.38×10^{-2}	6.80×10^{-2}	3.26×10^{-3}	2.32×10^{-8}	7.48×10^{-5}	1.40×10^{-4}	1.13×10^{-2}
CFA	1.43	—	—	1.12×10^{-10}	5.57×10^{-8}	1.20×10^{-5}	1.37×10^{-9}	8.14×10^{-8}	9.84×10^{-10}	6.32×10^{-9}	3.84×10^{-5}
CITRC	—	—	—	—	2.00×10^{-8}	—	2.23×10^{-9}	1.01×10^{-9}	8.17×10^{-11}	6.67×10^{-11}	6.23×10^{-10}
INTEC	335	2,163	—	2.45×10^{-3}	0.15	4.11×10^{-2}	6.37×10^{-3}	5.01×10^{-6}	1.11×10^{-2}	3.18×10^{-4}	7.26
MFC	28.1	2,420	—	2.16×10^{-13}	3.43×10^{-11}	1.43×10^{-3}	1.56×10^{-5}	1.46×10^{-13}	3.04×10^{-6}	6.37×10^{-11}	0.19
RWMC	400	7.41×10^{-11}	—	4.83×10^{-8}	5.55×10^{-8}	—	2.18×10^{-8}	1.45×10^{-8}	1.09×10^{-2}	1.37×10^{-3}	0.15
TAN	3.26×10^{-2}	—	—	—	1.04×10^{-4}	—	1.18×10^{-5}	—	—	—	2.62×10^{-6}
Total	**1,030**	**4,594**	**1,690**	**0.98**	**0.18**	**0.11**	**9.66×10^{-3}**	**5.13×10^{-6}**	**2.21×10^{-2}**	**1.83×10^{-3}**	**7.62**

a. ATR = Advanced Test Reactor, CFA = Central Facilities Area, CITRC = Critical Infrastructure Test Range Complex, 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.

b. Noble gases with half-lives less than 40 days released from the INL Site are: ^{41}Ar, ^{85m}Kr, ^{87}Kr, ^{88}Kr, ^{131m}Xe, ^{133}Xe, ^{133m}Xe, ^{135m}Xe and ^{138}Xe.

c. Fission products and activation products (T½ <3 hours) = ^{139}Ba, ^{138}Cs, ^{88}Rb, ^{89}Rb, ^{91m}Y, etc.

d. Fission products and activation products (T½ > 3 hours) = ^{36}Cl, ^{58}Co, ^{51}Cr, ^{134}Cs, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{55}Fe, ^{203}Hg, ^{103}Ru, ^{106}Ru, ^{95}Zr, etc.

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 and ^{238}U.

h. Plutonium = ^{236}Pu, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu and ^{242}Pu.

i. Other actinides = ^{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, ^{227}Th, ^{228}Th, ^{229}Th, ^{230}Th, ^{231}Th, ^{232}Th and ^{234}Th.

j. Other = radioisotopes of other elements that are not noble gases, activation or fission products or actinides.

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 (34 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.

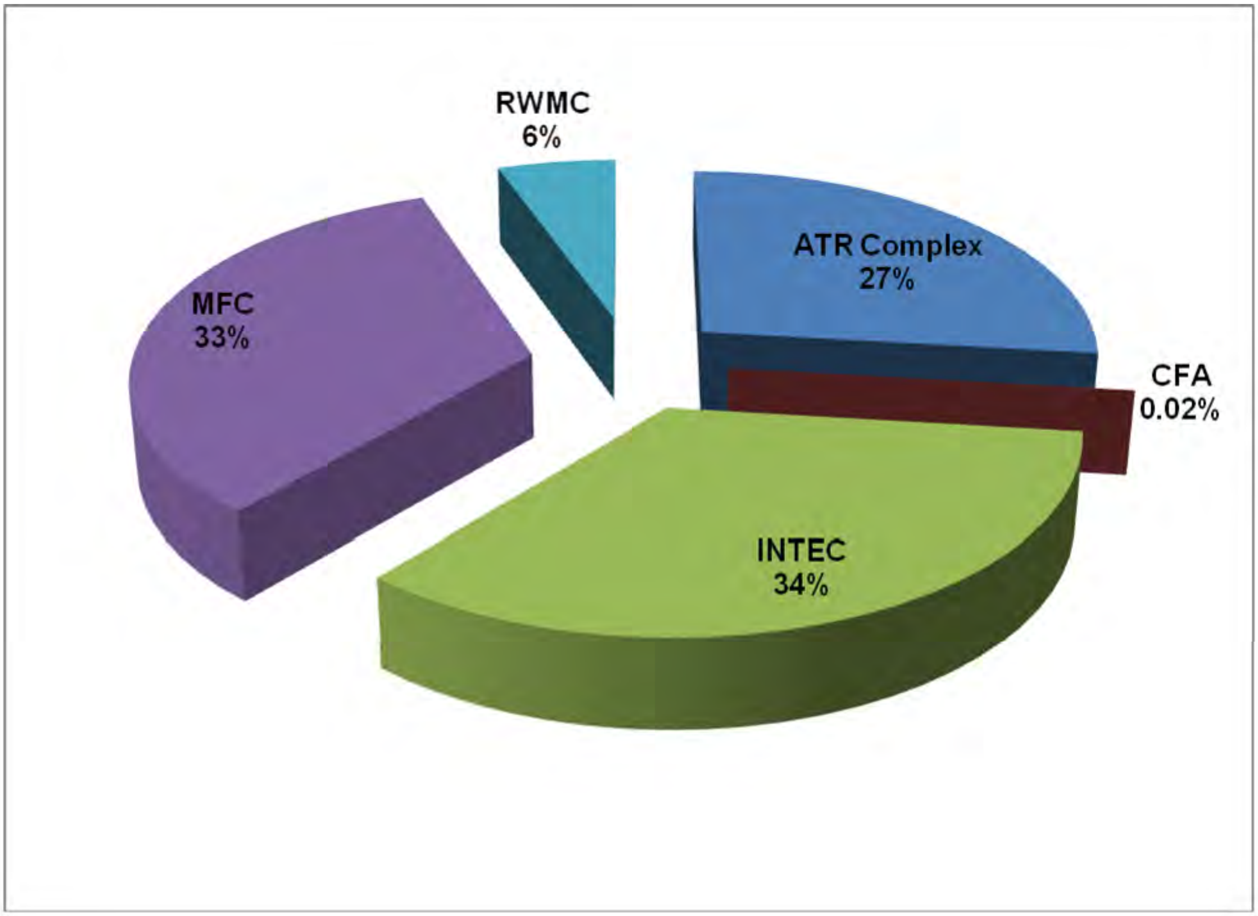

Figure 4-1. Percent Contributions, by Facility, to Total INL Site Airborne Radionuclide Releases (2009).

- **Materials and Fuels Complex (MFC) Emissions Sources (33 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. In 2009, ^{85}Kr was released when drums containing spent nuclear fuel were vented. This release accounted for approximately one-third of the total estimated INL Site airborne emissions for 2009.
- **Advanced Test Reactor Complex (ATR Complex) Emissions Sources (27 percent of total)** – Radiological air emissions from 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. In 2009, the ICP contractor conducted decontamination and demolition activities at the following areas of the ATR Complex that resulted in radiological emissions: TRA-603 (Materials Test Reactor Building), TRA-604 (Materials Test Reactor Laboratories), TRA-613 (Tank Vault Weather Enclosure), TRA-613-A and TRA-613 B Vaults (Hot Waste Storage Pump Vaults), TRA-630 (Catch Tank Pumphouse), TRA-635 (Reactor Services Building), TRA-654 (Engineering Test Reactor Criticality Facility), TRA-665 (Neutron Chopper House), TRA-661 and -668 (Materials Test Reactor Laboratories North and South Wings), and TRA-761 (Tank Truck Loading Facility). Radiological emissions from these activities were associated with contaminated equipment removal, demolition of contaminated structures, closure of mixed waste tank systems, and characterization and disposal of contaminated soils.
- **Radioactive Waste Management Complex (RWMC) Emissions Sources (6 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 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.

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 and ICP contractors and semiannually by the INL contractor for laboratory analysis of gamma-emitting radionuclides, such as cesium-137

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*On October 1, 2008, for budgetary reasons, the INL contractor lowered the flow to 28 L/minute (1 ft^3/minute) and changed to a biweekly (every other week) sampling schedule that alternated between north and south loops. The north loop includes monitors at Idaho Falls, Rexburg, Test Area North, Specific Manufacturing Capability, Gate 4, Naval Reactors Facility, Experimental Field Station, Advanced Test Reactor Complex, and Idaho Nuclear Technology and Engineering Center. The south loop includes monitors at Blackfoot, Craters of the Moon, Big Lost River Rest Area on Highway 20, Auxiliary Reactor Area, Power Burst Facility, Central Facilities Area, Van Buren Boulevard and Highway 20 intersection, Experimental Breeder Reactor-I, and Radioactive Waste Management Complex. The INL contractor subsequently ran statistical tests on the one-week and two-week gross alpha and beta data sets. The test results showed that data from the shorter collection period were not from the same distribution as those from the longer at the 95 percent confidence level. Although still well within the range of historical background concentrations, the gross alpha and beta concentrations from the longer sampling period were statistically higher, presumably because the longer sampling period allowed for in growth of natural radioactive progeny. The INL contractor returned to the 57-L/minute (2-ft^3/minute) weekly sampling period March 4, 2009.

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

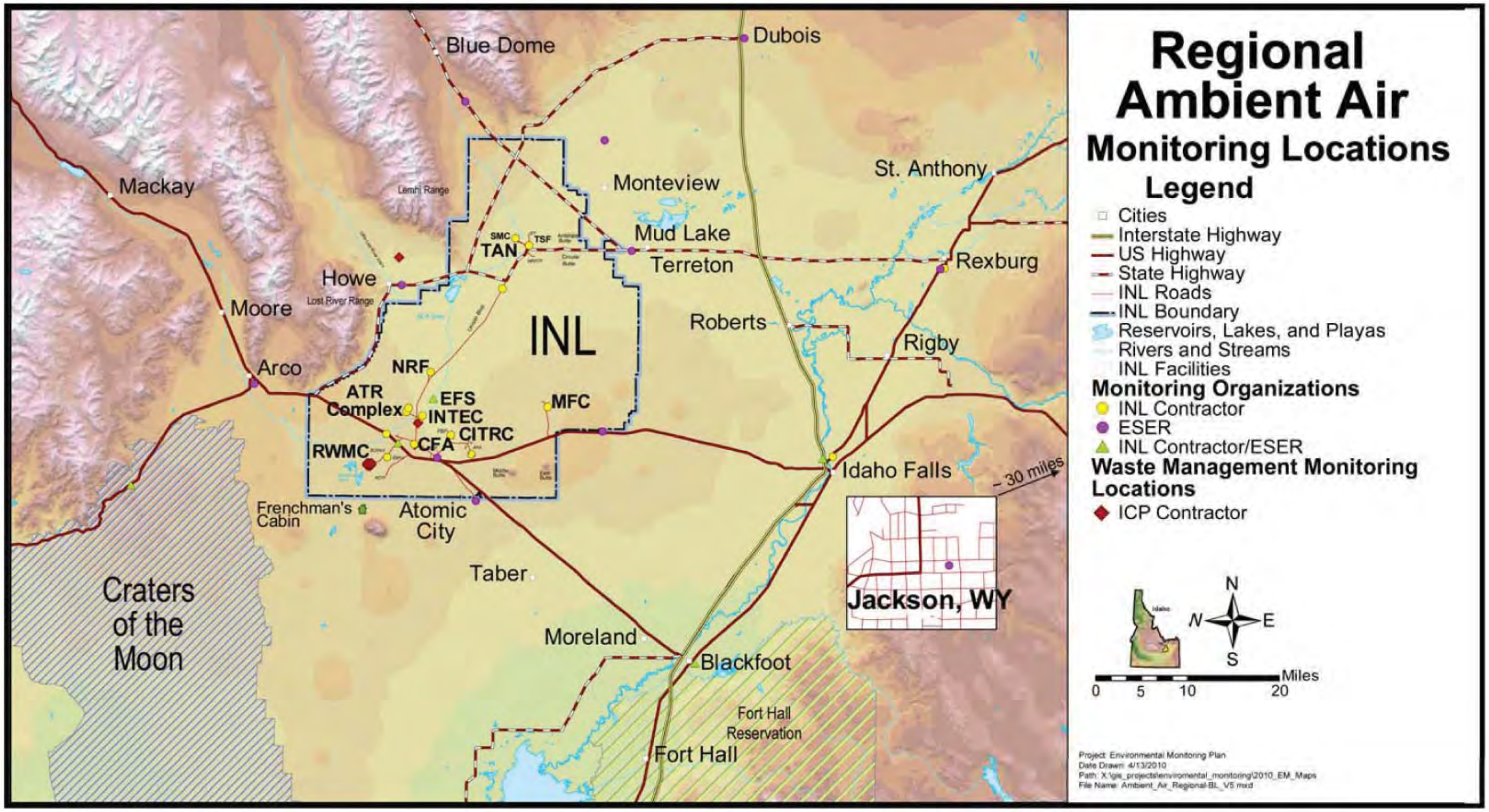


Figure 4-2. Idaho National Laboratory Site Environmental Surveillance Air Sampling Locations.

Scarab beetle

(^{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 composited samples for selected alpha- and beta-emitting radionuclides. These radionuclides include americium-241 (^{241}Am), plutonium-238 (^{238}Pu), plutonium-239/240 ($^{239/240}$Pu), and strontium-90 (^{90}Sr). They were selected for analysis because they have been detected historically in air samples and may be present due to resuspension of surface soil particles contaminated by INL Site activities or global fallout.

The charcoal cartridges are collected and analyzed weekly for iodine-131 (^{131}I). 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 adsorbent material (molecular sieve) that adsorbs water vapor in the air. Columns are sent to a laboratory for analysis when the material has adsorbed sufficient moisture to obtain a sample. The laboratory extracts water from the material by distillation and determines tritium concentrations by liquid scintillation counting. Tritium typically is present in air moisture due to natural production in the atmosphere, although it also is released by INL Site facilities (Table 4-2).

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

4.3.1 Ambient Air Monitoring Results

Gaseous Radioiodines – During 2009, the ESER contractor analyzed 935 cartridges, looking specifically for ^{131}I. Iodine-131 was not detected in any of the ESER samples.

The INL contractor collected and analyzed approximately 1,092 charcoal cartridges in 2009. Of these 1,092 cartridges, a single statistically positive detection (1.26×10^{-14} µCi/mL) of ^{131}I was reported by the laboratory for a sample collected July 22, 2009, from the onsite monitoring location at INTEC called “CPP;” however, statistically positive activity concentrations are reported in some instances where minimum nuclide identification criteria are not met. For example, the reported concentration for this sample was an order of magnitude less than the method detection limit, which means it likely was a false positive. The result also was well below the inhaled air Derived Concentration Guide (DCG) of 4×10^{-10} µCi/mL (see Table A-1 of Appendix A). In

Bristly Cutworm Moth

addition, no ^{131}I was detected by any other INL Site contractor sample collected in 2009.

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 -0.3 x 10^{-15} µCi/mL collected at Specific Manufacturing Capability on October 21, 2009, to a high of 8.7 × 10^{-15} µCi/mL collected at EBR-1 on July 22, 2009. Gross alpha concentrations measured in weekly ESER contractor samples ranged from a minimum of 0.05 × 10^{-15} µCi/mL at Craters of the Moon during the week ending July 15, 2009, to a maximum of 12.2 × 10^{-15} µCi/mL during the week ending April 22, 2009, at Van Buren Gate. This result was at the upper end normally measured by the ESER contractor for gross alpha concentrations and appeared to coincide with construction activities along the road near the sampler. During this week, road construction activities began on the public highway adjacent to the sampling location. The road construction activities, which involved tearing up the old roadbed, were initiated near the air sampler. Americium-241, an alpha-emitting radionuclide, was detected on the second quarter sample composited from weekly samples collected at the Van Buren Gate. This concentration was also above the normal range of detections (see discussion in “Specific Radionuclides” of this chapter). Elevated gross alpha activity was not detected in a collocated air monitor operated by the INL contractor during the same period. It is possible that the construction may have exposed contaminated materials used in the previous roadbed construction. The most plausible explanation for the unusual result is that during the road construction the ESER sampler may have intercepted a particle contaminated with ^{241}Am. The result (1.2 × 10^{-14} µCi/mL) was less than the 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.

  Median annual gross alpha concentrations calculated by the INL contractor ranged from 0.9 × 10^{-15} µCi/mL at Craters of the Moon to 1.3 × 10^{-15} µCi/mL at the Critical Infrastructure Test Range Complex (CITRC), EFS, Gate 4, and the Public Rest Area on Highway 20/26. Median annual gross alpha concentrations calculated by the ESER contractor for each location ranged from 1.1 × 10^{-15} µCi/mL at Blue Dome and the Federal Aviation Administration Tower

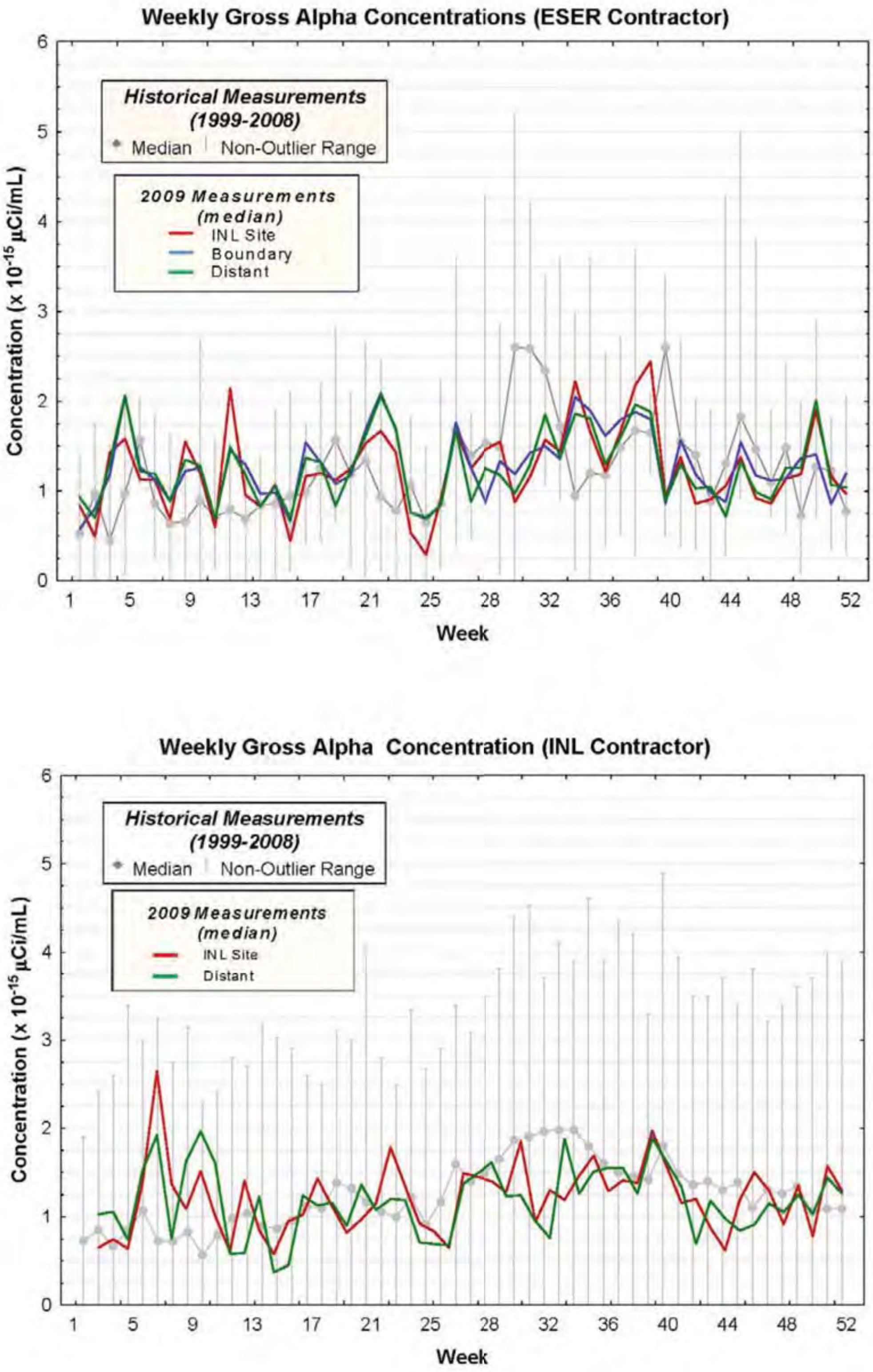


Figure 4-3. Median Weekly Gross Alpha Concentrations in Air (2009).

Bristly Cutworm Moth

to 1.5 × 10^{-15} µCi/mL at Rexburg (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 4.4 × 10^{-15} µCi/mL at a sampling location on the northeast side of the ATR Complex perimeter fence (referred to as “RTC”) on April 1, 2009, to a high of 1.3 × 10^{-13} µCi/mL at a sampling location on the south side of the ATR Complex perimeter fence (referred to as “TRA”) on December 16, 2009. Weekly gross beta concentrations detected in individual ESER contractor samples ranged from a low of 8.4 × 10^{-15} µCi/mL on January 14, 2009, at Federal Aviation Administration Tower to a high of 6.4 × 10^{-14} µCi/mL on January 21, 2009, 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 from 1999 to 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 2009 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]).

What is an inversion?

Usually within the lower atmosphere, air near the earth’s surface is warmer than air above it. 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 air is colder near the earth’s surface. 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.

ESER contractor median annual gross beta concentrations ranged from 2.5 × 10^{-14} µCi/mL at Blue Dome, Craters of the Moon, the Federal Aviation Administration Tower, and Jackson to 3.0 × 10^{-14} µCi/mL at Atomic City (Table 4-4). INL contractor data ranged from a median annual concentration of 2.3 × 10^{-14} µCi/mL at RWMC to 2.7 × 10^{-14} µCi/ mL at EFS and Gate 4. All results detected by the ESER and INL contractors were well within valid measurements

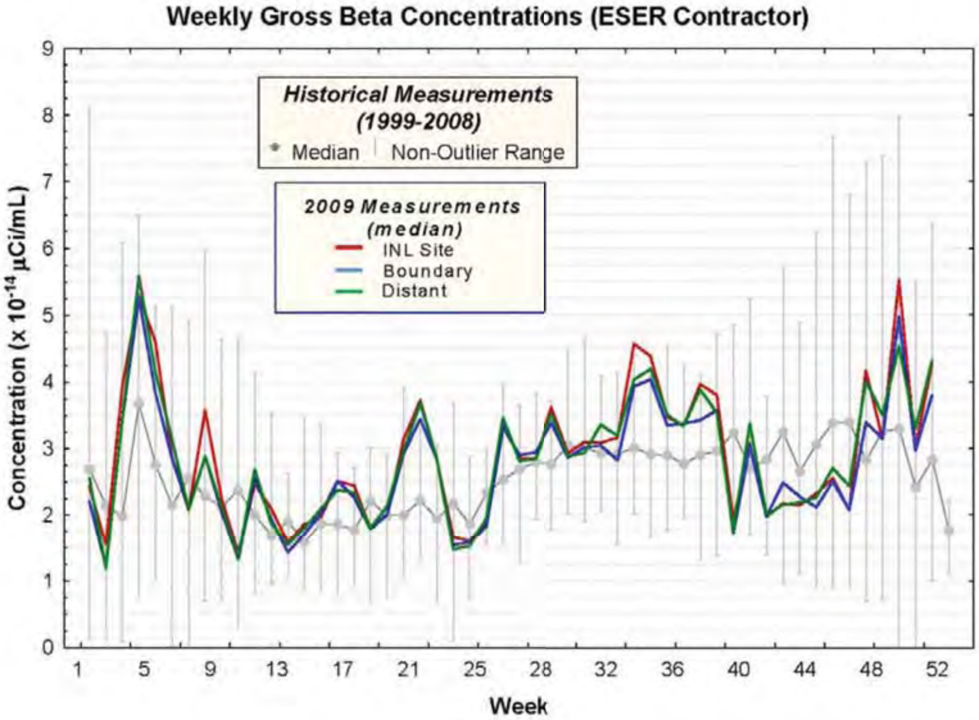
Table 4-3. Median Annual Gross Alpha Concentrations in Air (2009).

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	49	0.65 – 2.8	1.3
	Craters of the Moon	50	0.05 – 2.1	1.15
	Dubois	52	0.25 – 2.1	1.2
	Idaho Falls	52	0.70 – 3.0	1.4
	Jackson	50	0.09 – 2.2	1.2
	Rexburg CMS	50	0.50 – 3.3	1.5
			Distant Median:	1.3
Boundary	Arco	52	0.32 – 2.4	1.3
	Atomic City	48	0.37 – 2.3	1.2
	Blue Dome	49	0.44 – 2.6	1.1
	Federal Aviation Administration Tower	51	0.20 – 2.3	1.1
	Howe	51	0.48 – 2.2	1.3
	Monteview	51	0.50 – 2.6	1.4
	Mud Lake	52	0.48 – 2.6	1.3
			Boundary Median:	1.2
INL Site	EFS	51	0.28 – 2.4	1.2
	Main Gate	51	0.29 – 2.3	1.2
	Van Buren	52	0.42 – 12.2	1.2
			INL Site Median:	1.2
INL Contractor				
Distant	Blackfoot	46	0.07 – 3.0	1.2
	Craters of the Moon	46	0.02 – 3.1	0.9
	Idaho Falls	46	0.38 – 3.8	1.1
	Rexburg	46	-0.03 – 2.3	1.2
			Distant Median:	1.15
INL Site	ARA	21	0 – 2.2	1.0
	ATR Complex (south side)	45	-0.17 – 4.6	0.94
	ATR Complex (NE corner)	46	0.15 – 3.8	1.2
	CFA	45	0.13 – 3.7	1.2
	CITRC	45	-0.18 – 3.2	1.3
	INTEC (west side)	45	0.0 – 2.3	1.2
	EBR-I	44	0.1 – 8.7	1.2
	EFS	46	0.6 – 3.9	1.3
	Gate 4	46	0.29 – 3.6	1.3
	INTEC (NE corner)	45	0.04 – 3.9	1.2
	MFC	46	0.013 – 3.6	1.1
	NRF	46	-0.04 – 3.1	1.1
	Rest Area	46	-0.21 – 3.1	1.3
	RWMC	46	0.03 – 4.1	1.2
	SMC	46	-0.33 – 3.7	1.1
	TAN	46	-0.32 – 3.6	1.2
	Van Buren	45	0.24 – 2.7	1.2
			INL Site Median:	1.2

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 taken at EFS and Mud Lake.

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.



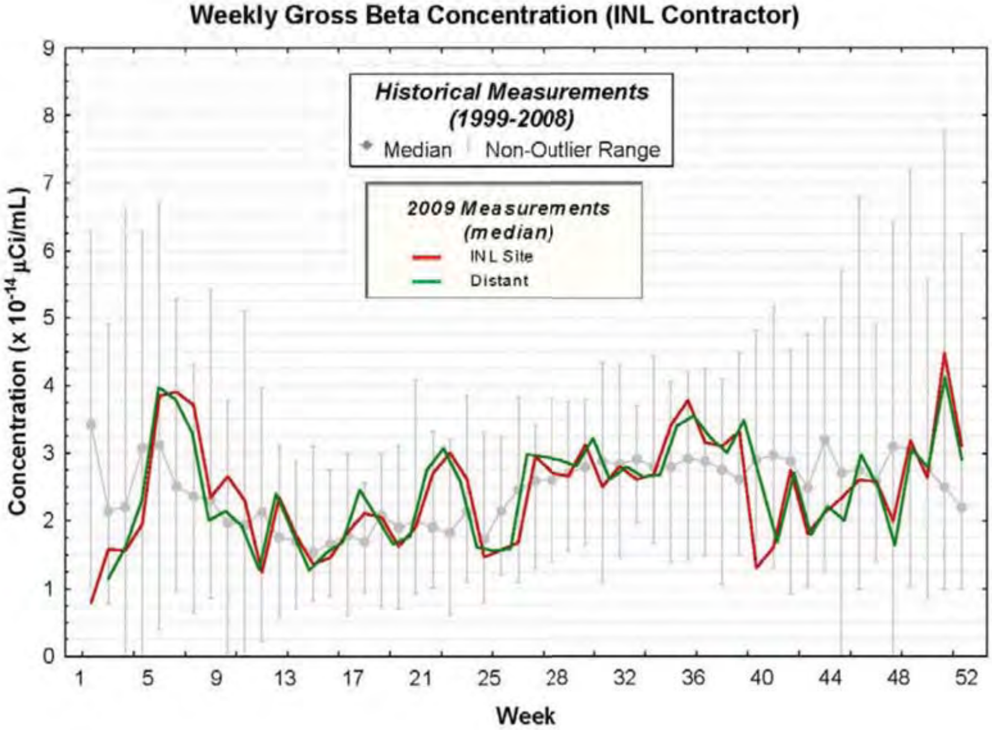


Figure 4-4. Median Weekly Gross Beta Concentrations in Air (2009).

Table 4-4. Median Annual Gross Beta Concentrations in Air (2009).

Group	Location[a]	No. of Samples[b]	Range of Concentrations[c] ($\times 10^{-14}$ μCi/mL)	Annual Median[c] ($\times 10^{-14}$ μCi/mL)
ESER Contractor				
Distant	Blackfoot CMS	49	1.1 – 6.0	2.8
	Craters of the Moon	50	1.0 – 4.8	2.5
	Dubois	52	1.2 – 5.1	2.7
	Idaho Falls	52	1.2 – 5.6	2.9
	Jackson	50	1.2 – 5.5	2.5
	Rexburg CMS	50	1.2 – 5.3	2.8
			Distant Median:	2.7
Boundary	Arco	52	1.2 – 5.7	2.8
	Atomic City	48	1.3 – 5.3	3.0
	Blue Dome	49	1.2 – 4.9	2.5
	Federal Aviation Administration Tower	51	0.84 – 4.9	2.5
	Howe	51	1.4 – 5.9	2.9
	Monteview	51	1.4 – 5.5	2.6
	Mud Lake	52	1.4 – 6.4	2.9
			Boundary Median:	2.8
INL Site	EFS	51	1.2 – 5.4	2.9
	Main Gate	51	1.1 – 5.7	2.9
	Van Buren	52	1.4 – 5.4	2.9
			INL Site Median:	2.9
INL Contractor				
Distant	Blackfoot	46	1.1 – 4.4	2.4
	Craters of the Moon	46	0.88 – 4.5	2.4
	Idaho Falls	46	1.1 – 4.7	2.4
	Rexburg	46	1.3 – 4.5	2.6
			Distant Median	2.4
INL Site	ARA	21	0.84 – 4.5	2.6
	ATR Complex (south side)	45	1.1 – 13	2.6
	ATR Complex (NE corner)	46	0.44 – 4.9	2.5
	CFA	44	1.3 – 4.1	2.6
	CITRC	45	0.89 – 4.6	2.6
	INTEC (west side)	46	0.97 – 4.3	2.5
	EBR-I	44	0.82 – 11	2.4
	EFS	46	0.75 – 4.9	2.7
	Gate 4	46	1.3 – 4.9	2.7
	INTEC (NE corner)	45	1.3 – 5.2	2.5
	MFC	46	1.1 – 4.0	2.4
	NRF	46	1.4 – 4.5	2.5
	Rest Area	46	1.3 – 4.5	2.6
	RWMC	46	0.95 – 4.6	2.3
	SMC	46	1.1 – 5.3	2.6
	TAN	46	1.2 – 5.2	2.5
	Van Buren	45	1.3 – 4.4	2.5
			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 taken at EFS and Mud Lake.

c. All measurements, including those <3s, are included in this table and in computation of median annual values.

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 2009.

  There were a few statistical differences between weekly boundary and distant data sets collected by the ESER contractor during the 52 weeks of 2009 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.stoller-eser.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 – Human-made radionuclides were detected in some ESER contractor quarterly composite samples (Table 4-5).

Since mid-1995, the ESER contractor has detected ^{241}Am in some air samples, although no pattern has been discernable with respect to time or location. Americium-241 was detected in

Table 4-5. Human-made Radionuclides Detected in ESER Contractor Quarterly Composite Air Samples (2009).[a]

Location	Cesium-137	Americium-241	Plutonium-238	Plutonium-239/240	Strontium-90
			(× 10^{-18} μCi/mL)		
			First Quarter 2009		
FAA[b] Tower	ND[c]	ND	ND	ND	82 ± 16
			Second Quarter 2009		
Idaho Falls	ND	7.6 ± 1.2	ND	ND	ND
Van Buren Gate	ND	146 ± 12	ND	ND	ND
			Third Quarter 2009		
Mud Lake	ND	2.1 ± 0.6	ND	ND	NA
			Fourth Quarter 2009		
			No radionuclides were detected		

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

b. FAA = Federal Aviation Administration.

c. ND = not detected.

d. NA = not analyzed for this radionuclide.

three quarterly composited samples collected on the INL Site at Van Buren, at boundary location Mud Lake and the distant location of Idaho Falls. The distant and boundary results detected in 2009 are within the historical range and were well below the ^{241}Am DCG of 20,000 × 10^{-18} µCi/mL (see Table A-1 of Appendix A). As discussed in the Gross Alpha section the ^{241}Am result was above the normal range of detections. It appeared to be associated with the initiation of road construction in the vicinity of the air sampler. This construction required tearing up the roadbed and the most likely source of the ^{241}Am is a particle in the materials used in the old roadbed. Although the measured concentration is outside the normal range it is still less than one percent of the DCG.

Plutonium isotopes were not detected in any INL Site and boundary ESER samples in 2009.

Strontium-90 was detected in one ESER sample from the boundary location at the Federal Aviation Administration Tower. The measured concentration was in the middle of the range of detections over the past few years and a small fraction of the DCG of 9,000,000 × 10^{-18} µCi/mL (see Table A-1 of Appendix A).

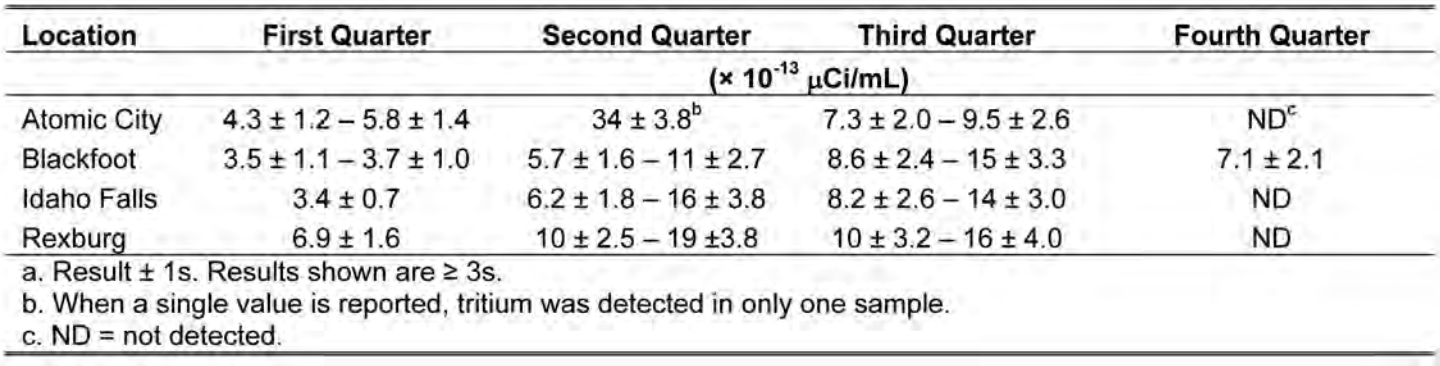
Cesium-137 was not detected in any ESER samples in 2009.

Natural ^{7}Be was detected in numerous 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, MFC, and Van Buren Boulevard on the INL Site and at Idaho Falls and Craters of the Moon off the INL Site. During 2009, 50 samples were collected. Tritium was not detected in any sample.

Table 4-6. Ranges of Tritium Concentrations Detected in ESER Contractor Atmospheric Moisture Samples (2009).[a]



Location	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
		($\times 10^{-13}$ µCi/mL)		
Atomic City	4.3 ± 1.2 – 5.8 ± 1.4	34 ± 3.8[b]	7.3 ± 2.0 – 9.5 ± 2.6	ND[c]
Blackfoot	3.5 ± 1.1 – 3.7 ± 1.0	5.7 ± 1.6 – 11 ± 2.7	8.6 ± 2.4 – 15 ± 3.3	7.1 ± 2.1
Idaho Falls	3.4 ± 0.7	6.2 ± 1.8 – 16 ± 3.8	8.2 ± 2.6 – 14 ± 3.0	ND
Rexburg	6.9 ± 1.6	10 ± 2.5 – 19 ±3.8	10 ± 3.2 – 16 ± 4.0	ND

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.

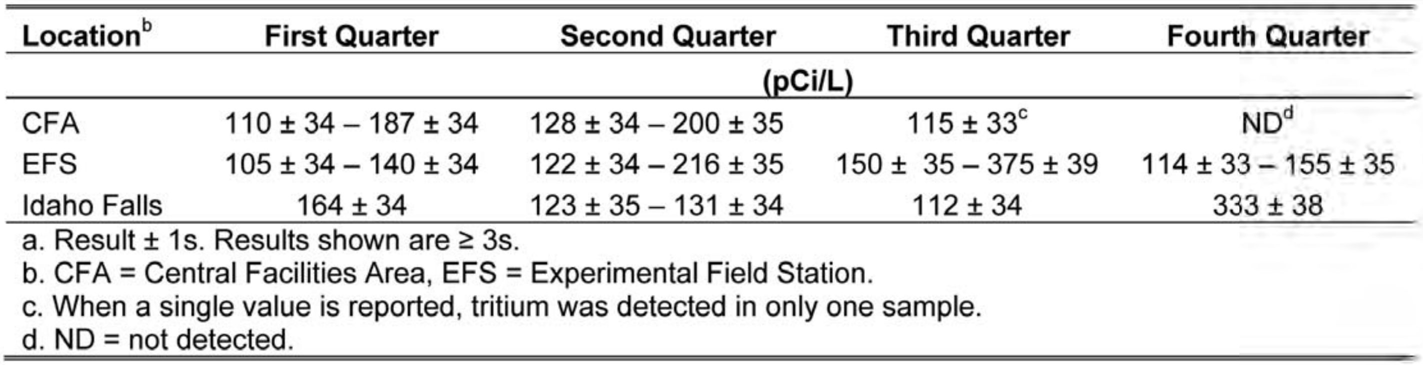
Bristly Cutworm Moth

During 2009, the ESER contractor collected 61 atmospheric moisture samples at Atomic City, Blackfoot, Idaho Falls, and Rexburg. Table 4-6 presents the range of values detected at each station by quarter. Tritium was detected in 31 samples, ranging from a low of 3.4 × 10^{-13} µCi/mL at Idaho Falls to a high of 34 × 10^{-13} µCi/mL at Atomic City. The detections are consistent with historical measurements. The highest concentration of tritium detected in an atmospheric moisture sample since 1998 was 38 × 10^{-13} µCi/mL at Atomic City. The results 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. 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 51 precipitation samples were collected during 2009 from the three sites. Tritium concentrations were detected in 32 samples, and results ranged from 105 pCi/L at EFS to 375 pCi/L, also at EFS. Table 4-7 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/).

Table 4-7. Ranges of Tritium Concentrations Detected in ESER Contractor Precipitation Samples (2009).[a]



Location[b]	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
		(pCi/L)		
CFA	110 ± 34 – 187 ± 34	128 ± 34 – 200 ± 35	115 ± 33[c]	ND[d]
EFS	105 ± 34 – 140 ± 34	122 ± 34 – 216 ± 35	150 ± 35 – 375 ± 39	114 ± 33 – 155 ± 35
Idaho Falls	164 ± 34	123 ± 35 – 131 ± 34	112 ± 34	333 ± 38

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.

4.3.4 Suspended Particulates Monitoring Results

In 2009, the ESER contractor measured concentrations of suspended particulates using filters collected from the low-volume air samplers. The filters are 99 percent efficient for collection of particles greater than 0.3 µm in diameter. That is, they collect the total particulate load greater than 0.3 µm in diameter.

Particulate concentrations ranged from 0 µg/m^3 at several stations to 33 µg/m^3 at Howe. In general, particulate concentrations were higher at distant 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

Table 4-8. Gross Activity Concentrations Measured in ICP Contractor Air Samples (2009).[a]

Activity	Low (µCi/mL)	High (µCi/mL)	Annual Mean (µCi/mL)
	Subsurface Disposal Area (SDA)		
Gross Alpha	$(-7.7 \pm 0.78) \times 10^{-16}$ 2nd half of July at SDA 9.3	$(1.2 \pm 0.3) \times 10^{-14}$ 2nd half of September at SDA 1.3	2.2×10^{-15}
Gross Beta	$(-6.6 \pm 3.5) \times 10^{-16}$ 2nd half of September Blank Filter	$(6.7 \pm 0.69) \times 10^{-14}$ 1st half of December at SDA 1.3	2.4×10^{-14}
	Idaho CERCLA Disposal Facility (INT)		
Gross Alpha	$(1.2 \pm 0.43) \text{ x } 10^{-15}$ 1st half of October at INT 100.3	$(4.2 \pm 1.4) \text{ x } 10^{-15}$ 1st half of May at INT 100.3	$2.7 \text{ x } 10^{-15}$
Gross Beta	$(1.5 \pm 0.24) \text{ x } 10^{-14}$ 2nd half of March at INT 100.3	$(4.7 \pm 0.7) \text{ x } 10^{-14}$ 2nd half of January at INT 100.3	$2.8 \text{ x } 10^{-14}$

a. Result ± 1s.

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 2009 (see 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. Table 4-8 shows the gross alpha and gross beta monitoring results. The results 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 2009, no human-made, gamma-emitting radionuclides were detected at the Subsurface Disposal Area of RWMC and the Idaho CERCLA Disposal Facility at INTEC.

Table 4-9 shows alpha- and beta-emitting radionuclides detected in air samples analyzed using radiochemistry in 2009. These detections are consistent with levels measured in resuspended soils at RWMC in previous years. The values and locations for plutonium and americium detections remained consistent from 2008 to 2009. Strontium-90 results also were consistent with previous years; however, they could not be compared to 2008 due to the fact that 2008 data were rejected based on analytical laboratory problems. All of the detections shown in

Figure 4-5. Locations of Low-volume Air Samplers at Waste Management Areas.

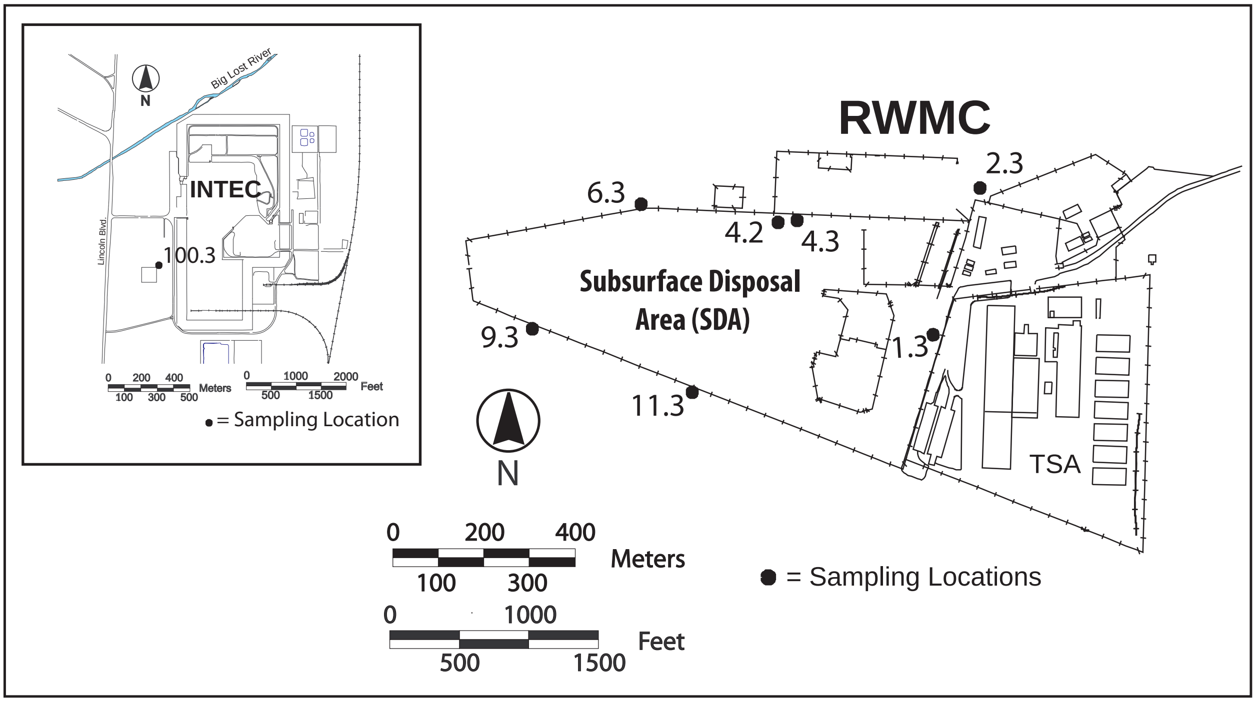


Table 4-9 likely are due to resuspension of contaminated soils at the Subsurface Disposal Area and the Accelerated Retrieval Project. In addition, the soils outside RWMC are contaminated as a result of early burial practices (Markham et al. 1978). The ICP contractor will continue to closely monitor these radionuclides for any changes in trends.

Table 4-9. Human-made Radionuclides Detected in ICP Contractor Air Samples (2009).[a]

Radionuclide	Result (µCi/mL)	Location	Quarter Detected
Am-241	(1.7 ± 0.39) × 10^{-17}	SDA[b] 4.2	2nd
	(2.7 ± 0.43) × 10^{-17}	SDA 4.3	2nd
	(1.3 ± 0.33) x 10^{-17}	SDA 11.3	2nd
	(3.1 ± 0.61) × 10^{-17}	SDA 1.3	3rd
	(3.8 ± 0.75) × 10^{-17}	SDA 2.3	3rd
	(2.2 ± 0.47) × 10^{-17}	SDA 4.3	3rd
	(1.2 ± 0.34 × 10^{-17}	SDA 6.3	3rd
	(1.8 ± 0.39) × 10^{-17}	SDA 11.3	3rd
	(1.4 ± 0.40) × 10^{-17}	SDA 4.2	4th
Pu-239/240	(1.3 ± 0.11) × 10^{-16}	SDA 4.2	2nd
	(5.8 ± 1.76) × 10^{-18}	SDA 4.3	2nd
	(7.4 ± 2.03) × 10^{-18}	SDA 6.3	2nd
	(3.6 ± 0.30) × 10^{-16}	SDA 1.3	3rd
	(4.5 ± 0.73) × 10^{-17}	SDA 2.3	3rd
	(1.1 ± 0.27) × 10^{-17}	SDA 6.3	3rd
	(2.6 ± 0.43) X 10^{-17}	SDA 11.3	3rd
	(4.0 ± 0.54 X 10^{-17}	SDA 4.2	4th
Sr-90	(1.0 ± 0.24) X 10^{-16}	INT[c]100.3	1st
	(1.0 ± 0.26) X 10^{-16}	SDA 4.2	1st
	(1.3 ± 0.29) X 10^{-16}	SDA 4.3	1st
	(1.5 ± 0.32) X 10^{-16}	SDA 6.3	1st
	(1.4 ± 0.36) X 10^{-16}	SDA 9.3	1st
	(6.5 ± 2.14) X 10^{-17}	SDA 11.3	1st
	(1.2 ± 0.38) X 10^{-16}	INT 100.3	2nd
	(1.5 ± 0.29) X 10^{-16}	INT 100.3	3rd
	(1.7 ± 0.34) x 10^{-16}	SDA 4.3	3rd
	(1.3 ± 0.34) x 10^{-16}	SDA 6.3	3rd
	(7.8 ± 2.5) x 10^{-17}	SDA 9.3	3rd

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

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REFERENCES

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

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DOE-ID, 2010, *National Emissions Standards for Hazardous Air Pollutants—Calendar Year 2009 INL Report for Radionuclides*, DOE/ID-10890(10), U.S. Department of Energy Idaho Operations Office.

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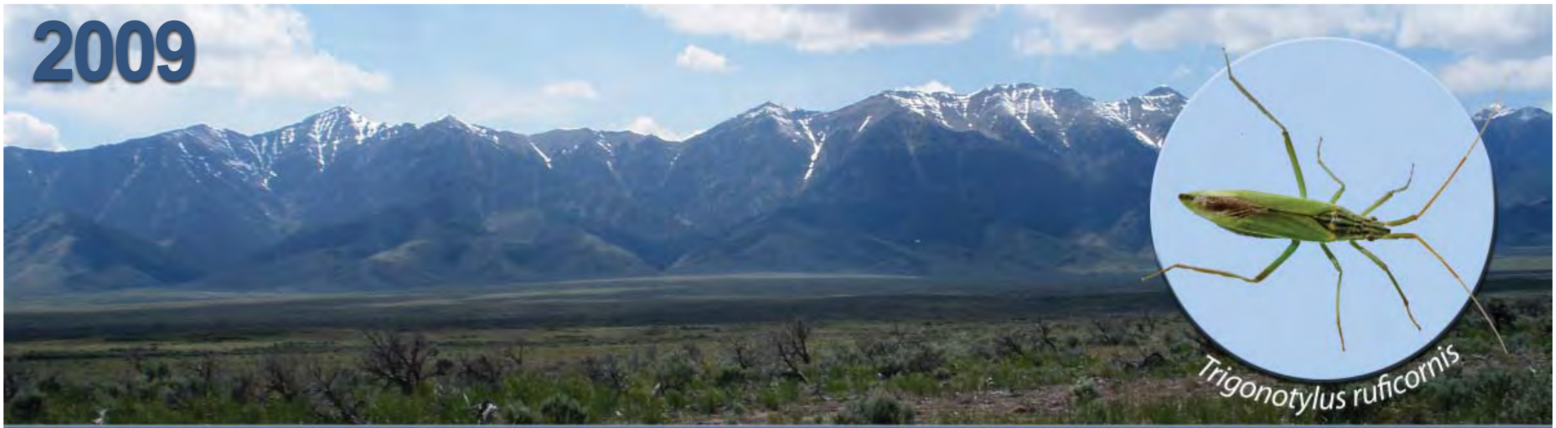
American Robin (Turdus migratorius) at Big Lost River Rest Area



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

Chapter Highlights

Liquid effluents, drinking water, and storm water runoff were monitored in 2009 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 2009, 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.

These facilities were sampled for parameters required by their facility-specific permits. No permit limits were exceeded in 2009.

Additional liquid effluent monitoring was performed in 2009 at Advanced Test Reactor (ATR) Complex, Central Facilities Area (CFA), Idaho Nuclear Technology and Engineering Center (INTEC), and Materials and Fuels Complex 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.

Eleven drinking water systems were monitored in 2009 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. It was 0.27 mrem for 2009. 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 2009 for radionuclides in compliance with DOE limits. Most results were within historical measurements. Exceptions were americium-241 and

Scarab beetle

plutonium-239/240, although these were below Department of Energy derived concentration guides and EPA maximum contaminant levels. In addition, plutonium-238 was detected for the first time in the fourth quarter. Surface water runoff will be monitored monthly 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 B.

5.1 Summary of Monitoring Programs

The INL contractor and ICP contractor monitor liquid effluent and groundwater that could be impacted by the release of liquid effluent, drinking water, and surface water runoff 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 2008).

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 either or both in the vicinity of or downgradient of the liquid releases. Wastewater is discharged to the ground surface at the following areas:

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

Discharge of wastewater to the land surface is regulated by wastewater rules (Idaho Administrative Procedures Act [IDAPA] 58.01.16 and .17). A wastewater reuse permit normally

requires monitoring of nonradioactive parameters in the influent waste, effluent waste, and groundwater, as applicable. However, some facilities may have specified radiological parameters monitored for surveillance (not required by regulations) purposes. 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 2009.

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,

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

	Media				
Area/Facility	**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				●	

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.

application rates, and effluent quality limits. Annual reports (ICP 2010a, 2010b; INL 2010a, 2010b, 2010c) were prepared and submitted to the state of Idaho Department of Environmental Quality (DEQ) as required for permitted facilities.

During 2009, the INL contractor and ICP contractor monitored, as required by the permits, the following facilities (Table 5-2):

- CFA Sewage Treatment Plant
- INTEC New Percolation Ponds
- ATR Complex Cold Waste Pond.

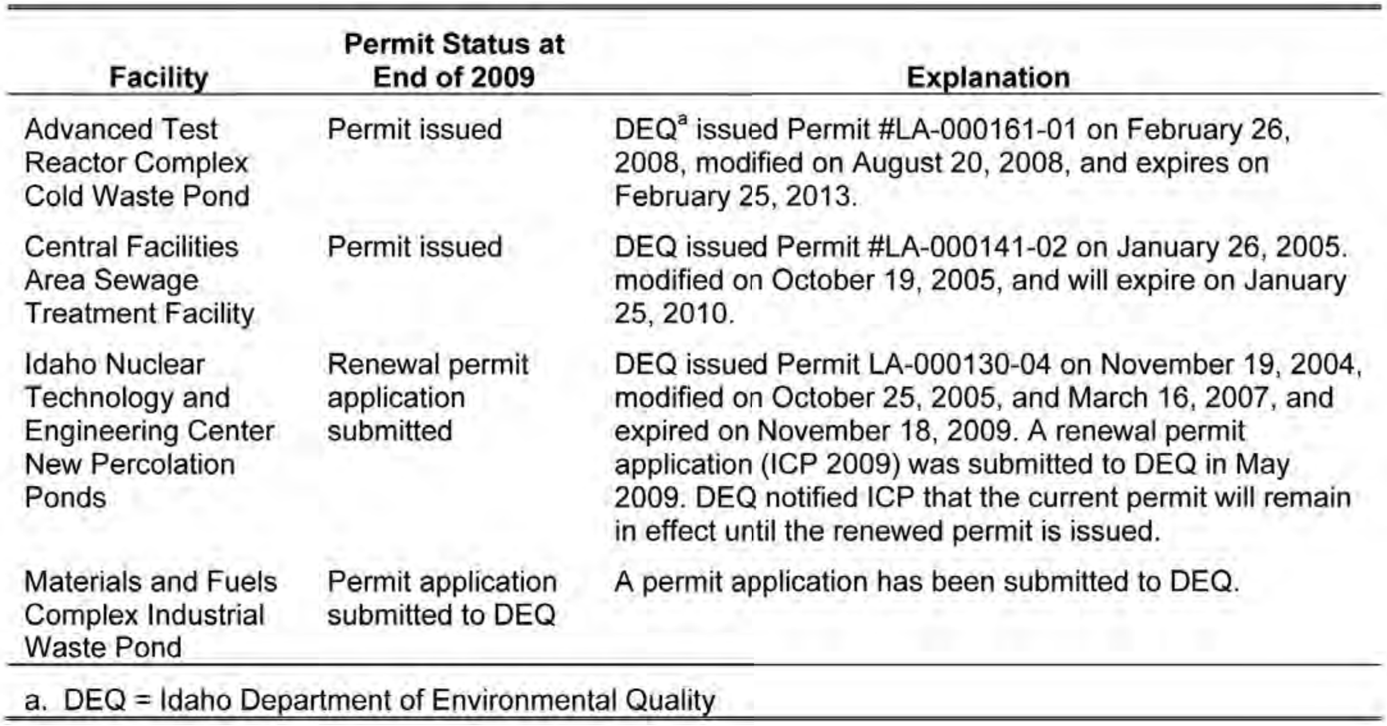
The following subsections present results of wastewater and groundwater monitored to comply with facility-specific permits.

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

Table 5-2. Status of Wastewater Reuse Permits.



Facility	Permit Status at End of 2009	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 that the current permit will remain in effect until the renewed permit is issued.
Materials and Fuels Complex Industrial Waste Pond	Permit application submitted to DEQ	A permit application has been submitted to DEQ.

a. DEQ = Idaho Department of Environmental Quality

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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 2009 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 – The permit requires influent and effluent monitoring and soil sampling in the wastewater reuse area (see Chapter 7 for results pertaining to soils). In 2009, influent samples were collected monthly from the lift station at CFA, and effluent samples were collected from the pump pit (prior to the pivot irrigation system) in September. All samples were collected as 24-hour flow proportional composites, except pH and coliform samples, which were collected as grab samples. Tables B-1 and B-2 summarize the results.

Wastewater was intermittently applied via the center pivot irrigation system in September 2009. On the days it operated, discharge to the pivot irrigation system averaged 765,739 L/day (202,155 gallons/day).

A total of 3.03 million gallons (MG) of wastewater was applied to the land in 2009, which is equivalent to a loading rate of 1.52 acre-in./acre/yr. This is significantly less than the permit limit of 46 MG (23.0 acre-in./acre/yr). The nitrogen loading rate (0.84 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 (16.03 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 (0.10 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.

The INL contractor tracks operating parameters for the CFA lagoon for information only. For example, removal efficiencies were calculated to gauge treatment. The removal efficiency for total suspended solids was above the design criterion of 80 percent, and the removal efficiency for chemical oxygen demand was 65 percent. The removal efficiency for total nitrogen was 83 percent.

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 average) of those permit-limited parameters are shown in Table 5-3. During 2009, 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 B-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.

Table 5-3. Total Nitrogen and Total Suspended Solids Effluent Monitoring Results at Advanced Test Reactor Complex Cold Waste Pond (2009).

Parameter	Minimum	Maximum	Median	Permit Limit
Total nitrogen[a] (mg/L)	0.994	4.338	2.846	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.

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 B-4).

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 a rapid infiltration system and 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.

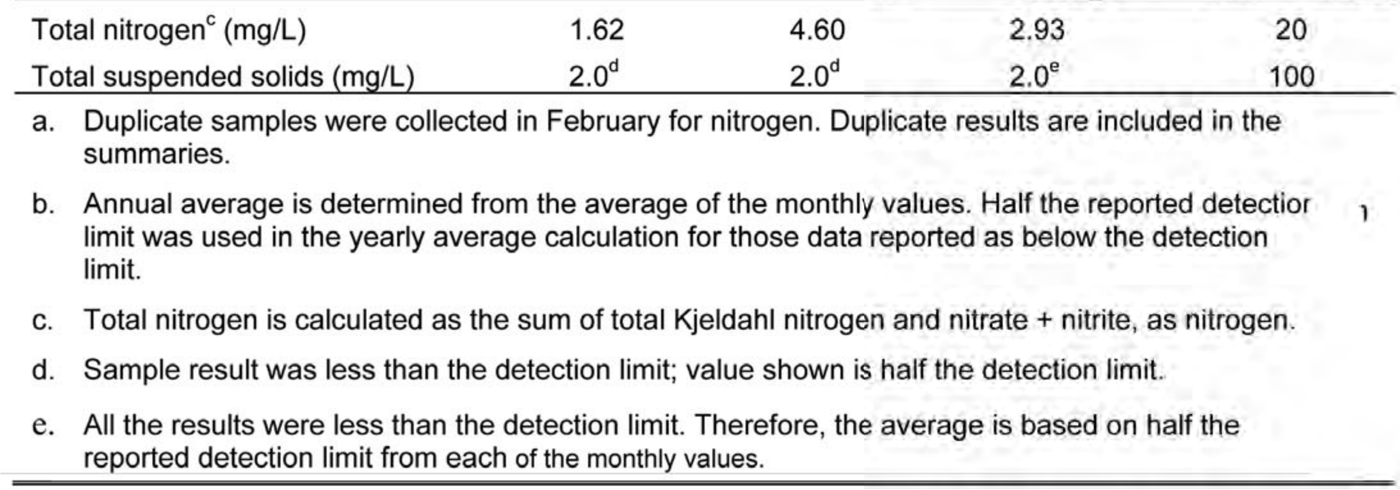
Wastewater Monitoring Results for the Wastewater Reuse Permit – Monthly samples were collected from:

- 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 B-5 and B-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 2009, 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 B-7.

Table 5-4. Total Nitrogen and Total Suspended Solids Effluent Monitoring Results at CPP-797 (2009).[a]



Parameter	Minimum	Maximum	Average[b]	Permit Limit
Total nitrogen[c] (mg/L)	1.62	4.60	2.93	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.

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 2009.

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
- 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.

Table 5-5. Hydraulic Loading Rates for Idaho Nuclear Technology and Engineering Center New Percolation Ponds (2009).

	2009 Flow	Permit Limit
Maximum daily (MG)	1.022	3
Yearly total (MG)	291.552	1,095

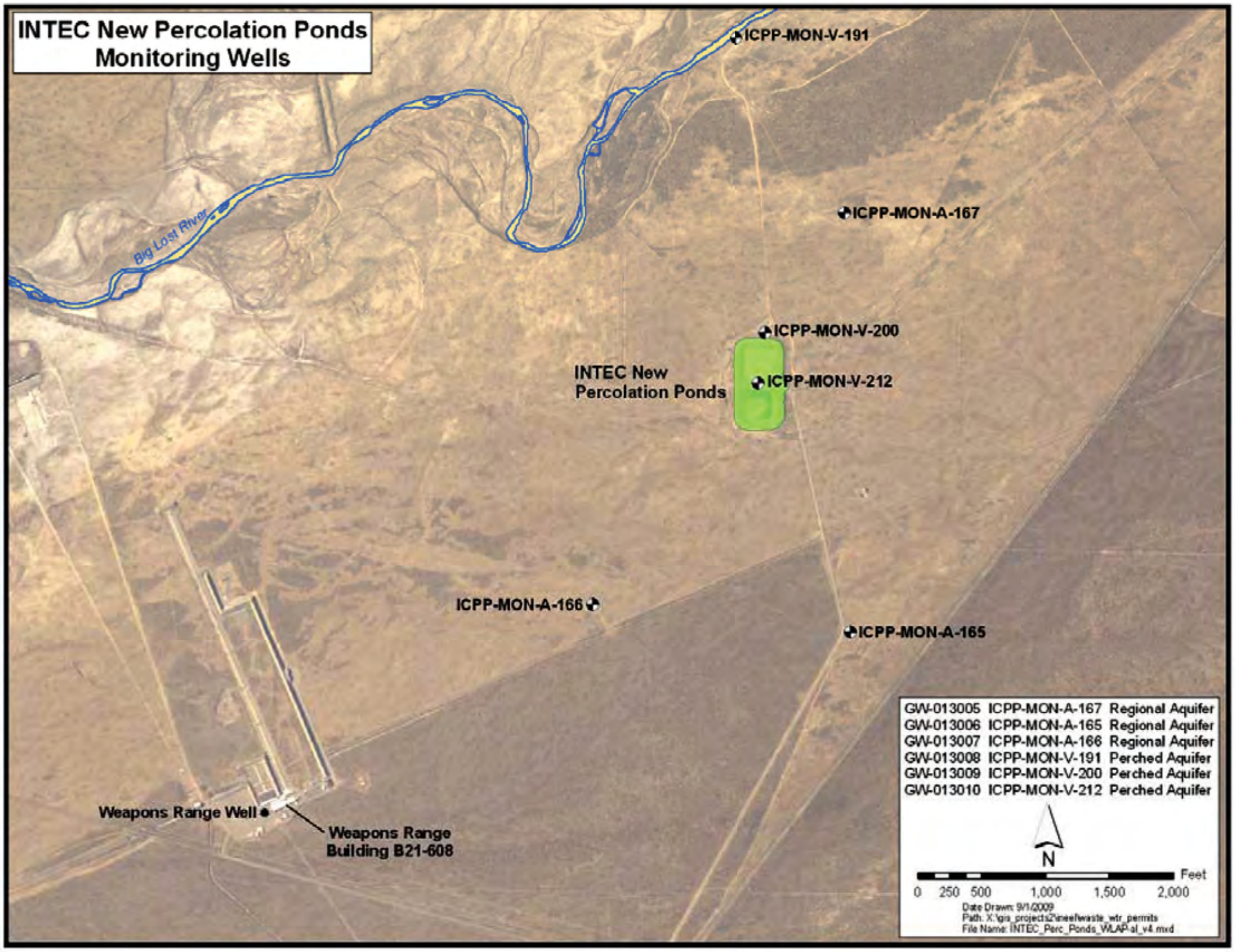


Figure 5-1. Permitted Monitoring Locations southwest of the Idaho Nuclear Technology and Engineering Center (*Weapons Range Well is not a permitted well and is shown for location reference only*).

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 B-8 shows the April and October 2009 analytical results (minimum, maximum, and average) for all parameters specified by the permit for the aquifer wells. Table B-8 also depicts the depth to water table and water table elevations determined before purging and sampling. Table B-9 presents similar information for the perched water wells. Most permit-required monitoring parameters remained below their respective primary constituent standard or secondary constituent standard during 2009 for all wells associated with the INTEC New Percolation Ponds. No permit noncompliances occurred.

Samples were collected from upgradient aquifer Well ICPP-MON-A-167 during the April 2009 and July 2009 sampling event using a bailer. During the October 2009 sampling event, the well only had 0.25 m (0.83 ft) of water in it. The well was considered dry, and therefore, no samples were collected.

Aluminum, Iron, and Manganese Concentrations – Aluminum and iron concentrations in unfiltered samples from permitted aquifer and perched water monitoring wells for the INTEC New Percolation Ponds have exceeded the associated groundwater quality standards in the past. Elevated concentrations were detected in preoperational unfiltered groundwater samples taken downgradient (aquifer Well ICPP-MON-A-166) and upgradient (aquifer Well ICPP-MON-A-167) of the INTEC New Percolation Ponds. For aquifer wells, the preoperational concentrations (Table 5-6) in the upgradient aquifer well (ICPP-MON-A-167) are considered the natural background level (IDAPA 58.01.11) and are used for determining compliance with the permit and the “Ground Water Quality Rule.” If concentrations of aluminum, iron, or manganese in aquifer wells exceed a secondary constituent standard, yet are below the preoperational upgradient concentrations, they are considered in compliance with the permit and the “Ground Water Quality Rule.”

Unlike the aquifer wells, preoperational samples could not be collected from the perched water wells because of insufficient water volumes. Therefore, the primary constituent standards and secondary constituent standards from the “Ground Water Quality Rule” (IDAPA 58.01.11) are used to determine compliance for the perched water wells.

Concentrations of aluminum, iron, and manganese in aquifer Well ICPP-MON-A-165, and iron and manganese in aquifer Well ICPP-MON-A-166, were below their associated secondary constituent standards, as shown in Table B-8. Concentrations of aluminum in aquifer Well ICPP-MON-A-166 exceeded the associated secondary constituent standard, but were below the preoperational concentrations in upgradient aquifer Well ICPP-MON-A-167 (Table 5-6) and are considered in compliance with the permit and the “Ground Water Quality Rule.”

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.

Concentrations of aluminum, iron, and manganese exceeded the secondary constituent standards and the preoperational concentrations in aquifer Well ICPP-MON-A-167 in April 2009 (Table B-8). There was not enough water in this well to sample during the October 2009 sampling event. Aquifer Well ICPP-MON-A-167 is an upgradient, noncompliance point and is outside the zone of influence of the INTEC New Percolation Ponds. Therefore, these exceedances of preoperational concentrations are not considered permit noncompliances.

Concentrations of aluminum, iron, and manganese in perched water Wells ICPP-MON-V-200 and ICPP-MON-V-212 were below their associated secondary constituent standards, as shown in Table B-9. Upgradient perched water Well ICPP-MON-V-191 was dry in April and October 2009, and, therefore, samples could not be collected. However, perched water Well ICPP-MON-V-191 was sampled in July 2009, and the concentrations of aluminum, iron, and manganese exceeded the associated secondary constituent standards (Table B-9). Perched water Well ICPP-MON-V-191 is an upgradient, noncompliance well.

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-V-200, ICPP-MON-V-191, 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 (ICP 2009), the ICP contractor recommended to DEQ that the permit be modified to require collecting both filtered and unfiltered metals samples and to base compliance on filtered samples.

Total Dissolved Solids and Chloride Concentrations in Groundwater – Total dissolved solids and chloride concentrations in perched water have declined from those of previous years. In 2009, total dissolved solids and chloride concentrations were below their secondary constituent standards in perched water Wells ICPP-MON-V-200 and ICPP-MON-V-212 (Table B-9).

Scarab beetle

Total dissolved solids and chloride concentrations in the downgradient aquifer monitoring Well ICPP-MON-A-165 had steadily increased since the INTEC New Percolation Ponds were placed into service in August 2002. However, significant increases in total dissolved solids and chloride concentrations have not been identified in downgradient aquifer monitoring Well ICPP-MON-A-166. Concentrations of total dissolved solids and chloride in groundwater near the INTEC New Percolation Ponds are influenced by the wastewater discharges from the CPP-606 Treated Water System (ICP 2007). To reduce concentrations of total dissolved solids and chloride in groundwater, a new water treatment system was installed at INTEC in December 2007. As shown in Tables B-8 and B-9, concentrations of total dissolved solids and chloride were below the groundwater quality standards in 2009.

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 B-10 lists wastewater surveillance monitoring results for those parameters with at least one detected result. Groundwater monitoring results are summarized in Table B-11. 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. Strontium-90 was detected in TRA-08 below the maximum contaminant level of 8 pCi/L.

5.3.2 Central Facilities Area

Both the influent and effluent to the CFA Sewage Treatment Facility are monitored according to the wastewater reuse permit. Table B-12 lists surveillance monitoring results for 2009 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 B-13 summarizes the additional monitoring conducted during 2009 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 2009, most additional parameters were within historical concentration levels, except for conductivity at CPP-769, which was about 150 μS/cm above its historical average, and conductivity at CPP-773, which was about 450 μS/cm above its historical average.

Bristly Cutworm Moth

5.3.4 Materials and Fuels Complex

During 2009, the Industrial Waste Pond, Industrial Waste Ditch, and Secondary Sanitary Lagoon were sampled monthly for iron, sodium, chloride, fluoride, sulfate, pH, conductivity, total suspended solids, turbidity, biochemical oxygen demand, gross alpha, gross beta, gamma spectrometry, tritium, and various other parameters. Additionally, samples for selected metals and radionuclides are collected once a year. Tables B-14 to B-16 summarize the analytical results for parameters that were detected in at least one sample. Because of heavy runoff in the spring and early summer, samples from the pond contained elevated levels of some analytes due to suspended sediment in the samples. The analytical results for the samples collected from the Sanitary Sewage Lagoon in March 2009 were rejected because the data suggest the samples were collected from snow melt on top of the ice and not representative of the lagoon.

Radioactive parameters were monitored and reported when detected. No radionuclides attributable to releases from MFC were detected.

5.4 Drinking Water Monitoring

The INL contractor and ICP contractor 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, Weapons 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 during months of operation. No compliance or construction samples were positive (present) for bacteria in 2009. Because of known groundwater plumes near two INL contractor drinking water wells, additional sampling is conducted for tritium at CFA and for trichloroethylene at TAN/TSF.

5.4.1 INL Site Drinking Water Monitoring Results

During 2009, the INL contractor collected 287 routine samples and 33 quality control samples from the nine INL Site drinking water systems. In addition to routine samples, the INL contractor also collected 23 nonroutine samples after a water main was repaired, a building put into service or maintenance repairs. Drinking water systems at Experimental Breeder Reactor I, CITRC, Weapons 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. Also, in 2009 uranium was monitored at all nine water systems. Because the results were less than the maximum contaminant level, they are not discussed further in this report. The same is true for the water systems that disinfect (e.g., ATR Complex, CFA, CITRC, Gun Range, MFC, TAN/CTF, and TAN/TSF). Total trihalomethanes and haloacetic acids were monitored, and those results were greatly less than the maximum contaminant levels of 80 and 60 ppb, respectively. 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 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 2009 calculation was based on the mean tritium concentration for the CFA distribution system in 2009. For the 2009 dose calculation,

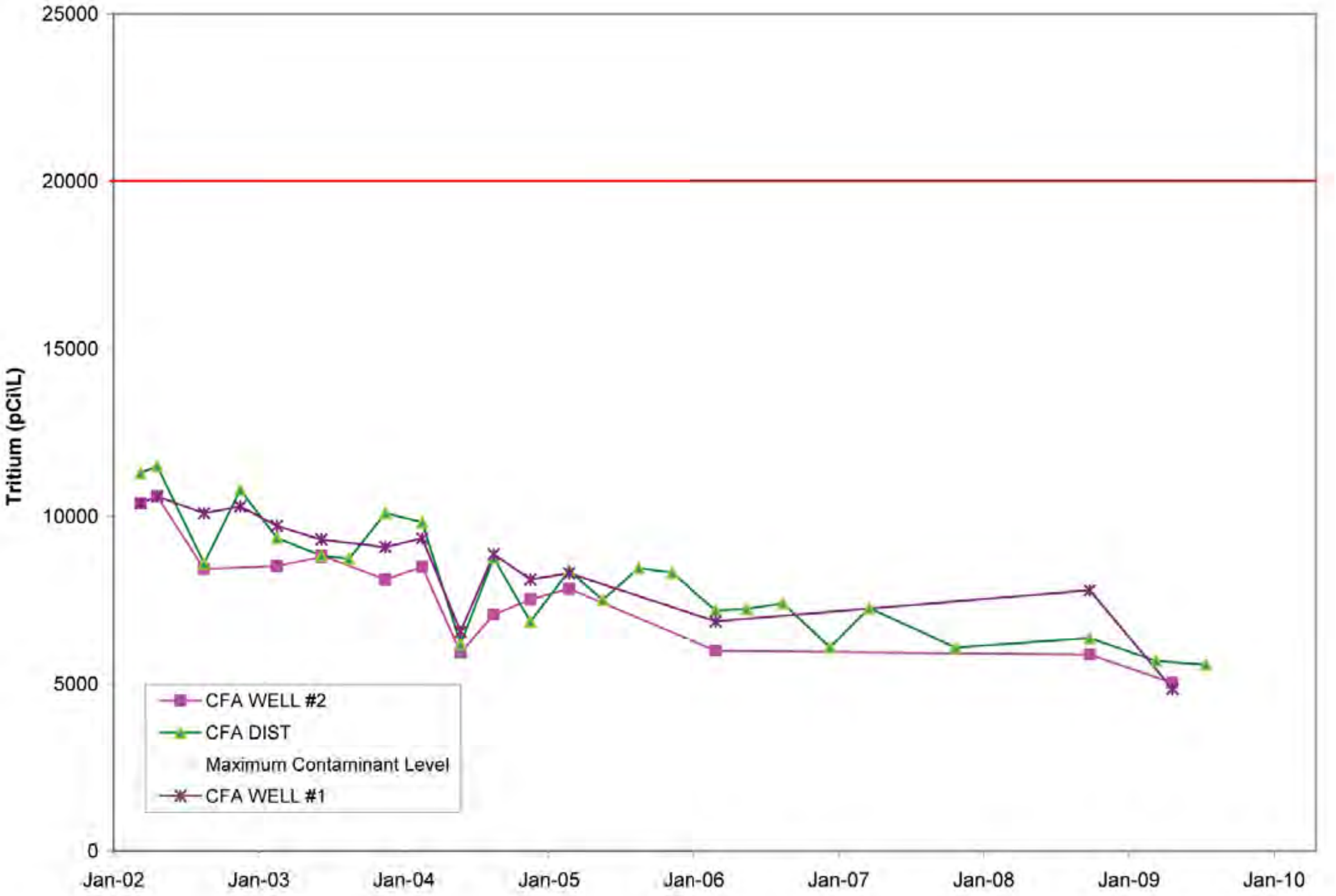


Figure 5-2. Tritium Concentrations in Two Central Facilities Area Wells and Distribution System (2002 – 2009).

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 2009 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

During 2009, the following drinking water samples were collected at INTEC:

- 29 routine (compliance) samples

- Two quality control samples (two field duplicates)
- 44 nonroutine samples (44 bacterial samples, associated primarily with water main repairs).

All parameters monitored at INTEC were below their respective drinking water limits in 2009.

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 at RWMC and the Advanced Mixed Waste Treatment Project.

During 2009, the following drinking water samples were collected at RWMC:

- 10 routine (compliance) samples
- 18 quality control samples (8 field duplicates, 4 trip blanks, 6 performance evaluation samples)
- 52 nonroutine samples (44 bacterial samples, primarily associated with water main repairs; 8 samples for 524.2 volatile organics).

Historically, carbon tetrachloride and trichloroethylene (524.2 volatile organics) had been detected in samples collected at WMF-603. In July 2007, a packed tower air stripping treatment system was placed into operation. During 2009, carbon tetrachloride and trichloroethylene were not detected (<0.5 µg/L) in any of the samples collected at WMF-604.

All other RWMC-monitored parameters were below their respective drinking water limits in 2009.

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 5-3 illustrates the trichloroethylene concentrations in both Well TSF #2 and the distribution system from 2001 through 2009. Table 5-7 summarizes the trichloroethylene concentrations at TSF #2 and the distribution system. The mean concentration at the distribution system for 2009 was less than the detection limit of 5.0 µg/L.

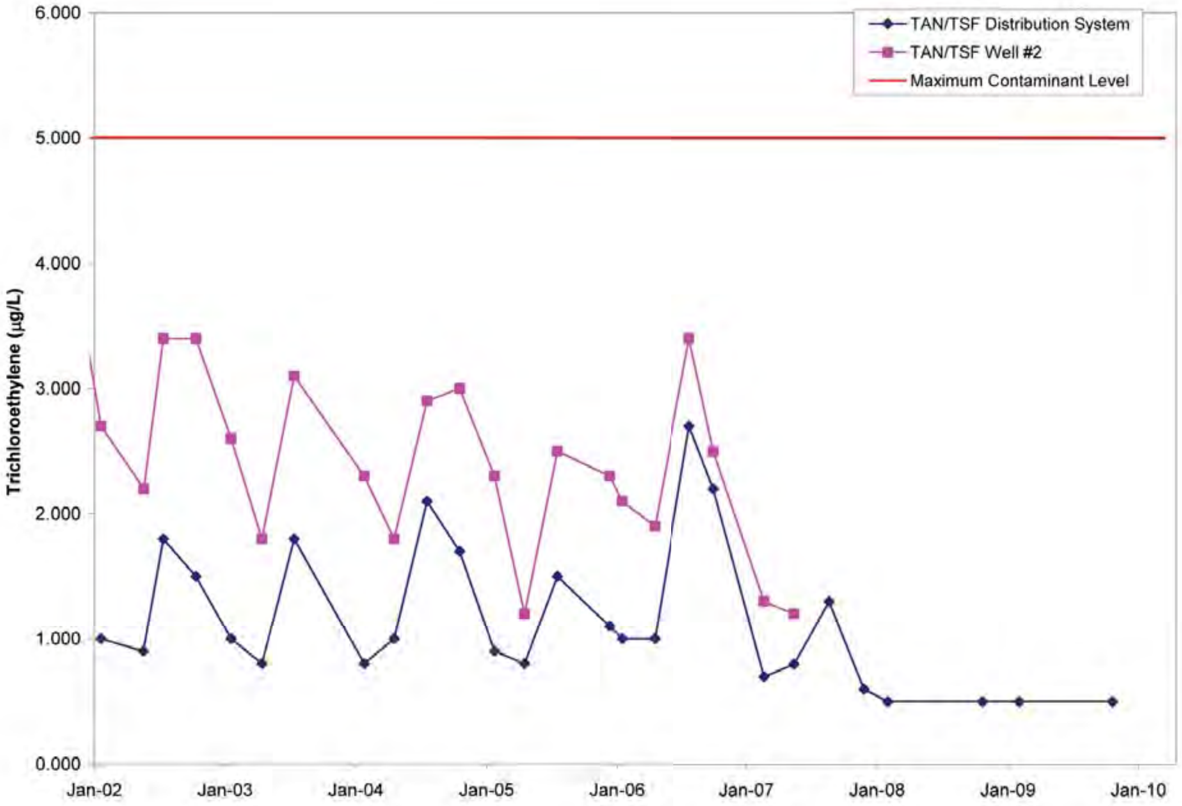


Figure 5-3. Trichloroethylene Concentrations in Technical Support Facility Drinking Water Well and Distribution System (2002 – 2009).

Table 5-7. Trichloroethylene Concentrations at Test Area North/Technical Support Facility Well #2 and Distribution System (2009).

Location	Number of Samples	Trichloroethylene Concentration (µg/L)			
		Minimum	Maximum	Mean	MCL
TAN/TSF #2 (612)[a]	0	NA	NA	NA	NA[b]
TAN/TSF Distribution (610)	2	<0.5	<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.

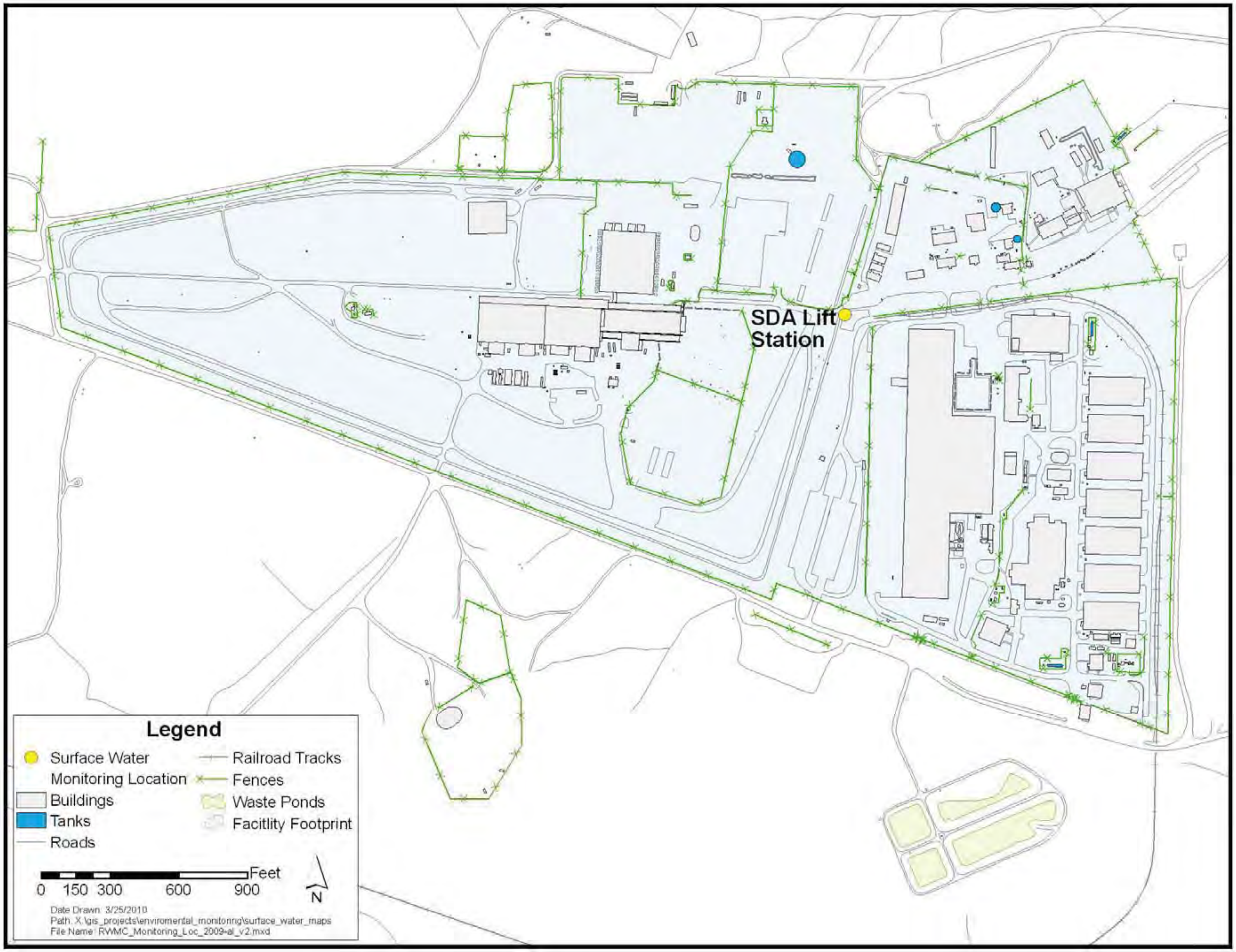


Figure 5-4. Surface Water Sampling Location at RWMC Subsurface Disposal Area.

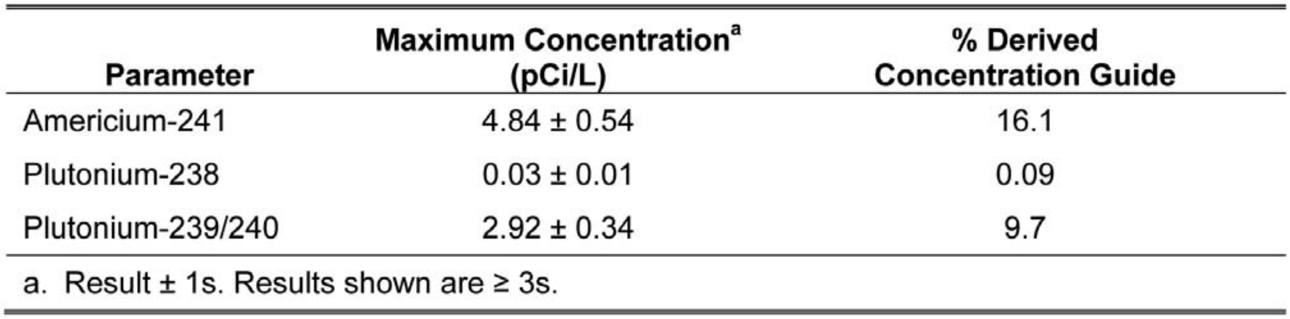
Bristly Cutworm Moth

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 5-4. The control location for the SDA is 1.5 km (0.93 mi) west from the Van Buren Boulevard intersection on U.S. Highway 20/26 and 10 m (33 ft) north on the T-12 Road. Surface water is collected to determine if radionuclide concentrations exceed administrative control levels or if concentrations have increased significantly compared to historical data.

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.

Table 5-8. Radionuclides Detected in Surface Water Runoff at the RWMC Subsurface Disposal Area (2009).



Parameter	Maximum Concentration[a] (pCi/L)	% Derived Concentration Guide
Americium-241	4.84 ± 0.54	16.1
Plutonium-238	0.03 ± 0.01	0.09
Plutonium-239/240	2.92 ± 0.34	9.7

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

Surface water runoff samples were collected at the SDA during the first, second, and fourth quarters of 2009. Table 5-8 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 remained consistent with 2008 detections. These detections are higher than historical concentrations. Even though these detections are higher than historical concentrations, they remain well below the applicable derived concentration guides and maximum contaminant levels. One positive plutonium-238 detection near the minimum detectable activity occurred during the fourth quarter. This is the first detection of plutonium-238, which has not been historically detected at the SDA. The ICP contractor will monitor monthly during 2010, when water is available, and evaluate the results to identify any abnormal trends.

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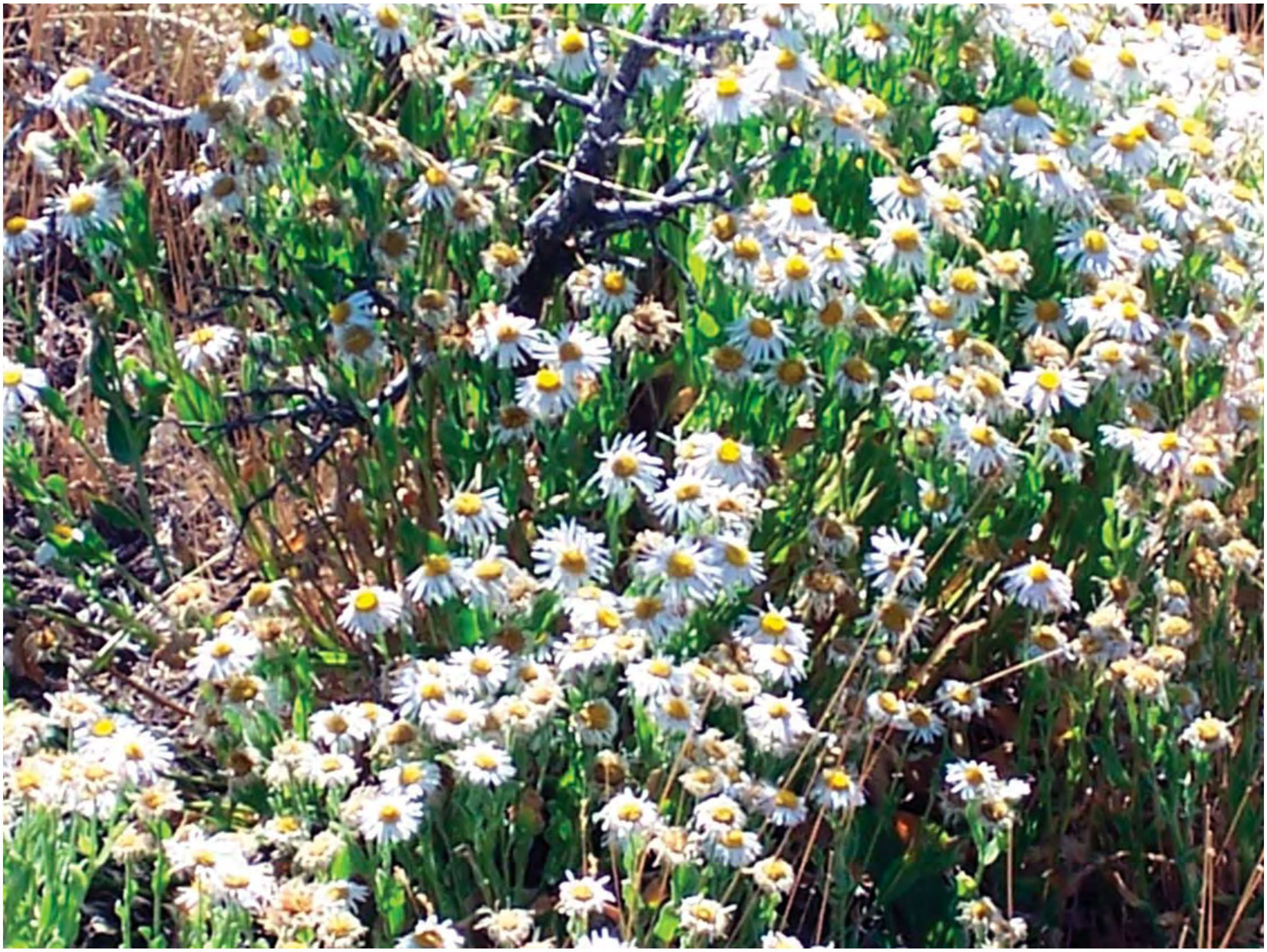
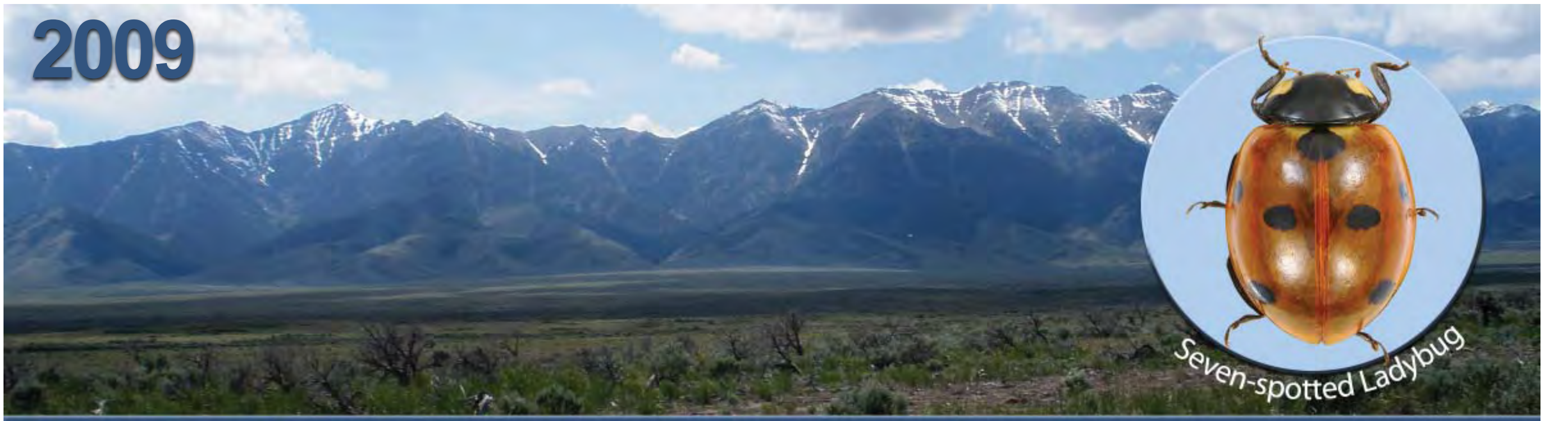


Showy Townsend Daisy (*Townsendia florifer)*



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 15 years.

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 2009. Concentrations of other organic compounds were below maximum contaminant levels and state of Idaho groundwater primary and secondary constituent standards for these constituents. Concentrations of chloride, sulfate, sodium, fluoride, and nitrate were also below the applicable standards in 2009. One chromium result was at the maximum contaminant level in 2009.

Groundwater surveillance monitoring required in area-specific Records of Decision under the Comprehensive Environmental Response, Compensation, and Liability Act was performed in 2009.

At Test Area North, in situ bioremediation is used to reduce the concentration of trichloroethene in the aquifer. The strategy is to promote the growth of naturally occurring bacteria that are able to break down the contaminant. Monitoring data for 2009 indicate the remedy is operating as planned.

Data from groundwater 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 19 monitoring wells at the Idaho Nuclear Technology and Engineering Center indicated strontium-90 concentrations exceed the maximum contaminant level at some locations. Technitium-99 and nitrate also exceed 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 only for volatile

compounds, and anions and two wells only for volatile organic compounds. Some nitrate concentrations exceeded their maximum contaminant levels in 2009, but concentrations were within historic levels. None of the organic compounds exceeded a maximum contaminant level.

At the Radioactive Waste Management Complex, nearly 3,500 analyses were performed on samples from monitoring wells in 2009. Carbon tetrachloride exceeded the maximum contaminant level in two wells but has shown a declining trend south of the facility since 2003. Gross beta activity was elevated in one well. It was conservatively assumed that the activity was entirely due to strontium-90 and therefore exceeded the maximum contaminant level for this radionuclide. However, gross beta activity typically includes naturally-occurring radionuclides, such as potassium-40, as well as other man-made radionuclides, and it is unlikely that the result represents a hazard to human health.

6. Environmental Monitoring Program – Eastern Snake River Plain Aquifer

This chapter discusses the hydrogeology of the Idaho National Laboratory (INL) Site and presents results from sampling conducted by the 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.

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 2009, 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.

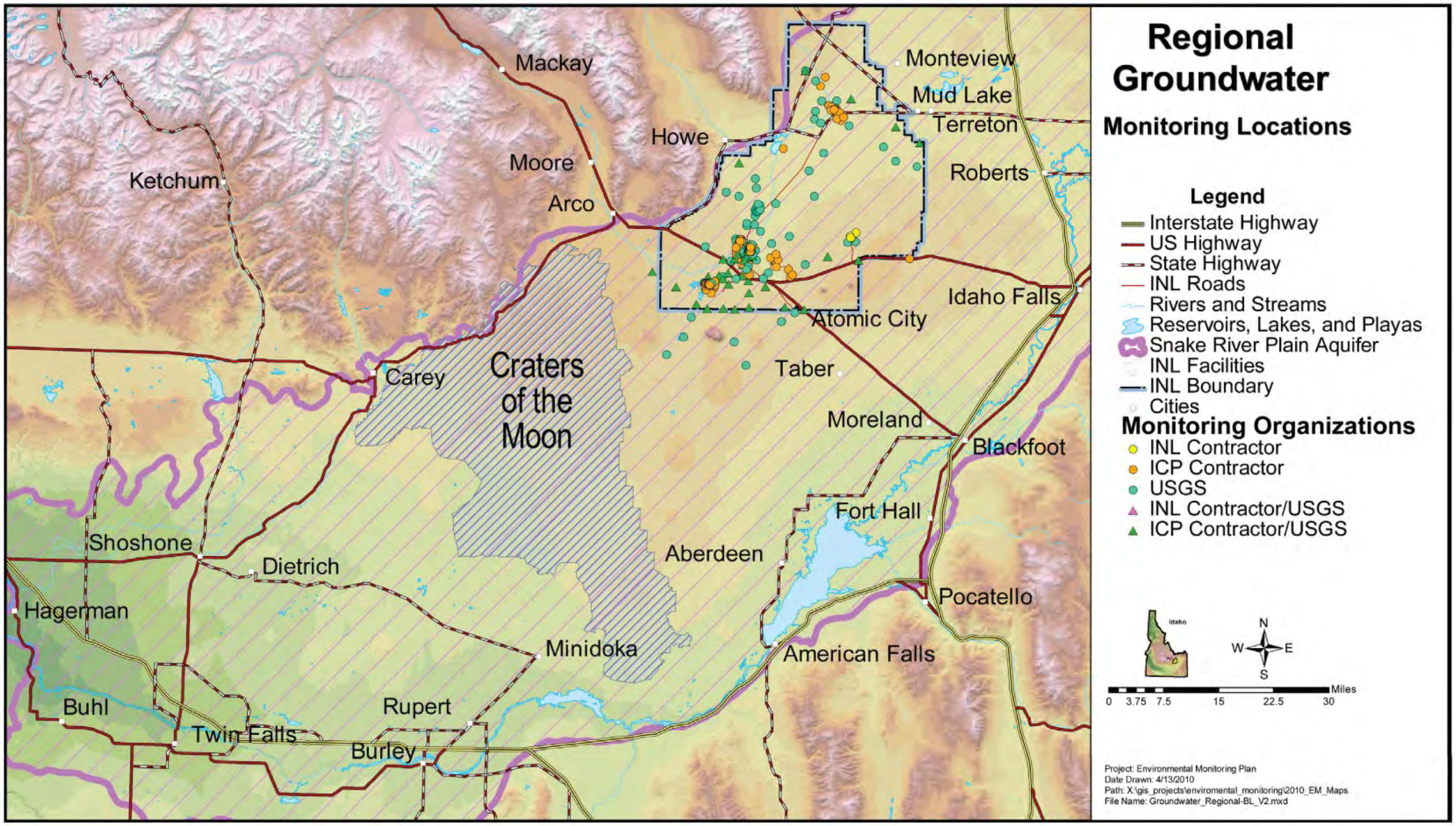


Figure 6-1. Regional Groundwater Monitoring Locations.

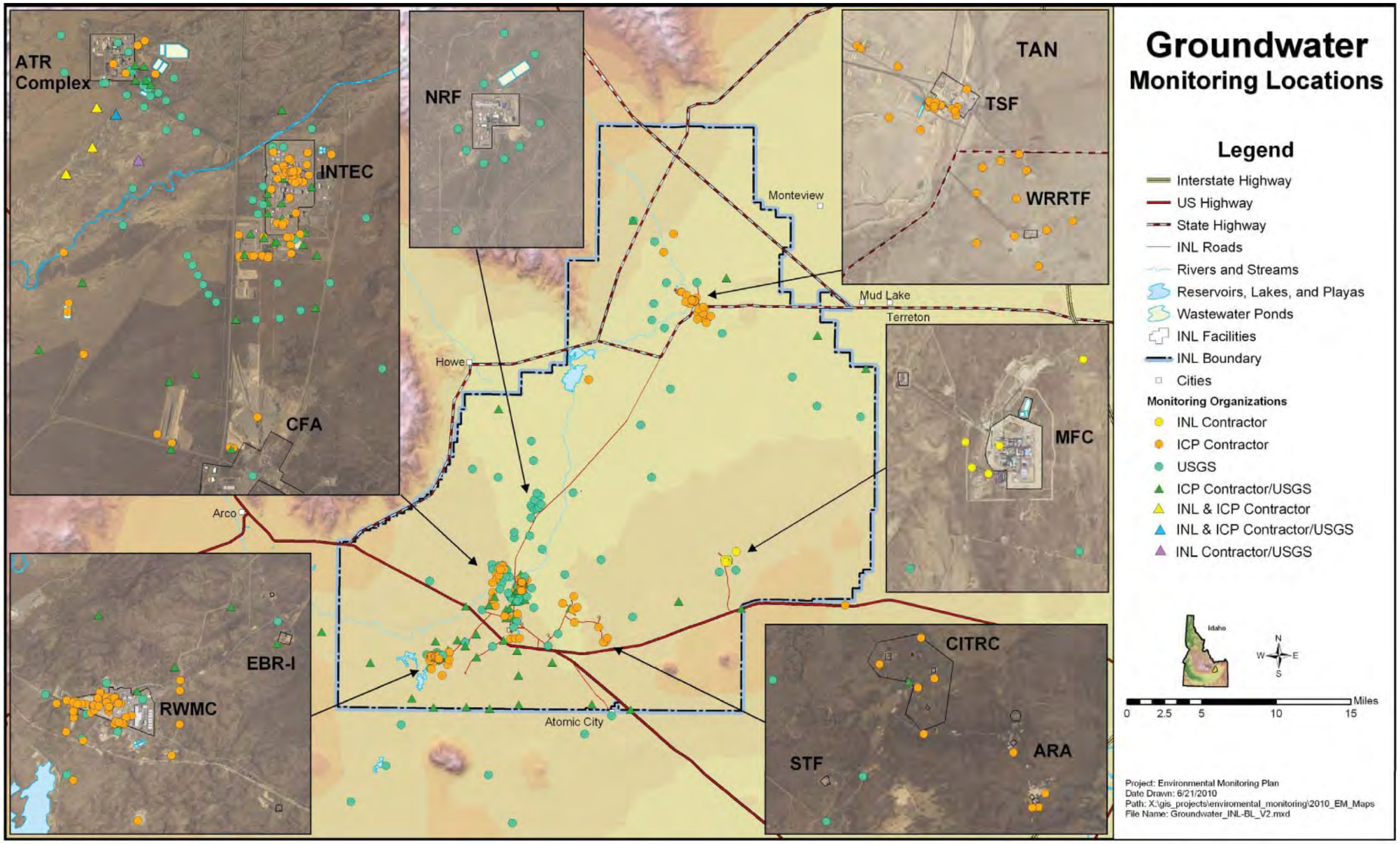


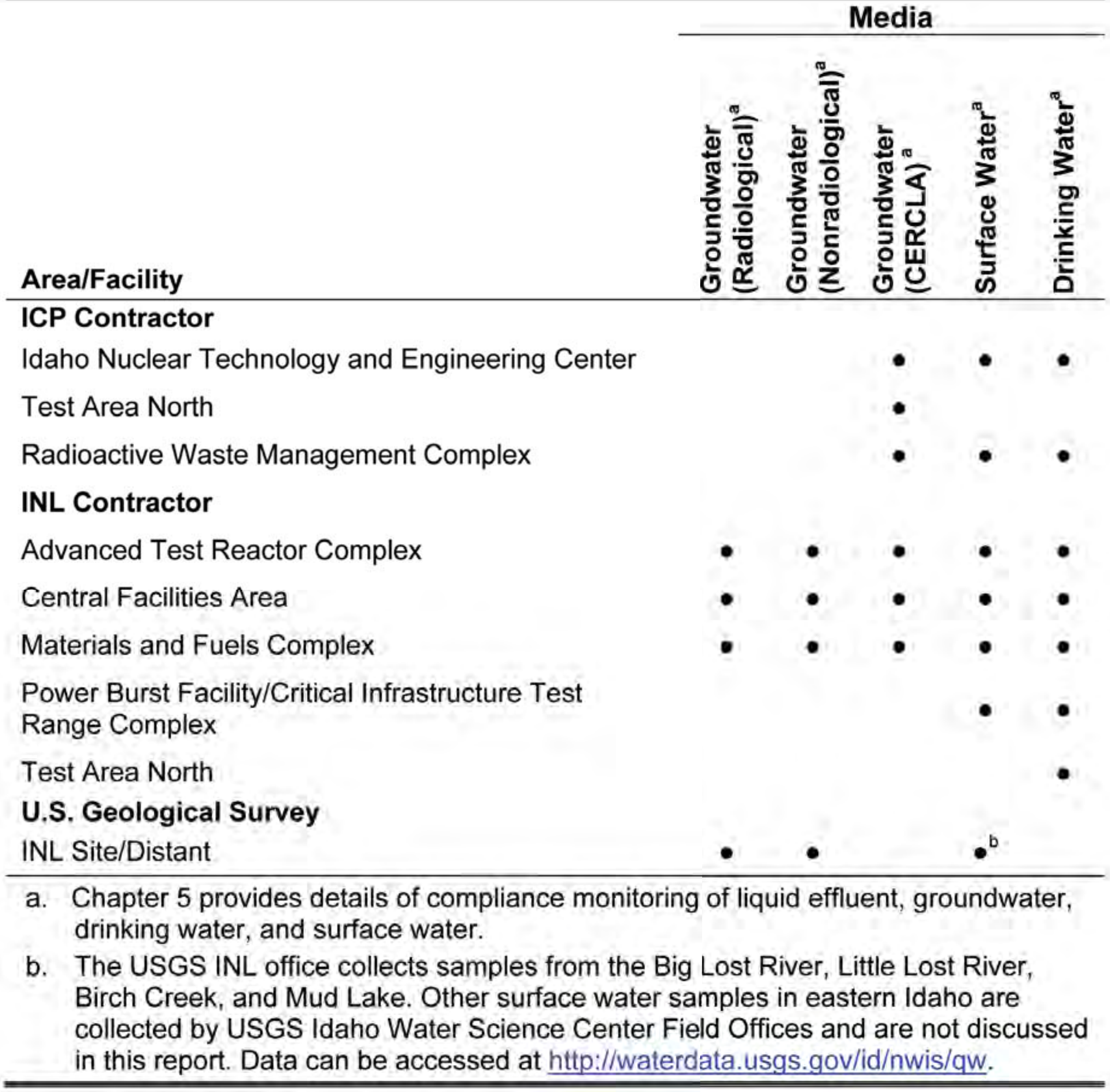
Figure 6-2. Idaho National Laboratory Site Groundwater Monitoring Locations.


Bristly Cutworm Moth

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.

Table 6-1 presents the various groundwater, surface water, and drinking water monitoring activities performed on and around the INL Site. Details may be found in the *Idaho National Laboratory Environmental Monitoring Plan* (DOE-ID 2008).

Table 6-1. Groundwater, Surface Water, and Drinking Water Monitoring at the INL Site and Surrounding Area.



	Media				
Area/Facility	**Groundwater (Radiological)[a]**	**Groundwater (Nonradiological)[a]**	**Groundwater (CERCLA)[a]**	**Surface Water[a]**	**Drinking Water[a]**
ICP Contractor					
Idaho Nuclear Technology and Engineering Center			●	●	●
Test Area North			●		
Radioactive Waste Management Complex			●	●	●
INL Contractor					
Advanced Test Reactor Complex	●	●	●	●	●
Central Facilities Area	●	●	●	●	●
Materials and Fuels Complex	●	●	●	●	●
Power Burst Facility/Critical Infrastructure Test Range Complex				●	●
Test Area North					●
U.S. Geological Survey					
INL Site/Distant	●	●		●[b]	

a. Chapter 5 provides details of compliance monitoring of liquid effluent, groundwater, drinking water, and surface water.

b. The USGS INL office collects samples from the Big Lost River, Little Lost River, Birch Creek, and Mud Lake. Other surface water samples in eastern Idaho are collected by USGS Idaho Water Science Center Field Offices and are not discussed in this report. Data can be accessed at http://waterdata.usgs.gov/id/nwis/qw.

Scarab beetle

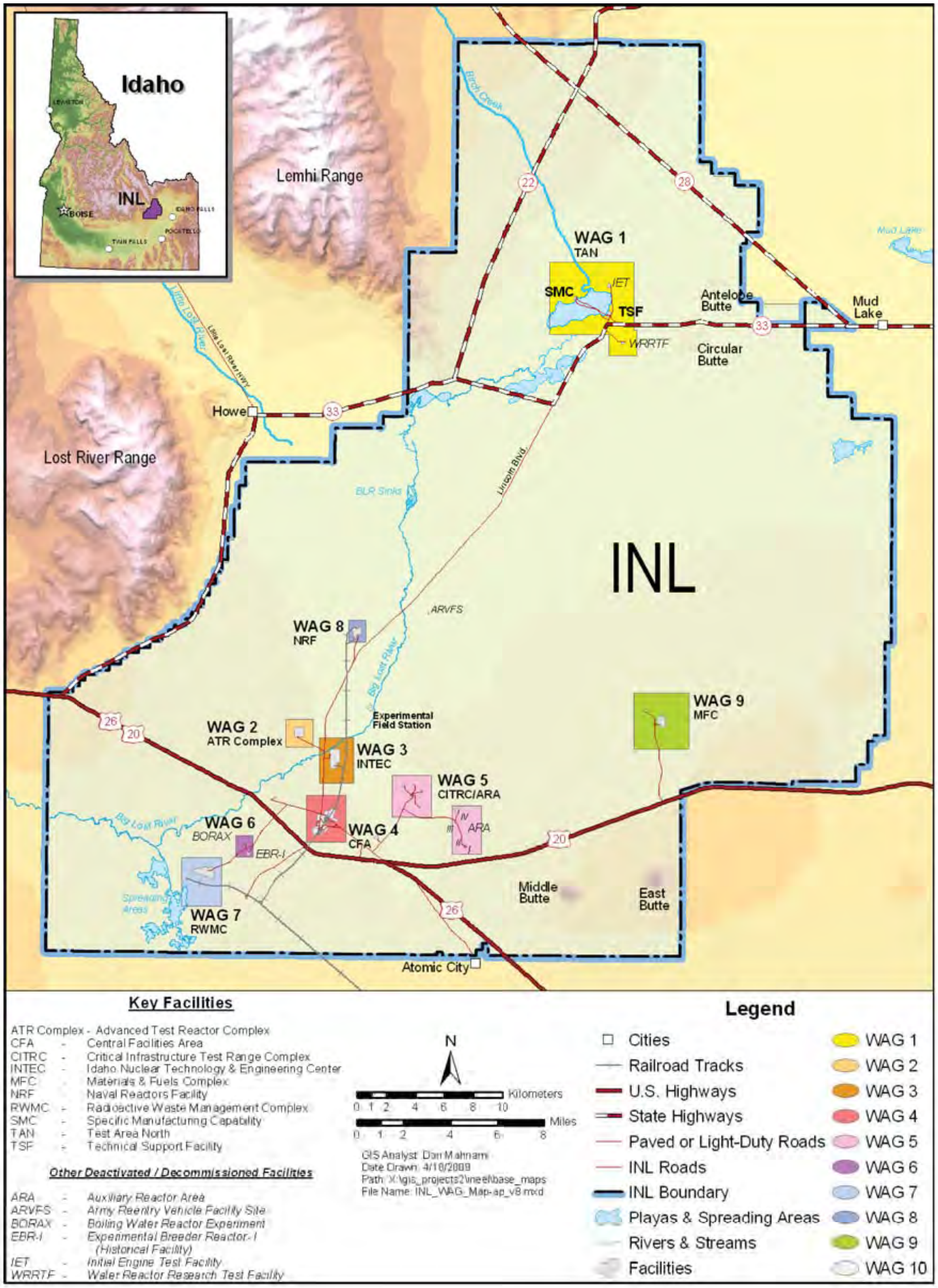


Figure 6-3. Map of the Idaho National Laboratory Site Showing Locations of Facilities and Corresponding Waste Area Groups.

Bristly Cutworm Moth

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 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.

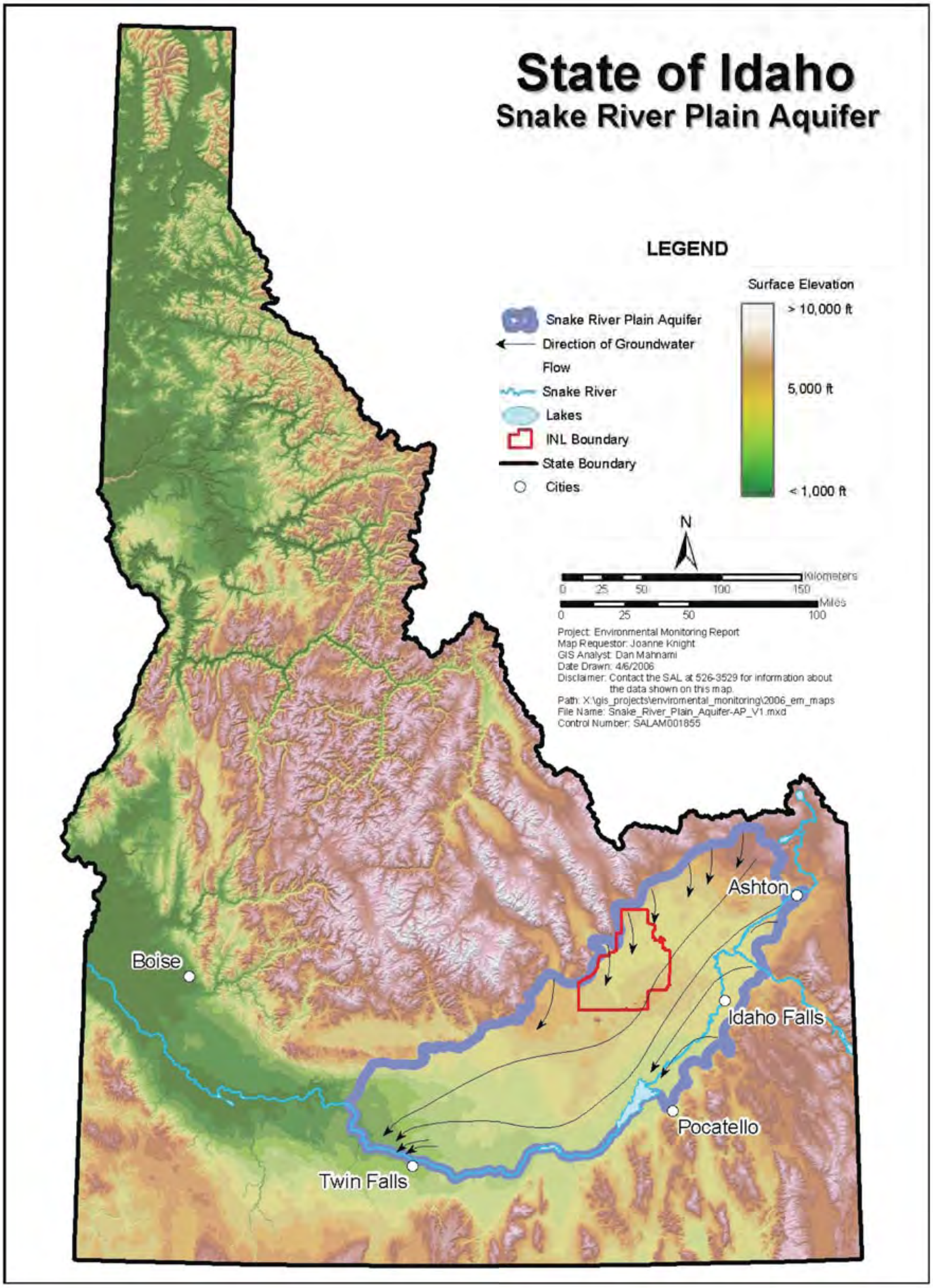


Figure 6-4. Location of the Idaho National Laboratory Site in Relation to the Eastern Snake River Plain Aquifer.

Bristly Cutworm Moth

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/pubs.html or requested from the USGS INL Project Office by calling (208) 526-2438. During 2009, USGS INL Project Office personnel published two 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 both of 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 (2005), are shown in Figure 6-5 (Davis 2008). 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).

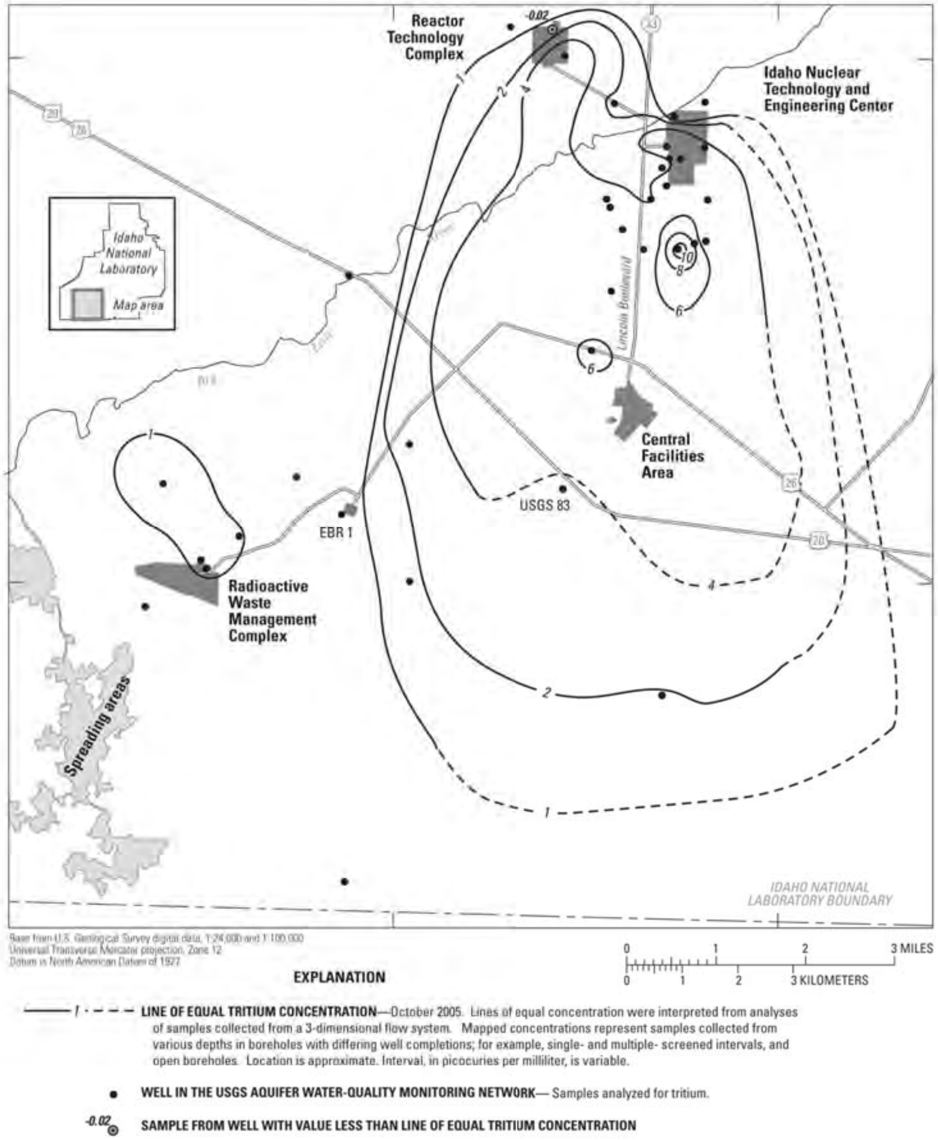


Figure 6-5. Distribution of Tritium in the Snake River Plain Aquifer on the Idaho National Laboratory Site in 2005 (from Davis 2008).

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 5,710 pCi/L in 2008 to 5,560 pCi/L in 2009; the tritium concentration in USGS-077 south of INTEC decreased from 5,620 pCi/L in 2008 to 5,480 pCi/L in 2009.

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

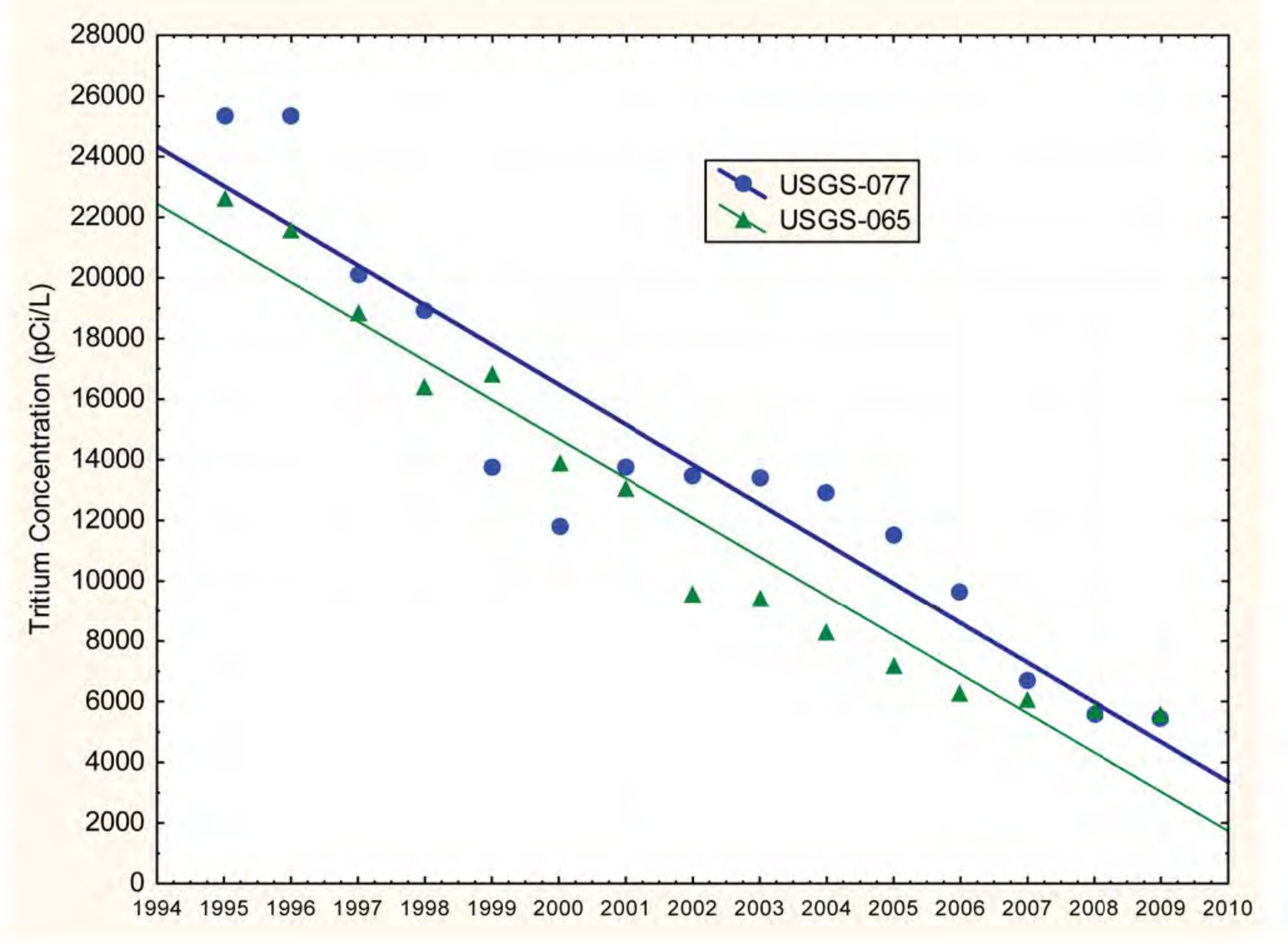


Figure 6-6. Long-Term Trend of Tritium in Wells USGS -065 and -077 (1995 – 2009).

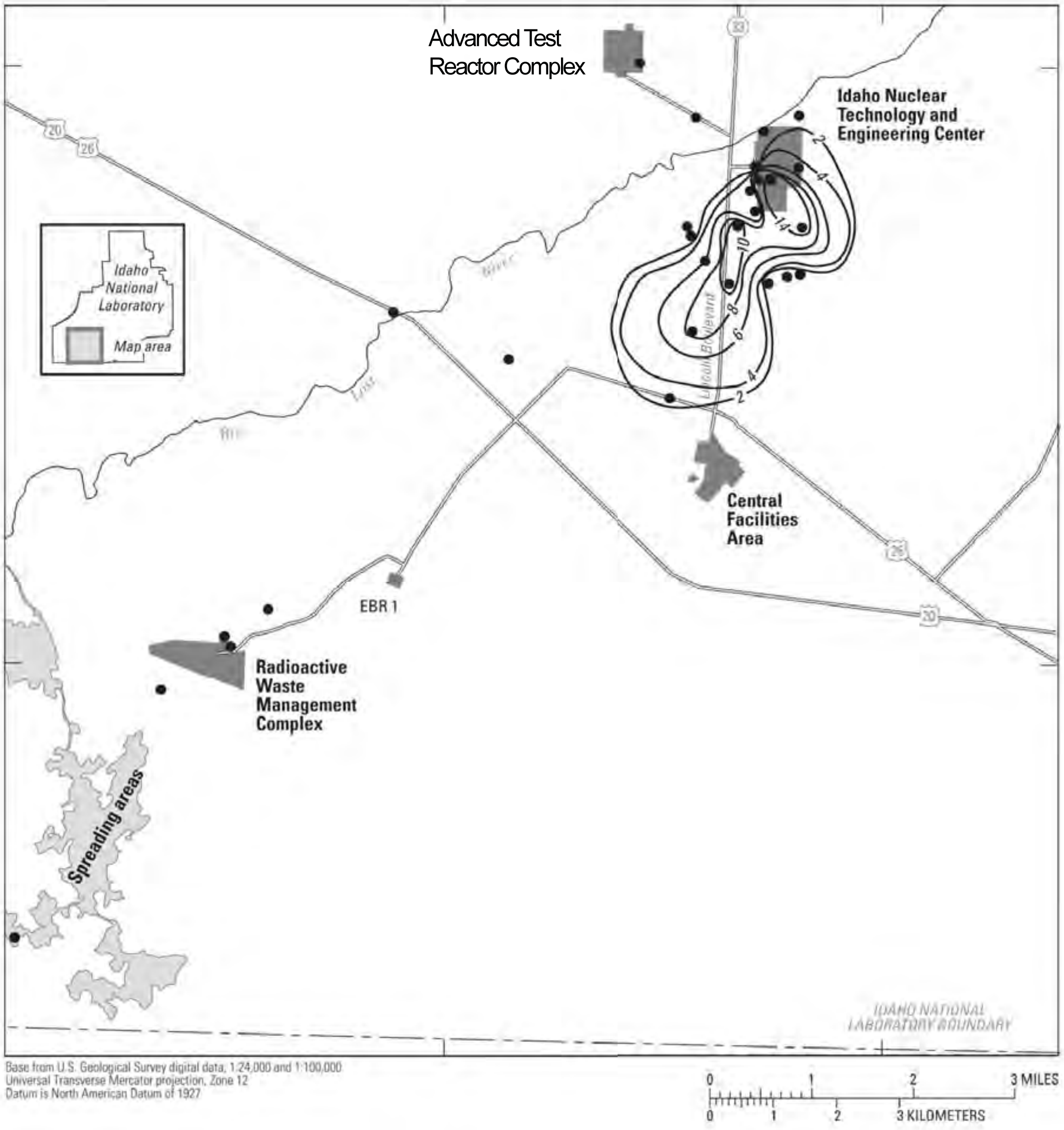
Wells USGS-065 and USGS-077 dropped below this limit in 1997 as a result of radioactive decay (tritium has a half-life of 12.3 years), ceased tritium disposal, advective dispersion, and dilution within the aquifer.

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 2008). 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 2009. 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 19 years (1990 – 2009) 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 2009 are available at http://waterdata.usgs.gov/id/nwis/. Monitoring results for 2002 – 2005 are summarized in Davis (2008). During 2002 – 2005, concentrations of cesium-137 (^{137}Cs) (as determined by gamma spectroscopy), plutonium-238, plutonium-239/240, americium-241, and gross alpha-particle radioactivity in all samples analyzed were less than the reporting level. Concentrations of gross-beta particle radioactivity exceeded the reporting level in 18 of 54 wells sampled, and concentrations ranged from 6 to 44 pCi/L. The gross-beta particle radioactivity showed steady or decreasing concentration trends during 2002 – 2005 (Davis 2008).

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 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



EXPLANATION

—2— **LINE OF EQUAL STRONTIUM-90 CONCENTRATION**—October 2005. Lines of equal concentration were interpreted from analyses of samples collected from a 3-dimensional flow system. Mapped concentrations represent samples collected from various depths in boreholes with differing well completions; for example, single- and multiple- screened intervals, and open boreholes. Location is approximate. Interval, in picocuries per liter, is variable.

● **WELL IN THE USGS AQUIFER WATER-QUALITY MONITORING NETWORK**— Samples analyzed for strontium-90.

Figure 6-7. Distribution of Strontium-90 in the Snake River Plain Aquifer on the Idaho National Laboratory Site in 2005 (from Davis 2008).

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 (2008) provides a detailed discussion of results for samples collected during 2002 – 2005. Chromium had a concentration greater than the MCL of 100 µg/L in Well 65 in 2005 (Davis 2008), and its concentration was exactly at the MCL of 100 µg/L in 2009, after having dropped below the MCL in 2008. 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 2005 (Davis 2008).

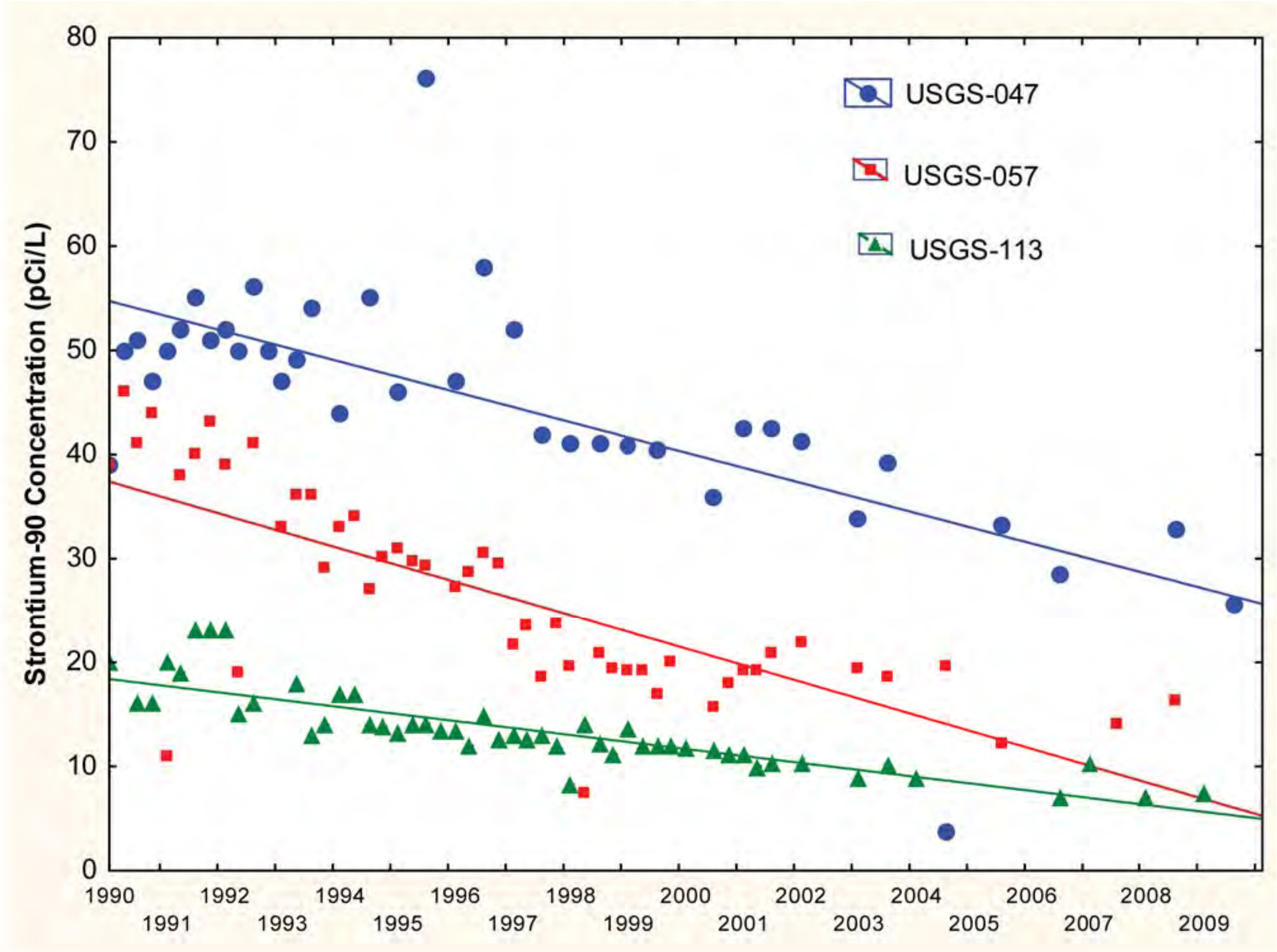
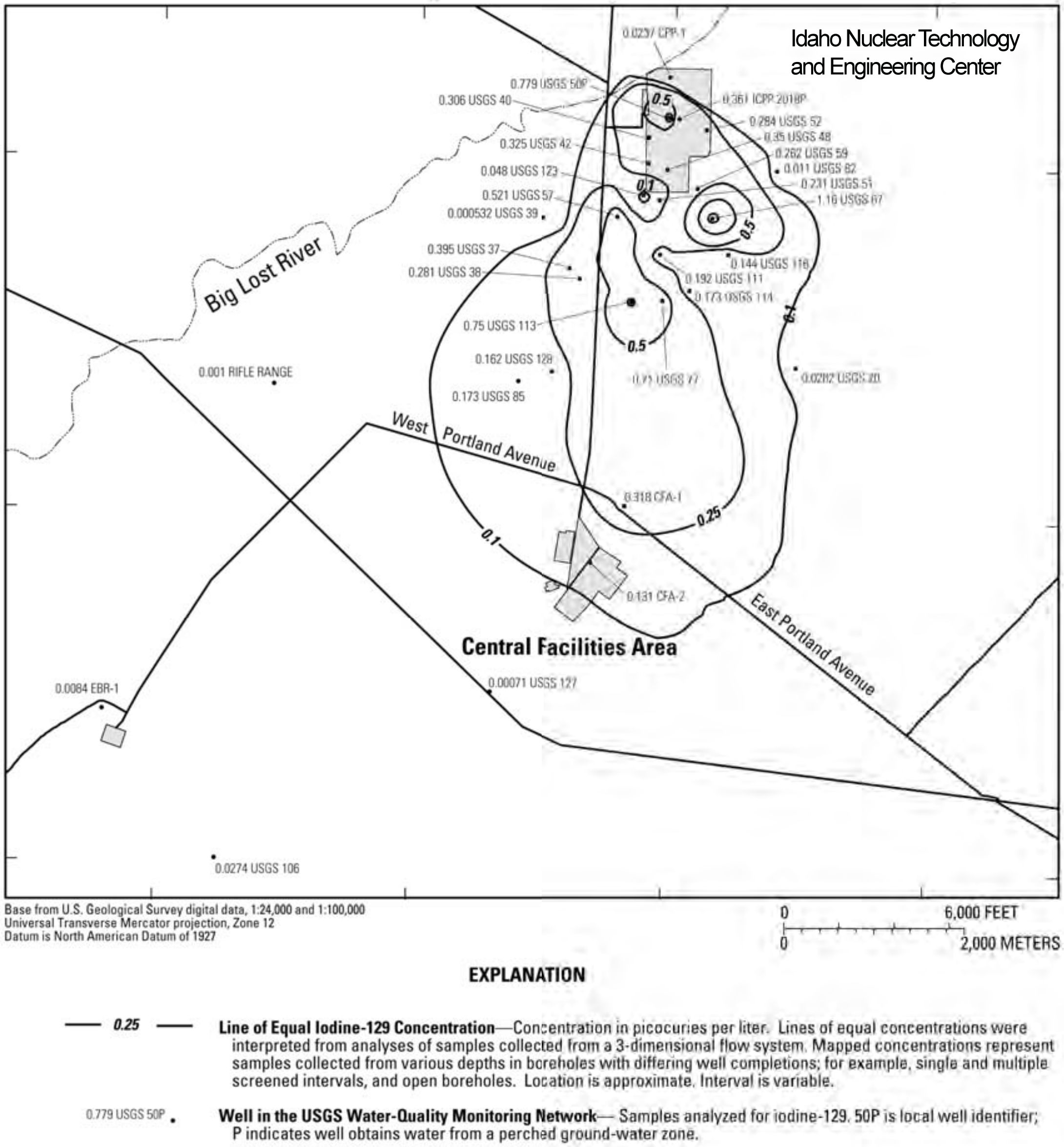


Figure 6-8. Long-Term Trend of Strontium-90 in Wells USGS-047 ,-057, and -113 (1990 – 2009).

USGS sampled for purgeable (volatile) organic compounds in groundwater at the INL Site during 2009. Samples from 29 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). Five 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



Base from U.S. Geological Survey digital data, 1:24,000 and 1:100,000
Universal Transverse Mercator projection, Zone 12
Datum is North American Datum of 1927

EXPLANATION

Line of Equal Iodine-129 Concentration—Concentration in picocuries per liter. Lines of equal concentrations were interpreted from analyses of samples collected from a 3-dimensional flow system. Mapped concentrations represent samples collected from various depths in boreholes with differing well completions; for example, single and multiple screened intervals, and open boreholes. Location is approximate. Interval is variable.

Well in the USGS Water-Quality Monitoring Network— Samples analyzed for iodine-129. 50P is local well identifier; P indicates well obtains water from a perched ground-water zone.

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

Scarab beetle

Protection Agency MCL of 5 µg/L all 12 months in 2009 (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 2008).

Table 6-2. Purgeable Organic Compounds in Annual U.S. Geological Survey Well Samples (2009).

Constituent	USGS-038	USGS-065	USGS-077	USGS-087	USGS-088	USGS-098	USGS-120	EBR-1	Highway 3
Tetrachloromethane (µg/L) (MCL=5)[a]	ND[b]	ND	ND	2.269	0.501	ND	1.154	ND	ND
Trichloromethane (µg/L)	ND	ND	ND	0.353	0.510	0.104	0.134	0.122	0.238
1,1,1-Trichloroethane (µg/L) (PCS=200)[c]	0.109	0.122	0.124	0.132	ND	ND	ND	ND	ND
Dichlorodifluoromethane (µg/L) (no standard established)	ND	ND	ND	0.624	ND	ND	ND	ND	ND
Trichloroethene (µg/L) (PCS=5)	ND	ND	ND	0.580	0.366	ND	0.160	ND	ND

a. MCL = maximum contaminant level from Environmental Protection Agency (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 (2009).

Constituent	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Tetrachloromethane (µg/L) (MCL=5)[a]	8.760	7.263	8.302	6.125	7.442	8.664	10.59	9.744	8.200	10.92	8.425	7.492
Trichloromethane (µg/L) (MCL=100)[b]	1.981	1.846	1.875	1.792	1.847	2.165	2.126	1.846	1.754	2.480	2.206	1.968
Tetrachloroethene (µg/L) (PCS=5)[c]	0.382	0.353	0.379	0.326	0.358	0.402	0.410	0.412	0.357	0.467	0.402	0.372
1,1,1-Trichloroethane (µg/L) (PCS=200)	0.598	0.544	0.553	0.466	0.493	0.568	0.645	0.547	0.517	0.638	0.585	0.530
Trichloroethene (µg/L) (PCS=5)	3.902	3.505	3.652	3.164	3.541	4.081	4.090	3.758	3.323	4.435	3.733	3.560

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.

Bristly Cutworm Moth

6.7 Comprehensive Environmental Response, Compensation, and Liability Act Groundwater Monitoring During 2009

CERCLA activities at the INL Site are divided into WAGs that roughly correspond to the major facilities, with the addition of the INL Site-wide WAG 10. Locations of the various WAGs are shown on Figure 6-3. The following subsections provide an overview of groundwater sampling results. More detailed discussions of the CERCLA groundwater sampling can be found in the WAG-specific monitoring reports within the CERCLA Administrative Record at http://ar.inel.gov. WAG 8 is managed by the Naval Reactors Facility and is not discussed in this report.

6.7.1 Summary of Waste Area Group 1 Groundwater Monitoring Results

Groundwater is monitored at WAG 1 to measure the progress of the remedial action at Test Area North (TAN). The groundwater plume at TAN has been divided into three zones to facilitate remediation. 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 does not reflect the current concentrations (Figure 6-10).

The injection strategy consisted of simultaneous two well injections of sodium lactate solution and whey powder to produce anaerobic reductive dechlorination conditions. The success of the current injection strategy is evidenced by complete degradation of TCE to ethene in the biologically active wells. In situ bioremediation operations in the hot spot continue to effectively maintain TCE concentrations below MCLs (Figure 6-11). TCE concentrations in the hot spot will continue to remain below MCLs as long as in situ bioremediation effectively maintains anaerobic reductive dechlorination.

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 these wells generally indicate that flux from the hot spot has been reduced, with the exception of Well TAN-28.

The 2009 groundwater monitoring data indicate that the in situ bioremediation hot spot remedy is operating as planned to reduce the concentration of volatile organic compounds in the hot spot zone, and progress toward the remedial action objectives is being made (DOE-ID 2010a).

Medial Zone (TCE concentrations between 1,000 and 20,000 µg/L) – A pump and treat process has been used in the medial zone, but operations have been on standby since November 15, 2007. The pump and treat process involves extracting contaminated

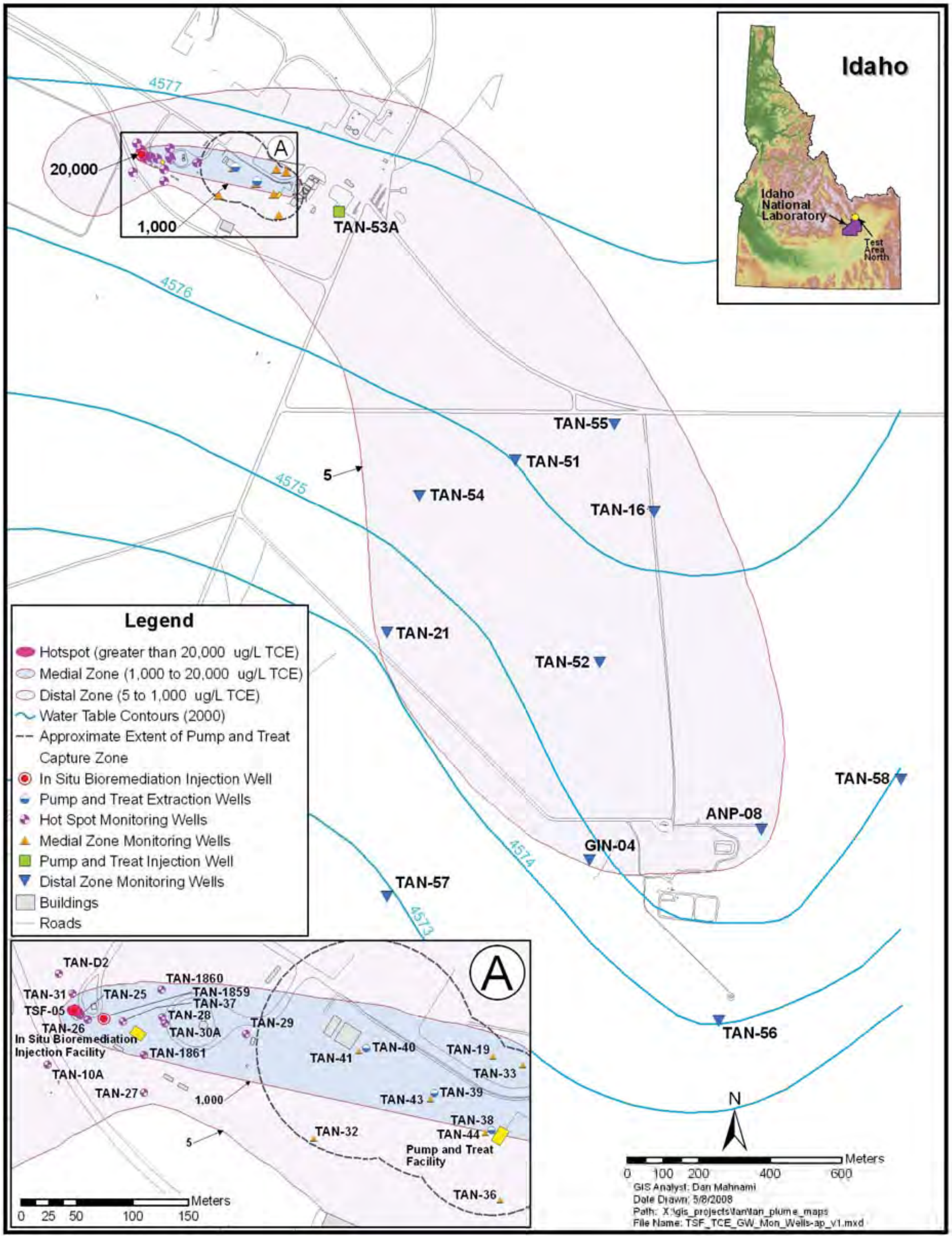


Figure 6-10. Trichloroethene Plume at Test Area North in 1997.

Bristly Cutworm Moth

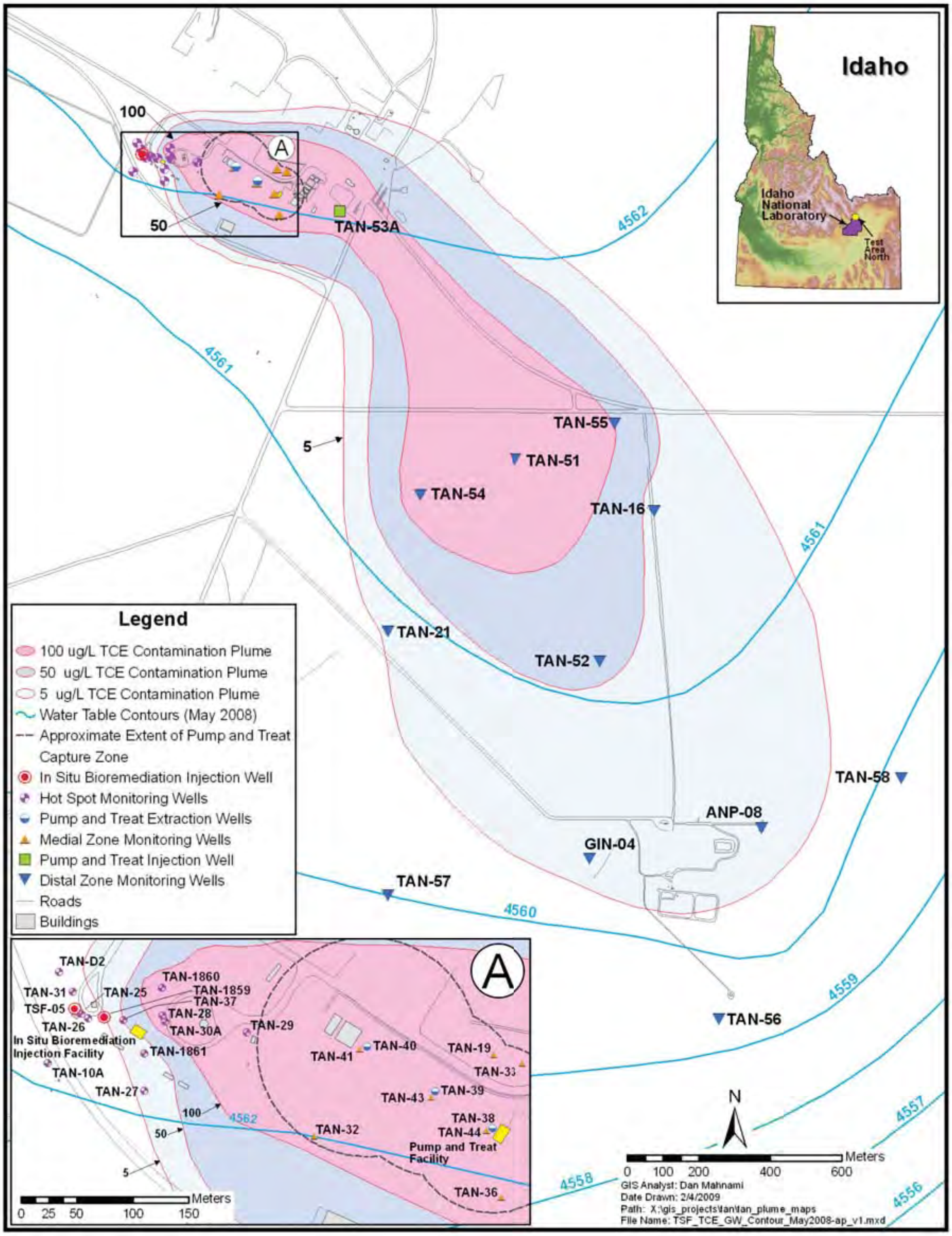


Figure 6-11. Trichloroethene Plume at Test Area North in 2009.

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.

TCE concentrations in medial zone Wells TAN-33, TAN-36, and TAN-44 remained below 200 µg/L in 2009. As a component of standby operations, the New Pump and Treat Facility is operated a few days each month to process purge water collected during routine groundwater monitoring. The New Pump and Treat Facility will continue to be operated using the revised operating strategy provided contaminant concentrations continue to decline or until it is determined that a more effective operating strategy should be employed and flux is cut off from the hot spot.

Distal Zone (TCE concentrations between 5 and 1,000 µg/L) – Monitored natural attenuation is the treatment for the distal zone of the plume as defined by 1997 TCE concentrations (Figure 6-10). Monitored natural attenuation is the sum of physical, chemical, and biological processes that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in groundwater. Engineering and administrative controls are in place to protect current and future users from health risks associated with groundwater contamination.

The Monitored Natural Attenuation Remedial Plan (DOE-ID 2009a) outlines three technical components to be evaluated annually. The first component is TCE concentration data. The TCE data are evaluated to determine if the natural degradation rates will meet MCLs by 2095 and meet the remedial action objective.

The second monitored natural attenuation component is evaluation of TCE plume dimensions. Samples are collected from Wells TAN-56, TAN-57, and TAN-58 every three years, and these wells were sampled in 2009. TCE concentrations in these wells indicate that the TCE plume may have marginally expanded (Figure 6-11).

The third monitored natural attenuation component is radionuclide concentration data. Although ^{137}Cs and ^{90}Sr concentrations have increased recently at TSF-05 and TAN-25 due to the effects of continued in situ bioremediation operations in the hot spot area of the plume, these increases in the in situ bioremediation area have not resulted in radionuclide concentration increases 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 2009. Locations of the wells are shown on Figure 6-12, except for the Highway 3 well (a public access potable water well), which is shown on the figure for WAG 10 sampling locations (Figure 6-17). Aquifer samples were analyzed for ^{90}Sr, gamma-emitting radionuclides, gross alpha, gross beta, and tritium. Samples also were analyzed for chromium (unfiltered and filtered). Unfiltered samples obtain the total concentration of the metal in the sample, including metals adsorbed onto suspended particulates; filtered samples are used to obtain the dissolved concentration. The data for the October 2009 sampling event are included in the Fiscal Year (FY) 2010 Annual Report for WAG 2 (ICP 2010a). The October 2009 sampling data are summarized in Table 6-4.

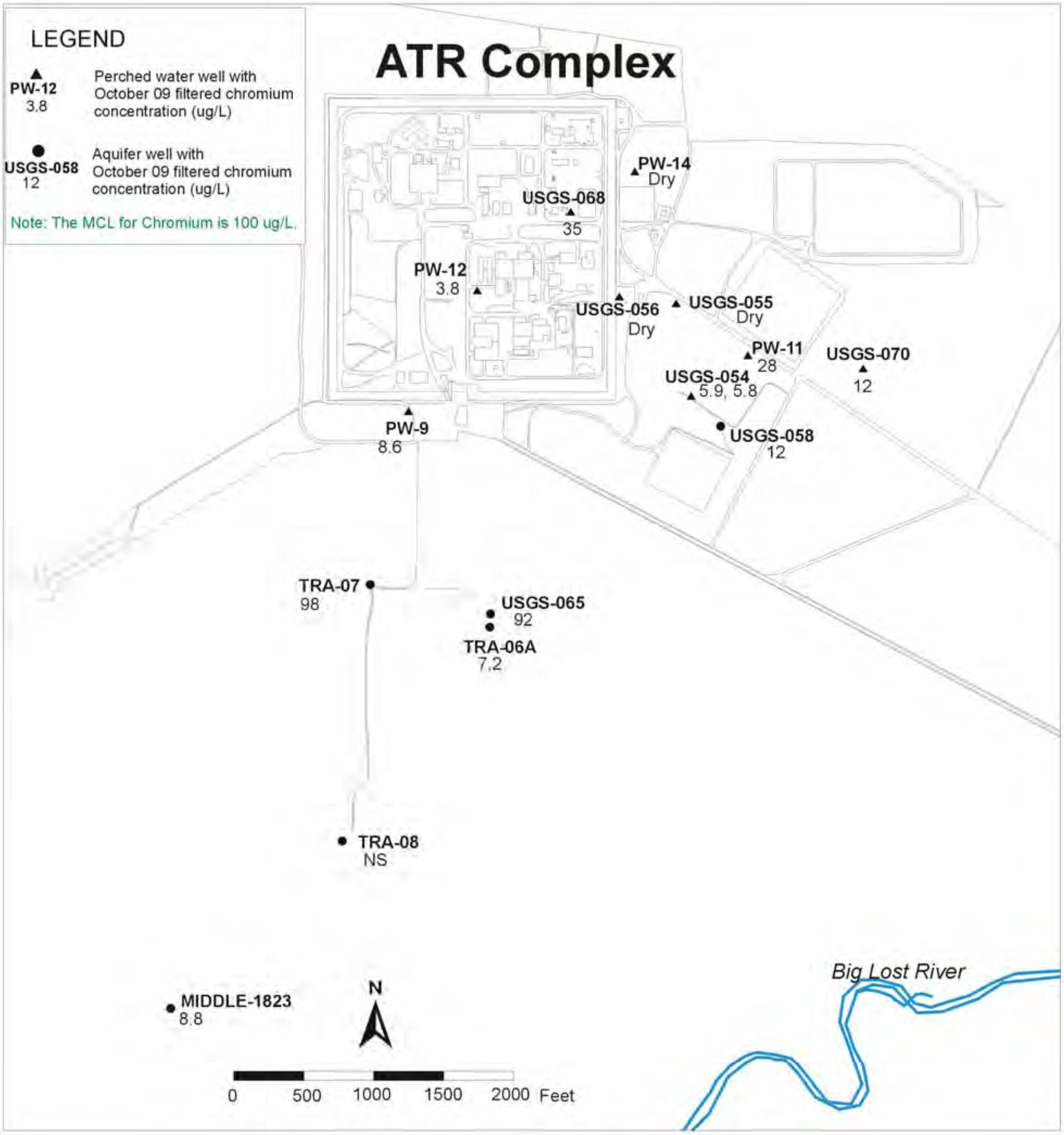


Figure 6-12. Locations of Waste Area Group 2 Monitoring Wells and Chromium Concentrations for 2009 (*Note: Highway 3 well is not shown on this map*).

Table 6-4. Waste Area Group 2 Aquifer Groundwater Quality Summary (2009).

Analyte	MCL	Background[a]	Maximum	Minimum	Number of Wells above MCL
Chromium (filtered) (µg/L)	100	2 – 3	98	2.3	0
Chromium (unfiltered) (µg/L)	100	NA	150	0.91	1
Strontium-90 (pCi/L)	8	0	6.31	ND	0
Tritium (pCi/L)	20,000	75 – 150	10,300	ND	0
Gross alpha (pCi/L)	15	0 – 3	5.6	ND	0
Gross beta (pCi/L)	NA	0 – 7	7.69	ND	NA

a. Background concentrations are from Knobel et al. (1992), except tritium, which is from Orr et al. (1991).

b. 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.

MCL	maximum contaminant level
NA	not applicable
ND	not detected

Only unfiltered chromium was detected above its MCL in aquifer wells. The highest unfiltered chromium concentration occurred in Well TRA-07, but the filtered chromium concentration was 98 µg/L and was just below the MCL of 100 µg/L in this well. The filtered chromium concentration in Well USGS-065 also was close to the MCL at 92 µg/L. Although the chromium concentrations in both Wells TRA-07 and USGS-065 are close to the MCL, both of these wells appear to show a downward trend in chromium concentrations.

The only well that has consistent ^{90}Sr concentrations is TRA-08. Strontium-90 was reported at 6.31 pCi/L in Well TRA-08 and was below the MCL of 8 pCi/L. The ^{90}Sr concentrations in TRA-08 have been decreasing in this well since it first occurred in 2005.

Consistent with past sampling, tritium concentrations were above background concentrations in all aquifer wells sampled, except the Highway 3 well. All tritium concentrations were below the MCL and generally declining.

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 2009 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 2010a). 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

During 2009, the CERCLA Operable Unit 3-14 Project collected groundwater samples from 19 aquifer monitoring wells and 16 perched water monitoring wells located at and near INTEC (Figure 6-13). Groundwater and perched water samples were analyzed by an offsite laboratory for radionuclides and inorganic constituents. Table 6-5 summarizes the laboratory results for WAG 3 perched water and groundwater samples. Three constituents exceeded drinking water MCLs in the Snake River Plain Aquifer during this reporting period: ^{90}Sr, technetium-99 (^{99}Tc), and nitrate. In addition, fuel oil was present in one perched water monitoring well. Results for the main contaminants of concern are discussed briefly in the following paragraphs, and more detailed discussions of laboratory results and trends are available in the 2009 Annual Report for Operable Unit 3-14 (DOE-ID 2010b).

At INTEC, ^{90}Sr continues to be the groundwater contaminant that exceeds action levels by the greatest margin and at the most monitoring locations (Table 6-5). Strontium-90 was detected at 15 of the 19 aquifer monitoring wells sampled in 2009, and samples from nine of these wells exceeded the ^{90}Sr MCL of 8 pCi/L (Table 6-5). As in the past, the highest ^{90}Sr concentration occurred immediately downgradient from the former INTEC injection well. The persistence of ^{90}Sr in the aquifer in this area is believed to be attributable to a combination of gradual desorption of ^{90}Sr from the aquifer matrix and drain-out of contaminated perched water that was impacted by past disposal of service waste to the injection well. The INTEC injection well was taken out of service in 1986. With the exception of monitoring Well ICPP-2021, which showed a slight increase, concentrations of ^{90}Sr in the aquifer have remained relatively constant over the past four years at INTEC.

Strontium-90 also was detected in perched water at most monitoring locations, and 11 of the perched water wells exceeded the ^{90}Sr MCL (8 pCi/L) (Table 6-5). As in the past, very high ^{90}Sr levels (>10,000 pCi/L) were observed in the northern shallow perched water, with the highest concentrations in wells southeast of the Tank Farm. During 2009, the maximum ^{90}Sr concentration detected was 130,000 pCi/L at Well ICPP-2018. At most wells, ^{90}Sr concentrations are approximately half those reported in these same wells during the mid-1990s.

Technetium-99 was detected at 13 of 19 aquifer monitoring wells sampled during 2009, and two wells exceeded the ^{99}Tc MCL (900 pCi/L) (Table 6-5). Groundwater at these two wells is believed to have been impacted by past releases from the INTEC Tank Farm, and the source

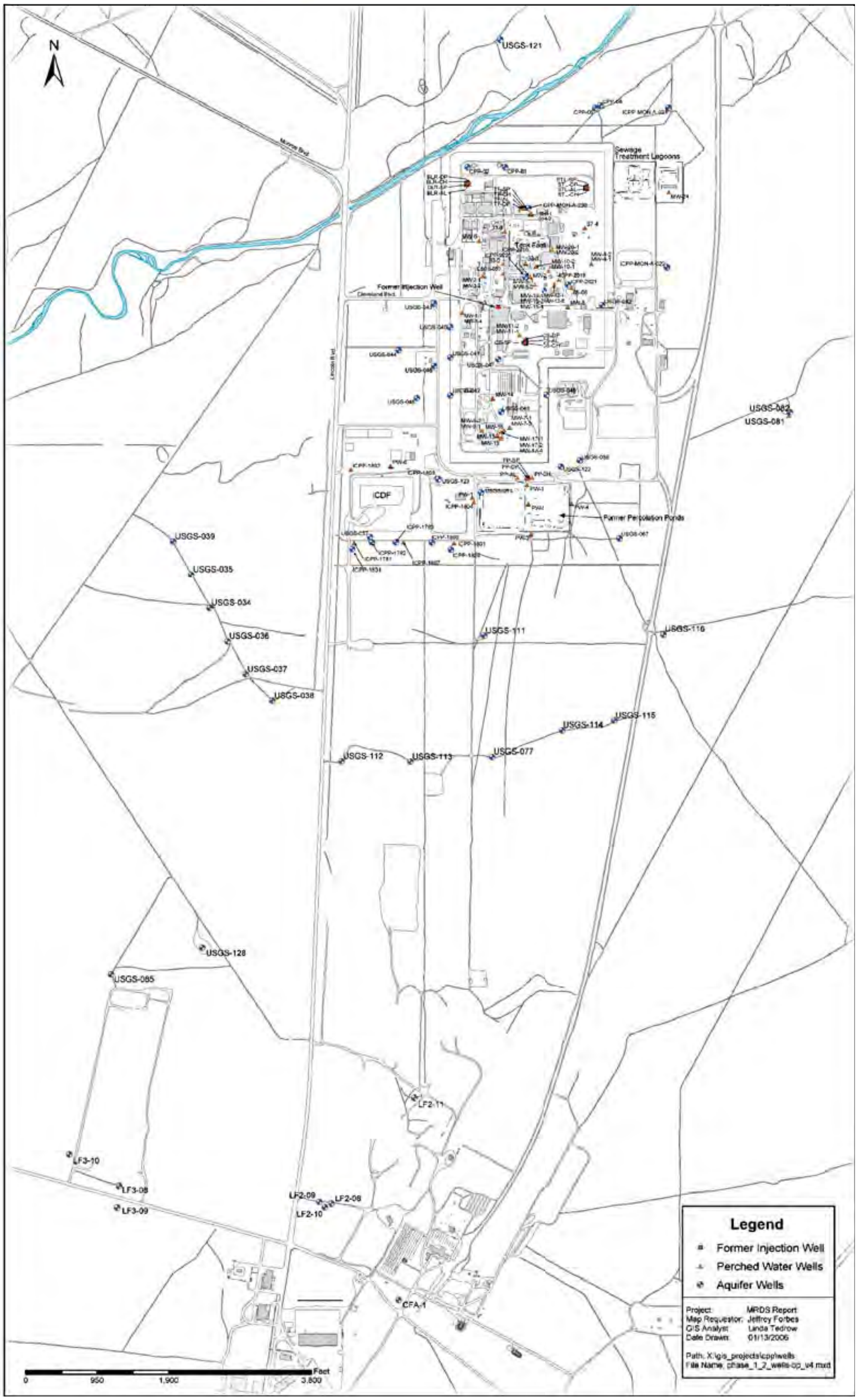


Figure 6-13. Locations of Waste Area Group 3 Monitoring Wells.

Table 6-5. Constituents Detected in Waste Area Group 3 Monitoring Wells (2009).

		Snake River Plain Aquifer Groundwater			Shallow Perched Water		
Constituent	MCL	Maximum Value[a]	Number of Results[b]	Number of Results > MCL[b]	Maximum Value[a]	Number of Results[b]	Number of Results > MCL[b]
Gross alpha (pCi/L)	15	4.68	20	0	**20.1**[c]	17	1
Gross beta (pCi/L)	NA	1,290	20	NA	311,000	17	NA
Cesium-137 (pCi/L)	200	ND	20	0	ND	18	0
Strontium-90 (pCi/L)	8	**24.8**	20	10	**130,000**	18	13
Technetium-99 (pCi/L)	900	**2,220**	20	2	263	18	0
Iodine-129 (pCi/L)	1	0.463	20	0	**1.77** J	13	2
Tritium (pCi/L)	20,000	6,470	20	0	**20,500**	18	1
Plutonium-238 (pCi/L)	15	ND	20	0	ND	17	0
Plutonium-239/240 (pCi/L)	15	ND	20	0	ND	17	0
Uranium-233/234 (pCi/L)	15	2.86	20	0	6.19	17	0
Uranium-235 (pCi/L)	15	0.183 J	20	0	0.24 J	17	0
Uranium-238 (pCi/L)	15	1.34	20	0	3.76	17	0
Alkalinity (mg/L)	NA	158	20	NA	402	13	NA
Calcium (mg/L)	NA	80.1	20	NA	89.2	13	NA
Chloride (mg/L)	250	150	20	0	119	14	0
Magnesium (mg/L)	NA	29.4	20	NA	55.1	13	NA
Nitrate (as N) (mg/L)	10	**15.6**	20	2	**24.1**	15	3
Potassium (mg/L)	NA	5.24	20	NA	11.6	13	NA
Sodium (mg/L)	NA	40.8	20	NA	78.2	13	NA
Sulfate (mg/L)	250	65.9	20	0	69.1	14	0
Total dissolved solids (mg/L)	500	499	20	0	**1,600**	14	2

a. Data-qualifier flags:
J = estimated value.

b. Includes field duplicates.

c. **Bolded** values exceed MCL.

MCL = maximum contaminant level
NA = not applicable
ND= constituent not detected in any sample

of elevated ^{99}Tc was discussed in the Operable Unit 3-14 Remedial Investigation/Baseline Risk Assessment (DOE-NE-ID 2006). Technetium-99 results continue to show stable or declining trends.

Nitrate was detected in all aquifer wells sampled during 2009, and two of the wells slightly exceeded the nitrate MCL (10 mg/L as N). These were the same two wells that exceeded the MCL for ^{99}Tc (Table 6-5). The presence of elevated nitrate in groundwater at these locations is attributed to impacts from past Tank Farm releases (DOE-NE-ID 2006). Nitrate concentrations have remained relatively constant over the past few years at INTEC.

A fuel oil release in 2005 impacted the vadose zone and groundwater near the INTEC Tank Farm (ICP 2008, 2010b). As a result, fuel oil free product accumulated in perched water monitoring Well ICPP-2018 during 2006 – 2007, and this well continued to contain measurable thicknesses of fuel oil during 2009. In April 2008, a passive skimmer device was installed in Well ICPP-2018 to recover residual free-floating product. As of the end of 2009, approximately 21 L (5.5 gal) of fuel oil had been removed from Well ICPP-2018 since the passive skimmer was first installed in the well. Aside from Well ICPP-2018, free product has not been detected in any other monitoring wells at INTEC.

Organic compounds are not routinely monitored by the CERCLA Program at INTEC, but the Resource Conservation and Recovery Act Program does monitor selected perched water monitoring wells for volatile organic compounds and polycyclic aromatic hydrocarbon compounds. Toluene and tetrachloroethene were detected repeatedly in perched water samples during the reporting period. Toluene has been reported in perched water samples from three wells and in groundwater from two aquifer wells. All of these wells are located near the INTEC Tank Farm. The highest toluene concentration reported during 2009 was 150 µg/L, which is less than the MCL of 1,000 µg/L. Tetrachloroethene was detected on several occasions in perched water samples at concentrations as high as 4.6 µg/L. The MCL for tetrachloroethene is 5 µg/L.

6.7.4 Summary of Waste Area Group 4 Groundwater Monitoring Results

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 only volatile organic compounds in accordance with the Long-term Monitoring Plan (DOE-ID 2009b). Because of falling water levels in the aquifer, Wells LF2-08 and LF2-09 are sampled for only volatile organic compounds. In addition to monitoring groundwater in the vicinity of the CFA landfills, 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 in Figure 6-14. 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 2009 Monitoring Report (ICP 2010c).

In the four wells sampled downgradient of CFA, the nitrate concentration of 16.9 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 Well CFA-MON-A-002 is 16 to 21 mg/L-N. The nitrate concentration of 9.35 mg/L-N in Well CFA-MON-A-003 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 relatively consistent since monitoring started in 1995.

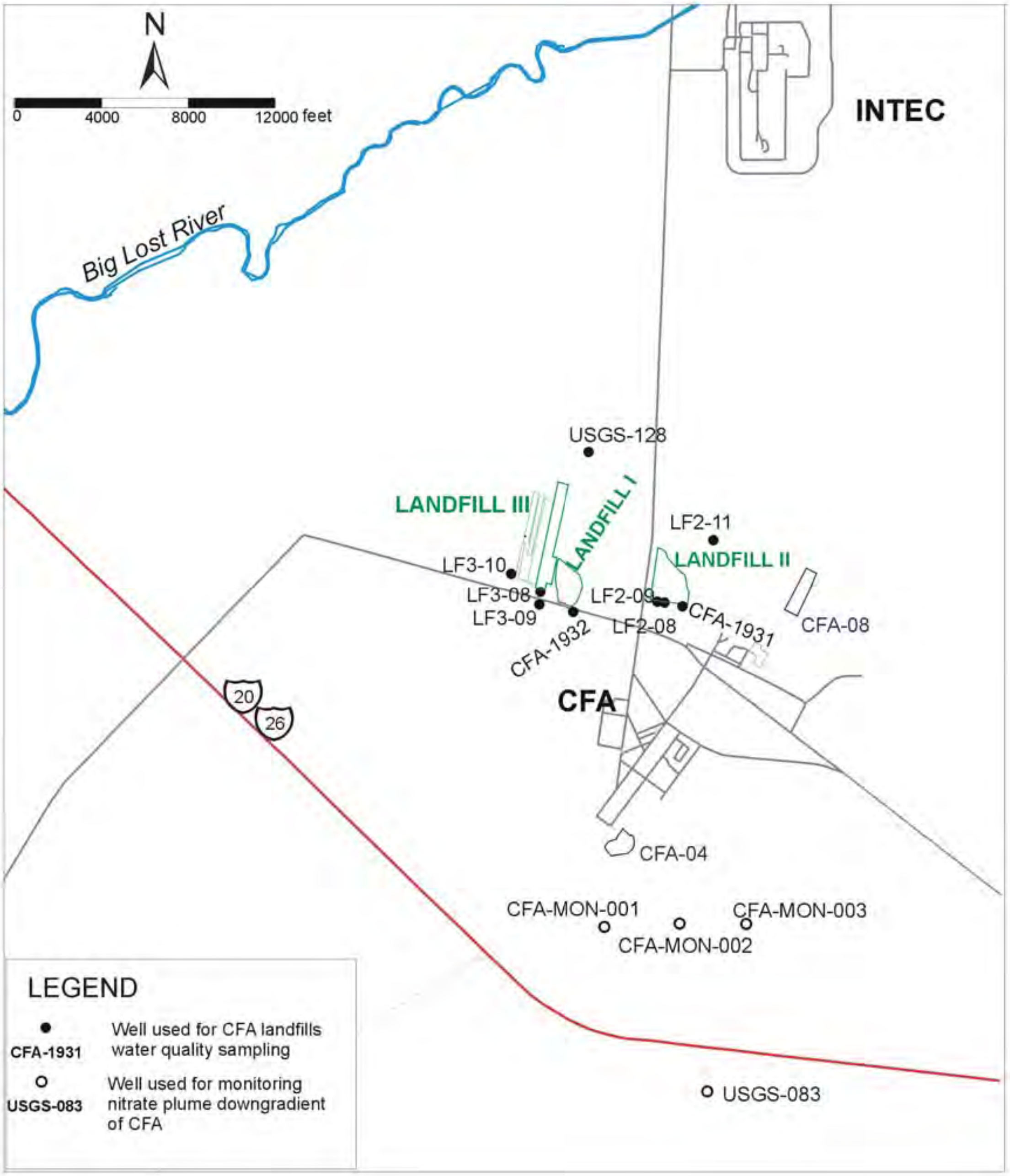


Figure 6-14. Locations of Waste Area Group 4/Central Facilities Area Monitoring Wells Sampled in 2009.

Scarab beetle

Table 6-6. Comparison of Waste Area Group 4 Groundwater Sampling Results to Regulatory Levels (2009).

Compound	MCL or SMCL[a]	Maximum Detected Value	Number of Wells above MCL or SMCL
Downgradient Central Facilities Area Wells			
Chloride (mg/L)	*250*	54.1	0
Fluoride (mg/L)	*2*	0.353	0
Sulfate (mg/L)	*250*	29	0
Nitrate/nitrite (mg-N/L)	10	16.9	1
Central Facilities Area Landfill Wells			
Anions			
Alkalinity-bicarbonate (mg/L)	None	400	NA
Chloride (mg/L)	*250*	80.8	0
Fluoride (mg/L)	*2*	0.405	0
Sulfate (mg/L)	*250*	54.3	0
Nitrate/nitrite (mg-N/L)	10	3.3	0
Common Cations			
Calcium (µg/L)	None	62,200	NA
Magnesium (µg/L)	None	16,700	NA
Potassium (µg/L)	None	5,260	NA
Sodium (µg/L)	None	42,500	NA
Inorganic Analytes			
Antimony (µg/L)	6	1.82	0
Aluminum (µg/L)	*50 – 200*	543	1
Arsenic (µg/L)	10	ND	0
Barium (µg/L)	2,000	110	0
Beryllium (µg/L)	4	ND	0
Cadmium (µg/L)	5	ND	0
Chromium (µg/L)	100	25.3	0
Copper (µg/L)	1,300/*1,000*	5	0
Iron (µg/L)	*300*	167	0
Lead (µg/L)	15[b]	ND	0
Manganese (µg/L)	50	5.66	0
Mercury (µg/L)	2	ND	0
Nickel (µg/L)	None	140	NA
Selenium (µg/L)	50	2.19	0
Silver (µg/L)	*100*	ND	0
Thallium (µg/L)	2	0.353	0
Vanadium (µg/L)	None	4.63	NA
Zinc (µg/L)	*5,000*	32.6	0
Detected Volatile Organic Compounds			
Acetone (µg/L)	None	21	NA
2-butanone (µg/L)	None	4.27	NA
Toluene (µg/L)	1,000	35.9	0

a. Numbers in *italics* are for the SMCL.

b. The action level for lead is 15 µg/L.

MCL	maximum contaminant level
NA	not applicable
ND	not detected
SMCL	secondary maximum contaminant level

In the CFA landfill monitoring wells, aluminum exceeded its secondary MCL in Well LF3-08. The high aluminum concentration in LF3-08 was accompanied by an elevated pH. The elevated pH and aluminum concentration in Well LF3-08 may have been caused by the interaction of grout put below the well screen with groundwater as a result of water level decreases in recent years.

The three volatile organic compounds detected in groundwater downgradient of the CFA landfills were acetone, toluene, and 2-butanone; however, all detections were well below established MCLs. The source of the three compounds is uncertain because vapor concentrations for these compounds collected from the vadoze zone near the landfills were low.

Water level measurements were taken at 33 wells in the CFA area, and data suggest that the sharp drop in water levels from 2000 to 2005 might be stabilizing because water levels have changed little in the past 4 years (i.e., 2005 to 2009). A water table map produced from water levels collected in September 2009 was consistent with previous maps in terms of gradients and groundwater flow directions.

6.7.5 Summary of Waste Area Group 5 Groundwater Monitoring Results

Groundwater was not monitored for WAG 5 in 2009. Groundwater monitoring for WAG 5 was concluded in November 2006 in accordance with the recommendations from the first five-year review (DOE-ID 2005).

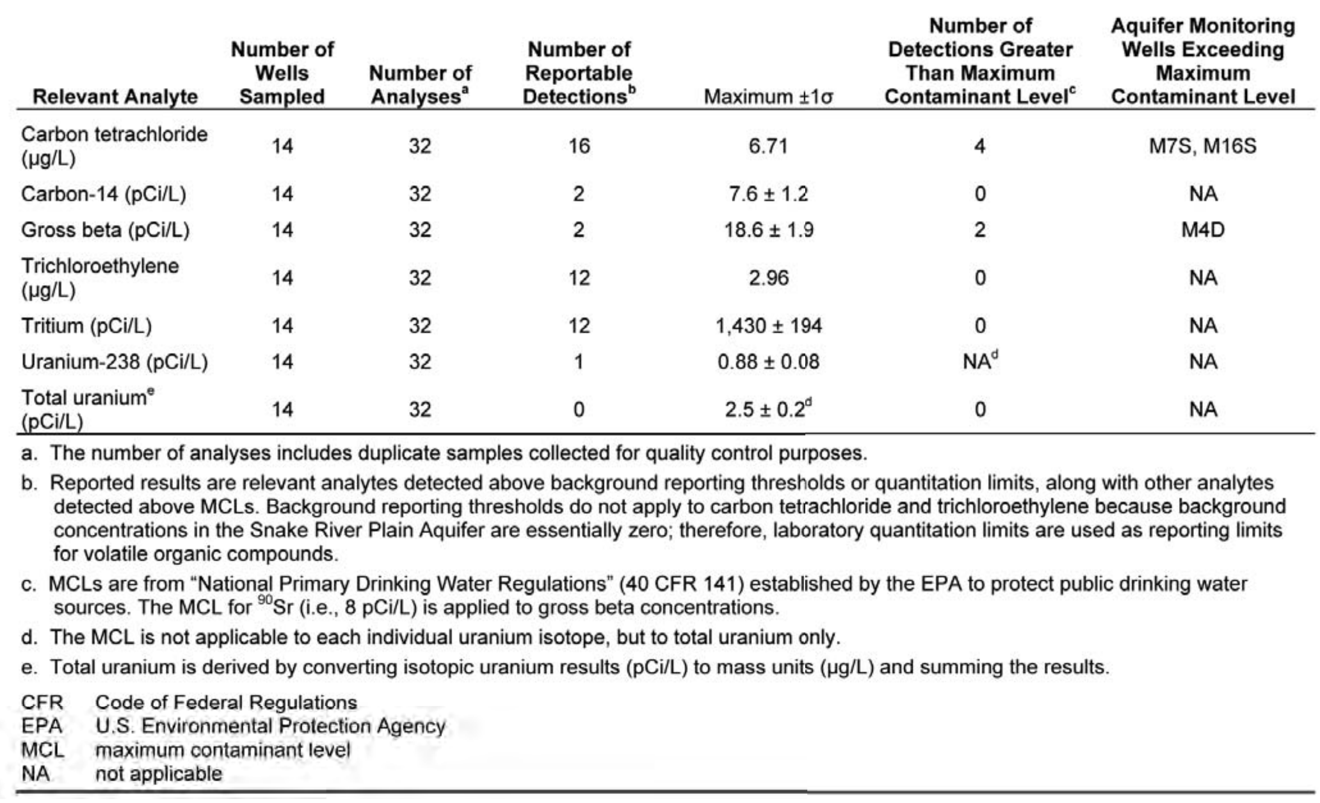
6.7.6 Summary of Waste Area Group 7 Groundwater Monitoring Results

Aquifer samples collected in the vicinity of RWMC in 2009 were analyzed for radionuclides, inorganic constituents, volatile organic compounds, and 1,4 dioxane. Nearly 3,500 analyses were performed on RWMC aquifer samples in 2009, and 45 exceeded background reporting thresholds or quantitation limits (Koeppen et al. 2009). Table 6-7 lists relevant analytes that were detected above reporting thresholds or quantitation limits and other analytes that exceeded the MCL in 2009. The majority of reportable detections were from wells located immediately east and northeast of the Subsurface Disposal Area (i.e., Wells M3S, M7S, M15S and M16S). Although Well M4D appears to have exceeded the MCL for gross beta activity, it should be noted that there is no MCL established for gross beta activity. Instead, for screening purposes, it was conservatively assumed that the result was due entirely to the presence of ^{90}Sr, a beta-emitting radionuclide. This is highly unlikely as gross beta activity typically reflects the presence of naturally-occurring radionuclides, such as potassium-40, as well as man-made radionuclides.

Carbon tetrachloride was detected at concentrations above the reporting (quantitation) limit of 1 µg/L at six monitoring locations in 2009, and the MCL was exceeded at Wells M7S and M16S. An increasing concentration trend previously was observed at Well M7S; however, a trend has not been evident since 2005. Monitoring locations where carbon tetrachloride concentrations were greater than the MCL are shown in Figure 6-15. Carbon tetrachloride in the aquifer is attributed to waste disposed of in the Subsurface Disposal Area because volatile organic

Scarab beetle

Table 6-7. Summary of Waste Area Group 7 Aquifer Sampling and Analyses Data for Relevant Analytes (2009).



Relevant Analyte	Number of Wells Sampled	Number of Analyses[a]	Number of Reportable Detections[b]	Maximum ±1σ	Number of Detections Greater Than Maximum Contaminant Level[c]	Aquifer Monitoring Wells Exceeding Maximum Contaminant Level
Carbon tetrachloride (µg/L)	14	32	16	6.71	4	M7S, M16S
Carbon-14 (pCi/L)	14	32	2	7.6 ± 1.2	0	NA
Gross beta (pCi/L)	14	32	2	18.6 ± 1.9	2	M4D
Trichloroethylene (µg/L)	14	32	12	2.96	0	NA
Tritium (pCi/L)	14	32	12	1,430 ± 194	0	NA
Uranium-238 (pCi/L)	14	32	1	0.88 ± 0.08	NA[d]	NA
Total uranium[e] (pCi/L)	14	32	0	2.5 ± 0.2[d]	0	NA

a. The number of analyses includes duplicate samples collected for quality control purposes.

b. Reported results are relevant analytes detected above background reporting thresholds or quantitation limits, along with other analytes detected above 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. MCLs are from "National Primary Drinking Water Regulations" (40 CFR 141) established by the EPA to protect public drinking water sources. The MCL for ^{90}Sr (i.e., 8 pCi/L) is applied to gross beta concentrations.

d. 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.

CFR	Code of Federal Regulations
EPA	U.S. Environmental Protection Agency
MCL	maximum contaminant level
NA	not applicable

compounds are not present in plumes from upgradient sources. Although the gross beta activity in samples from Well M4D is elevated, concentration trends are not evident.

Carbon tetrachloride concentrations in wells south of the Subsurface Disposal Area have been elevated for many years, reached peak levels that briefly exceeded the MCL between 1999 and 2003, and have been gradually decreasing since that time (Koeppen et al. 2008). In fact, chloride, sodium, sulfate, and carbon tetrachloride concentrations have followed the same trend pattern for more than 10 years. Similarities between inorganic ions and carbon tetrachloride concentration trends suggest water infiltrating through the waste zone has transported soluble analytes and volatile organic compounds to the aquifer.

6.7.7 Summary of Waste Area Group 9 Groundwater Monitoring Results

Five wells (four monitoring and one production [Figure 6-16] [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

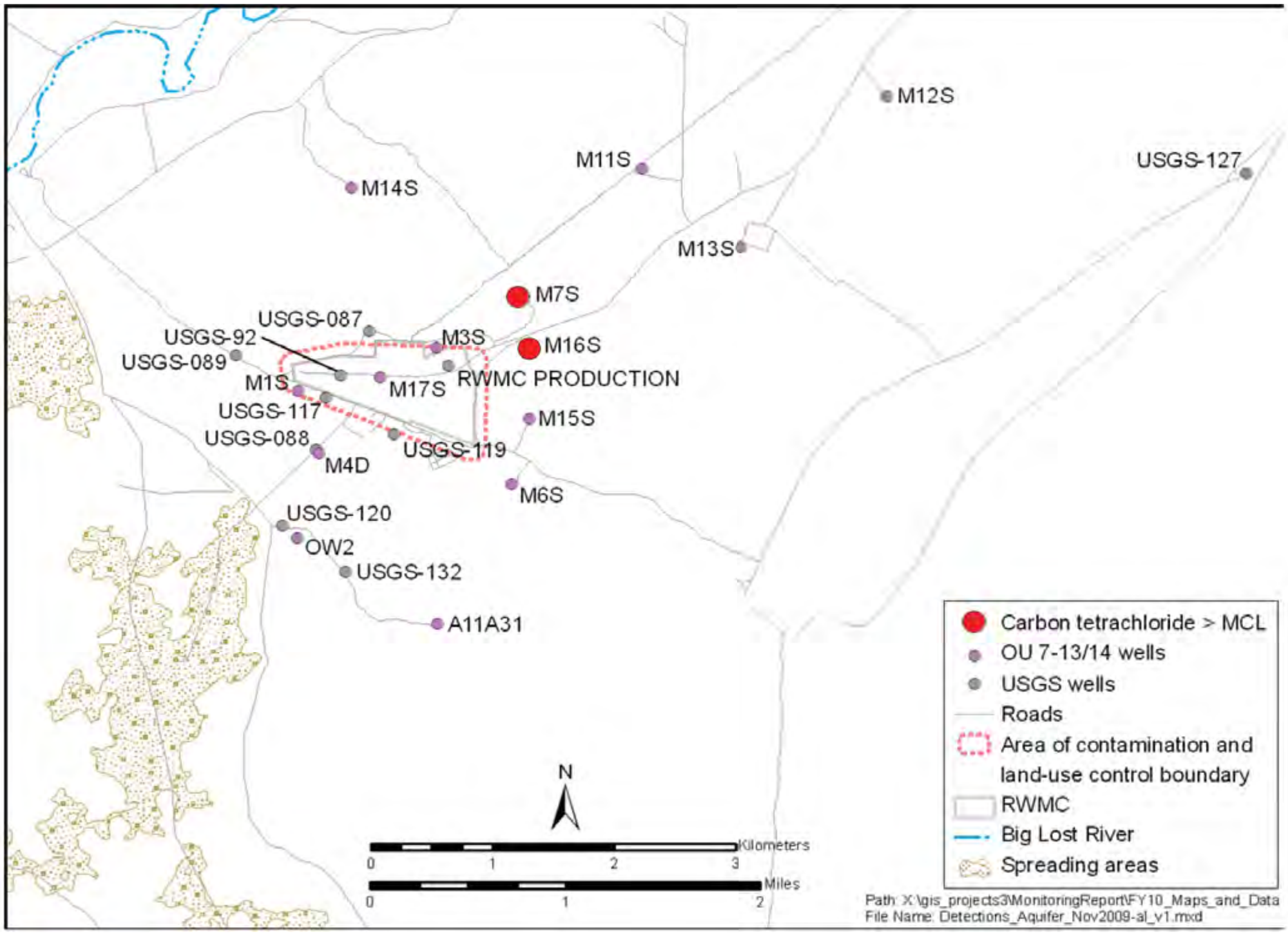


Figure 6-15. Locations of Waste Area Group 7 Aquifer Monitoring Wells where Carbon Tetrachloride Exceeded the Maximum Contaminant Level (2009).

quality parameters as required under the WAG 9 Record of Decision (ANL-W 1998). 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 evidence of impacts from activities at the Materials and Fuels Complex.

6.7.8 Summary of Waste Area Group 10 Groundwater Monitoring Results

WAG 10 groundwater monitoring activities included sampling groundwater from 12 boundary and guard wells (as shown in Figure 6-17) in accordance with the Field Sampling Plan (DOE-ID 2007). In addition, two Westbay wells, USGS-132 and USGS-103, with a total of ten sampling intervals were sampled in 2009. Wells USGS-105 and USGS-108 were not sampled because USGS-108 was being deepened by USGS, and USGS-105 was in the process of being converted into a multi-level Westbay well.

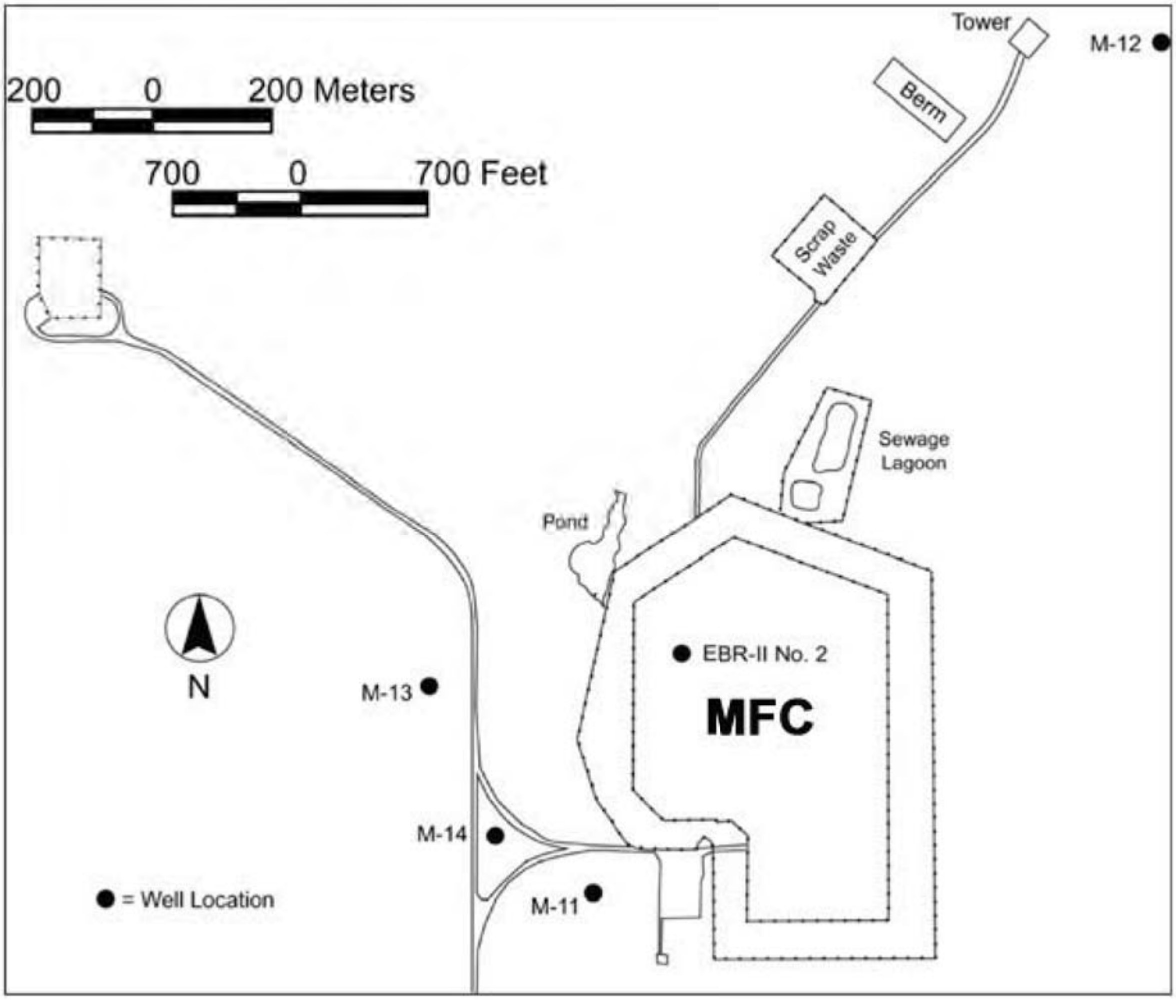


Figure 6-16. Locations of Waste Area Group 9 Monitoring Wells Sampled in 2009.

Each well was sampled for volatile organic compounds (contract laboratory program target analyte list), metals (filtered), anions, alkalinity, and radionuclides (^{129}I, tritium, ^{99}Tc, gross alpha, gross beta, and ^{90}Sr) during June – July 2009. The results are summarized in Table 6-9 and briefly described in the following paragraphs. The complete list of results can be found in the WAG 10 Annual Monitoring Status Report (DOE-ID 2010c).

No contaminant exceeded an MCL in a groundwater well along the southern INL Site boundary or in the guard wells in 2009. The iron concentration of 361 µg/L in Well USGS-110A is higher than its *secondary* MCL of 300 µg/L. However, the elevated iron concentration is not consistent with the observed high dissolved oxygen concentrations and the slightly alkaline pH of the aquifer. Dissolved iron concentrations in the aquifer should be low due to the oxidizing

Table 6-8. Comparisons of Detected Analytes to Drinking Water Standards at Waste Area Group 9 Monitoring Wells (2009).

Well	M-11		M-12		M-13		M-14		EBR-II[a] No. 2		
Sample Date	4/22/09	11/5/09	4/13/09	11/5/09	4/13/09	11/3/09	4/13/09	11/3/09	4/22/09	11/5/09	PCS/ SCS[b]
Parameter											
Radionuclides[c]											
Gross alpha (pCi/L)	0.833 ± 0.518 U[d]	1.24 ± 0.887 U	0.265 ± 0.544 U	1.39 ± 0.743 U	1.62 ± 0.645 U	1.17 ± 0.74 U	2.09 ± 0.6	0.0769 ± 0.595 U	1.64 ± 0.584	0.723 ± 0.792 U	15
Gross beta (pCi/L)	3.4 ± 0.586	1.39 ± 0.742	3.12 ± 0.523	4.89 ± 1.32	5.4 ± 0.864	2.33 ± 0.731	3.66 ± 0.538	3.7 ± 0.909	4.64 ± 0.611	3.88 ± 1.11	4 mrem/yr
Uranium-233/234 (pCi/L)	1.45 ± 0.208	1.39 ± 0.203	1.41 ± 0.202	1.45 ± 0.223	1.4 ± 0.2	1.35 ± 0.149	1.36 ± 0.205	1.26 ± 0.148	1.23 ± 0.188	0.803 ± 0.147	186,000
Uranium-238 (pCi/L)	0.571 ± 0.116	0.503 ± 0.107	0.638 ± 0.122	0.438 ± 0.11	0.545 ± 0.11	0.5 ± 0.0765	0.572 ± 0.119	0.685 ± 0.0976	0.56 ± 0.117	0.426 ± 0.1	9.9
Metals											
Aluminum (µg/L)	37.5 U	9.3	37.5 U	9.9	37.5 U	8.3	37.5 U	8.1	37.5 U	5.8	200
Arsenic (µg/L)	7.5 U	2.1	7.5 U	1.8	7.5 U	2	7.5 U	1.9	7.5 U	1.5	50
Barium (µg/L)	36.1	34.8	40.1	39.4	36.6	37	36.7	35.8	37.1	36.3	2,000
Calcium (mg/L)	39.4	38	41.1	39.5	40.2	39.8	39.5	38.3	40	39	NE[e]
Chromium (µg/L)	3.1	2.5 U	2.5 U	2.9	4.1	3.7	3.7	4.2	2.5 U	2.5 U	100
Copper (µg/L)	40.8	5.6	2.5 U	10.4	3.2	21.2	5.5	14.9	2.9	7.3	1,300
Iron (µg/L)	91.8	114	50 U	67.7	94.6	50 U	50 U	108	50 U	50 U	300
Lead (µg/L)	4.6	0.84	0.5 U	1.5	0.82	2.5	0.85	1.9	1.7	2.6	15
Magnesium (mg/L)	12.4	12	12	11.7	12.6	12.5	12.5	12	12.5	12.3	NE
Manganese (µg/L)	2.5 U	2.5 U	2.5 U	3	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	50
Nickel (µg/L)	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	3.1	5.3	19.3	NE
Potassium (mg/L)	3.29	3.18	3.64	3.52	3.38	3.24	3.31	3.18	3.31	3.18	NE

Table 6-8. Comparisons of Detected Analytes to Drinking Water Standards at Waste Area Group 9 Monitoring Wells (2009) (continued).

Well	M-11		M-12		M-13		M-14		EBR-II[a] No. 2		
Sample Date	4/22/09	11/5/09	4/13/09	11/5/09	4/13/09	11/3/09	4/13/09	11/3/09	4/22/09	11/5/09	PCS/ SCS[b]
Selenium (µg/L)	0.77	0.66	0.59	0.64	0.52	0.78	0.82	0.58	0.66	0.64	50
Sodium (mg/L)	17.4	17	17.6	17.5	18.4	19.2	17.6	17.4	17.7	17.4	NE
Vanadium (µg/L)	5.1	4.2	5.7	5.6	5.8	6.6	5.2	5.7	4.8	5.8	NE
Zinc (µg/L)	19.4	3.3	2.5 U	6.2	2.5 U	3	2.5 U	3.4	21.6	52.7	5,000
Anions											
Chloride (mg/L)	18.9	18.5	17.9	17.9	18.9	19.7	19.2	18.6	19.6	19.4	250
Nitrate (mg/L)	1.85	1.89	1.74	1.8	1.83	1.87	1.82	1.86	1.84	1.87	10
Sulfate (mg/L)	17.2	17.3	16.4	16.8	19.5	22.2	18.1	18	18.1	18.1	250
Water Quality Parameters											
Alkalinity (mg/L)	139	139	142	142	139	146	140	139	139	139	NE
Bicarbonate alkalinity (mg/L)	139	139	142	142	139	146	140	139	139	139	NE
Total dissolved solids (mg/L)	235	240	243	239	243	237	236	231	241	246	500
Total organic halides (µg/L)	10.2	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 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.

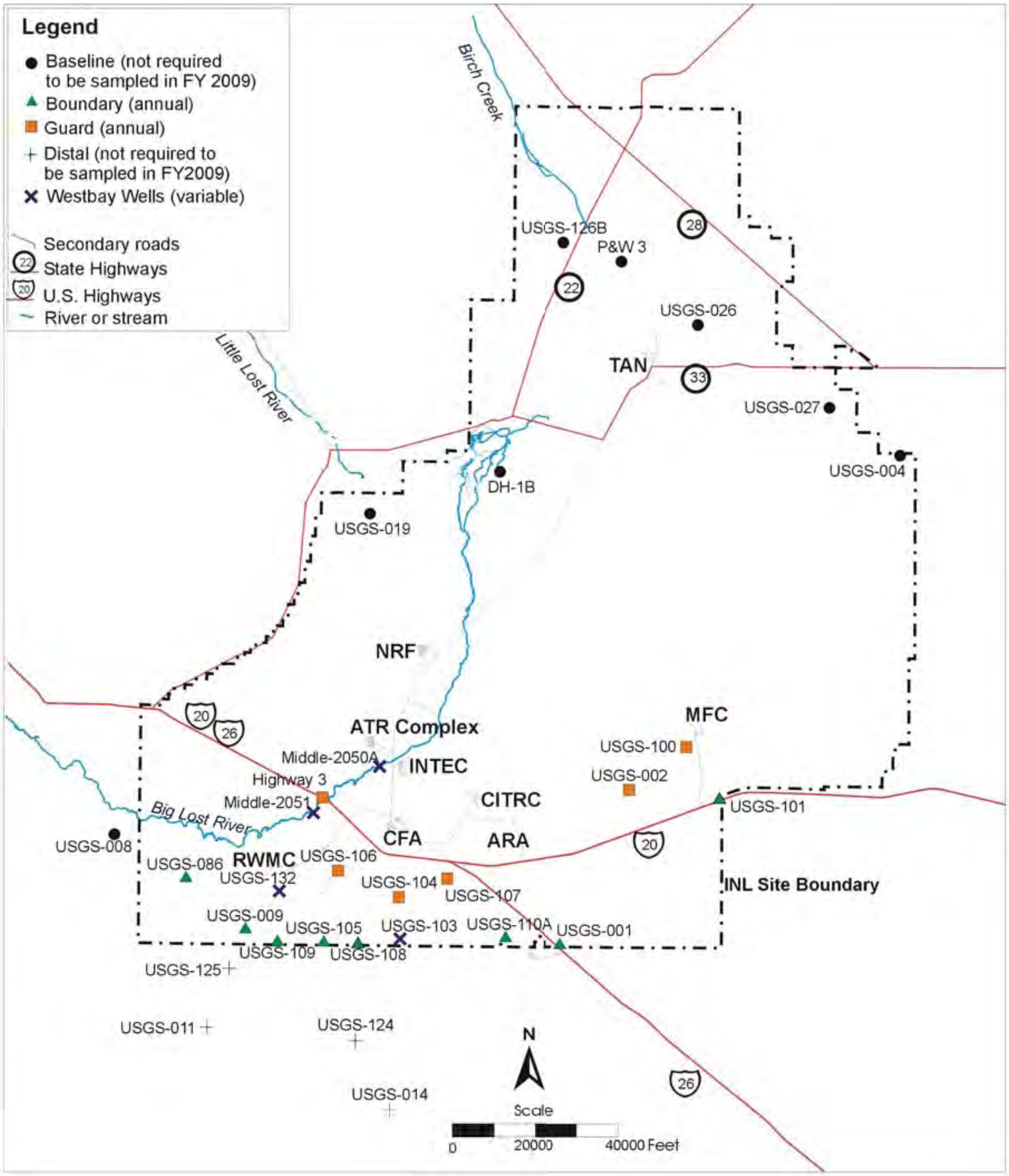


Figure 6-17. Locations of Waste Area Group 10 Monitoring Wells.

conditions and slightly alkaline pH. The cause of the high iron concentrations is uncertain because the iron and dissolved oxygen data are inconsistent.

Lead was detected just below its action level of 15 µg/L in Wells USGS-100 and USGS-106. However, the elevated lead concentrations in these wells are probably due to corrosion of galvanized riser pipes. Elevated zinc concentrations in these wells implicate the galvanized riser pipe as the cause of the elevated lead concentration. Once the galvanized pipe is replaced, both lead and zinc concentrations should decline as they have at other WAG 10 wells.

The primary radiological analytes detected in the boundary and guard wells included gross alpha, gross beta, and tritium (Table 6-9). These analytes were below their respective MCLs. The gross alpha and gross beta concentrations in the WAG 10 wells were similar to background concentrations, based on background values from Knobel et al. (1992). Tritium was detected in two wells, USGS-104 and USGS-106, and two intervals in the Westbay Well USGS-103. These wells have had a history of tritium detections. Over the past 20 years, Wells USGS-104 and USGS-106 have exhibited a downward trend in tritium concentration. The tritium detections in USGS-103 were less than 500 pCi/L and because the Westbay system was only recently installed, there are insufficient data to define a trend. All of the tritium detections were less than 800 pCi/L and considerably less than the MCL of 20,000 pCi/L (Table 6-9).

Two volatile organic compounds, toluene and carbon tetrachloride, were detected at concentrations well below MCLs. Carbon tetrachloride was detected in Well USGS-109 south of RWMC on the INL Site boundary and was detected in one interval from Westbay Well USGS-132 south of RWMC. The maximum detected carbon tetrachloride concentration was 0.452 µg/L in the uppermost sample, 646.7 ft below ground surface, from Well USGS-132 south of RWMC. A carbon tetrachloride plume originates at RWMC, and the carbon tetrachloride detections at Wells USGS-132 and -109 could represent migration from RWMC.

Toluene was detected in the sample from the Highway 3 well at a concentration of 0.56 µg/L. The toluene detection was well below the MCL for toluene (i.e., 1,000 µg/L) and near the practical quantitation limit (i.e., 1 µg/L). The source of toluene in this well is uncertain. Toluene could be from a laboratory contaminant or from vehicle exhaust because the well is located in a highway rest stop.

Table 6-9. Comparison of Detected Analytes with Maximum Contaminant Levels or Secondary Maximum Contaminant Levels for All Waste Area Group 10 (2009).

Analyte	MCL/SMCL[a]	Maximum Concentration	Detections above MCL/SMCL
Radionuclides			
Gross beta (pCi/L)	50[b]	6.42	NA
Gross alpha (pCi/L)	15	4.62	0
Iodine-129 (pCi/L)	1	ND	0
Technetium-99 (pCi/L)	900	ND	0
Strontium-90 (pCi/L)	8	ND	0
Tritium (pCi/L)	20,000	753	0
Volatile Organic Compounds[c]			
Carbon tetrachloride (µg/L)	5	0.452	0
Toluene (µg/L)	1,000	0.56	0
Anions			
Alkalinity (mg/L)	None	155	NA
Chloride (mg/L)	*250*	21.2	0
Fluoride (mg/L)	*2*	0.896	0
Nitrate/nitrite as N (mg/L)	10	1.95	0
Sulfate (mg/L)	*250*	37.2	0
Common Cations			
Calcium (µg/L)	None	43,300	NA
Magnesium (µg/L)	None	17,500	NA
Potassium (µg/L)	None	3,510	NA
Sodium (µg/L)	None	24,700	NA
Metals			
Aluminum (µg/L)	*50 to 200*	ND	0
Antimony (µg/L)	6	ND	0
Arsenic (µg/L)	10	5.37	0
Barium (µg/L)	2,000	56	0
Beryllium (µg/L)	4	ND	0
Cadmium (µg/L)	5	0.525	0
Chromium (µg/L)	100	11.5	0
Cobalt (µg/L)	None	4.33	NA
Copper (µg/L)	1,300/*1,000*	1.24	0
Iron (µg/L)	*300*	361	1
Lead (µg/L)	15[d]	14.1	0
Manganese (µg/L)	*50*	48.5	0
Mercury (µg/L)	2	ND	0
Nickel (µg/L)	None	1.82	NA
Selenium (µg/L)	50	1.55	0
Silver (µg/L)	None	ND	NA
Strontium (µg/L)	None	236	NA
Thallium (µg/L)	2	0.375	0
Uranium (µg/L)	30	3.06	0
Vanadium (µg/L)	None	10.4	NA
Zinc (µg/L)	*5,000*	189	0

a. Maximum contaminant levels are in regular text, and secondary maximum contaminant levels are in *italics*.

b. The MCL for gross beta activity is 4 mrem/yr. A value of 50 pCi/L has been established as a screening level concentration.

c. The volatile organic compounds listed are only the detected analytes.

d. The action level for lead is 15 µg/L.

NA not applicable
ND not detected

Scarab beetle

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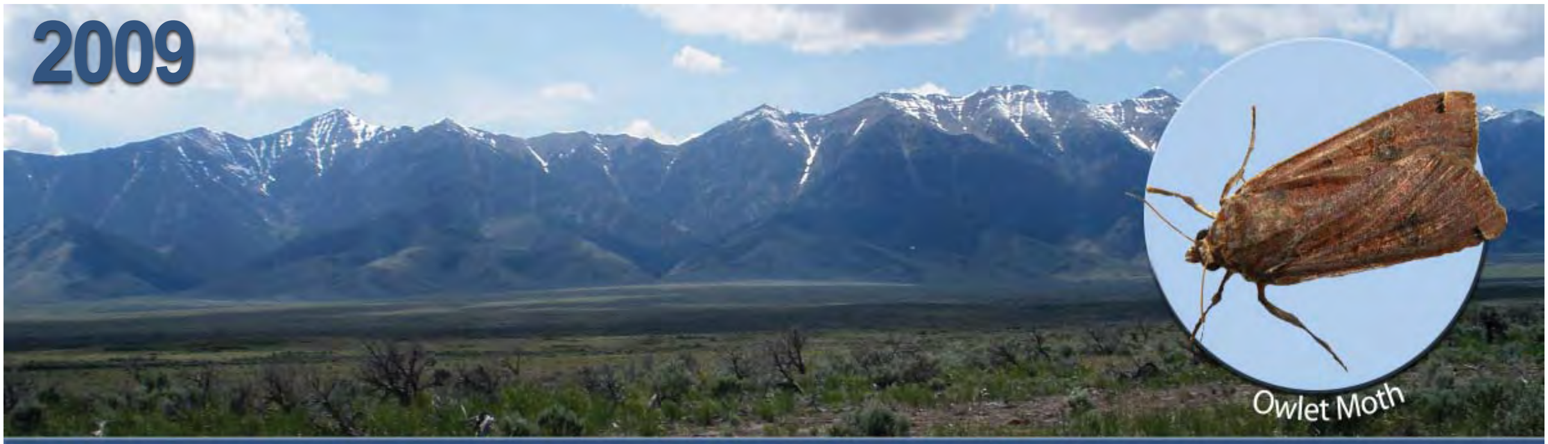


Chapter 7. Environmental Monitoring Programs – Agricultural Products, Wildlife, Soil, and Direct Radiation

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 (ESER) 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 2009. 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 two 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 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 soil samples collected at the Radioactive Waste Management Complex and analyzed in a laboratory had above-background concentrations of americium-241 and plutonium-239/240. This is attributable to past flooding of the buried waste area. The results are within environmental concentration guidelines established for the INL Site soils.

Human-made radionuclides were also found 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 detected in the meat of one of the three road-killed, large game animals sampled in 2009. The concentration was within the range of background samples collected

Scarab beetle

across the western United States in previous years and is most likely due to atmospheric fallout from past nuclear weapons testing.

Direct radiation measurements made at boundary and distant locations were consistent with background levels. The average annual dose equivalent from external exposure was 123 mrem at boundary locations and 124 mrem at distant locations. Radiation measurements taken in the vicinity of waste storage and soil contamination areas near INL Site facilities were consistent with previous measurements. Direct radiation measurements using a radiometric scanner system at the Radioactive Waste Management Complex were greater than background levels but lower than those made historically at that location. This is due to the fact that the active pit was covered in 2009.

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

This chapter summarizes results of environmental monitoring of agricultural products, wildlife, soil, and direct radiation on and around the Idaho National Laboratory (INL) Site during 2009. Details of these programs may be found in the *Idaho National Laboratory Environmental Monitoring Plan* (DOE-ID 2008). 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

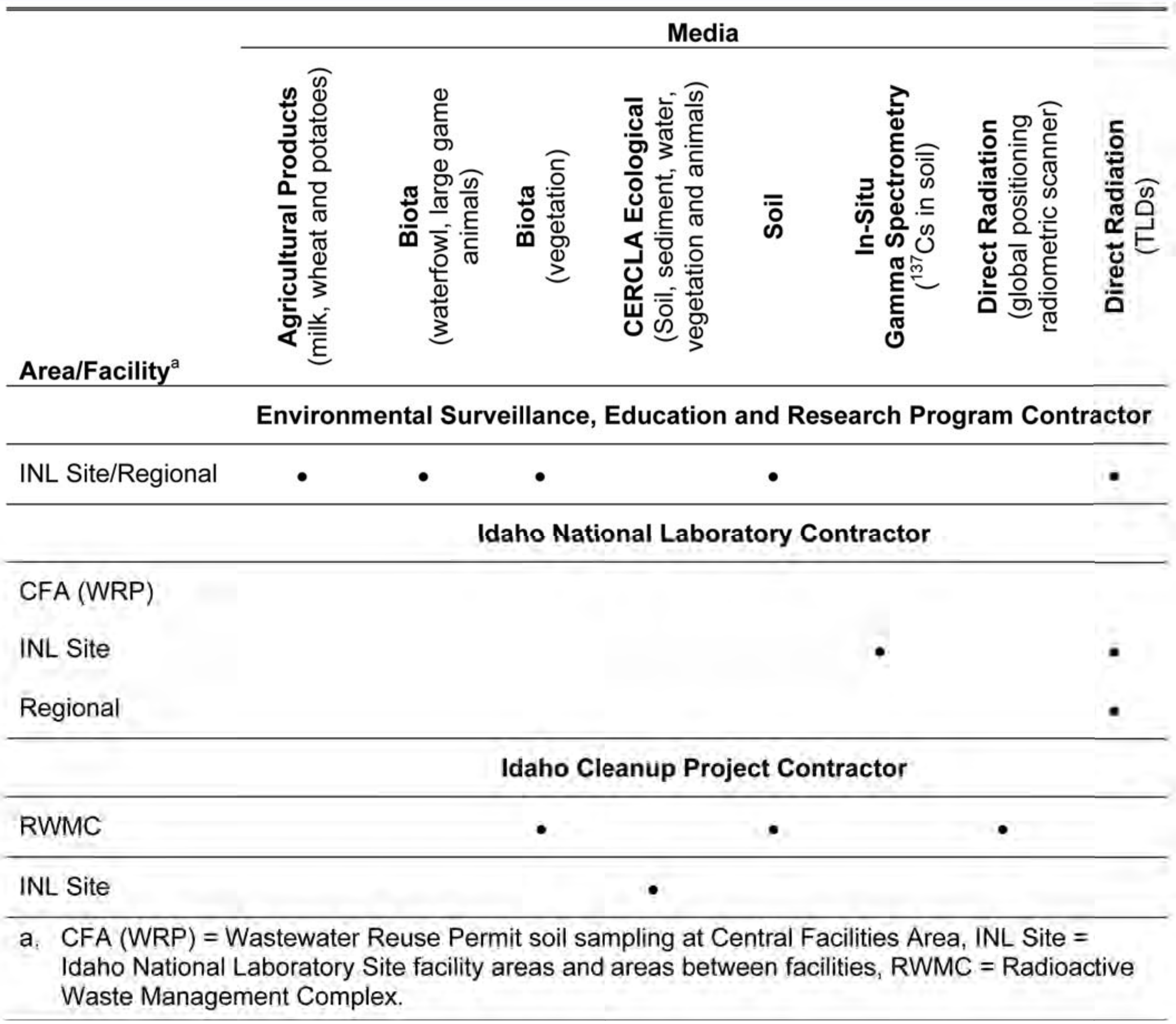
INL Site-released radionuclides may be assimilated by agricultural products and game animals which humans may then consume. These media are sampled by the ESER contractor because of the potential transfer of radionuclides to people through food chains (Figure 3-1).

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 2009, the ESER contractor collected 119 milk samples at various locations off the INL Site (Figure 7-1). The number and location of the dairies can vary from year to year as farmers enter and leave the business. Milk samples were collected weekly in Idaho Falls and monthly at other locations around the INL Site. All samples were analyzed for gamma-emitting radionuclides, including iodine-131 and cesium-137. During the second and fourth quarters, samples were analyzed either for strontium-90 or tritium.

Iodine is an essential nutrient element and is readily assimilated by cows eating plants containing the element. Iodine-131 is of particular interest because it is produced by nuclear

Table 7-1. Environmental Monitoring of Agriculture Products, Biota, Soil and Direct Radiation at the Idaho National Laboratory Site.



Area/Facility[a]	**Agricultural Products** (milk, wheat and potatoes)	**Biota** (waterfowl, large game animals)	**Biota** (vegetation)	**CERCLA Ecological** (Soil, sediment, water, vegetation and animals)	**Soil**	**In-Situ Gamma Spectrometry** (^{137}Cs in soil)	**Direct Radiation** (global positioning radiometric scanner)	**Direct Radiation** (TLDs)
	Environmental Surveillance, Education and Research Program Contractor							
INL Site/Regional	•	•	•		•			•
	Idaho National Laboratory Contractor							
CFA (WRP)								
INL Site						•		•
Regional								•
	Idaho Cleanup Project Contractor							
RWMC			•		•		•	
INL Site				•				

a. CFA (WRP) = Wastewater Reuse Permit soil sampling at Central Facilities Area, INL Site = Idaho National Laboratory Site facility areas and areas between facilities, RWMC = Radioactive Waste Management Complex.

reactors or weapons, is readily detected and, along with cesium-134 and cesium-137, 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 iodine-131 (approximately 8 mCi in 2009) is still released by the Advanced Test Reactor 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 2009.

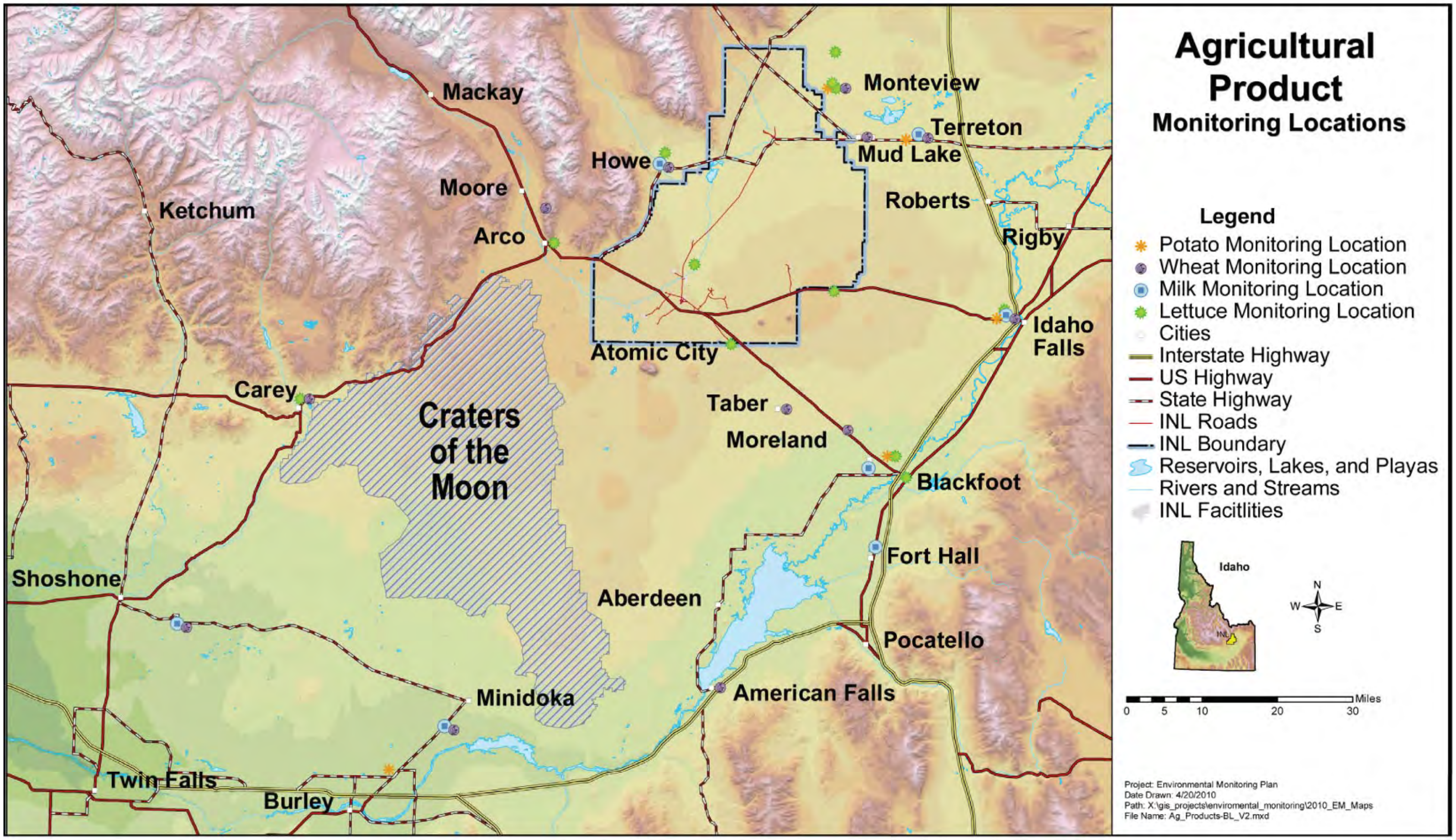


Figure 7-1. Locations of Agricultural Product Samples Collected (2009).

Cesium-137 is chemically analogous to potassium in the environment and behaves similarly. It has a half-life of about 30 years and tends to persist in soil, and if in soluble form can readily enter the food chain through plants. It is widely distributed throughout the world from historic nuclear weapons detonations, which occurred between 1945 and 1980, and has been detected in all environmental media at the INL Site. Regional sources include releases from INL facilities and resuspension of previously contaminated soil particles. Cesium-137 was not detected in any milk sample collected in 2009.

Strontium-90 is an important radionuclide because it behaves like calcium and can deposit in bones. Strontium-90, like cesium-137, 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 cesium-137, and therefore comparatively mobile in ecosystems. Strontium-90 was detected in all six milk samples analyzed, ranging from 0.28 pCi/L at Dietrich to 1.2 pCi/L at Idaho Falls (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 nine samples collected over the years covered (e.g. 2004-2009) ranged from 0 to 1.2 pCi/L (EPA 2009).

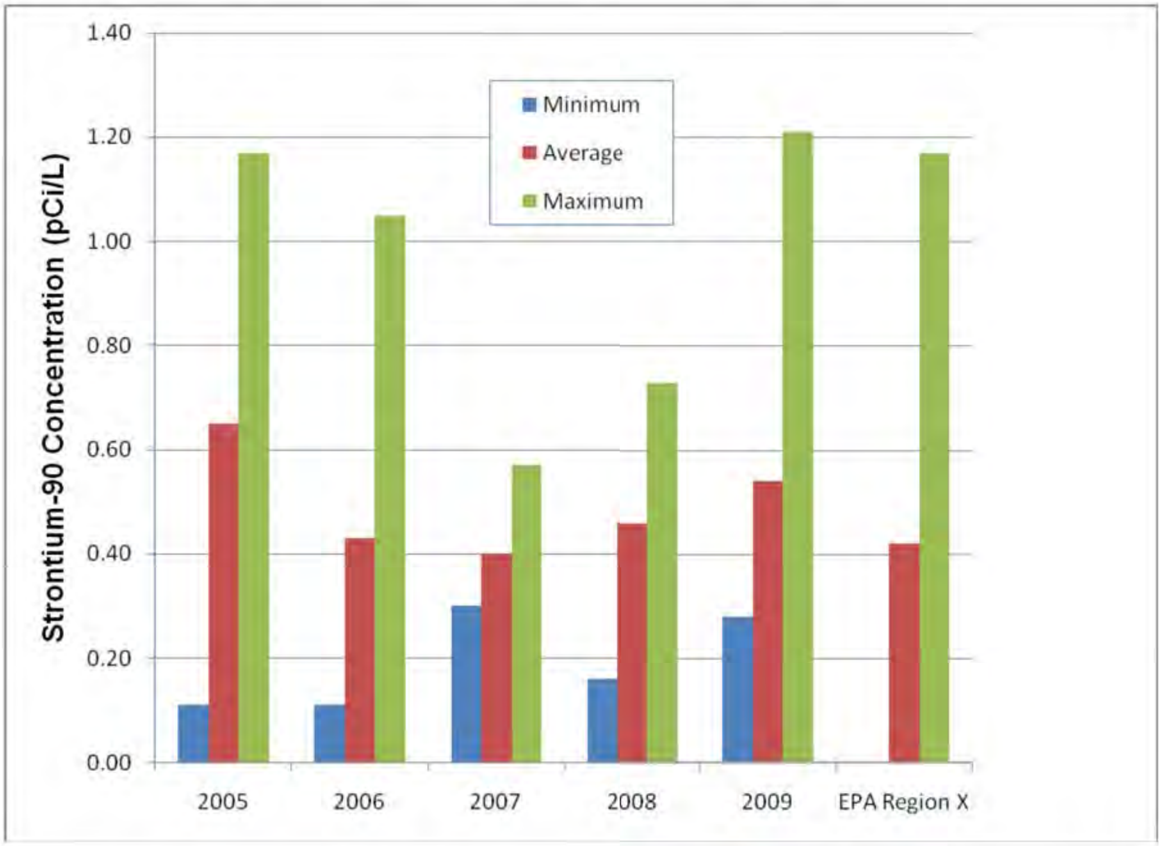


Figure 7-2. Strontium-90 Concentrations in Milk (2005 – 2009).

Scarab beetle

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 strontium-90 in water is 1,000 pCi/L. The maximum observed value in milk samples (1.2 pCi/L) is, therefore, just over 0.1 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 operations and nuclear weapons testing. Tritium enters the food chain through surface water that animals drink, as well as from plants that contain water. Tritium was detected in two of six milk samples analyzed at concentrations of 111 pCi/L in Blackfoot and 154 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 2,000 pCi/mL. The maximum observed value in milk samples is approximately 8 percent of the DCG.

7.1.2 Lettuce

Lettuce was sampled in 2009 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 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 duplicate sample was collected at Arco. The samples were analyzed for strontium-90 and gamma-emitting radionuclides.

Strontium-90 was detected in four of the ten lettuce samples (including the replicate) collected. The maximum strontium-90 detected concentration of 20 pCi/kg, measured in the lettuce sample from Carey, was within the range of concentrations detected in the past five years (17-111 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 below detection levels) from 2005 through 2009. 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 cesium-137 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 cesium-137 to plants depends highly on soil properties, such clay content or alkalinity, which can act to bind the radionuclide (Schultz 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 strontium-90 was detected in lettuce and cesium-137 was not.

Figure 7-3. Portable Lettuce Planter.

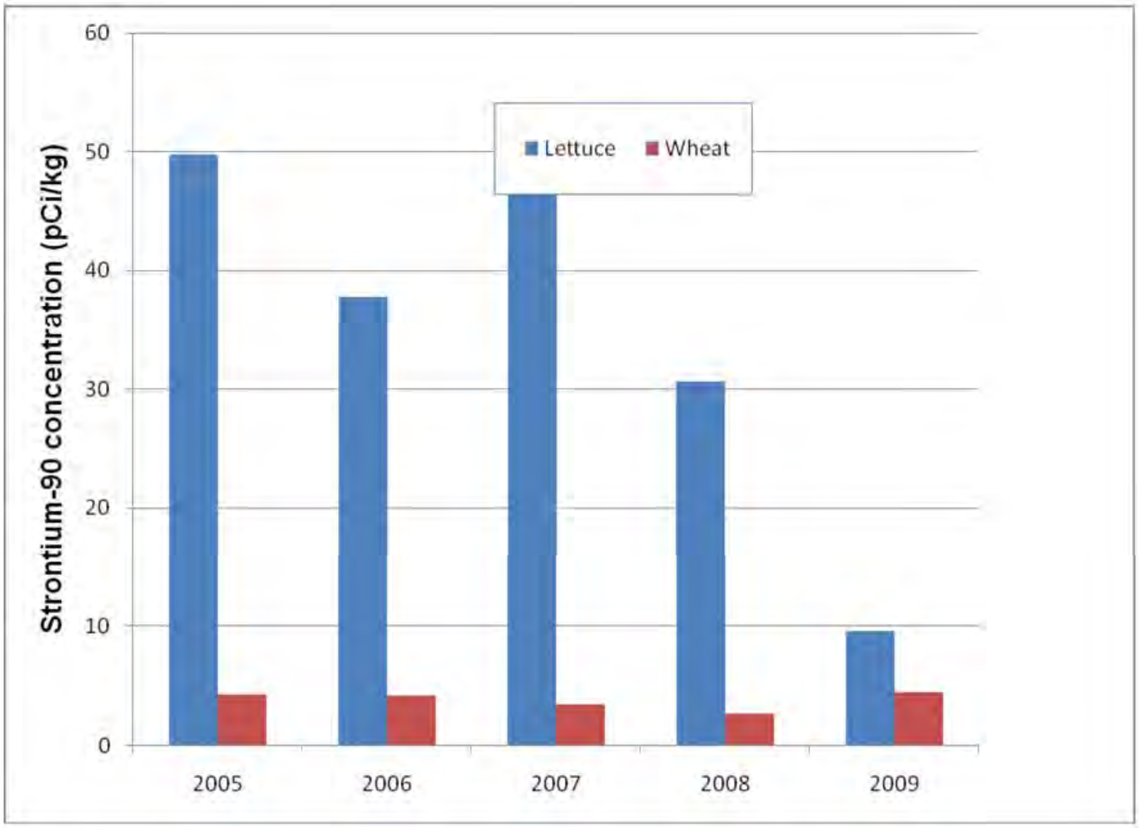


Figure 7-4. Average Strontium-90 Concentrations in Lettuce and Wheat (2005 – 2009).

7.1.3 Wheat

Wheat is sampled because it is a staple crop in the region. The ESER contractor collected 13 wheat samples from areas surrounding the INL Site in 2009. 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. Three of the 13 wheat samples collected in 2009 contained detectable concentrations of strontium-90, with a maximum result of 17 pCi/kg detected in the Idaho Falls sample. This is the maximum concentration measured in the last five years. Average current and historical results are presented in Figure 7-4. There appears to be no increasing or decreasing trend in the mean strontium-90 concentrations measured in wheat. 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.

Bristly Cutworm Moth

7.1.4 Potatoes

Potatoes are collected because they are one of the main crops grown in the region and are of special interest to the public. Because they are not exposed to airborne contaminants, they are not typically considered a key part of the ingestion pathway. Potatoes were collected by the ESER contractor at eight locations in the vicinity of the INL Site and at one location off the INL Site (Colorado). None of the nine potato samples collected during 2009 (including the one from Colorado) contained a detectable concentration of any human-made, gamma-emitting radionuclides or strontium-90.

7.1.5 Large Game Animals

Muscle and thyroid samples were collected by the ESER contractor from three game animals (two pronghorn and one mule deer) accidentally killed on INL Site roads. Liver samples were collected from two of the animals. The samples were all analyzed for cesium-137 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, cesium-137 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 4.0 to 11.7 pCi/kg.

Of the muscle and liver samples collected in 2009, cesium-137 was detected at a concentration of 3.54 pCi/kg from only one muscle sample collected in November. This value was just below the 4.0 to 11.7 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 cesium-137 concentrations, all values have been between about 4 and 12 pCi/kg.

No iodine-131 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. Ten ducks were collected during 2009: four from the Advanced Test Reactor Complex wastewater ponds, four from the Materials and Fuels Complex wastewater ponds, and two control samples from the Snake River near Roberts. 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, strontium-90, plutonium-238, plutonium-239/240, and americium-241. 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 Advanced Test Reactor Complex ponds, including cesium-137, cobalt-60, strontium-90, and zinc-65. All these radionuclides also were found in at least one edible tissue sample. Samples from Materials and Fuels Complex ponds contained cesium-137, strontium-90, and one detection each of plutonium-238 and plutonium-239/240 in a “remaining tissue” sample. Only cesium-137 also was found in edible tissue from Materials and Fuels Complex ducks. No man-made radionuclides were detected in ducks from the control location. Radionuclide concentrations measured in the edible tissues of waterfowl in 2009 are shown in Figure 7-5.

Because human-made radionuclides were found in ducks from the INL Site and not at control locations, it is assumed that the INL Site is the source of these radionuclides. Concentrations of the detected radionuclides from the Advanced Test Reactor Complex were slightly higher than those from 2006 through 2008, but cesium-137 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). 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. Further information on potential doses from consuming waterfowl is presented in Chapter 8.

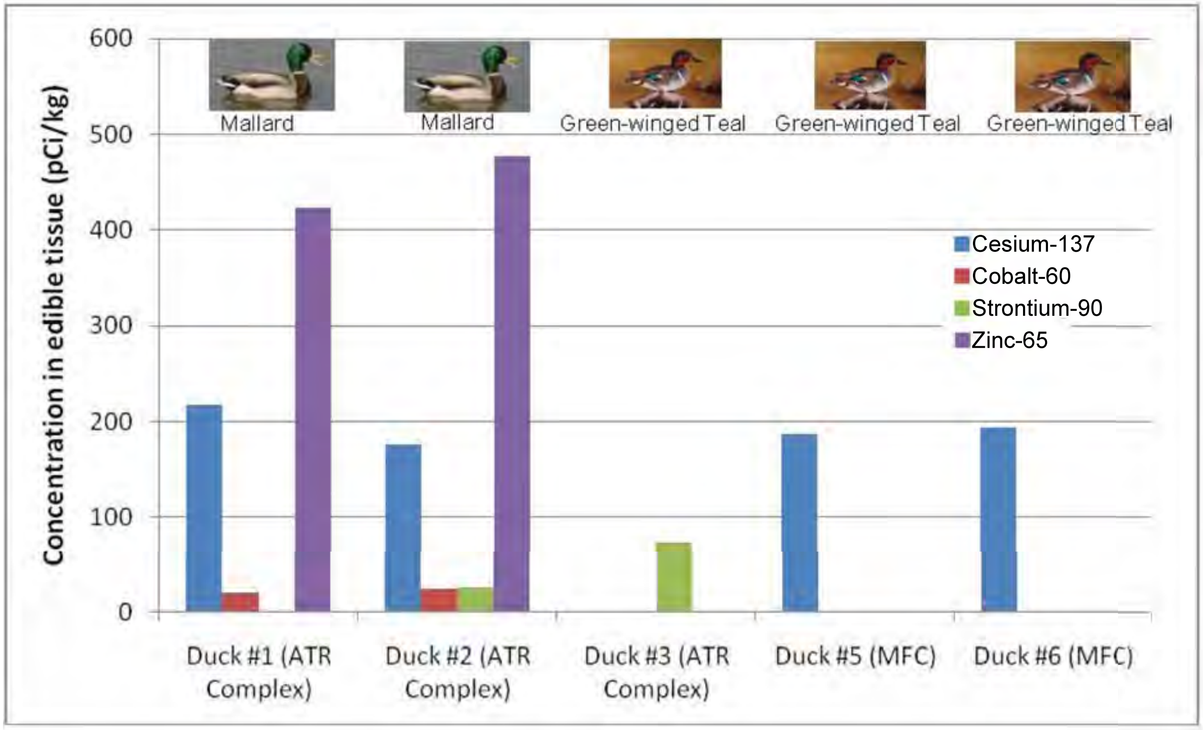


Figure 7-5. Radionuclide Concentrations Detected in Edible Tissues of Waterfowl (2009).

Bristly Cutworm Moth

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, strontium-90, plutonium-238, plutonium-239/240, and americium-241 are radionuclides that are 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., cesium-137 and strontium-90) or from their persistence in the environment due to long half-lives (e.g., plutonium-239/240, with a half-life of 24,110 years). Soil samples are collected by the ESER contractor every two years (in even-numbered years). Soil sampling locations are shown in Figure 7-6. Soil samples are analyzed for gamma-emitting radionuclides, strontium-90, americium-241, and plutonium radionuclides.

Soil was last sampled by the ESER contractor in 2008. Results from 1998 to 2008 are presented in Figure 7-7. The shorter-lived radionuclides (strontium-90 and cesium-137) show overall decreases through time, consistent with their approximate 30-year half-lives. Concentrations of plutonium-239/240, a long-lived radionuclide, have demonstrated a decreasing trend similar to that of strontium-90. However, concentrations of plutonium-238 and americium-241, which are long-lived radionuclides, show no apparent trend. This may be a function of either their inhomogeneous distribution in soil or a reflection of the specific laboratory and procedure used or both. For example, the samples collected in 2006 and 2008 were analyzed using an extraction procedure, which resulted in greater radionuclide yields than previous analyses.

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 ten 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 2008 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 2009 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. Soil salinity levels of 2 millimhos per centimeter (mmhos/cm) are generally accepted

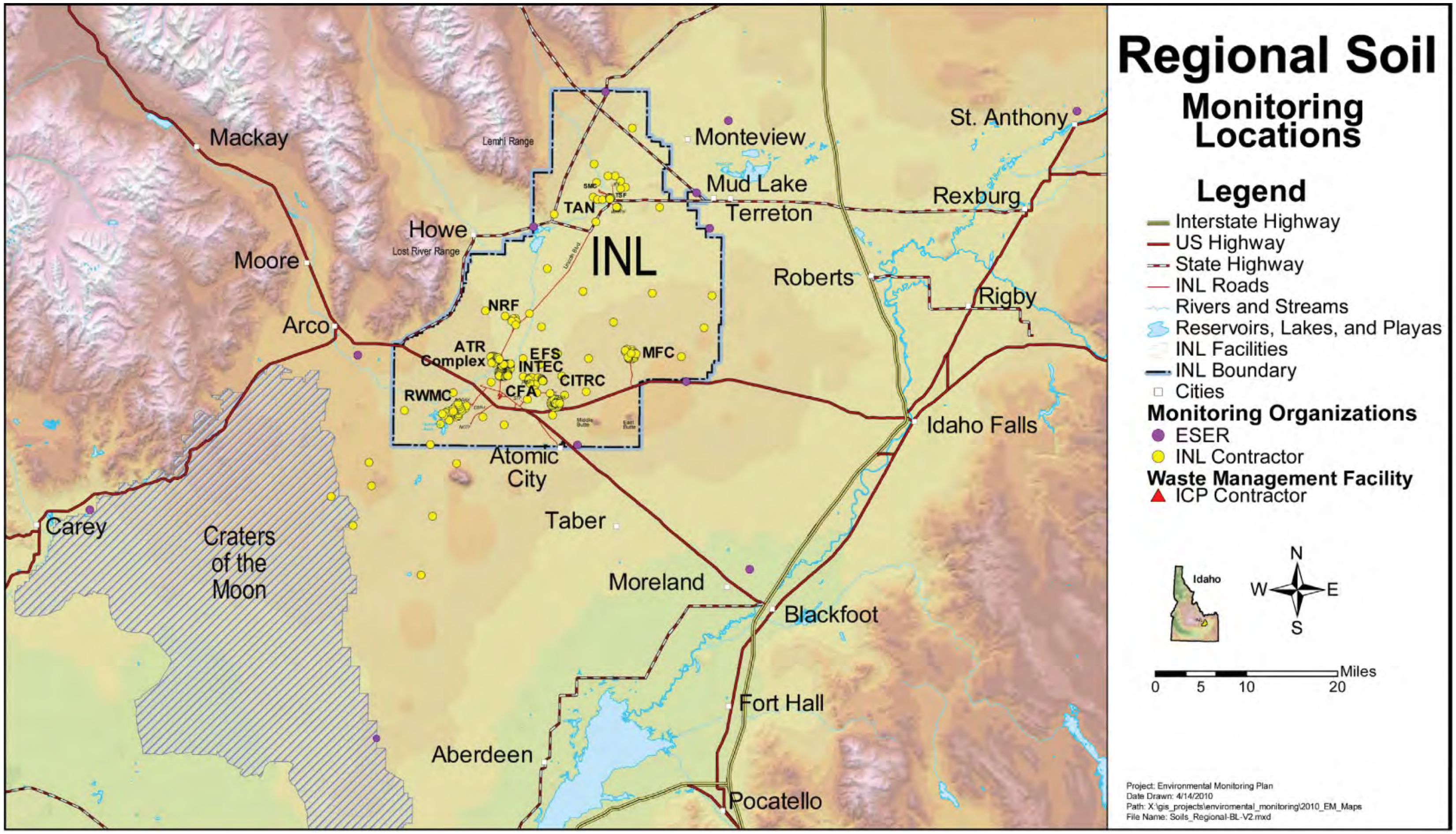


Figure 7-6. Soil Sampling Locations.

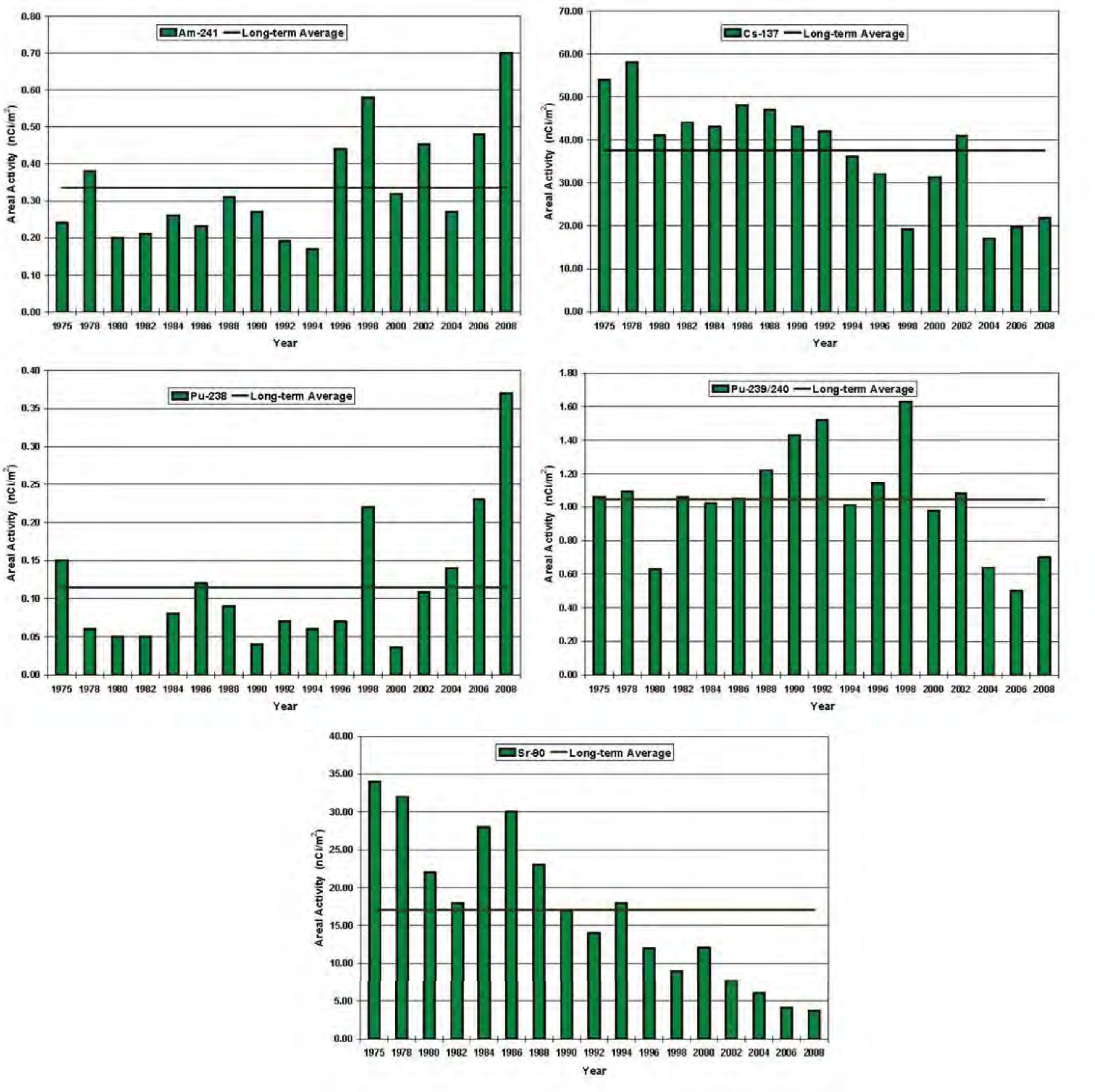


Figure 7-7. Mean Activities in Surface (0 – 5 cm [0 – 2 in.]) Soils off the INL Site (1975 – 2008).

Scarab beetle

Table 7-2. Soil Monitoring Results for the Central Facilities Area Sewage Treatment Facility Wastewater Reuse Permit (2008 and 2009).

Parameter	Depth (in.)	2008	2009
pH	0 – 12	8.21	8.26
	12 – 24	7.88	7.95
	24 – 36	8.00	8.05
Electrical conductivity (mmhos/cm)	0 – 12	0.722	0.675
	12 – 24	2.66	2.49
	24 – 36	2.20	1.937
Organic matter (%)	0 – 12	1.49	1.51
	12 – 24	0.874	0.655
	24 – 36	0.867	0.424
Nitrate as nitrogen (ppm)	0 – 12	1.16	1.62
	12 – 24	0.996 U[a]	0.998 U
	24 – 36	0.986 U	0.996 U
Ammonium nitrogen (ppm)	0 – 12	1.46	0.818
	12 – 24	0.498 U	0.499 U
	24 – 36	0.493 U	0.498 U
Extractable phosphorus (ppm)	0 – 12	11.2	7.77
	12 – 24	3.98	1.72
	24 – 36	2.84	1.28
Sodium adsorption ratio	0 – 12	4.06	3.83
	12 – 24	4.73	4.19
	24 – 36	3.48	2.5

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

to have negligible effects on plant growth. In 2009, the soil salinity levels at the 0-12-in. and 24-36-in. depths were below the 2-mmhos/cm level.

Poor drainage is the most common cause of salt buildup in soils (Blaylock 1994). 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).

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.”

Bristly Cutworm Moth

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 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 cesium-137, 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.

The INL contractor performed 335 field-based gamma spectrometry measurements in 2009 with an HPGe detector measurement system using the methodology described in the Environmental Measurements Laboratory Procedures Manual (DOE 1997). A summary of results is presented in Table 7-3.

In addition to the in-situ gamma spectrometry measurements, a series of soil samples was collected at select locations at each INL Site facility. These samples were collected at several locations according to a specific sampling pattern that encompassed the field-of-view of a detector. A total of 33 locations were sampled. Soil samples were collected using a split spoon sampler to a depth of 6–in. in 1–in. increments. The samples then were sorted by depth and packaged into pucks. They were analyzed using conventional laboratory-based gamma spectroscopy systems. The cesium-137 data consistently follow exponential trends when the concentration is plotted against depth. An example of an exponential depth profile is shown in the box on the right.

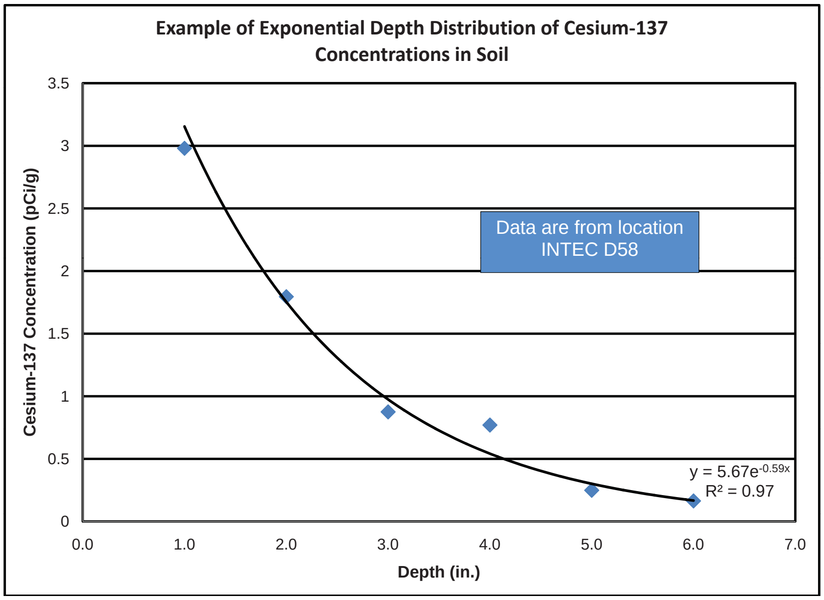


Table 7-3. In-Situ Gamma Scan Results for INL Site Locations (2009).

	Cesium-137 Concentration (pCi/g)			
Location	**Number of measurements**	**Minimum**	**Maximum**	**Mean**
Auxiliary Reactor Area	77	0.07	7.99	1.27
Advanced Test Reactor Complex	24	0.09	0.68	0.34
Critical Infrastructure Test Range Complex	16	0.06	0.22	0.16
Idaho Nuclear Technology and Engineering Center	90	0.05	3.76	1.12
Large Grid (a 24-mile radius around the Idaho Nuclear Technology and Engineering Center)	42	0.03	0.51	0.21
Materials and Fuels Complex	18	0.19	0.42	0.23
Naval Reactors Facility	5	0.11	0.31	0.18
Radioactive Waste Management Complex	45	0.10	0.46	0.18
Test Area North-Specific Manufacturing Capability	18	0.10	1.09	0.26
Overall	335	0.03	7.99	0.70

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 TLD packets are replaced in May and November of each year. The sampling periods for 2009 were from November 2008 through April 2009 (spring collection) and from May through October 2009 (fall collection).

The measured cumulative environmental radiation exposure for locations off the INL Site from November 2008 through October 2009 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 2005 to 2008 also are included for each location.

The mean annual exposures from distant locations in 2009 were 119 milliroentgens (mR) measured by the ESER contractor dosimeters and 121 mR measured by the INL contractor dosimeters. For boundary locations, the mean annual exposures were 118 mR measured by the ESER contractor dosimeters and 121 mR measured by the INL contractor dosimeters. Using both ESER and INL contractors' data, the average dose equivalent of the distant group was 124

Bristly Cutworm Moth

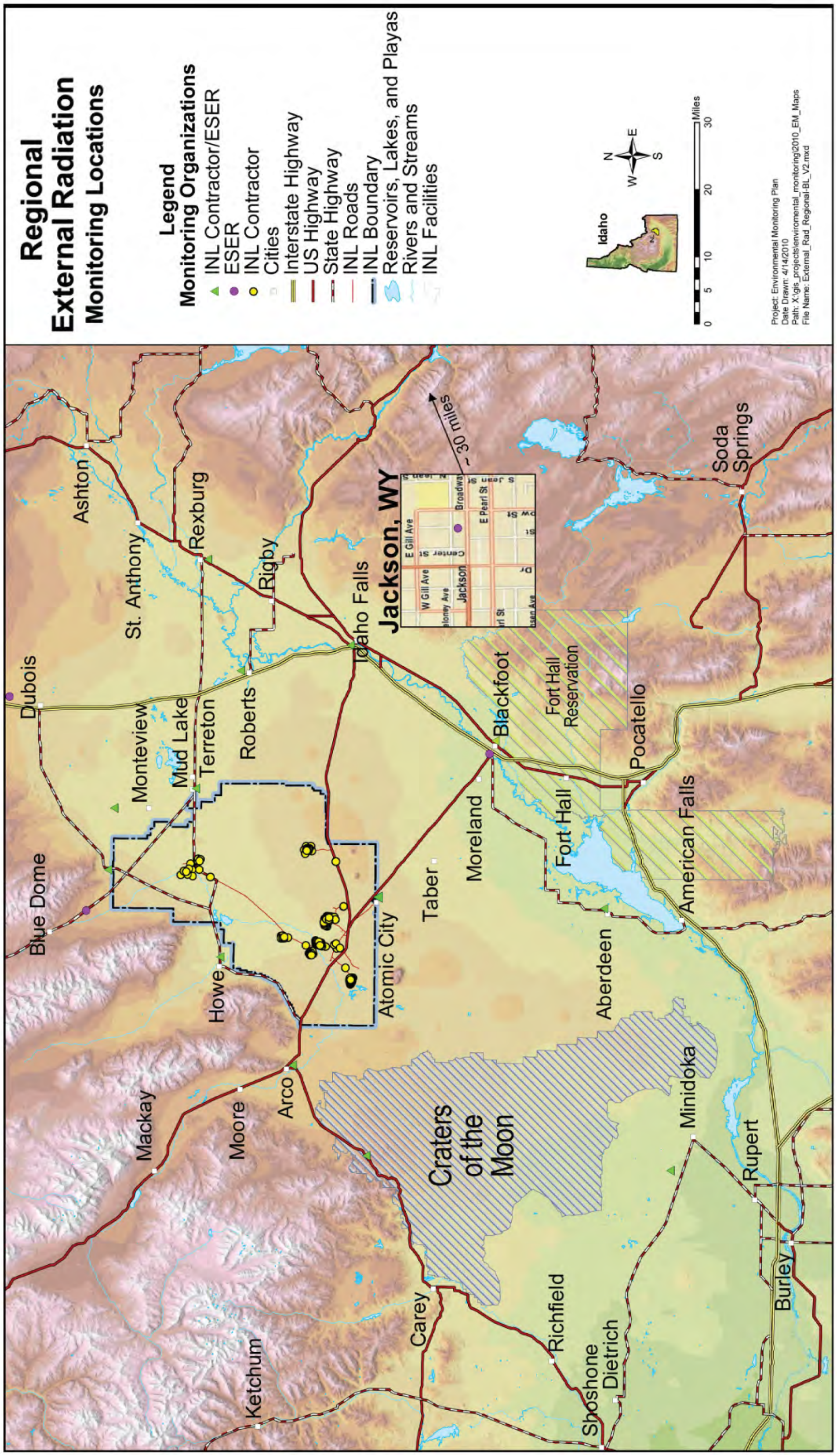


Figure 7-8. Regional Direct Radiation Monitoring Locations.

Table 7-4. Annual Environmental Radiation Exposures (2005 – 2009).

Location	2005 ESER[a]	2005 INL[b] Contractor	2006 ESER	2006 INL Contractor	2007 ESER	2007 INL Contractor	2008 ESER	2008 INL Contractor	2009 ESER	2009 INL Contractor
	(mR)									
Distant Group										
Aberdeen	124 ± 7	130 ± 9	126 ± 9	124 ± 9	129 ± 6	127 ± 6	128 ± 9	132 ± 9	130 ± 6	128 ± 9
Blackfoot	129 ± 9	113 ± 8	115 ± 8	104 ± 7	119 ± 6	109 ± 5	118 ± 8	111 ± 8	122 ± 6	113 ± 8
Blackfoot (CMS)[c,d]	117 ± 2	N/A	106 ± 7	N/A	109 ± 5	N/A	110 ± 8	N/A	110 ± 6	NA
Craters of the Moon	138 ± 8	122 ± 8	111 ± 7	112 ± 8	120 ± 6	129 ± 6	116 ± 8	117 ± 8	120 ± 5	125 ± 9
Dubois[d]	117 ± 5	N/A	95 ± 7	N/A	101 ± 5	N/A	100 ± 7	N/A	103 ± 5	NA
Idaho Falls	122 ± 2	116 ± 8	119 ± 8	110 ± 8	123 ± 2	119 ± 6	121 ± 8	117 ± 8	120 ± 6	121 ± 8
Jackson[d]	106 ± 7	N/A	90 ± 6	N/A	97 ± 5	N/A	102 ± 7	N/A	102 ± 5	NA
Minidoka	116 ± 3	112 ± 8	107 ± 7	103 ± 7	109 ± 5	111 ± 5	109 ± 8	112 ± 8	111 ± 5	111 ± 8
Rexburg	152 ± 2	121 ± 8	134 ± 9	113 ± 8	145 ± 7	120 ± 6	135 ± 9	116 ± 8	138 ± 7	118 ± 8
Roberts	126 ± 11	N/A	126 ± 9	123 ± 9	137 ± 7	133 ± 7	129 ± 9	132 ± 9	130 ± 6	130 ± 9
Mean	121 ± 6	119 ± 8	113 ± 8	113 ± 8	119 ± 6	121 ± 6	117 ± 8	120 ± 8	119 ± 6	121 ± 8
Boundary Group										
Arco	124 ± 9	120 ± 8	115 ± 8	111 ± 8	127 ± 6	125 ± 6	119 ± 8	121 ± 8	121 ± 6	124 ± 9
Atomic City	123 ± 9	—[e]	119 ± 8	112 ± 8	129 ± 6	124 ± 6	126 ± 9	120 ± 8	122 ± 6	120 ± 8
Blue Dome[d]	115 ± 8	N/A	101 ± 7	N/A	104 ± 5	N/A	106 ± 7	N/A	107 ± 5	NA
Howe	126 ± 9	116 ± 8	108 ± 8	105 ± 7	118 ± 6	120 ± 6	117 ± 8	116 ± 8	116 ± 6	117 ± 8
Monteview	109 ± 8	121 ± 8	110 ± 8	107 ± 7	115 ± 6	119 ± 6	115 ± 8	120 ± 8	116 ± 5	119 ± 8
Mud Lake	132 ± 9	130 ± 8	119 ± 8	120 ± 8	128 ± 6	132 ± 6	128 ± 9	129 ± 9	130 ± 6	135 ± 9
Birch Creek Hydro	110 ± 8	—[e]	104 ± 7	103 ± 7	111 ± 5	109 ± 5	110 ± 8	114 ± 8	112 ± 6	113 ± 8
Mean	120 ± 9	119 ± 8	111 ± 8	110 ± 8	119 ± 6	121 ± 6	117 ± 8	120 ± 8	118 ± 6	121 ± 8

a. ESER = Environmental, Surveillance, Education and Research

b. INL = Idaho National Laboratory

c. CMS = Community Monitoring Station

d. The INL contractor does not sample at this location.

e. Dosimeter was missing at one of the collection times.

Bristly Cutworm Moth

mrem when a dose equivalent conversion factor of 1.03 was used to convert from mR to mrem in tissue (NRC 1997). The average dose equivalent for the boundary group was 123 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 C, Figures C-1 through C-10. Dosimeters on the INL Site are placed on 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.

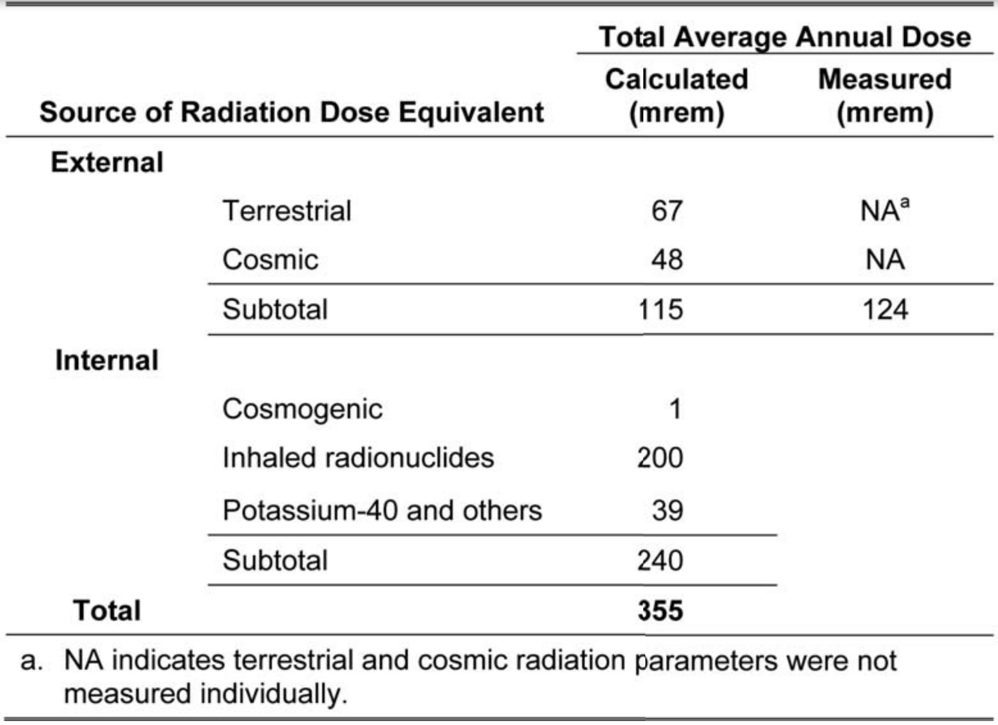
The maximum exposure recorded by a TLD on the INL Site during 2009 was 193 mR at the Advanced Test Reactor Complex. This location, TRA 13, is near controlled radioactive material areas where movement and storage of materials affect the exposure rate. This exposure is marginally higher than that of 2008 and 2007, which were 148 mR and 159 mR, respectively.

The annual exposure dropped at the Radioactive Waste Management Complex location RWMC 41 from 647 mR in 2008 (the highest at the INL Site in 2008) to 174 mR in 2009, most likely due to the fact that the active pit was covered in 2009 (Section 7.4.3).

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. 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 uranium-238, thorium-232, and potassium-40 were 1.5, 1.3, and 19 pCi/g, respectively. The calculated external dose equivalent received by a member of the public from uranium-238 plus decay products, thorium-232 plus decay products, and potassium-40 based on the above-average area soil concentrations were 21, 28, and 27 mrem/yr, respectively, for a total of 76 mrem/yr. 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 2009, this resulted in a corrected dose of 67 mrem/yr because of snow cover, which ranged from 2.54 to 43.2 cm (1 to 17 in.) deep over 96 days with recorded snow cover.

The cosmic component varies primarily with increasing altitude from about 26 mrem/yr at sea level to about 48 mrem/yr at the 1,500-m (4,900-ft) elevation of the INL Site (NCRP 1987). Cosmic radiation may vary slightly because of solar cycle fluctuations and other factors.

Table 7-5. Calculated Effective Dose Equivalent from Natural Background Sources (2009).



Source of Radiation Dose Equivalent		Total Average Annual Dose Calculated (mrem)	 Measured (mrem)
External			
	Terrestrial	67	NA[a]
	Cosmic	48	NA
	Subtotal	115	124
Internal			
	Cosmogenic	1	
	Inhaled radionuclides	200	
	Potassium-40 and others	39	
	Subtotal	240	
Total		**355**	

a. NA indicates terrestrial and cosmic radiation parameters were not measured individually.

The estimated sum of the terrestrial and cosmic components of dose to a person residing on the Snake River Plain in 2009 was 115 mrem/yr (Table 7-5). This is slightly lower than the 124 mrem/yr measured at distant locations by the ESER and INL contractor TLDs after conversion from mR to mrem in tissue. Measured values are very close, and within normal variability, of the calculated background doses. Therefore, it is unlikely that INL Site operations contribute to background radiation levels at distant locations.

The component of background dose that varies the most is inhaled radionuclides. According to the National Council on Radiation Protection and Measurements, the major contributor of external dose equivalent received by a member of the public from uranium-238 plus decay products is short-lived decay products of radon (NCRP 1987). 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 200 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. Therefore, the effective dose equivalent from natural background radiation for residents in the INL Site vicinity actually may be higher or lower than the total estimated background dose of about 355 mrem/yr shown in Table 7-5 and will vary from one location to another.

Bristly Cutworm Moth

7.4 Waste Management Surveillance Sampling

Vegetation and soil are sampled, and direct radiation is measured at the Radioactive Waste Management Complex to comply with DOE Order 435.1, “Radioactive Waste Management” (2001).

7.4.1 Vegetation Sampling at the Radioactive Waste Management Complex

At the Radioactive Waste Management Complex, vegetation is collected from the four major areas shown in Figure 7-9. Crested wheatgrass and perennials (invasive species) are collected in odd-numbered years if available. Control samples are collected near Frenchman’s Cabin, which is approximately seven miles south of the Subsurface Disposal Area at the base of Big

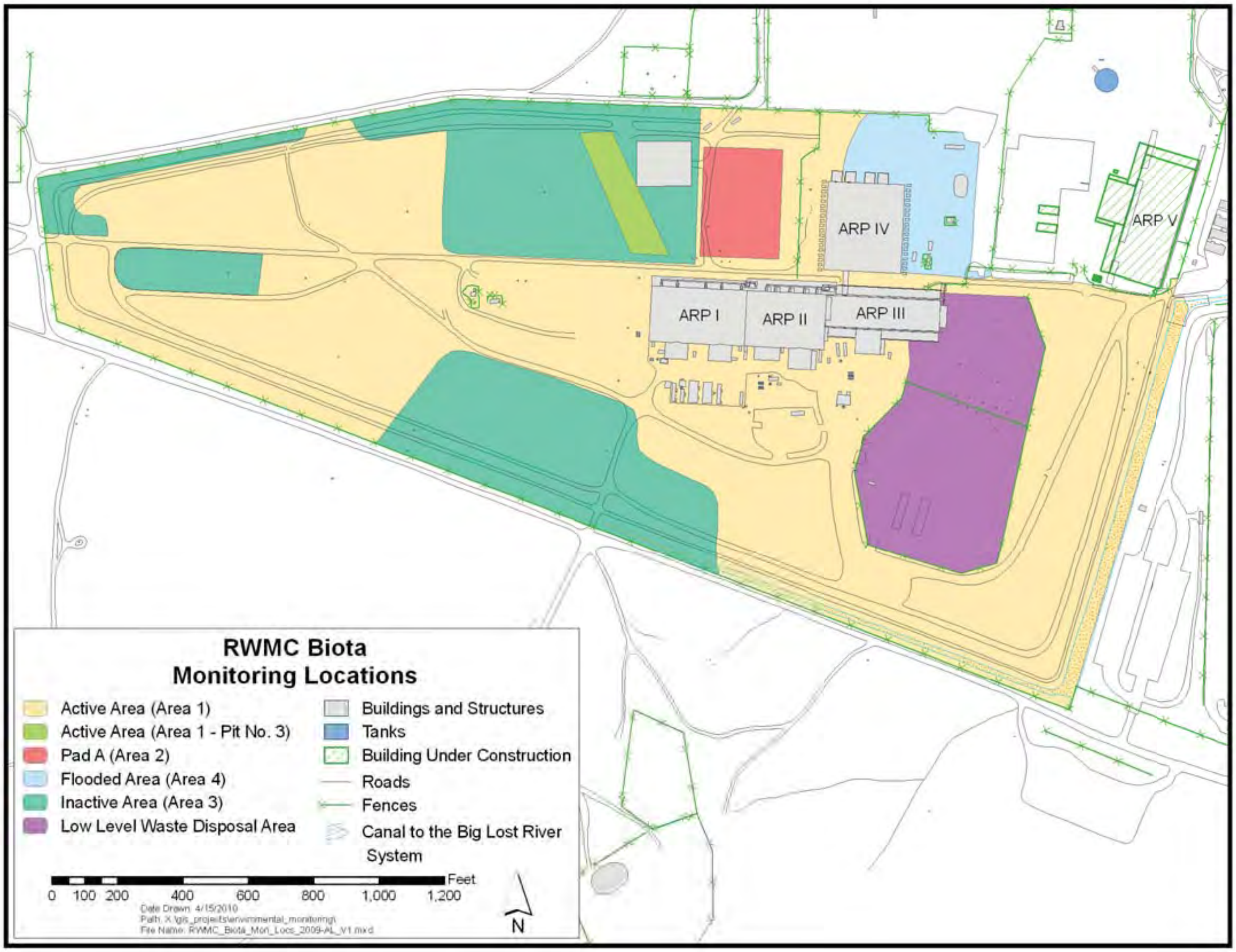


Figure 7-9. Radioactive Waste Management Complex Vegetation Sampling Locations (Areas 1 – 4).

Southern Butte. Crested wheatgrass samples were collected in all major areas of the Subsurface Disposal Area in 2009. Due to recontouring and construction activities at the Radioactive Waste Management Complex, perennials were not available for sampling in 2009.

The vegetation samples were analyzed for gamma-emitting radionuclides, strontium-90, and alpha-emitting transuranics. There were no positive detections in the crested wheatgrass collected in 2009.

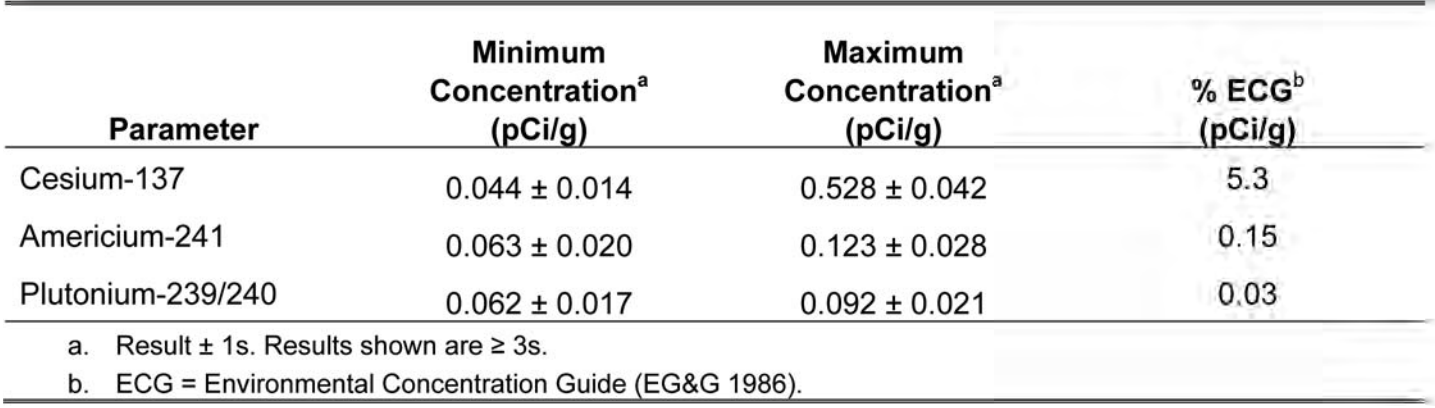
7.4.2 Soil Sampling at the Radioactive Waste Management Complex

Biennial soil sampling was conducted during 2009. Soil samples were collected to a depth of 5 cm (2 in.) at the Radioactive Waste Management Complex locations shown in Figure 7-10. The soils were analyzed for gamma-emitting radionuclides. The maximum concentration of cesium-137 measured in any sample was 0.53 pCi/g (Table 7-6). This is 5.3 percent of the Environmental Concentration Guide of 10 pCi/g for cesium-137 in soil (EG&G 1986). The Environmental Concentration Guides were calculated to establish INL Site-specific dose guidelines for decontamination and decommissioning projects. Each Environmental Concentration Guide represents the concentration of a radionuclide in soil that would conservatively result in a dose of 100 mrem in the first year after release of an area to a hypothetical subsistence farmer.

Selected samples were analyzed for specific radionuclides. The results for cesium-137, americium-241, and plutonium-239/240 are far below the Environmental Concentration Guides (EG&G Idaho 1986) established for soils (Table 7-6).

Cesium-137 concentrations are within the background range for the INL Site and surrounding areas and are likely attributable to past fallout. Americium-241 and plutonium-239/240 concentrations are above the background range for the INL Site, but are consistent with historical concentrations measured at the Radioactive Waste Management Complex. These results are attributable to previous flooding and increased operational activity in the Subsurface Disposal Area, including the Accelerated Retrieval Project (construction and operations).

Table 7-6. Radionuclides Detected in Radioactive Waste Management Complex Soils (2009).

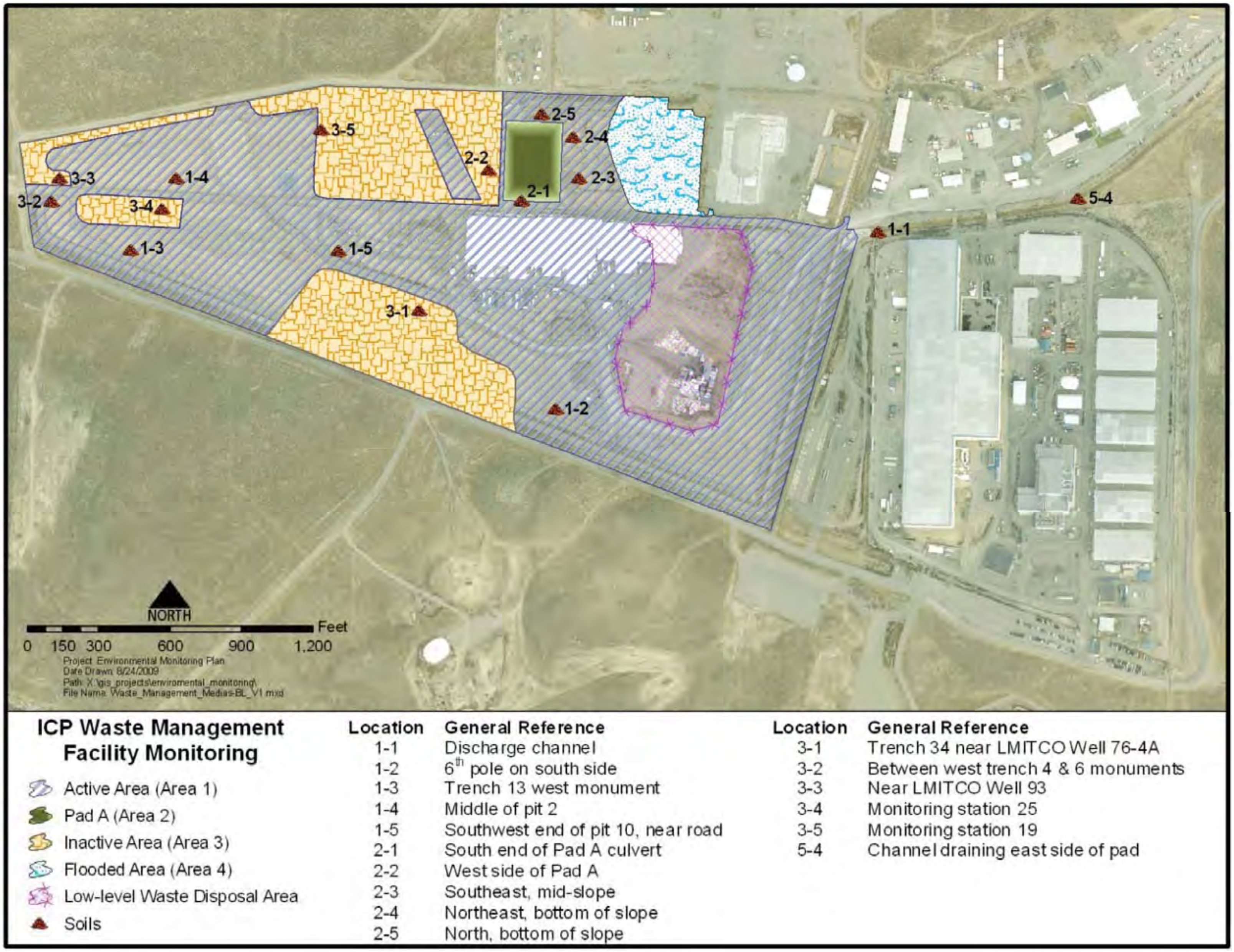


Parameter	Minimum Concentration[a] (pCi/g)	Maximum Concentration[a] (pCi/g)	% ECG[b] (pCi/g)
Cesium-137	0.044 ± 0.014	0.528 ± 0.042	5.3
Americium-241	0.063 ± 0.020	0.123 ± 0.028	0.15
Plutonium-239/240	0.062 ± 0.017	0.092 ± 0.021	0.03

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

b. ECG = Environmental Concentration Guide (EG&G 1986).

Bristly Cutworm Moth



Location	General Reference	Location	General Reference
1-1	Discharge channel	3-1	Trench 34 near LMITCO Well 76-4A
1-2	6th pole on south side	3-2	Between west trench 4 & 6 monuments
1-3	Trench 13 west monument	3-3	Near LMITCO Well 93
1-4	Middle of pit 2	3-4	Monitoring station 25
1-5	Southwest end of pit 10, near road	3-5	Monitoring station 19
2-1	South end of Pad A culvert	5-4	Channel draining east side of pad
2-2	West side of Pad A		
2-3	Southeast, mid-slope		
2-4	Northeast, bottom of slope		
2-5	North, bottom of slope		

Figure 7-10. Radioactive Waste Management Complex Soil Sampling Locations.

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 two seconds. The vehicle was driven less than or equal to 5 miles per hour, with the detector height at 36-in above the ground.

Figures 7-11 and 7-12 show the radiation readings from the 2008 and 2009 annual surveys. Although readings vary slightly from year to year, the 2009 results for most areas are comparable

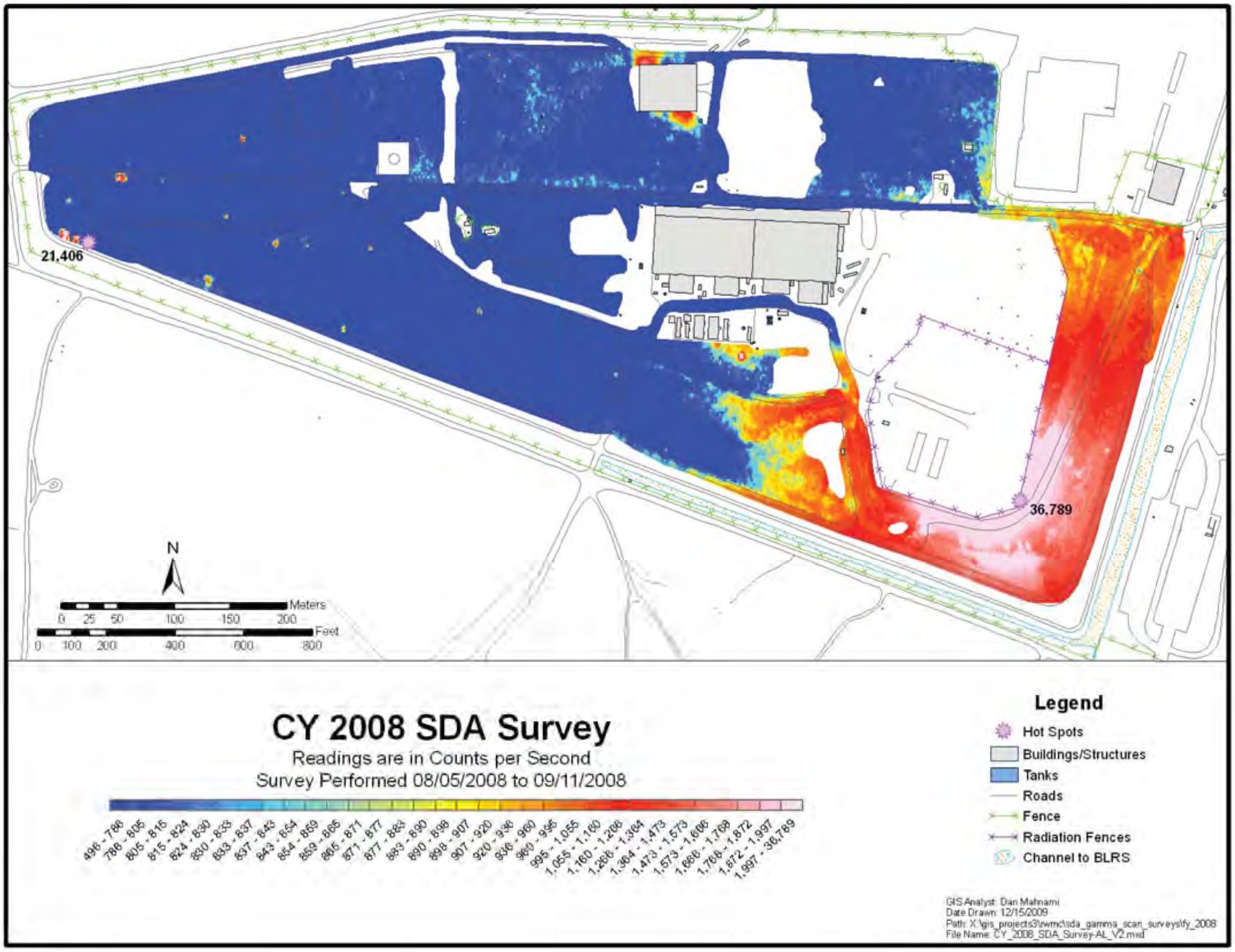


Figure 7-11. Radioactive Waste Management Complex Surface Radiation Survey (2008).

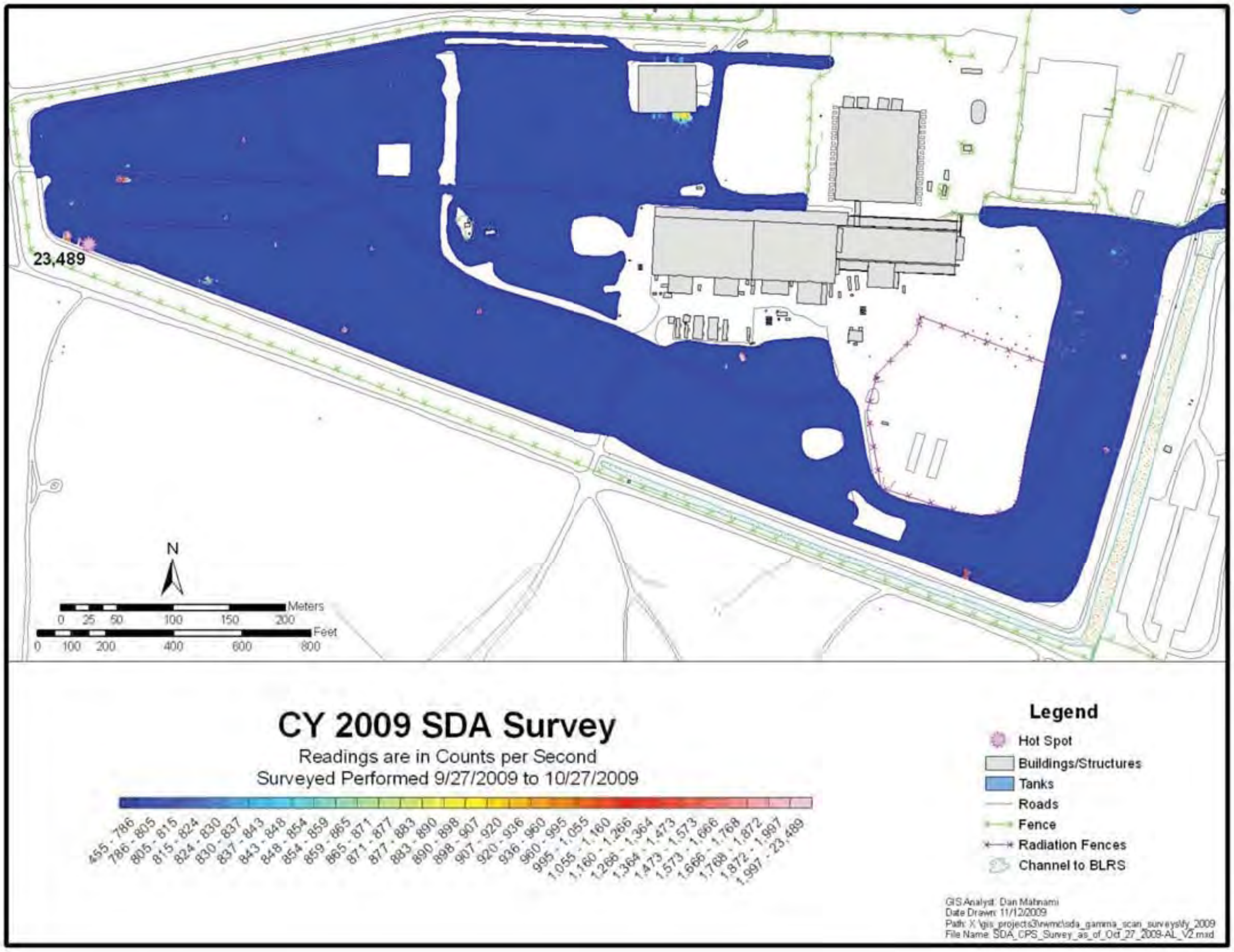


Figure 7-12. Radioactive Waste Management Complex Surface Radiation Survey (2009).

to previous years' measurements. The active pit was covered during 2009. Both maps are included to show how much the radiation levels (shine) decreased when the active pit was covered. The decrease in shine will allow elevated levels over pits and trenches to be identified that previously were overshadowed by the shine. The gross gamma radiation around the active low-level waste pit was near background levels. The maximum gross gamma radiation on the remainder of the Subsurface Disposal Area was 23,489 cps measured at the western end of the SVR-7 soil vault row.


Scarab beetle

7.5 CERCLA Ecological Monitoring

Ecological receptors also are monitored at the Idaho National Laboratory Site in support of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Program. Under CERCLA, the Operable Unit 10-04 Comprehensive Remedial Investigation/Feasibility Study used a population-based approach to assess risk to ecological receptors at the Idaho National Laboratory Site from contaminants remaining in the soil (DOE-ID 2001). The *Remedial Design/Remedial Action Work Plan for Operable Units 6-05 and 10-04*, Phase I (DOE-ID 2004) states that the Idaho National Laboratory Site-wide long term ecological monitoring will be implemented under the Operable Unit 10-04 Record of Decision (DOE-ID 2002 by the Long-Term Ecological Monitoring Plan (ICP 2007).

The Long-Term Ecological Monitoring Plan determined that a range of sampling would be performed for both analytical and effects characterization. At areas of concern identified by the Operable Unit 10-04 Comprehensive Remedial Investigation/Feasibility Study (DOE-ID 2001), yearly sampling was performed from 2003 through 2008 to support characterization of both contaminant levels and to evaluate possible effects. No sampling was performed in 2009.

The sampling from 2003 through 2008 for contaminant analysis and effects information was collocated spatially and contiguously to the greatest extent possible to minimize sources of variability. Analytical data were collected from soil, subsurface soil, *Peromyscus maniculatus* (deer mice), *Artemisia tridentata* (sagebrush), and *Agropyron cristatum* (crested wheatgrass) in potentially contaminated sites and from uncontaminated background or reference areas. Analytical data also were collected from ponds designated as CERCLA sites from sediments, surface water, and plants, as well as a background area. Data were collected to determine if adverse effects to plants and wildlife are occurring on the Idaho National Laboratory Site. The types of effects data that were collected included kidney-to-body-weight and-liver-to-body-weight ratios, liver and kidney histopathology, earthworm and seedling soil toxicity testing, avian population, reptile population, plant population, small mammal population, and soil fauna. These data are currently being compiled in a summary report that should be available at the end of 2010. Any future sampling under this program will be discussed in this summary report.

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Scarab beetle

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Chapter 8. Dose to the Public and Biota

Chapter Highlights

The potential radiological dose to the public from Idaho National Laboratory (INL) Site operations were 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 maximally exposed individual, as determined by this program, was 0.069 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 2009, the estimated potential dose was 0.52 person-rem. This is about 0.0005 percent of that expected from exposure to background radiation (108,608 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 0.005 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 DOE limits for biota.

There were no unplanned releases from the INL Site reported in 2009 and therefore no doses associated with unplanned releases.

Scarab beetle

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 2009 environmental monitoring measurements.

8.1 Possible Exposure Pathways to the Public

Air, soil, groundwater, agricultural products, and biota are routinely sampled to document the amount of radioactivity in these media and to determine if radioactive materials have been transported off the INL Site. The air pathway is the primary way people living beyond the INL Site boundary could be exposed to releases from INL Site operations (Figure 8-1). Airborne radioactive materials are rapidly carried from the source and dispersed by winds. The concentrations from routine releases are too small to measure at locations around the INL Site, 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 2009, doses were calculated for the radionuclides and data summarized in Table 4-2. 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 (plutonium-238 and -239, americium-241, cesium-137, and iodine-129) are typically associated with airborne particulates and were a very small fraction of the total amount of radionuclides reported.

Bristly Cutworm Moth

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 (NESHAP) 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 2009, this hypothetical person lived at Frenchman's Cabin, just south of the INL Site boundary (Figure 4-2).

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 2009 INL Report for Radionuclides* (DOE-ID 2010). 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

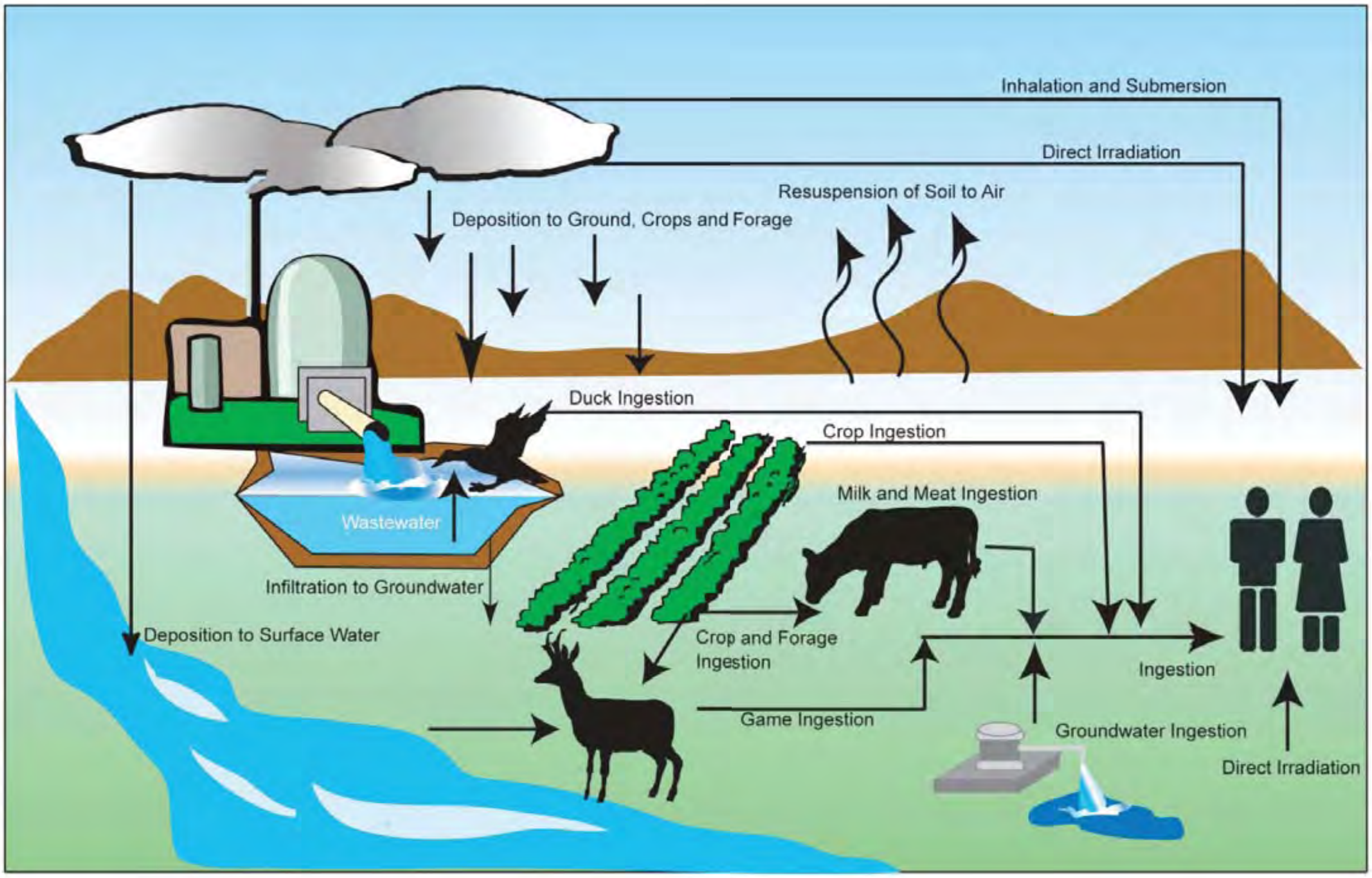


Figure 8-1. Potential Exposure Pathways to Humans from the INL Site.

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 0.069 mrem (0.69 μSv) was calculated for a hypothetical person living at Frenchman's Cabin during 2009.

Although noble gases were the radionuclides released in the largest quantities, they contributed very 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. The radionuclides which contributed the most to the overall dose (plutonium-238 and -239, americium-241, cesium-137, 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. Tritum and argon-41, which are not associated with particulates, resulted in a minor portion of the calculated doses.

Figure 8-2 compares the maximum individual doses calculated for 2000 through 2009. 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.

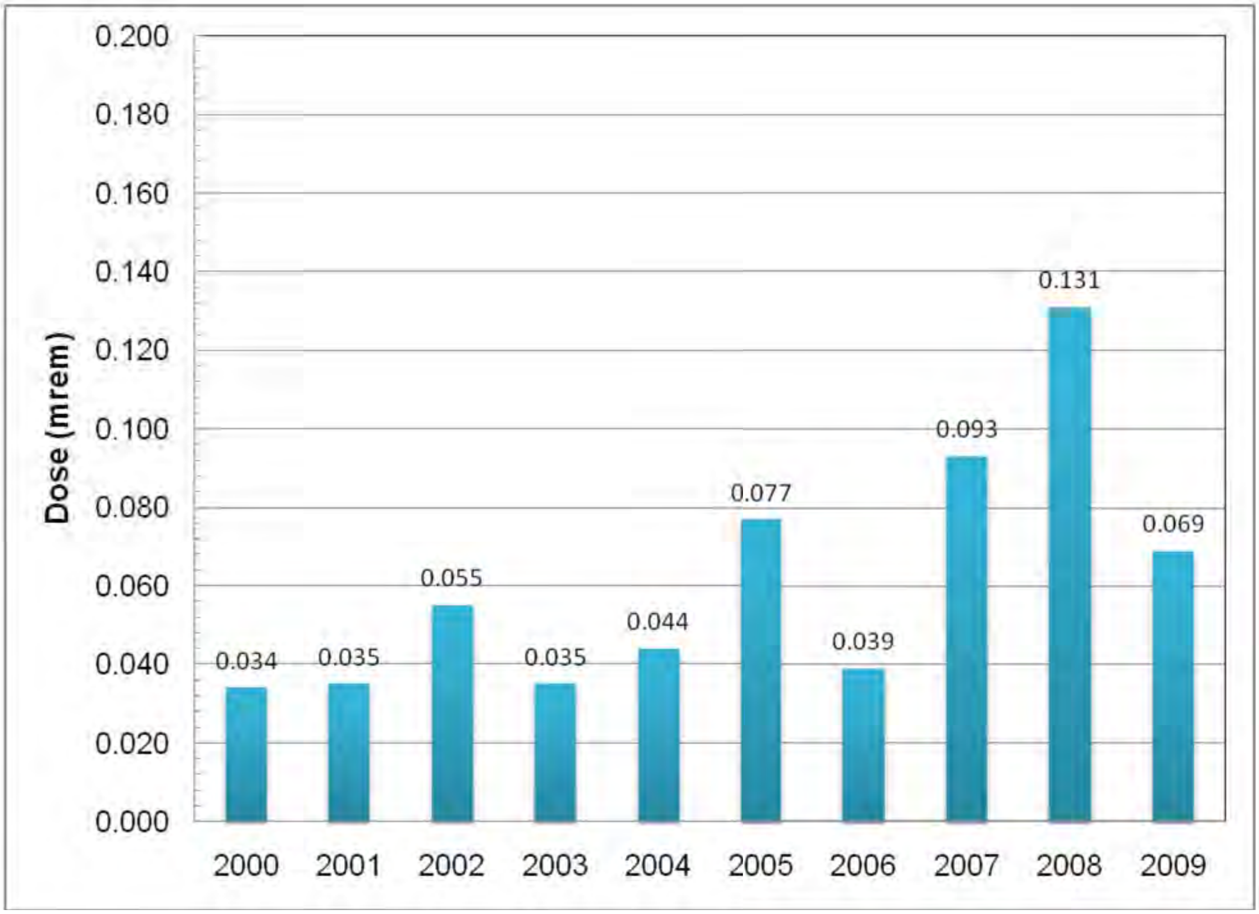


Figure 8-2. Maximum Individual Doses from INL Site Airborne Releases Estimated for 2000 – 2009.

The NOAA ARL-FRD gathered meteorological data continuously at 35 meteorological stations during 2009 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 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 2009 the maximally exposed individual was projected to live south of the INL boundary at Frenchman's Cabin, shown on Figure 4-2.

The average modeled air concentration at Frenchman's Cabin (about 30 on Figure 8-3) was then input into a spreadsheet used to estimate doses with Nuclear Regulatory Commission methods and EPA dose conversion factors.

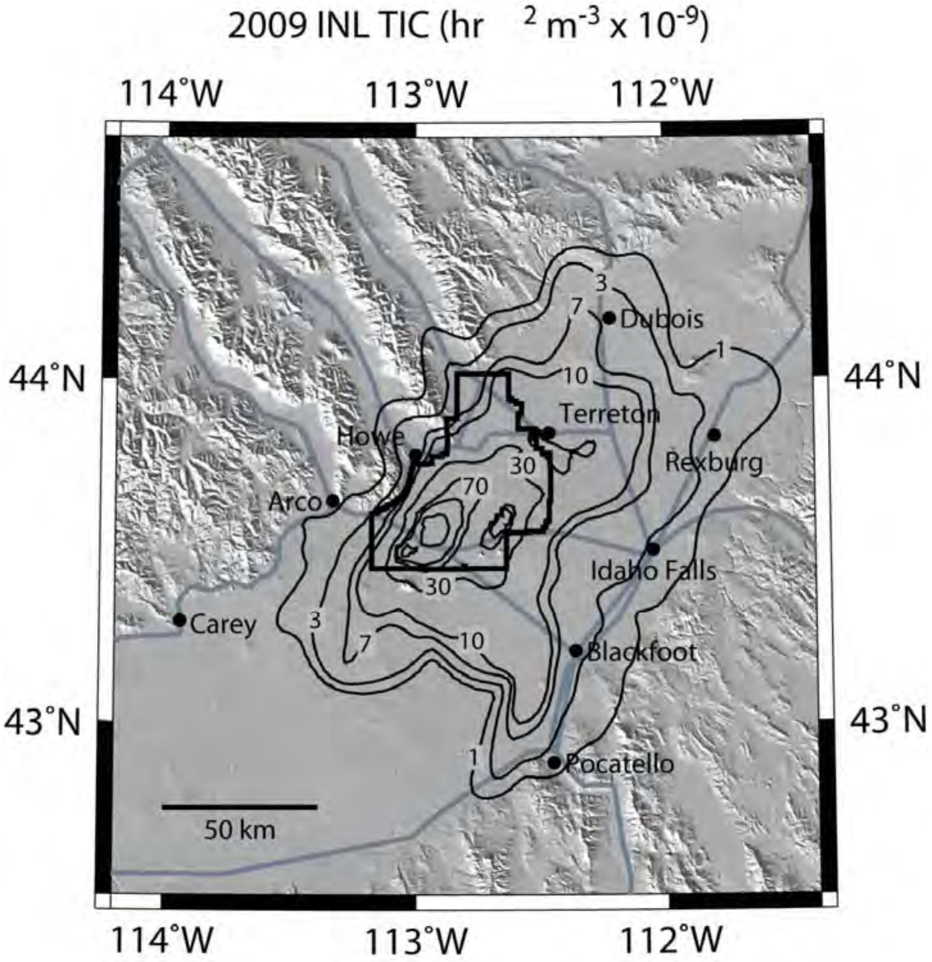


Figure 8-3. INL Site Time Integrated Concentrations (2009).

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 4-2)
- The MDIFF air concentration calculated for each location (a county census division)
- The population in each census division within that county division
- The dose calculated to be received by the 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 8-1).

The estimated potential population dose was 0.52 person-rem (5.2×10^{-3} person-Sv) to a population of approximately 305,938. When compared with the approximate population dose of 108,608 person-rem (1,086 person-Sv) estimated to be received from natural background radiation, this represents an increase of only about 0.0005 percent. The largest collective doses are in the Idaho Falls and Pocatello census divisions due to their greater populations.

The largest contributors to the population dose were two isotopes of plutonium, plutonium-239 and plutonium-240, which together contributed approximately 80 percent of the total population dose (Figure 8-4). Americium-241 accounted for about 11 percent of the dose, followed by cesium-137 and iodine-129, which each contributed about 2 percent.

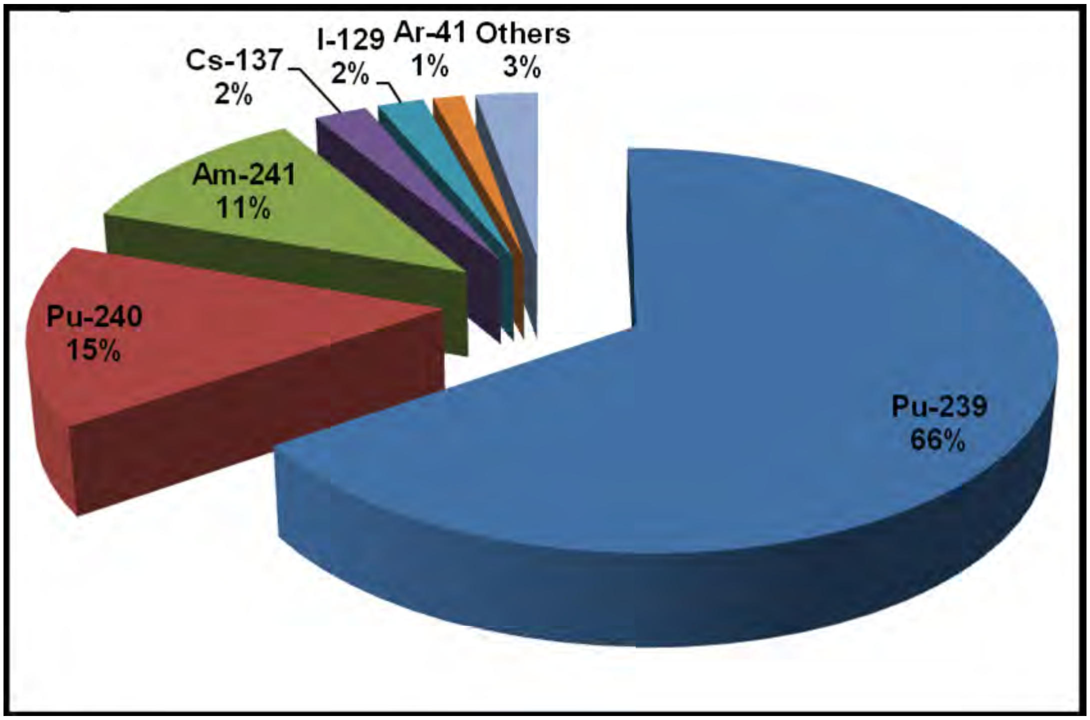


Figure 8-4. Radionuclides Contributing to Dose to Population Dose from INL Site Airborne Effluents as Calculated Using the MDIFF Air Dispersion Model (2009).

Scarab beetle

Table 8-1. Dose to Population within 80 Kilometers (50 miles) of INL Site Facilities (2009).

Census Division[a,b]	Population[c]	Population Dose	
		Person-rem	Person-Sv
Aberdeen	3,547	1.66×10^{-3}	1.66×10^{-5}
Alridge	807	7.75×10^{-5}	7.75×10^{-7}
American Falls	4,244	5.24×10^{-4}	5.24×10^{-6}
Arbon (part)	33	3.86×10^{-5}	3.86×10^{-7}
Arco	2,389	1.83×10^{-2}	1.83×10^{-4}
Atomic City (division)	4,097	3.77×10^{-2}	3.77×10^{-4}
Blackfoot	13,607	2.68×10^{-2}	2.68×10^{-4}
Carey (part)	1,398	1.06×10^{-3}	1.06×10^{-5}
East Clark	75	7.69×10^{-5}	7.69×10^{-7}
Firth	3,661	3.23×10^{-3}	3.23×10^{-5}
Fort Hall (part)	1,921	2.54×10^{-3}	2.54×10^{-5}
Hailey-Bellevue (part)	6	4.77×10^{-11}	4.77×10^{-13}
Hamer	2,378	2.79×10^{-2}	2.79×10^{-4}
Howe	357	7.37×10^{-3}	7.37×10^{-5}
Idaho Falls	84,448	6.80×10^{-2}	6.80×10^{-4}
Idaho Falls, west	1,869	7.27×10^{-3}	7.27×10^{-5}
Inkom (part)	621	4.62×10^{-4}	4.62×10^{-6}
Island Park (part)	86	9.72×10^{-5}	9.72×10^{-7}
Leadore (part)	3	3.84×10^{-8}	3.84×10^{-9}
Lewisville-Menan	4,547	1.47×10^{-2}	1.47×10^{-4}
Mackay (part)	1,157	3.53×10^{-6}	3.53×10^{-8}
Moody (part)	5,718	2.74×10^{-3}	2.74×10^{-5}
Moreland	10,040	6.24×10^{-2}	6.24×10^{-4}
Pocatello (part)	84,822	1.41×10^{-1}	1.41×10^{-3}
Rexburg (part)	24,198	2.85×10^{-2}	2.85×10^{-4}
Rigby	15,375	2.56×10^{-2}	2.56×10^{-4}
Ririe	1,613	3.92×10^{-4}	3.92×10^{-6}
Roberts	1,802	9.85×10^{-3}	9.85×10^{-5}
Shelley	7,787	8.08×10^{-3}	8.08×10^{-5}
South Bannock (part)	316	4.20×10^{-4}	4.20×10^{-6}
St. Anthony (part)	2,377	3.11×10^{-3}	3.11×10^{-5}
Sugar City	6,470	1.13×10^{-2}	1.13×10^{-4}
Swan Valley (part)	5,623	2.19×10^{-4}	2.19×10^{-6}
Ucon	6,897	9.93×10^{-3}	9.93×10^{-5}
West Clark	1,649	2.14×10^{-3}	2.14×10^{-5}
Total	**305,938**	**0.524**	**5.24×10^{-3}**

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 based on 2000 Census Report for Idaho and updated to 2009 based on county population growth from 1960 to 2000.

For 2009, the Radioactive Waste Management Complex contributed nearly 89 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. The remaining 11 percent of the total dose was by the Idaho Nuclear Technology and Engineering Center (9 percent) and the Advanced Test Reactor (ATR) Complex (2 percent).

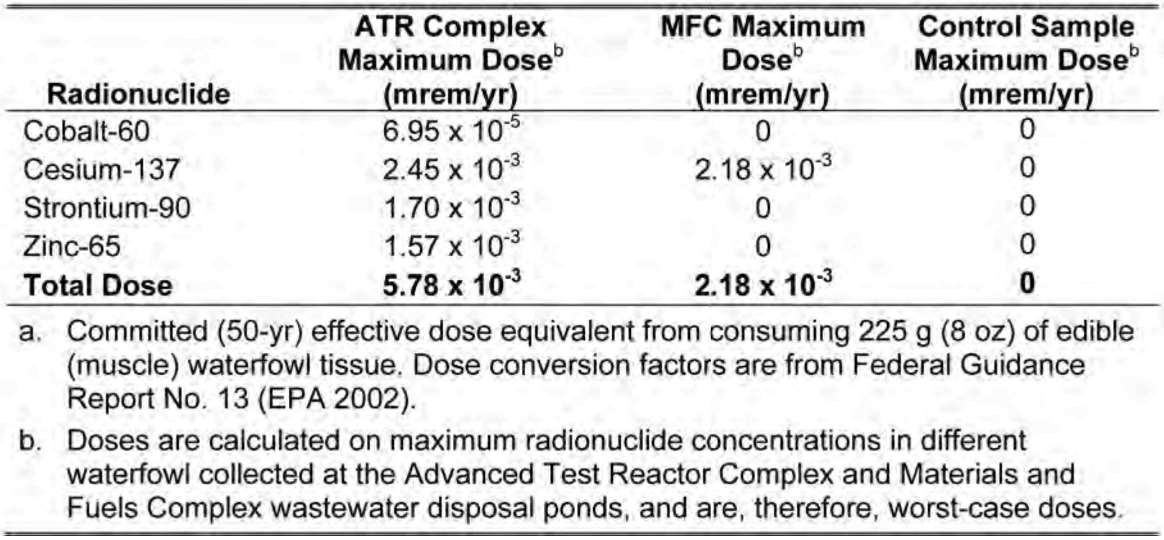
8.3 Dose to the Public from Ingestion of Wild Game from the INL Site

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 reside briefly 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 2009, four ducks were collected from disposal ponds at the ATR Complex and four from Materials and Fuels Complex wastewater ponds. Two ducks were collected off the INL Site (near Roberts) as control samples. The maximum potential dose from eating 225 g (8 oz) of duck meat collected in 2009 is presented in Table 8-2. 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.

Table 8-2. Maximum Annual Potential Dose from Ingestion of Edible Waterfowl Tissue Using INL Site Wastewater Disposal Ponds in 2009.[a]



Radionuclide	ATR Complex Maximum Dose[b] (mrem/yr)	MFC Maximum Dose[b] (mrem/yr)	Control Sample Maximum Dose[b] (mrem/yr)
Cobalt-60	6.95×10^{-5}	0	0
Cesium-137	2.45×10^{-3}	2.18×10^{-3}	0
Strontium-90	1.70×10^{-3}	0	0
Zinc-65	1.57×10^{-3}	0	0
Total Dose	**5.78×10^{-3}**	**2.18×10^{-3}**	**0**

a. Committed (50-yr) effective dose equivalent from consuming 225 g (8 oz) of edible (muscle) waterfowl tissue. Dose conversion factors are from Federal Guidance Report No. 13 (EPA 2002).

b. Doses are calculated on maximum radionuclide concentrations in different waterfowl collected at the Advanced Test Reactor Complex and Materials and Fuels Complex wastewater disposal ponds, and are, therefore, worst-case doses.

The maximum potential dose of 0.006 mrem (0.06 µSv) from these waterfowl samples is substantially below the 0.89-mrem (8.9 µSv) committed effective dose equivalent estimated from the most contaminated ducks taken from the evaporation ponds between 1993 and 1998 (Warren et al. 2001). These evaporation ponds have been remediated and are no longer available to waterfowl. The ducks were not collected directly from the wastewater disposal ponds at the ATR Complex but from sewage lagoons adjacent to them. However, they probably resided at all the ponds while they were in the area.

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 deer had a detectable concentration of cesium-137. The potential dose from consuming the meat was estimated to be approximately 0.005 mrem (0.05 µSv).

The contribution of game animal consumption to the population dose has not been calculated because only a limited percentage of the population hunts game, few of the animals killed have spent time on the INL Site, and most of the animals that do migrate from the INL Site would have reduced concentrations of radionuclides in their tissues by the time they were harvested (Halford et al. 1983). The total population dose contribution from these pathways would, realistically, be less than the sum of the population doses from inhalation of air, submersion in air, ingestion of vegetables, and deposition on soil.

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

Tritium has previously been detected in two U.S. Geological Survey monitoring wells located along the southern boundary of the INL Site. These wells, located in an uninhabited area, have shown a historical downward trend in tritium detections. The maximum concentration (<1,150 pCi/L) is considerably less than the maximum contaminant level established by EPA for drinking water (20,000 pCi/L). The maximum contaminant level corresponds to a dose from the drinking water ingestion pathway of 4 mrem per year. An individual drinking water from these wells would hypothetically receive a dose of less than 0.2 mrem in one year. Because no one uses these wells for drinking water, this is an unrealistic scenario and the groundwater ingestion pathway is not included in the total dose estimate to a maximally exposed individual.

8.5 Dose to the Public from Direct Radiation Exposure along INL Site Borders

The direct radiation exposure pathway from gamma radiation to the public is monitored annually using thermoluminescent dosimeters (Figure 7-8). In 2009, 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 2009, 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 received the highest calculated dose from INL Site airborne releases reported for 2009 (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 2009 (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 2009 (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 8-3. The total dose was conservatively estimated to be 0.08 mrem for 2009. For comparison, the total dose received by the maximally exposed individual in 2008

Table 8-3. Contribution to Dose by Pathway (2009).

	Dose to Maximally Exposed Individual			Estimated Population Dose			
Pathway	**(mrem)**	**(mSv)**	**Percent of DOE 100-mrem/yr Limit**	**(person-rem)**	**(person-Sv)**	**Population within 80 km**	**Estimated Background Radiation Population Dose (person-rem)**
Air	0.069	0.00069	0.069	0.52	0.0052	305,938	108,608
Waterfowl ingestion	0.006	0.00006	0.006	NA[a]	NA	NA	NA
Big game animals	0.005	0.00005	0.005	NA	NA	NA	NA
Total pathways	**0.08**	**0.0008**	**0.08**	NA	NA	NA	NA

a. NA = Not applicable

was calculated to be 0.41 mrem (0.13 mrem from the air pathway, 0.05 mrem from ingestion of waterfowl, and 0.23 mrem from ingestion of wild game.) The 2009 dose estimate was much lower than the 2008 estimate because of the following factors:

- Source terms used in the NESHAPs calculations changed. In 2008, cesium-137 and strontium-90, reported to be released from the INL CERCLA Disposal Facility, were the top two contributors to the calculated dose. In 2009, plutonium-239 and tritum, reported to be released from the Radioactive Waste Management Complex, were the top two contributors to the calculated dose.
- The 2008 dose from consuming big game was based on a much higher concentration of cesium-137 measured in the muscle sample collected from a mule deer found near the RWMC.
- The 2008 dose was correlated primarily with the presence of americium-241 in edible portions of duck tissue collected in the ATR Complex region. Americium-241 has a higher dose conversion factor (rem/µCi of tissue ingested) than the gamma-emitting radionuclides detected in the 2009 waterfowl samples collected.

The total dose calculated to be received by the hypothetical maximally exposed individual for 2009 (0.08 mrem) represents about 0.02 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.

8.7 Dose to Biota

8.7.1 Introduction

The impact of environmental radioactivity at the INL Site on nonhuman biota was assessed using *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE 2002) and the associated software, RESRAD-Biota (DOE 2004). The graded approach includes a screening method and three more detailed levels of analysis for demonstrating compliance with standards for protection of biota. The threshold of protection is assumed at the following doses: 1 rad/d (10 mGy/d) for aquatic animals, 0.1 rad/d (1 mGy/d) for terrestrial animals, and 1 rad/d (10 mG/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 in EPA (1998). RESRAD-Biota cannot perform these calculations.

8.7.2 Terrestrial Evaluation

Of particular importance for the terrestrial evaluation portion of the 2009 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
- ATR 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

Scarab beetle

of radionuclides in soil were used (Table 8-4.) 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 in surface soils. The results of these surveys are shown in Table 8-4.

Using the maximum radionuclide concentrations for all locations in Table 8-4, 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 B were used to represent surface water concentrations. The combined sum of fractions was less than one for both terrestrial animals (0.417) and plants (0.00383) and passed the general screening test (Table 8-5).

Based on the results of the graded approach, there is no evidence that INL Site-related radioactivity in soil is harming terrestrial plant or animal populations.

8.7.3 Aquatic Evaluation

For the aquatic evaluation, maximum effluent or pond radionuclide concentrations are typically used. The maximum concentration for each radionuclide reported in any pond or effluent in Appendix B 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 8-6 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 2009 were also available (Figure 7-5). Concentrations of radionuclides in tissue can be input into the RESRAD Biota code at the Level 3 step to calculate the internal dose to biota. To confirm that doses to waterfowl from exposure to radionuclides in the vicinity of the ATR Complex are not harmful, a Level 3 analysis was performed using the maximum tissue concentrations shown in Figure 7-5. The waterfowl were assumed in the model to be riparian animals, accessing both aquatic and terrestrial environments in the area. External dose was calculated using the maximum radionuclide concentrations measured in soils around the ATR Complex.

Results of the dose evaluation to waterfowl using radionuclide concentrations measured in tissue are shown in Table 8-7. The estimated dose to waterfowl was calculated by RESRAD BIODOSE 1.5 to be 1.08 x 10^{-4} rad/d (1.08 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 2009. As such, there are no doses associated with unplanned releases during 2009.

Table 8-4. Concentrations of Radionuclides in INL Site Soils, by Area.

		Detected Concentration (pCi/g)[b]	
Location[a]	**Radionuclide**	**Minimum**	**Maximum**
ARA	Cesium-137	7.00 x 10^{-2}	7.99
	Strontium-90	2.10 x 10^{-1}	3.70 x 10^{-1}
	Plutonium-238	NA	3.90 x 10^{-3}
	Plutonium-239/240	1.30 x 10^{-2}	1.80 x 10^{-2}
	Americium-241	5.50 x 10^{-3}	8.50 x 10^{-3}
ATRC	Cesium-137	9.00 x 10^{-2}	6.80 x 10^{-1}
	Strontium-90	NA	5.82 x 10^{-2}
	Plutonium-238	5.90 x 10^{-3}	4.30 x 10^{-2}
	Plutonium-239/240	1.70 x 10^{-2}	2.18 x 10^{-2}
	Americium-241	5.60 x 10^{-3}	1.13 x 10^{-2}
Large Grid	Cesium-137	3.00 x 10^{-2}	5.10 x 10^{-1}
	Plutonium-238	3.30 x 10^{-3}	4.00 x 10^{-3}
	Plutonium-239/240	1.00 x 10^{-2}	2.50 x 10^{-2}
	Americium-241	3.70 x 10^{-3}	7.60 x 10^{-3}
MFC	Cesium-137	1.90 x 10^{-1}	4.20 x 10^{-1}
	Plutonium-239/240	1.50 x 10^{-2}	2.90 x 10^{-2}
	Americium-241	4.30 x 10^{-3}	1.20 x 10^{-2}
INTEC	Cesium-137	5.00E-02	3.76E+00
	Strontium-90	4.90 x 10^{-1}	7.10 x 10^{-1}
	Plutonium-238	2.50 x 10^{-2}	4.30 x 10^{-2}
	Plutonium-239/240	1.10 x 10^{-2}	2.90 x 10^{-2}
	Americium-241	6.10 x 10^{-3}	8.10 x 10^{-3}
Large Grid	Cesium-137	3.00 x 10^{-2}	5.10 x 10^{-1}
	Strontium-90	NA	1.10 x 10^{-1}
	Plutonium-238	3.30 x 10^{-3}	4.00 x 10^{-3}
	Plutonium-239/240	1.00 x 10^{-2}	2.50 x 10^{-2}
	Americium-241	5.50 x 10^{-3}	8.50 x 10^{-3}
NRF	Cesium-137	1.10 x 10^{-1}	3.10 x 10^{-1}
	Plutonium-239/240	5.70 x 10^{-3}	1.60 x 10^{-2}
	Americium-241	4.30 x 10^{-3}	9.70 x 10^{-3}
RWMC[c]	Cesium-137	4.40 x 10^{-2}	5.28 x 10^{-1}
	Plutonium-239/240	6.20 x 10^{-2}	9.20 x 10^{-2}
	Americium-241	6.30 x 10^{-2}	1.23 x 10^{-1}
TAN/SMC	Cesium-137	1.00 x 10^{-1}	1.09
	Plutonium-239/240	1.25 x 10^{-2}	1.74 x 10^{-2}
	Americium-241	3.20 x 10^{-3}	5.70 x 10^{-3}
ALL	Cesium-137	3.00 x 10^{-2}	7.99
	Strontium-90	2.10 x 10^{-1}	7.10 x 10^{-1}
	Plutonium-238	3.30 x 10^{-3}	4.30 x 10^{-2}
	Plutonium-239/240	5.70 x 10^{-3}	9.20 x 10^{-2}
	Americium-241	3.20 x 10^{-3}	1.23 x 10^{-1}

a. ARA = Auxillary Reactor Area; ATRC = Advance Test Reactor Complex;
Large Grid = A 24-mile radius around INTEC; MFC = Materials and Fuels Complex
INTEC = Idaho Nuclear Technology and Engineering Center
NRF = Naval Reactors Facility; RWMC = Radioactive Waste Management Complex;
TAN/SMC = Test Area North/Specific Manufacturing Capability.

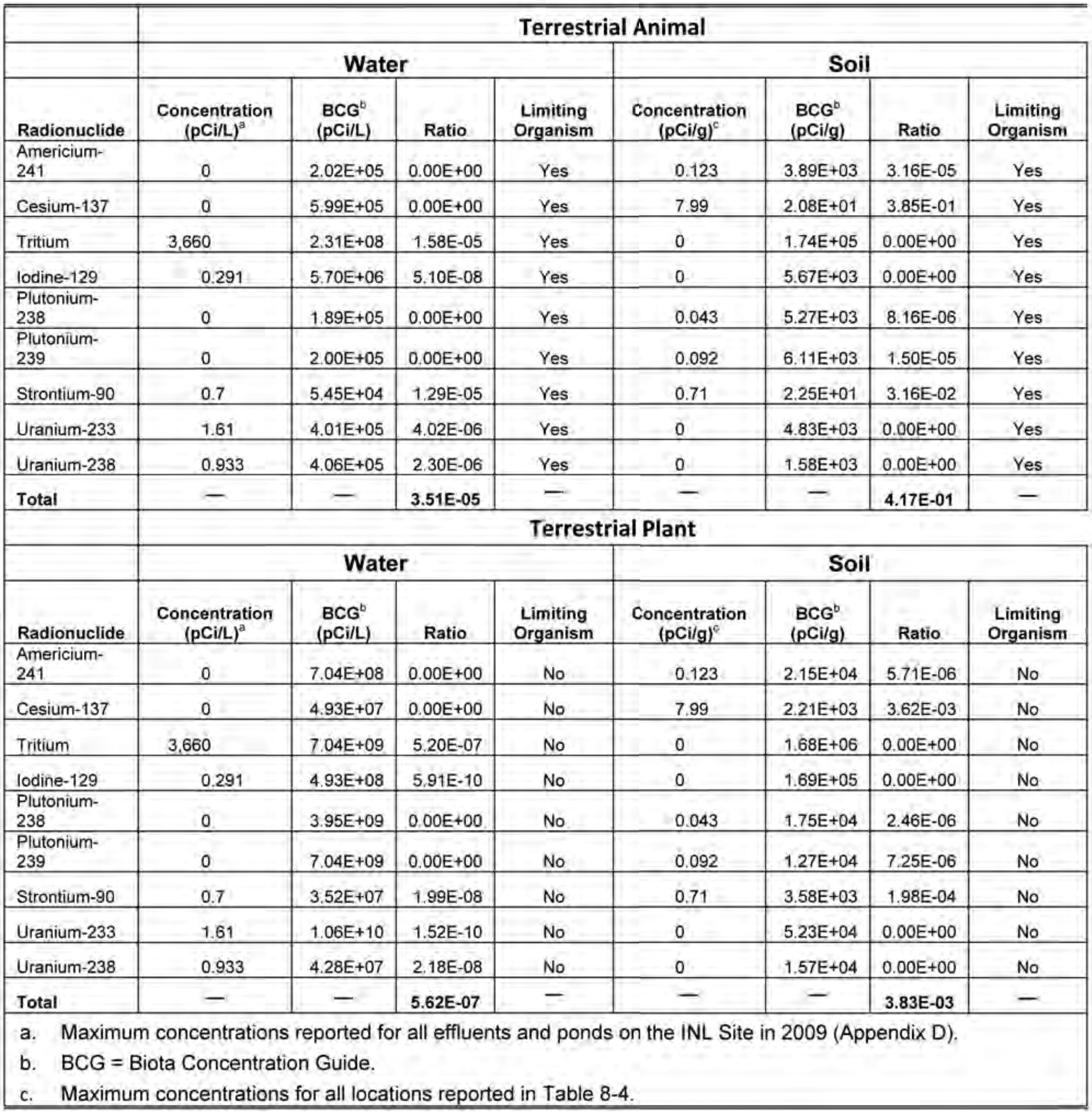
b. Legend:

🟨	Results measured in 2009 using in situ gamma spectroscopy
🟩	Results measured in soil samples collected in 2005
🟦	Results measured in soil samples collected in 2006
🟥	Results measured in soil samples collected in 2009.

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


Scarab beetle

Table 8-5. RESRAD Biota 1.5 Biota Dose Assessment (Screening Level) of Terrestrial Ecosystems on the INL Site (2009).



	Terrestrial Animal							
	Water				Soil			
Radionuclide	Concentration (pCi/L)[a]	BCG[b] (pCi/L)	Ratio	Limiting Organism	Concentration (pCi/g)[c]	BCG[b] (pCi/g)	Ratio	Limiting Organism
Americium-241	0	2.02E+05	0.00E+00	Yes	0.123	3.89E+03	3.16E-05	Yes
Cesium-137	0	5.99E+05	0.00E+00	Yes	7.99	2.08E+01	3.85E-01	Yes
Tritium	3,660	2.31E+08	1.58E-05	Yes	0	1.74E+05	0.00E+00	Yes
Iodine-129	0.291	5.70E+06	5.10E-08	Yes	0	5.67E+03	0.00E+00	Yes
Plutonium-238	0	1.89E+05	0.00E+00	Yes	0.043	5.27E+03	8.16E-06	Yes
Plutonium-239	0	2.00E+05	0.00E+00	Yes	0.092	6.11E+03	1.50E-05	Yes
Strontium-90	0.7	5.45E+04	1.29E-05	Yes	0.71	2.25E+01	3.16E-02	Yes
Uranium-233	1.61	4.01E+05	4.02E-06	Yes	0	4.83E+03	0.00E+00	Yes
Uranium-238	0.933	4.06E+05	2.30E-06	Yes	0	1.58E+03	0.00E+00	Yes
Total	—	—	**3.51E-05**	—	—	—	**4.17E-01**	—
	Terrestrial Plant							
	Water				**Soil**			
Radionuclide	**Concentration (pCi/L)[a]**	**BCG[b] (pCi/L)**	**Ratio**	**Limiting Organism**	**Concentration (pCi/g)[c]**	**BCG[b] (pCi/g)**	**Ratio**	**Limiting Organism**
Americium-241	0	7.04E+08	0.00E+00	No	0.123	2.15E+04	5.71E-06	No
Cesium-137	0	4.93E+07	0.00E+00	No	7.99	2.21E+03	3.62E-03	No
Tritium	3,660	7.04E+09	5.20E-07	No	0	1.68E+06	0.00E+00	No
Iodine-129	0.291	4.93E+08	5.91E-10	No	0	1.69E+05	0.00E+00	No
Plutonium-238	0	3.95E+09	0.00E+00	No	0.043	1.75E+04	2.46E-06	No
Plutonium-239	0	7.04E+09	0.00E+00	No	0.092	1.27E+04	7.25E-06	No
Strontium-90	0.7	3.52E+07	1.99E-08	No	0.71	3.58E+03	1.98E-04	No
Uranium-233	1.61	1.06E+10	1.52E-10	No	0	5.23E+04	0.00E+00	No
Uranium-238	0.933	4.28E+07	2.18E-08	No	0	1.57E+04	0.00E+00	No
Total	—	—	**5.62E-07**	—	—	—	**3.83E-03**	—

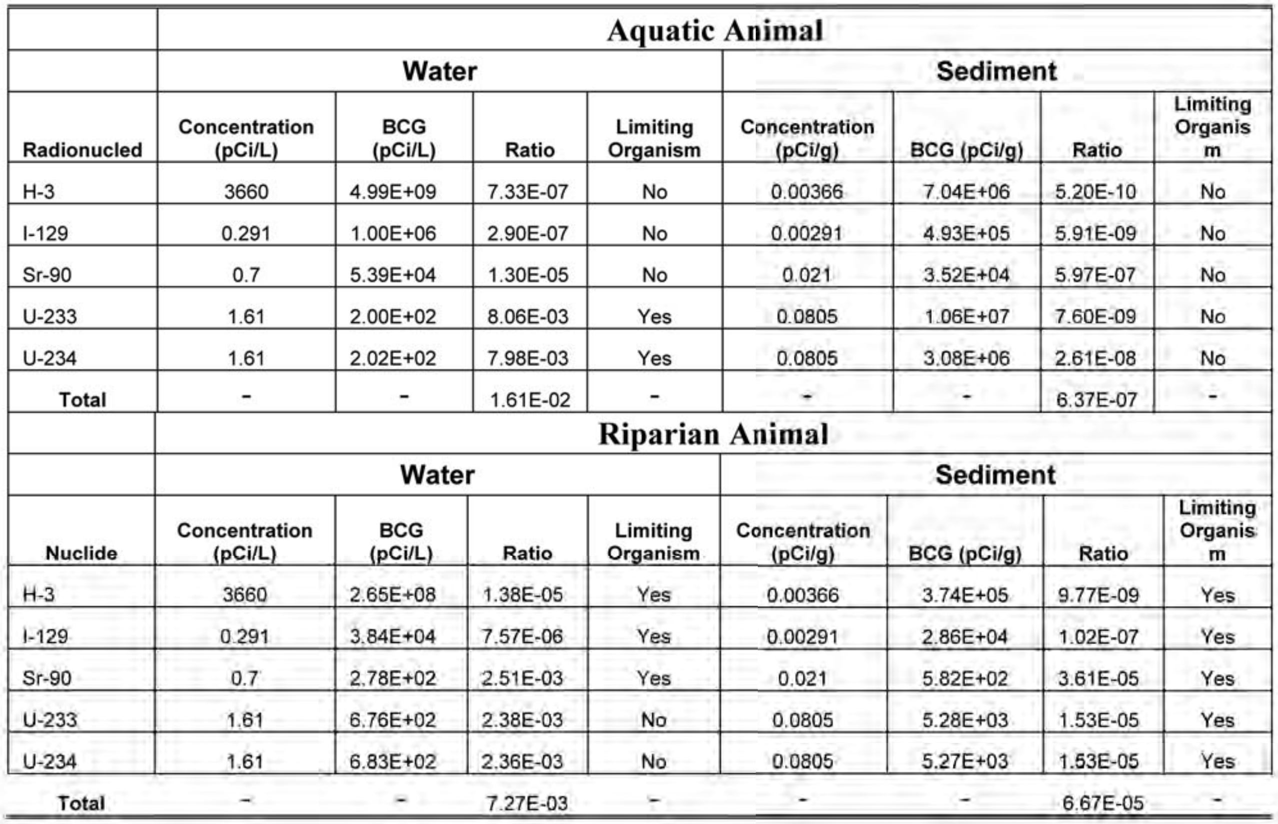
a. Maximum concentrations reported for all effluents and ponds on the INL Site in 2009 (Appendix D).

b. BCG = Biota Concentration Guide.

c. Maximum concentrations for all locations reported in Table 8-4.

Bristly Cutworm Moth

Table 8-6. RESRAD Biota 1.5 Assessment (Screening Level) of Aquatic Ecosystems on the INL Site (2009).



	Aquatic Animal							
	Water				Sediment			
Radionucled	Concentration (pCi/L)	BCG (pCi/L)	Ratio	Limiting Organism	Concentration (pCi/g)	BCG (pCi/g)	Ratio	Limiting Organism
H-3	3660	4.99E+09	7.33E-07	No	0.00366	7.04E+06	5.20E-10	No
I-129	0.291	1.00E+06	2.90E-07	No	0.00291	4.93E+05	5.91E-09	No
Sr-90	0.7	5.39E+04	1.30E-05	No	0.021	3.52E+04	5.97E-07	No
U-233	1.61	2.00E+02	8.06E-03	Yes	0.0805	1.06E+07	7.60E-09	No
U-234	1.61	2.02E+02	7.98E-03	Yes	0.0805	3.08E+06	2.61E-08	No
Total	-	-	1.61E-02	-	-	-	6.37E-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	3660	2.65E+08	1.38E-05	Yes	0.00366	3.74E+05	9.77E-09	Yes
I-129	0.291	3.84E+04	7.57E-06	Yes	0.00291	2.86E+04	1.02E-07	Yes
Sr-90	0.7	2.78E+02	2.51E-03	Yes	0.021	5.82E+02	3.61E-05	Yes
U-233	1.61	6.76E+02	2.38E-03	No	0.0805	5.28E+03	1.53E-05	Yes
U-234	1.61	6.83E+02	2.36E-03	No	0.0805	5.27E+03	1.53E-05	Yes
Total	-	-	7.27E-03	-	-	-	6.67E-05	-

Table 8-7. RESRAD Biota 1.5 Assessment (Level 3 Analysis) of Aquatic Ecosystems on the INL Site Using Measured Waterfowl Tissue Data (2009).

Radionuclide	Water[a]	Soil[b]	Sediment[a] (rad/d)	Tissue[b]	Total
Americium-241	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cobalt-60	0.00E+00	0.00E+00	0.00E+00	4.79E-06	4.79E-06
Cesium-137	0.00E+00	0.00E+00	0.00E+00	7.64E-05	7.64E-05
Plutonium-238	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Plutonium-239	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Strontium-90	0.00E+00	0.00E+00	0.00E+00	2.22E-05	2.22E-05
Zinc-65	0.00E+00	0.00E+00	0.00E+00	5.08E-06	5.08E-06
Total	**0.00E+00**	**0.00E+00**	**0.00E+00**	**1.08E-04**	**1.08E-04**

a. External doses to waterfowl calculated by RESRAD-BIOTA 1.5 using soil concentrations reported for ATR Complex in Table 8-4.

b. Internal doses to waterfowl calculated using maximum concentrations in tissue reported in Figure 7-5.

Scarab beetle

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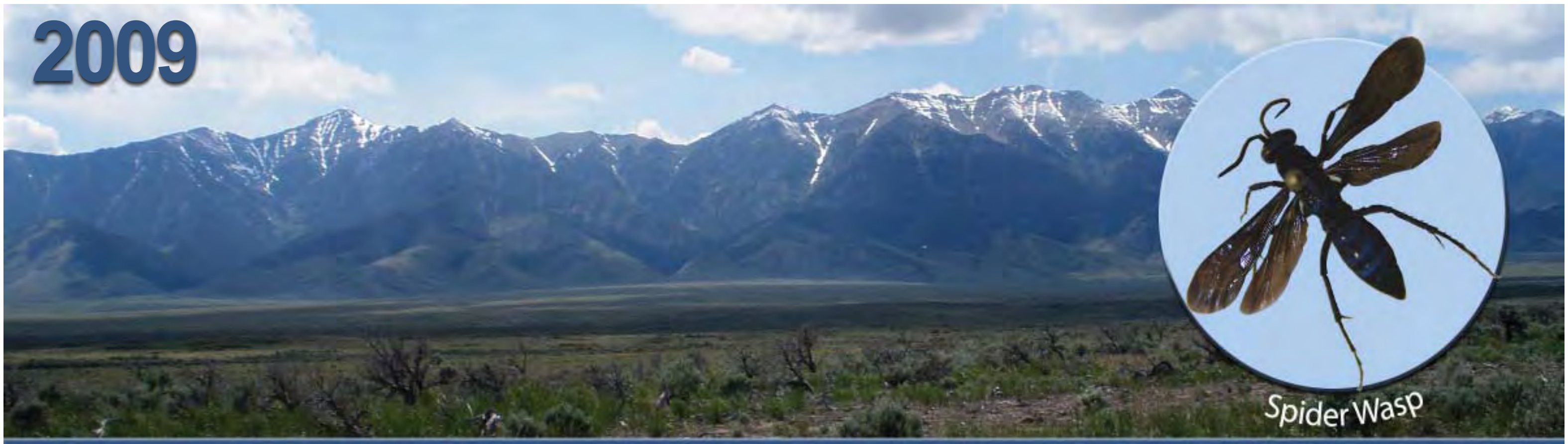
Big Southern Butte



Chapter 9. Environmental 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 2009, 19 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 2009
- Survey of Pygmy Rabbit (*Brachylagus idahoensis*) Occurrence on the Idaho National Laboratory Site
- Development and Evaluation of a Monitoring Program for Pygmy Rabbits
- Distribution, Abundance and Movements of Mammals on the Idaho National Laboratory Site
- Plant 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
- Long-Term Vegetation Transects

- Sagebrush Demography on the Idaho National Laboratory Site
- Developing a Habitat Selection Model to Predict the Distribution and Abundance of the Sagebrush Defoliator Moth (*Aroga websteri* Clarke)
- 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 in Idaho
- Spatial and Temporal Variability in Soil, Vegetation and Aerodynamic Properties in Wind-eroded, Post-fire Sagebrush Steppe
- Big Lost River Trenches Revegetation Demonstration Project
- 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. Two reports were published in 2009 by the INL Project Office:

- Iodine-129 in the Snake River Plain Aquifer at and Near the Idaho National Laboratory, Idaho, 2003 and 2007
- The Pliocene Lost River Found to West: Detrital Zircon Evidence of Drainage Disruption along a Subsiding Hotspot Track.

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 2009.

9.1 Ecological Research at the Idaho National Environmental Research Park

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

recommendations from citizens, scientists and members of Congress to set aside land for ecosystem preservation and study. This has been one of the few formal efforts to reserve land on a national scale for ecological research and education. In many cases, these protected lands became the last remnants of what were once extensive natural ecosystems.

Five basic objectives guide activities on National Environmental Research Parks:

- Develop methods for assessing and documenting environmental consequences of human actions related to energy development
- Develop methods for predicting environmental consequences of ongoing and proposed energy development
- Explore methods for eliminating or minimizing predicted adverse effects from various energy development activities on the environment
- Train people in ecological and environmental sciences
- Educate the public on environmental and ecological issues.

National Environmental Research Parks provide rich environments for training researchers and introducing the public to the ecological sciences. They have been used to educate grade school and high school students and the general public about ecosystem interactions at Department of Energy (DOE) sites; train graduate and undergraduate students in research related to site-specific, regional, national, and global issues; and promote collaboration and coordination among local, regional, and national public organizations, schools, universities, and federal and state agencies. Ecological research on National Environmental Research Parks is leading to better land-use planning, identifying sensitive areas on DOE sites so that restoration and other activities are compatible with ecosystem protection and management and increased contributions to ecological science in general.

Ecological research was conducted at federal laboratories long before National Environmental Research Parks were established. For example, at the INL Site, ecological research began in 1950 with the establishment of the long-term vegetation transect study. This is perhaps DOE’s oldest ecological data set and one of the most intensive data sets for sagebrush steppe. In addition, in 1989, a long-term reptile monitoring study was initiated, which is the longest continuous study of its kind in the world. Also, in 1993, a protective cap biobarrier experiment was initiated, which evaluated the long-term performance of evapotranspiration caps and biological intrusion barriers. Those long-term plots are now being used to test hypotheses on the potential effects of climate change.

The Idaho National Environmental Research Park provides coordination of ecological research and information exchange at the INL Site. It facilitates ecological research on the INL Site by attracting new researchers to use the area, providing background data for new research projects and assisting researchers to obtain access to the INL Site. The Idaho National Environmental Research Park provides infrastructure support to ecological researchers

through the Experimental Field Station and reference specimen collections. The Idaho National Environmental Research Park tries to foster cooperation and research integration by encouraging researchers to collaborate, developing interdisciplinary teams to address more complex problems, encouraging data sharing and leveraging funding across projects to provide more efficient use of resources. It also integrates research results from many projects and disciplines and provides analysis of ecosystem-level responses. The Idaho National Environmental Research Park has developed a centralized ecological database to provide an archive for ecological data and to facilitate data retrieval for new research projects and land management decisions. It also provides interpretation of research results to land and facility managers to support the National Environmental Policy Act process, natural resources management, radionuclide pathway analysis and ecological risk assessment.

A total of 41 graduate students, post-doctoral students, faculty and agency and contractor scientists participated in 19 research projects on the Idaho National Environmental Research Park in 2009. Several undergraduate students and technicians also gained valuable experience through participation in these research activities. The 19 projects include eight graduate student research projects, with students and faculty from Idaho State University, University of Idaho, University of Nevada Reno, Montana State University and University of Montana.

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. Thirteen of the 19 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, Idaho Department of Fish and Game, University of Idaho, Nevada Agricultural Experiment Station, Department of Energy, U.S. Department of Agriculture - Cooperative State Research, Education, and Extension Service Rangeland Research Program, Idaho Space Grant Consortium, Idaho National Laboratory, National Oceanic and Atmospheric Administration Office of Oceanic and Atmospheric Research Earth Systems Research Laboratory, Inland Northwest Research Alliance, National Center for Airborne Laser Mapping, 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 are presently 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.

The ecological research conducted on the INL Site in 2009 is detailed in *Ecological Research at the Idaho National Environmental Research Park in 2009*, edited by Roger Blew (STOLLER-ESER-134, September 2010). The following are summaries of the 19 ecological research projects.

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
- Scott Bergen, Ph.D., Associate Conservation Ecologist, North America Program, Wildlife Conservation Society, Pocatello, 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 Greater 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 during the past two years. 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

Scarab beetle

seven of the 11 broods survived until the end of the season in September 2009, and the fates of two broods are unknown.

Sage-grouse that lek on the INL Site tend to be seasonally migratory, and the data indicate that they migrated in at least two general patterns. Many grouse captured on the northern portion of the Site migrated north into Birch Creek during the summer and fall. Grouse captured on the southeastern portion of the Site remained in the vicinity of their leks or migrated south and east. Few grouse moved outside of these general patterns, and females almost never moved from one area (northern or southern) to another.

Throughout the summer of 2010, gathering of telemetry data will continue for nine sage-grouse whose collars continue to transmit a signal. During 2010, the investigators plan to organize all sage-grouse data collected on the INL Site since 2006 and draft a Candidate Conservation Agreement between DOE-ID and the United States Fish and Wildlife Service.

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

Investigators and Affiliations

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

Funding Sources

- U.S. Department of Energy Idaho Operations Office

Objective

The objective is to survey historical leks that were previously identified by Jack Connelly (1982) and the Idaho Department of Fish and Game to determine if sage grouse still use those sites.

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.

The 57 historical lek sites were visited one to three times (88 total visits). Surveys were performed, on average, 55 minutes after sunrise. Sage-grouse were not detected during surveys conducted in the most extreme weather events, such as during rain storms or wind speeds over 6 km/h.

Sage-grouse were detected, either visually or audibly, on or near 14 historical and two previously undocumented leks. At least two males were detected on all but one (N5) of the 16 sites during the survey period. Each lek was classified according to Idaho Department of Fish and Game criteria. At lek N5, only one male was observed, so it could not be designated as active. The other 15 leks where sage grouse were detected were designated as active. In addition, six leks were designated as inactive and 37 as unknown.

During the spring of 2010, all historical leks will be surveyed again, including the two that were newly identified in 2009. 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.

References

Connelly, Jack, 1982, *An Ecological Study of Sage-drouse in Southeastern Idaho*, Ph.D. Dissertation: Washington State University, Pullman, Washington.

9.1.3 Common Raven (Corvus corax) Abundance in Relation to Anthropogenic Resources within the Idaho National Laboratory Site in 2009

Investigators and Affiliations

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- 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

- Estimate raven and raptor densities on the INL Site
- Develop predictive model of broad-scale raven and raptor habitat use
- Identify anthropogenic factors that affect raven densities
- Determine the relationship between raven density and apparent sage-grouse nest success.

Summary

During the 2009 survey season, 176 raven and 157 raptor observations (≥1 bird) were recorded. Of the raven nests identified, 68 percent were located on artificial substrate and 32 percent on natural substrate. Of the raptor nests identified, 14 percent were located on artificial substrate and 86 percent on natural substrate. Digital geospatial data files were compiled, updated and incorporated into a Geographic Information System for land use and anthropogenic subsidies. Geospatial statistical analysis of these data will be performed to determine raven and raptor density in relation to habitat types, distances to anthropogenic resources. and land management activities. Preliminary analysis shows that ravens are occurring in higher numbers close to linear anthropogenic structures, roads and power lines. Reasons for these spatial behaviors of raven presence on the INL Site are currently under investigation through further analysis of the data collected.

9.1.4 Survey of Pygmy Rabbit (Brachylagus idahoensis) Occurrence on the Idaho National Laboratory Site

Investigators and Affiliations

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- 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

The purpose of this research is to determine the distribution of pygmy rabbits on the INL Site to support the development of a Candidate Conservation Agreement. The specific objective is to conduct surveys on randomly selected 16-ha plots to determine if active pygmy rabbit burrows are present.

Summary

The pygmy rabbit (*Brachylagus idahoensis*) depends on sagebrush for food and shelter. In fact, nearly 100 percent of its diet in winter is composed of sagebrush. Currently, the U.S. Fish and Wildlife Service is reviewing the status of the pygmy rabbit to determine if it must be listed as threatened or endangered under the Endangered Species Act of 1973. Unfortunately, little is known about this species, and techniques for monitoring populations and quantifying abundance are in their infancy.

Pygmy rabbits have been documented on the INL Site in the past, but the species' current distribution is unknown. Because the pygmy rabbit is considered a sensitive species in Idaho,

and because there is a potential for pygmy rabbits to be listed as threatened or endangered in the near future, it is important to conduct pygmy rabbit surveys on the INL Site not only to verify the presence and population abundance, but also to characterize critical habitat associated with active burrows.

Since winter 2006, 551 16-ha plots that were selected based on a stratified random design were surveyed. The investigators documented 1,141 burrow systems since 2006, and found at least one active pygmy rabbit burrow system on 31 percent of the 170 plots surveyed in 2006. In fall 2007, pygmy rabbits occurred on 37 percent of the 244 plots surveyed. In contrast, in winter 2009 only 12 percent of 178 plots had active burrows. During fall 2009, plots with active burrows comprised 44 percent of the 22 plots surveyed. Because analysis of these data is pending, the investigators cannot yet explain why the number of plots with recent pygmy rabbit activity was so much lower in winter 2009 than in other seasons. Further analyses will be conducted in 2010.

9.1.5 Development and Evaluation of a Monitoring Program for Pygmy Rabbits

Investigators and Affiliations

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- Janet Rachlow, Ph.D., Department of Fish and Wildlife Resources, University of Idaho, Moscow, Idaho
- Scott Bergen, Ph.D., North American Program, Wildlife Conservation Society, Pocatello, Idaho

Funding Sources

- U.S. Department of Energy Idaho Operations Office
- Idaho Bureau of Land Management Challenge Cost Share Program
- Idaho Department of Fish and Game
- University of Idaho.

Objectives

The purpose of this research on the Idaho National Laboratory (INL) Site is to develop and evaluate a standardized method to monitor abundance of pygmy rabbits. Specific objectives are to:

- Calibrate an index of abundance based on burrow systems by correlating the index with estimates of population density
- Design standardized protocols for monitoring abundance.

Scarab beetle

Summary

The accepted method of surveying pygmy rabbits is to count their burrow systems rather than individual animals. However, to provide a meaningful estimate of numbers of individuals occupying an area, the number of rabbits associated with each burrow must be understood. The study investigated the relationship between density of burrow systems and density of rabbits, and used this information to evaluate an index of rabbit abundance that could be employed by wildlife biologists to monitor changes in abundance of pygmy rabbit populations over time.

A total of six sites were identified in 2007 – 2008 in the Lemhi Valley, of which five were approximately 100 ha, and one was approximately 50 ha. A census of all burrow systems and mark-resight surveys were completed on all six sites. Mark-resight and snow-tracking techniques were used to evaluate and calibrate an index based on burrow systems. On the INL Site, 24 16-ha sites and one l00-ha site were surveyed for burrows during 2008. Mark-resight and snow surveys were used to estimate abundance on the large site; however, snow-track surveys were used as the sole method of estimating abundance on the 16-ha sites. Burrows were segregated into four classes of activity status: active, recently active, old, and very old.

Animals were trapped at the larger sites in the Lemhi Valley and on the INL Site. Captured animals were fitted with radio transmitters, implanted with passive integrated transponder tags, or “PIT tags” (which are small microchips about the size of a grain of rice that are injected under the skin), and standard mammalian measurements were collected. A total of 79 rabbits were collared over two seasons in the Lemhi Valley. Only one rabbit was captured at Atomic City during 2007.

After trapping was completed, mark-resight surveys commenced. When a rabbit was sighted, the investigators recorded (1) the presence of a radio collar, (2) rabbit’s relative location, and (3) rabbit’s global positioning system location. Other measurements taken at each resighting occasion included weather conditions, temperature, snow cover, wind, and date and time. Upon completion of each resight, all collared animals that were not detected were located to determine if they were onsite for survey. Animals that were either offsite or had died were removed from the pool of available marked rabbits for calculations of population estimates. On sites without radio-collared rabbits, the number of rabbits documented via snow-track surveys was used as the total number of rabbits onsite. At the INL Site, maximum numbers of rabbits then were converted into a density estimate for each 16-ha plot.

The density of active burrows and the density of rabbits from the larger sites on Lemhi Valley and the one large site on the INL Site were used to develop an index of pygmy rabbit abundance. A curvilinear relationship fit the data best because individual rabbits used more burrow systems as the density of burrow systems available to them increased.

The investigators chose not to include the 16-ha plots from the INL Site in the index development with the larger Lemhi Valley sites for several reasons.

The index developed on the larger sites was used to predict the number of rabbits based on active burrow systems on each 16-ha plot. As expected, the number of rabbits predicted by the index and the number counted during snow-track surveys were not tightly correlated. At

Bristly Cutworm Moth

extremely low densities of burrow systems (i.e., densities below 0.025 burrows/ha), the index is unreliable at estimating rabbit densities.

Until the index is validated in other areas, it should be used only to provide relative estimates of abundance at individual sites over time. The index is suitable, however, for monitoring changes in relative abundance over time within sites, assuming that environmental factors that significantly influence the rabbit-burrow relationship are relatively constant over time within a site.

The investigators suggest that larger plot sizes than those used on the INL Site during this study be monitored to track changes in relative densities of rabbits on the INL Site over time. Larger plot sizes would reduce the number of plots that contain too few active burrow systems to adequately estimate relative abundance of rabbits and would decrease variability among estimates across time.

Because the index of rabbit abundance is based on the presence of fresh pellets to categorize active burrow systems, persistence of pellets that appear fresh will influence estimates of densities of active burrows and, hence, rabbit abundance. Based on estimated rates of pellet degradation, this could result in a lag of one or more years between large population declines and detection of those declines based on annual burrow censuses.

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

Investigators and Affiliations

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- 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

Scarab beetle

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

Throughout 2009, 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, resulting in the capture of 634 individuals of five different species. For each animal captured, location, sex and weight were recorded. Initial preparations were made for conducting elk research in the Development Zone in early 2010.

Several key objectives of this project are planned for completion in 2010, including continuing small mammal trappings in the Development Zone with a focus on shrews, voles and northern grasshopper mouse; determining which bat species are present in the Development Zone; collecting hourly location data from March to November from collared elk; and analyzing the elk location data. Results of the study will be integrated into the INL Site Conservation Management Plan.

9.1.7 Plant Community Classification and Mapping at the Idaho National Laboratory Site

Investigators and Affiliations

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- Ken A. Aho, Ph.D., Department of Biological Sciences, Idaho State University, Pocatello, Idaho
- Roger D. Blew, Ph.D., Ecologist, 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 an 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

Throughout 2009, several key objectives were completed. A total working class list of 27 plant communities was identified and named according to National Vegetation Classification System conventions. During the summer of 2009, two field crews collected vegetation community data needed for independent validation of the final map polygons. A total of 534 validation plots were sampled.

Each validation plot consisted of a sampling plot array that included a focal plot and four peripheral subplots in the cardinal directions. At each validation subplot, Global Positioning System data were collected, a complete species list was created and each species was assigned a categorical ranking of abundance, and each subplot was assigned to a vegetation community using a field key generated from 2008 statistical results.

Draft polygon delineations also were completed for the INL Site in 2009. In the fall of 2009, the investigators drove many of the roads across the INL Site and visited observation points to identify what communities were within the map polygons. Using the ground observation data, the initial delineations were revised where appropriate, and the investigators began assigning community class labels to all polygons in the map.

In 2010, the plant community classifications will be completed, and a list of plant communities occurring on the INL Site will be finalized and cross-walked to the National Vegetation Classification System. An updated key to plant communities in the INL Site also will be

Scarab beetle

generated. Plant community descriptions will be written to accompany the final map. The final vegetation community map will be completed in 2010, and the accuracy assessment stage will follow.

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

Investigators and Affiliations

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- 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. The comparative surveys have 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 can be used qualitatively, as well as quantitatively, to examine the contributing factors and overall risk of invasion.

In late 2006 and early 2007, researchers established a series of two-species plant communities comprised of combinations of early-season native species, late-season native species or one of each group, in 50-gallon barrels. Precipitation experiments were conducted on the established communities. In the two-species plant communities, ambient-amount, irregular-distribution watering regime caused some stress to both cheatgrass and perennial transplants. Plants subjected to higher-precipitation treatments fared better. There was no effect of planted species on soil water content in the top 10 cm of soil, and minimal effect of the watering treatments on surface soil water content 24 hours after the water pulses were applied.

In 2009, investigators conducted an experiment to clarify soil property changes induced by invasive and native grasses and to examine how those changes influence subsequent plant growth. The grasses used included invasive and native species. Different mechanisms involved with nutrient dynamics, including plant uptake and changes in soil content, were investigated. Plant uptake was higher by invasive grasses for phosphorus, calcium, magnesium, and manganese. Native grasses increased available mineral nitrogen and potassium in the soil more than non-native grasses. However, investigators found that not all native grasses as a group and not all non-native grasses as a group affect nutrient dynamics similarly. Evaluating the species-specific effects of both native and non-native plants on soil nutrient dynamics will reveal one mechanism that influences both the ability of some species to invade and the potential effects of some invasions.

9.1.9 Surveying, Monitoring and Predicting the Occurrence and Spread of Native and Non-Native Plant Species at the 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

Scarab beetle

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

Incorporating information obtained by completing the above objectives into a decision support management prioritization framework can help resource managers prioritize populations to manage and help evaluate the potential impacts of different disturbance scenarios to minimize the negative (RPS) or positive (NIS) impacts on plant population dynamics.

In April of 2009, environmental data were secured from S.M. Stoller Corporation, and stratified random transects were delineated throughout the Conservation Management Plan Development Zone. In June and July, approximately 37 transects were completed. NIS and RPS presence and absence were recorded along each transect. On 20 of these transects, the presence and abundance of all plant species were recorded to assess plant biodiversity. Five of the 37 transects were repeated in late July to determine the within-season variability in NIS occurrence because precipitation in June and July 2009 exceeded the 30-year average threefold.

Seventeen NIS were observed in the 37 presence/absence transects. An additional five NIS were observed, for a total of 1 – 5 individuals, in the more detailed biodiversity evaluations. NIS proportional occurrences ranged from less than 0.1 percent to 82 percent, showing a broad range of representation in the community within the Development Zone. No RPS were found within these transects.

Approximately 60 - 80 transects are planned for June and July of 2010. Transect data will be collated to generate probability of occurrence maps and develop preliminary metapopulation

Bristly Cutworm Moth

dynamics models for the most frequent NIS. The metapopulation models will be finalized after the third year of sampling for a small number of NIS.

9.1.10 Long-Term Vegetation Transects

Investigators and Affiliations

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- Roger D. Blew, Ph.D., Ecologist, Environmental Surveillance, Education and Research Program, S.M. Stoller Corporation, Idaho Falls, Idaho
- Jackie R. Hafla, Natural Resource Scientist, Environmental Surveillance, Education and Research Program, S.M. Stoller Corporation, Idaho Falls, Idaho

Funding Sources

- U.S. Department of Energy Idaho Operations Office

Objectives

The eleventh Long-Term Vegetation data set was collected during the summer of 2006. During 2009, two tasks were undertaken in association with the 2006 data collection. The objectives of these two tasks include the following:

- Update and describe the data archives and data collection protocols
- Summarize and analyze the 2006 and all previously collected abundance data to characterize general plant abundance and community composition trends, and to characterize patterns of exotic species invasion and determine effects of invasion on vegetation cover and composition of native plant communities subsequent to invasion.

Summary

Accomplishments through 2009 include collection of the 2006 data and completion of quality assurance and quality control procedures on that data set. The 2006 data were also summarized, formatted, and imported into a comprehensive relational database. Analyses summarizing INL Site vegetation trends over the past 56 years were completed in 2009. Results of the mapping exercise were compared to changes in mean density and frequency of the target species or group of species between sample periods in an effort to characterize general spatial and temporal patterns of invasion on the INL Site.

The database includes seven raw data and metadata tables. The metadata tables include information about plant species on the INL Site, each of the permanent plots on the Long-Term Vegetation Transects, and the sampling history on the Long-Term Vegetation plots. Three data tables on vegetation abundance contain density and frequency data, cover data estimated using line interception, and cover data estimated using point interception. A photograph specifications

Scarab beetle

data table was designed to consolidate data associated with photos taken when Long-Term Vegetation data were collected.

Results from analyses on trends in species composition and abundance indicate that although cover of major functional groups remains relatively stable through time, cover of species within those groups can vary dramatically over just a decade. Cover of big sagebrush (*Artemisia tridentata*) has continued to decline through the 2006 sampling effort, and cover of crested wheatgrass (*Agropyron* spp.) is increasing rapidly, albeit at a local scale. Results from the analyses on trends of invasive species indicate that the spatial distribution of cheatgrass has increased over the study period; however, the mean density and frequency have not increased as predictably as expected. The abundance and distribution of other non-native annuals, specifically desert madwort (*Alyssum desertorum*), are increasing far more rapidly.

9.1.11 Sagebrush Demography on the Idaho National Laboratory Site

Investigators and Affiliations

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Funding Sources

- U.S. Department of Energy Idaho Operations Office

Objectives

The primary goal of the Sagebrush Demography Project is to support the Conservation Management Plan effort by facilitating the development of specific habitat management recommendations for sagebrush steppe at the INL Site and by providing guidance for assessing and monitoring the condition of big sagebrush stands. Two products will be developed for use in this conservation planning effort. The first is a comprehensive literature database and reprint collection containing sagebrush biology and ecology references pertinent to sagebrush steppe habitat management. The second product is a technical report resulting from a field investigation of sagebrush population biology (demography) at the INL Site. The specific objectives of the field study are to:

- Characterize the typical stand age structure or range of stand age structures for mature sagebrush stands
- Investigate how stand age structure relates to stand condition and shrub die-off for sagebrush
- Examine the dynamics of sagebrush stand replacement in the absence of wildland fire.

Bristly Cutworm Moth

Summary

This research effort was undertaken with the goal of providing enough INL Site-specific information about big sagebrush population biology to support the development of an effective adaptive management strategy for sagebrush steppe plant communities. Characterizing the population dynamics of big sagebrush on the INL Site will determine if: undisturbed stands tend to have an even or uneven age structure, current stand condition can be used to predict future stand condition, stand die-offs are a result of advanced age, disturbance is necessary for stand regeneration, and seed availability or germination restrictions limit establishment in poor-condition stands. Information gained from results of this research will be integrated into the Conservation Management Plan as a part of a habitat management approach for obligate species.

During the summer of 2006, 14 stands of Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) were sampled. The vegetation data collected included shrub cover, sagebrush density, and individual shrub rank data to develop criteria for measuring stand condition. At each stand, cross section samples of sagebrush also were collected. The cross sections were labeled and archived for subsequent sanding and ring counts. Preparation and counts of annual rings in the sagebrush cross sections began in 2009. Cross sections were prepared by trimming each slab as close to the root-shoot interface as possible and sanding it through a series of three sandpaper grit sizes. Rings on each cross section were counted under a dissecting microscope twice; each count was made by a separate observer. Approximately 90 percent of the slab processing and preparation and about 30 percent of the ring counts were completed in 2009.

Background

The INL Site boundaries encompass approximately 2,300 km^2 of the Upper Snake River Plain. The plant communities within the INL Site are characteristic of cold desert ecosystems, and many of them are dominated by sagebrush (*Artemisia*) species. The historical range of sagebrush steppe generally included much of the western United States; however, the extent and condition of sagebrush steppe plant communities have been declining rapidly in recent decades. Declines in sagebrush steppe have been followed in turn by declines in populations of sagebrush-obligate plant and animal species, which often result in consideration for regulatory protection for those species.

Although many of the sagebrush-dominated plant communities on the INL are still in good ecological condition compared to rangelands across the West, they have not been immune to the threats and stressors that have caused declines elsewhere. Results from the most recent analysis of the Long-term Vegetation Transects indicate that the abundance of non-native species is increasing across the INL Site and that the abundance of big sagebrush (*Artemisia tridentata*) is decreasing. Over the past three decades, big sagebrush cover has declined to about half of the mid-1970s values.

At-risk populations, such as those of several sagebrush-obligate species, cannot be readily conserved through direct population manipulation. Instead, successful conservation strategies often involve habitat conservation or improvement or both. At the INL Site, developing an

effective habitat management strategy for sagebrush-obligate species will certainly require defining best management practices for big sagebrush populations and associated plant communities. Adaptive management approaches for big sagebrush requires an understanding of current conditions, knowledge of the system dynamics, and an ability to predict future conditions.

Sagebrush steppe has been actively manipulated for a variety of reasons over the past century, often with unpredicted outcomes. The uncertainty associated with sagebrush steppe management likely stems from a lack of knowledge concerning the population biology of big sagebrush, arguably the most important species in the sagebrush steppe ecosystem. Although many researchers have addressed the effects of disturbances in the greater sagebrush steppe ecosystem and have studied the recruitment and germination phases of the big sagebrush lifecycle extensively, very few have attempted to characterize the population dynamics of relatively undisturbed, mature stands.

The Sagebrush Demography Project is a research effort undertaken with the goal of providing enough INL Site-specific information about big sagebrush population biology to support development of an effective adaptive management strategy for sagebrush steppe plant communities. Characterizing the population dynamics of big sagebrush on the INL Site will allow us to determine if: undisturbed stands tend to have an even or uneven age structure, current stand condition can be used to predict future stand condition, stand die-offs are a result of advanced age, disturbance is necessary for stand regeneration, and seed availability, or germination restrictions limit establishment in poor-condition stands. Information gained from the results of this research will be integrated into the Conservation Management Plan as a part of a habitat management approach for obligate species. Specific benefits of this research on habitat management planning include: tools that can be used to determine the probability of future declines or improvements in stand condition, improved ability to target stands for monitoring or manipulation, increased confidence in identifying appropriate restoration techniques, reduced uncertainty about the results of stand manipulations, and maximizing efficiency in monitoring, conservation and restoration efforts. In 2010, ring counts, data analysis, and report writing will be completed to conclude the field investigation.

9.1.12 Developing a Habitat Selection Model to Predict the Distribution and Abundance of the Sagebrush Defoliator Moth (Aroga websteri Clarke)

Investigators and Affiliations

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- Nancy Huntly, Ph.D., Professor, Department of Biological Sciences, Idaho State University, Pocatello, Idaho

Funding Sources

- Idaho State University Graduate Student Research and Scholarship Committee, Grant No. F07 R6

Objectives

The overall goal of this project is to use habitat data from sagebrush communities in southeastern Idaho to determine which variables (e.g., abundance or height of sagebrush, presence or abundance of other plant species, presence of other moth and insect species, or land use attributes) most strongly predict the presence or absence of *A. websteri*. Specific objectives for 2009 included the following:

- Compile and analyze 2007 and 2008 field data and document results
- Prepare specimens for taxonomic identification.

Summary

A better understanding of the location, timing and pattern of defoliator outbreaks would allow land managers to better maintain and manage critical sagebrush habitats. Simple correlation and linear regression were used to test the strength of relationships between nine independent variables used to characterize the habitat at each trapping location. Of these, one independent variable was eliminated to minimize effects of colinearity, and logistic regression was used to fit the presence and absence of *A. websteri* to the eight remaining independent variables, individually and in combination. Models for grazed and ungrazed habitats were analyzed separately for 2007 and 2008.

Alone or in combination, the simplistic metrics used to characterize habitat for each trapping location were not significant in predicting the presence or absence of *A. websteri*. Over 100 macrolepidopteran specimens representing nearly 30 species captured in 2007 and 2008 were pinned, labeled and are being submitted for identification as qualified taxonomists are located. Efforts to sort several hundred microlepidopteran specimens to morphospecies are ongoing.

9.1.13 Development of a Data-based Validation Network for State-and-Transition Models

Investigators and Affiliations

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- 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 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 September 2009, Jornada Experimental Range staff traveled to the INL Site to obtain archeological clearance for soil sampling at Long-Term Vegetation plots. The soil sampling will be used to assign Long-Term Vegetation plots to Ecological Sites used to specify variations in state-and-transition models based on ecological potential. Jornada Experimental Range staff and an INL archaeologist visited 68 Long-Term Vegetation plots during a four-day period. Suitable soil sampling locations were identified and marked. The archaeologist examined the area surrounding each marker and either cleared the site for excavation or indicated that an alternative site should be selected. Only one soil pit was excavated during this visit. Global Positioning System coordinates also were collected at each site to assist in relocating soil sampling points.

The investigators intend to revisit the monitoring sites in summer 2010 and characterize soil profiles at all or a subset of the marked locations.

9.1.14 Sagebrush Canopy Height and Shape Measurements Using Small-Footprint Discrete-Return LiDAR

Investigators and Affiliations

- Jessica J. Mitchell, Ph.D. Candidate, Engineering and Applied Science, Idaho State University, Boise, Idaho
- Nancy F. Glenn, Ph.D., Research Associate 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
- Idaho National Laboratory Grant (Laboratory-Directed Research and Development, Battelle Energy Alliance, FY-09)
- National Oceanic and Atmospheric Administration Office of Oceanic and Atmospheric Research, Earth Systems Research Laboratory, Physical Sciences Division, Grant # NA06OAR4600124.

Objectives

- Quantify shrub height and shape prediction errors by comparing light detection and ranging (LiDAR) (airborne laser scanning) point-cloud data to sagebrush canopy characteristics measured in the field
- Evaluate differences in LiDAR height and shape estimation results when using raw point-cloud data versus maximum vegetation height models derived from the data (at 0.5-m and 1.0-m grid resolutions)
- Evaluate sources of LiDAR underestimation error associated with target characteristics.

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.

Plans for continuation of this study include evaluating LiDAR-derived vegetation roughness estimates as an indicator of shrub height and investigating the potential for future research on shrub biomass estimation through the fusion of LiDAR data with hyperspectral imagery acquired from an unmanned aerial vehicle platform.

Scarab beetle

9.1.15 Dynamics of Post-wildfire Wind Erosion of Soil in Semiarid Rangelands, Idaho

Investigators and Affiliations

- Joel B. Sankey, Ph.D., Postdoctoral Researcher, Geosciences Department, Idaho State University, Pocatello, Idaho
- Nancy F. Glenn, Ph.D., Research Associate Professor, Geosciences Department, Idaho State University, Boise, Idaho
- Matthew J. Germino, Ph.D., Associate Professor, Biological Sciences Department, Idaho State University, Pocatello, Idaho

Funding Sources

- Inland Northwest Research Alliance
- National Center for Airborne Laser Mapping (supported by National Science Foundation)
- U.S. Department of Defense (U.S. Army Research Office and Army Research Laboratory under grant number W911NF-07-1-0481).

Objectives

The overall goal of the research is to determine and describe wildland fire effects on wind erosion potential of shrub steppe in southeastern Idaho. The research focuses on a field site that is partially located on the INL Site. The specific objective for the research at the site is to identify hydroclimatological, vegetation, and microtopographic controls on post-fire wind erosion potential.

Summary

In 2009, the investigators continued monitoring saltation, aeolian threshold wind velocity, aeolian sediment flux and soil loss and deposition at the Twin Buttes Fire, Moonshiner Fire, and an adjacent control site. Key findings regarding the relationship between hydroclimate and post-fire wind erosion include: burned soil surfaces became less erodible with time following burning; the decrease in erodibility could be explained by variability in soil water content and atmospheric moisture; and though erodibility generally decreased with increased moisture near the soil surface, examples of erodibility increasing linearly or varying curvilinearly with increased moisture were observed.

Key findings regarding the relationship between LiDAR-derived land surface roughness and post-fire wind erosion include: surface change (aeolian erosion and deposition) varied as a function of surface roughness among burned and unburned surfaces, with net erosion occurring on the relatively smooth, burned surfaces and net deposition occurring on the rough, unburned surfaces; erosion decreased (and deposition increased) with increased soil and vegetation

roughness derived from LiDAR remote sensing analysis; and surface change at fine spatial scales (length scales <1 m) suggest that aeolian processes occurred with strong spatial patterns on burned, but not unburned surfaces.

9.1.16 Spatial and Temporal Variability in Soil, Vegetation and Aerodynamic Properties in Wind-eroded, Post-fire Sagebrush Steppe

Investigators and Affiliations

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- Matthew J. Germino, Ph.D., Associate Professor, Biological Sciences Department, Idaho State University, Pocatello, Idaho
- Nancy F. Glenn, Ph.D., Professor, Geosciences Department, Idaho State University, Boise, Idaho
- Joel Sankey, Ph.D., Post-Doctoral Fellow, Geosciences Department, Idaho State University, Boise Idaho
- Lachy Ingram, Ph.D., Post-Doctoral Fellow, Biology Department, Idaho State University, Pocatello, Idaho
- Niles Hasselquist, Ph.D., Post-Doctoral Fellow, Biology Department, Idaho State University, Pocatello, Idaho

Funding Sources

- U.S. Department of Defense
- Bureau of Land Management.

Objectives

The goal is to increase understanding of the relationships between vegetation and geomorphic and atmospheric processes. More specifically, the following three main objectives will be addressed:

- Determine the relationship between post-fire heterogeneity of the soil surface morphology and vegetation in replicate areas that are unburned or that have been burned and wind-eroded in the last several years
- Determine if there is temporal variability in the aerodynamic parameters friction velocity and roughness length at multiple scales and identify how it relates to vegetation recovery after fire
- Determine nutrient exchanges occurring with wind erosion on the INL Site in burned and unburned areas; specifically, to determine horizontal sediment transport and associated nutrient redistribution occurring in the saltation zone in a sagebrush steppe ecosystem

exhibiting an episodic period of aeolian transport following wildfire; also examine how temporal trends in nutrient fluxes are affected by changes in particle sizes of eroded mass, as well as nutrient concentrations associated with different particle size classes.

Summary

This project focuses on heterogeneity in the relationship of soil and plants, specifically shrub “islands of fertility” and the relatively bare interspaces between them, in unburned areas and areas that burned and then experienced high levels of wind erosion. This project also assesses aerodynamic properties of the vegetation community as it recovers from wildfire and consequences of soil erosion for nutrient balances of sites.

Field studies to characterize soil surface morphological heterogeneity and vegetation corresponding to the soil morphologies on the post-erosion environment were conducted during summer 2008 and 2009 at the sites of three wildfires on the INL Site. In addition, data on temporal changes in aerodynamics and corresponding vegetation at the burn site were collected. Sediment captured from air was analyzed over an 18-month period for carbon, nitrogen, and particle sizes. Also, ground-based light detection and ranging (LiDAR) was used to evaluate surface microtopography in the research sites.

For the first objective, researchers investigated the correspondence between physical, chemical, hydrological, and vegetation properties of shrub-island (coppice) and interspace soil surfaces (or microtopographies) in sites that were unburned or burned and wind-eroded (n = 3) in the Snake River Plain of Idaho.

Data collected suggest that heterogeneity in microtopography is sustained following wildfire in the sagebrush steppe, even after large amounts of aeolian redistribution have occurred in the years following fire. Soil microtopography appears to influence plant diversity in this landscape by creating different microcommunities, and the relatively bare interspaces may increase water reserves for growth on coppices. Post-fire seeding with the intent of soil stabilization or exotic plant invasions could reduce this important plant-soil heterogeneity.

Regarding the third objective, temporal variation in carbon and nitrogen fluxes appeared to be largely attributable to the redistribution of saltation-sized particles, and to a lesser extent, the redistribution of the suspension-sized particles. Aeolian sediment also was enriched in carbon and nitrogen relative to surface soils, suggesting that aeolian transport following a disturbance, such as wildfire, has the potential to impact nutrient redistribution and ecosystem function in a landscape that otherwise experiences little wind erosion.

9.1.17 Big Lost River Trenches Revegetation Demonstration Project

Investigators and Affiliations

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

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

Funding Sources

- U.S. Department of Energy Idaho Operations Office

Objectives

The primary purpose of the Big Lost River Trenches Revegetation Demonstration Project is to assess the efficacy of several revegetation techniques that often are recommend but rarely employed on the INL Site, such as using container stock seedlings, providing supplemental irrigation, and applying intensive weed management practices. Successfully implementing these techniques could increase the recovery rate of revegetation sites, thereby reducing the amount of time and long-term maintenance required to reach regulatory revegetation standards. Some of the techniques used for the Big Lost River Trenches Project also may reduce uncertainty associated with the outcome of revegetation on the INL Site, which also translates to increases in long-term efficiencies for revegetation and restoration projects.

Summary

All activities related to backfilling and planting were completed in 2007. Maintenance activities have been completed on at least a monthly basis from April through October 2008 and 2009. Data to support formal revegetation assessments were collected in July 2009. General estimates for background vegetation cover were obtained from plot data collected as a component of the INL Site Plant Community Classification and Vegetation Mapping Project in 2008.

Annual species were abundant on all of the trenches. Native, perennial cover values were highest at BLR-8 and fell within the range of values estimated from background plots. Native, perennial cover values were lowest at Big Loop and fell well below the range of values estimated from background plots. This result likely is related to a combination of low shrub cover in the background estimate values for this set of trenches due to a fire in 2000 and soils favoring herbaceous germination and establishment.

Informal site inspections, maintenance activities, formal revegetation assessments, and stakeholder interaction will continue until all eight trenches have reached 70 percent of native, perennial background cover. Site-specific control data will be collected at the BLR-8 trenches in 2010 to support statistical hypothesis testing.

9.1.18 Spectroscopic Detection of Nitrogen Concentrations in Sagebrush: Implications for Hyperspectral Remote Sensing

Investigators and Affiliations

- Jessica J. Mitchell, Ph.D. Candidate, Engineering and Applied Science, Idaho State University, Boise, Idaho

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- Nancy F. Glenn, Ph.D., Research Associate 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
- Idaho National Laboratory Grant Laboratory-Directed Research and Development, Battelle Energy Alliance, FY-09
- National Oceanic and Atmospheric Administration Office of Oceanic and Atmospheric Research, Earth Systems Research Laboratory, Physical Sciences Division, Grant # NA06OAR4600124.

Objectives

- Relate sagebrush leaf and shrub nitrogen concentrations to corresponding spectral responses
- Examine differences between sagebrush nitrogen concentrations and spectral response at leaf and shrub scales
- Identify transformed bandwidth intervals most closely related to nitrogen concentrations
- Examine the strength at which narrow absorption features are expressed using a field radiometer versus an unmanned aerial vehicle-based sensor platform (PIKA, 400 – 900 nm); evaluate results in the context of extending sagebrush nitrogen concentration to a larger scale project

Summary

From May to October 2009, the following measurements were collected in the field for each of 35 individual, spatially isolated sagebrush: absolute canopy reflectance measurements (350 – 2,500 nm) using a field spectroradiometer (ASD); photographs oriented orthogonal to the ground for calculating proportional leaf area; and sagebrush green leaf samples for analysis of nitrogen content. The following measurements were collected in the laboratory for green leaf samples: single sided leaf mass/unit area measurements, leaf-level nitrogen concentrations of oven-dried ground foliage, and absolute reflectance spectra for dried and ground leaf samples. Hyperspectral imagery was acquired concurrent with data collection using a PIKA sensor mounted on an unmanned aerial vehicle.

Correlation coefficients were plotted against wavelengths for both sagebrush dry leaf and shrub canopy ASD data. The dry leaf data indicate potentially strong predictors of sagebrush nitrogen concentration near 520 nm, 1,725 nm, 2,209 nm, and 2,307 nm. The shrub canopy data indicate wavelengths near 530 nm and 2,250 nm are potentially strong predictors of sagebrush

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nitrogen concentration. However, noise in the short-wave infrared makes it difficult to isolate additional wavelengths of interest.

Additional processing techniques will be applied to the shrub canopy spectral data to reduce the noise in the short-wave infrared. The spectral data also will be analyzed using chemometric software and multivariate statistics as an approach to isolate wavelengths of predictive interest. The PIKA hyperspectral imagery will be examined closely to determine the feasibility of extending this project to the landscape scale. Potential for fusion with LiDAR data also may be evaluated.

9.1.19 The Influence of Precipitation, Vegetation and Soil Properties on the Ecohydrology of the Eastern Snake River Plain

Investigators and Affiliations:

- Matthew Germino, Ph.D., Associate Professor, Department of Biological Sciences, Idaho State University, Pocatello, Idaho
- Keith Reinhart, Ph.D., Post-Doctoral Fellow, Department of Biological Sciences, Idaho State University, Pocatello, Idaho
- Kevin Feris, Ph.D., Assistant Professor, Department of Biological Sciences, Boise State University, Boise, Idaho
- Pat Sorensen, M.S. Candidate, Department of Biological Sciences, Boise State University, Boise, Idaho
- Daniel Mummey, Ph.D., Division of Biological Sciences, The University of Montana, Missoula, Montana

Funding Sources

- Experimental Program to Stimulate Competitive Research in Idaho, 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.

Researchers found that areal cover of plants in the plots have been affected by the treatments, and, thus, show some surprisingly minor changes in species diversity and changes in cover types. Sagebrush and exotic crested wheatgrass have come to dominate all plots that were planted with native species only. The foliar-crown volume was measured and biomass of sagebrush populations was estimated. Researchers detected substantially greater sagebrush presence this way in plots that had deeper soils or supplemental irrigation, particularly where it is added in winter. Differences in the carbon isotopic composition and foliar morphological attributes were much fewer, indicating physiological or plant form adjustments to different water levels. Purosequencing and restriction fragment length polymorphism analyses of soil microbial communities revealed considerable differences among treatments.

9.2 U.S. Geological Survey 2009 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 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/.)

Two reports were published by the USGS INL Project Office in 2009. The abstracts of these studies and the publication information associated with each study are presented below.

9.2.1 Iodine-129 in the Snake River Plain Aquifer at and Near the Idaho National Laboratory, Idaho, 2003 and 2007 (Roy Bartholomay)

From 1953 to 1988, wastewater containing approximately 0.94 curies of iodine-129 (^{129}I) was generated at the Idaho National Laboratory (INL) in southeastern Idaho. Almost all of this wastewater was discharged at or near the Idaho Nuclear Technology and Engineering Center (INTEC) on the INL site. Most of the wastewater was discharged directly into the Eastern Snake River Plain Aquifer through a deep disposal well until 1984; however, some wastewater was also discharged into unlined infiltration ponds or leaked from distribution systems below the INTEC.

In 2003, the U.S. Geological Survey (USGS) in cooperation with the U.S. Department of Energy collected samples for ^{129}I from 36 wells used to monitor the Snake River Plain Aquifer and from one well that monitors a perched zone at the INTEC. Concentrations of ^{129}I in the aquifer ranged from 0.0000066 ± 0.0000002 to 0.72 ± 0.051 picocuries per liter (pCi/L). Many wells within a 3-mile radius of the INTEC showed decreases of as much as one order of magnitude in concentration from samples collected during 1990–91, and all of the samples had concentrations less than the Environmental Protection Agency’s Maximum Contaminant Level (MCL) of 1 pCi/L. The average concentration of ^{129}I in 19 wells sampled during both collection periods decreased from 0.975 pCi/L in 1990-91 to 0.249 pCi/L in 2003. These decreases are attributed to the discontinuation of disposal of ^{129}I in wastewater after 1988 and dilution and dispersion in the aquifer.

Although water from wells sampled in 2003 near the INTEC showed decreases in concentrations of ^{129}I compared with data collected in 1990-91, some wells south and east of the Central Facilities Area, near the site boundary and south of the INL showed slight increases. These slight increases may be related to variable discharge rates of wastewater that eventually moved to these well locations as a mass of water from a particular disposal period.

In 2007, the USGS collected samples for ^{129}I from 36 wells that are used to monitor the aquifer south of INTEC and from 2 wells that are used to monitor perched zones at INTEC. Concentrations of ^{129}I in the Eastern Snake River Plain Aquifer ranged from 0.000026 ± 0.000002 to 1.16 ± 0.04 pCi/L and the concentration at one well exceeded the MCL (1 pCi/L) for public drinking water supplies. The average concentration of 19 wells sampled in both 2003 and 2007 did not differ; however, slight increases and decreases of concentrations in several areas around the 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 the movement into the aquifer of remnant perched water below the INTEC. In 2007, the USGS also collected samples from 31 zones in six wells equipped with multi-level Westbay^{TM} packer sampling systems to help define the vertical distribution of ^{129}I in the aquifer. Concentrations ranged from 0.000011 ± 0.0000005 to 0.0167 ± 0.0007 pCi/L. For three wells, concentrations of ^{129}I between zones varied one to two orders of magnitude. For two wells, concentrations varied for one zone by more than an order of magnitude from the other wells’ zones. Similar concentrations were measured for all five zones sampled in one well. All the 31 zones had concentrations two or more magnitudes below the MCL.

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), 27 p.

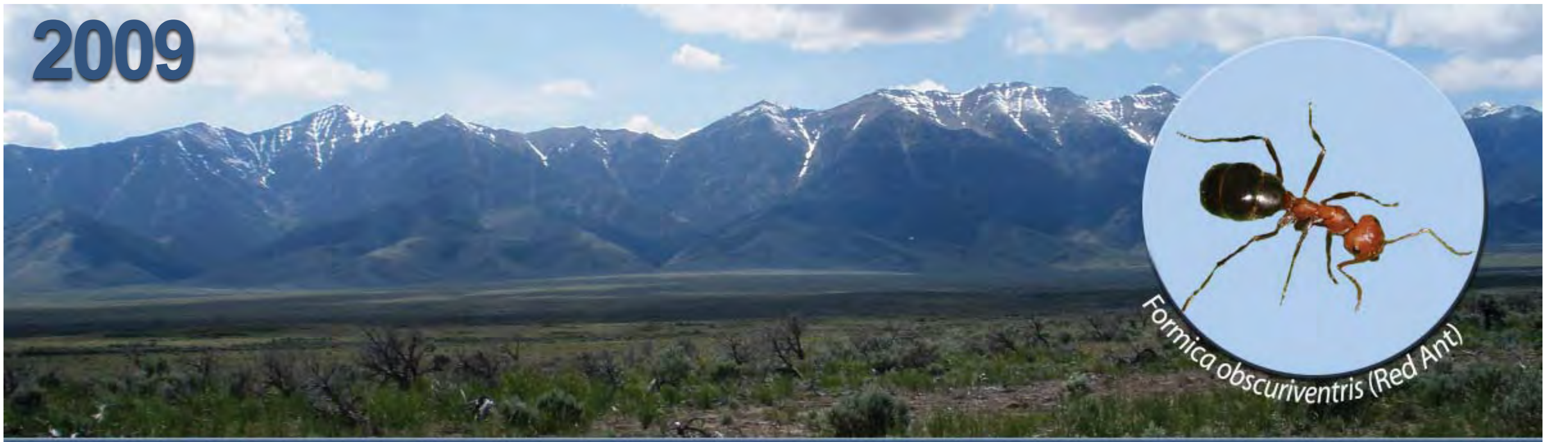
9.2.2 The Pliocene Lost River Found to West: Detrital Zircon Evidence of Drainage Disruption along a Subsiding Hotspot Track (Mary K.V. Hodges, Paul Karl Link and C. Mark Fanning)

SHRIMP analysis of U/Pb ages of detrital zircons in twelve late Miocene to Pleistocene sand samples from six drill cores on the Snake River Plain (SRP), Idaho suggests that an ancestral Lost River system was drained westward along the northern side of the SRP. Neoproterozoic (650 to 740 Ma, Cryogenian) detrital zircon grains from the Wildhorse Creek drainage of the Pioneer Mountains core complex, with a source in 695 Ma orthogneiss, and which are characteristic of the Big Lost River system, are found in Pliocene sand from cores drilled in the central SRP (near Wendell) and western SRP (at Mountain Home). In addition to these Neoproterozoic grains, fluvial sands sourced from the northern margin of the SRP contain detrital zircons with the following ages: 42 to 52 Ma from the Challis magmatic belt, 80 to 100 Ma from the Atlanta lobe of the Idaho batholiths and mixed Paleozoic and Proterozoic ages (1400 to 2000 Ma). In contrast, sands in the Mountain Home Air Base well (MHAB) that contain 155-Ma Jurassic detrital grains with a source in northern Nevada are interpreted to represent an integrated Snake River, with provenance on the southern, eastern and northern sides of the plain.

We propose that late Pliocene and early Pleistocene construction of basaltic volcanoes and rhyolitic domes of the Axial Volcanic Zone of the eastern SRP and the northwest-trending Arco Volcanic Rift Zone (including the Craters of the Moon volcanic center), disrupted the paleo-Lost River drainage, confining it to the Big Lost Trough, a volcanically dammed basin of internal drainage on the Idaho National Laboratory (INL). After the Axial Volcanic Zone and the Arco Volcanic Rift Zone were constructed to form a volcanic eruptive and intrusive highland to the southwest, sediment from the Big Lost River was trapped in the Big Lost Trough instead of being delivered by surface streams to the western SRP. Today, water from drainages north of the SRP enters the Snake River Plain regional aquifer through sinks in the Big Lost Trough, and the water resurfaces at Thousand Springs, Idaho, about 195 km to the southwest.

Holocene to latest Pliocene samples from drill core in the Big Lost Trough reveal interplay between the glacio-fluvial outwash of the voluminous Big Lost River system and the relatively minor Little Lost River system. A mixed provenance signature is recognized in fine-grained sands deposited in a highstand of a Pleistocene pluvial-lake system.

Hodges, M. K. V., Link, P. K. and Fanning, C. M., 2009, “The Pliocene Lost River Found to West: Detrital Zircon Evidence of Drainage Disruption along a Subsiding Hotspot Track,” in Morgan, L.A., Cathay, H. and Pierce, K.L., eds., *The Track of the Yellowstone Hotspot: Multi-disciplinary Perspectives on the Origin of the Yellowstone-Snake River Plain Volcanic Province, Journal of Volcanology and Geothermal Research*, Vol. 188, Issue Nos. 1-3, pp. 237-249.



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 2009 to ensure the quality of data collected and presented in this annual report.

10.1 Independent Assessment

In 2010, the U.S. Department of Energy (DOE) Headquarters Office of Independent Oversight within the Office of Health, Safety, and Security will review QA in conjunction with an independent assessment of the INL Site environmental monitoring program (see Section 3.1.2). Data quality is a key component of the independent assessment scope, both as to how QA is managed and implemented within individual contractor monitoring programs, as well as how those programs are reported each year in this report. The independent assessment may indicate opportunities for improvement in the overall INL Site environmental monitoring QA program and specific opportunities for improvement within individual contractor programs. The results of the independent assessment will be reported in the Calendar Year 2010 Site Environmental Report.

10.2 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.” 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 next page. The INL Site environmental monitoring programs take a graded approach to quality for determining the level of rigor that effectively provides assurance of performance and conformance to requirements.

Scarab beetle

Each 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

10.3 Environmental Monitoring Program Documentation

Strict adherence to program procedures is an implicit foundation of QA. In 2009, 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.

10.4 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.

Bristly Cutworm Moth

Table 10-1. Idaho Cleanup Project Environmental Program Procedures.

Procedure No.[a]	Procedure Title
GDE-149	Cleaning of Environmental Services Project (ESP) Sampling Equipment
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-1264	Ambient Air Surveillance Instrumentation Calibration
MCP-1298	Sample and Analytical Data Management Process for The Sample and Analysis Management Program
MCP-9227	Environmental Project Support Logkeeping Practices
MCP-9229	Validating, Verifying and Controlling Environmental Monitoring Data
MCP-9439	Environmental Sampling Activities at the INL
PLN-1305	Groundwater Monitoring Program Plan
PLN-491	Laboratory Performance Evaluation Program Plan
PLN-720	Environmental Surveillance Program Plan
PLN-729	Idaho Cleanup Project Liquid Effluent Monitoring Program Plan

Scarab beetle

Table 10-1. Idaho Cleanup Project Environmental Program Procedures (continued).

PLN-730	Idaho Cleanup Project Drinking Water Program Plan
SPR-101	Liquid Effluent Sampling
SPR-106	Biotic Monitoring
SPR-107	Waste Management Low-Volume Suspended Particulate Air Monitoring
SPR-110	Surface Soil Sampling
SPR-162	Measuring Groundwater Levels And Sampling Groundwater
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
SPR-193	Ambient Air Monitoring for NESHAP Compliance at Accelerated Retrieval Project
SPR-213	Surface Water Sampling at Radioactive Waste Management Complex
TPR-6525	Surface Radiation Surveys Using the Global Positioning Radiometric Scanner
TPR-6526	In Situ Soil Radiation Measurements
TPR-6539	Calibrating and Using the Hydrolab Quanta Water Quality Multiprobe
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

a. GDE = Guide
MCP = Management Control Procedure
PLN = Plan
SPR = Sampling Procedure
TPR = Technical Procedure.

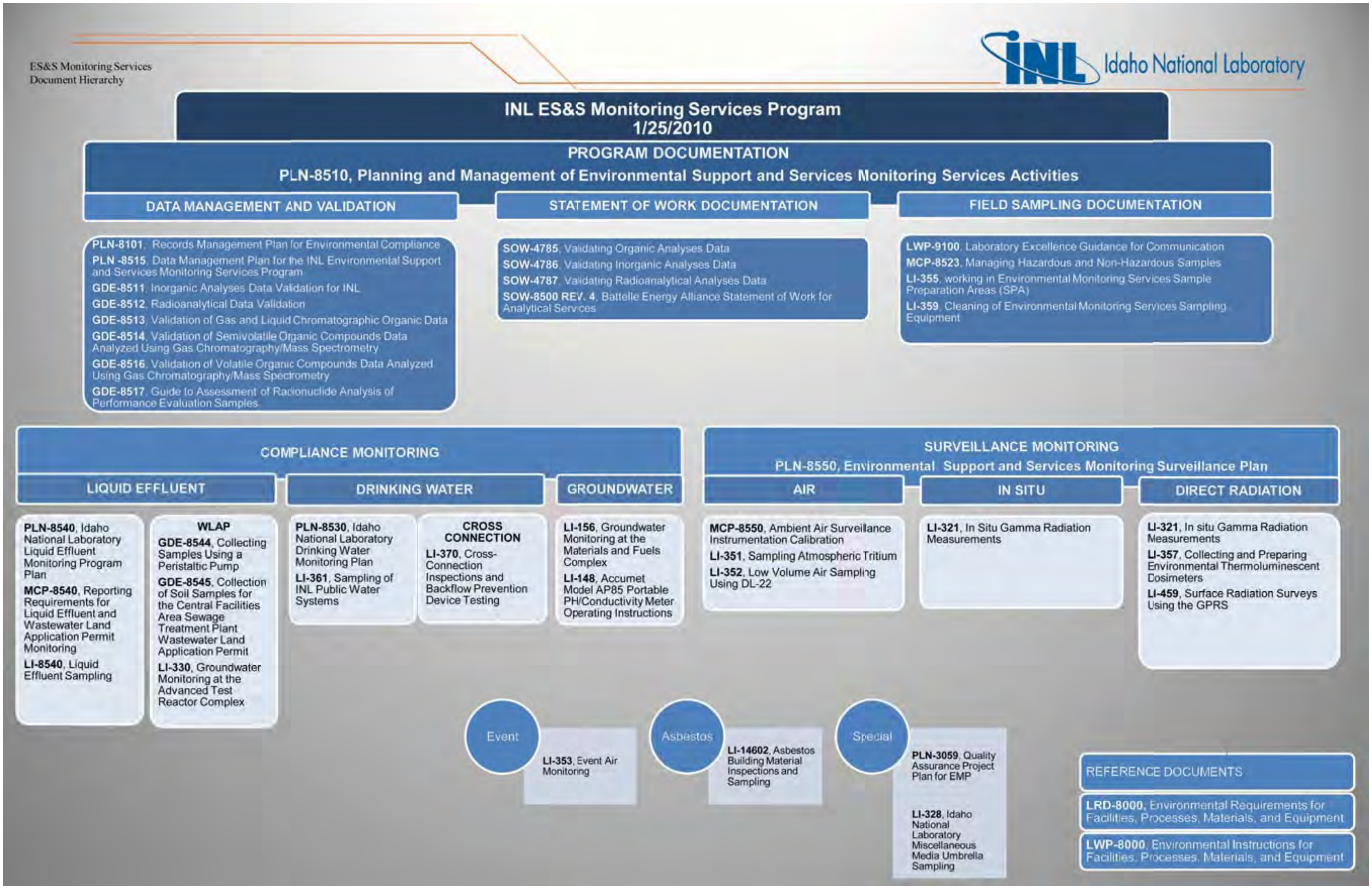
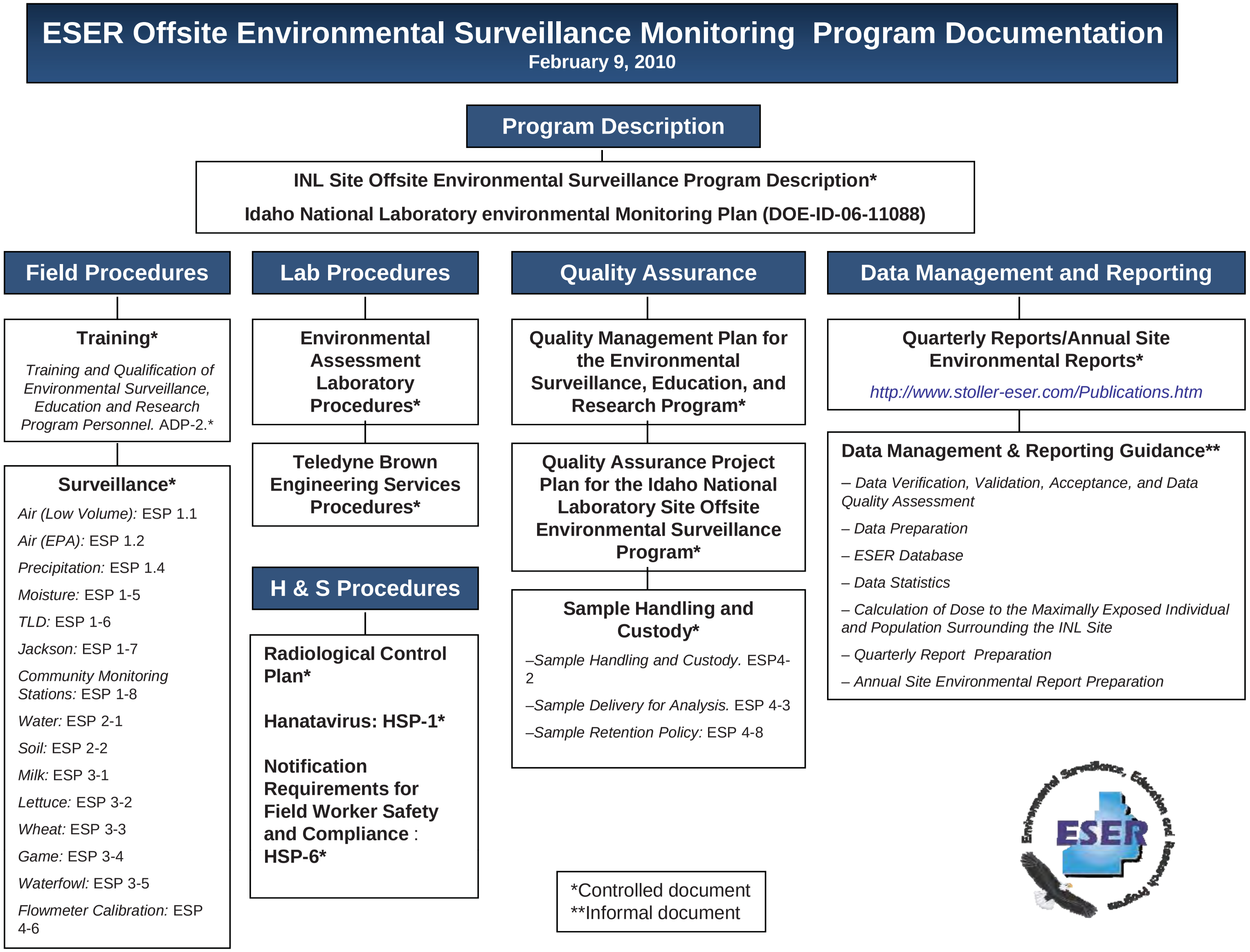


Figure 10-1. Idaho National Laboratory Environmental Support and Services Program Documentation.



ESER Offsite Environmental Surveillance Monitoring Program Documentation

February 9, 2010

Program Description

INL Site Offsite Environmental Surveillance Program Description*

Idaho National Laboratory environmental Monitoring Plan (DOE-ID-06-11088)

Field Procedures

Training*

Training and Qualification of Environmental Surveillance, Education and Research Program Personnel. ADP-2.*

Surveillance*

Air (Low Volume): ESP 1.1

Air (EPA): ESP 1.2

Precipitation: ESP 1.4

Moisture: ESP 1-5

TLD: ESP 1-6

Jackson: ESP 1-7

Community Monitoring Stations: ESP 1-8

Water: ESP 2-1

Soil: ESP 2-2

Milk: ESP 3-1

Lettuce: ESP 3-2

Wheat: ESP 3-3

Game: ESP 3-4

Waterfowl: ESP 3-5

Flowmeter Calibration: ESP 4-6

Lab Procedures

Environmental Assessment Laboratory Procedures*

Teledyne Brown Engineering Services Procedures*

H & S Procedures

Radiological Control Plan*

Hanatavirus: HSP-1*

Notification Requirements for Field Worker Safety and Compliance : HSP-6*

Quality Assurance

Quality Management Plan for the Environmental Surveillance, Education, and Research Program*

Quality Assurance Project Plan for the Idaho National Laboratory Site Offsite Environmental Surveillance Program*

Sample Handling and Custody*

–*Sample Handling and Custody.* ESP4-2

–*Sample Delivery for Analysis.* ESP 4-3

–*Sample Retention Policy:* ESP 4-8

Data Management and Reporting

Quarterly Reports/Annual Site Environmental Reports*

http://www.stoller-eser.com/Publications.htm

Data Management & Reporting Guidance**

– Data Verification, Validation, Acceptance, and Data Quality Assessment

– Data Preparation

– ESER Database

– Data Statistics

– Calculation of Dose to the Maximally Exposed Individual and Population Surrounding the INL Site

– Quarterly Report Preparation

– Annual Site Environmental Report Preparation

*Controlled document
**Informal document

Figure 10-2. Environmental Surveillance, Education and Research Program Offsite Environmental Surveillance Documentation.

The following sections summarize how each monitoring organization at the INL Site implements QA requirements.

10.4.1 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.

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.

10.4.2 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.”

10.4.3 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*.

10.4.4 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.

10.4.5 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.

10.4.6 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.

10.5 Analytical Laboratories

Analytical laboratories used to analyze environmental samples collected on and off the INL Site are presented in Table 10-2.

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 of Pocatello	Microbiological
	Underwriters Laboratories, Inc.	Inorganic and organic
ICP Environmental Program	GPL Laboratories Alabama, LLC (aka Centauri Labs)	Radiological
ICP Effluent Monitoring Program	ICP Wastewater Laboratory	Microbiological
	General Engineering Laboratories, LLC	Inorganic and microbiological
	Southwest Research Institute	Inorganic
ICP Groundwater Monitoring Program	General Engineering Laboratories, LLC	Inorganic and microbiological
	Southwest Research Institute	Inorganic and radiological
INL Drinking Water Program	General Engineering Laboratories	Radiological
	Intermountain Analytical Service – EnviroChem and Teton Microbiology Laboratory of Idaho Falls	Inorganic and bacterial
	Underwriters Laboratory	Inorganic and organic
INL Liquid Effluent and Groundwater Programs	General Engineering Laboratories	Radiological
	Southwest Research Institute	Nonradiological
INL Environmental Surveillance Program	ALS Laboratory Group (formerly Paragon Analytics)	Radiological

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
Environmental Surveillance, Education and Research Program	Environmental Assessments Laboratory at Idaho State University	Gross radionuclide analyses (e.g., gross alpha and gross beta), tritium, 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

Radioanalytical laboratories used for routine analyses of radionuclides in environmental media were selected by each environmental monitoring program based on each laboratory's capabilities, reputation, and past results in performance evaluation programs, such as the Mixed Analyte Performance Evaluation Program (MAPEP) described in Section 10.7.1. 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:

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- 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.

10.6 Quality Assurance/Quality Control Results for 2009

Results of the QA measurements for 2009 are summarized in this section. The QA measurements include completeness, data usability, and results of QC checks. QC 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. QC samples measure precision and accuracy of sampling and analysis activities. **Precision** is a measure of agreement among repeated measurements of the same property under identical, or substantially similar, conditions and is expressed generally in terms of the standard deviation. **Accuracy** is a measure of the overall agreement of a measurement to a known value. Accuracy includes a combination of random error (precision) and systematic error (bias) components that are due to sampling and analytical operations. QC samples include blind spike samples, field replicate samples, split samples, performance evaluation samples, trip blanks, and field blanks. These terms are defined on the following page. Definitions used specifically by USGS for their QA/QC program may be found on page 12 of Knobel et al. (2008).

10.6.1 Liquid Effluent Program Quality Assurance/Quality Control

Idaho National Laboratory Contractor – The INL contractor Liquid Effluent Monitoring Program has 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. One duplicate sample is collected each year at each location.

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

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Blind Spike **—** Used to assess the accuracy of the analytical laboratories. Contractors obtain samples spiked with known amounts of radionuclides or nonradioactive substances from suppliers whose spiking materials are traceable to National Institute of Standards and Technology (NIST). These samples are then submitted to the laboratories with regular field samples using the same labeling and sample numbering system. The analytical results are expected to compare to the known value within a set of performance limits. Generally used to establish intra-laboratory or analyst-specific precision and accuracy or to assess the performance of all or a portion of the measurement system. A **double blind spike** is a sample submitted to evaluate performance with concentration and identity unknown to both the submitter and the analyst.

Performance Evaluation Sample **—** A type of blind sample. The composition of performance evaluation samples is unknown to the analyst. Performance evaluation samples are provided to evaluate the ability of the analyst or laboratory to produce analytical results within specified limits. Performance evaluation samples (submitted as double blind spikes) are required to assess analytical data accuracy.

Field Replicates (duplicates or collocated samples) **—** Two samples collected from a single location at the same time. Two separate samples are taken from the same source, stored in separate containers, and analyzed independently. In the case of air sampling, two air samplers are placed side by side and each filter is analyzed separately. Duplicates are useful in documenting the precision of the sampling process. Field duplicates provide information on analytical variability caused by sample heterogeneity, collection methods, and laboratory procedures.

Split Sample **—** A sample collected and later divided into two portions that are analyzed separately. The samples are taken from the same container and analyzed independently. Split samples are used to assess analytical variability and comparability.

Trip Blank **—** A sample of analyte-free media taken from the sample preparation area to the sampling site and returned to the analytical laboratory unopened. A trip blank is used to document contamination attributable to shipping and field handling procedures. This type of blank is useful in documenting contamination of volatile organics samples.

Field Blank **—** A clean analyte-free sample which is carried to the sampling site and then exposed to sampling conditions, returned to the laboratory, and treated as an environmental sample. Collected to assess the potential introduction of contaminants during sampling. This blank is used to provide information about contaminants that may be introduced during sample collection, storage, and transport.

calculating the relative percent difference (RPD) using Equation 1:

$$RPD = \frac{|R_1 - R_2|}{(R_1 + R_2)/2} \text{ x } 100 \qquad (1)$$

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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 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 2009.

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 2009 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 2009, performance evaluation samples were submitted to the laboratory with routine monitoring samples on January 14, 2009, May 6, 2009, September 23, 2009, and November 11, 2009. Most results were within performance acceptance limits.
- Field duplicate samples were collected at CPP-769, CPP-773, and CPP-797 on February 18, 2009, and CPP-773 on April 22, 2009. The RPD between the duplicate samples is used to assess data precision. For 2009, 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 July 23, 2009. 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 2009, this goal was met.

10.6.2 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 2009, 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, which was dry in April 2009. However, samples were collected from that well in July 2009. All permit-required samples were collected.

All groundwater sample results were usable, except the October 2009 biochemical oxygen demand sample result for Well ICPP-MON-A-166, which was rejected based on historical results and uncertainties related to the performance evaluation sample result.

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 2009.

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 2009 sampling event, one performance evaluation sample was analyzed for metals. The metals performance evaluation sample results were within the performance acceptance limits.

During the October 2009 groundwater sampling event, performance evaluation samples were analyzed for fecal and total coliforms, inorganics, and metals. The laboratory was notified of the

results outside the performance acceptance limits so they could evaluate whether corrective action was necessary.

10.6.3 Drinking Water Program Quality Assurance/Quality Control

Idaho National Laboratory Contractor – The INL contractor Drinking Water Program has specific QA/QC objectives for analytical data. Drinking Water Program goals are established for precision of less than or equal to 35 percent for 90 percent of the analyses and 100 percent completeness. All Drinking Water Program analytical results, except bacteria, are validated following standard EPA protocols. The Drinking Water Program submits field duplicates to provide information on analytical variability caused by sample heterogeneity, collection methods, and laboratory procedures.

For nonradiological analytes, if the reported concentration in the first sample and the duplicate exceeded the detection limit by a factor of five or more, the laboratory precision was evaluated by calculating the RPD.

The INL contractor Drinking Water Program requires that the RPD from field duplicates be less than or equal to 35 percent for 90 percent of the analyses. For nonradiological duplicate sample sets in which one or both of the results reported for a particular analyte were less than 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 2009, the INL contractor had five sets of inorganic and 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:

$$\left| R_1 - R_2 \right| \leq 3\,(\sigma_1{}^2 + \sigma_2{}^2)^{1/2} \qquad (2)$$

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 2009, the Drinking Water Program had four 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.

The INL contractor established a completeness goal to collect, analyze and verify 100 percent of all compliance samples. Completeness is determined by ensuring that the regulatory samples are collected and are valid. This goal was met during 2009.

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 2009.

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 2009 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 2009.

All blind spike results were within the QC performance acceptance limits except the April 22, 2009, styrene result. The laboratory was notified the result was outside the performance acceptance limits, and the laboratory implemented a corrective action plan.

10.6.4 Environmental Surveillance, Education and Research Program Quality Assurance/Quality Control

The ESER contractor met its completeness and precision goals. Samples were collected and analyzed as planned from all available media. Duplicate, blank, and control samples were submitted with routine samples for analyses as required by the ESER Quality Assurance Project Plan.

Each analytical laboratory conducted an internal spike sample program using standards traceable to the National Institute for Standards and Technology (NIST), and each laboratory participated in MAPEP. In addition, the ESER contractor obtained a spike sample with the biannual soil sample.

Precision was measured using duplicate and split samples and laboratory recounts. In 2009, approximately 98 percent of the results were within the criteria specified for these types of comparisons.

Both field blanks and laboratory blanks were used by the ESER contractor and analytical laboratories to detect contamination from sampling and analysis. No issues were reported in 2009 for either field or laboratory blanks.

10.6.5 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.

10.6.6 ICP Waste Management Surveillance Quality Assurance/Quality Control

The ICP contractor analytical laboratory analyzed all Waste Management Surveillance Program samples as specified in the statement of work. The laboratory 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. The laboratory met the performance objectives specified by MAPEP and the National Center for Environmental Research.

All performance evaluation samples submitted to the contract laboratory for analysis in 2009 for the Waste Management Surveillance Program showed satisfactory agreement except the following: the vegetation samples showed poor agreement and may be biased low, and the water samples showed poor agreement for plutonium-238, plutonium-239/240, and strontium-90 and may also be biased low.

The Waste Management Surveillance Program met its completeness and precision goals. Samples were collected and analyzed as planned from all available media. The Waste Management Surveillance Program submitted duplicate and blank samples to the contract laboratory with routine samples for analyses as required. In 2009, the results for these samples were within the acceptable range.

10.6.7 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, p. 12). 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).

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10.7 Performance Evaluation Programs

10.7.1 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 generally distributes samples of air, water, vegetation, and soil for analysis during the first and third quarters. Series 20 was distributed in February 2009, and Series 21 was distributed in July 2009.

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.

The ESER contractor laboratory, Teledyne Brown Engineering, received an “N” (result not acceptable) on an analysis of an air filter spiked with isotopic plutonium by the MAPEP laboratory during the Series 20 test. The laboratory initiated a formal study and issued a nonconformance report that identified the problem as a failed commercially available resin used in the procedure. ESER samples are plated directly and counted, so the failure did not impact those samples. The laboratory passed the Series 21 test.

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10.7.2 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 2009.

10.7.3 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.

10.7.4 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.

10.8 Additional Quality Assurance Checks

10.8.1 Duplicate Sampling within Organizations

Both the ESER contractor and the INL contractor maintained duplicate air samplers at two locations during 2009. The ESER contractor operated duplicate samplers at the Blue Dome and Atomic City locations. The INL contractor duplicate samplers were located at the Test Area North and Radioactive Waste Management Complex. The INL contractor sampled weekly through September and then biweekly to the end of the year.

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10.8.2 Duplicate Sampling between Organizations

Data quality can be measured by comparing data collected simultaneously by different organizations. The ESER contractor, the INL contractor, and the state of Idaho’s INL Oversight Program collected air monitoring data throughout 2009 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 2009 is not yet available, however according to the INL Oversight Program Annual Report 2008 (available at http://www.deq.state.id.us/inl_oversight/library/2008_annual.pdf):

> Comparisons of suspended particulate matter results from co-located monitoring stations used by DEQ-INL OP, the Environmental Surveillance, Education and Research Program (ESER), and Battelle Energy Alliance (BEA) for 2008 agreed within 20 percent, with the exception of the comparison of gross beta results between DEQ-INL OP and BEA, which agreed within ~34 percent and DEQ-INL OP and Stoller which agreed within ~ 40 percent …. Slight variations in sampling methods and schedules and random uncertainty are the likely causes for the small differences observed. These differences have been an ongoing trend in recent years and will continue to be investigated by DEQ-INL OP in 2009 to try to quantify the variations in sampling methods between the different organizations that perform air sampling at the INL. However, all the results agree in that they are several orders of magnitude below minimum regulatory limits. The results from all three monitoring agencies indicate no public health risk.

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.

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.

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Appendix A. Environmental Statutes and Regulations

The following environmental statutes and regulations apply, in whole or in part, to the Idaho National Laboratory (INL) or at the INL Site boundary:

- 36 CFR 79, 2002, "Curation of Federally-Owned and Administered Archeological Collections," U.S. Department of the Interior, National Park Service, *Code of Federal Regulations*, Office of the Federal Register

- 40 CFR 50, 2010, "National Primary and Secondary Ambient Air Quality Standards," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register

- 40 CFR 61, 2010, "National Emission Standards for Hazardous Air Pollutants," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register

- 40 CFR 112, 2010, "Oil Pollution Prevention," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register

- 40 CFR 122, 2008, "EPA Administered Permit Programs: the National Pollutant Discharge Elimination System," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register

- 40 CFR 141, 2010, "National Primary Drinking Water Regulations," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register

- 40 CFR 260, 2010, "Hazardous Waste Management System: General," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register

- 40 CFR 261, 2010, "Identification and Listing of Hazardous Waste," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register

- 40 CFR 262, 2010, "Standards Applicable to Generators of Hazardous Waste," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register

- 40 CFR 263, 2010, "Standards Applicable to Transporters of Hazardous Waste," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register

- 40 CFR 264, 2010, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register

- 40 CFR 265, 2010, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," U.S. Environmental Protection Agency, *Code of Federal Regulations*, Office of the Federal Register

- 40 CFR 267, 2006, “Standards for Owners and Operators of Hazardous Waste Facilities Operating under a Standardized Permit,” U.S. Environmental Protection Agency, *Code of 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 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”
- Executive Order 11514, 1970, “Protection and Enhancement of Environmental Quality”

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- 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.

Scarab beetle

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).

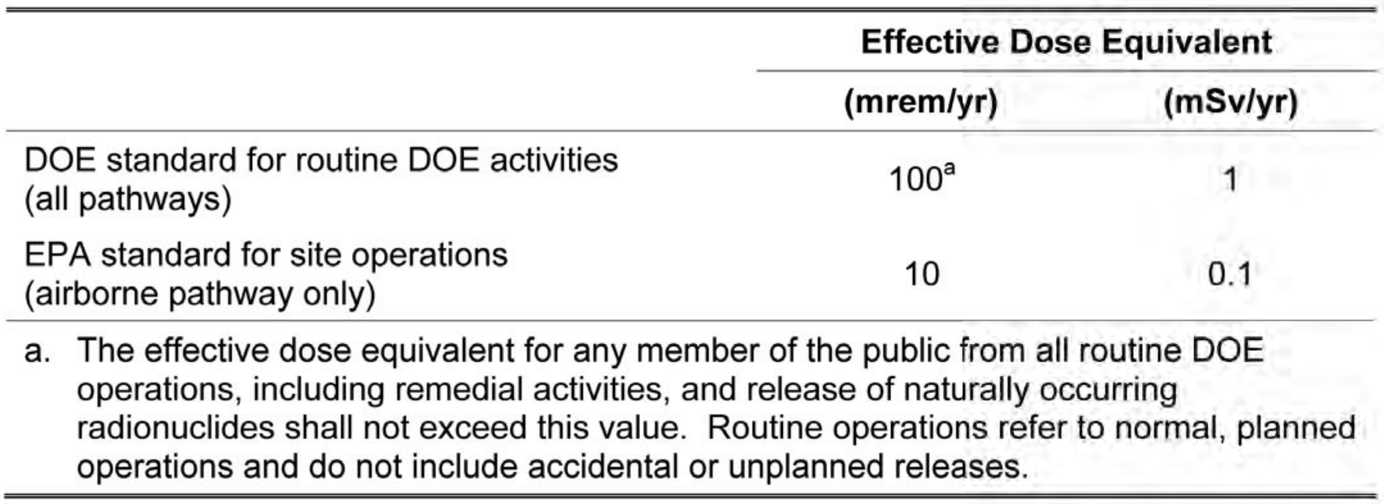
c. Based on the most restrictive beta emitter (^{228}Ra).

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.

Bristly Cutworm Moth

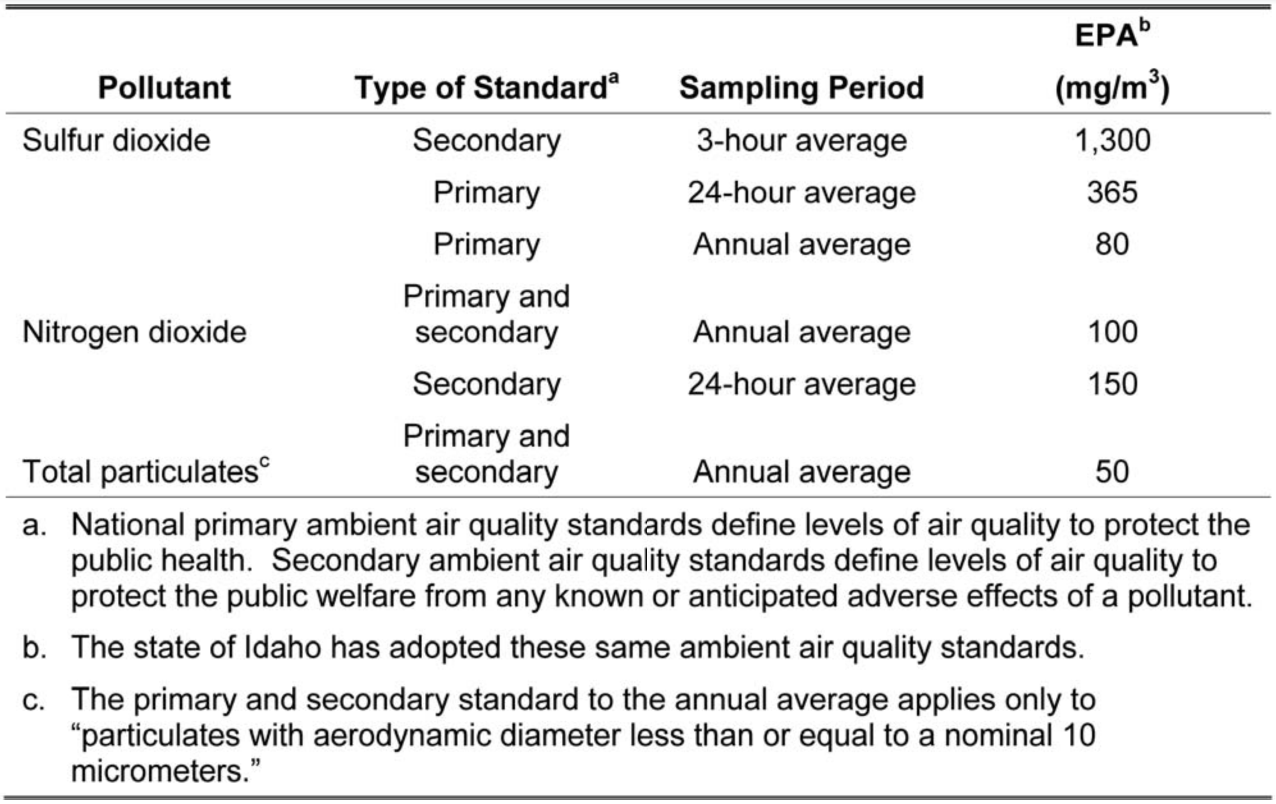
Table A-2. Radiation Standards for Protection of the Public in the Vicinity of Department of Energy Facilities.



	Effective Dose Equivalent	
	(mrem/yr)	**(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.”

Scarab beetle

Table A-4. Environmental Protection Agency Maximum Contaminant Levels for Public Drinking Water Systems and State of Idaho Groundwater Quality Standards for Radionuclides and Inorganic Contaminants.

Constituent	Maximum Contaminant Levels	Groundwater Quality Standards
Gross alpha (pCi/L)	15	15
Gross beta (mrem/yr)	4 [a]	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[b] (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. As a matter of practicality a screening level concentration of 50 pCi/L is used for comparison.

b. Treatment technique action level, the concentration of a contaminant which, if exceeded, triggers treatment or other requirements that a water system must follow.

Bristly Cutworm Moth

Table A-5. Environmental Protection Agency Maximum Contaminant Levels for Public Drinking Water Systems and State of Idaho Groundwater Quality Standards for Organic Contaminants.

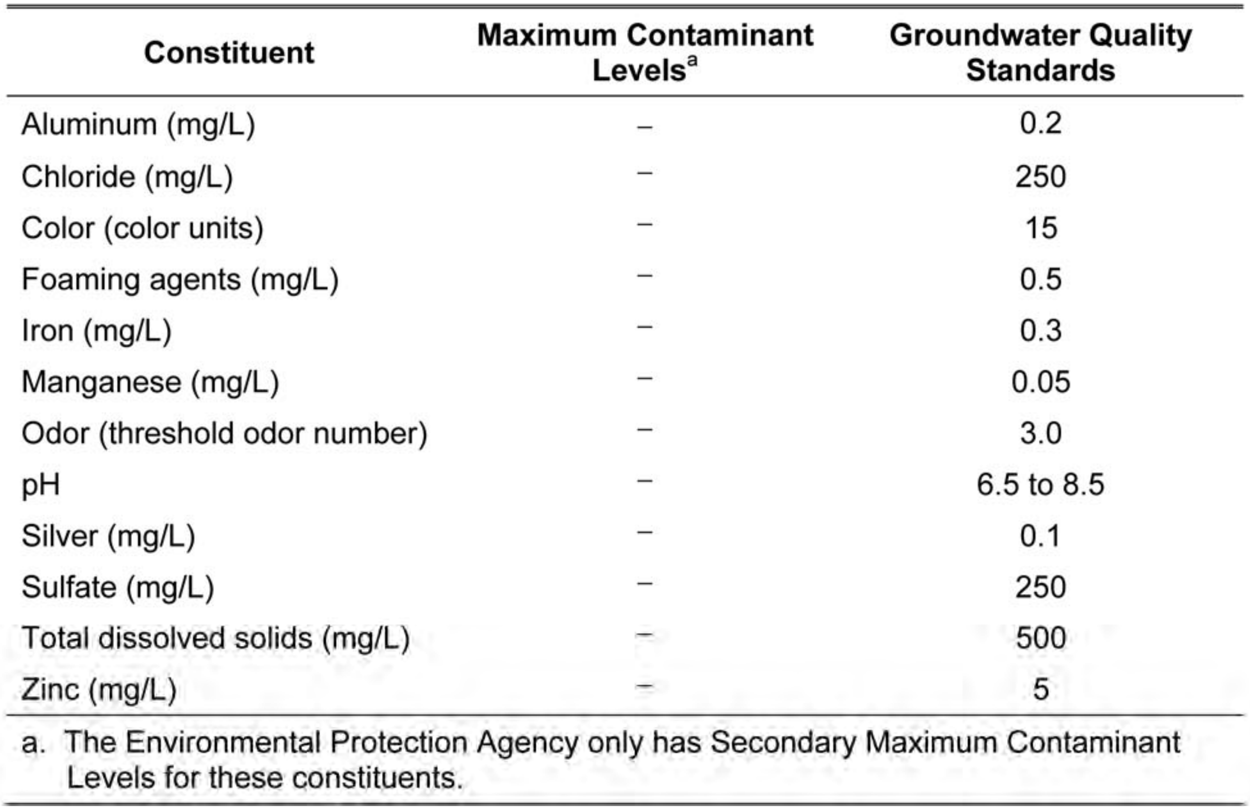
Constituent	Maximum Contaminant Levels (mg/L)	Groundwater Quality Standards (mg/L)
Benzene	0.005	0.005
Carbon tetrachloride	0.005	0.005
m-Dichlorobenzene		0.6
o-Dichlorobenzene	0.6	0.6
para-Dichlorobenzene	0.075	0.075
1,2 – Dichloroethane	0.005	0.005
1,1 – Dichloroethylene		0.007
cis-1,2-Dichloroethylene	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}

Bristly Cutworm Moth

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.

Scarab beetle

Water quality standards are dependent on the type of drinking water system sampled. Tables A-4 through A-7 list maximum contaminant levels set by the Environmental Protection Agency for public drinking water systems in 40 CFR 141 (2010) and the Idaho groundwater quality values from IDAPA 58.01.11 (2010).

REFERENCES

40 CFR 141, 2010, “National Primary Drinking Water Regulations,” U.S. Environmental Protection Agency, Code of Federal Regulations, Office of the Federal Register.

DOE Order 5400.5, 1993, “Radiation Protection of the Public and the Environment,” Change 2,

U.S. Department of Energy.

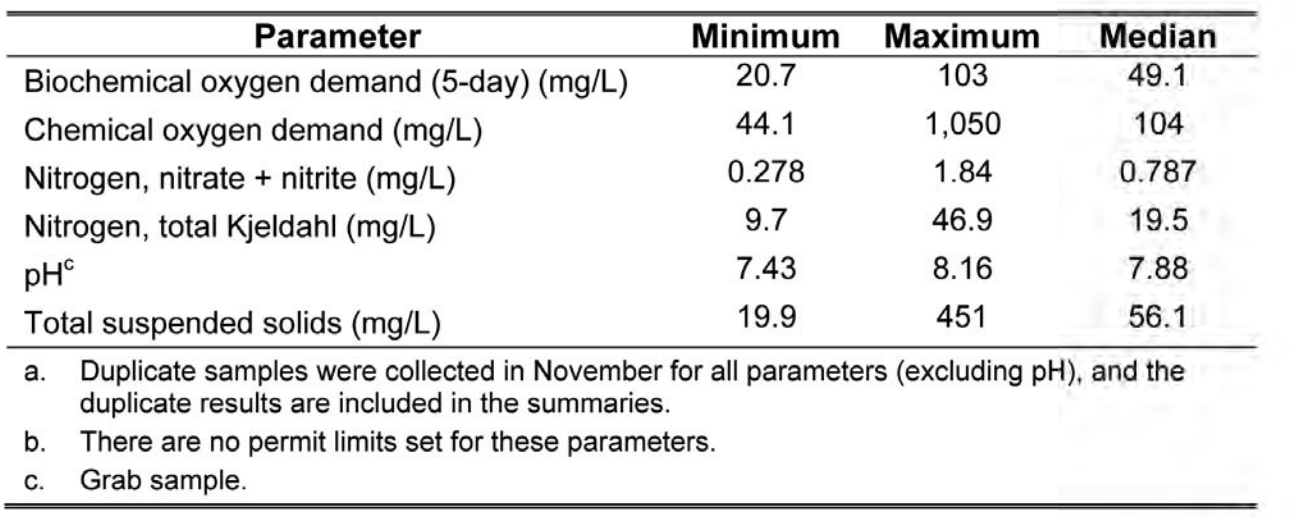
DOE, 1988a, Internal Dose Conversion Factors for Calculation of Dose to the Public, DOE/EH-0071, U.S. Department of Energy.

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.

Appendix B . Chapter 5 Addendum

Table B-1. Central Facilities Area Sewage Treatment Facility Influent Monitoring Results (2009).[a,b]



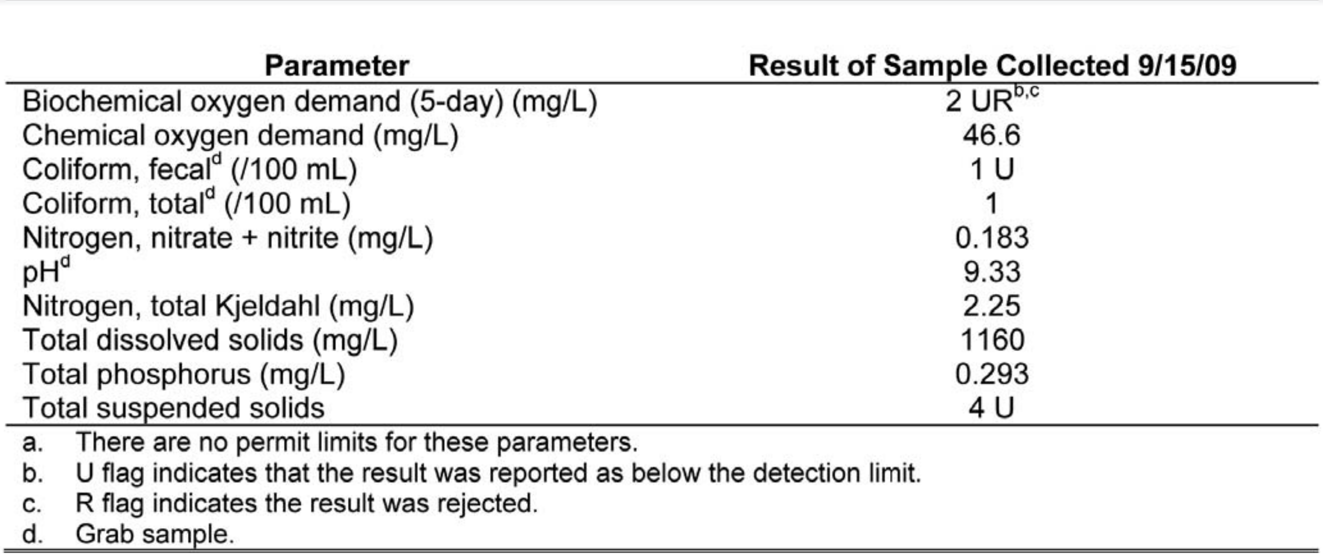
Parameter	Minimum	Maximum	Median
Biochemical oxygen demand (5-day) (mg/L)	20.7	103	49.1
Chemical oxygen demand (mg/L)	44.1	1,050	104
Nitrogen, nitrate + nitrite (mg/L)	0.278	1.84	0.787
Nitrogen, total Kjeldahl (mg/L)	9.7	46.9	19.5
pH[c]	7.43	8.16	7.88
Total suspended solids (mg/L)	19.9	451	56.1

a. Duplicate samples were collected in November for all parameters (excluding pH), and the duplicate results are included in the summaries.

b. There are no permit limits set for these parameters.

c. Grab sample.

Table B-2. Central Facilities Area Sewage Treatment Facility Effluent Monitoring Results (2009).[a]



Parameter	Result of Sample Collected 9/15/09
Biochemical oxygen demand (5-day) (mg/L)	2 UR[b,c]
Chemical oxygen demand (mg/L)	46.6
Coliform, fecal[d] (/100 mL)	1 U
Coliform, total[d] (/100 mL)	1
Nitrogen, nitrate + nitrite (mg/L)	0.183
pH[d]	9.33
Nitrogen, total Kjeldahl (mg/L)	2.25
Total dissolved solids (mg/L)	1160
Total phosphorus (mg/L)	0.293
Total suspended solids	4 U

a. There are no permit limits for these parameters.

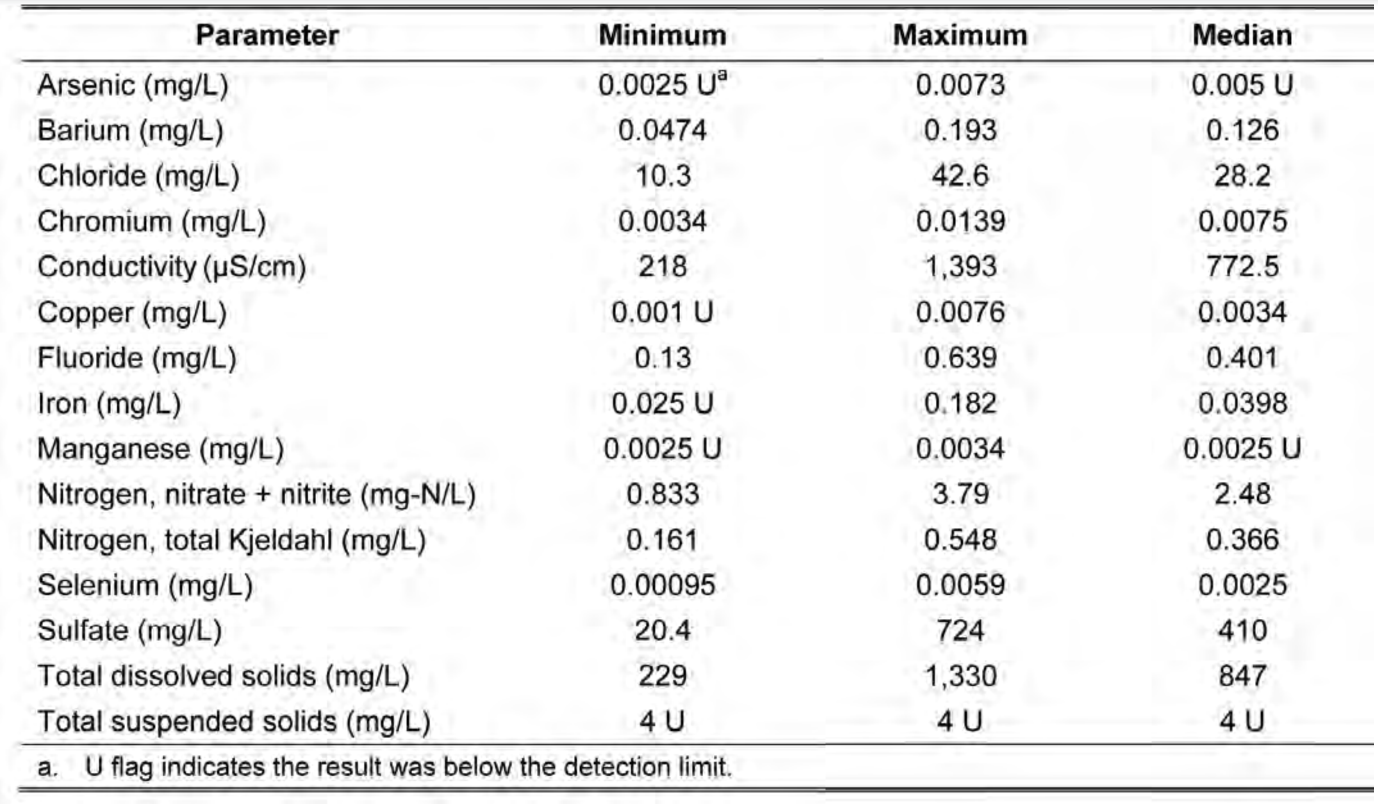
b. U flag indicates that the result was reported as below the detection limit.

c. R flag indicates the result was rejected.

d. Grab sample.

Scarab beetle

Table B-3. Advanced Test Reactor Complex Cold Waste Pond Effluent Monitoring Results (2009).



Parameter	Minimum	Maximum	Median
Arsenic (mg/L)	0.0025 U[a]	0.0073	0.005 U
Barium (mg/L)	0.0474	0.193	0.126
Chloride (mg/L)	10.3	42.6	28.2
Chromium (mg/L)	0.0034	0.0139	0.0075
Conductivity (µS/cm)	218	1,393	772.5
Copper (mg/L)	0.001 U	0.0076	0.0034
Fluoride (mg/L)	0.13	0.639	0.401
Iron (mg/L)	0.025 U	0.182	0.0398
Manganese (mg/L)	0.0025 U	0.0034	0.0025 U
Nitrogen, nitrate + nitrite (mg-N/L)	0.833	3.79	2.48
Nitrogen, total Kjeldahl (mg/L)	0.161	0.548	0.366
Selenium (mg/L)	0.00095	0.0059	0.0025
Sulfate (mg/L)	20.4	724	410
Total dissolved solids (mg/L)	229	1,330	847
Total suspended solids (mg/L)	4 U	4 U	4 U

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

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Table B-4. Advanced Test Reactor Complex Cold Waste Pond Aquifer Monitoring Well Groundwater Results (2009).

Well Name	USGS-065 (GW-016102)		TRA-07 (GW-016103)		USGS-076 (GW-016104)		TRA-08 (GW-016105)		Middle-1823 (GW-016106)		PCS/SCS[a]
Sample Date	04/14/09	10/12/09	04/20/09	10/14/09	04/21/09	10/21/09	04/20/09	10/12/09	4/14/09	10/14/09	
Water table depth (ft bgs)	475.69	476.01	484.14	484.52	483.59	483.83[b]	489.43	489.72	492.99	493.44	NA[c]
Water table elevation (ft above mean sea level)[d]	4,452.83	4,452.51	4,450.94	4,450.56	4,449.62	4,449.38[b]	4,449.01	4,448.72	4,449.88	4,449.43	NA
pH	7.93	8.01	7.82	7.88	8.02	7.98	8.36	—[e]	7.83	7.93	6.5 – 8.5
Total Kjeldahl nitrogen (mg/L)	0.189	0.188	0.211	0.226	0.303	0.281	0.482	—	0.300[f]	0.223	NA
Nitrite nitrogen (mg/L)	0.05 U[g]	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	—	0.05 U[f]	0.05 U	1
Nitrate nitrogen (mg/L)	1.34	1.38	0.996	1.08	0.998	1.05	0.775	—	0.906[f]	0.965	10
Total nitrogen[h] (mg/L)	1.554	1.593	1.232	1.331	1.326	1.356	1.282	—	1.231	1.213	NA
Total dissolved solids (mg/L)	430	399	432	454	269	277	331	—	269[f]	268	500
Aluminum (mg/L)	0.0375 U (0.0375 U)[i]	0.0064 (0.0058)	**1.780**[j] (0.0375 U)	**1.490** (0.0022)	0.0375 U (0.0375 U)	0.0058 (0.0051)	**19.7** (0.0375 U)	—	0.0375 U[f] (0.0375 U)[f]	0.111 (0.0046)	0.2
Antimony (mg/L)	0.0005 U (0.0005 U)	0.0005 U (0.0005 U)	0.0005 U (0.0005 U)	0.0005 U (0.0005 U)	0.0005 U (0.0005 U)	0.0005 U (0.0005 U)	0.00099 (0.0005 U)	—	0.0005 U[f] (0.0005 U)[f]	0.0005 U (0.0005 U)	0.006
Arsenic (mg/L)	0.0075 U (0.0075 U)	0.0011 (0.0012)	0.0075 U (0.0075 U)	0.0016 (0.0012)	0.0075 U (0.0075 U)	0.0018 (0.0018)	0.0075 U (0.0075 U)	—	0.0075 U[f] (0.0075 U)[f]	0.0016 (0.0017)	0.05
Barium (mg/L)	0.0485 (0.0466)	0.0451 (0.0452)	0.0966 (0.0662)	0.0804 (0.0616)	0.0731 (0.0732)	0.0708 (0.071)	0.158 (0.0281)	—	0.0684[f] (0.0661)[f]	0.0675 (0.0662)	2
Cadmium (mg/L)	0.0025 U (0.0025 U)	0.00025 U (0.00025 U)	0.0025 U (0.0025 U)	0.00025 U (0.00025 U)	0.0025 U (0.0025 U)	0.00025 U (0.00025 U)	0.005 (0.0025 U)	—	0.0025 U[f] (0.0025 U)[f]	0.00025 U (0.00025 U)	0.005

Table B-4. Advanced Test Reactor Complex Cold Waste Pond Aquifer Monitoring Well Groundwater Results (2009) (continued).

Well Name	USGS-065 (GW-016102)		TRA-07 (GW-016103)		USGS-076 (GW-016104)		TRA-08 (GW-016105)		Middle-1823 (GW-016106)		PCS/SCS[a]
	(0.005 U)	(0.0025 U)	(0.005 U)	(0.0025 U)	(0.005 U)	(0.0025 U)	(0.005 U)		(0.005 U)^{f}	(0.0025 U)	
Copper (mg/L)	0.106 (0.0025 U)	0.0025 U (0.0025 U)	0.0978 (0.0025 U)	0.0119 (0.0025 U)	0.0216 (0.0025 U)	0.0245 (0.0025 U)	0.0431 (0.0025 U)	—	0.0025 U^{f} (0.0025 U)^{f}	0.0033 (0.0025 U)	1.3
Fluoride (mg/L)	0.185	0.247	0.17	0.232	0.128	0.198	0.148	—	0.133^{f}	0.184	4
Iron (mg/L)	0.050 U (0.050 U)	0.050 U (0.050 U)	**2.62** (0.050 U)	**1.26** (0.050 U)	0.050 U (0.050 U)	0.050 U (0.050 U)	**296.0** (0.0805)	—	0.050 U^{f} (0.050 U)^{f}	0.050 U (0.050 U)	0.3
Manganese (mg/L)	0.0025 U (0.0025 U)	0.0025 U (0.0025 U)	0.0404 (0.0049)	0.0167 (0.0025 U)	0.0025 U (0.0025 U)	0.0025 U (0.0025 U)	**1.240** (0.0054)	—	0.0025 U^{f} (0.0025 U)^{f}	0.0052 (0.0032)	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^{f} (0.0002 U)^{f}	0.0002 U (0.0002 U)	0.002
Selenium (mg/L)	0.0018 (0.0018)	0.0017 (0.0019)	0.0015 (0.0015)	0.0016 (0.0014)	0.0012 (0.0013)	0.0014 (0.0012)	0.00062 (0.0011)	—	0.00115^{f} (0.0011)^{f}	0.0011 (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^{f} (0.005 U)^{f}	0.005 U (0.005 U)	0.1
Sulfate (mg/L)	156	161	155	157	31.7	32.8	92.7	—	34.0^{f}	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. Water depth measurements presented were taken on 10/12/09.

c. NA = not applicable.

d. Elevation data provided using the North American Vertical Datum of 1988 (NAVD 88).

e. Well had insufficient volume of water to purge well and collect samples.

f. The result shown is the average of the original and the duplicate sample collected.

g. U flag indicates that the result was reported as below the instrument detection limit by the analytical laboratory.

h. 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.

i. Sample results in parentheses are from filtered metals sample.

j. Concentrations shown in bold are above the “Ground Water Quality Rule” secondary constituent standard.

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Table B-5. Idaho Nuclear Technology and Engineering Center Sewage Treatment Plant Influent Monitoring Results at CPP-769 (2009).[a]

Parameter	Minimum	Maximum	Average[b]
Biochemical oxygen demand (5-day) (mg/L)	124	594	290
Nitrate + nitrite, as nitrogen (mg/L)	0.025[c]	0.540	0.241
Total Kjeldahl nitrogen (mg/L)	50.2	101	78.0
Total phosphorus (mg/L)	5.78	10.40	8.28
Total suspended solids (mg/L)	77	390	193

a. Duplicate samples were collected in February 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 B-6. Idaho Nuclear Technology and Engineering Center Sewage Treatment Plant Effluent Monitoring Results at CPP-773 (2009).[a]

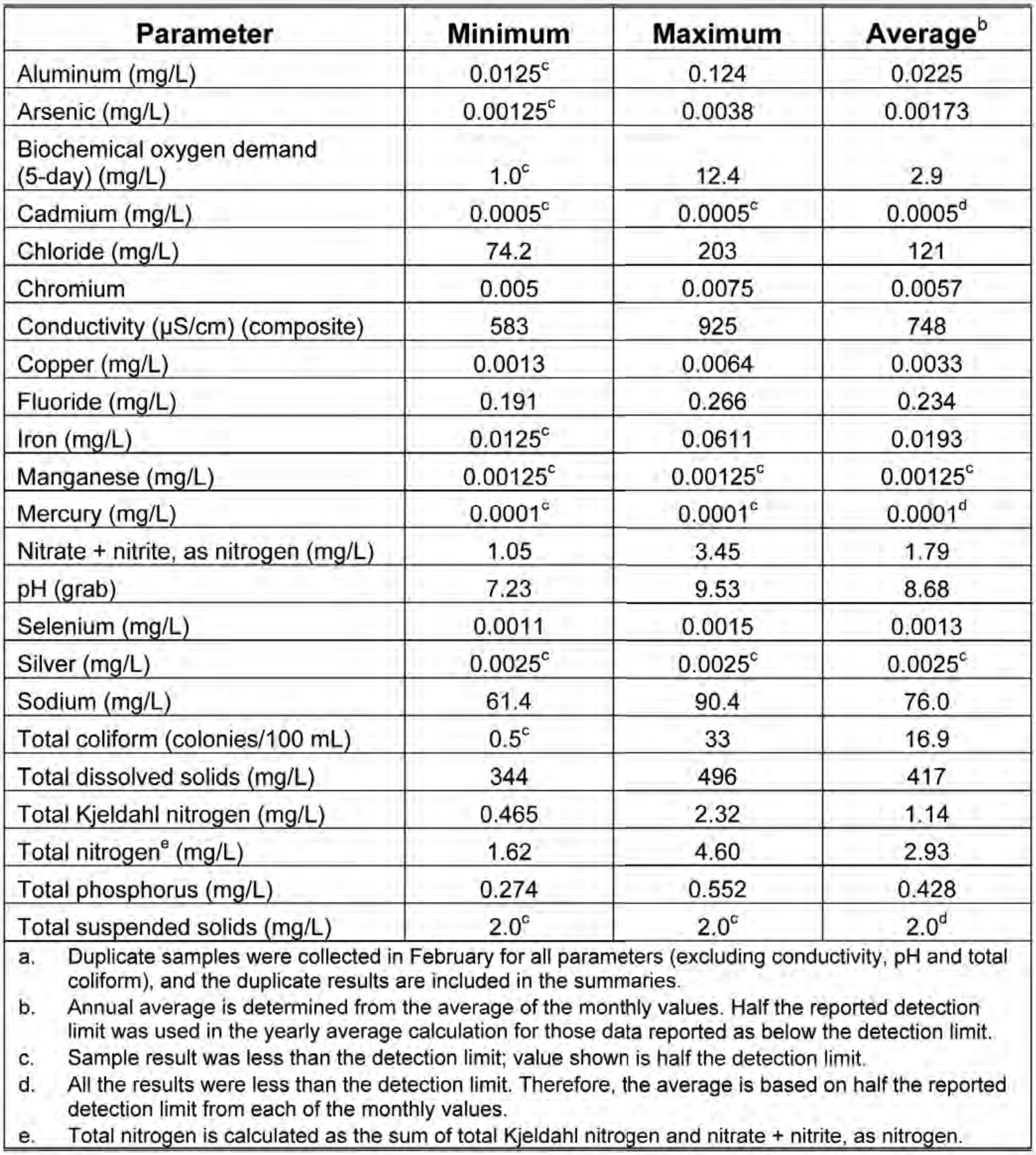
Parameter	Minimum	Maximum	Average[b]
Biochemical oxygen demand (5-day) (mg/L)	5.36	46.4	15.46
Chloride (mg/L)	118	303	206
Conductivity (µS/cm) (composite)	1,064	1,720	1,334
Nitrate + nitrite, as nitrogen (mg/L)	0.273	6.43	2.33
pH (standard units) (grab)	6.86	8.98	8.13
Sodium (mg/L)	81.9	181	131
Total coliform (colonies/100 mL)	94	4,100	1
Total dissolved solids (mg/L)	539	838	666
Total Kjeldahl nitrogen (mg/L)	18.5	48.4	34.3
Total phosphorus (mg/L)	5.14	8.69	6.82
Total suspended solids (mg/L)	2.0[c]	29.2	11.6

a. Duplicate samples were collected in February for all parameters (excluding conductivity, pH and total coliform), and the duplicate results are included in the summaries.

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

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

Table B-7. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Effluent Monitoring Results at CPP-797 (2009).[a]



Parameter	Minimum	Maximum	Average[b]
Aluminum (mg/L)	0.0125[c]	0.124	0.0225
Arsenic (mg/L)	0.00125[c]	0.0038	0.00173
Biochemical oxygen demand (5-day) (mg/L)	1.0[c]	12.4	2.9
Cadmium (mg/L)	0.0005[c]	0.0005[c]	0.0005[d]
Chloride (mg/L)	74.2	203	121
Chromium	0.005	0.0075	0.0057
Conductivity (µS/cm) (composite)	583	925	748
Copper (mg/L)	0.0013	0.0064	0.0033
Fluoride (mg/L)	0.191	0.266	0.234
Iron (mg/L)	0.0125[c]	0.0611	0.0193
Manganese (mg/L)	0.00125[c]	0.00125[c]	0.00125[c]
Mercury (mg/L)	0.0001[c]	0.0001[c]	0.0001[d]
Nitrate + nitrite, as nitrogen (mg/L)	1.05	3.45	1.79
pH (grab)	7.23	9.53	8.68
Selenium (mg/L)	0.0011	0.0015	0.0013
Silver (mg/L)	0.0025[c]	0.0025[c]	0.0025[c]
Sodium (mg/L)	61.4	90.4	76.0
Total coliform (colonies/100 mL)	0.5[c]	33	16.9
Total dissolved solids (mg/L)	344	496	417
Total Kjeldahl nitrogen (mg/L)	0.465	2.32	1.14
Total nitrogen[e] (mg/L)	1.62	4.60	2.93
Total phosphorus (mg/L)	0.274	0.552	0.428
Total suspended solids (mg/L)	2.0[c]	2.0[c]	2.0[d]

a. Duplicate samples were collected in February 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.

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Table B-8. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Aquifer Monitoring Well Groundwater Results (2009).

	ICPP-MON-A-167 (GW-013005)			ICPP-MON-A-165 (GW-013006)					ICPP-MON-A-166 (GW-013007)			PCS/SCS[a]
Sample Date	4/23/2009	7/6/2009	10/5/2009	4/1/2009	4/1/2009[b]	7/6/2009	7/6/2009	10/6/2009	4/1/2009	7/6/2009	10/6/2009	
Depth to water table (ft below brass cap)	500.48	500.29	501.17	503.56	503.56	503.58	503.58	504.1	512.14	510.24	511.37	NA[c]
Water table elevation at brass cap (ft)[d]	4,449.73	4,449.92	4,449.04	4,449.44	4,449.44	4,449.42	4,449.42	4,448.9	4,447.35	4,449.25	4,448.12	NA
Aluminum (mg/L)	**165**[e]	—	—[f]	0.0250 U[g]	0.0250 U	—	—	0.0250 U	0.246[h]	—	0.219[h]	0.2
Aluminum-filtered (mg/L)	0.0250 U	—	—	0.0250 U	0.0250 U	—	—	0.0250 U	0.0250 U	—	0.0250 U	0.2
Arsenic (mg/L)	0.0066	—	—	0.0050 U	0.0050 U	—	—	0.0050 U	0.0050 U	—	0.0050 U	0.05
Arsenic-filtered (mg/L)	0.0050 U	—	—	0.0050 U	0.0050 U	—	—	0.0050 U	0.0050 U	—	0.0050 U	0.05
Biochemical oxygen demand (mg/L)	6.0 U	—	—	2.0 U	2.0 U	—	—	1.17	2.0 U	—	27.8 R[i]	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	—	0.0025 U	0.005
Chloride (mg/L)	—	9.98	—	—	—	67.2	74.3	80.1	—	8.56	8.08	250
Chromium (mg/L)	0.101	—	—	0.0136	0.0124	—	—	0.0140	0.0077	—	0.0052	0.1
Chromium-filtered (mg/L)	0.0025 U	—	—	0.0061	0.0061	—	—	0.0062	0.0051	—	0.0047	0.1
Coliform, fecal (colonies/100 mL)	Absent	—	—	Absent	Absent	—	—	Absent	Absent	—	Absent	NA
Coliform, total (colonies/100 mL)	Absent	—	—	Absent	Absent	—	—	Absent	Absent	—	Absent	1 col/100 mL
Copper (mg/L)	0.351	—	—	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	1.3
Fluoride (mg/L)	—	0.256	—	—	—	0.228	0.226	0.233	—	0.301	0.299	4
Iron (mg/L)	**121**[e]	—	—	0.0500 U	0.0500 U	—	—	0.0500 U	0.285	—	0.206	0.3
Iron-filtered (mg/L)	0.050 U	—	—	0.0500 U	0.0500 U	—	—	0.0500 U	0.0500 U	—	0.0500 U	0.3
Manganese (mg/L)	**1.78**[e]	—	—	0.0025 U	0.0025 U	—	—	0.0025 U	0.0334	—	0.0417	0.05
Manganese-filtered (mg/L)	0.0270	—	—	0.0025 U	0.0025 U	—	—	0.0025 U	0.0240	—	0.0319	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	—	0.00020 U	0.002
Nitrate, as nitrogen (mg/L)	0.374	—	—	0.859	0.854	—	—	0.987	0.178	—	0.254	10
Nitrite, as nitrogen (mg/L)	0.0500 U	—	—	0.0500 U	0.0500 U	—	—	0.0500 U	0.0500 U	—	0.0500 U	1
pH	8.23	8.05	—	8.00	8.00	7.66	7.66	7.94	7.90	7.64	7.94	6.5 – 8.5
Selenium (mg/L)	0.0031	—	—	0.0010	0.0010	—	—	0.0014	0.00067	—	0.00082	0.05
Selenium-filtered (mg/L)	0.00080	—	—	0.0011	0.00097	—	—	0.0014	0.00056	—	0.00085	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	—	0.0050 U	0.1
Sodium (mg/L)	51.6	—	—	21.5	21.4	—	—	20.2	9.34	—	8.71	NA
Sodium-filtered (mg/L)	22.8	—	—	21.6	21.5	—	—	20.7	9.39	—	8.61	NA
Total dissolved solids (mg/L)	250	—	—	329	324	—	—	386	172	—	193	500
Total Kjeldahl nitrogen (mg/L)	—	1.31	—	—	—	0.425	0.421	0.244	—	0.100 U	0.100 U	NA
Total phosphorus (mg/L)	—	8.93	—	—	—	0.0189	0.0196	0.0201	—	0.0264	0.0341	NA

a. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in IDAPA 58.01.11.200.01.a and b.
b. Duplicate sample.
c. NA = not applicable.
d. Water level elevations referenced to NAVD88 datum.
e. **Bold** = 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, these exceedances are not considered permit noncompliances.
f. ICPP-MON-A-167 only had 0.83 ft of water. This was not enough water for the bailer to reach. Therefore, the well could not be sampled.
g. U flag indicates the result was below the detection limit.
h. Exceedance of secondary constituent standard. However, the exceedance is below the preoperational concentrations and is considered in compliance with the permit and the “Ground Water Quality Rule.”
i. The reported result was rejected based on historical results and uncertainties related to the performance evaluation sample result.

Table B-9. Idaho Nuclear Technology and Engineering Center New Percolation Ponds Perched Water Monitoring Well Groundwater Results (2009).

	ICPP-MON-V-191 (GW-013008)		ICPP-MON-V-200 (GW-013009)				ICPP-MON-V-212 (GW-013010)			
Sample Date	April 2009	7/6/2009[a]	October 2009	4/2/2009	7/6/2009[b]	10/5/2009	4/2/2009	7/6/2009	10/5/2009	PCS/SCS[c]
Depth to water table (ft below brass cap)	Dry[d]	108.77	Dry[d]	109.02	114.78	116.3	235.65	235.78	235.97	NA[e]
Water table elevation at brass cap (ft)[f]	—	4,839.19	—	4,844.00	4,838.24	4,836.72	4,722.73	4,722.60	4,722.41	NA
Aluminum (mg/L)	—	**12.7**[g]	—	0.0250 U[h]	—	0.0700	0.0250 U	—	0.032	0.2
Aluminum-filtered (mg/L)	—	0.173	—	0.0250 U	—	0.0250 U	0.0250 U	—	0.0250 U	0.2
Arsenic (mg/L)	—	0.0050 U	—	0.0050 U	—	0.0050 U	0.0050 U	—	0.0050 U	0.05
Arsenic-filtered (mg/L)	—	0.0050 U	—	0.0050 U	—	0.0050 U	0.0050 U	—	0.0050 U	0.05
Biochemical oxygen demand (mg/L)	—	6.0 U	—	2.0 U	—	-0.0562 U	5.25	—	2.06	NA
Cadmium (mg/L)	—	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)	—	3.12	—	—	139	127	—	130	124	250
Chromium (mg/L)	—	0.0126	—	0.0050	—	0.0062	0.0048	—	0.0056	0.1
Chromium-filtered (mg/L)	—	0.0025 U	—	0.0057	—	0.0050	0.0052	—	0.0050	0.1
Coliform, fecal (colonies/100 mL)	—	Absent	—	Absent	—	Absent	Absent	—	Absent	NA
Coliform, total (colonies/100 mL)	—	Absent	—	Absent	—	Absent	Absent	—	Absent	1 col/100 mL
Copper (mg/L)	—	0.0262	—	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)	—	0.269	—	—	0.265	0.273	—	0.225	0.257	4
Iron (mg/L)	—	**8.86**	—	0.0500 U	—	0.0899	0.0500 U	—	0.0502	0.3
Iron-filtered (mg/L)	—	0.0937	—	0.0500 U	—	0.0500 U	0.0500 U	—	0.0500 U	0.3
Manganese (mg/L)	—	**0.306**	—	0.0025 U	—	0.0025 U	0.0025 U	—	0.0025 U	0.05
Manganese-filtered (mg/L)	—	0.0112	—	0.0025 U	—	0.0025 U	0.0025 U	—	0.0025 U	0.05
Mercury (mg/L)	—	0.00020 U	—	0.00020 U	—	0.00020 U	0.00020 U	—	0.00020 U	0.002
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)	—	0.591	—	2.04	—	1.53	1.51	—	1.48	10
Nitrite, as nitrogen (mg/L)	—	0.0500 U	—	0.0500 U	—	0.120	0.0500 U	—	0.109	1
pH	—	7.48	—	7.81	7.56	7.82	7.92	**9.42**	**9.83**	6.5 – 8.5
Selenium (mg/L)	—	0.0015	—	0.0011	—	0.0012	0.0011	—	0.0013	0.05
Selenium-filtered (mg/L)	—	0.0013	—	0.0011	—	0.0013	0.0011	—	0.0013	0.05
Silver (mg/L)	—	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)	—	11.2	—	81.7	—	83.7	63.4	—	63.4	NA
Sodium-filtered (mg/L)	—	10.3	—	81.9	—	84.0	63.8	—	63.7	NA
Total dissolved solids (mg/L)	—	194	—	427	—	434	433	—	440	500
Total Kjeldahl nitrogen (mg/L)	—	0.329	—	—	0.957	0.353	—	0.626	0.321	NA
Total phosphorus (mg/L)	—	0.256	—	—	0.696	0.0695	—	0.0266	0.0264	NA

a. ICPP-MON-V-191 samples collected on 7/6/2009 in conjunction with the other wells being sampled per footnote b.

b. Samples recollected for chloride, fluoride, total phosphorus and total Kjeldahl nitrogen because they were missed during the April 2009 sampling event.

c. Primary constituent standards (PCS) and secondary constituent standards (SCS) in groundwater referenced in IDAPA 58.01.11.200.01.a and b.

d. ICPP-MON-V-191 is a perched well and was dry in April 2009 and October 2009.

e. NA = not applicable.

f. Water level elevations referenced to NAVD88 datum.

g. **Bold** = Exceedance of groundwater quality standard. Well ICPP-MON-V-191 is an upgradient, noncompliance point, and is outside the zone of influence of the New Percolation Ponds. Therefore, these exceedances are not considered permit noncompliances.

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

Bristly Cutworm Moth

Table B-10. Advanced Test Reactor Complex Cold Waste Pond Surveillance Results (2009).[a]

Parameter	Minimum	Maximum	Median
Aluminum (mg/L)	0.025 U[b]	0.105	0.025 U
Antimony (mg/L)	0.00025 U	0.0012	0.00069
Gross alpha (pCi/L ± 1s)	0.618 ± 0.582 U	5.31 ± 1.58	Not calculated
Gross beta (pCi/L ± 1s)	0.227 ± 0.708 U	18.5 ± 1.62	Not calculated
Lead (mg/L)	0.00025 U	0.00044	0.00025 U
pH (standard units)	7.54	8.12	7.94
Potassium-40 (pCi/L ± 1s)	-25.6 ± 10.6 U	46.7 ± 13.2	Not calculated
Sodium (mg/L)	7,940	35,900	25,200
Zinc	0.0025 U	0.0037	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 B-11. Advanced Test Reactor Complex Cold Waste Pond Industrial Wastewater Reuse Permit Monitoring Well Results (2009).

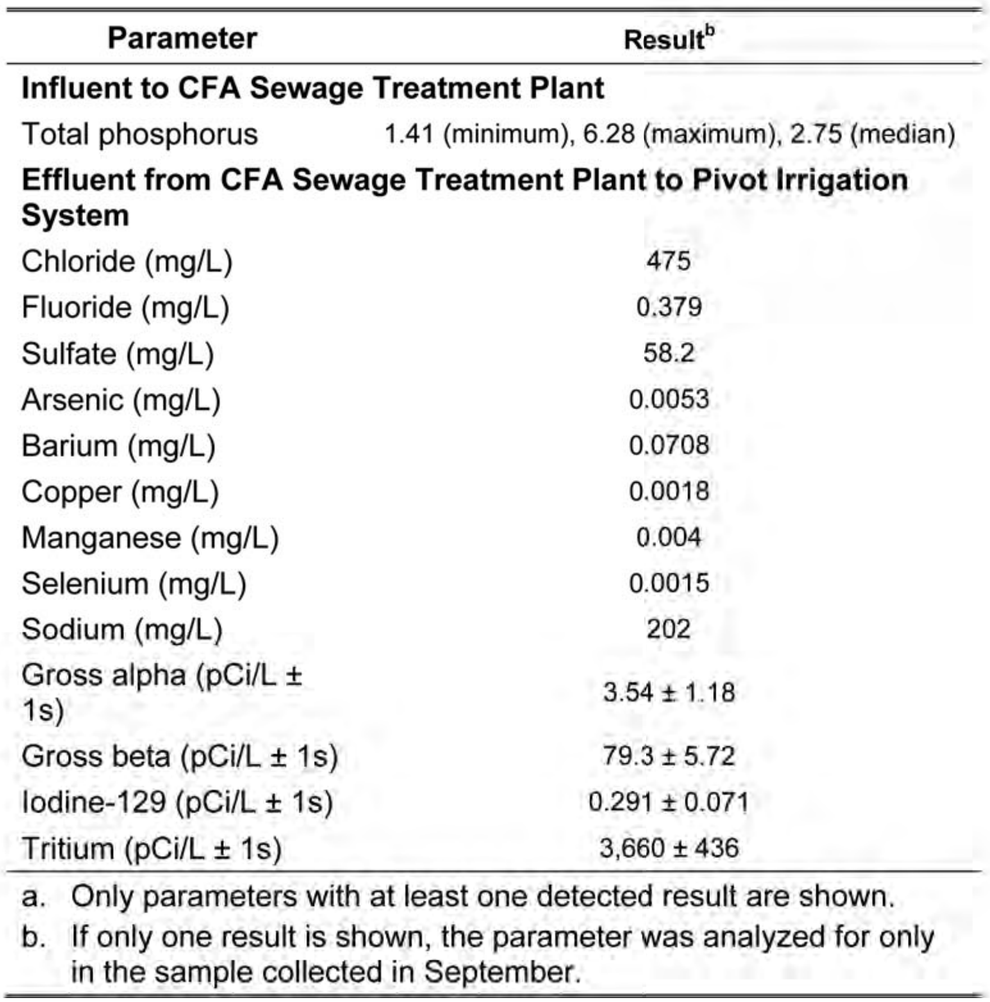
Monitoring Well	Sample Date	Parameter	Sample Result[a] (pCi/L)
USGS-065	04/14/09	Gross alpha	2.8 ± 0.846
		Gross beta	5.27 ± 0.766
		Tritium	5,150 ± 541
	10/12/09	Gross beta	4.4 ± 0.977
		Tritium	6,240 ± 649
TRA-07	04/20/09	Gross alpha	4.2 ± 1.03
		Gross beta	9.45 ± 1.09
		Tritium	12,100 ± 1,220
	10/14/09	Gross beta	6.15 ± 1.05
		Potassium-40	48.1 ± 14.6
		Tritium	13,900 ± 1,400
TRA-08	04/20/09	Gross beta	11.7 ± 1.32
		Strontium-90	2.72 ± 0.35
		Tritium	3,110 ± 341
USGS-076	04/21/09	Gross beta	2.38 ± 0.737
		Tritium	873 ± 134
	10/12/09	Tritium	939 ± 153
Middle-1823	04/14/09	Gross alpha	1.97 ± 0.604[b]
		Gross beta	2.07 ± 0.512
		Tritium	1,395 ± 179[b]
	10/14/09	Tritium	1,800 ± 225

a. Result ± one sigma uncertainty.

b. The result and uncertainty shown is the average of the original and duplicate samples.


Bristly Cutworm Moth

Table B-12. Liquid Influent and Effluent Surveillance Monitoring Results for Central Facilities Area (2009).[a]

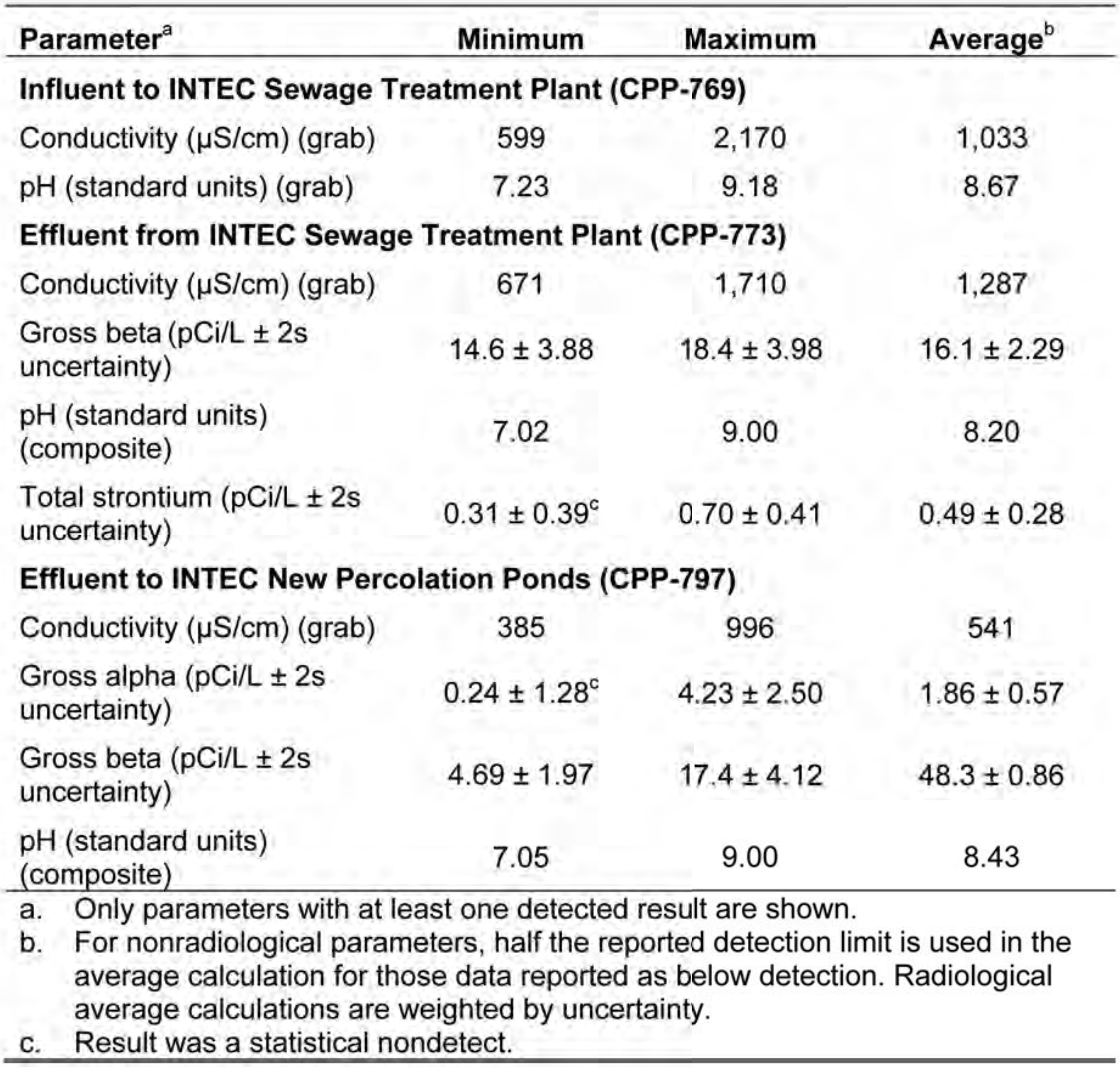


Parameter	Result[b]
Influent to CFA Sewage Treatment Plant	
Total phosphorus	1.41 (minimum), 6.28 (maximum), 2.75 (median)
Effluent from CFA Sewage Treatment Plant to Pivot Irrigation System	
Chloride (mg/L)	475
Fluoride (mg/L)	0.379
Sulfate (mg/L)	58.2
Arsenic (mg/L)	0.0053
Barium (mg/L)	0.0708
Copper (mg/L)	0.0018
Manganese (mg/L)	0.004
Selenium (mg/L)	0.0015
Sodium (mg/L)	202
Gross alpha (pCi/L ± 1s)	3.54 ± 1.18
Gross beta (pCi/L ± 1s)	79.3 ± 5.72
Iodine-129 (pCi/L ± 1s)	0.291 ± 0.071
Tritium (pCi/L ± 1s)	3,660 ± 436

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 September.

Table B-13. Liquid Influent and Effluent Surveillance Monitoring Results for Idaho Nuclear Technology and Engineering Center (2009).



Parameter[a]	Minimum	Maximum	Average[b]
Influent to INTEC Sewage Treatment Plant (CPP-769)			
Conductivity (µS/cm) (grab)	599	2,170	1,033
pH (standard units) (grab)	7.23	9.18	8.67
Effluent from INTEC Sewage Treatment Plant (CPP-773)			
Conductivity (µS/cm) (grab)	671	1,710	1,287
Gross beta (pCi/L ± 2s uncertainty)	14.6 ± 3.88	18.4 ± 3.98	16.1 ± 2.29
pH (standard units) (composite)	7.02	9.00	8.20
Total strontium (pCi/L ± 2s uncertainty)	0.31 ± 0.39[c]	0.70 ± 0.41	0.49 ± 0.28
Effluent to INTEC New Percolation Ponds (CPP-797)			
Conductivity (µS/cm) (grab)	385	996	541
Gross alpha (pCi/L ± 2s uncertainty)	0.24 ± 1.28[c]	4.23 ± 2.50	1.86 ± 0.57
Gross beta (pCi/L ± 2s uncertainty)	4.69 ± 1.97	17.4 ± 4.12	48.3 ± 0.86
pH (standard units) (composite)	7.05	9.00	8.43

a. Only parameters with at least one detected result are shown.

b. For nonradiological parameters, half the reported detection limit is used in the average calculation for those data reported as below detection. Radiological average calculations are weighted by uncertainty.

c. Result was a statistical nondetect.

Table B-14. Monitoring Results for Material and Fuels Complex Industrial Waste Pond (2009).[a]

Parameter	Minimum	Maximum	Median
Barium[b] (mg/L)	0.0403	0.0403	Not calculated
Chloride[b] (mg/L)	18.5	41.6	31.45
Chromium[b] (mg/L)	0.005	0.005	Not calculated
Copper[b] (mg/L)	0.002	0.002	Not calculated
Fluoride (mg/L)	0.298	0.728	0.627
Iron (mg/L)	0.0541	23.1	0.947
Lead[b] (mg/L)	0.00033	0.00033	Not calculated
Manganese (mg/L)	0.153	0.153	Not calculated
Nitrogen, nitrate + nitrite (mg-N/L)	0.21	1.76	0.726
Nitrogen, total Kjeldahl (mg/L)	0.408	1.9	0.901
Selenium[b] (mg/L)	0.00098	0.00098	Not calculated
Sodium (mg/L)	14.1	55.2	26.4
Sulfate (mg/L)	12.4	22.1	19.85
Total dissolved solids (mg/L)	239	435	297.5
Total phosphorus (mg/L)	0.104	1.37	0.239
Total suspended solids (mg/L)	4 U[c]	196	7.85
Zinc[b] (mg/L)	0.004	0.004	Not calculated
Gross alpha (pCi/L ± 1s)	0.72 ± 0.676 U	17 ± 2.8	Not calculated
Gross beta (pCi/L ± 1s)	2.84 ± 0.947	24.4 ± 2.14	Not calculated
Potassium-40 (pCi/L ± 1s)	-15.6 ± 11.6 U	37.1 ± 8.67	Not calculated
Uranium-233/234[b] (pCi/L ± 1s)	1.28 ± 0.199	1.28 ± 0.199	Not calculated
Uranium-238[b] (pCi/L ± 1s)	0.732 ± 0.142	0.732 ± 0.142	Not calculated

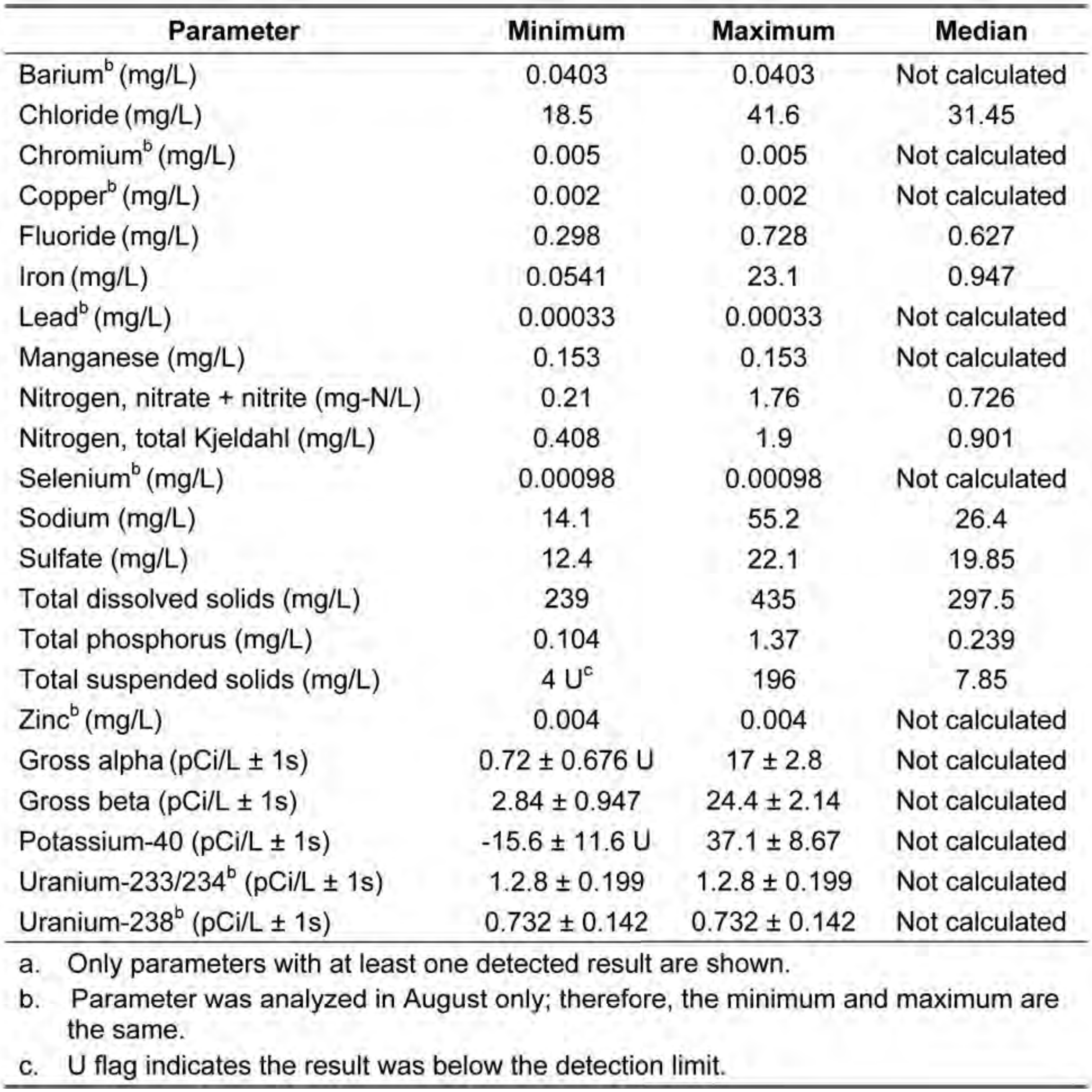
a. Only parameters with at least one detected result are shown.

b. Parameter was analyzed in August only; therefore, the minimum and maximum are the same.

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

Scarab beetle

Table B-15. Surveillance Monitoring Results for Materials and Fuels Complex Industrial Waste Ditch (2009).[a]



Parameter	Minimum	Maximum	Median
Barium[b] (mg/L)	0.0403	0.0403	Not calculated
Chloride (mg/L)	18.5	41.6	31.45
Chromium[b] (mg/L)	0.005	0.005	Not calculated
Copper[b] (mg/L)	0.002	0.002	Not calculated
Fluoride (mg/L)	0.298	0.728	0.627
Iron (mg/L)	0.0541	23.1	0.947
Lead[b] (mg/L)	0.00033	0.00033	Not calculated
Manganese (mg/L)	0.153	0.153	Not calculated
Nitrogen, nitrate + nitrite (mg-N/L)	0.21	1.76	0.726
Nitrogen, total Kjeldahl (mg/L)	0.408	1.9	0.901
Selenium[b] (mg/L)	0.00098	0.00098	Not calculated
Sodium (mg/L)	14.1	55.2	26.4
Sulfate (mg/L)	12.4	22.1	19.85
Total dissolved solids (mg/L)	239	435	297.5
Total phosphorus (mg/L)	0.104	1.37	0.239
Total suspended solids (mg/L)	4 U[c]	196	7.85
Zinc[b] (mg/L)	0.004	0.004	Not calculated
Gross alpha (pCi/L ± 1s)	0.72 ± 0.676 U	17 ± 2.8	Not calculated
Gross beta (pCi/L ± 1s)	2.84 ± 0.947	24.4 ± 2.14	Not calculated
Potassium-40 (pCi/L ± 1s)	-15.6 ± 11.6 U	37.1 ± 8.67	Not calculated
Uranium-233/234[b] (pCi/L ± 1s)	1.2.8 ± 0.199	1.2.8 ± 0.199	Not calculated
Uranium-238[b] (pCi/L ± 1s)	0.732 ± 0.142	0.732 ± 0.142	Not calculated

a. Only parameters with at least one detected result are shown.

b. Parameter was analyzed in August only; therefore, the minimum and maximum are the same.

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

Bristly Cutworm Moth

Table B-16. Surveillance Monitoring Results for Materials and Fuels Complex Secondary Sanitary Lagoon (2009).[a]

Parameter	Minimum	Maximum	Median
Arsenic[b] (mg/L)	0.0058	0.0058	Not calculated
Barium[b] (mg/L)	0.0427	0.0427	Not calculated
Chromium[b] (mg/L)	0.0027	0.0027	Not calculated
Chloride (mg/L)	20.1	59.3	30.5
Fluoride (mg/L)	0.577	0.687	0.642
Iron (mg/L)	0.025 U[c]	0.153	0.02835
Lead[b] (mg/L)	0.00064	0.00064	Not calculated
Nitrogen, nitrate + nitrite (mg-N/L)	1.78	2.32	1.985
Nitrogen, total Kjeldahl (mg/L)	0.134	1.23	0.2565
Selenium[b] (mg/L)	0.00065	0.00065	Not calculated
Sodium (mg/L)	20.1	41.5	25.6
Sulfate (mg/L)	17.5	22.5	19
Total dissolved solids (mg/L)	238	320	267
Total phosphorus (mg/L)	0.14	0.695	0.2925
Total suspended solids (mg/L)	4 U	15.6	4 U
Zinc[b] (mg/L)	0.0254	0.0254	Not calculated
Gross alpha (pCi/L ± 1s)	-0.295 ± 0.493 U	7.57 ± 1.7	Not calculated
Gross beta (pCi/L ± 1s)	2.25 ± 1.16 U	5.02 ± 0.705	Not calculated
Potassium-40 (pCi/L ± 1s)	-13 ± 10.7 U	47.5 ± 9.07	Not calculated
Uranium-233/234[b] (pCi/L ± 1s)	1.68 ± 0.23	1.68 ± 0.23	Not calculated
Uranium-235[b] (pCi/L ± 1s)	0.0714 ± 0.0417	0.0714 ± 0.0417	Not calculated
Uranium-238[b] (pCi/L ± 1s)	0.886 ± 0.151	0.886 ± 0.151	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.

Blue penstemon (*Penstemon cyaneus*)

Figure C-1. Environmental Radiation Measurements at Auxiliary Reactor Area (2009).

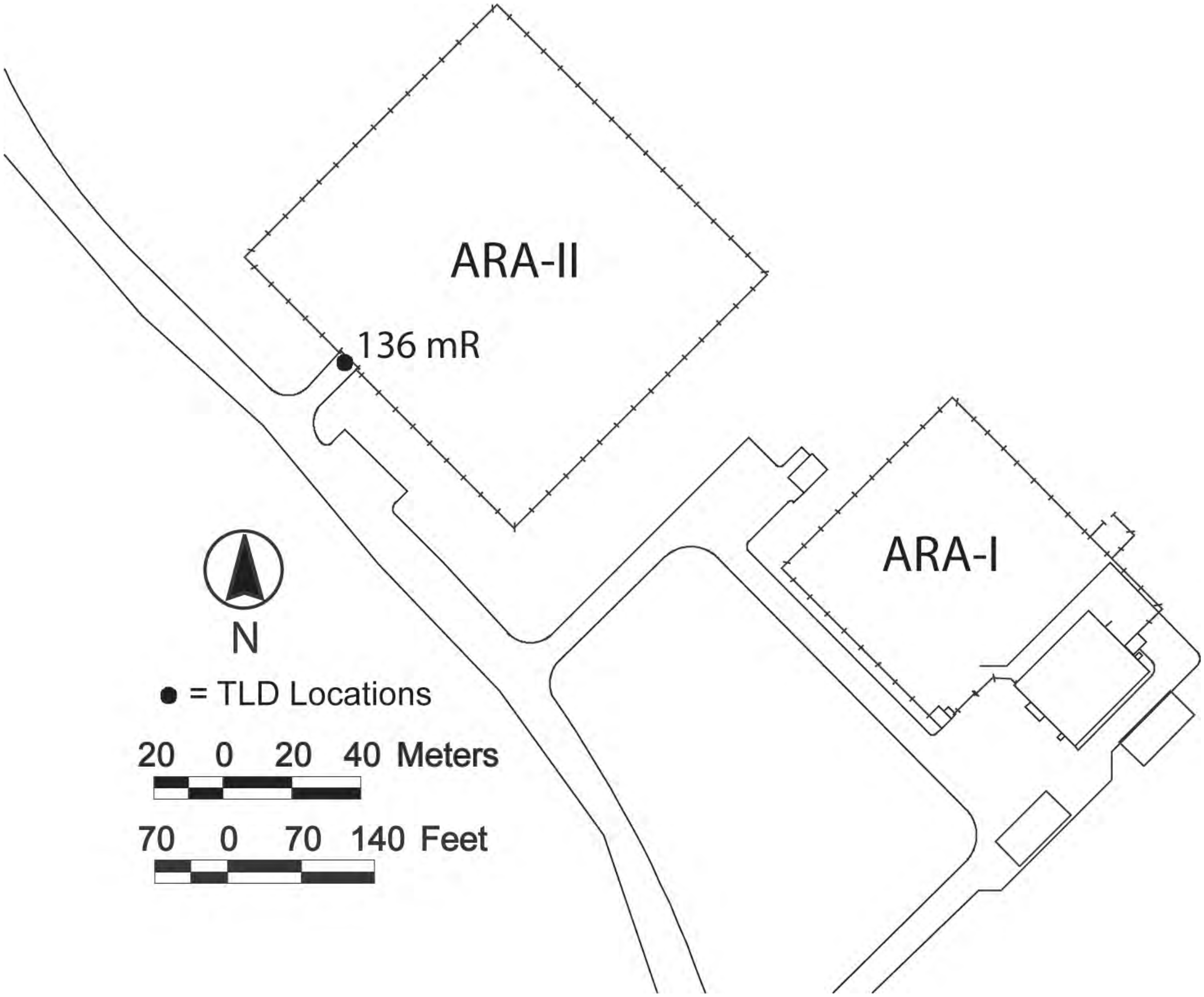
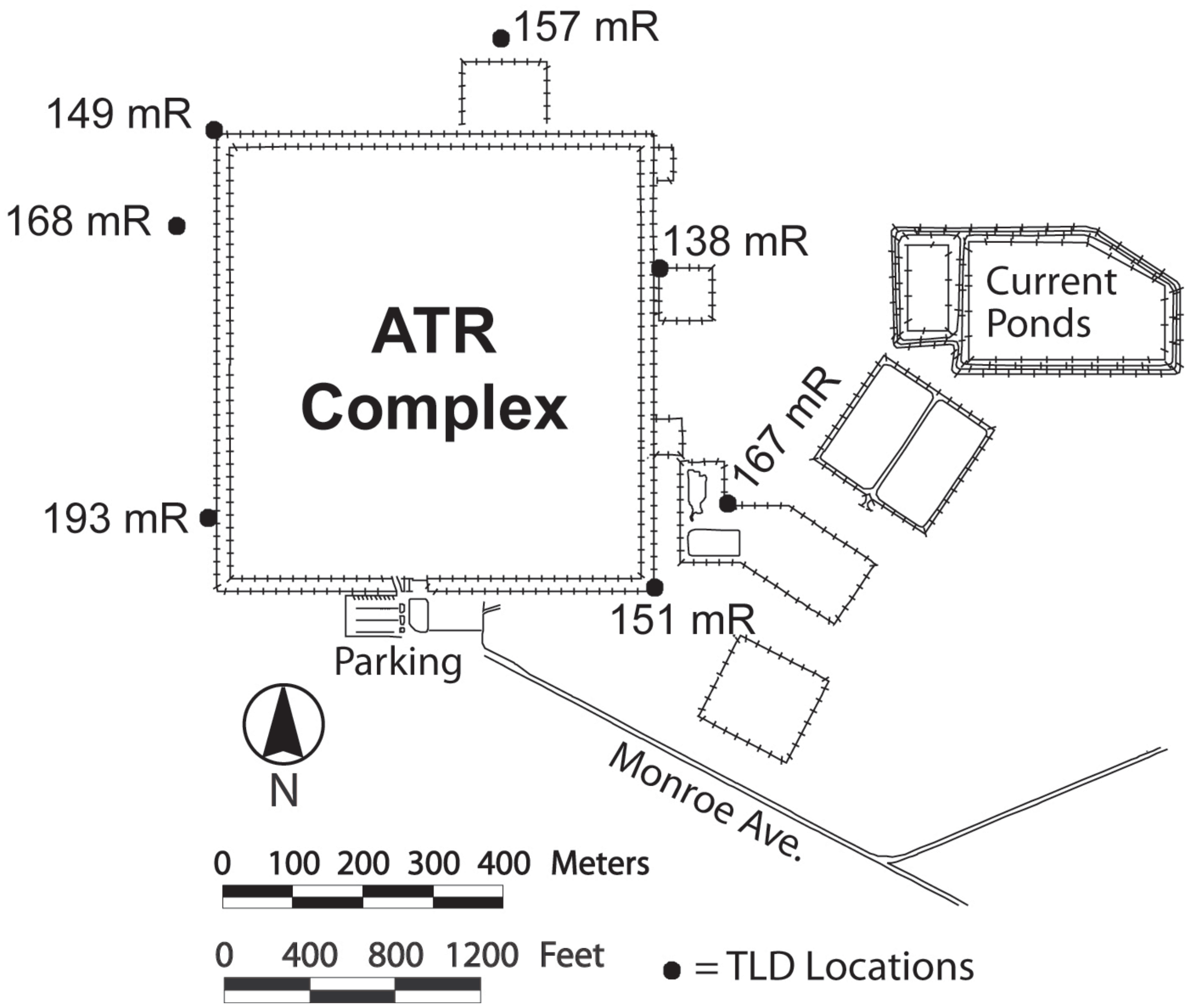


Figure C-2. Environmental Radiation Measurements at Advanced Test Reactor Complex (2009).



Bristly Cutworm Moth

Figure C-3. Environmental Radiation Measurements at Central Facilities Area (2009).

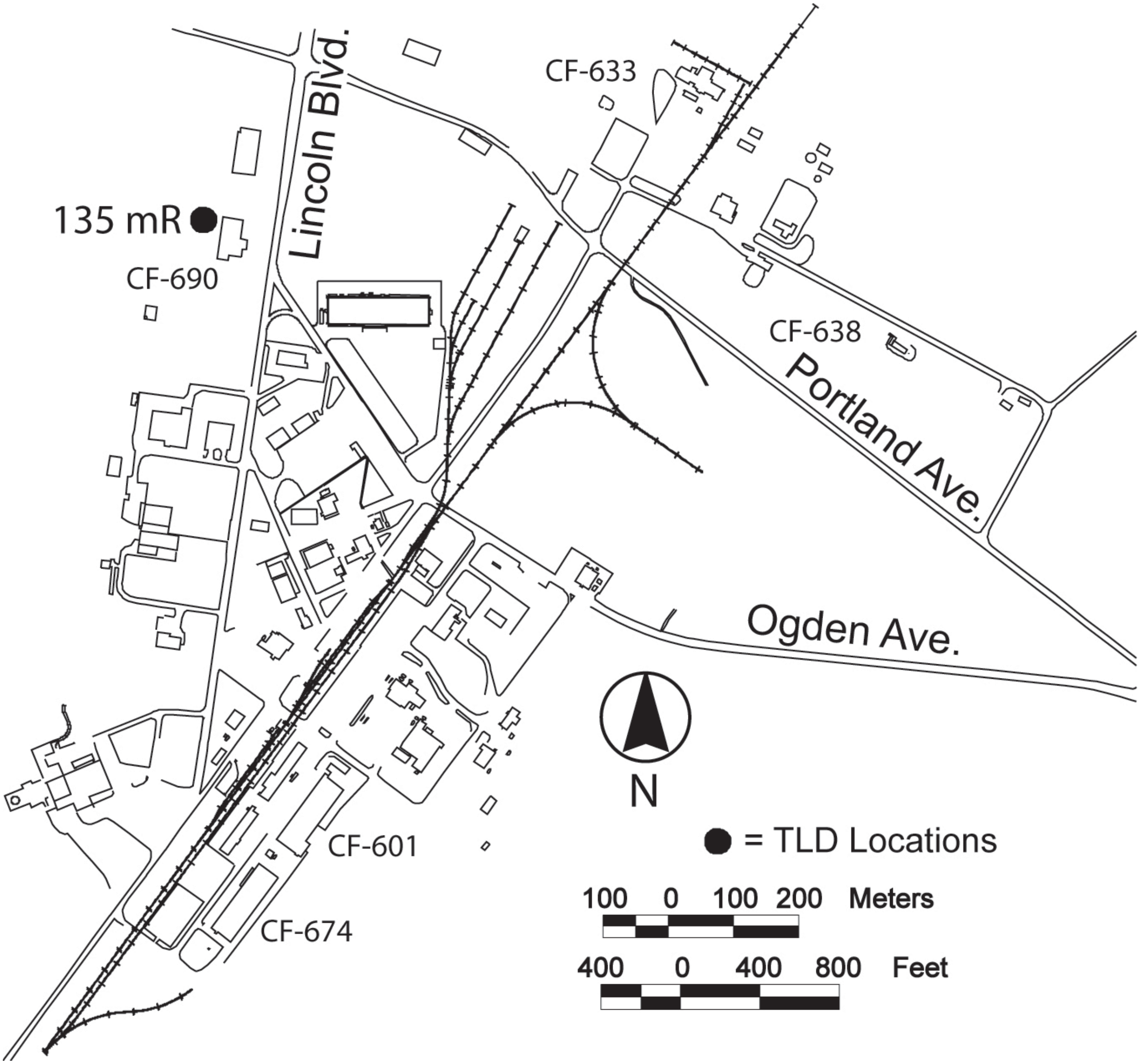


Figure C-4. Environmental Radiation Measurements at Critical Infrastructure Test Range Complex (2009).

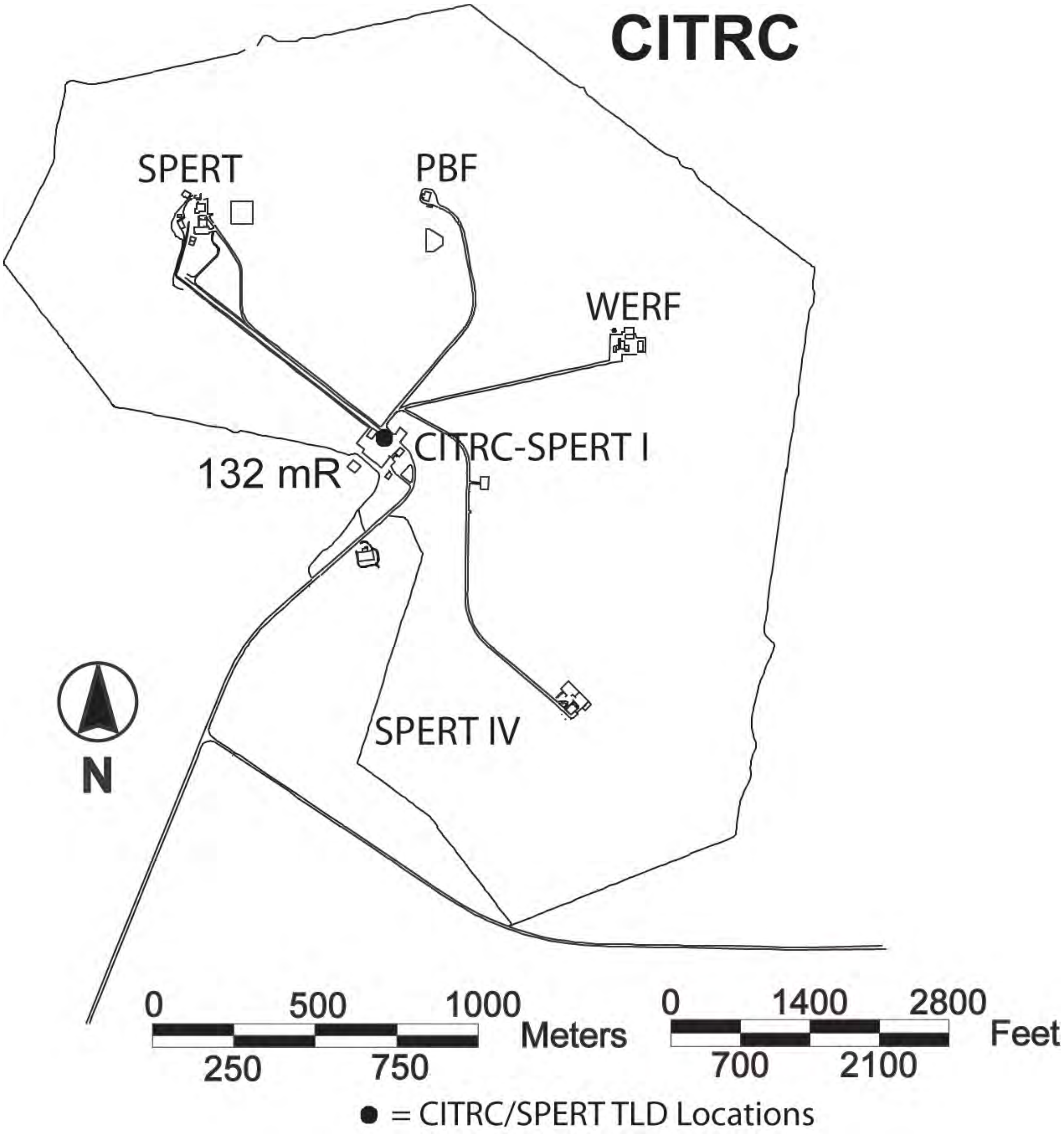


Figure C-5. Environmental Radiation Measurements at Idaho Nuclear Technology and Engineering Center (2009).

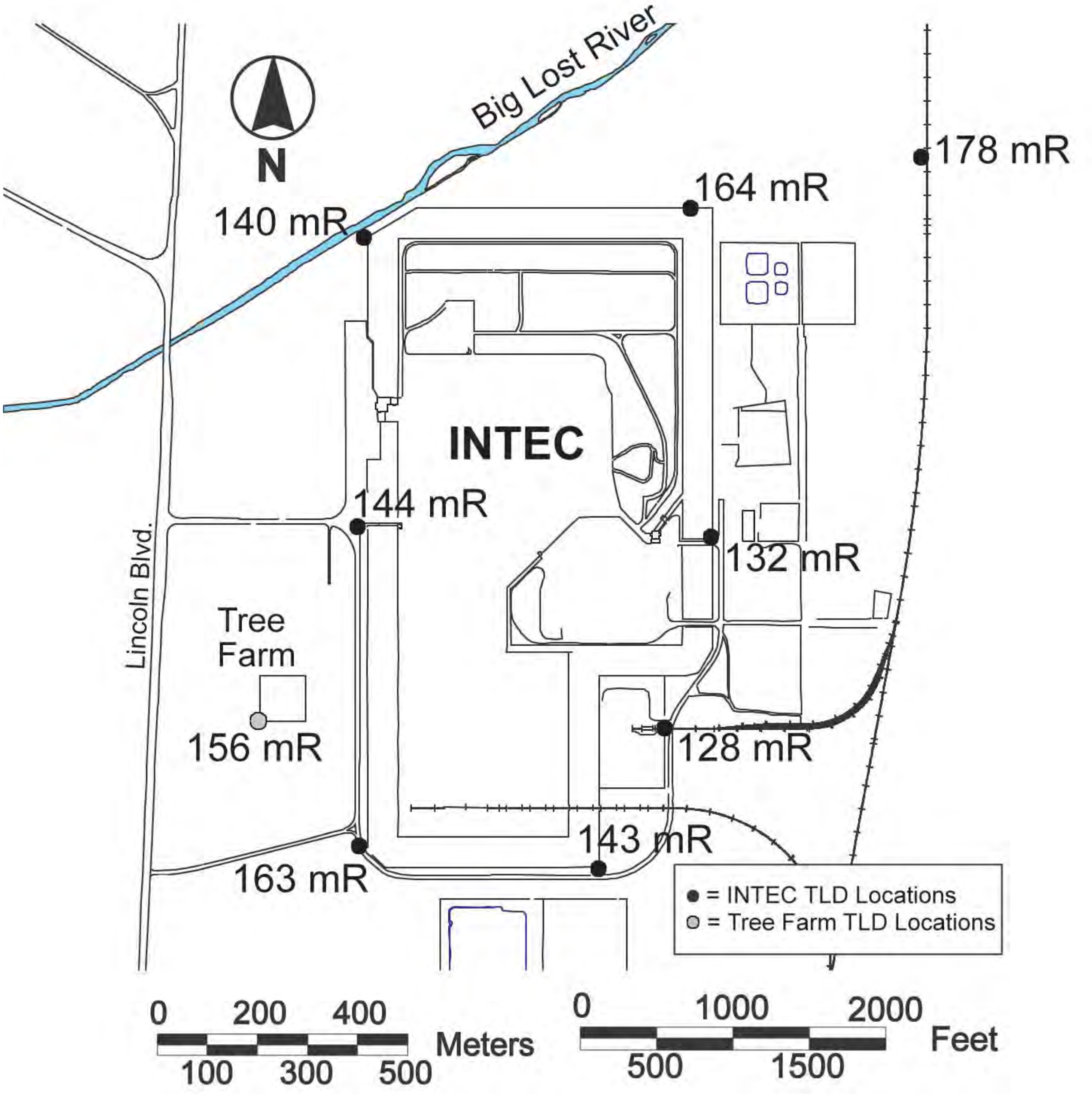


Figure C-6. Environmental Radiation Measurements at Materials and Fuels Complex (2009).

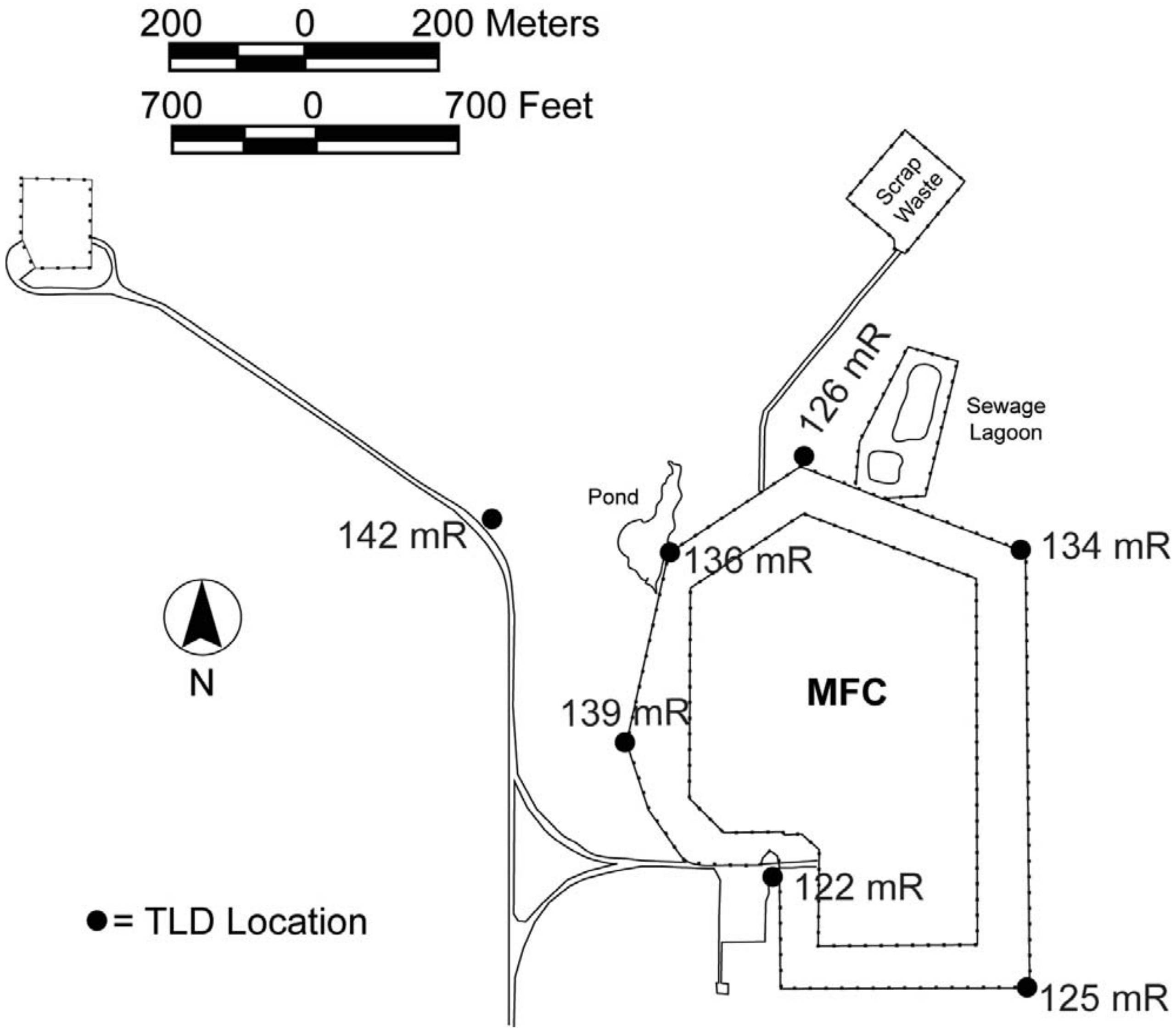


Figure C-7. Environmental Radiation Measurements at Naval Reactors Facility (2009).

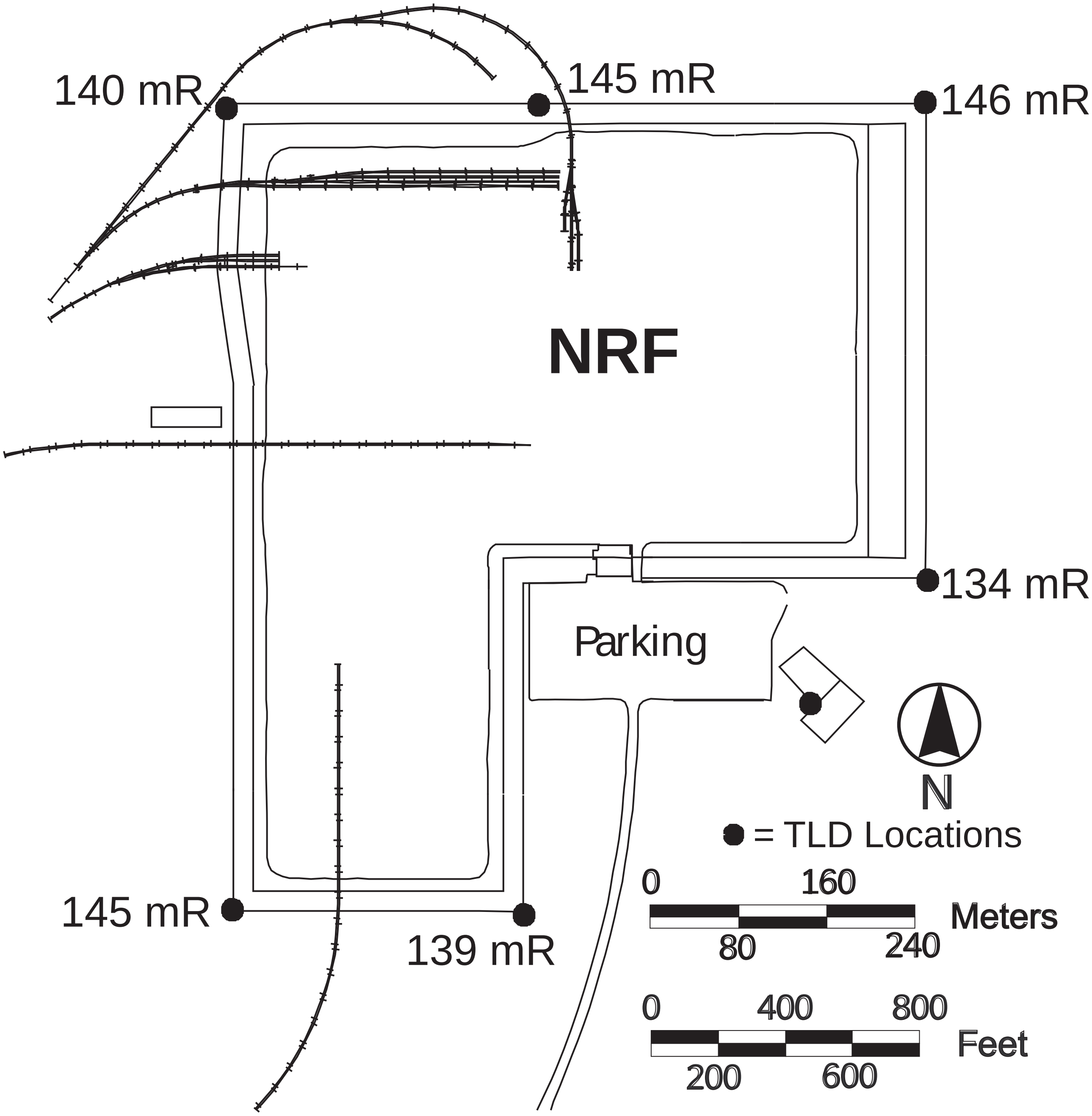


Figure C-8. Environmental Radiation Measurements at Radioactive Waste Management Complex (2009).

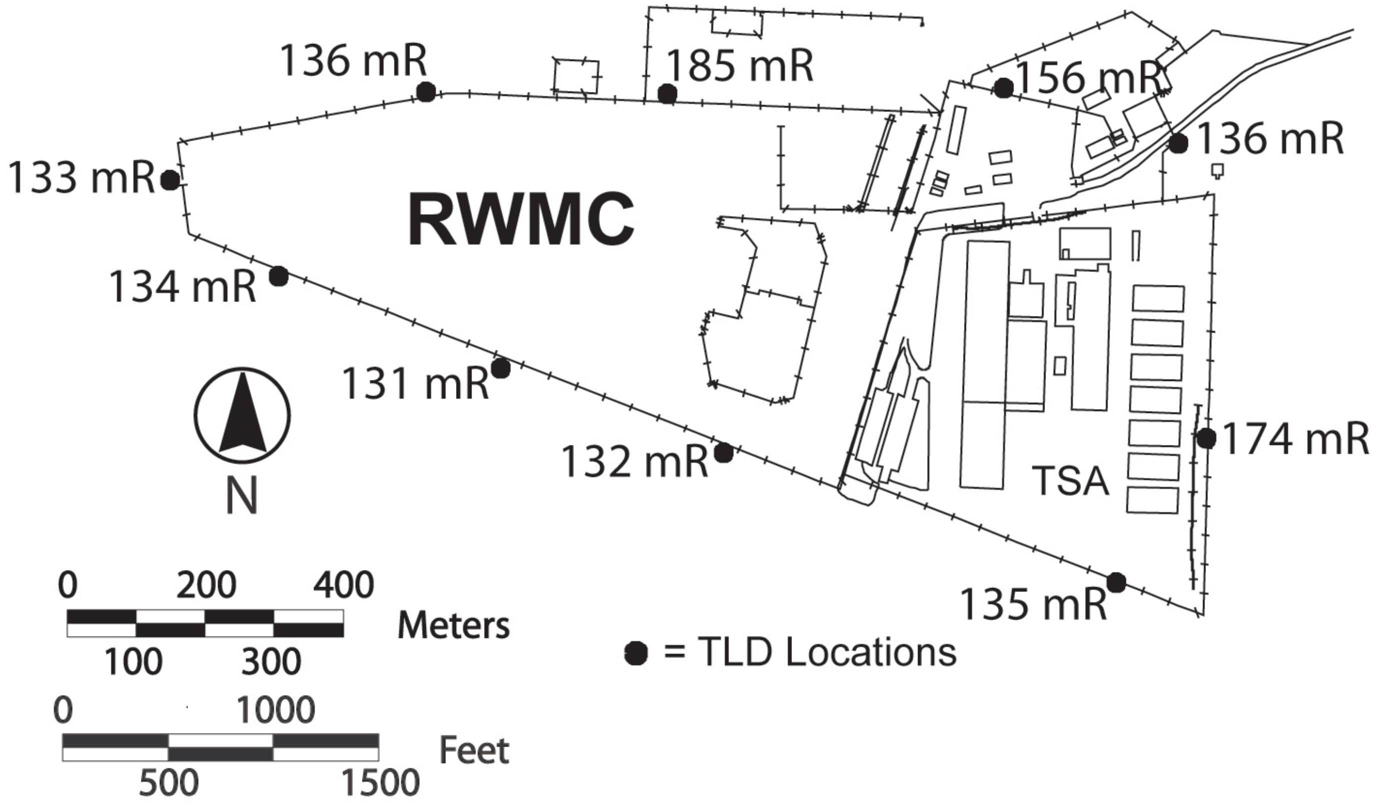


Figure C-9. Environmental Radiation Measurements at Test Area North (2009).

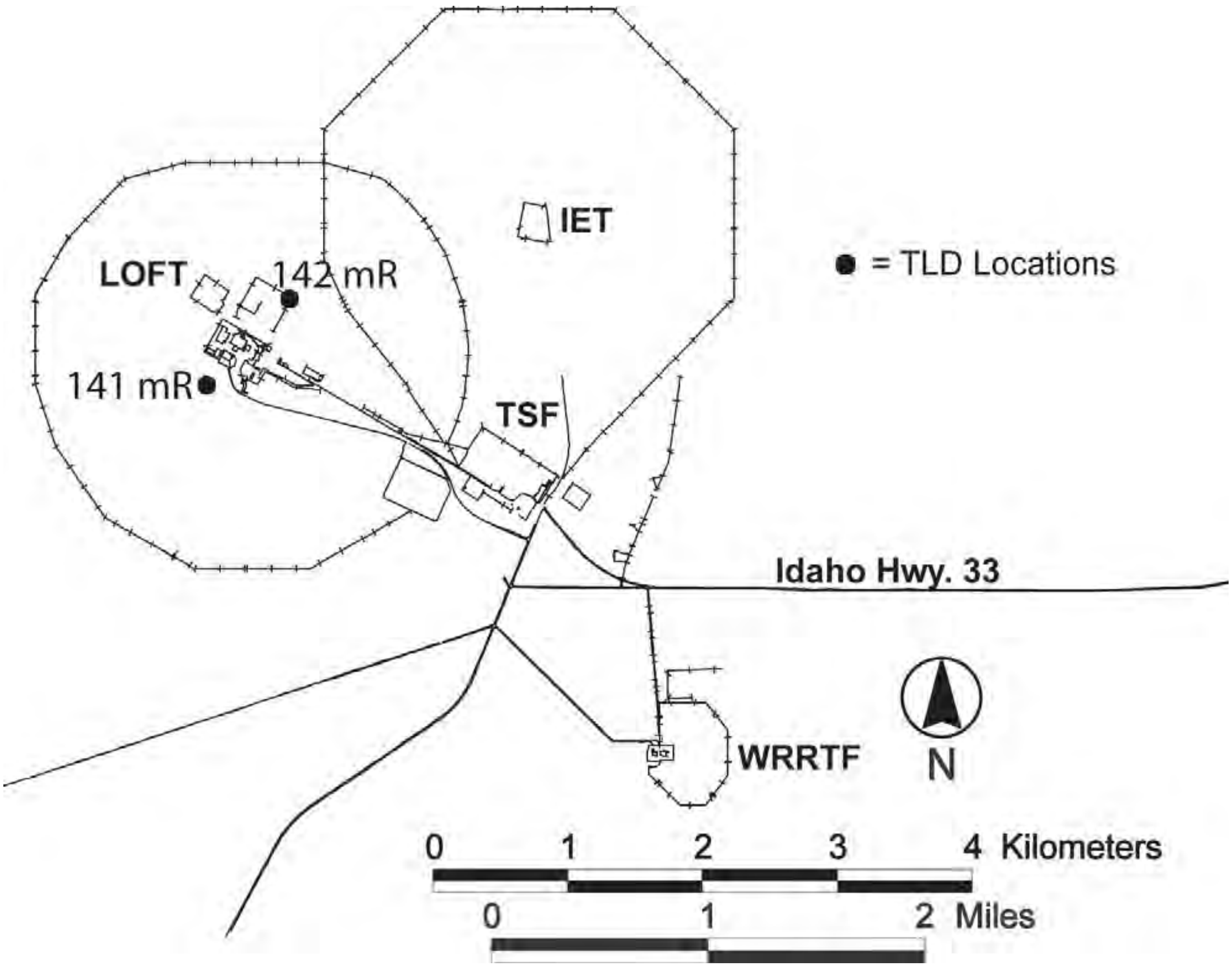
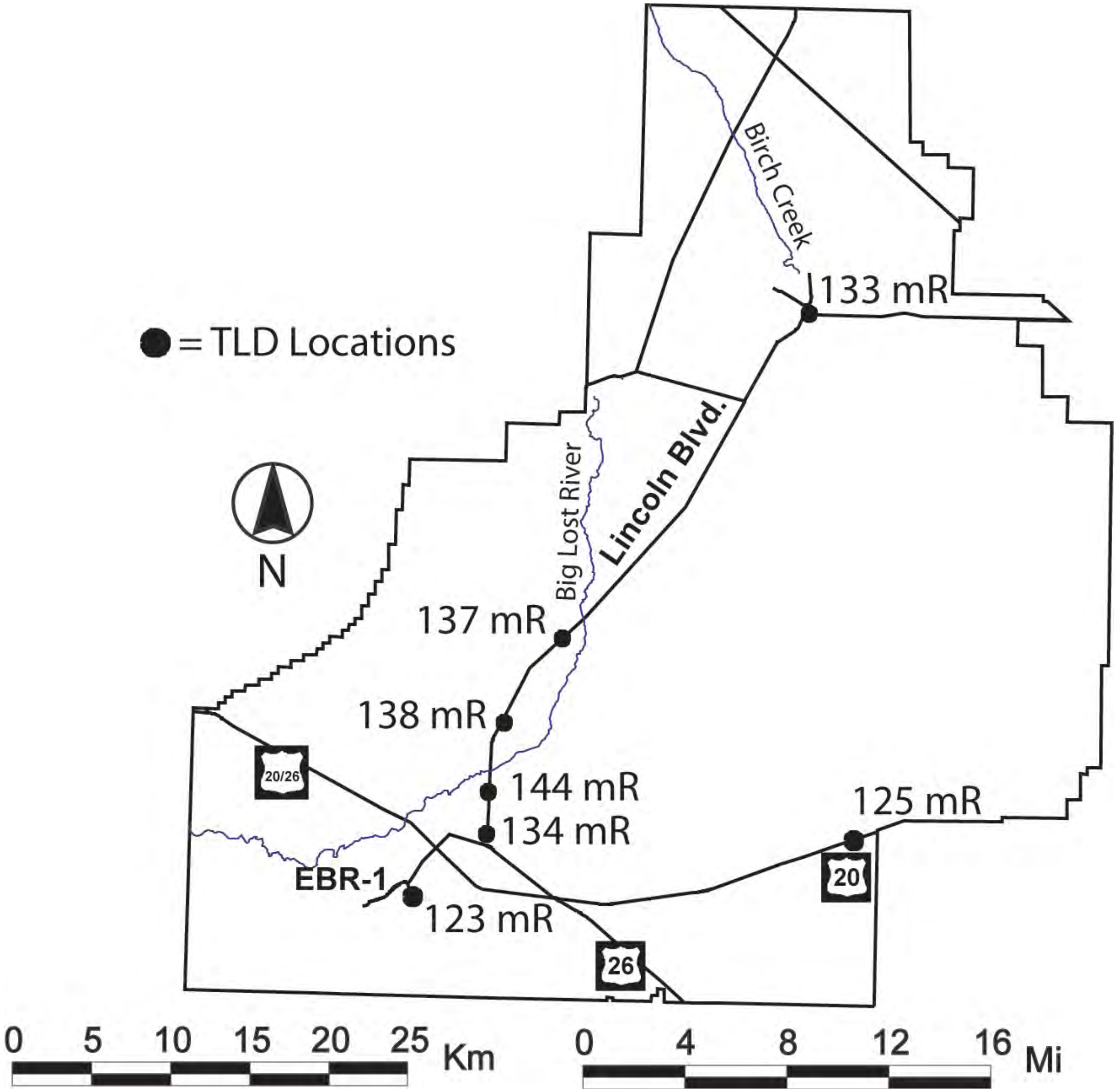


Figure C-10. Environmental Radiation Measurements at Sitewide Locations (2009).



Appendix D. 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.

Scarab beetle

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

Bristly Cutworm Moth

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

Scarab beetle

organ-sievert). The 50-mile distance is measured from a point located centrally with respect to major facilities or U.S. Department of Energy program activities.

dosimeter: Portable detection device for measuring the total accumulated exposure to ionizing radiation.

dosimetry: The theory and application of the principles and techniques involved in the measurement and recording of radiation doses.

drinking water: Water for the primary purpose of consumption by humans.

duplicate sample: A sample collected from the same sampling location using the same equipment and sampling technique and placed into an identically prepared and preserved container. Duplicate samples are analyzed independently as an indication of gross errors in sampling techniques.

E

Eastern Snake River Plain Aquifer: One of the largest groundwater "sole source" resources in the United States. It lies beneath a rolling topography extending some 308 km (191 mi) from Ashton to King Hill, Idaho, and ranges in width from 64 to 130 km (40 to 80 mi). The plain and aquifer were formed by repeated volcanic eruptions that were the result of a geologic hot spot beneath the earth's crust.

ecosystem: The interacting system of a biologic community and its nonliving environment.

effective dose equivalent (EDE): A value used to express the health risk from radiation exposure to a tissue in terms of an equivalent whole body exposure. It is a normalized value that allows the risk from radiation exposure received by a specific organ or part of the body to be compared with the risk due to whole body exposure. It is equal to the sum of products of the dose to each tissue or organ multiplied by their respective weighting factor for each tissue or organ. The weighting factor is used to put the dose to the different tissue and organs on an equal basis in terms of health risk. The EDE is expressed in units of rem or sieverts.

effluent: Any liquid discharged to the environment, including storm water runoff at a site or facility.

effluent waste: Treated wastewater leaving a treatment facility.

electrometallurgical treatment: The process of treating spent nuclear fuel using metallurgical techniques.

environment: Includes water, air, and land and the interrelationship that exists among and between water, air, and land and all living things.

environmental indicators: Animal and plant species that are particularly susceptible to decline related to changes, either physical or chemical, in their environment.

environmental media: Includes air, groundwater, surface water, soil, flora, and fauna.

environmental monitoring: Sampling for contaminants in air, water, sediments, soils, agricultural products, plants, and animals, either by direct measurement or by collection and analysis of samples. It is a combination of two distinct activities (effluent monitoring and environmental surveillance) that together provide information on the health of an environment.

equipment blank: Sample prepared by collecting uncontaminated water passed over or through the sampling equipment. This type of blank sample is normally collected after the sampling equipment has been used and subsequently cleaned. An equipment blank is used to detect contamination introduced by the sampling equipment either directly or through improper cleaning.

exposure: The interaction of an organism with a physical or chemical agent of interest. Examples of such agents are radiation (physical) and carbon tetrachloride (chemical).

exposure pathway: The mechanism through which an organism may be exposed to a contaminant. An example is the surface water pathway, whereby an organism may be exposed to a contaminant through the consumption of surface water containing that contaminant.

extremely hazardous chemical: A substance listed in the appendices to 40 CFR 355 “Emergency Planning and Notification.”

F

fallout: Radioactive material made airborne as a result of aboveground nuclear weapons testing that has been deposited on the earth’s surface.

field blank: A blank used to provide information about contamination that may be introduced during sample collection, storage and transport. A known uncontaminated sample, usually deionized water, is exposed to ambient conditions at the sampling site and subjected to the same analytical or measurement process as other samples.

fissile material: Material capable of starting and sustaining a nuclear chain reaction.

fission: The nuclear reaction resulting from the splitting of atoms.

flood plain: Lowlands bordering a river that are subject to flooding. A flood plain is comprised of sediments carried by rivers and deposited on land during flooding.

G

gamma radiation: A form of electromagnetic radiation, like radio waves or visible light, but with a much shorter wavelength. It is more penetrating than alpha or beta radiation, capable of passing through dense materials such as concrete.

gamma spectroscopy: An analysis technique that identifies specific radionuclides that emit gamma radiation. It measures the particular energy of a radionuclide’s gamma radiation emissions. The energy of these emissions is unique for each radionuclide, acting as a fingerprint to identify a specific radionuclide.

gross alpha activity: The total radioactivity due to alpha particle emission as inferred from measurements on a dry sample. See alpha radiation.

gross beta activity: The total radioactivity due to beta particle emission as inferred from measurements on a dry sample. See beta radiation.

groundwater: Water located beneath the surface of the ground (subsurface water). Groundwater usually refers to a zone of complete saturation containing no air.

H

half-life: The amount of time it takes for the radioactivity of a radioactive material to be reduced by half.

hazardous air pollutant: See hazardous substance.

hazardous chemical: Any hazardous chemical as defined under 29 CFR 1910.1200 (“Hazard Communication”) and 40 CFR 370.2 (“Definitions”).

hazardous material: Material considered dangerous to people or the environment.

hazardous substance: Any substance, including any isomers and hydrates, as well as any solutions and mixtures containing these substances, designated as such under Section 311 (b) (2)(A) of the

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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.

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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.

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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

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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.

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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.

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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).

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weighting factor: A factor that, when multiplied by the dose equivalent delivered to a body organ or tissue, yields the equivalent risk due to a uniform radiation exposure of the whole body.

wetland: An area inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include playa lakes, swamps, marshes, bogs, and similar areas as sloughs, prairie potholes, wet meadows, prairie river overflows, mudflats, and natural ponds.

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